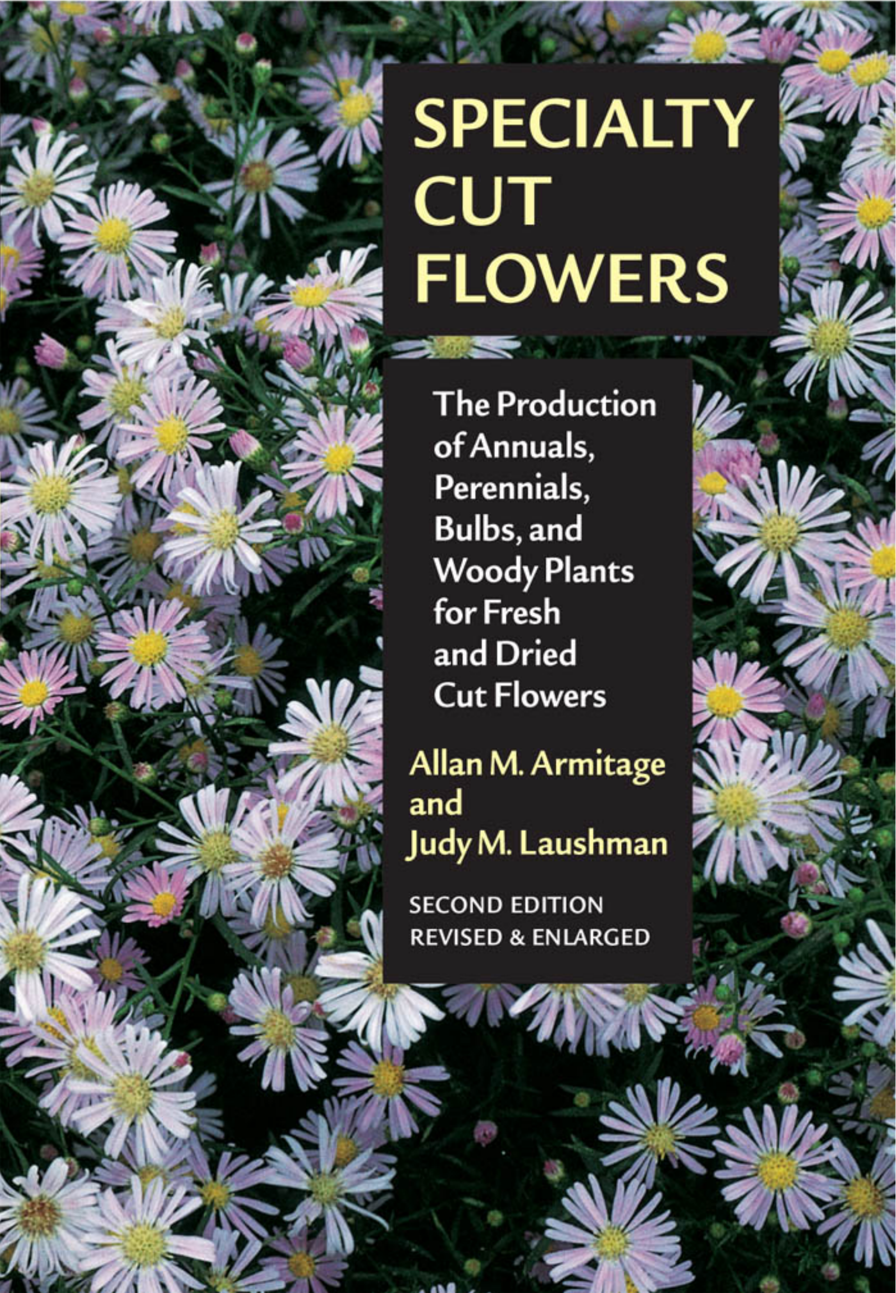


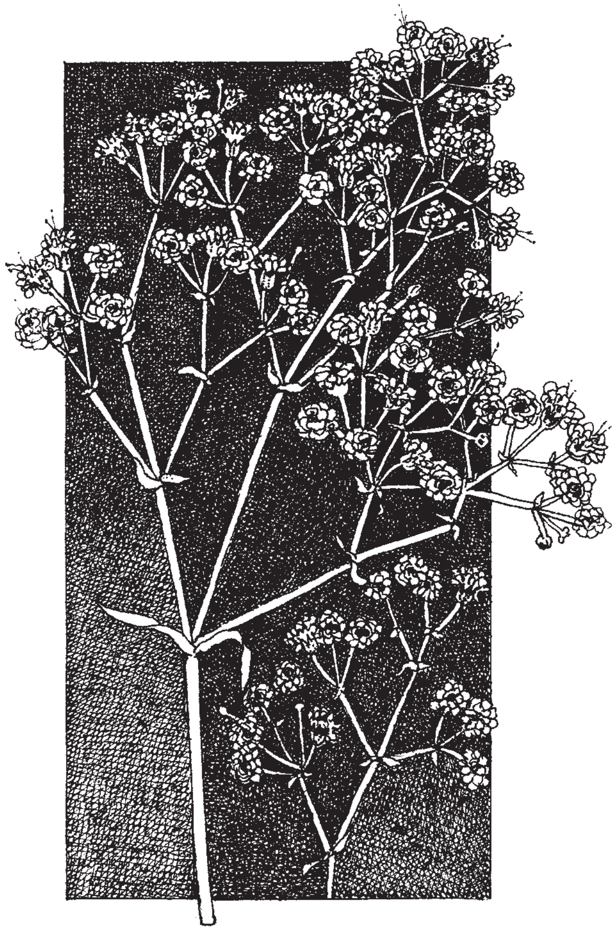
SPECIALTY CUT FLOWERS

The Production of Annuals, Perennials, Bulbs, and Woody Plants for Fresh and Dried Cut Flowers

Allan M. Armitage
and
Judy M. Laushman

SECOND EDITION
REVISED & ENLARGED

SPECIALTY CUT FLOWERS



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The Production of Annuals, Perennials, Bulbs, and Woody Plants for Fresh and Dried Cut Flowers

Second Edition, Revised and Enlarged

Allan M. Armitage and Judy M. Laushman

Illustrations by Patti Dugan

Timber Press
Portland • Cambridge

Photographs by Allan M. Armitage unless otherwise noted.

Frontispiece (*Gypsophila paniculata* 'Bristol Fairy') and all other illustrations by
Patti Dugan
2235 Azalea Drive
Roswell, GA 30075
770.643.8986
email Kdugan3000@aol.com

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To my wife, Susan, who constantly strives for perfection in everything she attempts. She is my role model.

—A.M.A.

In memory of my mom, Catherine Brennan Marriott; and with gratitude and love to Roger, Dan, and Katie for their support, patience, and unique humor.

—J.M.L.

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PREFACE

The first edition of *Specialty Cut Flowers* arrived on book stands in 1993 and immediately became a highly popular book on the subject. A good deal has changed since the first edition, including the emergence of additional crops in the cut flower market and the decline of others. The world has seen new leaders, breakthroughs in medicine and science, boom and bust of economic indicators, conflicts, peace, and unimagined visions of terrorism. Through all these events, people went about their business. Companies emerged and others failed, money was made and life savings were lost. The cut flower business was no exception.

Florida and California are home to major flower farms, and a scattering of farms greater than 50 acres can be found in various other states; but large growing facilities are mainly found overseas. The dominance of the overseas grower has had an interesting effect on the cut flower market in America. Certainly, American growers cannot compete in the rose, carnation, and mum markets, nor are staples like baby's breath easy to grow profitably. These flowers are such commodity items, it is difficult to be profitable, regardless of where or how these plants are grown. But while the bulk of flowers still arrives from overseas, American growers have filled in many of the gaps because they are able to serve small markets and to capitalize on the issues of freshness and diversity of material. Markets are always changing, but as long as the consumer wants the product, there are enough outlets for everyone.

The marketing of flowers has changed. The traditional route of grower to wholesaler to retailer continues to be the highway for large numbers of cut stems; however, smaller and equally efficient avenues have reemerged. The small grower has made a huge comeback, supporting farmers' markets in many small towns and large cities.

When the first edition was written, specialty cut flowers were just beginning to be recognized as "real" crops, not just flunkies of the Big 3—roses, carnations, and mums. Today, the trend toward specialty crops is even stronger because of the willingness of the market to try unusual material and the willingness of growers to provide it. For example, marginal crops like verbena and cardoon are found as cut stems; florists are offering dodecatheon, Chinese forget-me-nots, and weed-like plants like chenopodium, atriplex, and even Johnson grass. And who would have thought that vegetables like okra, artichoke, ornamental kale, and eggplant would be considered useful crops for cut stems? But growers are producing them, and they are being sold. One thing is certain about the cut flower market: the only limitation to what can be used as a cut stem is the imagination of the user.

The consumer remains the key. The cut flower market is like a burlap bag full of puppies: the edges are always moving, it constantly changes position, and it is not made up of a single predictable element but rather of many elements, moving randomly. Nobody can predict what the strength of the market will be, nobody can predict the next great flower or the next great color. The question remains, how do we keep the consumer interested in our product? It really doesn't matter if the stems come from Bogota, Quito, or Omaha, what matters is that someone wants to buy flowers. Promotional campaigns, television ads, Grandmother's Day all help—but what keeps everyday consumers and professional floral arrangers coming back is the perception of value. Most producers don't have the funds to create ad campaigns, and to be honest, who pays attention to ads anymore? No amount of advertising is going to talk anyone into a bouquet or some stems if they don't believe that those flowers push an emotional button, such as love, beauty, sympathy, or gratitude. These buttons are genetically programmed in the human race; the only difference is what pushes them. Fine food, fine wine, and good movies all compete for these spots in a person's soul, so what is a cut flower farmer in Dubuque to do? The answer is uncomplicated: grow fine flowers—not just flowers, but fine flowers. Provide the best freshness, the best stems, the best bouquets, and the best service you know how, and service those buttons. That is all you can do, but if that is done well, the rest takes care of itself.

The answer might be simple, but the techniques needed to grow fine flowers and provide fine service are constantly changing. Production methods, cultivar selection, postharvest procedures, transportation, floral displays, and running the day-to-day aspects of a business are challenging and tiring. To be successful, one must be a horticulturist, agronomist, and pathologist, mixed with the skills of a salesperson and truck driver, and topped off with the enthusiasm of a cheerleader. Larger operations can delegate these activities; smaller ones find a few people balancing them all.

This edition serves the same function as the first—to help growers produce the fine flowers needed to be profitable. But some changes are obvious. Two authors are better than one, and the addition of Judy Laushman as co-author has elevated the quality of the book significantly. The format has been changed for easier reference (bulb or woody, plants now appear in single, straightforward A-to-Z order), crops have been added, and research findings and readings have been updated (so you know we didn't just make all this stuff up). We debated long and hard over the addition of several flowers. We know they're being grown, sold, and accepted by the market; however, unless we could find current research as well as sufficient production information, we decided that crop would have to wait until the next edition.

But the most important change has been the input of the cut flower growers themselves, the vast majority of whom are members of the Association of Specialty Cut Flower Growers. They not only reviewed the sections, they gave us permission to use their candid comments about their experiences in growing the crops. These personal, "real world" comments provide invaluable insights and are a refreshing contrast to the many impersonal words and numbers in the book. To everyone who helped, you have the thanks of every reader, in every state and country.

Allan M. Armitage
Judy M. Laushman

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The information contained in a book of this magnitude is only as good as the people who helped generate it. We were extraordinarily fortunate to have had the help of several talented reviewers. They read, corrected, critiqued, and suggested changes to various sections; their comments and suggestions were invaluable. Many of the people below assisted in the first edition (1993), and affiliations and locations may have changed since that time.

Carolyne Anderson, Anderson Farms, Clark, Mo.
Bob Anderson, Dept. of Horticulture, University of Kentucky, Lexington
Kelly Anderson, WildThang Farms, Ashland, Mo.
Frank Arnosky, Texas Specialty Cut Flowers, Blanco, Tex.
Linda Baranowski-Smith, Blue Clay Plantation, Oregon, Ohio.
J. B. Barzo-Reinke, Small Pleasures Farm, Bandon, Ore.
Bill Borchard, PanAmerican Seed Company, Santa Paula, Calif.
Pat Bowman, Cape May Cut Flowers, Cape May, N.J.
Jo Brownold, California Everlastings, Dunnigan, Calif.
Lynn Byczynski, Growing for Market, Lawrence, Kans.
Maureen Charde, High Meadow Flower Farm, Warwick, N.Y.
Phillip Clark, Endless Summer Flower Farm, Camden, Maine
Ken and Suzy Cook, Atlanta, Ga.
Douglas Cox, Dept. of Horticulture, University of Massachusetts, Amherst
Ralph Cramer, Cramers' Posie Patch, Elizabethtown, Pa.
Mimo Davis, WildThang Farms, Ashland, Mo.
Elizabeth Dean, Wilkerson Mill Gardens, Palmetto, Ga.
August De Hertogh, Raleigh, N.C.
John Dole, Dept. of Horticultural Science, North Carolina State University, Raleigh
Dave Dowling, Farmhouse Flowers, Brookeville, Md.
Fran Foley, Aptos, Calif.
Janet Foss, J. Foss Garden Flowers, Everett, Wash.
Keith Funnell, Dept. of Horticulture, Massey University, Palmerston North, New Zealand
Jim Garner, Atlanta, Ga.

Karen Gast, Kansas State University, Manhattan
Chas Gill, Kennebec Flower Farm, Bowdoinham, Maine
Ken Goldsberry, Dept. of Horticulture, Colorado State University, Fort Collins
Jack Graham, Dramm and Echter, Watsonville, Calif.
Bernadette Hammelman, Hammelman's Dried Floral, Mt. Angel, Ore.
Jeff Hartenfeld, Hart Farm, Solsberry, Ind.
Will Healy, Ball Seed Company, West Chicago, Ill.
Brent Heath, The Daffodil Mart, Gloucester, Va.
Mel Heath, Bridge Farm Nursery, Cockeysville, Md.
Peter Hicklenton, Agriculture Canada, Kentville, Nova Scotia
Christy Holstead-Klink, Floral Communication and Technical Services, Nazareth, Pa.
Mark Hommes, Bulbmark, Inc., Wilmington, N.C.
Steve Houck, Accent Gardens, Boulder, Colo.
Cathy Itz, McCall Creek Farms, Blanco, Tex.
Jennifer Judson-Harms, Cricket Park Gardens, New Hampton, Iowa
Corky Kane, Germania Seed Company, Chicago, Ill.
Philip Katz, PanAmerican Seed Company, Santa Paula, Calif.
John Kelley, Dept. of Horticulture, Clemson University, Clemson, S.C.
Huey Kinzie, Stoney Point Flowers, Gays Mills, Wis.
Roy Klehm, Klehm Nursery, South Barrington, Ill.
Mark Koch, Robert Koch Industries, Bennett, Colo.
Bob Koenders, The Backyard Bouquet, Armada, Mich.
Ginny Kristl, Johnny's Selected Seeds, Albion, Maine
John LaSalle, LaSalle Florists, Whately, Mass.
Dave Lines, Dave Lines' Cut Flowers, La Plata, Md.
Dale Lovejoy, Anderson Levitch/Lovejoy Farms, Eltopia, Wash.
Howard Lubbers, Ottawa Glad Growers, Holland, Mich.
Tom Lukens, Golden State Bulb Growers, Watsonville, Calif.
Robert Lyons, Dept. of Horticultural Science, North Carolina State University, Raleigh
Roxanne McCoy, Lilies of the Field, West Falls, N.Y.
Shelley McGeathy, McGeathy Farms, Hemlock, Mich.
Jeff McGrew, Jeff McGrew Horticultural Products, Mt. Vernon, Wa.
Mike Mellano Sr., Mellano & Company, San Luis Rey, Calif.
Ruth Merrett, Merrett Farm, Upper Kingsclear, N.B.
Kent Miles, Botanicals by K&V, Seymour, Ill.
Susan Minnich, Coles Brook Farm, Becket, Mass.
Don Mitchell, Flora Pacifica, Brookings, Ore.
Brian Myrland, Floral Program Management, Middleton, Wis.
Sally Nakasawa, Nakasawa Everlastings, Yuma, Ariz.
Jim Nau, Ball Seed Company, West Chicago, Ill.
Knud Nielsen III, Knud Nielsen Company, Evergreen, Ala.
Peter Nissen, Sunshine State Carnations, Hobe Sound, Fla.
Leonard Perry, Dept. of Horticulture, University of Vermont, Burlington

Ed Pincus, Third Branch Flower, Roxbury, Vt.
Bob Pollioni, Ventura, Calif.
Bill Preston, Bill Preston Cut Flowers, Glenn Dale, Md.
Whiting Preston, Manatee Fruit Company, Palmetto, Fla.
Jeroen Ravensbergen, PanAmerican Seed Company, The Netherlands
Jim Rider, Jim Rider Flowers, Watsonville, Calif.
Jan Roozen, Choice Bulb Farm, Mount Vernon, Wash.
Roy Sachs, Flowers and Greens, Davis, Calif.
Paul Sansone, Here and Now Garden, Gales Creek, Ore.
Craig Schaafsma, Kankakee Valley Flowers, St. Anne, Ill.
Bev Schaeffer, Schaeffer Flowers, Conestoga, Pa.
Ray Schreiner, Schreiner's Iris Gardens, Salem, Ore.
Mary Ellen Schultz, Northbloom Farm, Belgrade, Mont.
Gay Smith, Pokon & Chrysal, Portland, Ore.
Ron Smith, R. Smith Farm, Renfrew, Pa.
Roy Snow, United Flower Growers, Burnaby, B.C.
George Staby, Perishables Research Organization, Grafton, Calif.
Vicki Stamback, Bear Creek Farm, Stillwater, Okla.
Rudolf Sterkel, Ernst Benary of America, Sycamore, Ill.
Dennis Stimart, Dept. of Horticulture, University of Wisconsin, Madison
Mindy Storm, Blairsville, Ga.
Joan Thorndike, Le Mera Gardens, Ashland, Ore.
Ralph Thurston, Bindweed Farm, Blackfoot, Idaho
Ann Trimble, Trimble Field Flowers, Princeton, Ky.
Bernie Van Essendelft, Dual Venture Farm, Pantego, N.C.
Kate van Ummersen, Sterling Flowers, Brooks, Ore.
Alice Vigliani, Maple Ridge Peony Farm, Conway, Mass.
Mike Wallace, Wood Creek Farm, Cygnet, Ohio
Ian Warrington, HortResearch, Palmerston North, New Zealand
Van Weldon, Wood Duck Farm, Cleveland, Tex.
Eddie Welsh, Palmerston North, New Zealand
Linda White-Mays, Sundance Nursery and Flowers, Irvine, Ky.
Roxana Whitt, Wise Acres, Huntingtown, Md.
Tom Wikstrom, Happy Trowels Farm, Ogden, Utah
Blair Winner, PanAmerican Seed Company, Santa Paula, Calif.
Bob Wollam, Wollam Gardens, Jeffersonton, Va.
Jack Zonneveld, M. van Waveren Co., Mt. Airy, N.C.
Patrick Zweifel, Oregon Coastal Flowers & Bulbs, Tillamook, Ore.

INTRODUCTION

In the first edition of this book, the term "specialty cut flower" was defined as any crop other than roses, carnations, and chrysanthemums. In the years since, the market has changed so much, and the diversity of flowers in the market has become so great, that the term "specialty" really means very little any more. Bob Wollam, president of the Association of Specialty Cut Flower Growers, Inc. (2002–03), defines a specialty cut as "something that isn't on the market on a regular basis or is there only for an exceptionally short time period. It can't be used in a numbered bouquet, like FTD #46, which requires flowers you can get all year round." John Dole of North Carolina State University adds that the definition is continuously evolving: "Soon . . . we will simply refer to 'cut flower' production in the U.S., not 'specialty' cut flower [production]."

However, the Big 3 traditional crops have historically comprised the largest portion of cut flower production and sales in the world market and, in all likelihood, will continue to do so. The unwieldy number of specialty species, the difficulty in controlling field conditions, the lack of standards for specialty cuts, and the popularity of greenhouse-grown flowers made traditional crops easier to fund, and information flowed readily. The business of growing specialty cut flower crops, however, has been practiced for hundreds of years. European and Asian growers produced a vast variety of cut flowers in fields and conservatories. The American grower joined in with large acreages of peonies, tuberose, larkspur, gypsophila, and gladiolus, especially during the 1940s and 1950s. Growers come and go, the world market rises and falls, and while consumption of cut flowers has been stagnant in recent years, there is still significant room for expansion.

The type of floral product purchased and the amount of money spent is more dependent on the use for which it is intended than on the product itself. In America, the most important reason is to celebrate special occasions: anniversaries, birthdays, Valentine's Day, funerals, weddings. Competition for the special-occasion dollar is fierce. Flowers must go neck-and-neck against restaurants, movies, theaters, chocolates, and gifts. A second reason is to express emotions, such as love, thanks, condolence, apology, and congratulations. The third and still untapped reason for purchasing cut flowers is to create a pleasant atmosphere at home and work; promoting the use of flowers in these everyday ways must increase if they are to become a mainstream item. Whatever the consumer's impulse to buy, enhanced sales can be accomplished only through production of high-quality flowers, aggressive promotion, and an increased number of outlets.

The Role of Imports

In some overseas countries, cut flowers have been politically expedient, and their development has been aggressively supported. Standard flowers—roses, carnations, mums, gypsophila, gladiolus—arrive from offshore suppliers daily, and, although many may disagree, their presence has had a positive influence on the American grower. The marketing skills of the Dutch, the inexpensive stems from Colombia and Ecuador, and the acceptance of these crops by the American florist have resulted in more crops and a significantly higher volume of cut flowers sold in this country than ever before. Competition from abroad will no doubt increase for all species of cut flowers, yet American growers will adjust and use that competition to their advantage. Some buyers will always base their purchases solely on price, but what else is new?

The question, then, begs to be asked. How can the American grower compete? He can best compete by growing the highest quality product possible, providing the best service available, and ensuring proper handling and harvesting methods at a reasonable price. Local growers can supply specific products that ship poorly or that can be produced efficiently in their area. In fact, growers must always look for local niches for flowers that are poor shippers and otherwise difficult to find. Quality, freshness, and consistency are the keys to competitiveness, whether one is competing with Holland or California. Domestic growers must provide fresh-dated flowers and guarantee on-time delivery of all flowers on the contract. If flowers are going to be supplied by overseas growers, make those growers earn every dollar. The American grower can waste his time looking over his shoulder, or spend it doing a better job providing a consistently high-quality fresh-dated crop, on time and for a realistic price.

Product Mix

Many species are useful as cut flowers, but the decision of what to grow must be based on climatic conditions, availability of seed and plants, and, most important, what will sell in a given area. Diversity of product is important; growers should always be on the lookout for something new, and the importance of staying up-to-date cannot be overstated. But just remember: it is impossible to grow everything, and it is easy to turn around and suddenly find oneself producing 100 different species and cultivars.

More than ever before, the consumer reacts to and is willing to pay for the unusual. It used to be that the buying public was unaware of many lesser-grown plants, but times have changed, and the lesser-known specialty crops are in high demand. With the emergence of better cultivars and aggressive marketing, obscure species may turn out to be major winners. Growers of specialty flowers should not believe their products will replace the rose, or even the carnation; to believe so is unrealistic and self-defeating. Growers, wholesalers, and retailers should be striving, instead, to complement the rose, enhance the carnation, show off the mum, and liven up the gladiolus.

Plant Diversity

The diversity of available plants and seeds includes annuals, perennials, bulbs, and woody species. Each class of cut flowers (or berries, foliage, stems) includes a wealth of plant species and cultivars, which may be used throughout the growing season. All these stems are now seen in wholesale coolers, florist outlets, and garden shops. Such species may end up routed through auctions or local flower or farmers' markets, or sold directly to florists. Personal contacts between growers and salespersons can be made and sustained if there is a will to do so. Nowhere is it written that all produce must go through a distributor, ending up as generic product in a generic market for faceless people.

A movement toward cut flowers grown for the local market has taken place, and consumers shopping at local florists and farmers' markets are benefitting the most from this return to hometown roots. No longer is it necessary to ship a majority of flowers long distances before selling them. Growing areas near small towns and large cities have been established to provide material for distribution to those areas. There is no reason why growers near New York or Chicago or Denver should not be efficient enough to supply their own areas with product first, supplemented with materials from distant fields and lands.

Volume and Price

The volume of material in the market directly affects its price, creating a trap that many growers fall into. A new grower, for example, may find the demand for his crop is higher than expected, so immediately doubles production. More than likely, such a decision will prove unprofitable. Simply because 2000 bunches of flowers sold for $5 a bunch does not mean that 4000 bunches will sell for the same price. Not only does the unit price for his product fall, so do prices for other growers of the same product. The classic grower thinking that more is better must be changed. Similarly, the price a grower demands for a crop should not automatically fall in times of market glut. If the quality is consistent throughout the year, the grower need not acquiesce to claims of cheaper sources by the buyer. If trust and consistency of quality have been cultivated with the buyer, discounting the product to the point where profit has disappeared is poor business. Sometimes it is better not to harvest the excess than to sell it for a loss. No one wants to throw away potential earnings; however, once prices are lowered, it is difficult to raise them once again.

Grading

Most specialty cut flowers in America are not graded. The lack of standards reflects the inability to adequately enforce them in a country with such diverse market outlets. Specific crops may call for specific standards, and it would seem to make sense to establish minimum baseline standards for appearance and quality of all American crops. Until such time as standards are agreed upon, grading will continue to be the domain of the producer—which is not all bad. Good businesses will become known not only for the quality of their product but for the consistency of their grading. Strict grading enhances trust: the buyer will soon realize that bunch after bunch, box after box, week after week, the product is consistent and true to grade.

One's grading system should be based on a combination of flower quality, stem strength, and stem length—standards that once established must be adhered to throughout the growing season. The numbers of flowers in a bunch should be established and maintained. For most flowers, a minimum of 10 stems per bunch is the standard. Let's keep it simple: people know how to count by 10s, while 8, 12, or 15 stems per bunch simply confuses the issue. Obviously, some larger flowers will not be bunched in 10s, and filler-type products are often sold by weight. Simply because stems are fatter or flowers a little larger does not excuse bunches with fewer stems. Similarly, if stems are thin, adding more flowers to the bunch does not raise the quality of the flowers—they still have thin stems! Placing poor-quality stems in the middle of a bunch or at the bottom of the box fools no one. Such tactics eventually fail, and someone gets hurt. Flowers must be graded as if the grower were the buyer, not the seller.

Consignment

Let the system of consignment die; it is wasteful and unproductive, benefiting no one in the long run. The product should be bought, not rented from the grower, and the responsibility for final sale and distribution of the fresh product must rest with the florist, distributor, or wholesaler, not the producer. Consignment systems inevitably result in ill will between producer and distributor and tend to weigh down a distribution system already burdened with lingering mistrust.

Trust

Trust between wholesaler and producer is a necessity in any business transaction. This will never change. In a good working relationship, problems on either the producer's or wholesaler's part can be discussed and corrected in professional terms. An open and frank communication makes the business of cut flowers far more enjoyable for all concerned. Similarly, discussion between growers is essential if the cut flower industry is to blossom and succeed in this country. People who put on cloaks of secrecy and refuse to share experiences and methods with others do themselves a great disservice. We have enough problems—seasonality, imports, hail, rain, freezing temperatures, drought, heat, and rodents—without tripping over each other to keep "secrets" secure. A free-flowing exchange of ideas is essential in any business, and this one is no exception.

To that end, membership in trade associations, such as those that follow, is highly recommended for anyone dealing with specialty cut flowers.

Association of Specialty Cut Flower Growers, Inc.
MPO Box 268
Oberlin, OH 44074-0268
phone 440.774.2887
fax 440.774.2435
www.ascfg.org

International Cut Flower Growers
P.O. Box 99
Haslett, MI 48840
phone 517.655.3726
fax 517.655.3727
ICFG@voyager.net

Preserved Floral Products Association
2287 Ash Point Road
White Cloud, KS 66094
phone 785.595.3327
fax 785.595.3283

Society of American Florists
1601 Duke Street
Alexandria, VA 22314
phone 800.336.4743
www.safnow.org

The Association of Specialty Cut Flower Growers (ASCFG) is the only group devoted solely to the business of specialty cut flowers; their electronic bulletin board, on which members air problems and discuss solutions, is particularly effective.

POSTHARVEST CARE

Whether flowers are delivered in a Volkswagen bus to the farmers' market down the road or shipped thousands of miles across the world, comprehensive postharvest care and handling are essential. It may be argued that no one step in the chain of marketing flowers to the consumer is more important than any other. That is, if even one step is poorly accomplished, the whole chain is weakened: if water quality is poor, the fertility program is out of balance; if the incorrect cultivar is grown, the quality and potential sales of the crop suffer. These comments are true; however, once the stem is cut, proper harvesting, handling, and postharvest treatments are essential for maintaining the quality of the flowers. Without a suitable postharvest program, the wholesaler, florist, or consumer is being sold a defective item.

The grower is responsible for the first stage of postharvest treatment, but others who handle the flowers (wholesaler, trucker, florist) have equal responsibility. It is easy to understand the importance of postharvest techniques when flowers must be shipped a long distance, but perhaps not so easy to justify the expense and trouble when they are only going across town. That thinking gets everyone in trouble. A lack of a consistent postharvest program can limit the sale of fresh flowers and greens. Consumers feel cheated when the flowers they purchase decline prematurely. The perception of "not getting one's money's worth" is extremely dangerous to this industry and must be eliminated.

Carnations and chrysanthemums are popular because, in addition to shipping well, florists and the public perceive they are a good value for the money. *That perception is the key to success in the fresh cut flower industry*. Message to American growers: if your flowers are not fresher, of better quality, and longer lasting than those from overseas, then you should think seriously about another line of work.

We need to sell more flowers, period. Better postharvest care translates into more flowers being sold, regardless of origin. More flowers sold translates to higher public visibility and a perceived necessity of the product. Purchasing flowers should be as commonplace as renting a video or dining out, but this won't happen until the value for the money spent is perceived to be at least equal to that movie or meal. The industry must not only believe in the importance of correct postharvest treatments but practice them as well, for if flowers are not well handled, the future of the cut flower grower is questionable.

Considerations of the Crop in the Field

Steps to enhance postharvest longevity of the flower may be taken before any flowers are cut. These practices begin with the selection of the cultivar to be grown and extend to maintaining the health of the plant in the field.

Species and cultivar selection: Proper cultivar selection can mean the difference between profitability and economic struggle. Choose cultivars not only for flower color but for their potential vase life; simple tabletop tests of old favorites and new introductions will provide valuable data to help with plant selection. Test new products in vases and in foam; the more information the buyer receives, the more he will rely on the grower. Relying on information from the breeder is useful but should not be the final criterion for selection. Do it yourself.

The environments under which plants will be grown must be considered. If a crop is grown in an unsuitable area, plants will never be as vigorous and active as they would be under more hospitable conditions. In general, plants grown in marginal environments are stunted and produce fewer flowers (each of which has a shorter vase life) compared to plants grown in a favorable environment. Why try to grow delphiniums in Phoenix in June? Attempting to grow a crop unsuitable to the area invariably results in a low-quality product and a decline in postharvest life.

Health of the plants in the field: Integrating good postharvest methods with a growing regime that produces reasonable yields and high-quality stems is a goal to which all growers should aspire. Research has shown that anything that results in prolonged stress (improper fertility, over- or underabundance of water, cold, or heat) reduces postharvest life. Healthy plants produce long-lasting flowers, but it does not necessarily follow that the lushest, most vigorous plants bear flowers with the best postharvest life. In fact, flowers from plants that have been heavily fertilized or grown under warm temperatures often exhibit shorter shelf life than those that are grown a little "leaner" and cooler. In the greenhouse, plants are often hardened off by reducing temperature, fertilizer, or water prior to harvest to increase the life of the flower.

Harvesting: The best time to harvest flowers is always a compromise, reached by weighing various factors. Flowers harvested in the heat of the day can be stressed by high temperatures. Dark-colored flowers can be as much as 10F (6C) warmer than white flowers on a bright, hot day. It may be argued that harvesting should be accomplished in late afternoon because the buildup of food (for subsequent flower development) from photosynthesis is greater than it is in the morning, but in the morning, water content of the stem is high and temperatures are low. These beneficial factors, combined with the practical considerations of packing, grading, and shipping of the same stems, mean that stems are generally cut early in the day. Harvesting should be delayed, however, until plants are dry of dew, rain, or other moisture. Cutting at high temperatures (above 80F, 27C) and high light intensity should be avoided whenever possible.

After harvest, transfer all stems immediately to a hydrating solution and then to a cool storage facility to prevent water loss. Ethylene-sensitive flowers (see list later in this section) should also be placed in a hydrating solution in the field until treated with silver compounds in the grading area.

Stage of development of the flower: In general, harvesting in the bud stage or as flowers begin to show color results in better postharvest life for many crops. One reason for cutting flowers in a tight stage is to reduce space during shipping. Tight flowers are not as susceptible to mechanical damage or ethylene, and more stems may be shipped in the box than stems with open flowers. Another is that tight-cut flowers, if handled well, provide more vase life to the consumer. But the tight flower stage is not optimum for all flowers; spike-like flowers, such as aconitum, delphiniums, and physostegia, should have 1 or 2 basal flowers open, while yarrow and other members of the daisy family require that flowers be fully open prior to harvest. If one is not shipping long distances, harvesting during the tight stage is not necessary; if you're displaying your flowers at a farmers' market, give your customers some color to view. In general, if flowers are cut tight, placing stems in a bud-opening solution is useful for the secondary user (wholesaler, florist, consumer). Research has not been conducted for every specialty cut flower, but the optimum harvest stage is provided at each entry for all crops discussed in the book. The optimum stage has been determined by research, observation, or discussion with growers and wholesalers. Appendix I is a brief summation of the recommendations.

Considerations of the Cut Stem

Air temperature: No factor affects the life of cut flowers as much as temperature. At every stage along the cut flower system—after harvest, boxing, shipping, at the wholesaler and the florist—the cut stems should be wrapped in cold. The importance of cold is directly related to the length of the journey. Michael Reid, perhaps the nation's leading researcher in cut flower postharvest, states emphatically that the life of most flowers is 3–4 times longer when they're held at 32F (0C) than at 50F (10C); some short-lived flowers, such as daffodils, persist 8 times longer (Reid 2000). Even if flowers are hydrated and held and shipped in water, warm temperatures still result in loss of postharvest quality.

For the producer, growing cut flowers without a cooler is like having a restaurant without a kitchen. Warm temperatures cause increased water loss, loss of stored food, and rapid reduction of vase life. Most cut stems should be cooled to 33–35F (1–2C). It is imperative to rapidly reduce field heat and to maintain cool temperatures throughout the marketing chain of the flowers. If possible, stems should be graded and packed in the cooler; though this is not particularly popular with employees, the quality of the flowers is greatly enhanced. If field heat is not removed, or if loose flowers or flower boxes are simply stacked in a refrigerated room, rapid deterioration takes place. In rooms without proper air movement, it can take 2–4 days to cool a stack of packed boxes of warm flowers, and this same stack will never reach recommended temperatures, even after 3 days in a refrigerated truck (Holstead-Klink 1992). Proper box design and forced-air cooling of boxes to quickly remove heat significantly enhance the postharvest life of flowers.

Having said all that, not all cut flowers should be cooled at 33–35F (1–2C); tropicals such as anthuriums and celosia prefer temperatures above 50F (10C).

Forced-air cooling: Boxes with holes or closeable flaps are necessary for forced-air cooling, in which air is sucked out of (or blown into) the boxes with an inexpensive fan. In general, cooling times are calculated as the time to reach 7/8 of the recommended cool temperature for a particular species; often that temperature is 40F (4C). Half-cooling time (the time required to reduce the temperature by 50%) ranges from 10 to 40 minutes (Nell and Reid 2000), depending on product and packaging. Flowers should be cooled until they are 7/8 cool or about 3 half-cooling times. Work by Rij et al. (1979), an excellent early synopsis of precooling, provided methods of setting up small forced-air systems and information for calculating cooling times. Proper packing of the boxes is necessary to reduce temperature quickly. A minimum of 3″ (8 cm) between the ends of the flowers and the ends of the boxes will prevent petal damage and enhance cold temperature distribution inside the boxes (Reid 2000).

Initial and final box temperature at the packing shed should be measured and entered on data sheets. Actual temperatures should be appraised with a long-probed thermometer; the final temperature of the flowers can be estimated by using a temperature probe to measure the air being exhausted from the box. The air coming out of the box will always be cooler than the flowers, and an experienced operator knows the relation between flower temperature and exhaust temperature.

The retailer is responsible for maintaining proper temperature control through to the sale. When the boxes arrive at their final destination, the box temperature can be again measured with an inexpensive needle-type probe even before the boxes are opened. If temperature inside the box is above 37F (3C), the flowers have likely been exposed to improper temperatures during transportation and/or storage. Once unpacked, stems should be rehydrated and placed immediately in coolers at 33–35F (1–2C). Retailers must insist on proper cooling from suppliers and then consistently maintain proper temperatures at the retail outlet.

Water temperature: Although water uptake is more rapid at warm temperatures than at cool, flower stems should not be placed in warm water unless needed. Some growers actually immerse stems up to the flowers in a deep bucket of cold water, creating a mini hydro-cooling system. Warm water is useful if flowers are particularly dehydrated coming out of the field or for bud opening. In such cases, water heated to 100–110F (38–43C) is most effective for rehydration. Using warm water seldom causes problems, but it is not particularly beneficial on a routine basis. Water at room temperature is fine for mixing floral preservatives unless otherwise noted by the manufacturer.

Water quality: The water used for holding cut flowers affects the quality of the flower. Tap water is most commonly used; depending on the source, it may be high in salinity, vary in pH, or be contaminated with microorganisms. Sensitivity to saline conditions varies with species, but measurements of salinity must be treated with caution. More important is the measurement of the buffering capacity of the water, or its alkalinity. A salinity reading of 190 ppm appears dangerously high at first glance; however, the reading may consist of 40 ppm alkalinity and 150 ppm saline components. Such water is fine. The higher the alkalinity, the more difficult it is to adjust the pH of the water. This can be important when using preservatives. Most preservatives are effective at low pH (3.0–5.5), and if the pH cannot be adjusted, the preservative may be useless. Some preservative solutions work well in high alkaline waters, others do not. Knowing the alkalinity of the water used to treat cut flowers allows one to choose the most efficient preservative. Water may be tested through state universities or private laboratories for a reasonable price. It is money well spent.

Flowers persist in acidic water longer than in basic pH water. Water that is acidic (pH 3.0–5.5) is taken up more rapidly and deters the growth of numerous microorganisms. The pH of the solution also affects the efficacy of the germicide in the preservative. Matching the proper preservative with the available water should result in good water quality and enhanced postharvest life of the flowers.

Tap water often contains fluoride, which can be injurious to some cut flowers. The presence of as little as 1 ppm may injure gerberas, freesias, and other flowers. Snapdragons and other crops are less sensitive; daffodils, lilacs, and some orchids are insensitive.

Depth of water: Relatively little water is absorbed through the walls of the stem (the majority is absorbed through the base), therefore the water or solution in which stems are held need not be deep, if stems are turgid or nearly so. The only advantage of plunging stems into 6″ (15 cm) of water rather than 1″ (2.5 cm) is that the water flows 6″ (15 cm) up the water-conducting tissues of the stem, reducing the height the water must be moved by capillary action. Plunging stems in water more than 6″ (15 cm) deep reduces air circulation around the leaves and crowds the stems and flowers together. If stems are severely wilted (often due to blockage by air bubbles), plunge them in water to a depth of at least 8″ (20 cm); they will be more likely to revive than if put in shallow water (Nell and Reid 2000).

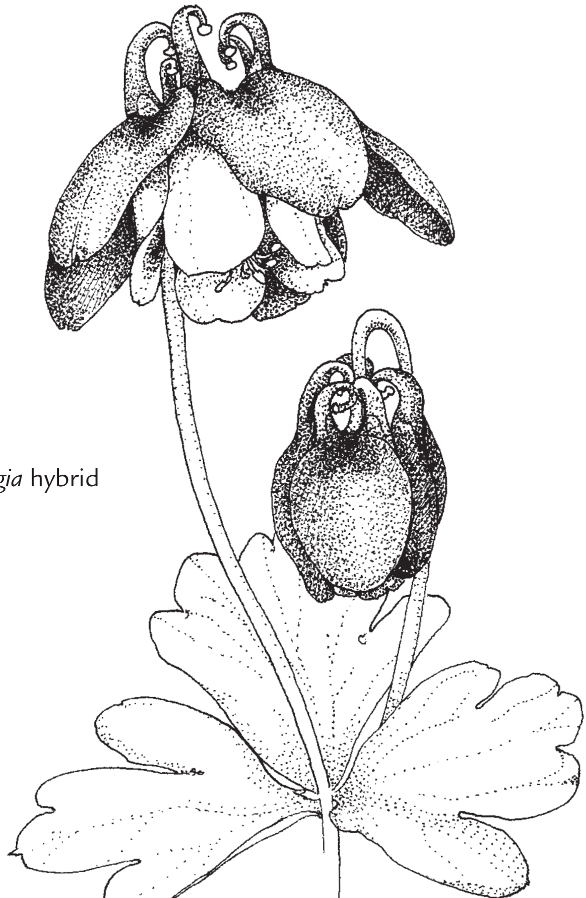
Shipping wet or dry: Historically, shipping flowers in water was possible only for short distances; dry shipping (i.e., in boxes) is the norm when shipping by air or by truck, or when large volumes of flowers are involved. Some firms ship more fragile flowers across the country in innovative wet pack systems such as Procona™ and Freshpack™. Brian Myrland of Floral Program Management points out a few of the many advantages to setting up a program based on this fast-developing technique: “Cutting stages [can] be tighter, more product [can] be packed in the wet pack, and less damage to open flowers [results].” Most wet packing is done by truck; however, transportation costs for air shipments are not as affected as one might anticipate, as air bills are often based on volume rather than weight. Retailers can use the containers as ready-to-sell, and shippers find that the expense continues to decline (Anon. 2000). Wet shipping methods will become far more popular as techniques improve and costs decline.

Ethylene: Ethylene is released by all flowers, although ripening fruit and damaged flowers result in a significant increase in concentrations of the gas. It is also produced during the combustion of gasoline or propane and during welding. Low levels (<1 ppm) for short periods can result in premature senescing, shattering, or other damage to ethylene-sensitive flowers. To avoid the effects of ethylene, hold flowers in a cool, well-ventilated area, away from aging flowers or ripening fruit. The metal silver, which reduces the effects of ethylene, has historically been provided by silver thiosulfate (STS). This product, however, is not available in many states (see next section, on STS).

The following genera are listed by Floralife, Inc., or Pokon & Chrysal as sensitive to ethylene. Not all are equally responsive to ethylene; for example, *Rudbeckia* is very much less sensitive and therefore less responsive to ethylene inhibitors than *Delphinium*.

Achillea	Curcuma	Lilium
Aconitum	Cymbidium	Lysimachia
Agapanthus	Daucus	Matthiola
Alchemilla	Delphinium	Narcissus
Allium	Dendrobium	Ornithogalum
Alstroemeria	Dianthus	Paeonia
Anemone	Dicentra	Penstemon
Anethum	Digitalis	Phlox
Antirrhinum	Doronicum	Physostegia
Aquilegia	Echium	Ranunculus
Asclepias	Eremurus	Rosa
Astilbe	Eustoma	Rudbeckia
Astrantia	Francoa	Saponaria
Bouvardia	Freesia	Scabiosa
Callicarpa	Gladiolus	Silene
Campanula	Gypsophila	Solidago
Celosia	Helianthus	Trachelium
Centaurea	Ilex	Triteleia
Chamaelaucium	Ixia	Trollius
Chelone	Juniperus	Tulipa
[Clarkia]	Kniphofia	Veronica
Consolida	Lathyrus	Veronicastrum
Crocosmia	Lavatera	

STS: In the late 1990s, silver thiosulfate (STS) was banned in the United States. In this country and abroad, the status of STS remains in a state of flux, and we asked postharvest expert Gay Smith of Pokon & Chrysal to clarify the situation. Her summary: Floralife essentially abandoned STS and threw their efforts into research and distribution of EthylBloc™. Pokon & Chrysal started the registration process to get their STS solution, called AVB, approved by the EPA at federal and state levels; AVB received federal registration in September 2001, then state-by-state registration began. Florida registration was approved in January 2002; approval in California and other states is expected in the near future. But STS was never banned in South or Central America, and flowers can still be treated at the grower level in South and Central American countries. In fact, some California growers moved production of ethylene-sensitive crops (e.g., delphinium, satin flower) to Mexico so they could continue to treat them.

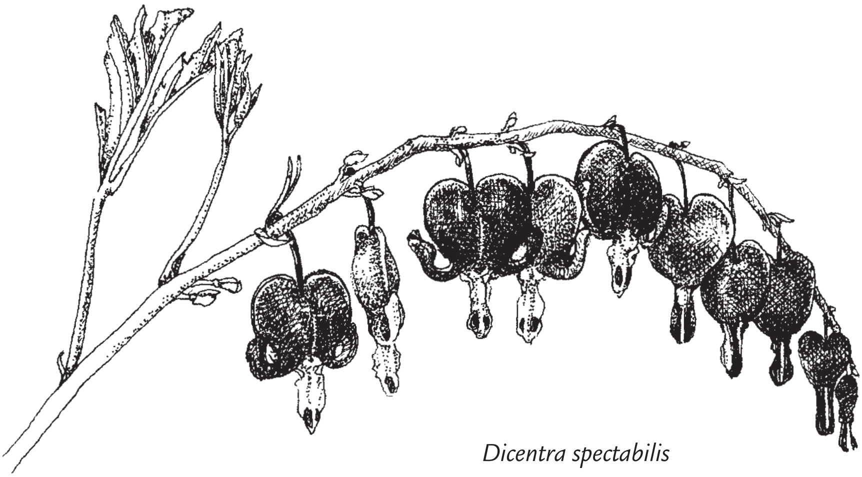


Aquilegia hybrid

Pulsing: Placing freshly harvested flowers for a short time (a few seconds to several hours) in a solution to extend vase life is referred to as pulsing. Hydration solutions, sugar, and STS are common pulsing ingredients; short pulses (10 seconds) of silver nitrate (100–200 ppm) have also been successful with a few species. Silver nitrate, however, is seldom used commercially.

Removal of leaves: As a rule, ⅓ of the leaves are removed from the base of the stem, and in some cases all leaves are removed, especially if flowers will be dried. Foliage immersed in water leads to bacterial growth and toxin buildup, reducing the postharvest life of the flower.

Clean buckets: At every conference, at every meeting, and at every farm, the importance of clean buckets is discussed. This is not arguable—it is as basic as a surgeon scrubbing up before an operation. Buckets must be cleaned with soap, and a protocol to wash them must be established. Why go to all the trouble and expense of growing a crop only to lose it in the bucket?



Dicentra spectabilis

Availability of food: Since few or no leaves are cut along with flowers, little food is available to the stem and flower. The quality and longevity of cut flowers are improved when stems are pulsed in a solution containing sucrose or table sugar. In general, concentrations of 1.5–2% sugar are used, although higher concentrations are effective for certain species. Most commercial preservatives contain approximately 1% sugar, which is sufficient for most flowers. Sugar solutions can be made up, if necessary, by the grower. Add 13 oz of sucrose to 10 gallons of water per percentage required. That is, for a 1% solution, dissolve 13 oz (370 g) of sucrose in 10 gallons (38 l) of water; for a 4% solution, add 52 oz (1482 g) to 10 gallons (38 l) of water.

Air bubbles: Air bubbles, which restrict the upward flow of water, occur after harvesting with many types of flower stems. Recutting stems (approximately 1″, 2.5 cm) under water reduces the blockages. Nell and Reid (2000) suggest a creative home remedy for rehydration. Fill a soft plastic container, like a 1 gallon (4 l) milk jug, to the top with hot water (150–160F, 65–71C). Cap it and place it in the refrigerator or cooler. As the water cools, the container shrinks, air is excluded, and the remaining water is air-free. When stems with trapped air in their stems are placed in this water, the water acts as a scavenger for the trapped air and removes it from the stems. Flowers placed into degassed water will hydrate quickly. Placing stems in citric acid (pH 3.5) also reduces air emboli.

Cutting stems under water: Staby (2000) reinvestigated the benefit of cutting stems under water. After all, it is an inconvenient practice, and if there really is no difference between cutting in air or under water, then it need not be done. He found that if plants rehydrate properly when put in water, it does not matter how they are recut, but that most do rehydrate faster when recut under water. His most important finding was that if the water under which the stems are cut is contaminated (excessive levels of microorganisms, dirt, debris, sap from stems being cut), it is better to cut the stems in air. Of course, cutting under clean water extends vase life anyway, so keep the water fresh. Add household bleach to the water, and rinse the bottom half of the flower stems before cutting under water.

Bacteria can also block the ends of stems. Clean containers and acidified water greatly reduce this problem, as do commercial floral preservatives, which contain antibacterial and antifungal agents, such as 8-hydroxyquinoline citrate or sulfate (8-HQC, 8-HQS). Additional agents should not be necessary.

Conditioning: Conditioning or hardening of cut stems restores the turgor of wilted flowers. In general, demineralized water should be used when conditioning solutions are prepared. When stems are placed in solutions, they should be held at room temperature initially (a few hours to overnight) then placed in cold storage for several hours. Warm water (110F, 43C) is highly recommended for restoring turgor only in badly wilted stems. Badly wilted stems, especially those with woody stems, may benefit from being placed in hot water (180–200F, 82–93C) prior to being placed in room temperature solutions.

Postharvest Solutions

Rehydration solutions: This is an essential step after harvest. Freshly harvested flower stems are placed in water to restore turgidity, a process called rehydration. Rehydration solutions contain no sugar and are essentially used to jump-start the flow of water through the plant's plumbing system. They include a germicide and wetting agent and have a pH around 3.5. If possible, rehydration should take place immediately after cutting.

Pulsing solutions: Generally, pulsing solutions are used to provide sugars (sucrose or glucose, 2–20% added to flower food) and silver compounds (STS), and occasionally to reduce leaf yellowing (cytokinins) and as a germicide (5- to 10-second silver nitrate dip on specific crops). The uptake of all solutions is affected by both the temperature of the solution and the temperature of the air. Colder temperatures require a longer pulsing period than warmer temperatures.

Bud-opening solutions: Flowers that are cut bud-tight respond to bud-opening solutions prior to sale to the final consumer. These consist mainly of a fresh flower food and additional sugar. Nell and Reid (2000) suggest that bud-opening solutions be used at 70–75F (21–24C), 60–80% relative humidity, and relatively high light.

Fresh flower food: These solutions are known and sold as flower preservatives, but the term "fresh flower food" is kinder and gentler, and that is a good thing. Most consist of sugar (the food), a biocide to reduce bacterial growth, and an acid to reduce the pH; sometimes they contain a growth regulator to reduce leaf yellowing or an anti-ethylene substance. Fresh flower food can increase vase life up to 75% (Nell and Reid 2000), and while not all flowers will respond dramatically, few will be harmed by the products.

In-house mixing: Flower preservatives, silver solutions, bactericides, bud openers, conditioners, and sugar solutions are all part of the postharvest jargon. While these various components can be mixed in the back room, what is the point? It is doubtful that homemade solutions will significantly differ from commercial mixes, and often mistakes are made in the process, resulting in solutions that are either ineffective or phytotoxic. A grower is a busy enough, already functioning as farmer, market analyst, and information gatherer combined. Why add chemist, waste disposal technician, and preservative manufacturer to the list? Preservative companies provide information, effective chemicals, and good service. Growers don't manufacture insecticides, why should they concoct preservatives? Last but not least, it is illegal to manufacture preservatives "in-house" without necessary Materials Safety Data Sheets.

Some mixing is always necessary. That is why we learn to read, so routine flower preservatives can be mixed properly. Almost always, when flower foods are mixed improperly, they are used at weaker-than-recommended levels (Staby 2000). When insufficient amounts of floral food are used, the sugar in the food actually promotes the growth of microorganisms because there is insufficient biocide to control them. Better to use no flower food at all than one that is mixed improperly. Do some simple tests on your own to determine which flower food or other chemical is best for your flowers.

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Many thanks to George Staby, Christy Holstead-Klink, Gay Smith, and Brian Myrland for reviewing this section.

DRYING AND PRESERVING

Dried flowers are an important segment of the specialty market. Growers of dried flowers must be efficient because their products may be shipped from anywhere at any time. Quality, however, is still a significant marketing advantage. Producers who provide dried material should do so as a primary focus, not as means of using up unsold fresh production. Cultural methods, harvest stage, and postharvest techniques differ for dried production. Two ways to go out of business: thinking that "material that could not be sold fresh can always be dried" and that "material of inferior quality for fresh can always be dried." Garbage in equals garbage out. "Fresh" dried material—harvested at the optimum stage, treated correctly, and smartly displayed—can compete with flowers anywhere and is far more appealing than leftovers dried as an afterthought.

Dried materials are not "dead sticks and twigs," but include colorful flowers, preserved fruits, and soft, supple stems whose postharvest life is far superior to that of fresh material. Significant gains in methods for rapid drying have been made in recent years, methods that maintain the color, shape, and size of the plant material. But methods are often poorly excecuted, and materials useful for drying misunderstood. It is wrong to believe that dried flowers are easier to produce than fresh; in fact, dried flower producers must produce a high-quality fresh product before the process of drying even begins. The highest-quality dried material begins with the highest-quality fresh material, and the trend in the marketplace is to grow for the fresh market or the dried market, but not both.

Dried flower producers face a great deal of competition from plastics, silks, and other faux products. According to Shelley McGeathy of Hemlock, Mich., who has been producing dried material for many years, "It is more important than ever to produce top-quality, incredibly colored dried materials. Only outstanding preserved products will keep the market strong for dried materials." So the questions beg to be asked. What should one expect from dried materials? And how is that elusive excellent quality attained?

In answer to the first question, Mark Koch of Robert Koch Industries suggests that dried floral products should have a minimum useful life of one year. As to the second, he has produced an excellent series of technical bulletins on the many aspects of drying floral product; the information contained therein is easy to comprehend, and they should be read by anyone involved in the cut flower business. They are available through Robert Koch Industries, Bennett, Colo. Much of the information in this section is based on Mark's work.

Drying

Air drying: Air drying is the most widely used method for preserving material: it's simple, it allows a large volume of material to be processed, and it requires low capital investment. In passive air drying, the most common process, plant materials are dried in an uncontrolled environment, like a barn or converted shed. Active air drying is a controlled process that directs heated air across the plant surfaces; it requires a furnace or other heat source and fans and blowers to direct the heat. The advantages of active air drying are more rapid drying and the ability to control humidity and eradicate insects.

Plants for drying: In general, plant material with a high water content (e.g., peonies) do not dry as well as those with a moderate or low moisture volume. Delicate flowers (iris, carnations) are more difficult to air dry than tougher flowers (sinuata statice). Tropical flowers do not air dry well. Essentially, materials with a higher lignin content tend to be easier to dry than those with a high water content. Unfortunately, flowers that do not dry well are equally difficult to preserve with glycerine treatments. Some flowers with high water content are more easily dried using freeze-dry techniques. Roses, calla lilies, and peonies can all be freeze-dried and preserved for many years.

Facilities for air drying: Drying sheds range from basements to elaborate greenhouses or storage areas with sophisticated equipment. Whether flowers are dried in the attic or in converted warehouse space, all sheds must have a few characteristics in common. Protection from excessive sunlight, wind, water, and dust is important. Concrete floors are expensive but highly recommended. Not only do they act as excellent heat sinks, warming up during the day and slowly releasing heat at night, they also reduce dust. Dust particles become permanently attached to stems that have been treated with sealers or flame retardants. Dirt floors are never recommended; however, gravel floors have been used successfully. Lining floors with straw or wood shavings is done, but these materials can be a haven for insects. Protection from insects and rodents can be accomplished through screens.

Ventilation is another important consideration. During the drying process, materials release moisture to the air. Without adequate air movement, drying rates are considerably prolonged. Sheds should be constructed to take advantage of natural ventilation (e.g., prevailing winds), but fans are often incorporated to aid air circulation. Poor air movement also encourages the buildup of molds and disease organisms. If fumigation is necessary to kill insects, the shed must be airtight. Some drying sheds are constructed so that all or a portion of space may be sealed for fumigant application and then properly vented in keeping with regulatory statutes.

The rate of drying increases with increasing temperature and decreasing humidity. Plant materials with waxy cuticles and large stem diameters take longer to dry; so do those with high moisture content. Temperatures in the drying shed vary widely, averaging 70–120F (21–49C). Humidity levels are seldom controlled by smaller producers and generally reflect the outside humidity. Air-drying equipment with humidity and temperature control is popular with larger processors and those whose natural environment is humid. Optimum humidity levels of 20–60% should be monitored by all processors.

Some materials are best dried in darkness, others in sunlight. Drying sheds with the ability to adjust the amount of light will allow the grower to dry a range of materials. Most plant materials, when exposed to sunlight, fade to pale yellow, which is advantageous when material is to be dyed—a pastel shade is easier to color than green. This sun bleaching is used by many processors in preparation for drying; grasses, for example, must be bleached if light color shades are to be produced. Sun bleaching also provides an autumnal look for grasses, grains, and thin-stemmed flowers. If the natural plant color is to be retained, drying in the absence of light is recommended.

Required drying times: Drying times vary considerably, depending on species, location, drying shed design, and season. Drying times also depend on the amount of water in the fresh material and the desired water content of the dried product. This is known as the dry fraction. Dry fractions for all crops are best obtained by doing simple weighing experiments at the beginning and end of the drying cycle. This can be done by occasionally weighing individual bunches; to obtain the dry fraction, divide the dry weight of the plant by the fresh weight. For example, sinuata statice is approximately 70% water, therefore the dry fraction is 30% (or 0.3). If 100 pounds (46 kg) of fresh sinuata statice is to be dried, drying is complete when the weight is 30 pounds (13.6 kg). In general, drying times range from 3 days to 2 weeks in a passive system. In an active system, plant materials typically dry in 24 hours or less. Failure to adequately dry a plant can lead to serious mold problems if material is sleeved and boxed too early.

Bunch size and handling: Stems are generally grouped in bunches for resale. Bunch size is determined by the desired weight of the dried product and the dry weight fraction of that product. If the final weight of a dried bunch of sinuata statice (dry weight fraction = 0.3) is to be 4 ounces (114 g), then the initial fresh bunch weight should be 4/0.3 or 13.3 ounces (379 g). Bunches with too many stems may reduce air circulation within the bunch, and bunches should not be placed so close together as to reduce air movement between them. They are normally hung on strings or wires from the roof, and it is common to date each line as stems are hung, to ensure proper drying times. In active systems, plants are often placed on drying racks that can be rolled into the drying chamber.

Mold and insect problems: Poor air circulation, prolonged periods of high humidity, excessively large bunch size, and overcrowding in the drying facility are common causes of mold formation. Low humidity and adequate air flow greatly reduce mold problems. Insects can be treated with chemicals, but these are highly restricted and require licensing. Heat is an effective way to reduce insect problems but is usually only possible in active systems or in passive systems where a heat source is available. Mark Koch (1996a) suggests the following exposures to control insects:

Drying temperature	Exposure time
110F (43C)	24 hours
120F (49C)	3 hours
150F (66C)	20 minutes

Storage after drying: Material is usually boxed and stored after drying. Boxes should be stored in a pest-free area with low humidity. Air temperatures should be low but are not as important as low humidity.

Glycerine

The replacement of water with glycerine results in soft, pliable plants that behave as if they have been preserved. Material to be preserved should be treated as soon after harvest as possible. For most plants, incorporation of glycerine is accomplished through systemic uptake through the base of the stem. In general, 1 part of glycerine, mixed with 3 parts hot water (by volume), and a surfactant, to reduce the surface tension of water, is recommended. Avoid using tall buckets, which reduce air circulation around the leaves; place stems in approximately 3″ (8 cm) of solution in a well-ventilated area indoors at 70–85F (21–29C). After treatment, the portion of the stems immersed in glycerine/dye should be removed; the solution bleeds from the treated area otherwise. In general, the smaller the diameter of the stem, the less glycerine is used. Normal preserving time is 3–7 days. Water-soluble dyes may be added at the same time.

If stems are allowed to remain in glycerine too long, the glycerine will move through the plants and be pumped out through the flowers and foliage, resulting in stems that may be wet, oily, and essentially unusable. After treating, the stems should be rinsed with clear water and hung to dry. If stems are still not sufficiently soft 4–5 days after removal from the glycerine, a misting of the glycerine solution over the foliage helps to make them more supple. A drying time of about 1–2 weeks is necessary. Most plants are preserved in the dark; however, eucalyptus is light-treated, and baby's breath is preserved in the light to give an amber glow to the stems and flowers. The glycerine solution may be reused up to 3 times; simply pour through a fine screen to remove leaves and other debris. If the solution is to be stored for more than a week or used over a long period of time, antimicrobial agents, such as potassium sorbate and citric acid, should be added (Koch 1996b).

Some plants do not absorb glycerine well and must be immersed in the glycerine solution, for 1–2 days if the solution is unheated, for 6–12 hours if heated to 180F (82C). As with the absorption method, material is removed, rinsed, and hung to dry for 1–2 weeks.

Freeze-drying

Freeze-drying allows the water in plants to pass from the solid state (frozen) to the vapor state (steam) without passing through the liquid phase. Advances in freeze-drying equipment and polymer chemistry have resulted in more and more flowers being freeze-dried, particularly stems and flowers with high water content. Small equipment designed for the florist industry is available, as well as high-volume dryers for wholesalers and wholesale growers. Freeze-drying provides flowers with a natural shape and color and extended longevity. Freeze-drying is highly technical and requires a significant capital investment; however, it creates a marvelous product and is a viable method for delicate flowers.

Silica Gel

For many dried products, the water in the plant is transferred to a desiccant, such as silica gel. Plants are completely embedded in the gel and remain there until all the water has been removed. The main benefits of silica gel are excellent retention of color and shape. Useful flowers to treat with gel are those with high moisture content and little fiber, such as zinnias and sunflowers. Stems seldom dry well with silica gel, and flowers dried by this method are cut with very little stem remaining. Silica gel can be reactivated after use by heating in an oven at 250–300F (120–150C) for 2–3 hours. Drying time will vary with the product but is usually accomplished in 1–3 days (Koch 1995).

Dying Flowers

Many stems and flowers are colored for the marketplace, and the systemic water-soluble dyes developed for the floral industry will provide almost any color desired. Choice of container, solution temperature, dye concentration and handling, wetting agents, the necessity of avoiding contamination—all are considerations when using dyes. We recommend reading Mark Koch's product sheet on dying fresh flowers (Koch 1999) for more detailed information.

Reading

Koch, M. 1995. Drying flowers and foliage with silica gel. *Robert Koch Industries Tech. Bul.* 460:1–8.

———. 1996a. Air drying flowers, foliage and ornamental plant materials. *Robert Koch Industries Tech. Bul.* 430:1–15.

———. 1996b. Overview of current technology for drying and preserving flowers and foliage. Robert Koch Industries Product Sheet.

———. 1999. Systemically dying fresh cut flowers and foliage with absorption (systemic) floral dyes before air drying. Robert Koch Industries Product Sheet 102:1–4.

Many thanks to Mark Koch and Shelley McGeathy for reviewing this section.

CUT FLOWERS:
ACHILLEA TO *ZINNIA*

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Achillea yarrow Asteraceae

perennial

Four of the approximately 100 species are useful as commercial cut flowers. The best yellow-flowered forms are *Achillea* 'Coronation Gold' (coronation gold yarrow) and *A. filipendulina* (fern leaf yarrow). *Achillea millefolium* (common yarrow) is available in numerous colors; *A. ptarmica* (sneezewort) is white-flowered. Hybrid selections of yarrow with flower stems 1½–2½′ (45–75 cm) long have potential for cut flower production. Yarrows may be used fresh or dried. For Armitage, sneezing and yarrow are synonymous: they go together like popcorn and a movie, but not nearly as pleasant.

Achillea 'Coronation Gold' coronation gold yarrow Asteraceae

perennial, Zones 3–9 hybrid origin yellow 3–3½′/3′ (0.9–1.1 m/0.9 m)

Coronation gold yarrow is a hybrid between *Achillea filipendulina* and *A. clypeolata*. No seed is available (the seed occasionally offered is most likely *A. filipendulina*). The gray-green foliage is fragrant (some say smelly), and flower heads are approximately 3″ (8 cm) wide, although 4–4½″ (10–11 cm) wide inflorescences are not uncommon.

Propagation

Division: Plants may be divided any time after flowering. From a mature 3-year-old plant, up to 100 divisions may be made. Divisions should be sorted to size, with large crowns planted in the production bed, smaller ones planted in pots for growing-on or in a separate production area. Water divisions well.

Environmental Factors

Temperature: Cold is not necessary for the flower development of cultivars with *Achillea filipendulina* in their parentage. Plants are perennials and flower as far south as south Florida, indicating that cold temperatures are not critical. Temperatures below 40F (4C), however, are beneficial by increasing uniformity and plant vigor. The optimum duration of cold is likely less than 4 weeks. Plants have a wide range of temperature adaptability and are useful as cut flowers from Minnesota to Florida.

Photoperiod: No photoperiod control is necessary in the field, although plants respond to lengthening days. Plant maturity is more important for flowering than photoperiod is.

Soil pH: Yield and stem length are better with a soil pH of 6.4 than a soil pH of 3.7 (Escher and Ladebusch 1980).

Field Performance

Longevity: 'Coronation Gold' produced consistent quality and yield for 5 years in the Georgia trials. The following results were recorded on a 1 × 1′ (30 × 30 cm) spacing.

Longevity of *Achillea* 'Coronation Gold'.

Year	Stems/ plant	Stems/ ft^{2z}	Stem length $(in)^y$	Stem width $(mm)^x$
1	7	7	23	4.9
2	41	41	25	4.6
3	46	47	28	5.1
4	45	45	29	4.8
5	45	45	25	5.3

z = multiply (stems/ft^2) by 10.8 to obtain (stems/m^2)
y = multiply (in) by 2.54 to obtain (cm)
x = divide (mm) by 25.4 to obtain (in)

Similar results were obtained in second-year in trials in Burlington, Vt. Two-year-old plants yielded 54 stems/plant, approximately 19″ (48 cm) tall. In that trial, 2 × 2′ (60 × 60 cm) spacing was used (Perry 1989).

Stem length: Distribution of stem lengths over a 5-year period is presented in the following table; plants were on a 1 × 1′ (30 × 30 cm) spacing.

Stem length distribution of *Achillea* 'Coronation Gold' over time.

	Stem length (%)		
Year	<10"^{z}	10–20"	>20"
1	3	96	1
2	9	53	38
3	3	36	61
4	0	13	87
5	0	5	95

z = multiply (in) by 2.54 to obtain (cm)

In the sixth and last year of testing of 'Coronation Gold' at Athens, Ga., plants originally spaced 2 × 2′ (60 × 60 cm) yielded 58 stems/plant and 16 stems/ft^2 (173 stems/m^2) with an average stem length of 22″ (55 cm). Plants originally spaced 3–4′ (0.9–1.2 m) apart yielded 97 stems/plant with an average stem length of 24″ (60 cm).

Spacing: 'Coronation Gold' does not spread as aggressively as many other yarrows, and high-density planting is not detrimental. The yield per plant increases as spacing distance increases but yield/ft^2 declines. Stem length also increases as spacing distance becomes smaller (Armitage 1987). Spacing closer than 1′ (30 cm) apart is feasible if plants remain in production no more than 3 years. Close spacing results in additional root rot and foliar disease problems.

Greenhouse Performance

The financial return on yarrow may make it economically questionable to force in heated greenhouses, however, off-season production will provide better prices and justify added expenses.

For 'Coronation Gold', treatment of the plugs with cold is not required or recommended. Plants should be potted up, placed under short days (winter conditions), and grown on until plants fill the containers. This will require several weeks, depending on greenhouse temperatures. It may be more feasible financially to grow them at 50F (10C) for 5–6 weeks rather than 65F (18C) for 4 weeks; avoid temperatures above 70F (21C). Long days (either 16-hour or 4-hour night interruption) after bulking up in SD is highly recommended; continue LD until flowers appear (Nausieda et al. 2000). At Michigan State University, 'Coronation Gold' required 9 weeks to flower at 68F (20C), 'Gold Plate' required 7.5 weeks (Nausieda et al. 2000).

Botrytis and powdery mildew can be problems, particularly if plants are overwatered or overfertilized. Do not mother these plants to death.

Guideline for Foliar Analyses

At field trials in Athens, Ga., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis.

'Coronation Gold'

(%)				
N	P	K	Ca	Mg
2.9	0.24	3.15	0.70	0.18
(ppm)				
Fe	Mn	B	Al	Zn
210	33	35	156	30

Stage of Harvest

Flowers should not be harvested until pollen is visible on the inflorescence. Stems harvested prior to pollen shed have unsatisfactory shelf life.

Postharvest

Fresh: Flowers persist 7–12 days in water if harvested at the proper stage (Blomme and Dambre 1981).

Dried: Yarrow can be hung upside down to air dry, but flowers will shrivel if picked too early. Good results with small numbers of stems are obtained by placing the stems in 1–2″ (2.5–5 cm) of water and allowing the water to evaporate in the drying area (Vaughan 1988).

Grower Comments

"With 'Coronation Gold' and Colorado Mix you must cut them as mentioned and wait until the pollen is out on the flower, otherwise they will droop. I have cut mine and simply placed in tepid water with preservative and have had no problem getting 2-plus weeks from them in the vase." Shari Keefe, Shari's Berries & Garden, Hiram, Ohio.

Achillea filipendulina fern leaf yarrow Asteraceae

perennial, Zones 3–9 Caucasus yellow 3–4′/2′ (0.9–1.2 m/0.6 m)

Fern leaf yarrow is the common "yellow yarrow" of florists and outdoor markets. The bright yellow inflorescences are up to 4″ (10 cm) across and held on longer stems than 'Coronation Gold'. Plants differ from 'Coronation Gold' by having green rather than gray-green foliage, brighter yellow flowers, and fewer breaks. It is popular for its strong tall stems, ease of culture, and availability from seed or crowns.

Propagation

Seed: Seed germinates in 7–14 days at 65–70F (18–21C) and high humidity. Cover the seed lightly. Approximately 1/64 oz (0.4 g) of seed yields 1000 seedlings (Nau 1999). Direct sowing is not recommended.

Division: Plants should be divided in the early spring or early fall (or any time after flowering).

Growing-on

Transplant to 4″ (10 cm) pots or large cell packs about 3 weeks after sowing. Temperatures of 55–60F (13–15C) are optimum for growing-on. Fertilize with 100 ppm N until ready to transplant to the field.

Environmental Factors

Temperature: As with ‘Coronation Gold’, cool temperatures are useful only for quality and uniformity. Plants are tolerant of warm temperatures and may be grown as far south as central Florida. They also do well in cool climates and are the leading yellow yarrow in northern European countries. With its longer stem lengths, fern leaf yarrow may be a better choice than ‘Coronation Gold’ in northern states.

Photoperiod: Photoperiod does not significantly affect flowering.

Field Performance

Spacing: 1 × 1′ (30 × 30 cm) or 12 × 18″ (30 × 45 cm) between plants and 2–3′ (60–90 cm) between rows.

Yield: Fewer stems are produced compared with ‘Coronation Gold’, but stem lengths are generally longer with *Achillea filipendulina* ‘Parker’s Variety’.

Longevity: Plants are productive 3–5 years.

Greenhouse Performance

See *Achillea* ‘Coronation Gold’.

Stage of Harvest

See *Achillea* ‘Coronation Gold’.

Postharvest

See *Achillea* ‘Coronation Gold’.

Cultivars

Few differences between these cultivars occur in the field; all are suitable.

‘Altgold’ is only about 2′ (60 cm) tall and bears deep yellow flowers. Plants often bloom twice a year; the spring bloom is far heavier.

‘Cloth of Gold’ is a popular gold-flowered cutting form. Stems are 2–3′ (60–90 cm) long and flowers are 3–4″ (8–10 cm) wide.

‘Gold Plate’ has large, golden-yellow flowers and long stems.

‘Moonwalker’ has 4–5″ (10–13 cm) wide yellow blooms on 2–3′ (60–90 cm) stems.

‘Parker’s Variety’ has long stems, 2–3′ (60–90 cm), and deep yellow flowers, 3–4″ (8–10 cm) wide.

Achillea millefolium and hybrids common yarrow Asteraceae

perennial, Zones 2–9 Europe many colors 2–2½′/3′ (60–75 cm/90 cm)

Large color selection makes this one of the most popular yarrows for cut flowers, although attention to post production is important. Common yarrow is a mat-forming species with deeply cut, dark green foliage. The flower heads are small and arranged in flattened inflorescences (corymbs). The species itself is predominantly creamy white, but nobody grows it: selections and hybrids abound in pink, rose, mauve, and bicolors. Plants spread rapidly, and beds fill in within 2 years after planting. They are highly productive and may be propagated readily.

Propagation

Seed: Seed germinates in 10–15 days at 70–72F (21–22C) under humid (sweat tent or mist bed) conditions. The small seed should be covered lightly with vermiculite or clean sand. Approximately 1/64 oz (0.4 g) of seed yields 1000 seedlings (Nau 1999).

Division: Plants may be divided at any time but preferably in early spring or immediately after flowering. Even root pieces (essentially root cuttings) reproduce a new plant. A 2- to 3-year-old plant yields hundreds of single crown divisions. Place divisions in a propagation bed for growing-on.

Growing-on

If seedlings are planted in plugs, grow for 3–5 weeks at 55–62F (13–17C) in full light. Fertilize with 50–100 ppm N to maintain green foliage. Do not over-fertilize, or plants become spindly. Transplant to field when plants are large enough to handle.

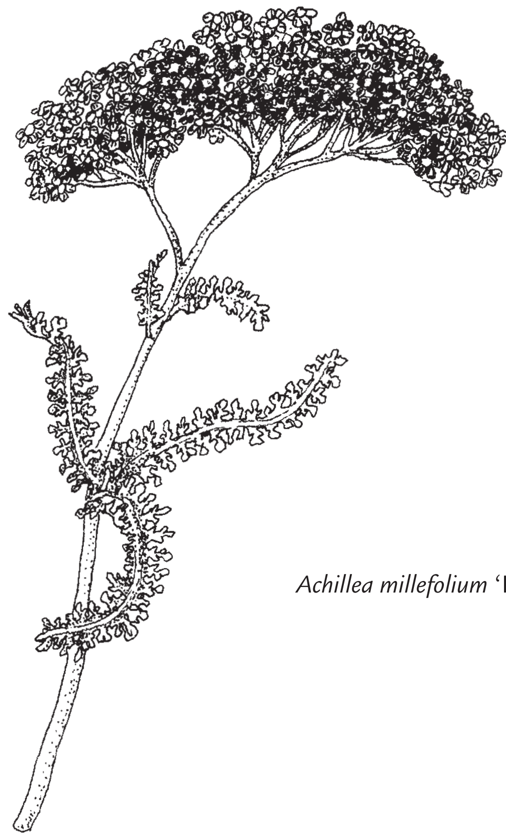
If seeds are sown in a seed flat, transplant seedlings to cell packs after the first true leaves have formed. Grow on as with plugs.

Sort divisions by size. Transplant large divisions directly to the field; place the smallest ones in pots or cell packs and grow on in the greenhouse or cold frame.

Environmental Factors

Cold is not necessary for optimum flower development, although 3–4 weeks of 40F (4C) temperatures may contribute to uniformity and stem quality. Cool temperatures delay flowering time, however. Plants are particularly cold hardy and are common from the prairies of Canada to the Piedmont of Georgia. Stem strength and flower color is enhanced by cool night temperatures, and stems are of higher quality in the North than in the South.

Work with ‘Summer Pastels’ showed that long days were necessary for flowering. Zhang et al. (1996) determined that plants grown under 8-hour photoperiods remained vegetative and that the critical photoperiod was between 12 and 16 hours. Photoperiod is an important consideration when considering forcing for winter production.



Achillea millefolium 'Paprika'

Field Performance

Longevity: Plants are tenacious and spread rapidly. Long-lived perennials, they are productive 3–5 years. Divide every 2–3 years to rejuvenate the planting, otherwise plants become less vigorous and yield declines.

Longevity of *Achillea millefolium* 'Rose Beauty' at Athens, Ga. Spacing 1' (30 cm).

Year	Stems/ plant	Stems/ ft^{2z}	Stem length (in)^{y}	Stem width (mm)^{x}
1	14	14	27.0	3.3
2	42	42	31.5	3.4
3	36	36	38.1	4.4

z = multiply stems/ft^2 by 10.8 to obtain stems/m^2
y = multiply (in) by 2.54 to obtain (cm)
x = divide (mm) by 25.4 to obtain (in)

Stem length: Stem lengths are short the first year of planting, but as plants mature, the percentage of saleable stems greater than 20″ (50 cm) increases as shown in the following table.

Stem length distribution of *Achillea millefolium* 'Rose Beauty' over time. Spacing 1' (30 cm).

	Stem length (%)		
Year	<10"[z]	10–20"	>20"
1	7	17	76
2	4	9	87
3	0	0	100

z = multiply (in) by 2.54 to obtain (cm)

Spacing: Common yarrow spreads aggressively and forms a dense mat. Any semblance of spacing in our trials disappeared by the third year; even those spaced 3′ (90 cm) apart were a solid mat at that time. As the following table shows, flowering stems/plant increased as spacing distance increased, but stems/ft^2 declined. A 1′ (30 cm) spacing is recommended.

The effect of spacing on yield and stem quality of *Achillea millefolium*. Second-year data.

Spacing (in)[z]	Stems/plant	Stems/ft^{2}[y]	Stems >20" (%)
'Rose Beauty'			
12	42	42	90
24	91	23	83
36	107	12	91
'Cerise Queen'			
12	94	94	68
24	143	36	42
36	185	21	58

z = multiply (in) by 2.54 to obtain (cm)
y = multiply (stems/ft^2) by 10.8 to obtain (stems/m^2)

Work in Italy also found up to 12 stems/ft^2 (130 stems/m^2) in the second year when planted at a little less than 1′ (30 cm) spacing (Zizzo et al. 1994).

Fertilization: Plants need little additional fertilizer if planted in organic soils. High rates of nitrogen result in rapid vegetative growth at the expense of flower development. If planted in pots, however, higher rates of nitrogen and potassium should be supplied compared to that required with field production (El-Kholy 1984).

Greenhouse Performance

Common yarrow is seldom forced for winter production, but it could be, if financially feasible.

For cultivars and hybrids of common yarrow, treatment of the plugs with cold is not required. Some benefits occur (additional stems, faster and more uniform flowering) but perhaps not enough to warrant the use of coolers. At the University of Georgia, Zhang et al. (1996) grew plants under normal photoperiods (i.e., short days) until plants reached approximately 10 nodes. Long days (>14 hours) were used to force flowering. Nightbreak lighting (4 hours with incandescent lamps) may be used, but beware of potential stretch of flower stems. Supplemental lighting (e.g., high-intensity lamps) is recommended when winter light is low. We recommend low forcing temperatures for stronger stems, around 55F (13C) with bright light; however, warmer temperatures result in faster cropping time. Researchers at Michigan State University bulked plants up under SD, then forced flowers under LD until flowering, but they grew plants at 68F (20C); the number of weeks to flower varied with cultivars (Nausieda et al. 2000).

Anthea	7 weeks
Apple Blossom	6 weeks
Fireland	9 weeks
Hope	6.5 weeks
Moonshine	3.5 weeks
Paprika	7 weeks
Terra Cotta	7 weeks

Botrytis and powdery mildew can be problems, particularly if plants are overwatered or overfertilized.

Guideline for Foliar Analyses

At field trials in Athens, Ga., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis.

'Lilac Beauty'

(%)				
N	P	K	Ca	Mg
2.76	0.34	5.04	0.85	0.19
(ppm)				
Fe	Mn	B	Al	Zn
127	62	32	49	47

'Paprika'

(%)				
N	P	K	Ca	Mg
3.08	0.43	5.56	0.75	0.19
(ppm)				
Fe	Mn	B	Al	Zn
135	60	29	54	48

Stage of Harvest

Flowers should not be harvested until pollen is visible on the inflorescence. Stems should be harvested in the coolest part of the day, such as the morning.

Postharvest

Fresh: Shelf life in water or appropriate preservative is only 3–4 days at room temperature. If necessary, place stems in warm water, to aid water uptake. The use of silver thiosulfate (STS) increases postharvest life only slightly. Stems placed directly in a cooler (40F, 4C) may be held for about one week.

Dried: See *Achillea* 'Coronation Gold'.

Cultivars

Many cultivars and hybrids are available to the American grower. A few were subjects in 2-year production in trials in Athens, Ga., and Watsonville, Calif.; results are shown in the following table.

Yield and stem length of yarrow cultivars.

Cultivar	Flower color	Year	Stems/ plant Ga.	Stems/ plant Calif.	Stem length (in)[z] Ga.	Stem length (in)[z] Calif.
Heidi	dark violet	1	15	21	11.8	21.0
		2	46	*	20.6	*
Kelwayi	dark red	1	26	25	14.5	38.0
		2	56	*	17.8	*
Kelwayi[y]	dark red	1	20	16.2		
		2	60	21.0		
Lilac Beauty	lilac	1	6	17	15.5	33.0
		2	51	*	18.0	*
Lilac Beauty[y]	lilac	1	7	18.3		
		2	43	18.2		
Paprika	red with	1	12	13	14.4	33.0
	yellow center	2	46	*	18.7	*
Weserandstein	light rose	1	11	21	14.4	33.0
		2	31	*	23.3	*
White Beauty	creamy white	1	10	26	13.3	27.0
		2	28	*	19.2	*

z = multiply (in) by 2.54 to obtain (cm)
y = grown under 55% shade, Georgia only
* = no data available

First-year production in coastal California conditions saw higher yield and significantly longer stems than Georgia did; but unfortunately, stem lengths were so short in the second year in California that no data were taken. Second-year yield and stem lengths in Georgia improved dramatically over first-year data.

Many cultivars are available from seed, but variability from seed is great. Some of the more useful cultivars are also vegetatively produced. Many offerings are hybrids, which have longer, stronger, and straighter stems; their uniformity makes it easier to sell a 10-stem bunch.

'Anthea' has 3–4″ (8–10 cm) wide sulphur-yellow flowers on 2½′ (75 cm) stems. A terrific hybrid introduction and increasingly useful to cut flower growers.

'Borealis' bears dense clusters of rose-pink flowers.

'Cassis' is about 2′ (60 cm) tall with deep cherry-red blooms. Blooms first year from seed.

'Cerise Queen' is an old-fashioned red-flowered cultivar that performs well throughout the country. It grows about 18″ (45 cm) tall and provides bright drifts of color. Losing favor as a cut flower as newer hybrids are introduced.

'Citronella' bears butter-yellow flowers on an erect habit.

'Colorado' has wonderful rosy terra-cotta color and fine foliage. A popular color. A series of colors is also available.

'Creamy' bears large heads of creamy yellow flowers. Plants fill in quickly.

'Credo' is a 3–4′ (0.9–1.2 m) cultivar with light yellow flowers that tend to fade to creamy white. Excellent for cut flowers.

'Debutante' is a mixture of plants bearing rose to creamy white flowers. 'Pink Debutante' is an excellent selection.

'Fire King' and 'Fire Beauty' have dark red flowers; there is little difference between them.

'Fireland', bred in Germany, opens red then fades to pink and finally to a tawny gold. Plants grow about 3′ (90 cm) tall, but the stems are reasonably stout. A popular form for cuts.

'Jambo' bears mid-yellow flowers on 15–18″ (38–45 cm) stems.

'Kelwayi' bears magenta-red flowers on 18″ (45 cm) stems.

'Lilac Beauty' produces lilac flowers on strong, upright stems.

'Lilac Queen' has flat heads of pastel lilac flowers and is offered occasionally by mail-order nurseries.

'Lusaka' is a vigorous grower with white flowers.

'Martina' has large, flat yellow flower heads on 2–2½′ (60–75 cm) stems. Foliage is ferny and green.

'Maskarade' bears interesting pale yellow flower heads with red flecks along the edges as they mature. Quite a different look.

'Nakuru' produces purple and white bicolor flowers.

'Orange Queen' has unusual orange-gold flowers. Plants are about 30″ (75 cm) tall and 18″ (45 cm) wide.

'Ortel's Rose' blooms heavily with rosy pink and white flowers. A terrific selection for southern gardeners, introduced by Goodness Grows Nursery of Lexington, Ga.

'Paprika' produces red and yellow flowers on a flattened inflorescence. One of the most handsome cultivars available.

'Pink Island Form' is about 2′ (60 cm) tall and produces pastel pink flowers.

'Red Beauty' bears 2′ (60 cm) tall cerise-red flowers in mid summer.

'Rose Beauty' has rather nondescript rose-pink flowers on 2′ (60 cm) stems.

'Sawa Sawa' bears lavender-purple flowers on 20″ (50 cm) stems.

'Schneetaler' ('Snowtaler') is a hybrid with pure white flowers. Plants are good for cut flowers and may rebloom if cut back hard after the initial bloom.

'Snow Sport' is a vigorous grower with dark green foliage and dozens of clean white flowers on 18″ (45 cm) stems.

'Summer Pastels' is a seed-propagated hybrid that includes various pastel colors (pink, rose, lavender, salmon to orange) on 2′ (60 cm) tall plants. Plants flower the first year from seed. The yellow hues are particularly good.

'Terra Cotta' has wonderful terra-cotta flowers with strong stems. Outstanding color.

'Weser River Sandstone' ('Weserandstein') has deep rose-pink flowers on 2–3′ (60–90 cm) tall plants.

'White Beauty' produces creamy white flowers.

Galaxy series, a cross of *Achillea millefolium* × *A. taygetea*, has resulted in numerous selections. They are similar in leaf shape and texture to *A. millefolium* but are not quite as rampant. The flower heads, however, are much larger and more colorful. Available cultivars include 'Appleblossom' ('Apfelblute'; mauve), 'Beacon' ('Fanal'; red), 'Great Expectations' ('Hoffnung'; pale yellow) and 'Salmon Beauty' ('Lachsschonheit'; salmon-peach). Unfortunately, all fade badly, at least in the heat of Georgia summers—a serious drawback to the series becoming a major cut flower. Flower stems arise from lateral breaks, resulting in many short stems, another problem more prevalent in the South than the North. Cultivars were originally selected as garden plants, and their relative lack of height and propensity to fade may limit their usefulness as cut flowers in the United States.

Grower Comments

"I am astonished by how happy folks are with yarrow, which I think is lovely but nothing exotic in my book. Colorado's colors seem to mix nicely with lots of things." Eliza Lindsay, Puzzle Creek Gardens, Portland, Ore.

"I have learned with 'Summer Pastels' to wait until the florets are totally open, flat (or a little beyond) before cutting, to strip off the side shoots that aren't completely open, and to put the stems immediately into water when cut. Then I clean the remaining dirt off and put into Floralife™ solution. Drooping, for me, has mainly been the result of cutting it too soon." Julie Marlette, Blue Heron Gardens, Fall Creek, Wis.

Achillea ptarmica sneezewort Asteraceae

perennial, Zones 3–7 Europe white 2–3′/3′ (60–90 cm/90 cm)

Obviously someone with allergies bestowed the common name upon this species, although the flowers are less allergenic than those of common yarrow. Few common names in the plant kingdom are as ugly, and hearing the name for the first time certainly doesn't endear this species to anyone. The common name is derived from the fact that the "floures make one sneese exceedingly." In Victorian England the leaves and roots, dried and reduced to powder, were used as an inexpensive substitute for snuff.

The creamy white flowers are held in terminal corymbs. *Achillea ptarmica* is less important commercially than *A. filipendulina* and *A. millefolium*, but interest in it is increasing. We think it is a poor cut flower crop compared with other available yarrows; however, yield is good, the crop continues into the fall, and shelf life is better than the colored types.

Propagation

See *Achillea millefolium* for seed techniques. About 0.03 oz (0.9 g) yields 1000 plants (Nau 1999). For vegetative propagation, tip cuttings are best for rapid growth (Geertsen and Bredmose 1986).

Environmental Factors

Production under greenhouse conditions is best for cuttings taken in early February and grown at 60F (15C) (Geertsen and Bredmose 1986).

Field Performance

Yield: First-year harvests for Georgia and California and second-year harvest for Vermont are shown in the following table (Perry 1989).

Yield and stem length of *Achillea ptarmica* in Georgia, Vermont, and California.

Location	Stems/plant	Stem length (in)^z
Athens, Ga.	13	12.2
Burlington, Vt.	25	17.0
Watsonville, Calif.	19	27.0

z = multiply (in) by 2.54 to obtain (cm)

Second-year harvest at Georgia was significantly higher, with over 100 stems/plant. Flowers were harvested until mid November with an average stem length of 20″ (50 cm). Work in Italy found up to 10 stems/ft^2 (108 stems/m^2) in the first year when planted at approximately 1′ (30 cm) spacing (Zizzo et al. 1994).

Greenhouse Performance

Sneezewort is greenhouse-grown in some European countries, but it is seldom produced this way in the United States. In Finland, with supplemental lighting, flowers were harvested for 3–5 weeks 12 weeks after planting (Sarkka 1991). The second harvest was also faster with supplemental lighting. Work at Michigan State University (Nausieda et al. 2000) found 'The Pearl' could be forced (see 'Coronation Gold') in 4.5 weeks under LD and 68F (20C) temperatures. Mildew, however, is a serious problem under greenhouse forcing conditions.

Stage of Harvest

Harvest when flowers are fully open.

Postharvest

Fresh: Flowers last 5–8 days in water.
Dried: Flowers may be air-dried.
Storage: Flowers may be stored wet for 2–3 days at 40F (4C).

Cultivars

'Angels' Breath' bears many ½″ (13 mm) wide clean white flowers on 15–18″ (38–45 cm) tall plants. Good filler for bouquets.

'Ballerina' is a relatively new cultivar with clean white flowers. Good as a dried cut flower.

'Globe' has small button-like blossoms on 12–18″ (30–45 cm) stems.

'Perry's White' is tall (up to 30″, 75 cm), with flowers similar to the species but opening about a week earlier.

'The Pearl' ('Boule de Neige', 'Schneeball') is the most popular cultivar and bears a profusion of double, creamy white flowers on 2′ (60 cm) stems. In warm climates, plants sprawl and are weedy looking. All double-flowered cultivars produce some single flowers as well—up to 30% singles, depending on weather and cultivar.

Additional Species

Achillea ageratum (sweet yarrow) has for centuries been used as a fragrant and medicinal herb. The flower head is similar to that of *A. filipendulina* 'Parker's Variety' but about ⅓ the size. The species itself is not particularly useful as a cut flower, although 'Moonwalker' has been selected for its cut flower habit. Plants grow 2½–3′ (75–90 cm) tall; the flowers are useful as fillers in a fresh bouquet and also dry well. Approximately 1/256 oz (110 mg) of seed yields 1000 seedlings. No cold treatment is needed, and if sown sufficiently early, plants flower the first year. 'Golden Princess' bears flat, golden inflorescences on 3–4′ (0.9–1.2 m) stems.

Achillea sibirica is probably too short for cut flowers, but a few growers are trying it. The dark green leathery leaves are sessile, more compact than other yarrows and quite handsome. The ray flowers are yellow; the disk is brown. 'Love Parade' (var. *camtschatica*) grows to 20″ (50 cm) tall and bears soft pink flowers; sometimes sold as 'Kamschaticum'. 'Kiku-San', about 18″ (45 cm) tall with creamy white ray flowers and brown center, has been an exceptional performer in the Georgia trial garden.

Pests and Diseases

Most yarrows are relatively pest and disease free, although downy and powdery mildew can be a problem. Aphids and spittlebugs are also common.

Downy mildew results in small, yellow spots on the upperside of the leaves and white mold on the underside.

Powdery mildew results in white spots on both sides on the leaves.

Stem rot (*Rhizoctonia solani*) may result in decay of the stem base. Application of fungicides and crop rotation alleviate the problem.

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Many thanks to Ron Smith for reviewing this section.

Aconitum monkshood Ranunculaceae

perennial, Zones 2–6 central China blue 2–3′/3′ (60–90 cm/90 cm)

Flowers of monkshood provide some of the finest blue cut flowers available; however, production in the United States is limited to areas with cool nights and warm (but not hot) days. Although we have seen successful plantings as far south as St. Louis, only the coastal areas of California, the Northwest, and the Northeast are producing significant numbers of monkshood. Monkshood is well established in several European markets but is only sporadically shipped to the United States. The most popular species for cut flowers is *Aconitum napel-*

lus (common monkshood). In all species, one of the sepals is enlarged, covering the floral parts like a hood, thus accounting for the common name. The flowers are held in terminal racemes and open in mid to late summer. *Aconitum* grows from tubers (enlarged roots); the number and size of these tubers directly influence the success of the crop. The tubers are extremely poisonous, containing significant amounts of aconite, and the foliage is only slightly less toxic. No taste tests need be conducted with this crop.

Propagation

Seed: Although many companies offer seed of monkshood, the seed is notoriously difficult to germinate. Seed develops a deep dormancy upon ripening; 12-month germination times are not uncommon (Armitage 1997). To speed up the process, sow seed for all *Aconitum* species in moist, well-drained medium and place at 65–70F (18–21C) for 2–4 weeks. Transfer seed flat to 20–25F ($^{-}$7–$^{-}$4C) for 6–8 weeks. Avoid soil temperatures below 16F ($^{-}$9C). Place in cool temperatures around 45–55F (7–13C) even if germination has occurred. Grow at cool temperatures until ready to transplant. Sowing in the fall and placing the flats where they will be snow-covered during the winter is a cost-effective way to provide these conditions. Winter provides the cold, the melting snow in the spring reduces inhibitors, and germination occurs in early spring. Germination is erratic; it may take 2 years for 50–70% germination rates. However, recent work has shown that soaking seed in 50 ppm GA_3 enhances germination (Lurie et al. 1997).

Division: The tubers may be carefully divided in early spring. The larger the tuber, the faster the plant will flower. Small tubers can be planted in a holding area; handle them as gently as possible when moving to the final field site. Do not divide for at least 2 years after planting; waiting 3 years is even better.

Environmental Factors

Tuber size: Flower quality—as measured by stem and raceme lengths, stem diameter, and flowers per stem—is directly related to the mother tuber size (Lurie et al. 1992). Daughter tubers are formed from the mother tuber; they reach final size and weight approximately 4–6 weeks after flowering (Watad et al. 1999). Flowering is highly dependent on tuber weight: 30–40 g tubers provide flowers of optimal quality, whereas plants from tubers 5 g or less will not flower (Watad et al. 1999). Anything that enhances tuber weight enhances flower yield and quality.

Temperature: *Aconitum* is a cool crop and performs poorly south of Zone 6. Plants require moist, cool conditions for adequate establishment, and summer temperatures in much of the country preclude high yields and quality. If plants are subjected to temperatures greater than 70F (21C) for any length of time, stems weaken, making support necessary (Lurie et al. 1992), and basal leaves quickly turn yellow. Performance is best in the Pacific Northwest and the Northeast.

A cold period of 32–35F (0–2C) provided during winter (or for 10–12 weeks during the forcing period in a cooler) is necessary for flowering. Tubers may be stored at 28F ($^{-}$2C) to delay flowering. Frozen tubers may be planted as late as early July for late fall flowering. Attempts to force *Aconitum napellus* to flower earlier in the field using plastic tunnels advanced flowering only 4–5 days; quality was unaffected (Loeser 1986).

Gibberellic acid: Preplant application of 200 ppm GA_3 to the tubers eliminated the need for cold and enhanced sprouting. Also, a single application of 100 ppm GA_3 as the plants start to bolt increased stem length significantly (Lurie et al. 1992). Use caution when applying GA; experiment on a small portion of the crop to determine if unwanted side effects occur.

Light and photoperiod: Grow in full sun or afternoon shade. Long days increase stem and raceme length as well as the number of flowers per stem (Lurie et al. 1992).

Soil pH: Yield and stem length are better with a soil pH of 6.4 than a soil pH of 3.7 (Escher and Ladebusch 1980).

Field Performance

Longevity: Plants are long-lived perennials and are productive for at least 5 years. Replanting 20% of the area every year allows for a constant supply of flowers.

Spacing: For first-time planting, purchased tubers can be planted as wide as 12 × 32″ (30 × 80 cm). Although yield will be low the first year, by the third year, yield will be as high as if planted far more densely. Spacing at 18 × 18″ (45 × 45 cm) or 2 × 2′ (60 × 60 cm) also works just fine. If tubers are plentiful, plant as close as 8 × 12″ (20 × 30 cm) (Sprau 1991).

Tubers should not be planted deeply. Although research has shown that tubers will emerge even if planted up to 2′ (60 cm) deep, increased planting depth delayed emergence and reduced the number of shoots and the percentage that flowered. The number and size of tubers were also negatively correlated with depth of planting. Interestingly, new tubers were formed much closer to the surface no matter how deep they were planted (Hagiladi et al. 1992). In general, plant no deeper than 6″ (15 cm).

Light: The further north the plants are grown, the higher the light intensity the plants can tolerate. Afternoon shade does not appear to diminish yield or quality.

Yield: Eight to 12 flowers per mature plant is not uncommon.

Greenhouse Performance

Precooled tubers may be planted in ground beds or in 8–10″ (20–25 cm) pots. Temperatures should be approximately 45–50F (7–10C) for 6–8 weeks then raised to 55–60F (12–15C) during crop growth. Crops planted in late February flower in late May. High light is important; blind shoots result from low winter light and restricted root systems (Lurie et al. 1997). Long days are not essential but are beneficial; begin LD when plants are about 4″ (10 cm) high and continue at least until bud color. Heating greenhouses to 40F (4C) for the entire duration can be successful, although flowering will be slower. Plants must be supported with netting. Monkshood, with its low energy requirements, has excellent potential for winter cropping.

Stage of Harvest

Inflorescences (racemes) should be harvested when 3 basal flowers are open. If cut too early, flower buds will not open. Plunge immediately into flower preservative. 'Spark's Variety' (a cultivar of *Aconitum henryi*) should be cut with more open flowers than *A. napellus*. The question of how much stem to leave behind arises with all species of *Aconitum*, because the leaf area affects the tuber formation for the next year. Leave as much behind as possible; there is no magical node number at which to cut. Work in Israel (Watad et al. 1991) showed that more tubers were formed when cutting height was raised.

Postharvest

Fresh: Monkshood persists 7–10 days in preservative, fewer in plain water. Flowers are susceptible to chilling injury, and blackening of flowers is said to occur if they are stored below 45F (7C) (Vaughan 1988); however, Ed Pincus of Roxbury, Vt., has been storing flowers at 33F (1C) for years with no problems. Do avoid storage temperatures above 70F (21C). Flowers are sensitive to ethylene. Silver thiosulfate (0.75 mM for 12 hours) together with 2% sucrose and a bactericide improves vase life (Kalkman 1983, Lurie et al. 1997). Products containing STS are recommended as long as they remain available.

Dried: *Aconitum* may be air-dried and will persist many months. Strip the foliage prior to hanging stems upside down. It may not be a good idea to preserve poison on a stem, however, regardless of how well it dries.

Species and Cultivars

The following species of *Aconitum* are useful as cut flowers. Nomenclature may change on some of these, but the plants are still the same.

Aconitum ×cammarum is the class of hybrids between *A. napellus* and *A. variegatum*. 'Bicolor' (blue and white), 'Blue Sceptre' (deep blue), 'Bressingham Spire' (violet-blue), and 'Newry Blue' (dark blue) are excellent cultivars with stiff, upright racemes. 'Bicolor' and 'Newry Blue' are sometimes sold as selections of *A. napellus*.

Aconitum carmichaelii is a common garden species whose cultivars are sometimes used as cut flowers. Forms include 'Arendsii' (Arend's aconite), which bears some of the largest flowers and stoutest stems in the genus; it is sometimes listed as *A. ×arendsii*. The rich, dark blue flowers and strong, upright stems are excellent for flower production. If obtainable, it is the cultivar of choice for the cut flower grower. Unfortunately, it is more difficult to find than many others. 'Barker's

Variety' and 'Kelmscott' have light blue and violet-blue flowers, respectively. Some authorities claim that these cultivars are derived from var. *wilsonii*, which is 5–6′ (1.5–1.8 m) tall and bears dark blue flowers. Support is required.

Aconitum henryi has indigo-blue flowers and is best known for its 3–5′ (0.9–1.5 m) tall 'Spark's Variety', with dark blue flowers and strong stems.

Aconitum orientale (Oriental monkshood) and *A. lamarckii* (yellow wolfsbane) have sulphur-yellow flowers but do not have the strong, upright stems or the market potential of blue-flowered species.

Pests and Diseases

Crown rot (*Sclerotinium delphinii*) produces symptoms of leaf yellowing, plant wilt, and rot at the crown where the stems emerge. It causes black streaks in the water-conducting vessels of the stems and roots.

Mosaic virus causes yellow mottling and stripes on leaves. Plants should be culled.

Verticillium wilt (*Verticillium albo-atrum*, *Cephalosporium* spp.) results in leaves that fade to green-yellow, often on one side of the plant only. Leaves die, flowers are of poor quality, and black to brown discoloration in the cut stem is apparent. Can also be caused by bacterial infections, mainly from *Pseudomonas* spp.

Grower Comments

"I trialed small amounts of aconitum and the only ones to do well are napellus and 'Bressingham Spire'." Ron Smith, R. Smith Flowers, Renfew, Pa.

"We plant in 4′ wide beds, 10–12″ apart on centers. We do minor harvests the first year and then heavy harvests for the next 2–4 years, and then divide. We mulch with wood chips 3-plus inches deep. We use no supports except for 'Sparks', which can grow 7–8′ with somewhat weak stems. Though napellus does okay in sun, it does much better with some shade, but too much shade causes the flower head to be elongated increasing the space between florets." Ed Pincus, Third Branch Flower, Roxbury, Vt.

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Many thanks to Ed Pincus for reviewing this section.

Agastache Mexican hyssop, giant hyssop Lamiaceae

annual/perennial

Agastache, a member of the mint family, is used as a filler in mixed bouquets, providing attractive flowers and scented foliage. The flowers are magnets for butterflies and hummingbirds. All sorts of agastaches are available in the landscape trade, ranging from hard-to-find species to trendy salmon- and rose-colored hybrids, such as 'Tutti Frutti'. Many hybrids are perennial, at least to Zone 6; however, they may not have sufficient "substance" to serve even as fillers. The blue-flowered forms, such as *Agastache foeniculum*, provide vigor and substance and are probably the first choice when agastache is tried for the market. The common names come from the hyssop-like fragrance, but the actual herb *Hyssopus officinalis* (hyssop) is not worth growing for cuts.

Agastache foeniculum anise hyssop Lamiaceae

perennial, Zones 5–8 southwestern U.S. blue

20–30″/30″ (50–75 cm/75 cm)

Break off a leaf and smell the licorice fragrance of anise, to some a little too strong, depending on the selection.

Propagation

Seed: Seed sown at 70–72F (21–22C) germinates in 7–10 days. There are approximately 64,000 seeds/ounce (2300/g), and about 0.06 oz (2 g) of seed yields 1000 seedlings (Kieft 1996). Cover lightly with soil mix; seed benefits from

Agastache foeniculum
'Licorice Blue'

light during germination. Plants may be direct sown at a rate of 0.01 oz per 100′ (1 g per 100 m), but germination may be erratic. Terminal cuttings may also be used.

Growing-on

Transplant into cell packs or small containers 15–20 days after sowing. Grow under 60F (15C) temperatures until ready to place in the field. Plants flower 12–16 weeks after seeding.

Environmental Factors

High light and well-drained soils are basics for all hyssops. With *Agastache rupestris* and *A. cana*, however, excellent drainage is imperative. Plants flower in the summer; cultivars of *A. foeniculum* have the longest flowering time. Long photoperiods are likely beneficial, if not necessary for continued flowering.

Field Performance

Space plants 9–12″ (23–30 cm) apart in the row, 1–2′ (30–60 cm) between rows.

Greenhouse Performance

Seldom grown in the greenhouse. We suggest 65/60F (18/15C) day/night temperatures. If flowers are to be forced in early winter, the use of LD through night-break lighting approximately 6 weeks before flowers may be useful.

Stage of Harvest

Harvest when the inflorescence is ½ to ⅔ open.

Postharvest

Vase life is approximately 6–10 days using a general-purpose preservative. Suzy Neessen of Cedar Falls, Iowa, reports that vase life is 10 days in water.

Cultivars

'Alabaster' has creamy white flowers. Plants are about 3′ (90 cm) tall.

Honey Bee series, presented as a landscape plant, is also an excellent form for cut flowers. Stems grow to 24–32″ (60–80 cm).

Licorice series has 36″ (90 cm) flower spikes in blue and white. Likely hybrids involving *Agastache rugosa*. Zone 6(7).

'Snowspire' grows up to 4′ (1.2 m) with clean upright white flowers. Zone 6.

Additional Species

Agastache cana has rosy-pink flowers, much darker than those of *A. rupestris*. A filler.

Agastache rugosa (Korean mint) has purple-rose flowers; plants grow to 24″ (60 cm).

Agastache rupestris has wonderful airy salmon-peach flowers. Definitely a filler —stems are not sufficiently full to stand alone. Strong, pleasant foliage odor.

A good deal of hybridization has also occurred. The only reason this is important is in the overwintering characteristics of the cultivars. Some are hardy to Zone 4, nearly all overwinter in Zone 7b. For most of these hybrids, consider Zone 7 as the winter cutoff, plus or minus a zone.

'Apricot Sprite', a cross between *Agastache coccinea* and *A. auriantica* hybridized by Richard Dufresne of North Carolina, has 2–3′ (60–90 cm) stems and a marvelous flower color that stops people in their tracks. 'Apricot Sunrise' bears many 1½″ (4 cm) golden-orange tubular flowers.

'Blue Fortune' is an exceptionally good hybrid, growing 2–3′ (60–90 cm), hosting lavender-blue flowers from July to September. Zone 6.

'Firebird', also from Richard Dufresne, is a hybrid of *Agastache coccinea* and *A. rupestris*. It bears many orange-salmon flowers on 3′ (90 cm) tall plants. Plants are fuller than either of the parents and are cold hardy to Zone 6. Terrific plant for hummingbirds.

Fragrant Delight Mix grows 2–3′ (60–90 cm) with flower spikes of blue, white, rose, and lilac. Zone 6(7). The foliage is particularly fragrant.

'Pink Panther' (*Agastache coccinea* × *A. mexicana*) grows 3–4′ (0.9–1.2 m) tall and produces many 1½″ (4 cm) long tubular rose-pink flowers held in long racemes, starting in mid summer.

'Tutti Frutti' (*Agastache barberi* × *A. mexicana*) has tubular pink flowers from mid summer to frost on 2–3′ (60–90 cm) stems. The foliage, to some noses, smells like tutti frutti. What does tutti frutti smell like, anyway? Actually, like bubble gum. Zone 6(7).

Pests and Diseases

The biggest problem with agastaches is poor drainage or overly wet soils, resulting in root rot. Many need replacement after 2 years. Botrytis, aphids, and thrips are also commonplace.

Grower Comments

"I grew agastache for cuts for the first time this year, and I absolutely love it! Great vase life (at least 10 days), wonderful fragrance, easy to cut, just keeps producing. I grew the 'Licorice' blue and white, as well as 'Tutti Frutti', which was slow to get started and not nearly as prolific, but smelled just like bubble gum. It makes a great filler for bouquets." Suzy Neessen, The Flower Farm, Cedar Falls, Iowa.

Reading

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Ageratum houstonianum flossflower Asteraceae

annual Mexico blue, lavender, white 2–3′/2′ (60–90 cm/60 cm)

Flossflower provides spring- and summer-blooming flowers whose color range has expanded from the common lavenders of the past to whites and violets. The flowers are excellent for local markets, although they may be shipped short distances. Most cultivars have been bred for the bedding plant trade; however, recent breeding has resulted in many cut flowers forms. Flowers are persistent on the plant; the generic name comes from the Greek *a* ("not") and *geras* ("old age"), presumably because the flowers retain their color for a long period of time. The species name has nothing to do with the Texas city but rather commemorates William Houston (1695–1733), a Scottish surgeon who collected plants in Central America and the West Indies.

Propagation

Seed: Seed germinates in 8–10 days if sown at 78–82F (26–28C), slower with cooler temperatures, under intermittent mist or in a sweat tent. Cover lightly or not at all, as seed germinates better under light. Seeds are not often direct sown,

Ageratum houstonianum
'Blue Bouquet'

but if accomplished, wait for soils to rise above 55F (13C), then sow approximately 1/100 oz (0.3 g) of seed for 100′ (Kieft 1996). Approximately 1/64 oz (0.4 g) of seed yields 1000 transplants at 80–90% germination (Nau 1999).

Growing-on

Grow plugs at 60–65F (15–18C) for 4–6 weeks. If sown in open flats, transplant to 72-cell plugs 3–4 weeks after sowing. Fertilize with 100 ppm N, using a complete fertilizer, until plants are ready to transplant to the field. Approximately 7 weeks are needed between sowing and transplanting to the field.

Environmental Factors

Plants flower slightly faster under LD, but photoperiod is of minor concern. Flowering is mostly influenced by temperature. Flowering occurs throughout the summer. Ageratum is most productive in moderate temperatures of 60–70F (15–21C).

Field Performance

The goal of 10–20 stems/plant is easily attainable at a 9 × 12″ (23 × 30 cm) spacing. Place in full sun in the field after the danger of frost has passed (Utami et al. 1990). Best yields in the South occur from mid spring to mid summer; in the North, plants continue flowering unless summers become excessively hot. In general, temperatures below 50F (10C) and above 90F (32C) inhibit flowering. Make at least 2 separate plantings in southern locations. The first planting should be done in April, another in June; if the market is strong for fall material, consider another planting in August. A single tier of netting is useful because plants easily lodge (fall over) in inclement weather, and the netting minimizes this potential catastrophe.

Pinching: Some breeders recommend pinching, although with newer cultivars and if sequential plantings are accomplished, it may not be required. If pinching is done, pinch to about 4 leaf nodes (around 1–2 weeks after planting out).

Greenhouse Performance

Flowers may be forced any time in the greenhouse without artificial photoperiod control. Under 62–65F (17–18C) nights and 70F (21C) days, 12–13 weeks are required between sowing and flowering; 5–6 weeks are needed for finishing from plugs. Flowering occurs 10–14 days earlier in the South. According to Jeff McGrew of Jeff McGrew Horticultural Products, Mt. Vernon, Wa., 3–4 harvestable stems will be produced 10 weeks after pinching. Additional time is needed if temperatures are maintained below 62F (17C). Plant in final containers or in ground beds at 6–10″ (15–25 cm) spacing. Zizzo et al. (1998), working in unheated greenhouses in Sicily, Italy, showed that increased density of planting, up to 55 plants/100 ft^2 (6 plants/m^2) resulted in the highest yield, 10 flowers/ft^2 (107 flowers/m^2). Fertilize with 125–150 ppm N and K with potassium nitrate/calcium nitrate or 20-10-20 in the winter. A complete fertilizer, such as 20-20-20, may be used when light levels and temperatures increase in the spring. It makes no sense to grow anything but cultivars bred for cut flower use, therefore a single tier of netting is useful. Reduce fertilization by 50% when flowers begin to show color.

Stage of Harvest

Harvest when the center floret is fully open and lateral florets are well colored.

Postharvest

Fresh: Flowers persist 7–10 days in floral preservative. Flowers do not store well and are best for local markets. Little or no ethylene sensitivity.

Dried: Flowers may be air-dried, but flower color often fades.

Cultivars

'Blue Bouquet' has mid-blue flowers. Somewhat similar to but later-flowering than 'Blue Horizon'. Yields in the 2000 ASCFG National Cut Flower Seed Trials (Dole 2001) averaged 9 stems/plant, with an average stem length of 19″ (48 cm).

'Blue Horizon', an F_1 cultivar, was the first acceptable tall-flowered ageratum and is still as good as any. Plants grow 2–3′ (60–90 cm) tall and provide mid-blue flowers. Yields in the 1994 ASCFG National Cut Flower Seed Trials (Dole 1995) averaged 16 stems/plant, with an average stem length of 23″ (58 cm). Its drawback: it is only available in a single color.

'Dondo Blue' boasts 30″ (75 cm) stems with deep blue flowers; 'Dondo White' is slightly shorter.

'Escapade', with lavender-blue flowers, is a vegetative cultivar that should be pinched.

'Escobar' bears bordeaux-red flowers and is later to flower than many others. A vegetative cultivar that should be pinched.

'Estafette' produces white flowers and is early. Another vegetative cultivar—pinching recommended.

'Market Growers Blue' is an older tall offering, growing to about 2′ (60 cm). Superseded by newer cultivars but still seen occasionally.

'Red Top' ('Red Sea') is closer to purple, although descriptions suggest it is rich burgundy. Flower stems are 24–28″ (60–70 cm) and branch strongly when pinched (though not as strongly as 'Blue Horizon'). Yields in the 1997 ASCFG National Cut Flower Seed Trials (Dole 1998) averaged 15 stems/plant, with an average stem length of 17″ (44 cm).

'White Bouquet' carries clear white flowers on 20–28″ (50–70 cm) stems. They seem to have a narrower stem diameter and are therefore more susceptible to lodging.

Pests and Diseases

No diseases peculiar to *Ageratum* occur, although leaf rust (*Puccinia conoclinii*) has been a problem in outdoor plantings. The worst pests are whiteflies, which seem to be able to detect the presence of *Ageratum* from miles away. Once they've detected it, they tell all their friends and the banquet begins. Aphids can also be a problem, often resulting in curling of leaves and distortion of new growth. Plants tend to "melt out" in areas of hot humid summers (e.g., southern United States), particularly if summer rain is heavy. In staggered plantings, this problem is of little concern. If plants lodge in the field, fungal diseases can occur more readily. Nematodes don't appear to be a significant problem, as shown by experiments in which *Ageratum* 'Blue Mink' was nearly free of galling even after inoculation with root-knot nematodes (McSorley 1994).

Grower Comments

"In my perennial border 'Blue Horizon' does self-seed; it behaves like a hardy annual where young plants would overwinter, and it did seem as though they bloomed taller and stronger than the year before." Janet Foss, J. Foss Garden Flowers, Everett, Wash.

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Many thanks to Janet Foss for reviewing this section.

Agrostemma githago corn cockle Caryophyllaceae

annual western Europe purple 3–4′/2′ (0.9–1.2 m/0.6 m)

Corn cockle, native to the meadows and fields of western Europe, is considered little more than a weed in its native habitat. Flowers are generally 1½–2″ (3–5 cm) wide, but in cooler areas, flowers 3″ (8 cm) wide have been reported. The purple-mauve flowers have dark veins and are borne singly or in groups of 3–5 on thin, branched stems. Plants perform best in cool summers and cannot be recommended as a summer crop in the South. However, if planted in mid March to mid April, southern growers can succeed with this crop. Nothing spectacular, but a useful filler for bouquets.

Propagation

Seed: Seed may be direct sown 0.62 oz per 100′ (58 g per 100 m) in early spring (Kieft 1996). Indoors, seed may be germinated at 65–70F (18–21C) under mist or a sweat tent. Germination under controlled temperatures occurs in 6–10 days. Approximately 0.03 oz (0.9 g) should be sown in the greenhouse for 1000 plants at 65–75% germination (Nau 1999).

Studies from the Czech Republic showed that approximately 85% of corn cockle seeds still germinated even after 3 years of storage (Novakova 1996). The seed of *Agrostemma* is poisonous; it contains saponin, which can account for 5–7% of the dry weight of the seed (Kingsbury 1964). In 1997, a pair of Holstein cattle died in Kentucky after ingesting seeds and calyx tubes of corn cockle in the hay used for feed (Smith et al. 1997), so be careful! Seed may be stored dry at 32F (0C) for up to 20 years (Zeevaart 1989).

Cuttings: Take 1–3″ (2.5–8 cm) long vegetative cuttings. Rooting hormone is not necessary. Cuttings root in 10–12 days if placed in 70F (21C) root-zone propagation beds.

Growing-on

Most plants are direct sown to the field. They may also be grown in the greenhouse at 65/55F (18/13C) day/night temperatures. Grow on in cell packs (18–32 cells/tray) or 4″ (10 cm) pots. Fertilize with 50–75 ppm N in the form of potassium or calcium nitrate at each irrigation. Plants are ready to transplant to the field in 4–5 weeks. Warmer temperatures and high nitrogen nutrition result in internode elongation and soft transplants that are prone to injury in the field.

Environmental Factors

Photoperiod: *Agrostemma* is a long day rosette plant (Zeevaart 1989). That is, plants remain vegetative (in a rosette) and stems do not elongate under short days. Transfer of plants to LD results in rapid stem elongation and subsequent flowering. Flowering occurs approximately 40 days after transfer to LD. The critical photoperiod (i.e., the length of the long day) is not known, but probably a

12-hour day minimum is necessary. Long days are needed for initiation and subsequent flower development (Jones and Zeevaart 1980).

Temperature: Plants are cool-season crops. Linda Baranowski-Smith reports that in northwest Ohio (Zone 5b), field transplants in April or early May are finished by mid to late July, with as little as 3 weeks to as much as 6 weeks harvest time. Yield and stem length decline as temperatures rise. Plants are short-lived in hot humid summers. Plants planted in early April in north Georgia (Zone 7b) also declined by mid July.

Field Performance

Spacing: Plants are normally spaced 9″ (23 cm) apart or on 6–9″ (15–23 cm) centers, but may be planted as close as 6 × 6″ (15 × 15 cm) or as wide as 18″ (45 cm) apart.

Yield: Plants were trialed in north Georgia at different spacings to evaluate yield and stem quality. Stems were harvested June–July.

The effect of spacing on yield and stem quality of *Agrostemma* 'Purple Queen'.

Spacing (in)[z]	Stems/plant	Stems/ft^{2}[y]	Stem length (in)[z]
12	2.3	2.3	24.0
15	2.5	1.1	22.6
24	2.9	0.7	22.9

z = multiply (in) by 2.54 to obtain (cm)
y = multiply (stems/ft^2) by 10.8 to obtain (stems/m^2)

Each stem carries 4–6 flowers. Although stems/plant and stem length slightly increase with greater spacing, the differences are not dramatic. The yield/ft^2 declines rapidly as spacing increases, therefore close spacing is recommended. In northern Ohio, in poor years (drought, weeds), yields were as low as 0.5 stems/plant, and in favorable years, much higher yields were noted (see comments by Baranowski-Smith). Flowers, particularly white varieties, are prone to rain spotting.

Direct sowing: Seed broadcast over 150 ft^2 (14 m^2) on 15 February in Athens, Ga., resulted in 806 stems (5.4 stems/ft^2, 58 stems/m^2) with an average stem length of 26″ (66 cm). This is a significantly higher yield than from plants spaced on 12″ (30 cm) centers (see previous table); flowering time and stem length were similar. Direct sowing is useful in climates where seed may be sown early.

Successive sowings/transplanting: Two to 3 successive sowings, 2 weeks apart, early in the season are most useful. This is particularly true for southern growers, who can put plants out early in the year. The further north, the shorter the season, and the less the benefit of successive plantings for *Agrostemma*.

Greenhouse Performance

Plants can be produced in the greenhouse, although stem prices are seldom high enough to justify greenhouse production. To force flowers, space transplants 6–12″ (15–30 cm) apart and maintain under short days (<12 hours) until plants are well rosetted. Temperatures of 55–60F (13–15C) result in optimum growth. Incandescent lamps to provide 10–20 fc of light may be used to provide LD. This may be done by extending the days by 4–5 hours or using nightbreak lighting (lights on from 11 p.m. to 2 a.m.). Nightbreak lighting causes less stretch. Continue for approximately 4 weeks or until flower buds appear. Flowers occur 6–7 weeks after the beginning of LD. Fertilize with 100–150 ppm N using a fertilizer high in nitrates until flowers show color.

Stage of Harvest

Single stems should be harvested when 1 or 2 flowers are open on the inflorescence. Many growers harvest the entire plant, strip the foliage, and bunch the stems. In that case, a sufficient number of flowers must be open on each stem to provide a full bunch. Chas Gill and other growers suggest that it is not worth the time and expense to harvest stems over a period of time and that plants be harvested all at once. Agrostemma is recommended for mixed or market bouquets, but several growers have been successful selling them as straight bunches. The drawback of straight bunches is that it often takes more than 20 stems to make an attractive bunch.

Postharvest

Place cut stems immediately in a postharvest solution in the field prior to grading. Place in fresh solution and store upright in a 40F (4C) cooler after grading. Vase life is 5–7 days. Stems do not ship particularly well, though they may be shipped dry. They are best used for local markets.

Cultivars

'Contessa Pale Pink' produces numerous 36–40″ (90–100 cm) stems in mid summer bearing pastel pink blooms.

'Milos' has lilac-pink flowers with dark veins.

'Ocean Pearls' has 2″ (5 cm) white flowers with small black freckles on 2–3′ (60–90 cm) stems.

'Purple Foam' grows 30–36″ (75–90 cm) and bears deep purple flowers with a paler center.

'Purple Queen' produces purple-rose flowers.

Pests and Diseases

Leaf spots and aphids are the most serious diseases of corn cockle.

Grower Comments

"Spacing on 6″ centers, in black plastic mulch in northwest Ohio produced 3.7 stems per plant with stem length of 24–30″. Maybe this was just the right combination of factors—mild temperatures, regular rainfall, weed suppression, care, and long daylength. . . . It needs to be picked when cool [and immediately] placed into floral preservative. The few florists we sell to love it and market customers like it also." Linda Baranowski-Smith, Blue Clay Plantation, Oregon, Ohio.

"We plant several plantings, and pick entire plants, and bunch and sell it at the market. It is easy to pick 30 bunches in no time at all when you pick the entire plant. . . . Many customers equate the flowers with cosmos for beauty and longevity. . . . We have had the best luck with 'Purple Queen'. 'Ocean Pearls' has not performed well due to tarnished plant bug issues." Chas Gill, Kennebec Flower Farm, Bowdoinham, Maine.

Related Genera

Various species of *Lychnis*, a short-lived perennial, are similar. *Lychnis coronaria* (rose campion), *L. chalcedonica* (Maltese cross), and *L. coeli-rosa* (rose of heaven) have potential as cut flowers.

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Many thanks to Chas Gill and Linda Baranowski-Smith for reviewing this section.

Allium ornamental onion Liliaceae

bulb

The genus consists of approximately 750 species widely distributed over the northern hemisphere, many of which are useful for cut flowers. The pungent smell of onion, present in all species to varying degrees, is noticeable on most species only when stems are cut, damaged, or crushed. Seldom is any smell detectable after they have been placed in a vase. The principal cut flower species are *Allium giganteum* and *A. sphaerocephalon*, although *A. aflatunense*, *A. caeruleum*, *A. christophii*, *A. moly*, *A. triquetrum*, and numerous hybrids are also grown. The genus has it all: plants are easy to grow, have handsome flowers, bear long stems, and are relatively insect and disease resistant (Davis 1992).

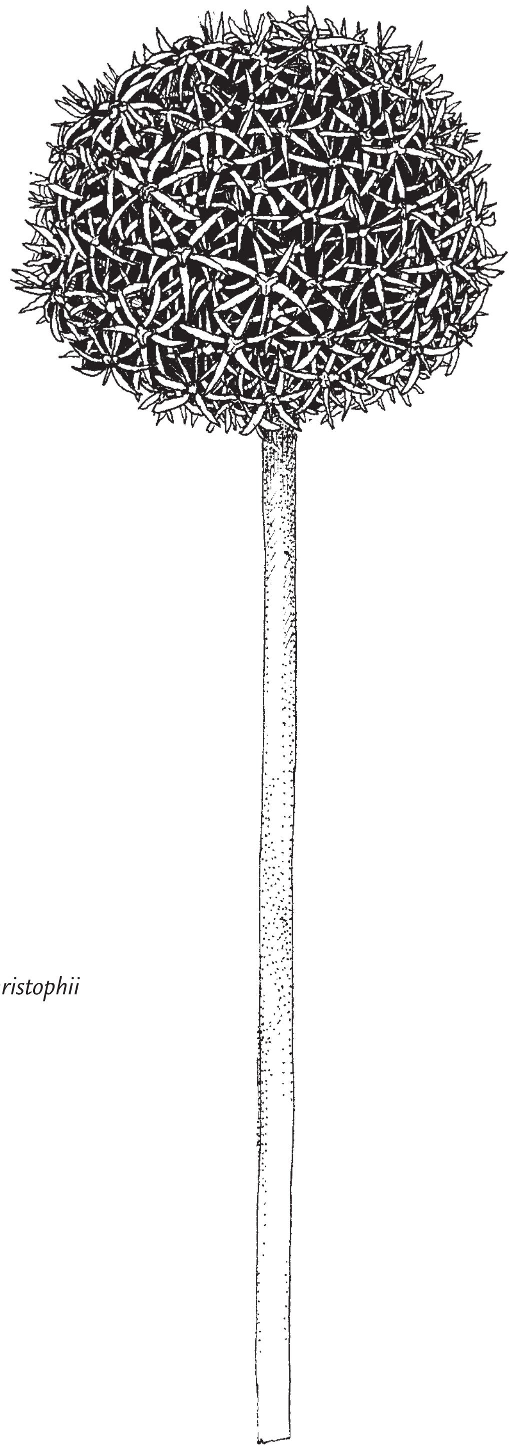
Know and trust your bulb dealer, and once trusting, be ready to pay a little more for high-quality bulbs. This is true for all bulbous material, but confusion seems to be particularly rampant in this genus. In general, cut all flowers on the ripe side; resist the pressure to cut and ship green. They will not do well if you do.

All we need now is a decent name. "Ornamental onions" conjures up no warm feelings of beauty and romance—more like purple-skinned circles on display in the salad bar. "Chives" is no better. For better marketing, a better name has been needed for years. We're still waiting.

Bulb size: In most species, size does make a difference. In general, the biggest, healthiest bulbs make the biggest, healthiest stems and flowers. Here are some of the choices and the size of the bulb commonly available. Smaller (and cheaper) bulb sizes can be obtained but should be avoided; they will be of inferior quality. Bulb circumference is always given in centimeters.

Species	Bulb circumference	Flower color
Allium aflatunense	12/+	purple
Allium aflatunense 'Purple Sensation'	12/+	violet
Allium caeruleum	4/+	blue
Allium christophii	12/+	purple
Allium cowanii	4/+	white
Allium 'Firmament'	10/+	dark purple
Allium giganteum	20/+	purple
Allium 'Gladiator'	18/20	lilac-purple
Allium 'Globemaster'	18/20	purple
Allium jesdianum	10	rosy pink
Allium 'Mars'	16/+	dark purple
Allium 'Mt. Everest'	20/+	white
Allium nigrum	10/12	creamy white
Allium roseum	4/+	pink
Allium schubertii	14/16	pink
Allium sphaerocephalon	6/+	burgundy
Allium triquetrum	6/+	white

Mulching: Most species are naturally cold hardy to Zones 3 or 4, and mulching of the bulbs is not necessary, although many growers recommend mulching for the addition of organic matter as well as to slow the freezing–thawing cycle. Bob



Allium christophii

Koenders of The Backyard Bouquet in Armada, Mich., always grows a companion cover crop, such as annual rye grass.

Cold storage prior to planting: Bulbs of all onions are stored (in Holland or wherever the source) until shipped. Studies have shown that most species do not require cold storage if fall planted, as any cold needed for initiation and development is provided during the winter. For forcing in the greenhouse, 4–8 weeks of storage (preplanted in the crate or pot) at 40F (4C) improves flower percentage and stem length for some species, such as *Allium giganteum* and *A. aflatunense* (Dubouzet et al. 1994).

Staggered planting times: Staggered planting times for spring-flowering species provide only a small expansion of the season, because as soil temperatures warm up, flowers develop more rapidly and often on shorter scapes. Also, staggered plantings usually involve longer periods of cold storage, and this can have a negative effect on flower quality. Instead of staggered plantings, select species and cultivars that flower at different times, thereby expanding the season.

Allium giganteum giant onion Liliaceae

bulb, Zones 4–8 Himalayas purple 3–4′/3′ (0.9–1.2 m/0.9 m)

Still among the most common onions for cut flowers, stems may be found in most major markets in the spring and early summer. The globe-shaped bulb is 2–3″ (5–8 cm) across and up to 12″ (30 cm) in circumference, making it among the largest bulbs in the genus. Small flowers are clustered close together in a lilac-purple ball (umbel), 4–5″ (10–13 cm) wide, on top of a naked 3–4′ (0.9–1.2 m) stem. Well-grown flowers are particularly eye-catching and command excellent prices. The bulbs are prone to virus, however, and clean stock is expensive relative to other *Allium* species. Flowers must realize high prices to be profitable.

Propagation

Seed: Seeds require 3–5 years to reach flowering size. Seeds should be sown lightly in a cold frame or other cool semi-protected area. Germination is erratic, and seeds may require up to one year for complete germination. Don’t mess with seed unless you are a hobbyist, or a masochist.

Division: Bulbs split about every 2 years and may be divided and replanted in the field immediately. Flowering occurs the second year from a split bulb, although flowers are smaller.

Environmental Factors

Temperature: Experimental evidence suggests cold is not necessary for flowering (Rees 1985), but it appears to be beneficial. Storing bulbs for 8 weeks at 40F (4C) improved the flowering percentage (Dubouzet et al. 1994) and is a useful practice in areas where little or no cooling occurs.

Field Performance

Bulb size: Use 8″ (20+ cm) circumference bulbs.

Spacing: Space bulbs 9–12″ (23–30 cm) apart and 4″ (10 cm) below the surface for best yields.

Planting time: In most climatic zones, bulbs may be planted in the fall, although early spring planting may be practiced. Planting from October through January did not affect yield in Zone 7b.

In general, each bulb yields a single stem and occasionally a shorter second stem. Foliage may be damaged by spring frosts, but flowers are unaffected. Foliage declines before the flowers are harvested. General performance is shown in the following table (De Hertogh 1996).

Location (Zone)	First harvest	Harvest duration (days)	Stem length (in)^z
Ottawa (4)	18 Jun	30	46
East Lansing, Mich. (5)	27 Jun	23	44
Washington, D.C. (7)	10 May	18	44
Raleigh, N.C. (8)	26 May	9	44
San Francisco (9)	5 Jul	30	28

z = multiply (in) by 2.54 to obtain (cm)

Many growers find harvest duration is shorter than this table shows. In fact, depending on methods used, many alliums are harvested in a 4- to 7-day period. If left in the field too long, damage may occur. Harvest times are generally earlier and shorter as plants are grown in areas of warmer summers. The consistently cool climate in San Francisco resulted in delay of flower harvest.

Longevity: Commercial production is possible for years. Some growers, such as Bob Koenders of Michigan, cut from the same bulbs for 10 years, whereas others replace after 2–3 years. In trials in north Georgia, flowering declined after 2 years and was dismal the third. Most parts of North America lack the proper combination of cold winters, warm summers, and good soils necessary for longevity.

Shading: Not necessary. Full sun is best.

Stage of Harvest

Flowers should be harvested when ½ the flowers are open. The remainder open naturally in any normal postharvest solution. Place flowers in a 36–42F (3–6C) cooler after harvesting. Storage has a negative effect on vase life, reducing marketable time after stems emerge from coolers (Kalkman 1984).

Postharvest

Fresh: Flowers have a vase life of approximately 14 days (Sacalis 1989). Shipping of fully open flowers results in visible damage and decreases postharvest life.

Storage: Stems may be stored for up to 6 weeks (Sacalis 1989). Recut stems after flowering and place in a preservative solution of pH 4.0.

Allium sphaerocephalon drumstick chives Liliaceae

bulb, Zones 4–8 western Europe to Iran purple
2–3′/2′ (60–90 cm/60 cm)

In early summer, the oval flower heads, 2″ (5 cm) in diameter, are green and purple, but they mature to a deep purple. The inflorescence consists of many bell-shaped flowers. The oval bulbs may be planted in the fall. Each bulb produces many offsets in the summer and can become almost weedy in some areas.

Propagation

Seed: Seeds require 2–4 years to reach flowering size. Seed should be sown lightly in a cold frame or other cool semi-protected area. Seeds may require up to one year for germination. Buy bulbs.

Division: Offsets are routinely formed and may be divided after 1–2 years. Separate bulbs by diameter and replace larger ones in the production area.

Environmental Factors

Cold does not appear to be necessary for flowering. Bulbs, once dug, may be stored at room temperature prior to planting. Dormancy occurs approximately 4 weeks after flowering.

Field Performance

Bulb size: Optimum size is 2–3″ (5/6 or 6/7 cm) circumference (De Hertogh 1996).

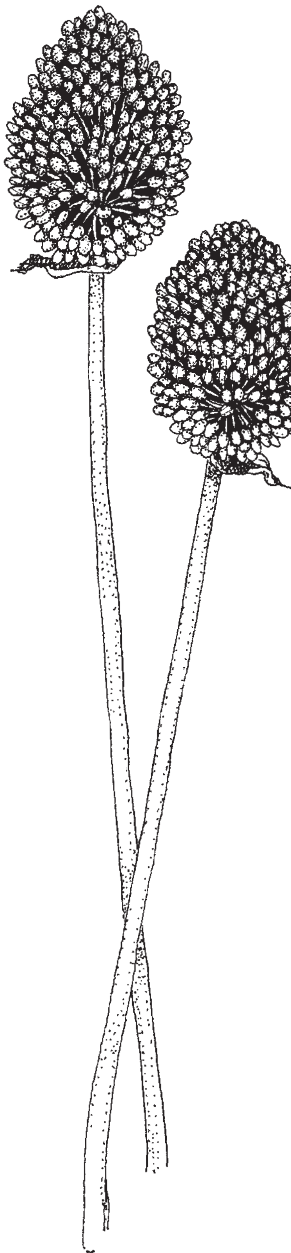
Spacing: Space 1″ (2.5 cm) apart and 4″ (10 cm) below the soil surface.

Planting time: Yield, harvest times, and stem length do not seem to be affected by planting date; stem width was only slightly affected by a later planting, as shown in the following table (Armitage and Laushman 1990).

The effect of planting date on *Allium sphaerocephalon*.

Month planted	Flowers/ bulb	First harvest	Harvest duration (days)	Stem length (in)^z	Stem width (mm)^y
Nov	1.1	4 Jun	10	27.4	7.2
Dec	1.2	31 May	13	26.6	6.4

z = multiply (in) by 2.54 to obtain (cm)
y = divide (mm) by 25.4 to obtain (in)



Allium sphaerocephalon

Harvest times and stem lengths in Nova Scotia (Zone 5), East Lansing, Mich. (Zone 5), and Fayetteville, Ark. (Zone 7) were 22 June/26″, 1 July/24″, and 15 May/12″, respectively (De Hertogh 1996).

Longevity: *Allium sphaerocephalon* is productive for 2–3 years before problems with diseases and offset production reduce yield.

Spacing: Space bulbs 2–4″ (5–10 cm) apart. De Hertogh (1996) recommended 1″ (2.5 cm) apart, and we have had success with bulbs spaced as far as 8″ (20 cm) apart.

Shading: Not necessary.

Stage of Harvest

Harvest when the bottom 3 or 4 whorls of flowers are open (when ¼ to ½ of the inflorescence is open). Flowers continue to open if placed in clean water. Place stems in cooler at 40F (4C) only if necessary, as cold storage may reduce shelf life.

Postharvest

Fresh: Stems have a vase life of approximately 10–14 days in water.

Storage: Flowers may be stored in water up to 4 weeks at 32–35F (0–2C) (De Hertogh 1996).

Dried: Wait until nearly all flowers are open; some seed may be formed from the basal flowers (Bullivant 1989). Stems may be hung upside down but that is not necessary.

Additional Species

Many species and their hybrids are useful for cut flowers, and not much distinguishes one tall form from another. The main limitation is availability. The other concern is that labeling on alliums is terribly confused and often incorrect. The problem is far less severe when dealing with reputable sources. Be suspicious when prices are too good to be true.

Allium aflatunense (Persian onion; Zones 4–8) has ball-shaped flowers similar to *A. giganteum* but plants are significantly shorter, about 2–3′ (60–90 cm) tall. Space bulbs 2–3″ (5–8 cm) apart and 4″ (10 cm) below the surface. Longevity and performance are poor south of Zone 7. Bulbs must be precooled at 41F (5C) for 8–10 weeks prior to planting south of Zone 7. Average stem length in Zones 4–7 is approximately 26″ (66 cm) (De Hertogh 1996); south of Zone 7, stems are shorter. Bulbs are readily available and relatively inexpensive. Some outstanding cultivars are available, the most common and best being ‘Purple Sensation’, whose flowers always seems to be in high demand and low supply. ‘Blue Powderpuff’ is similar to ‘Purple Sensation’ but with shorter stems, larger heads, and lilac-blue flowers. Hybrids in which *A. aflatunense* is a dominant parent include ‘Gladiator’, ‘Mars’, and ‘Mt. Everest’. These produce some excellent flowers in lilac-purple, dark purple, and white. All have starburst-like flowers on 4–5′ (1.2–1.5 m) stems. Hardy in Zones 4–8.

Allium atropurpureum (Zones 5–8) has dark purple flower heads, so purple as to be almost black. Stems are about 2½′ (75 cm). Sometimes sold as *A. nigrum* var. *atropurpureum*. Stems should not be harvested until neck has "hardened" and about ½ the flowers are open.

Allium caeruleum (syn. *A. azureum*; blue globe onion; Zones 2–7) has grass-like foliage and deep blue flowers. Stem length averages 18″ (45 cm) and inflorescences are 1–2″ (2.5–5 cm) in diameter. Plant 2–3″ (5–8 cm) apart and 4″ (10 cm) below soil surface. One of the most finicky of bulbs; treat as an annual in most of the country.

Allium christophii (Zones 4–8) has metallic-blue, many-flowered umbels on 6–8″ (15–20 cm) tall plants. The flowers are handsome and dry well; however, the stem length may be too short for wholesale markets. Flowers do not ship well and are best grown for local sales. 'Firmament', a hybrid between *A. christophii* and *A. atropurpureum*, bears heads similar to the former but taller (approximately 2′, 60 cm) and with darker flowers.

Allium 'Globemaster' (Zones 4–8) is a hybrid between *A. christophii* and *A. macleanii*. Plants are 3–4′ (0.9–1.2 m) tall and have large, round, light purple heads consisting of hundreds of small flowers. An exceptional performer but still relatively expensive.

Allium hirtifolium (Zones 4–8) has rosy red flowers in a drumstick head, similar to *A. stipitatum*. A more common form bears pure white flowers on 3–4′ (0.9–1.2 m) stems.

Allium jesdianum (Zones 5–8) is another "tall" (2½–3′, 75–90 cm) drumstick onion, with purple-lilac flowers. Interesting flowers have white stamens.

Allium nigrum (syn. *A. multibulbosum*; Zones 5–8) is an excellent hardy onion, with many star-shaped white to pale pink flowers, each with a green center. Ball-shaped head is formed on 3–4′ (0.9–1.2 m) stems.

Allium schubertii (tumbleweed onion; Zones 6/7–9) is one of the weirdest onions, with 2–3 rows of pink flowers arranged loosely on a circular inflorescence 6″ (15 cm) wide. Stems are only 12–18″ (30–45 cm) tall, but it is unique among the onions and may do well in local markets. Pick with only a few flowers open. Gaining popularity.

Allium siculum (Zones 5/6–8) is actually *Nectaroscordum siculum* var. *bulgaricum* but is still sold under alliums. Stems are up to 4′ (1.2 m) tall; inflorescence consists of multicolored tubular flowers that hang down. After fertilization, seed pods stand erect and can be dried. Cut with 4 or 5 flowers open; remove any leaves that are cut with the stem. Stems become curly as they grow and are difficult to harvest and bunch. Caution: this can be quite smelly (garlicy) and very invasive.

Allium stipitatum (pink and white giant onion; Zones 4–8) is similar to *A. giganteum* but less available in this country. Variety *album* is a white form.

Allium thunbergii (Zones 5–8) produces rose-lilac flowers in the fall that persist on the plant until frost. If the flowers are not harvested, they literally dry on the plant. Although plants are only 12–15″ (30–38 cm) tall, the late-flowering habit and drying ability make this a potential species for cut flowers.

Allium triquetrum (three-cornered onion; Zones 5–9) is grown in the field and occasionally forced in the greenhouse. The pendulous white flowers have a green central stripe and are held on a three-cornered scape, thus the common name. Scapes are usually less than 18″ (45 cm) long and are reasonably fragrant.

Pests and Diseases

Bulb rot (*Sclerotinia cepivorum*) causes abortion and destruction of the flowering stem and eventual death of the bulb. Tips of the leaves turn yellow and finally brown. The bulbs are covered in a mat of white mycelia, on which appear small black sclerotia. Destroy infected bulbs. Excellent drainage is key to reducing this serious disease.

Grower Comments

"We grew *Allium caeruleum* this year along with *A. sphaerocephalon*, *nigrum*, *christophii*, and *schubertii*. The caeruleums had quite a strong oniony smell—true, only when you cut the stems—but enough to scare even our most adventurous florists away. Nigrum and christophii were borderline on odor but sold ok. Sphaerocephalon and schubertii were by far our best allium sellers." Michelle Smith, Blossoms, Inc., Fletcher, N.C.

"I love [*Allium aflatunense*] 'Purple Sensation'. Three-foot stems, heads that are big and showy, but not so big as to be difficult to design with, and always very reasonably priced." Susan O'Connell, Fertile Crescent Farm, Hardwick, Vt.

"I grew *Allium nigrum* for the first time this year, and I think it was perhaps my favorite allium—the large white heads were quite impressive and made great cuts." Cynthia M. Holloway, "The Wild Bunch" Flower Farm, Bradyville, Tenn.

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Many thanks to Bob Koenders and Jan Roozen for reviewing this section.

Alstroemeria Peruvian lily Amaryllidaceae

annual South America many colors 2–4′/2′ (0.6–1.2 m/0.6 m)

The popularity of *Alstroemeria* continues unabated in florists shops worldwide. Most flowers are greenhouse-grown in Europe, South America, and England, but greenhouse production occurs in the northern United States, and field production is popular in coastal California. All commercial cultivars are hybrids whose parentage is not well known; however, *Alstroemeria aurea*, *A. ligtu*, *A. pelegrina*, *A. pulchra*, and *A. violacea* are key to their makeup. The environmental responses of the parents greatly affect the responses of the hybrids, therefore, cultivars do not always react to the environment similarly. Few cut flower cultivars are produced from seed; the great majority are obtained from commercial propagators. Most breeding has taken place in Holland and England, although American hybridizers have also turned out some fine cultivars.

Shoots arise from a rhizome that has fibrous and fleshy storage roots. Depending on the cultivar, *Alstroemeria* can be flowered year-round, but flowering is heaviest in spring and early summer. Outdoor production in California occurs in fall and early spring, with some flowering in the winter.

Propagation

Seed: Approximately 1.5 oz (42 g) of seed per 1000 seedlings is required, and after sowing, the seed flats are generally cooled 2–4 weeks at 45–50F (7–10C). Germination is 50–70% (Nau 1999).

Tissue culture: New cultivars are routinely propagated by tissue culture for rapid buildup of numbers.

Rhizome division: Commercially, rhizomes with 3 or more vegetative shoots are commonly available.

Environmental Factors

Temperature: Flowering is controlled by the temperature of the rhizome, which can perceive the temperature of the soil surrounding it. Soil temperature of 41F (5C) for 6 weeks is most effective; however, initiation still occurs at 55F (13C), although slower (Healy and Wilkins 1981, 1985). Newer cultivars are not as sensitive to low temperatures as older cultivars are. Soil temperatures are more important than air temperature for *Alstroemeria*; if soil temperature is maintained below 60F (15C), plants continue to flower, regardless of air temperature (Healy and Wilkins 1981, Doi et al. 1999). Dry-stored rhizomes do not respond to cool temperature treatments (Vonk Noordegraff 1975), thus they must be planted and watered in for temperature to be effective. Soil temperatures above 70F (21C) inhibit flower initiation by devernalizing the rhizomes. If plants have been subjected to inductive temperatures, flowering is reduced if they are given subsequent temperatures above 62F (17C) (Healy and Wilkins 1982). For continuous production of flowers, maintain greenhouse temperatures at 50–55/60–65F (10–13/16–18C) night/day (Dole and Wilkins 1999).

Alstroemeria
'Rebecca'

Photoperiod: Long days result in faster flowering than short days. The optimum photoperiod appears to be 14–16 hours and can be provided from late September to late March (Dole and Wilkins 1999). The LD treatment is not effective unless rhizomes have been subjected to cool temperatures.

Supplementary light and CO_2: Supplementary lighting is useful, particularly in the winter, and results in increased flower stem production and quality. Supplementing carbon dioxide to 900 ppm CO_2 had even more positive results (Labeke and Dambre 1998). In cold climates, such as Norway, where cool soil temperatures can be maintained all year, supplemental lighting of 18–36 W/m^2 can be effective all year (Bakken and Baevre 1995). Supplemental lighting seems to be more cost-effective when less light per unit time is spread out over a 20-hour photoperiod rather than higher light over a 16- or 12-hour photoperiod (Bakken and Baevre 1999).

Field Performance

Soil: Soil should be well drained with a pH of 6.0–6.5.

Covering: Many growers provide a saran or low-density shade cloth covering over the top and on the side toward the prevailing winds. Plants are expensive, and some protection from wind and rain is good insurance.

Spacing: Space plants on 12–18″ (30–45 cm) centers or 18 × 20″ (45 × 50 cm) in 2 rows in a 3′ (90 cm) wide bed. Correct spacing depends on cultivar.

Planting: Bury rhizomes at the same depth as in the pot (or in the liner). Plant so that the growing point is headed into the center of the bed. Carefully spread roots out when planting. The fat storage roots are necessary for continuous flowering and should be handled with respect.

Support: Provide at least 2 tiers of support mesh. They may be raised as the shoots grow. Place the bottom layer approximately 1′ (30 cm) above the soil.

Harvesting: Stems are usually pulled, not cut. Remove with a rapid upward pulling motion. Not all stems should be pulled; many butterfly types do not produce sufficiently strong stems and should be cut. Similarly, when young plants start to flower, stems should be cut to reduce chances of removing the rhizome. Some people report skin rashes when handling *Alstroemeria*. Use of gloves and long-sleeved shirts is recommended.

Thinning: For longer flowering, thin vegetative shoots as often as possible. No more than 30% of the shoots should be removed at one time.

Scheduling: In many cases, rhizomes arrive in November, are potted and placed in a greenhouse until April, and are then planted to the field. Flowering begins in June, but the early flowers are removed to strengthen the plant; yield from April planting peaks in August. In warm climates, rhizomes planted in August start to flower in October; peak flowering occurs in March and April, when soil temperatures are cool.

Yield: Fifty to 100 stems per plant per year are reasonable for field-grown *Alstroemeria*, depending on latitude, cultivar, and spacing. Plants spaced in rows 3′ (90 cm) wide produce higher yield per plant than those on 2′ (60 cm) rows.

Greenhouse Performance

The great majority of flowers worldwide are grown under protection. Use ground beds for best production. Rhizomes should be immediately planted 3–4″ (8–10 cm) deep and at 16 × 20″ (40 × 50 cm) or 20 × 24″ (50 × 60 cm) spacing (De Hertogh 1996). Use 2 rows per 3′ (90 cm) wide planting bed. Provide cool soil temperatures (<55F, 13C is optimal) for at least 6 weeks. If planted in the summer, vegetative growth will commence, followed by flower initiation triggered by cool temperatures in the fall and winter. The cooling requirement should be completed by mid December in northern states. Provide 14- to 16-hour photoperiods once the 6 weeks of cooling have been completed. The long days during the winter may be provided by day extension or by providing 4–5 hours of incandescent light during the night. Provide high light intensities in the winter. If necessary, use HID lamps; they facilitate increased growth as well as providing the long day during the winter. Remove vegetative shoots every month once flowering begins.

Fertilization: Continuous application of calcium nitrate and potassium nitrate at 200–280 ppm N is recommended (Dole and Wilkins 1999). Avoid ammoniacal forms of nitrogen, particularly during the winter. An N:K ratio of 1:1 to 1:4 and a pH of 5.5 has been suggested (Bik and van den Berg 1981).

Harvest: Pull, don't cut, flowering stems from the rhizome, except with young plants.

Timing: Rhizomes planted August to December have peak production in March and April.

Yield: Roy Sachs of Flowers and Greens in Davis, Calif., reports annual flower production of patented varieties in greenhouse trials to be 20–28 flowering stems per ft^2 (215–300 stems per m^2).

Stage of Harvest

Pull stems when the first flowers are fully colored and the majority are showing color. For long-distance shippers, stems may be harvested when the first buds are swollen and about to open.

Postharvest

Fresh: Flowers will continue to open for 10–14 days; however, the foliage may start to yellow earlier. The use of STS and other preservatives enhances flower longevity and reduces leaf yellowing. Petal drop can be delayed by pretreatment with 1-MCP (EthylBloc™) or STS. A fresh flower food containing gibberellins or cytokinins can delay leaf yellowing (Nell and Reid 2000).

Storage: Flowers may be stored wet for 2–3 days at 38–40F (3–4C) (Nowak and Rudnicki 1990) or dry at 33–35F (1–2C) for up to a week (Sacalis 1989). Pulsing with 4 mM silver thiosulfate and 4% sucrose prior to dry storage increased the length of time flowers may be stored (Menguc and Zencirkrian 1996).

Dried: Alstroemerias do not dry well.

Cultivars

Most of the many available cultivars evolved from European sources. 'Rebecca' is among the most popular; other useful cultivars for cut flowers include 'Amazone', 'Ballet', 'Cinderella', 'Diamond', 'Dusty Rose', 'Irena', 'Jubilee', 'Lorena', 'Pacific Sunset', 'Sacha', 'Sunny Rebecca', 'Victoria', 'Virginia', and 'Yellow Dream'. Most stems are sold as mixed bunches, not as individual colors (e.g., whitish, lavender). Consult your sales representative for current availability.

Additional Species

Alstroemeria aurea (syn. *A. aurantiaca*) has bright orange and yellow florets. A parent of several hybrids.

Alstroemeria ligtu (St. Martin's flower) bears large numbers of small red to pink flowers; sometimes the perianth segments are streaked with white. One of the dominant parents of the Ligtu hybrids.

Alstroemeria magnifica provides light bluish to purple flowers.

Alstroemeria pelegrina has lilac and white flowers spotted with red-purple; the perianth segments are streaked with white.

Alstroemeria pulchella and *A. psittacina* are probably the same thing. The dark red flowers are long and narrow, with dark red perianth segments. Hardy to Zone 7. 'Parrot' is a hybrid with *A. pulchella*.

Pests and Diseases

Normal pathogens such as *Botrytis*, *Pythium*, and *Rhizoctonia* affect plants, but no diseases specific to *Alstroemeria* occur. It is essential to provide adequate ventilation and spacing for plants. Aphids, spider mites, and whiteflies can be a problem.

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Many thanks to Fran Foley and Will Healy (first edition) and Roy Sachs and Roy Snow (second edition) for reviewing this section.

Amaranthus caudatus love-lies-bleeding Amaranthaceae

annual tropics red, green 4–6′/2′ (1.2–1.8 m/0.6 m)

Amaranthus comes from the Greek *amarantos* ("unfading"), a reference to the flowers on some species, which act much like everlastings. As the name implies, flowers can be persistent. All amaranths are showy; some are grown for the flowers, others are harvested for the colorful foliage.

Plants of love-lies-bleeding bear drooping, deep red flowers on 12–15″ (30–38 cm) long racemes. In the first edition of this book, Armitage said he found the plants in this genus "rather gaudy" and related how his friend Jo Brownold had tried to set him straight: "Not every cut or dried flower needs the grace of lilies or the charm of larkspur. Amaranths have long histories as food, religious, and ceremonial plants; their use as ornamentals is just the latest chapter." Jo's perceptive comments notwithstanding, Armitage still finds them gaudy but must admit: they capture the eye as well as the imagination. Flowers may be used fresh or dried, and their ease of cultivation makes them attractive to growers looking for gaudy additions to their crop palette.

Amaranthus caudatus
var. *atropurpureus*

Propagation

Seed: In the greenhouse, lightly cover seed in a peat/perlite medium and place under mist at 70–75F (21–24C). Germination occurs in 7–10 days. Approximately 0.03 oz (0.9 g) of seed yields 1000 plants (Nau 1999). Most amaranth seed is direct sown. Seed may be direct sown in the field after potential for frost has passed. Rates of 0.13 oz per 100′ (12 g per 100 m) are common; Ralph Cramer in Elizabethtown, Pa., uses a higher rate, up to 0.4 oz per 100′ (38 g per 100 m). Higher rates yield smaller flower heads, which may be more useful for certain purposes.

Growing-on

Seedlings should be transplanted to final containers about 3 weeks from sowing. Grow at 62–65F (17–18C) or as warm as 68F (20C) if needed, until ready to transplant to the field. Fertilize sparingly with 50–75 ppm N once a week. Green plants (plants not in flower) are generally ready for field planting 6–7 weeks from sowing. If purchased or produced from plugs, the plugs may be directly transplanted once a strong root ball has developed.

Environmental Factors

Photoperiod: *Amaranthus* is a short day plant, although critical daylengths may be as high as 16 hours (Kohdi and Sawhney 1979). Plants provided with 8-hour photoperiods flower 1½–2 times faster than those provided with 16-hour photoperiods (Kigel and Rubin 1985). Plants become sensitive to short days after a 4-week juvenile period (i.e., as young plants) (Zabda 1961).

Light intensity: Full sun is best; flowering time is delayed and plants become significantly taller under shade, regardless of daylengths (Koller et al. 1975).

Temperature: No cold treatment (vernalization) is necessary for *Amaranthus*. Temperatures above 70F (21C) result in faster flowering than cool temperatures (<65F, 18C), particularly under long days (Koller et al. 1975).

Field Performance

Temperature: Foliage may take a hit, but mature flowers may still be usable and harvested after a light frost. Light frost is usually defined as 1 or 2 nights at 28–32F (⁻2–0C).

Spacing: If plants are transplanted, spacings of 12 × 12″ (30 × 30 cm) to 12 × 15″ (30 × 38 cm) are common. Closer spacing of less than 9″ (23 cm) centers results in spindly stems.

Pinching: According to Ralph Cramer, pinching is beneficial; more yield results, and the smaller laterals that form are sufficiently large for the market.

Irrigation: Infrequent, deep irrigation is best. Overwatering can cause plants to fall over, especially if overhead irrigation is used.

Fertilization: Lightly or not at all in the field.

Support: Although stems are relatively sturdy, 1 or 2 layers of support netting prevent stems from falling over in areas of frequent summer rainfall. Stems can become brittle after flowering.

Shading: Not necessary, except where longer stems are required. Shading will delay flowering and increase stem length and leaf number. Too much shade (>30%) results in tall but weak stems.

Greenhouse Performance

Transplant to ground beds or 8–10″ (20–25 cm) pots, and place in full sun under long days of at least 17 hours to keep plants vegetative initially. This can be done with extended days or nightbreak lighting. Place under natural short days or SD of 8–10 hours when plants are approximately 2′ (60 cm) tall. Fertilize with 75–100 ppm N using a complete nitrogen fertilizer (e.g., 20-20-20, 15-16-17). Maintain temperatures of 68–70F (20–21C) during long days, and reduce to 60–65F (15–18C) during short days. Reduce further to 55F (13C) 5–7 days prior to harvesting to enhance color. Support is necessary.

Stage of Harvest

For fresh flowers, cut when at least ¾ of the flowers on the inflorescence are open. If producing dried flowers, allow the flowers to grow until seed has begun to set and the flowers feel firm to the touch. If picked too early, they shrivel to thin strings. Harvest the main flowers and allow side flowers to develop.

Postharvest

Fresh: Flowers persist 7–10 days in water. If flowers must be stored, keep at 36–41F (2–5C) but no longer than 7 days.

Dried: Flowers may be air-dried. Hang upside down to dry for approximately 10 days. If you can accelerate the process with heat, it locks in a much better color. This is actually true of most plants, but amaranthus particularly benefits.

Cultivars

var. *atropurpureus* has blood-red leaves and is usually more dwarf than the species.

'Pony Tails' grows 3–5′ (0.9–1.5 m) long, with bead-like flowers on the trailing spike.

'Red Tails' has multiple, brilliant red cascading flower spikes, about 12″ (30 cm) long. 'Green Tails' bears similar spikes in green and yellow.

var. *roseus* bears rose-pink tassels on 4–5′ (1.2–1.5 m) tall plants. One of the more handsome choices in the species.

var. *viridis* has hanging, yellow-green spikes that are not even remotely appealing.

Additional Species

Stage of harvest for all species grown for their flowers is ½ to ¾ open for fresh, open for dried. All are native to tropical climes, and all grow rapidly but can collapse at maturity equally fast. If you're lucky, you will find plants listed under cultivar names (don't expect any accuracy in listing of botanical names), but glowing descriptions can be found with nothing more than *Amaranthus*. We need to be more professional than that; let's at least get the cultivars right.

Amaranthus cruentus (purple amaranth, red amaranth, red cathedral) has leaves that are smooth above, coarsely hairy beneath; the sharp apex usually terminates in a soft "spine." Flowers are greenish red and droop from the leaf axils. Plants are 3–6′ (0.9–1.8 m) tall. This species is terribly mixed up taxonomically speaking (the plant has been called *A. paniculatus*, *A. hybridus*, and a few others), but it has given rise to some really neat cultivars.

'Aurora' is excellent for hot growing areas, with an eye-popping combination of yellow and dark green foliage. Top leaves are creamy yellow and lower are dark green. Height is about 3½′ (1.1 m).

'Bronze Standard' bears bronze flower spikes and deep green foliage.

'Foxtail' has long deep red spike-like racemes of flowers over bronze foliage. Plants grow 2–3′ tall (0.6–0.9 m). Often sold as 'Red Cathedral'.

'Giant Copperhead' from Cramers' Posie Patch has greenish yellow leaves and beautiful copper stems and flowers. Grows to 4′ (1.2 m). Yield from the ASCFG's national trials was 6 stems/plant with 3′ (90 cm) stems (Dole 1999).

'Hopi Red Dye' will dye your fingers, but the red stem and red flower are outstanding fresh. Better transplanted than direct seeded. Available from heirloom catalogs.

'Hot Biscuits' is really cool. Plants grow 5–6′ (1.5–1.8 m) tall, with 2′ (60 cm) feathery plumes of earthy cinnamon flowers. Difficult to obtain, unfortunately.

'Komo' is completely burgundy-colored, growing 5–6′ (1.5–1.8 m) tall. Outstanding!

'Oeschberg' grows to 6′ (1.8 m) in height and bears dark scarlet flower spikes.

'Red Cathedral' is probably the most diverse of all cultivars in the amaranth trade. Tall, 4–5′ (1.2–1.5 m), with bronze-red leaves and large flower heads of shocking burgundy. If you are growing 'Red Cathedral', you are probably growing the species itself or 'Foxtail'.

'Split Personality' is 3–4′ (0.9–1.2 m) tall, with irregularly patterned red and golden-green inflorescences that can be up to 18″ (45 cm) long.

Twin Towers series grows 28–40″ (70–100 cm). Both the green and red forms provide good height and attractive, long-lasting flowers (Dole 2002).

Amaranthus hypochondriacus (prince's feather) can be a spectacular plant that shows off both foliage and flowers during the summer and, under cool summer conditions, remains colorful until frost. In general, they are upright plants, 3–6′ (0.9–1.8 m) tall, with leaves dark green or deeply flushed with purple. The deep crimson axillary flower spikes stand erect above the foliage, like popping fireworks. As garish as these plants are, we think they are more graceful than love-lies-bleeding. Plants are sometimes sold as *A. erythrostachys*. Only a few cultivars sold belong to this species, among them 'Prince's Feather', a 3–5′ (0.9–1.5 m) tall blood-red selection, and 'Pygmy Torch', 2–3′ (60–90 cm) tall with deep maroon flowers and purple foliage.

Amaranthus tricolor (joseph's coat, tampala, Chinese spinach) is shorter, only 1–2′ (30–60 cm) tall. The 1″ (2.5 cm) long flower spikes, found in most of the leaf axils, are insignificant compared to the colorful upper leaves. Not the best cut flower (actually cut stems), and leaves are best used for local markets only. They do not ship well, nor do they persist more than a few days. Keep cool as long as possible after cutting. Many cultivars are available through garden sources; the following are most useful for the cut trade.

'Early Splendor' bears bright crimson uppermost leaves and bronze bottom foliage.

'Flaming Fountain' has thin, willow-like leaves of carmine, crimson, and bronze.

'Illumination' almost looks like a poinsettia, with large orange to scarlet leaves with golden centers. Lower leaves are green to bronze.

'Intense Purple' is just that, with red-veined, deep purple leaves and intense red-purple tassels.

'Molten Fire' has a scarlet growing center over green to bronze leaves.

'Opopeo' from Mexico bears striking bronze foliage. It grows to 6′ (1.8 m) tall.

'Splendens' is probably one of the most colorful varieties, if not the showiest. The leaves are deep red, the uppermost ones a brilliant light red. An even more exotic blend, particularly useful for shock value, is 'Splendens Tricolor' ('Splendens Perfecta') whose uppermost leaves combine red and gold in a gaudy but not uninteresting combination.

The many new *Amaranthus* cultivars of unknown parentage that have appeared like magic on the market may be worth a try as cut flowers and stems. One, Cascade series, produces 3–5′ (0.9–1.5 m) ropy stems.

Pests and Diseases

Few serious pests or diseases affect ornamental amaranths. They may be scared of them.

Grower Comments

"It's a good money maker for us; 90% of what we sell is direct seeded." Ralph Cramer, Cramers' Posie Patch, Elizabethtown, Pa.

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Ammi majus false queen anne's lace Apiaceae

annual Europe, Asia, N. Africa white 2–3′/2′ (60–90 cm/60 cm)

No longer new to the cut flower market, *Ammi* is now produced throughout the United States, Europe, and South America. Approximately 6 species occur, but only *Ammi majus* and a closely related species, *A. visnaga*, are grown commercially. The white flowers of *A. majus* are similar to the common roadside weed, queen anne's lace, thus its common name. Although native to the Old World, the species appears to be as adaptable to Alabama as it is to Arizona.

Ammi majus

Harvesting of *Ammi majus* requires the use of gloves and protective clothing. The sap of the cut stems may result in severe contact dermatitis in sensitive individuals. Serious cases may cause permanent scars.

Propagation

Seed: In the greenhouse, chill seed at 40–45F (4–7C) for 1–2 weeks prior to sowing. Sow in plugs or directly to the field. In controlled environments, cover seed lightly and place at alternating night/day temperatures of 68/86F (20/30C). Germination of prechilled seed placed at alternating temperatures is approximately 75–80%; without alternating temperatures, germination may be well below 50%. Germination occurs in 7–14 days. Approximately 0.06 oz (2 g) of seed yields 1000 seedlings (Nau 1999).

Seed may be sown directly in the field in the fall (this is a must in southern areas) or early spring. Temperatures may fall to as low as 18F (⁻8C) during the winter without significant damage to seedlings if hardened off. Night temperatures should be consistently below 50F (10C) for best germination. Sow 0.03 oz per 100′ (2.8 g per 100 m) in the field. There are 40,000 tiny seeds/oz (1400 seeds/g), and spacing is often dictated by available equipment. Germination is often better in the field than in the greenhouse because of natural alternating temperatures. If sown in the field in the summer, chill the seed prior to planting. Two to 3 successive sowings, 2 weeks apart, are often used. Some growers have found that they had better success waiting to plant until the ground was a little warmer, but no later than mid May in the Midwest. Even then, successive plantings can be accomplished, often with longer stems produced from the last planting.

Growing-on

If not direct sown, transplant seedlings to 2–3″ (5–8 cm) containers approximately 3 weeks after sowing or maintain in 200-cell plugs for 4–5 weeks. Fertilize with 50–75 ppm N after transplanting. Temperatures of 58–62F (14–17C) are recommended to establish the seedlings. Place in the field when plants are large enough to handle (about 3 weeks after transplanting) at approximately 6 × 8″ (15 × 20 cm) spacing.

Environmental Factors

No photoperiodic response is known. Plants do not perform well at temperatures above 85F (29C) and are best handled as a winter crop in Zones 8–10. In areas where summer temperatures are not excessive (Zones 3–7), it is a useful summer crop. Total crop time from greenhouse sowing to flowering in the field is approximately 15 weeks (White-Mays 1992).

Field Performance

Yield: Plants transplanted to 12″ (30 cm) centers yielded 4–6 stems/plant at Maryland (Healy and Aker 1989). Spring planting is important because plants should be 3–4′ (0.9–1.2 m) tall prior to budding up. If they flower before 3′ (90 cm), they have probably been planted too late. Plants transplanted on 2 April in Kentucky flowered in late May. Eight to 12 stems/plant with stem lengths of 18–24″ (45–60 cm) occurred over a 4- to 5-week harvest period (White-Mays 1992).

Spacing: Direct sow in fall (South), after danger of heavy frost in the North (see "Propagation" for rates) or transplant 9–12″ (23–30 cm) apart. A spacing of 6 × 8″ (15 × 20 cm) is sometimes recommended, but disease pressure is increased at high-density plantings. If spring planting, transplant no later than 20 April in the South, 15 May in the Midwest, 21 May in the North. Late frosts, after warm spring temperatures, may result in significant losses.

Support: Plants can grow 5–6′ (1.5–1.8 m) tall and should be supported with at least one tier of mesh, 2 layers if spring rains are common. Without fail, torrential rainstorms will occur the day before harvest. Each small, perfect blossom collects water, and without support, plants wind up in the mud. The lateral stems do not always grow straight, and although the twists and curves cause problems with bunching, they are handsome and should still be marketable.

Greenhouse Performance

Transplant to ground beds at a 12–15″ (30–38 cm) spacing in January and February for flowering plants in May and June. Start plants under night temperatures of 60–63F (15–17C) to establish the crop. After 2–4 weeks, reduce night temperatures to 55–60F (13–15C) until flowering. Expect about 3 months from transplanting to flower in the winter, at least 2 weeks earlier in the summer.

Stage of Harvest

Harvest when approximately 80% of the flowers in the inflorescence are open. Flowers cut too early (50% open) do not take up water and tend to wilt. The flowers should be a crisp white with only the slightest green tint and no hint of pollen shed. Once pollen sheds, flowers decline rapidly. This is an excellent local item because it is difficult to cut at the proper stage if plants are to be shipped long distances. Some growers cut the initial center flower with only a 6–12″ (15–30 cm) stem length, allowing the secondary flowers to bloom on 20–24″ (50–60 cm) stems.

Postharvest

Fresh: Flowers persist 5–8 days in preservative. They may be stored at 37–40F (3–4C) for approximately one week.

Dried: Flowers may be air-dried for 2–3 weeks in a dark, dry place. Darkness is necessary to maintain green stems and keep the white flowers from browning.

Cultivars

'Queen of Africa' is recommended for greenhouse production. This generally indicates that plants are not as weather tolerant as field-grown forms, which is certainly not a criticism. Sow in mid June for flowering in mid September. In national field trials, plants yielded 9 stems/plant with 2′ (60 cm) stems (Dole 1997).

'Snowflake' has 2–3″ (5–8 cm) wide flower heads and grows 3′ (90 cm) tall.

'White Dill' bears flowers that are slightly whiter than the species; otherwise, plants are the same.

Additional Species

Ammi visnaga, known and sold as green mist ('Green Mist'), is a coarser, and, in our opinion, larger and more beautiful form than false queen anne's lace. The chartreuse flowers open slowly and can be outstanding cuts as well. A little more difficult to locate, but well worth the search. Some people find the odor of the flowers mildly unpleasant; Lynn Byczynski of Lawrence, Kans., compares it to a turpentine-like smell.

The genus has been studied extensively in pharmaceutical circles. Numerous flavonols, alkaloids (some poisonous to livestock), and cumarins have been isolated from leaves and fruits of *Ammi* species. *Ammi visnaga* contains visnadine, extracted from the fruit, which exhibits peripheral and coronary vasodilator activities and has been used in the treatment of angina pectoris (Duarte et al. 1997). Off the subject but interesting information nevertheless.

Related Genera

Daucus carota (queen anne's lace) is a popular filler for eastern and southern growers. It can usually be distinguished by the small black center flower ("Queen Anne") in the inflorescence. The species is biennial; 2 years are necessary for efficient flowering. Many growers simply cut from roadside populations which, if done too aggressively, may result in significant decline in plant numbers. Since this plant is not native to North America, this may not be a concern. Plants may be easily grown from seed and planted in the field. Populations can be continued through self-seeding. Some wholesalers accept queen anne's lace as readily as *Ammi*.

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Many thanks to Knud Nielsen III and Linda White-Mays (first edition) and Lynn Byczynski (second edition) for reviewing this section.

Anemone coronaria poppy anemone Ranunculaceae

bulb, Zones 6–8 Mediterranean many colors 8–15″/8″ (20–38 cm/20 cm)

Anemones have been produced as cut flowers for years. Plants are not tolerant of warm weather, and cut flowers are produced in the cool season: spring in the field or winter in the greenhouse. Most production must be accomplished under some sort of protection to minimize wind and rain damage. Active selection and breeding of anemones have resulted in numerous hybrids from controlled crosses in many colors. The market is strongest prior to Mother's Day; demand decreases after that date.

Propagation

Tubers: Anemones are not usually propagated by the grower but can be divided if clumps are large. With low growth rates, this is seldom feasible. Tubers are usually soaked in water overnight prior to other treatments such as cold storage. Tubers may be soaked in running water at room temperature water for up to 48 hours, with a fungicide added for the last half hour or so (water turned off). After soaking, and allowing them to drip dry, they should be packed into perforated or ventilated plastic bags with moist (but not wet) perlite, peat moss, or vermiculite for subsequent cold treatment (Gloeckner 2001).

Cold treatment of tubers: Research in Japan (Ohkawa 1987) suggested that 100% of tubers stored 4 weeks at 41F (5C) initiated flowers after planting, but that 50F (10C) was optimal for flower quality and yield. Other work in Florida suggested that 7 weeks at 43F (6C) was best. If planting tubers, we suggest 4–5 weeks at 45–50F (7–10C) prior to planting.

Seed: Sow seeds on top of soil and place at 55–60F (13–15C). Germination occurs in 10–14 days. Plugs are available for most cultivars through plug specialists.

Growing-on

Seedlings should be fertilized lightly (50–75 ppm N) and placed in high light and cool temperatures around 45–55F (7–13C). Soak tubers for 12–48 hours in water prior to planting.

Anemone 'De Caen White' and 'Saint Brigid (Saint Bridgid) Blue'

Environmental Factors

Temperature: Cold treatment (vernalization) of the tubers is discussed earlier. Natural vernalization occurs in the field if tubers are planted in the fall in mild-winter climates or in early spring elsewhere. Poppy anemones are winter hardy only to Zone 6, perhaps to Zone 5 if sufficient mulch is applied. Warm temperatures during production inhibit flowering and result in poor-quality flower stems, therefore field production is practiced mainly in Mediterranean climates, or in areas with mild winters and cool springs in the United States. Weather protection is highly recommended. High temperatures signal the onset of tuber dormancy.

Research in the greenhouse has provided guidelines for day/night temperatures that optimize flower yield and quality (Albrecht 1987, Ohkawa 1987). In general, day temperatures of 54–60F (12–15C) and night temperatures of 45–48F (7–9C) will provide excellent yield and quality. Temperatures as high as 61F (16C) were optimal when combined with 16-hour daylengths in Alaska (Karlsson 1997).

Photoperiod: Photoperiod studies are not definitive, but it appears that SD accelerate flowering and LD result in early termination of flowering and hastening of dormancy (Kadman-Zahavi and Horovitz 1980, Kadman-Zahavi et al. 1984). Under normal flowering times, natural SD occur during flowering and need not be changed. Supplemental light, however, during the SD of winter, is recommended if economically feasible.

Field Performance

Tuber size: Use tubers 4/5 cm in circumference (De Hertogh 1996). Since tubers cannot be easily measured, use at least one-year-old tubers to be confident of tubers of sufficient size. Tubers above 5 cm should be avoided; they become quite woody and can be a problem. Some English gardeners learned the hard way: "Such monsters should be put straight on the fire, they are worth neither time nor space for their planting" (Genders 1960).

Spacing: Plant tubers 1–2″ (2.5–5 cm) apart. Research in Israel showed that tubers can emerge from as deep as 12″ (30 cm) below the surface (Hagiladi et al. 1992). We suggest planting about 1″ (2.5 cm) deep, but it is nice to know that tubers are so adaptable.

Planting time: The best planting time for tubers is in the fall in Zones 7–9 and in early spring further north. Late planting results in significant decrease in yield and quality. The effect of different planting times in Zone 7b, Athens, Ga., is shown in the following table (Armitage and Laushman 1990).

The effect of planting date on *Anemone coronaria* De Caen Group.

Month planted	Tuber survival (%)	Flw/tuber	First harvest	Harvest duration (days)	Stem length (in)[z]
Nov	96	10.2	27 Feb	65	9.5
Dec	89	4.8	30 Mar	33	7.4
Jan	25	1.1	15 Apr	17	5.4
Feb	20	0.2	30 Apr	5	5.5

z = multiply (in) by 2.54 to obtain (cm)

Obviously, early planting is essential, at least in Zone 7. With late planting and subsequent delay of first harvest date, flowers emerged as weather became warmer, but warm weather shortens duration of harvest and decreases stem length, stem diameter, and flower diameter.

Planting zones: In other locations, flowering time and stem lengths of De Caen were 20 May/10″ in Glencoe, Ill. (Zone 5); 2 May/12″ in Washington, D.C. (Zone 7); and 27 January/6″ in Baton Rouge, La. (Zone 9) (De Hertogh 1996). Data based on planting from October to December.

Longevity: Anemones should be treated as annuals for commercial production. Research on tubers that remained in place for 3 years showed that productivity declined after the first year (Armitage and Laushman 1990).

Longevity of *Anemone* tubers for cut flower production in the field.

Year	Tuber survival (%)	Stems/tuber	Stem length (in)[z]
1	90	6.5	10.0
2	30	7.0	9.3
3	20	5.4	8.5

z = multiply (in) by 2.54 to obtain (cm)

Although the number of stems per tuber and stem length were only slightly affected, the survival of tubers was dramatically reduced each year. Survival was affected by warm summer soil temperatures, pests, and diseases. This work was done in Georgia, but most growers in the United States find that yearly renewal of tubers is necessary for best production and quality (De Hertogh 1996).

Shading: Shading results in longer stem lengths. In research at Georgia, stems of De Caen Group hybrids were approximately 9″ (23 cm) and 12″ (30 cm) long under full sun or 67% shade, respectively (Armitage 1991). Yield was unaffected. This may not be the case in areas of cooler temperatures and less light intensity.

Tubers vs. plugs: Tubers often do not germinate as well as growers would like, even when they are soaked and cooled, and field planting of seedlings (plugs) is often practiced. The use of plugs results in better stands of plants, but the yield and quality of cut stems are not affected.

Greenhouse Performance

Greenhouse production in northern states occurs October through December in cool greenhouses. Commercial production in the South is also possible, but harvesting must be finished before 1 April because of warm day temperatures in the winter. Most growers plant plugs in ground beds or 4–6″ (10–15 cm) pots. Space approximately 6″ (15 cm) apart and maintain temperatures below 55F (13C).

In general, crop time in the greenhouse from vernalized tubers can be as fast as 16 weeks or as slow as 32 weeks, depending on latitude. With purchased plugs, 12–13 weeks are needed (De Hertogh 1996).

Stage of Harvest

Some recommendations suggest that flowers should be harvested after they have opened and closed once or twice. This is difficult to monitor, however, and most growers harvest flowers when the petals (actually sepals) have started to separate from the center but are not fully open.

Postharvest

Fresh: Bud-cut flowers open well in water alone and persist 4–6 days. Exposure to ethylene causes petal shatter and reduces vase life. Additional vase life occurs if pulsed with silver thiosulfate (STS) for 15–30 minutes. Transfer stems to a solution containing 2–4% sugar (Nowak and Rudnicki 1990). Recut the base of the stems with each transfer. Stems should be shipped in an upright position if possible.

Storage: Flowers may be stored dry at 38–44F (3–8C) for 1–2 days, after conditioning with 100 ppm hydroxyquinoline sulphate plus 1.4 oz/gallon of sugar (Nowak and Rudnicki 1990).

Dried: Flowers may be dried in a microwave (Vaughan 1988). Place the flowers on approximately 2″ (5 cm) of warm silica gel and cover the flower with additional gel. Heat for 1–3½ minutes, depending on the fleshiness of the flower.

Cultivars

Cleopatra series is only recommended for the greenhouse. Available as seeds, plants bear 18–24″ (45–60 cm) long scapes. Flowers are available in single colors and a mix.

De Caen Group hybrids, the most popular field-grown anemones, consist of single, saucer-shaped flowers. They are available as a mix or as single colors.

La Beau is a tetraploid series of anemones, with strong thick stems and large early-season flowers.

Mona Lisa Group is mainly used in the greenhouse trade. The stems are longer than De Caen hybrids, and the vase life is better. In the field, they flower a little later than De Caen.

Saint Brigid (Saint Bridgid) hybrids have semi-double to double flowers. They are also available as a mix and as single colors.

St. Piran Mix has long stems of single and semi-double flowers.

Additional Species

Anemone ×fulgens also grows from a tuber and should be treated similarly to *A. coronaria* (De Hertogh 1996). The most popular cultivars are members of the Saint Bavo Group.

Anemone hupehensis, a Japanese species, and the hybrids of *A. ×hybrida* are effective cut flowers, but vase life is short. However, their flowers occur in late summer and fall, an important time for field flowers. White cultivars like *A. ×hybrida* 'Honorine Jobert' are particularly effective for fall weddings.

Pests and Diseases

Leaf spots and tuber rots are caused by various fungi. Apply appropriate fungicides after the foliage has emerged. Anthracnose (*Colletotrichum acutatum*) can be a problem, but hot water treatment (118F, 48C) of the corms for one minute killed 99% of the spores (Doornik 1990).

Grower Comments

"I sold some white Japanese anemones this fall for a wedding, and then got an additional request for some for another wedding. They have nice long stems, and the unopened buds are interesting, even though there aren't too many flowers open on a stem at once. In this climate, they can be rampant spreaders." Carol Paschal, Island Flowers, Anderson Island, Wash.

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Antirrhinum majus snapdragon Scrophulariaceae

annual Mediterranean many colors 3–4′/2′ (0.9–1.2 m/0.6 m)

The market for snapdragons continues to fluctuate, and always will, primarily due to over- and underproduction. When prices are poor, production is decreased, and, in time, prices become sufficiently strong to warrant additional volume, resulting in another cycle. The length of time the highs persist is directly related to the number of growers producing snapdragons. While this is true of all crops, snaps seem to have been buffeted around more than most. In the early 2000s, the market for snapdragons is strong and getting stronger.

There will always be a market for spike flowers, and few other species can provide the range of colors and strength of stem commonplace in today's snap cultivars. Most of the breeding is directed toward cultivars for the greenhouse, and greenhouse production is common in all areas of the country. Snaps may also be field-produced in the spring in southern and far western states, and in the summer further north. Snapdragons have cultural requirements similar to other cool-loving plants, such as larkspur, lupines, and delphiniums. In areas where winters are sufficiently cold for flower production, but not so cold as to damage or destroy the plants (Zones 7–10), early spring production in the field is feasible.

Propagation

All plants are raised from seed, generally in plug trays. For optimum germination, seed should be sown, watered in, and cooled at 40F (4C) for 2 weeks (Nau 1999). After cooling, germinate at 72F (22C) under mist or sweat tent. Although cooling is beneficial, it is not a requirement; if it is not possible to provide cooling, commence germination temperatures immediately. Seedlings should

Antirrhinum majus
'Potomac Yellow'

emerge in 7–14 days. Thomas McElroy of Newton Greenhouses suggests placing sown plugs in chambers in the dark for 3 days, then for 2 days under fluorescent lights for 24 hours a day (McElroy 1998). Approximately 1/128 oz (221 mg) of seed yields 1000 seedlings, depending on cultivar (Nau 1999).

Growing-on

After plants have 3–5 true leaves, grow at 50–55F (10–13C) night temperature. Maintain day temperatures as close to 60F (15C) as possible. Warm temperatures cause stem elongation, resulting in lanky transplants. Fertilize at approximately 200 ppm N when grown in warm temperatures; reduce by 50% when growing at 50–55F (10–13C). Transplant to field or greenhouse as soon as plants can be handled without damage (usually 5–6 weeks). In spring (late March through early May, depending on frost dates), transplant to the field. In areas where fall transplanting may be accomplished, transplant from mid September through early November. In the greenhouse, transplanting may take place year-round.

Environmental Factors

Photoperiod: The snapdragon is essentially a quantitative long day plant, meaning that it is capable of flowering under short days but flowers earlier and at a lower leaf number in LD (Laurie and Poesch 1932, Maginnes and Langhans 1961). Although this is a typical response, many current greenhouse cultivars have been bred to be virtually unaffected by daylength, particularly the late-flowering ones. Plants grown under SD produce more vegetative growth, while LD mainly affects the initiation of flowers. Once initiated, the subsequent development is relatively unaffected by daylength (Maginnes and Langhans 1961). Photoperiod also affects the juvenile stage, that is, the number of leaves that must form before flowers occur. The minimum number of leaves is higher under SD than LD (Cockshull 1985). Greenhouse (forcing) cultivars have been bred to flower at virtually any time of year under natural daylengths; photoperiod is less important than it was for older cultivars. However, HID lamps are often used for both additional light and long days (adding 2–5 hours to the natural day) in the winter, particularly in northern houses.

Light intensity: Snapdragons flower with stronger stems, more rapidly, and with higher yields under high light. Low light results in more blind shoots and reduces yield and stem quality. Light intensity is more of a concern for winter greenhouse production than field production. Some winter cultivars have been bred for low light response and may be used for winter production, however to assure high-quality stems, the use of HID lamps is recommended.

Temperature: Snapdragons have no vernalization requirement, but those grown cool (50F, 10C or below) initiate and open flowers later than those grown warmer (Maginnes and Langhans 1960, 1961). Although warm temperature hastens flowering, it reduces spike length and stem strength (Post 1955). During summer, stem strength is poor in the field in the Southeast.

Field Performance

Planting time: In general, successive plantings are practiced, often 3 per season. In the Midwest and North, plant as soon as the ground can be worked in the spring. Harden transplants by putting greenhouse plantlets outside during the day or placing them in cold frames day and night for about 2 weeks prior to planting out. If properly hardened off, plants can survive 25–28F (⁻4–⁻2C) frosts; if not hardened, they will produce snapper soup. In the South, plant in September through early November. In north Georgia, 5F (⁻15C) temperatures were recorded in late December, and plants flowered well the next spring; plants had, however, gone through a cool fall.

Fall planting is always a difficult decision, because of freezing problems. In Zone 7 and warmer, fall planting is common; however, when freezes come, some protection is recommended. Frost protection fabrics must be secured against gusty winds. Some growers use an inexpensive line of incandescent bulbs under plastic tunnels during freezing nights (see comments by Landwer). From the plant's perspective, if fall temperatures cool down well and plants harden off, winter temperatures are far less devastating. The major cultivars for field production are the Rockets and Potomacs, but others are also used (see "Cultivars" and "Grower Comments").

Spacing: Plant on approximately 9–12″ (23–30 cm) centers. Two to 3 rows in a 3′ (90 cm) wide bed are often used. If plants are to be pinched, place on 12–15″ (30–38 cm) centers.

Yield: In Maryland, yields of crops planted out on 15 April produced averages of 7 and 10 stems/plant for Potomac and Rocket strains, respectively (Healy and Aker 1989).

Fertilization: Side dress with a complete fertilizer as soon as temperatures warm up. The fertilization of outdoor snaps has been the subject of much discussion. In general, phosphorus is not absorbed well when temperatures are low; after fall growth has occurred (fall planting), nitrogen is generally reduced and P-levels are increased. In spring-planted materials, do the opposite, that is, increase the N as temperatures increase. Nutrient deficiencies of snapdragons are well discussed in the article by Ray Campbell and his colleagues (2000).

Shade: Shade is not necessary, but growing under cloth tents (such as cheesecloth) results in longer stems and better-quality flowers. In snapdragons, petal shatter follows pollination; the absence of bees under the tent will assure more persistent flowers.

Greenhouse Performance

Cultivar selection is very important in greenhouse production. Winter cultivars should be selected for winter forcing, summer varieties for summer (see "Cultivars"). Talk with a seed supplier for the best cultivars for a particular area and season. A great deal of information is available in manuals and books.

Successive plantings every week (or every 10 days) is common for greenhouse forcing. Transplant to ground beds as close as 9″ apart or as wide as 15″ (38 cm) apart. Place transplants at 3 × 5″ to 4 × 5″ (8 × 13 cm to 10 × 13 cm) for winter production and approximately 3 × 5″ (8 × 13 cm) for summer production (Stefanis and Langhans 1982). After transplanting, provide as much light as possible. If cultivars are properly selected, manipulation of photoperiod is not particularly important; but it is often practiced nevertheless, and providing LD (12–16 hours) ensures flowering. Set temperatures to 50–55F (10–13C) throughout the crop cycle. Higher temperatures during the day are unavoidable in most areas, and occasional 70F (21C) temperatures are not detrimental, if not too persistent. Larger plants with heavier stems can be obtained if held at warm temperatures in the early stages and lower temperatures at later stages.

Growers supplement the greenhouse with 900–1200 ppm CO_2 in the winter, particularly in the North, where greenhouses are seldom vented. Fertilize with a complete liquid fertilizer (150–200 ppm N and K) that is low in ammonium at each irrigation; double the concentration if feeding only once a week. Fertilize only until flower buds begin to swell. At least 2 tiers of support are needed, the bottom one about 12″ (30 cm) from the soil. A cheesecloth cover inhibits pollination by bees.

Stage of Harvest

For local markets, harvest flowers when ⅓ to ½ of the flowers are open. This would consist of 8 or more open flowers on the stem. For long-distance shipping, stems may be harvested when ⅓ of the flowers are open (5–7 open flowers) (Sacalis 1989). For long-term storage or if preservatives are to be used, flowers can be cut as early as when 2 or 3 buds are showing color (Nowak and Rudnicki 1990).

Postharvest

Fresh: Fresh flowers persist 5–8 days in water; they will persist a little longer if treated with STS, if available. Treatment with a one-hour STS pulse is common, although it does not always provide additional vase life. Differences in STS efficacy may be due to cultivar differences or treatment variability. A 1–2% sugar solution (combined with a biocide) improves the color of unopened flowers and increases vase life from 8 to 21 days. Nell and Reid (2000) suggest an overnight pulse of flower food with 7% sugar enhances vase life. The gas 1-MCP, marketed under names such as EthylBloc™, has been used effectively with snaps as a substitute for STS (Serek et al. 1995). EthylBloc™ may be commonplace in the future in small operations, but distribution methods and techniques must be simplified before use becomes widespread. A natural lipid, lysophosphatidylethanolamine (LPE), has also been shown to enhance vase life (Kaur and Palta 1997), but that material is difficult to obtain.

Storage: Stems may be stored at 40F (4C) for 3–4 days either dry or wet. If wrapped in plastic film to reduce desiccation, they may be stored up to 10 days. Preservatives and temperature have been shown to affect wet storage. At 32–35F (0–2C), storage can occur for 1–2 weeks in water, 4–8 weeks in a preservative. Use a fungicide to inhibit *Botrytis* spp. if storing for more than 4 days. A bud-opening solution should be used after long-term storage. Place stems in a solution at 70F (21C), 75–85% relative humidity, under 16-hour daylengths and high light intensity (approximately 200 fc) (Nowak and Rudnicki 1990). Long-term storage can result in poor flower development and faded color (Post 1955).

Gravity: If not stored upright, snapdragon stems bend upward. This may be an ethylene-induced or a calcium-mediated response; work with calcium inhibitors, such as lanthanum chloride ($LaCl_3$) showed inhibition of the stem curvature (Friedman et al. 1998), as did the use of ethylene inhibitors, such as STS and 1-MCP (Philosoph-Hadas et al. 1999). Much more work is needed. It is best to always store and ship stems upright. Ship stems in refrigerated trucks, even if traveling a short distance. Warm temperatures, such as those found in airport loading docks, are disastrous. Maintaining cool temperatures is essential.

Dried: Flowers may be dried in warm air, but the use of silica gel improves color retention (Vaughan 1988).

Grading

The Society of American Florists (SAF) has developed grading standards for snapdragons. All bunches consist of 12 stems.

Grade	Weight per stem (oz)^z Min.	Weight per stem (oz)^z Max.	Min. open flowers per stem	Min. stem length (in)^y
Blue (special)	2.5	4.0	15	36
Red (fancy)	1.5	2.4	12	30
Green (extra)	1.0	1.4	9	24
Yellow (first)	0.5	0.9	6	18

z = multiply (oz) by 28 to obtain (g)
y = multiply (in) by 2.54 to obtain (cm)

Cultivars

Outdoor

Rocket, Maryland, and Potomac strains are the 3 main forms used for outdoor production. Potomac appears to be more rust resistant than Rocket (Healy and Aker 1989). In north Georgia, the Liberty Strain, a greenhouse (forcing) variety, was also successful. The Ribbon series was designed for landscapers, but colors are strong enough to use if stem length is not an issue. Animation series is available in several colors, and although it is used in greenhouse forcing, the series has potential for field production; early flowering was frequent in national trials. For additional cultivars, contact seed suppliers in your area.

National field trials

Snapdragons have been evaluated since 1994, the inception of national trials conducted by the ASCFG. The following table (Dole 1995–1999, 2001) is a summary of the average stem lengths and yields of snaps submitted for trialing.

These data are averages over a wide geographical range and must be viewed as guidelines only; individual experience may differ significantly.

Cultivar	Year of trial	Stem length (in)[z]	Stems/ plant
Animation Crimson	1997	16	5
Animation Deep Rose	1997	15	14
Animation Red	1997	15	7
Animation Yellow	1997	18	6
Apollo Ivory	1998	17	7
Apollo Purple	1998	18	7
Potomac Plum Blossom	1994	22	6
Sonnet Mix	1995	15	5
Sonnet White	1995	11	7
Sunshine Deep Purple Eye	2001	18	5
Sunshine Lemon Eye	2001	18	6

z = multiply (in) by 2.54 to obtain (cm)

Greenhouse

Four main groups of snaps for forcing are offered, based on the environment under which they are grown. These groupings are guidelines only, not written in stone. Groups 1 and 2 are recommended for winter and early spring harvest, groups 2 and 3 for autumn and spring harvest, and groups 3 and 4 for late spring, summer, and autumn harvest. Growers in the North may use all cultivars from all groups, while those in the South should use groups 3 and 4 only. A few are listed here, but many more are available from a reputable seed supplier. Some cultivars perform equally well in more than one group, and not all colors in a series fit the same group (for example, 'Monaco Yellow' fits in 2, 3, while 'Monaco Pink' fits better into 3, 4). Similar groupings for European greenhouse production are also available. Check with your salesperson.

Group	Harvest	Temp. range	Examples of series
1, 2	winter, early spring	45–50F (7–10C) to 50–55F (10–13C)	Admiral, Alaska, Bismarck, Chicago, Cheyenne, Maryland, Oakland, Overture, Winter
2, 3	autumn, spring	50–55F (10–13C) to 55–60F (13–15C)	Apache, Apollo, Flamenco, Glorious, Monaco, Spires
3, 4	late spring, summer, autumn	55–60F (13–15C) to >65F (18C)	Bali, Orlando, Navaho, Opus, Potomac, Tropicana, Winchester

Pests and Diseases

High humidity, overhead watering, and debris around the plants increases the incidence of botrytis. Spray with proper fungicide, and keep area clear of plant trash.

Rust is among the most serious diseases of snapdragons. Brown pustules break out in large numbers surrounded by yellowish areas of leaf tissue. Selecting rust-resistant cultivars is important; increasing spacing density is helpful. Avoid overhead watering and apply a preventative fungicide. Once rust begins, it is very difficult to eradicate.

Aphids, spider mites, and caterpillars are the most troublesome pests on snapdragon. Given consumer concern about postharvest chemical fumigation, much research has focused on nonchemical insect control, including the use of elevated levels of CO_2 in the postharvest area or in transit. Preliminary work showed that 80% CO_2 killed thrips and aphids with no detrimental effect to vase life (Reid et al. 1995). Such modified atmosphere work appears to have merit, but a good deal more research is needed.

Grower Comments

"Last winter I successfully grew Potomac in an open field with no protection. We had a spell of cold weather that took nighttime temps down to the low teens, but we had snow cover. More typical nighttime lows are in the 20s, but I know that we had many nights lower than 27. I had them in the ground by mid October, so they hardened gradually. They were spectacular last spring. Around July 4, I cut them back, and I got a second flush in September–October. I was so pleased with Potomac that I am trying it again this year." Rachel Frantz Jones, Bunn, N.C.

"We use row covers in Florida to protect from freezes, and . . . to assure safe passage [we] string 100-watt bulbs down our rows under the cover (we just use agfabric, 1 or 1½ oz hooped over pvc and purlined with saran tape). The bulbs lie on the ground and are protected by plastic cages, . . . spaced about 10′ apart. I use somewhere around 10 of these in 20 100′ beds. The cost is for wire (black and white #12 stranded), the receptacles, and the cages. All the electrical stuff you can get at a professional electrical supply store. It has worked well for us, giving us a big margin of security. I couldn't tell you how many sleepless nights we spent trying to protect our crops. When we are successful, we make money—when we lose to the freeze, we lose money. Sometimes big money." Jon Landwer, Dragonfly Farm, Eustis, Fla.

"Once my snaps have suitable growth, I let off on the nitrogen and start with a high phosphate feed. I fertigate with 100 ppm N, 500 ppm P, and 300 K. If your soils are low in organic matter (less than 2.5%) continuous light doses of humic acid may be beneficial. . . . Uniformly high soil moisture is important. It seems, for us, that once a plant becomes hardened (checked, stressed) it seldom seems to make satisfactory growth again." Paul Shumaker, Never Should Have Started Farm, Bangor, Pa.

"We're fertilizing with our irrigation water at 200 ppm N, 50 ppm P, 100 ppm K, 350 ppm calcium. We add a small amount of minors, but our soil is adequately supplied. The calcium may be a bit high, but our water has about 150 ppm calcium before we add any fertilizer. We adjust the pH of our feed water to about 6.5." Laurie Constable, Avalon Flowers, Santa Barbara, Calif.

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Many thanks to Peter Nissen (first edition) and Corky Kane (second edition) for reviewing this section.

Artemisia wormwood Asteraceae

annual/perennial

A well-known group of plants, from the medicinal gardens of the Middle Ages to the fine perennials in our gardens. The species most used as a cut flower, *Artemisia annua*, is no slouch when it comes to the medicinal properties this large genus (200 species) boasts: it contains artemisinin, which is used to treat malaria.

Artemisia annua sweet annie Asteraceae

annual Europe, Africa yellow 3–5′/3′ (0.9–1.5 m/0.9 m)

Sweet annie or sweet wormwood, a vigorous tall plant, is popular in the potpourri and wreath-making trade. Small yellow flowers are produced in loose, spreading panicles in the summer; plants can be cut throughout the season and hung to dry. As a general rule, the aroma of artemisia foliage is not particularly welcome in houses, but the fragrance of this species is much more pleasant, even sweet-smelling (as Annie would say), and remains after drying. To be fair, however, some people think it stinks.

Propagation

Seeds may be sown in the field as early as the ground can be worked; but seed is very small, and transplanting generally yields stronger plants.

Stage of Harvest

Plants are harvested for the foliage and stems; the flowers are not significant to the wholesaler or retailer. Harvest time is somewhat debatable for sweet annie.

Shelley McGeathy of McGeathy Farms in Hemlock, Mich., harvests stems just before the flower appears: “Once it flowers, the stem gets brown (so does the flower) when it dries. The small yellow flowers are of no importance when used for drying. As far as cutting for fresh, the florists love it for a filler. They use it when there are just leaves all of the way through the beaded stage. Again, we have been told that once it blooms, it’s messy and not as neat of a filler.”

Ralph Cramer of Cramers’ Posie Patch cuts “right after the pollen is mostly gone. We actually check pollen by kicking the bush to see if there’s a puff of yellow or not!” For fresh, he suggests stems be cut any time after they look nice and green and full. For dried stems, harvest right before they turn slightly yellowish.

Postharvest

Most product is dried, but a small percentage is sold fresh. Vase life of fresh stems is 5–7 days in plain water, 10 days when processed. Dry quickly with heat to retain good green color. McGeathy also mentions that they have “wreath people” who like to get the artemisia when it is first cut from the field, as it is more pliable at that stage. They put the unfinished wreath in an area that gets good air circulation to dry down, so it can then be decorated.

Cultivars

‘Cramers’ Yardstick’ is compact (about 3′, 90 cm), and the branches are more full (and thus more appealing fresh) than the species. It may also be harvested earlier. Cramer also produces a scentless form of sweet annie for fresh or dried stems.

Artemisia ludoviciana white sage Asteraceae

perennial, Zones 4–9 North America white

2–3′ (60–90 cm)/2–3′ (60–90 cm)

Unlike other artemisias, *Artemisia ludoviciana* has entire, rather than dissected, leaves. This is a particularly useful species for cutting, since stems grow back quickly after pruning. With their efficient roots, plants spread quickly and can be invasive, but nothing that herbicides cannot handle.

Propagation

In general, propagation is accomplished by cuttings and divisions. Stem cuttings should be taken during late spring and summer. Cuttings root best with bright, indirect light and 75F (24C) media temperatures. Intermittent mist can be used for rooting, but be sure to avoid overwatering, which results in foliar diseases and rots. Cuttings take 14–20 days to root; late season or stressed cuttings may take up to 4 weeks (Nau 1999).

Stage of Harvest

For dried stems of 'Silver King', Cramer waits until the buds elongate into an egg shape. If cut too early (i.e., when buds are still round), the dried material is of poorer quality. For fresh, he suggests any time from leafing out to when the buds start opening, about a 6-week period.

Cultivars

'Cramers' Silver' has silvery foliage and provides at least 8 weeks of harvest. Harvest is best the second year; by the fourth, it is probably best to start over. Plants are about 4′ (1.2 m) tall.

'Silver King' is an old standby that (if properly labeled) is more compact than the species. Hardy to Zone 3 and offers excellent foliage. The flower plumes sport red fall color not found in the species. Very invasive where comfortable. The ASCFG's 2001 Dried Cut Flower of the Year.

'Silver Queen' produces sparse flowers and wide silvery leaves with deeply cut jagged margins. A little shorter than 'Silver King' but with slightly larger leaves.

Additional Species

The foliage of nearly all the species can be dried and used wherever smelly foliage is needed.

Artemisia abrotanum is used in potpourris.

Artemisia dracunculus (tarragon) is popular; some producers offer several useful selections for cut stems.

Artemisia lactiflora (mugwort) and the darker selection 'Guizhou' make reasonable fresh cut stems and are excellent dried. Large white flowers set this species apart from other artemisias. Excellent filler and much more tolerant of wet soils, which most artemisias abhor. Harvest stems for drying when plants are full but before the yellowing begins; harvest stems for fresh use when plants are green.

Pests and Diseases

Aphids are usually the predominant pest; root-knot nematode is also possible. Diseases include white rust, downy and powdery mildews, botrytis, rust, and dodder (Perry 1998).

Grower Comments

"I grow only *Artemisia* 'Guizhou', which is a really nice fresh cut and a great dried." Joan Thorndike, Le Mera Gardens, Ashland, Ore.

"Wormwood wilts if cut too early. It is hard to tell when it is in bloom, since the blooms are so small and ugly. But experiment with it once it starts setting those balls, to find out how early you can pick it. A consideration when using wormwood: lots of people are allergic to the artemisias. I used to use a lot of wormwood and sweet annie. Then one year after making far too many wreaths, I developed allergies to the wormwood. The next year it was sweet annie, and now I can't get near the stuff. I miss them terribly in the fall, and most of my customers do too, but some really appreciate not being subjected to the stuff!" Susan O'Connell, Fertile Crescent Farm, Hardwick, Vt.

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Many thanks to Ralph Cramer and Shelley McGeathy for reviewing this section.

Asclepias tuberosa butterfly weed Asclepiadaceae

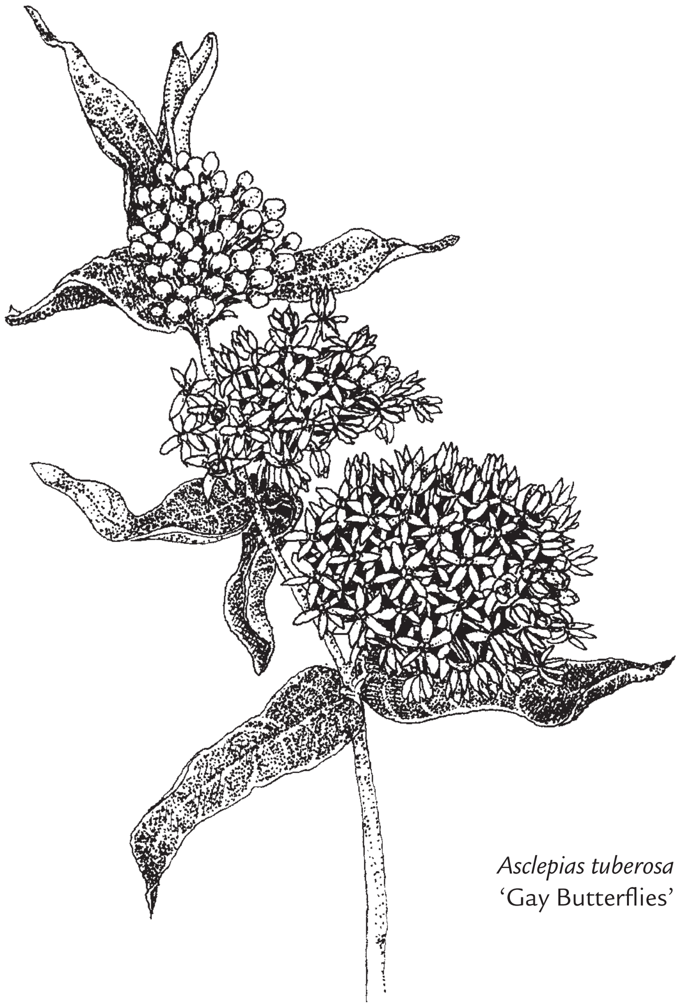
perennial, Zones 3–8 eastern North America orange
1½–2½′/2′ (45–75 cm/60 cm)

Butterfly weed is native from Maine to Florida and as far west as Arizona. The bright orange flowers are held in inflorescences above the leaves. Although orange is most common, flower color ranges from red to yellow. The subsequent fruits are long and narrow and are considered ornamental by some designers. Both flowers and fruits may be used fresh or as dried ornaments to augment bouquets of grasses and potpourri. It is one of the few members of the milkweed family that does not produce abundant quantities of milky sap and, therefore, is not as difficult to handle as other species of the family. Another benefit of butterfly weed is that it lacks the invasive qualities typical of many of its more obnoxious milkweed relatives.

Propagation

Seed: Fresh seed germinates readily. Remove seed as a mass from the fruit (follicles) when they turn yellowish brown and begin to split, but before the down is fluffy and visible. Check the follicles occasionally and allow to ripen naturally; seeds are ripe when they turn brown. Do not allow follicles to split completely or seed will be lost. Immediately after collection, clean the seed by grasping the mass with one hand and gently sliding the clasped fingers of the other hand downward. A good firm tug separates the seed from the compacted down and eliminates the laborious job of cleaning individual seed (Phillips 1985). Of course, this is easier said than done.

Purchasing seed is a lot simpler than the job just described; 0.5–0.75 oz (14–21 g) of seed yields 1000 seedlings (Nau 1999). Sow the seed immediately or, if not possible, store the seed in moistened peat at 40F (4C) for several weeks. Sow at 70–72F (21–22C) under high humidity; germination usually occurs within 15 days.



Asclepias tuberosa
'Gay Butterflies'

Cuttings: Terminal stem cuttings approximately 3–4″ (8–10 cm) in length can be taken in spring prior to flowering and stuck under a sweat tent or mist system. Rooting hormone is not necessary; rooting requires 4–6 weeks.

Root cuttings are an easier means of propagation. Cut the taproot into 2–3″ (5–8 cm) long sections. For best uniformity and most rapid growth and flowering, use only the sections of roots closest to the plant. Upper segments emerge and flower faster than the middle or lower segments; the middle segments emerge last of all (Ecker and Barzilay 1993). The orientation of the root segments does not appear important, but try to place the segments vertically, maintaining polarity, in a well-drained, sterilized medium. Keep medium warm and moist.

Bare root plants can be stored up to 6 months at 28F ($^{-}$2C) without damage. If necessary, roots may be stored and regrowth occurs normally, but this is not a recommendation and should be avoided (Maqbool and Cameron 1994).

Digging from the wild: Plants have a long taproot, and survival percentage is very low when gathered from the wild. Don't even think about it!

Growing-on

Butterfly weed immediately begins taproot growth upon germination; should it at any time become potbound, plantlets rapidly deteriorate. If seedlings are sown in a seed flat, transplant to 4″ (10 cm) pots by the time the second set of true leaves appears. Provide bright light and temperatures near 65F (18C), and feed with 200 ppm N once a week using a complete fertilizer. Always hold under LD: plants will simply sit on the bench under natural winter conditions. This can be done with night interruption or extended daylength. Do not overwater; plants are more tolerant of drought than overwatering. Regardless of propagation technique, hold in pots only until vigorous growth occurs. Plants resent transplanting, particularly by "mean" hands. Think about growing-on in peat pots, so as little trauma as possible occurs. Regardless of container, avoid damaging the taproot when transplanting. If the taproot is broken, the plant requires 2 years to recover—if it survives.

Environmental Factors

Temperature: *Asclepias* goes through a winter dormancy period and benefits from a chilling period (<40F, 4C). Winter-sown seed flowers during the summer, however, indicating that cold is not an absolute requirement for flowering. Still, cold results in better quality of the first flower and enhances development of subsequent flowers.

Crowns may be sprouted in the greenhouse after cold storage of at least 12 weeks at 38F (3C). Crowns stored 16 weeks sprouted in 9 days; those that did not receive a cold treatment never sprouted. Prolonged cold storage also reduced the time to flower, from 70 days for plants stored 12–14 weeks to 56 days for those held 16 weeks (Albrecht and Lehmann 1991).

Photoperiod: Plants grow and flower more rapidly under long days; flower abortion and blind shoots resulted when plants were forced under 9-hour photoperiods. Days-to-flower in a warm greenhouse was reduced by about 10 days for plants forced under 17-hour photoperiod compared to 13-hour (Albrecht and Lehmann 1991). Long days also promote vigorous shoot extension, leaf production, more flowers per inflorescence, and inhibition of lateral branching (Lyons and Booze 1983, Lyons 1985).

In the field, plants tolerate high temperatures and full sun to partial shade. Soils must be deep and well drained, as the taproot is susceptible to root rots in poorly drained soils. Butterfly weed is one of the latest plants to emerge and care must be taken not to disturb the dormant crowns in the spring.

Field Performance

Longevity: Once established, plants are long-lived perennials and may be kept in the same bed for many years. Clump diameter increases with age, as does the number of flowering stems. Three- to 5-year production cycles are not uncommon.

Spacing: Space plants 18–24″ (45–60 cm) apart. A 12 × 18″ (30 × 45 cm) grid has also been used successfully. Plants commonly grow 2–2½′ (60–75 cm) tall by the second year; spacing closer than 18″ (45 cm) results in additional insect and disease pressure. In our trial, average stem length of 22.1″ (55 cm) occurred on our first harvest at 18″ (45 cm) spacing.

Greenhouse Performance

Plant established seedlings or rooted cuttings in deep ground beds on 6–9″ (15–23 cm) centers. Temperatures should be 50–55F (10–13C) in late spring and 60–65F (15–18C) as temperatures rise. Cuttings planted January through March flower from May to June and continue until early fall. Plants may be started under short daylengths in the winter or spring, but daylength must be lengthened when plants have approximately 2 leaves, and LD are an absolute requirement to force flowering. For heaviest yield, best shoot length, and earliest flowering, use incandescent lights to provide 14- to 16-hour LD or nightbreak lighting (4–6 hours during the middle of the dark period). Cropping time in the greenhouse is 15–20 weeks from seed, depending on season. If crowns are purchased, plant in sufficiently large containers and store at 38F (3C) for approximately 14 weeks. Remove cooled crowns to a 60–65F (15–18C) greenhouse. Emergence occurs in 5–7 weeks. Provide LD (14–16 hours) as above. Flowering occurs 60–80 days after cooling crowns.

Stage of Harvest

Harvest when at least ½ to ⅔ of the flowers are open; flowers do not open well once stems are cut. If fruits are to be harvested, harvest when green before they start to split.

Postharvest

Stems do not exude a great deal of milky sap (unlike other members of the family), thus no special heat treatments or dipping solutions are necessary for cut stems. Stems should be immediately placed in water. After a few minutes, the water should be discarded and stems replaced in fresh warm water, then put into the cooler at 40–45F (4–7C). The water can be changed again a few hours after initial cutting to eliminate all vestiges of the latex. Store stems in water containing a citric-acid preservative and store in the cooler. Stems should be recut under water by the florist and consumer to provide additional shelf life. Silver thiosulfate has a beneficial effect on vase life. Average shelf life in water at room temperature is 8–10 days.

Cultivars

Few cultivars are available; however, seed propagation yields sufficient variation in flower color for selections to be made.

'Gay Butterflies' is a seed-propagated mix of flowers in several colors, with orange-red predominating. Plants grow about 2′ (60 cm) tall.

Additional Species

Asclepias curassavica (blood flower) should be used more often as a cut flower and is best treated as an annual in most parts of the country. Seed may be direct sown. Native to the West Indies, plants should be grown in full sun; however, in the South, partial shade may provide better height and performance. 'Red Butterfly' has deep red flowers and grows 2–2½′ (60–75 cm) tall. Silky series has flowers in deep red, gold, or scarlet (seed is also available as a mix); plants grow to about 3′ (90 cm) tall.

Asclepias incarnata (swamp milkweed) is a perennial with lovely pink and white flowers on 2–3′ (60–90 cm) stems. Plants perform best in moist soils but also tolerate "normal" soils. Like butterfly weed, *A. incarnata* requires approximately 16 hours of daylight for flower initiation and flower development. 'Cinderella' has rose-red flowers and grows 3–3½′ (0.9–1.1 m) tall, 'Soulmate' has rose-pink flowers and grows 2–3′ (60–90 cm) tall. 'Ice Ballet' has been used as a cut flower, with 3′ (90 cm) stems and pure white flowers. 'Milkmaid' is 3–4′ (0.9–1.2 m) tall with white flowers.

Asclepias physocarpa (swan plant) may be worth a try for the ornamental fruit. The plants, which can reach 6′ (2 m) tall, bear small cream to green-white flowers. The inflated fruit, 2½″ (6 cm) in diameter, is a translucent pale green, softly spiny, and with its wide "body" and sigmoid "neck," it does sort of resemble a swan. Might be useful for drying. Probably best treated as an annual.

Asclepias syriaca (common milkweed) is a perennial weed occasionally used for its pods. It is better known for its ability to colonize entire pastures in the northern states and Canada. If anyone feels that this weed is useful as a cut flower, simply ask your local farmer if you can cut them from his field; you will have a friend for life.

Pests and Diseases

Aphids are ever-present if plants are not treated. It is almost as if all *Asclepias* species have a built-in dinner bell for aphids. Spider mites can also be a major problem on butterfly weed, particularly in rich soils and where plants are grown too succulent through overwatering or overfertilization. Plants are less susceptible if neglected (i.e., do not feed or water them heavily); however, sprays should be readied by late May in the South and mid June in the North. Thrips can also be a problem. According to Bill Preston of Glenn Dale, Md., *Asclepias* species are a primary host for many butterfly larvae. Therefore, you can expect an "invasion" of brightly colored worms voraciously enjoying your plants. Be kind to everyone, and grow enough to allow some of the larvae to complete their life cycle.

Wilt is caused by *Pythium intermedium* and *Rhizoctonia* spp. The same organisms cause dry rot of the root system (Tsror et al. 1997).

Viruses result in bright green or yellow-green spots and lines on the foliage. Cull infected plants.

Grower Comments

"Asclepias enjoy being cut in the early morning and taken to the cooler quickly. Cut into cool water, then change to solution at the cooler, since the milk will have run out by then. Swizzle the whole bucket of water around to rinse the milk off. They have a super vase life, usually 10-plus days, and the leaves persist well too. They seem to be able to be picked almost fully open with no decrease in vase life. If you attend a farmers' market, they must remain in the shade, as, once cut, they seem to dislike direct sunlight." Ruth Merrett, Merrett Farm, Upper Kingsclear, N.B.

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Many thanks to Robert Lyons (first edition) and Bill Preston and Paul Sansone (second edition) for reviewing this section.

Aster Asteraceae

perennial

The name "aster" is commonly used for both annual asters, which belong to the genus *Callistephus* (see *Callistephus chinensis*), and the perennial species of the genus *Aster*, which contains over 600 species. A half dozen or so of these are useful as cut flowers. Nearly all greenhouse production and most field production of asters is concentrated on the filler types, mainly hybrids involving *Aster ericoides* (heath aster) and *A. novi-belgii* (New York aster, Michaelmas daisy). *Aster novae-angliae* (New England aster) has been superseded by the hybrids but is still produced in significant numbers as a cut. Asters are grown around the world, with significant production in Holland, Israel, South America, and the United States. All are perennial and are generally cropped 3–4 years. Although the natural flowering time for most asters is the fall, many flower in late summer. Production occurs under protection as well as in the field. In the field, flower yield and stem length are less the first year than subsequent years, particularly in areas of warm summer temperatures. Growers in coastal California, with their cooler summer temperatures, enjoy better yields and stem lengths the first year compared with eastern growers; however, differences are fewer as plants age. In general, plants respond to photoperiod and can be forced to flower year-round under protection, one of the main advantages of growing this crop. Asters are often used as fillers in mixed bouquets and occasionally as primary flowers in single-species bouquets.

In this section, all asters will be treated together, with any differences in production systems and cultivars noted as necessary.

Aster novae-angliae 'Purple Dome'

Propagation

Most cultivars are propagated through meristematic culture, ensuring virus-free plantlets. Growers who purchase vegetative plantlets will pay more but are assured of clean material. This is the recommended means of producing cut asters.

Most cut flower cultivars are bred by a handful of breeders and are protected. Cultivars that are not protected can be propagated by basal cuttings, often referred to as juvenile ground shoots; terminal cuttings, which are commonly used for pot plant production, result in shorter plants and should be avoided for cut flower use. Cuttings should be taken after flowering, in late fall, winter, or spring; summer cuttings will likely prove unsatisfactory. Place unrooted cuttings in peat/perlite or a comparably well-drained mix at 70–75F (21–24C) under a sweat tent or intermittent mist. Cuttings root in 7–14 days. Rooting hormone is useful but not necessary.

The environment under which the plants are rooted and maintained makes a difference in subsequent growth and flowering. Some companies maintain vegetative cuttings under SD; plants pinched to induce branching provide significant yield the first year. Plants that are rooted and maintained under LD are particularly useful for dense plantings and single-stem production. The latter is more common in the United States, the former overseas. If purchasing cuttings, be sure to ask how the stock plants and cuttings were maintained.

Growing-on

Rooted cuttings may be planted immediately in the field or greenhouse or can be grown-on prior to planting. If growing-on for field production, place in 3–4″ (8–10 cm) pots under long days, and immediately fertilize with 75 ppm N using potassium nitrate. Grow at temperatures no higher than 60F (15C). Approximately 2 weeks later, raise fertility level to 150 ppm N with a complete fertilizer at every irrigation. Plant in the field 3–5 weeks after potting. If planting in the greenhouse, rooted cuttings may be placed in the ground bed or bench immediately and treated as just described.

Environmental Factors

Asters appear to be highly regulated in their flowering behavior. Cooling (vernalization) was once widely used, followed by long days for stem elongation, shortening days for flower initiation, and finally short days to induce dormancy. In nature, this sequence is satisfied by the chill of winter, the long days of spring and summer, the shortening days of late summer, and finally the short days of late fall. If you are planting in the field and waiting for natural flowering, get them in the ground and get out of the way. However, an understanding of the processes involved may help make forcing a little easier.

Many aster cultivars used for cut flowers do not need vernalization, and non-vernalized cuttings can produce quality cut stems for several years, with no vernalization between flowering periods.

Photoperiod: In general, asters must go through a long day/short day sequence. Long days result in shoot elongation and are necessary for flowering. Even without chilling, LD promote flowering, although the number of flowers is significantly fewer than if chilling has been given (Schwabe 1985). Approximately 4 weeks of LD of at least 16 hours are promotive, but continuous lighting (24 hours) can be used. The number of LD cycles differs with cultivar; some may require up to 8 weeks of LD.

For most aster cultivars, short days are provided after LD, but they are not particularly short. A SD of 12–14 hours is normal for many cultivars, although some cultivars will flower even with 16-hour photoperiods. Avoid daylengths of less than 12 hours; they result in flower abortion and onset of dormancy. With hybrids such as 'Painted Lady', 13-hour photoperiod gave far superior results than either 14.5- or 16-hour photoperiods (Farina et al. 1994).

Research in southern Europe under greenhouse conditions showed that plants of 'Monte Casino', 'White Star', and 'Blue Star' were maintained in 16-hour photoperiods until they reached a height of approximately 2′ (60 cm), after which time, natural short days resulted in flowering. Cyclic lighting (2 minutes of lighting out of 10) could be used to provide the LD period (Farina et al. 2000).

Since *Aster ericoides* flowers later in the fall than *A. novi-belgii*, this species either requires additional numbers of short days, or more likely, the SD photoperiod (i.e., number of hours of light per day) necessary for flowering is shorter than that needed by *A. novi-belgii*.

Temperature: During the SD period, temperatures of 86F (30C) and 72F (22C) resulted in more flowers than 60F (15C) did. Increasing temperatures result in the greatest flower number. However, in comparing day temperatures of 85F (29C) and 62F (17C), work in Israel using cultivars from the Sun series showed that highest temperatures resulted in fastest flowering but also in less longevity and smaller flowers. Temperatures around 72/60F (23/15C) day/night temperature appeared to be an excellent choice for these hybrid asters (Oren-Shamir et al. 2000). Low temperatures (<50F, 10C) during SD caused a tendency to flower delay and abortion.

Temperature also plays a significant role in the plant's response to photoperiod. Plants remain vegetative if night temperatures are around 40F (4C), even at 12-hour photoperiods. They may bud up much earlier under warm nights (65F, 18C) and hot days, even under long days. This is not uncommon in the South.

Gibberellic acid: GA_3 substitutes for vernalization and LD, as long as the appropriate SD are given (Schwabe 1985). Two sprays of GA_3 at 50 mg/l hasten stem growth and can be used to decrease the vegetative period under supplementary lighting (Farina et al. 2000).

Field Performance (*Aster novae-angliae, A. novi-belgii*)

Grown-on rooted cuttings of New England and New York asters should be set out in early spring to June. Plants respond to the lengthening of the days from spring to summer and then the shorter days of late summer.

Pinching: Plants may be pinched for more yield per plant, but plant density must be decreased for a pinched crop. Pinching needs to be done as soon as possible after the majority of plants in a block is starting to elongate (approximately 3 weeks after planting). Leave approximately 4 leaf or bud pairs on the plant. Pinch a whole block at once to get uniform regrowth. A nonpinched (straight ups) crop is also possible; there will be less time between planting and harvest (approximately 3 weeks), allowing more flushes to be harvested in a year, and the quality of harvested flowers is generally better.

South and North: In the South, where warm temperatures can occur in early spring under natural SD, late spring flowering can occur. The yield and stem length will be poor, and, unless flowers are needed, plants should be cut back. Normally, asters flower in late August through September, although some may flower as early as late July. First-year production data reveal that stem lengths in particular are significantly longer under coastal California conditions than in Georgia. Differences in data for the second year are not as large. Second-year harvest times for New England asters in Athens, Ga., ranged from 10 September to 10 October, but *Aster ericoides* flowers 3–4 weeks later, allowing for a longer harvest period. In general, yield and stem length of first-year harvests are less than subsequent years, particularly in warm climates. This can be explained by the relative lack of vernalization in these climates. In areas of the West Coast, where night temperatures in spring and early summer approach 40F (4C), some vernalization occurs and shoots elongate even in the first year.

Two-year yields and stem lengths of cultivars grown in Athens, Ga., and Watsonville, Calif., show how yield improves over time. In the first year (fall planted), yield was around 12 stems/plant in Athens but improved to over 20 stems/plant the second season. The same cultivars in Watsonville improved from approximately 11 stems to over 25 per plant. Although the cultivars used in that study are seldom grown today, the data would likely be appropriate for other cultivars. Stem length showed no significant improvement from one year to the next (Armitage 1993).

Spacing: Plant 12 × 12″ (30 × 30 cm) for smaller cultivars and 12 × 18″ (30 × 45 cm) for larger ones. In Vermont, a 2 × 2′ (60 × 60 cm) spacing of *Aster novi-belgii* 'Benary's Composition' resulted in 44 stems/plant in the second year of production. The average stem length was 36″ (90 cm) (Perry 1989).

Shading: Work by Armitage (1993) showed that shade increased stem length only slightly and decreased yield in some cultivars. Disease was much more prevalent under shade in the second year compared with the first; data were not even taken the second year. Shade cannot be recommended due to the increased prevalence of mildew, root rot organisms, and various other diseases. The use of a low-density shade structure to reduce damage from rain is all that can be recommended.

Longevity: Asters are true perennials, and if disease is not a problem, they should be productive 3–4 years. Where disease problems render their long-term commercial performance questionable, they can be treated as annuals.

Field Performance (*Aster ericoides*, hybrid asters)

Aster hybrids usually consist of some *Aster ericoides* parentage but may also be hybrids involving other species. Plants may be planted out in the fall, early spring, and as late as June. *Aster ericoides* is a short day plant and flowers in October through November in the East; it flowers earlier in the West, regardless of planting date. Dates in Athens, Ga., ranged from 10 October to 8 November for second-year harvest. Planting later than mid June may result in plants with insufficient stem length.

Spacing: Plant approximately 12 × 12″ (30 × 30 cm) or 12 × 18″ (30 × 45 cm). This corresponds to 1 or 0.67 plants/ft^2 (10.8 or 7.2 plants/m^2).

Yield: 'Monte Casino' aster and other cultivars were grown in Athens, Ga., and Watsonville, Calif., and data were collected for 2 years (Armitage 1993). In Athens, yields were approximately 15 stems/plant the first year, 22 stems/plant the second year, depending on cultivar. In Watsonville, yields in the first and second year were approximately 13 and 45 stems per plant, respectively. Stem length was also improved the second year. The differences between California and Georgia trials were more dramatic the second year than the first, the trials in California being more productive (Armitage 1993). This is not uncommon, particularly when comparing the growing conditions of Watsonville, Calif., to the hot, humid conditions of Athens, Ga.

Shading: Studies in Athens, Ga., showed that yield was reduced under shade (Armitage 1993). Disease was also more prevalent under shade in the second year compared with the first, and therefore shade cannot be recommended. Some of the worst instances of disease occurred in hybrids, such as 'Pink Star' and 'Rose Star'. Most likely, such outbreaks were due to poor ventilation and the fact that shaded plants do not dry out as rapidly after rain as those in full sun.

Greenhouse Performance (*Aster novae-angliae*, *A. novi-belgii*)

With the advent of hybrid aster cultivars, New England and New York asters are seldom used for cut flowers, but they have not yet disappeared. For greenhouse forcing, cuttings or clumps should be vernalized. Rooted cuttings should be cooled to 35–40F (2–4C) for 4–6 weeks. Plant in 6–8″ (15–20 cm) pots or in ground beds at a spacing of 9 × 12″ (23 × 30 cm) by the end of July. When the natural daylength is too short, nightbreak lighting or day extension is necessary to simulate LD. The lighting can be cyclic: at least 6 minutes per half hour.

Maintain photoperiods greater than 17 hours and temperatures of 60–65F (15–18C). Grow under LD until stems are 12–18″ (30–45 cm) long (approximately 3–4 weeks) and then maintain a SD of 13–14 hours. Avoid daylengths less than 11 hours. Photoperiods can be manipulated with incandescent lamps and black cloth. Temperatures during SD should average 65F (18C) for longest stem lengths. Flowering time is 6–10 weeks after the beginning of SD treatment, depending on cultivar and temperature.

If noncooled cuttings are used, stems may be shorter and flowering delayed compared with cooled stems. Maintain cool temperatures during LD stage in the greenhouse for vernalization. Unheated greenhouses or plastic frames can be used for late spring and early summer crops. Cuttings planted in November or December will be vernalized naturally after approximately 6 weeks of temperatures below 40F (4C). At that time, the LD-SD sequence described earlier may begin.

Greenhouse Performance (*Aster ericoides*, hybrid asters)

Plants can be forced for year-round production. Plants flower under short day conditions and grow vegetatively under long days, much like chrysanthemums. If forcing on a year-round schedule, it is necessary to have incandescent lamps and black cloth facilities for best uniformity and control of flowering time.

Asters can be grown pinched or unpinched (straight-ups). In general, plants are not pinched in the greenhouse, yielding faster flowering times and additional flushes if grown year-round. If pinching is to be done, it should be accomplished 3–4 weeks after planting in the field or the greenhouse. Leave at least 4–8 leaves on the plant. Pinch a whole block at once to get uniform regrowth. Spacing will increase if plants are pinched.

Unpinched plants can be spaced as close as 5″ centers, yielding 5½ plants/ft^2 (13 cm centers, 60 plants/m^2) or as wide as 6″ centers, 4 plants/ft^2 (15 cm centers, 45 plants/m^2). For pinched crops, more space is provided, approximately 10 × 10″ (25 × 25 cm) spacing, or for pinched crops, 1½ plants/ft^2 (15 plants/m^2). Spacing is determined by yield, air movement, and disease control measures. Place rooted cuttings in 6–8″ (15–20 cm) pots or in ground.

Fertilize with 50–75 ppm N from potassium nitrate. If natural daylength is less than 12 hours, use incandescent lights as day extension (photoperiod >14 hours) or as cyclic lighting (see "Greenhouse Performance" for *Aster novae-angliae* and *A. novi-belgii*). Fertilize with 150–200 ppm N using a complete fertilizer. Apply long days until stems attain a height of 12–18″ (30–45 cm). Short days may be artificially applied by black cloth from late spring through early fall, when natural daylength is too long to naturally trigger flowering. Jeff McGrew of Jeff McGrew Horticultural Products, Mt. Vernon, Wa., summarizes well: in general, stem length is manipulated by the number of weeks given to long day treatment (14-plus hours) followed by a short day treatment (black cloth to reduce light levels to under 12 hours daily). A stem length of 3′ (90 cm) can easily be reached when 6–8 weeks of long days are followed by 5–7 weeks of short days, if average night temperature are around 60F (15C). This will vary somewhat with the temperature regime under which plants are grown and the time of year they are produced.

Reduce fertilizer when SD begin; after 3 weeks of SD, terminate fertilizer and reduce watering to the point of plant wilt. Water only to keep plants from wilting; this "stress" results in flowers ready to be cut 4–7 weeks after the beginning of short days, depending on cultivar.

After harvesting, cut plants back to the ground, remove all partially cut stems and stubble, and leach thoroughly with plain water. Place plants back in LD (>16 hours), thin to 4–6 stems/plant and start cycle again. In high-light areas such as California, Florida, and Colorado, or during the spring and summer cycles, 5–7 stems may be allowed to remain. Plants may be cropped for 12–15 months in this manner prior to discarding.

Temperatures of 60/70F (15/21C) night/day result in excellent vegetative and reproductive growth. Night temperatures below 55F (13C) after SD result in erratic bud development and poor vase life. Terminal flowers open but the lateral flowers are delayed or may not open at all. The period from planting until harvest is approximately 13–15 weeks when the cuttings are pinched (8–10 weeks for the vegetative period and 6 weeks for the generative period). The whole period will be about 3 weeks shorter when cuttings are not pinched.

Guideline for Foliar Analyses

At field trials in Athens, Ga., and Watsonville, Calif., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis.

'Rosa Sieger' (Ga.)

(%)				
N	P	K	Ca	Mg
3.0	0.45	3.29	1.68	0.20
(ppm)				
Fe	Mn	B	Al	Zn
168	65	37	83	72

'Climax' (Ga.)

(%)				
N	P	K	Ca	Mg
3.1	0.65	3.64	0.98	0.18
(ppm)				
Fe	Mn	B	Al	Zn
162	88	39	48	121

'Climax' (Calif.)

(%)				
N	P	K	Ca	Mg
2.2	0.24	3.67	1.39	0.35
(ppm)				
Fe	Mn	B	Al	Zn
180	273	46	52	26

Stage of Harvest

Cut stems when approximately ¼ of the flowers in the inflorescence have opened. Place immediately in water or floral preservative. Although the benefits of STS have not been consistent, low concentrations may result in additional vase life with some cultivars. Using a bactericide in the postharvest solution for 4–5 hours increases vase life.

Postharvest

Fresh: New England asters (*Aster novae-angliae*) persist only 5–7 days. Flowers are relatively insensitive to ethylene. In general, vase life of New York aster (*A. novi-belgii*) cultivars is better than that of New England aster cultivars. Hybrids persist 8–12 days, depending on temperature and postharvest treatment.

Storage: Flowers may be stored in preservative in the cooler at 40F (4C) for approximately 5 days without loss in quality.

Dried: Flowers do not dry well.

Cultivars

Only a few species of asters have been bred for use as cut flowers. Cut flower breeders have spent significant time and money on cultivars of *Aster ericoides* and some of the hybrids listed below, whereas New England and New York asters and other species are seldom grown. New England asters in particular are prone to whiteflies and have relatively poor vase life; they can only be recommended for local consumption, such as farmers' markets and local florists. New York asters are better, and some hybrids, such as 'Lambada', have a good deal of New York aster in their parentage. The fact that they are not used widely may be a perfect reason to try them for your market. There is no reason not to use any cultivar if it provides unique flower colors or other commercial benefits. Here are a few that may be of value.

Aster novae-angliae (New England aster)

'Alma Pötschke' ('Andenken an Alma Pötschke') is an excellent 3–4′ (0.9–1.2 m) bright rose selection. Flowers are 1–2″ (2.5–5 cm) across and have slightly curled petals. It is more compact (but still requires support) than other selections and less prone to topple.

'Fanny's Aster' is covered with blue flowers and grows up to 4′ (1.2 m) tall. She flowers in late fall and is spectacular combined with fall sunflowers. Absolutely terrific, particularly in the South.

'Harrington's Pink', developed by Millard Harrington of Williamsburg, Iowa, is one of the most popular garden asters. This 3–5′ (0.9–1.5 m) tall plant bears 1½″ (4 cm) salmon-pink flowers in September through October.

'Mt. Everest' is 3′ (90 cm) tall with good, clear white flowers.

'Purple Dome', a short but terrific introduction from Mt. Cuba Gardens in Delaware, offers mid summer flowering on compact 18–24″ (45–60 cm) plants, which maintain a mounded habit even while supporting hundreds of deep blue flowers. In high-humidity environments, leaf and stem disease can be a problem in mid July and August.

'Rosa Sieger' has large salmon-rose flowers on 4′ (1.2 m) tall plants. Very eye-catching.

'Rose Serenade' is about 30″ (75 cm) tall and bears soft pink flowers in early fall.

'September Ruby' has deep ruby-red flowers on 3–5′ (0.9–1.5 m) stems, especially if planted in rich soils or overfertilized. Although classified as a late bloomer, flowering begins in late May in north Georgia and continues through late June. If the flowers are removed, it blooms again in September. Flowering is 3–4 weeks later in the Northeast, but seldom do flowers peak in the fall. This is true of many so-called fall-flowering asters.

'Treasure' is 4–6′ (1.2–1.8 m) tall with light purple to violet flowers.

'Wedding Lace' is 3–4′ (0.9–1.2 m) with clean white flowers in early fall.

Aster novi-belgii (New York aster)

Medium cultivars (<4′, 1.2 m): Many require netting, especially those with large flowers.

'Ada Ballard' has double lavender-blue flowers atop 3′ (90 cm) stems.

'Arctic' bears double white flowers.

Bartels Stek's collection of *Aster novi-belgii* cultivars bred for cut flower use includes 'Amor' (dark red/rose), 'Cha-Cha' (violet), 'Caroline Blue' (blue), 'Celine' (red/brown), 'Cindy Special Pink' (rose), 'Cirina Dark' (dark rose), 'Colinda' (dark rose), 'Lambada' (pink), and 'Salsa' (red/violet). Differences are noted in flowering time, leaf size, and sensitivity to disease.

'Beechwood Rival' produces wine-red flowers on 3′ (90 cm) stems. At least 5 cultivars carry the Beechwood name, a popular series of cultivars all with rather large flowers.

'Bonningdale Blue' and 'Bonningdale White' grow nearly 3′ (90 cm) tall and produce 1–2″ (2.5–5 cm) wide blue and white semi-double to double flowers in September and October.

'Crimson Brocade' is about 3′ (90 cm) tall and produces crimson-red flowers in late fall.

'Ernest Ballard' has reddish pink semi-double flowers up to 3″ (8 cm) wide. Ernest Ballard of Colwall, Malvern, England, a leader in the hybridizing of New York asters, bred for large flowers on 2½–3′ (75–90 cm) tall plants.

'Eventide' produces large semi-double violet-blue flowers on 3–4′ (0.9–1.2 m) plants.

'Patricia Ballard' has semi-double rose-pink flowers.

'Priory Blush' is at least 4′ (1.2 m) tall with double white flowers tinged with a little pink. Needs some judicious early summer pruning.

'Royal Ruby' and 'Royal Velvet' are 20–30″ (50–75 cm) tall and produce semi-double red and violet-purple flowers, respectively.

'The Bishop' ('The Archbishop') bears deep red flowers on 2–3′ (60–90 cm) tall plants.

'Winston Churchill' would be proud of the handsome red daisy flowers on 2–3′ (60–90 cm) stems. They were outstanding performers in our cut flower trials at Georgia.

Tall cultivars (>4′, 1.2 m): Many of these are too tall even for cut flower growers, require extensive support, and can become a nuisance. If grown well, however, they are like huge dahlias.

'Cardinal' has deep rosy red flowers surrounding a yellow center.

'Climax' is a 5′ (1.5 m) giant with outstanding large, light blue flowers in early fall. Raised in the early 1920s, it is one of the few old-time michaelmas daisies still in cultivation.

'Fellowship' bears large clear semi-double pink flowers on 4–5′ (1.2–1.5 m) stems.

'Mount Everest' has large semi-double white flowers in September and October.

'White Ladies' is 5–6′ (1.5–1.8 m) tall with clear white flowers and an orange-yellow center.

Aster ericoides (heath aster)

'Blue Wonder' has blue flowers with a tinge of pink.

'Esther' has white flowers with a tinge of pink and is similar in growth habit to 'Monte Casino'. Plants were less perennial in Athens, Ga., than other cultivars, dying after 2 years.

'Monte Casino' has been the most popular cultivar, bearing clusters of small white flowers. Several strains of 'Monte Casino' have been bred and may appear as 'Monte Euro' (an improved 'Monte Casino'), or 'Monte Casino #1', and so forth. Name recognition, higher yields, faster flowering (particularly under greenhouse conditions), and excellent vase life keep Monte Casino types ahead of the pack.

'San Carlos' and 'San Remo', white-flowered introductions, are more floriferous and less light-sensitive than 'Monte Casino'. Better adapted to greenhouse than to field production.

'White Wonder' is similar in growth habit to 'Blue Wonder' but has creamy white flowers.

Aster hybrids

Hybridized from various species, these asters are finding a place in specialty cut flower offerings. All are best grown in the greenhouse.

Butterfly series goes under such flighty names as 'Lilac Blue Admiral', 'Purple Monarch', 'Painted Lady' (pink), and 'Skipper' (dark pink). We have not tested these, but they are supposed to have larger flowers than 'Monte Casino' and stiff, erect stems.

Master series includes 'White Master', 'Pink Master', and 'Blue Master' (lilac-blue). They are similar in flower and habit to the Butterfly series. Both Butterfly and Master series appear to be excellent for greenhouse culture.

Star series of hybrid asters includes 'Blue Star', 'Pink Star', 'Snow Star', and 'White Star'. Flowers are smaller than New England asters and New York asters but larger than those of *Aster ericoides*. They are prolific but do not appear particularly heat tolerant and require good drainage.

Sun series are used as filler flowers, similar to those of *Aster ericoides*. White forms consist of 'Suncarlo' with small white flowers, 'Sunrio' with medium flower size, 'Sunsimon' with 2 rows of petals, and 'Sunspring' with larger flowers. Pink flowers may be found in 'Sunbird', purple-blue flowers in 'Suntop', and purple flowers in 'Sungal'. Harvest time is 5–8 weeks from beginning of SD, total time 10–15 weeks, depending on cultivar (Danziger 1998).

Universum series, bred by Bartels Stek, is mainly used for fillers. All are hybrids with small- to medium-sized flowers. Someone in Holland enjoys the letter C, as shown by 'Cassandra' (light blue), 'Catherine' (blue), 'Carola' (purple-blue), 'Chelsea' (white), 'Claudia' (pink), 'Cerina White', and 'Cindy Special' (lavender-blue). Who says creativity is dead? All flower 5–7 weeks from beginning of SD.

Additional Species

Aster cordifolius is represented most often by the lavender-blue cultivar 'Ideal'. Plants are harvested in late September and early October in the Southeast. Second-year yield was 22 stems/plant with an average stem length of 32″ (80 cm). Foliage was larger and less susceptible to mildew or rust than other species tested.

Aster tataricus (Tatarian aster) bears many small, lavender-blue flowers in late fall (September and October in the Southeast). The plants attain 4–6′ (1.2–1.8 m) in height and are among the last of the asters to flower. Most useful in southern states, where a long autumn is normal.

Pests and Diseases

Leaf spots are caused by *Alternaria* spp., *Cercospora asterata*, *Leptothyrium doellingeriae*, *Septoria* spp., and other leaf-spotting fungi. Spray at weekly or 10-day intervals with sulfur or copper fungicide, particularly in rainy seasons.

Downy mildew is prevalent in the Midwest and South.

Powdery mildew is more prevalent in the lower leaves of many asters. The disease usually develops in late August to mid September.

Sclerotinia rot (*Sclerotinia sclerotiorum*) first appears in the center leaves and penetrates the stem. Black infection can be seen inside the stem of damaged plants. More prevalent in high-humidity conditions.

Rust is caused by various organisms, including *Coleosporium solidaginis* and *Puccinia asteris*. Infected plants dehydrate, turn brown, and remain stunted. Some cultivars are more susceptible than others. For example, the most susceptible cultivars in trials in Georgia were 'Snow Star' and 'Pink Star', whereas 'Rose Star' was not affected.

Aphids pierce the stem and leaves and secrete honeydew, the presence of which can result in the development of sooty mold.

Caterpillars ruin the foliage but are seldom a problem at time of flowering.

Leaf nematodes cause brown or black blotches between the veins. They also feed in buds and young shoots, causing distortions. Sterilize the soil.

Spittle bugs are more common on *Aster ericoides* than on other species. A general-purpose insecticide is effective.

Thrips are increasingly a problem. Flowers are distorted or fail to open or senesce after only a few hours. Thrips are vectors for virus; control is important.

Whiteflies are a major pest, particularly in the greenhouse.

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Many thanks to Fran Foley, Jeff McGrew, and Jack Graham for helping with the data and reviewing this section.

Astilbe ×arendsii false goat's beard Saxifragaceae

perennial, Zones 3–7 hybrid origin many colors

2–4′/2′ (0.6–1.2 m/0.6 m)

Cut flowers of the shade-tolerant *Astilbe* continue to gain acceptance with florists and consumers every year. Flowers, ranging from white to purple to red, are borne in widely branched panicles. The genus was greatly enhanced by the hybrids raised by Georg Arends of Ronsdorf, Germany, and many subsequent breeders have also left their mark in recent years. Cultivars of various heights and flower colors abound, not to mention those with green and bronze foliage.

Propagation

Many commercial cultivars are available as a result of tissue culture, though growers may still raise additional plants from seed or division.

Seed: Seed is not available for most cultivars; however, seed of some hybrids may be purchased in various shades (e.g., 'Rose Tones'). Seed is tiny, about

384,000/oz (13,400/g), and should be covered lightly. Seed germinates in 3–4 weeks if placed at 70–73F (21–23C) under mist or sweat tent. Buy plugs!

Division: Named hybrids are best propagated by dividing the rootstock. Lift plants and divide into 1- or 2-eyed pieces in late fall after foliage dies back. Root pieces sold in the spring by commercial propagators can be stored over the winter in moist sphagnum at 33–35F (1–2C). Growers wishing to increase their own cultivars should divide in the fall or early spring every 3–5 years. A 1- or 2-eyed division should provide a 5- to 8-eyed crown after one growing season (Stimart 1989).

Growing-on

Grow seedlings at 60–65F (15–18C) for 6–8 weeks and transplant to 4″ (10 cm) pots when seedlings can be handled without damage. Small divisions should be potted into 4″ (10 cm) containers immediately. Fertilize propagules with 50 ppm N from a complete fertilizer for 4 weeks and raise to 100 ppm N as plants grow more rapidly. Reduce temperature to 55–60F (13–15C) until plants are ready for the field. Green (i.e., nonflowering) plants may be put in the field 14–16 weeks after sowing, 4–6 weeks after taking divisions.

Partial shade (e.g., high shade from pines, or some afternoon shade) is recommended for growers in the South and Midwest; full sun can be used without problems in the cooler areas of the country (e.g., Pacific Northwest, Northeast). However, if planted in a moist area of the field, and if consistent moisture can be maintained, the need for shade becomes less critical.

Environmental Factors

Temperature: *Astilbe* requires a cold treatment to flower and should be allowed to go dormant. The longer the duration of the cold treatment, the more uniform the flowering time (Iwanami 1989). In general, bare-root material from Holland receives approximately 10–12 weeks of 41F (5C) after digging (De Hertogh 1996). Specific cultivars differ in their needs; research has shown that white-flowered cultivars such as ‘Avalanche’ and ‘Deutschland’ require at least 9 weeks at 40F (4C), but only 6 weeks are necessary for the red cultivars ‘Fanal’ and ‘Red Sentinel’ (Beattie and Holcomb 1983). Lower temperatures of 32–35F (0–2C) can also used to break dormancy (Stimart 1989).

Seed-propagated cultivars also require cooling. This may be accomplished at the plug stage (50–105 plug density). We found when using ‘Bella’ that 12 weeks of cooling at 40F (4C) was sufficient with no loss of quality. Runkle et al. (2000) suggest 15 weeks in a cooler (treatment with only 9–12 weeks resulted in decreased inflorescence count). Cooling may be accomplished in a cold greenhouse with natural SD or in a cooler. When cooling in a cooler, use of a 9-hour photoperiod at 25–50 fc is recommended (Runkle et al. 2000).

Flowers may be forced at almost any temperature; however, temperatures of 60–75F (15–24C) are recommended. Floral abortion may occur at high temperatures. Pemberton and De Hertogh (1992) showed that plants forced at day/night temperatures of 78/72F (26/22C) had more aborted flowers than those forced at 65/58F (18/14C) or 72/65F (22/18C). Forcing time is delayed with cool temperatures.

Photoperiod: In general, for bare-root cultivars that have been cooled in transit or in storage, photoperiod has no significant effect on flowering. Some studies suggest that long photoperiods (14 hours) result in taller flower stems than short photoperiods (8 hours) (Stimart 1989), but more recent work (Runkle et al. 1998) found no such result. With seed-propagated cultivars, however, LD (24 hours) can accelerate flowering by about a week, but based on overall quality and flowering, 12-hour photoperiods are recommended (Runkle et al. 2000). Avoid photoperiods of less than 12 hours.

Water: Consistent moisture is essential for optimum yield and stem length. If plants dry out dramatically, plant longevity and foliar and flower quality are reduced.

Field Performance

Longevity: Under proper conditions, plants are long lived and need not be replaced for 3–5 years. If placed in areas where consistent moisture cannot be provided, however, plants rapidly deteriorate. Longevity is also enhanced where cooler summer conditions prevail. Production, insignificant the first year, begins in earnest the second to third year.

Longevity of *Astilbe ×arendsii* 'Bridal Veil'. Spacing 12" (30 cm).

Year	Stems/plant	Stem length (in)^z
1	2.3	15.4
2	4.6	18.0
3	6.4	18.5

z = multiply (in) by 2.54 to obtain (cm)

Spacing: Space at 10 × 12″ (25 × 30 cm) or 12 × 15″ (30 × 38 cm). Plants do not spread rapidly, and original spacings are maintained throughout the productive life of the planting.

Greenhouse Performance

Precooled crowns may be planted in 6–10″ (15–25 cm) pots or in ground beds with a density of approximately 1 plant/ft^2 (11 plants/m^2). Some old research (Latta and Doucette 1932) suggested that crowns should be given a one-hour hot water bath of 140–150F (60–66C) prior to forcing, resulting in more foliage and flowers of a higher quality; however, this is seldom done in commercial practice.

After cooling (see "Environmental Factors"), plants should be grown at 62–72F (17–22C) under natural photoperiods if using bare-root material or LD if using seed-propagated plugs. Because of differences that may occur between cultivars, nightbreak lighting or extended days may be used to ensure adequate yield and stem length. Avoid temperatures above 75F (24C) whenever possible, as inflorescence count may be reduced (Runkle et al. 2000). Little or no fertilization is necessary during the forcing stage (Wilkins 1985), but constant moisture is necessary. Shade plants after April. Crop time after forcing varies from 7 to 11 weeks, depending on cultivar and forcing temperatures (Runkle et al. 2000).

Stage of Harvest

Harvest inflorescences when ½ to ¾ of the flowers are open. The uppermost buds should be swollen and showing color. Flower buds harvested when the panicles are less than 50% open do not develop further when placed in water, and develop only slightly more in a preservative solution (Sacalis 1989). Roxanne McCoy of New York State reports that "they usually wilt and are useless if harvested when less than half open." Some references suggest that at least one lower leaf per harvested stem should remain on the mother plant for continued development of the storage root (Stimart 1989); however, many growers, such as Ed Pincus from Vermont, have noticed no decrease in vigor when stems are harvested to the ground. Do a little experimentation on your own.

Postharvest

Fresh: Flowers require significant attention throughout the postharvest chain. They persist longest when pretreated by placing cut stems in 130F (54C) water, cooling to room temperature, sleeving in paper, and placing in floral preservative (Kalkman 1986). This is an important part of the harvest, and flowers so treated persist significantly longer compared to the 2–4 days in room temperature water. Fresh flowers are sensitive to ethylene and must be isolated from fresh fruit or other ethylene-producing tissue. If possible, ship stems in water. Pulsing with STS reduced ethylene damage (Sacalis 1989).

Storage: Flowers may be stored for a few days at 33–40F (1–4C). Leaves senesce more rapidly than the flowers. Work using dry storage showed that when held for 24 hours at 68F (20C) and 60% humidity, 'Cattleya' did not regain turgor when subsequently placed in water; however, if treated with a surfactant prior to dry storage, plants regained turgor after dry storage (Doorn et al. 1993).

Dried: Both flowers and seed heads can be air-dried, preferably in an upright position, and will last indefinitely. For drying, harvest when all the flowers are open or only a few buds remain at the tip of the panicle.

Cultivars

Many cultivars are available; the following are useful as cut flowers. All are hybrids and may be listed under *Astilbe ×arendsii*, *A. ×hybrida*, *A. ×japonica*, *A. ×rosea*, or *A. ×thunbergii*.

	Cultivar	Plant height (in)^{z}
Pink	Bressingham Beauty	36–40
	Elizabeth Bloom	18–24
	Erica	30–36
	Europa	18–24
	Finale	16–18
	Gloria Rosea	25–30
	Granat	24–30
	Grete Pungel	30–36
	Hyazinth	30–36
	Peach Blossom	18–24
	Venus	24–30
Magenta	Amethyst	36–40
	Dusseldorf	20–24
	Gloria Purpurea	25–30
	Jo Ophurst	36–40
	Mainz	20–24
Rose-pink	Bonn	18–24
	Catherine Deneuve	18–24
	Cattleya	36–40
	Gloria	24–30
	Ostrich Plume	30–36
	Rheinland	24–30
Red	Bella*	18–20
	Etna	18–24
	Fanal	15–18
	Glow	18–20
	Glut	18–24
	Koblenz	18–24
	Montgomery	20–24
	Red Sentinel	36–40
	Spinell	30–36
White	Bridal Veil	18–24
	Bumalda	20–24
	Deutschland	24–30
	Diamond (Diamont)	24–36
	Snowdrift	24–30
	Washington	24–36
	White Gloria	15–18
Mixed colors	Bunter Zauber*	24–28
	Grande*	30–34

z = multiply (in) by 2.54 to obtain (cm)
* = available from seed

Additional Species

Astilbe chinensis bears magenta flowers and is generally too short for cut flower work. However, var. *taquetii* 'Superba' has magenta flowers in 3–4′ (0.9–1.2 m) tall, narrow, erect panicles; 'Purple Lance' ('Purpurlanze') has magnificent purple-red blooms on 4–4½′ (1.2–1.4 m) stems; and 'Visions' bears dense, upright pink-purple blooms. The seed heads too are highly ornamental and attractive. The use of this late-flowering species extends the cropping time of *Astilbe*.

Astilbe ×japonica and *A. davidii* are some of the species crossed to produce the various hybrids. The species have limited color selection, but they are useful for cut flower production if they can be located in sufficient quantity.

Astilbe simplicifolia cultivars have dark green leathery leaves and flowers ranging from shell-pink to rose. They are short, however, at best growing 15″ (38 cm) tall. If stem length is not an issue, they make fine cuts. 'Sprite', 'Hennie Graafland', and 'Bronze Elegans' are the most common forms. The handsome seed heads also have potential in a cut flower program. Dry flower stems in water.

Pests and Diseases

Few diseases affect *Astilbe*, however, some leaf spotting may occur.

Powdery mildew is caused by *Erysiphe polygoni*. A white mold appears on the undersides of the foliage; defoliation occurs in serious cases.

Wilt, generally caused by *Fusarium* spp., may be alleviated by placing healthy plants in *Fusarium*-free soil.

Gray mold results when humidity is high and healthy stems become infected with *Botrytis cinerea*. If plants are well spaced and growing vigorously, little botrytis occurs.

Japanese beetles are a serious insect pest of *Astilbe*, although in some parts of the country, their arrival occurs when the harvest is complete.

Tarnished plant bugs are a major problem, disfiguring both foliage and flowers.

Grower Comments

"For raspberry and red colors, I grow 'Granat' and 'Red Cattleya'. I have 'Amethyst', and it's an interesting color, something different for the bouquet. By far and away, my favorite is 'Snowdrift'. I cut flowers for a mid July wedding last year, and this was a real hit. The blossom timing couldn't have been better—clear white, about 2′ tall. Not good for tall arrangements, but excellent for the dining room table vase." Karen Hanley, Stork Road Farm, North Creek, N.Y.

"At the Flower Auction our best-selling cut varieties for 1999 and 2000 were 'Cattleya', 'Diamant', 'Erica', 'Europa', 'Gloria Purpurea', 'Granat', 'Spinell', and 'Washington'." Roy Snow, United Flower Growers, Burnaby, B.C.

"We disliked 'Amethyst', a dark magenta pink-purple that lacks purity. Magenta flowers are usually prolific and not popular. 'Gloria Rosea' is a not-pretty pink, and 'Grete Pungel' was a loser for us." Ed Pincus, Third Branch Flower, Roxbury, Vt.

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Many thanks to Dennis Stimart (first edition) and Roxanne McCoy and Ed Pincus (second edition) for reviewing this section.

Astrantia major masterwort Apiaceae

perennial, Zones 4–6 Austria white, pink 2–4′/3′ (0.6–1.2 m/0.9 m)

The unique flowers are greenish white with a pale green collar of narrow bracts, which gives the whole flower a starry appearance. The flowers are small but grouped together in a dense head. Plants are best grown in areas of cool summers and cool night temperatures; they are poor crops under warm growing temperatures. Masterwort is uncommon, even as a garden plant, in most of the country because of temperature extremes we experience in summers and winters. When offered, however, it is readily accepted by the market and may well be worth a try.

Astrantia major 'Lars'

Propagation

Seed: Sow seed in moist medium and place at 60–65F (15–18C) for 2–4 weeks. Seed flats should then be placed at 30–35F (⁻1–2C) for a minimum of 4–6 weeks. After the cold treatment, put flat in cold frame or a greenhouse at 50–55F (10–13C). Alternating temperatures are beneficial for germination.

Growing-on

Grow seedlings at 55F (13C) for 4–6 weeks. Fertilize with 50–75 ppm N from potassium nitrate then increase to 100 ppm N of a complete fertilizer. High nitrogen results in poorly colored flowers. Plant in the field as soon as ground is workable. Spacing of 12 × 12″ (30 × 30 cm) is appropriate. Plants flower more prolifically the second year than the first.

Field Performance

Constant moisture is necessary for best growth. Yields in the Netherlands were reported as approximately 7 flowers/ft^2 (75 flowers/m^2) the first year and 10–12 flowers/ft^2 (107–129 flowers/m^2) the following year. Plants may require support the second year.

Longevity: Expect 3–5 years of production.

Stage of Harvest

Harvest time is critical. Harvest when the uppermost flowers are open; if harvested too early, plants will wilt and flowers will not open (similar to yarrow). If harvest is further delayed, vase life will suffer.

Postharvest

Fresh: Flowers persist 5–7 days in water (Vaughan 1988), but immediate hydration after cutting is recommended.

Dried: Flowers may be dried with silica gel; they shrink less with desiccants than by air drying alone. Cover the bottom of a box with silica gel or borax. Carefully work the crystals between the petals and lay the stems in the box. Once stems are in place, cover with additional desiccant and leave for 5–6 days (Bullivant 1989).

Cultivars

'Alba' bears white flowers. Quite uncommon.

subsp. *involucrata* includes a number of cultivars with an extra long collar of pink bracts. One of the most impressive cultivars is 'Margery Fish', better known as 'Shaggy', a most apt description of the flowers. Plants may not produce sufficient yield to make a profitable cut flower crop. The true cultivar should be vegetatively reproduced from cuttings, although some seedlings with long bracts will occur.

'Lars' is a vigorous selection with improved vigor and spectacular dark red flowers.

'Moira Reid' is a most interesting plant with large pink flowers and salmon-peach collars.

'Primadonna', a seed-propagated cultivar with 24–30″ (60–75 cm) stems, bears many rose-red flowers.

'Rainbow' is another seed variety with a long bloom season, large flowers, and a good mix of colors. Plants grow to 28″ (70 cm).

'Rosea' bears rose-colored flowers with deeply incised leaves.

'Rose Symphony' ('Rosensymphonie') is a wonderfully handsome plant with rosy pink flowers with a silver collar of bracts. Plants are about 2′ (60 cm) tall.

'Ruby Cloud' is a seed-propagated cultivar with red to purple flowers, growing to 28″ (70 cm).

'Sunningdale Variegated' is most handsome in the spring, when the margins of the light green leaves are splashed with yellow and cream; the variegation fades in summer. A better landscape plant than a cut flower.

Additional Species

Astrantia carniolica is available as 'Rubra', a purple- to maroon-flowered plant. Plants are a little shorter than *A. major* and have darker foliage.

Astrantia maxima bears wonderfully handsome pink flowers on vigorous plants. Unfortunately, the supply is low and the price for plants is therefore high. When prices decline, more flowers should appear in the market.

Pests and Diseases

Aphids are the most common pests, although thrips and spider mites can also be a problem. If plants are allowed to dry out, physiological problems such as leaf margin die-back occur. *Astrantia* is considered highly susceptible to nematode galls caused by *Meloidogyne hapla* (LaMondia 1996).

Grower Comments

"*Astrantia* can be difficult to germinate. It is typically a cold germinator and needs a period of low temperature to induce germination. Germination will tend to be erratic over the last 21–30 days. For this reason, it is sometimes better to germinate this variety in late fall." Corky Kane, Germania Seed Company, Chicago, Ill.

"My favorite seed variety is *Astrantia* hybrid 'Rainbow'—it has a nice mix of colors, very long stems, and blooms a long time, with good-sized blooms, very productive. The darker colors in this mix bloom earlier than other reds and medium pinks for me." Janet Foss, J. Foss Garden Flowers, Everett, Wash.

"Surface sow [*Astrantia*] on medium, then cold treat for 6–8 weeks. Germination rate is usually quite high if seed is fresh. Germinate at 68–70F, then lower temps to 55F once the seedlings have their first true set of leaves. Lower growing-on temps will give you a good root system. If you're planting for cuts, use a semi-shaded area or shade cloth in full sun for stems long enough to cut." Jennifer Judson-Harms, Cricket Park Gardens, New Hampton, Iowa.

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Many thanks to Janet Foss and Jennifer Judson-Harms for reviewing this section.

Baptisia australis false blue indigo Papilionaceae

perennial, Zones 3–7 North America purple 3–4′/3′ (0.9–1.2 m/0.9 m)

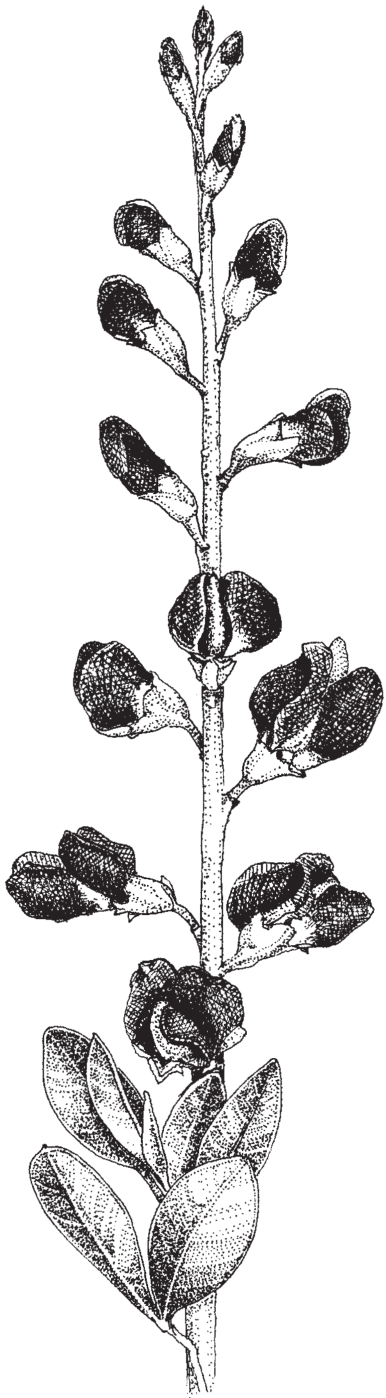
An underused cut flower, whose limitation appears to be a long maturity period and perhaps a limited availability of plants; however, seed can easily be germinated and flowers are well received by the consumer. The genus sports flowers in many colors, mainly in purple, white, and yellow, as well as a couple of hybrids in rather unusual colors. Although flowers are most noticeable, the foliage and the pods can also be harvested successfully.

The genus, which contains about 35 species, is rife with folklore. The genus comes from the Greek word *bapto* ("to dip"), a reference to the flower extract's once being used as a substitute for indigo. *Baptisia australis* was often used for blue dyes, while *B. tinctoria* was a source of yellow dye in the southern United States. *Baptisia* is one of the most rewarding and historically fascinating genera available to growers and landscapers alike. Native to large areas of the United States, plants afford exceptional performance and a mini-lesson in early American history. The common name refers to its use as a substitute, albeit not a great substitute, for the true indigo, *Indigofera*, of the West Indies. When *Indigofera* was in short supply, the English government contracted with farmers in Georgia and South Carolina in the mid 1700s to "farm" false blue indigo, *B. australis*, to increase the supply of the dye.

The farming of baptisia was one of the first recorded examples of agricultural subsidies. The process used to extract the dye was incredibly cumbersome and time-consuming. A report in the *Georgia State Gazette* of 10 May 1788 provided directions "for the Cultivation and Manufacture of Indigo" by "an Indigo Planter." What with planting, cutting, beating, draining, and pressing, the process was doomed to a short life. Today, baptisia provides growers with a living example of Americana and, more importantly, with useful, beautiful cut flowers.

Propagation

It is best to gather seeds from existing plants, although seeds may be purchased. The key to successful seed harvest is to gather the seed as the seed pods turn black and sow when fresh. Seed propagation is less erratic when seeds are given a scarification treatment. Piercing or scraping the seeds with sandpaper or another abrasive substance is helpful, but not essential. This allows moisture and oxygen to penetrate the seed coat. Acid scarification is used commercially but should be performed only by trained individuals. Once the seeds have been treated, place them in a peat/vermiculite mix in a moist, warm environment.



Baptisia australis

Germination of over 90% occurred regardless of acid and mechanical scarification, cold and hot water soaking, or cold stratification (Dirr 1987). A cold treatment of approximately 40F (4C) is also useful and can be accomplished in a cold frame or in a refrigerator or incubator. Seed germinates in 10–18 days at 70F (21C). The fleshy roots may also be divided between October and March.

Growing-on

Transplant plugs or seedlings to 4–5″ (10–13 cm) containers and grow on at 50–58F (10–14C) until they are large enough to be placed in the field. Once in the field, they should not be disturbed.

Environmental Factors

Temperature: Cold is beneficial for growth and flowering of false blue indigo, but plants are tolerant of warm summer weather. Plants are perennials and flower for many years.

Photoperiod: Plants do not appear to have a photoperiodic requirement.

Field Performance

Yield: Little information on yield is available, but nothing should be harvested the first year, and minimal harvesting should be done the second. By the third or fourth year, plants are fully mature, and a dozen stems per plant can easily be harvested.

Spacing: We recommend spacing of at least 2′ (60 cm) between plants to allow them to fill in. Plants will be productive for many years, so dense spacing is counterproductive.

Fertilization: Plants belong to the pea family, so they are able to produce their own nitrogen; however, this does not mean that plants do not need feeding. Side dress with a complete fertilizer as new shoots arise. No additional fertilizing is needed after early summer.

Longevity: If plants are properly cared for, production for 10 years is not unusual.

Stage of Harvest

Flowers are harvested when approximately ⅓ of the flowers on the inflorescence are open. Janet Foss of Everett, Wash., cuts her fresh blooms when just a few flowers are open (not more than ⅓) but all the buds are colored. She has problems with shattering if they're left too long in the field. In Vermont, Ed Pincus cuts 2–3′ (60–90 cm) main stems and then obtains additional side branches, which he can cut or leave to develop the green pods. The pods eventually turn black. Either way, he notes, the foliage and the pods are quite attractive.

Pods start green and eventually turn black. Pods remain green longer in the South and West Coast because cool weather is slower to arrive. Not all inflorescences produce pods, so do not expect the same yield of fruit as flowers. They can be harvested when they are green, but better contrast between leaves and fruit occurs if they are brown to black. Waiting too long is not recommended, however, if the foliage is an important part of the "podded" stem. The foliage turns black in the fall and declines rapidly, at which time, put your falsies to bed.

Postharvest

Growers who cut into a hydrating solution report postharvest life of 7–10 days. Warm water in the bucket is particularly recommended for baptisia.

Cultivars

No cultivars of *Baptisia australis* are available; several hybrids have been released, however.

'Purple Smoke' is a hybrid between *Baptisia australis* and *B. alba*, a white-flowered species, released by the North Carolina Botanical Garden in Chapel Hill. The smoky-blue flowers are held in upright inflorescences on 3′ (90 cm) tall plants with gray stems.

Additional Species

Baptisia alba (white baptisia) is an exceptional species, laden with white flowers on black stems. Plants are more shade tolerant than *B. australis*, and earlier to flower. 'Pendula' is similar in flower but with pendulous seed pods. The nomenclature of the genus is mixed up, other white-flowered forms include *B. lactea* and *B. leucantha*.

Baptisia sphaerocarpa (yellow baptisia) has golden-yellow flowers on 2½–3′ (75–90 cm) tall plants. Native to Arkansas and Oklahoma, plants are excellent choices for the western states.

Pests and Diseases

Leaf spots, powdery mildew (*Ersiphe*, *Microsphaera*), rust (*Puccinia*), and root rots are not uncommon (Perry 1998).

Foliar nematodes (*Aphelenchoides* spp.) cause discolored spots on foliage that can worsen to leaf blight later in the season (Gill et al. 1999).

Grower Comments

"I have a patch of baptisia that is 6 years old. The original plugs were purchased and planted in our field before we had a well. I had heard it was drought tolerant and sure enough, it established itself and flourished without a lot of TLC." Maureen Charde, High Meadow Flower Farm, Warwick, N.Y.

"I have grown *Baptisia australis* for 4 years, and I think it is a real winner. Not only can I sell the flower, but the foliage and seed pods are wonderful too. The plants 'last forever,' like peonies, and are natives in North America." Pat Bowman, Cape May Cut Flowers, Cape May, N.J.

"I started cutting them May 14, and the indigo blooms have opened gradually, lasting over a week. The foliage is gorgeous, and they make a really nice blue/green flower and foliage base for these early bouquets. It has taken about 5 years for my plants to put on size enough to cut abundantly from, baptisia being very slow and 'permanent,' and I'd love to have a huge hedge of it." Mary Ellen Gambutti, Springfield Cut Flower Exchange, Coopersburg, Pa.

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Buddleia davidii butterfly-bush Loganiaceae

woody, Zones 5–9 China many colors 5–10′/5–10′ (1.5–3 m/1.5–3 m)

Butterfly-bush bears flowers on new growth, which makes it an excellent woody: the plant can be cut to the ground in the spring and never get out of control. Plants grow rapidly, reaching 5–8′ (1.5–2.4 m) tall in one season, even after being cut back. Flowers are available in white, pink, lavender, purple, and blue, and additional species also have potential. The length of the inflorescence is 6–30″ (15–75 cm) long, depending on the vigor of the plant: the more vigorous the vegetative growth, the larger the inflorescence. This is an excellent plant for florists who are looking for unusual spikes for bouquets.

Propagation

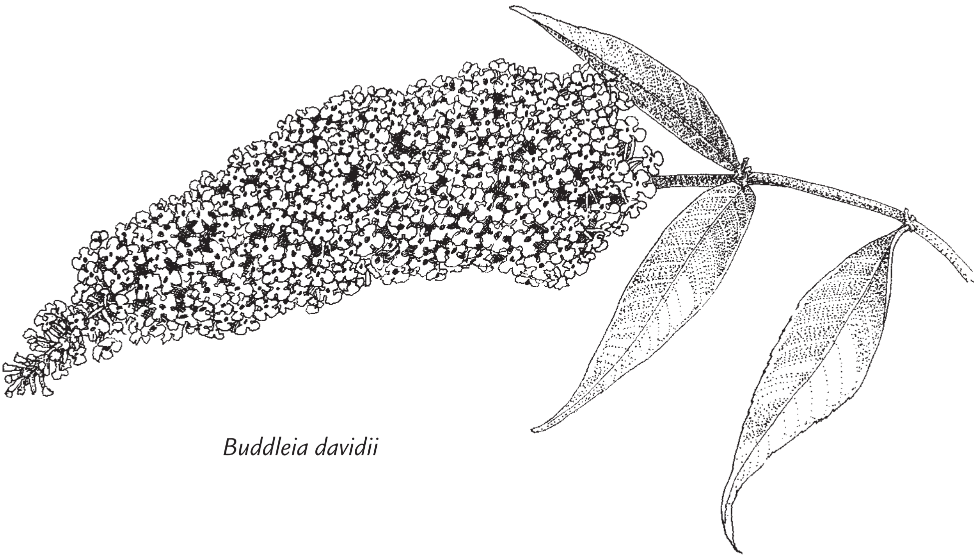
Seed: Seed requires no pretreatment and germinates rapidly under intermittent mist or sweat tent and soil temperature of 70–75F (21–24C).

Cuttings: Collect cuttings from June through August and provide a quick dip of 1000–3000 ppm IBA (Dirr 1998). Remove rooted cuttings from the bench as soon as possible; cuttings rot rapidly with excess moisture.

Field Performance

Habit: Plants are large, multistemmed shrubs that routinely reach heights in warmer locations of 5–10′ (1.5–3 m). In northern areas (Chicago, Ill.), plants are herbaceous perennials, dying back to the ground each year. North of Zone 5, the usefulness of plants for cut flowers is marginal.

Transplanting: Plants transplant to the field easily; in fact, butterfly-bush is almost weedlike in its ability to withstand abuse. Rooted cuttings in plug trays



Buddleia davidii

are the most economical means of propagating and transplanting. From plugs, 4′ (1.2 m) tall plants can be produced the first year with approximately 10 stems/plant. Plants may also be transplanted from 1 gallon (4 l) containers into moist, well-drained soil.

Spacing: Close spacing should be possible because plants can and should be severely cut back each season. Armitage and Dirr (1995) planted ‘Black Knight’ on 5½, 2½, or 1½′ (165, 75, or 45 cm) centers and harvested stems for 3 years. The number of harvested stems per plant decreased, but the number of stems per ft^2 (m^2) increased with greater plant density. Bob Wollam of Wollam Gardens in Jeffersonton, Va., recommends 2½′ (75 cm) spacing, and even when plants are cut back to 1′ (30 cm) in the spring, 1′ (30 cm) remains between plants. A close spacing of 15 plants/20 linear ft (8 plants/m^2) may be used if plants are cut back to the ground in the fall, but probably would be useful for only about 3 years.

Harvesting: Harvest stems as long as possible, remembering that a sufficient leaf area must remain to nourish the roots and provide next year’s growth. Allow at least ⅓ of the plant height to remain, or harvest alternate branches.The inflorescences are tender, and stems should not be harvested mechanically.

Yield: The number of flowering stems depends on cultivar, severity of previous harvest, and winter conditions. On a 3-year-old plant, 60–100 stems is not uncommon.

Greenhouse Performance

There seems to be little reason why *Buddleia* could not be forced out of season under greenhouse conditions. From observation of natural growing sequence, plants respond to long days and warm temperatures.

Stage of Harvest

The proper stage of harvest is critical but debatable. Kasperski (1956) advised harvesting when ½ the flowers on the inflorescence are open but before the open flowers have started to fade, but many growers ignore this advice. Certainly, it is important to deadhead spent flowers on the inflorescence, so, whenever you choose to cut, harvest every 2–3 days in order to avoid spending time deadheading. Having a longer vaselife is less important than having too many flowers open at harvest. Regardless of when they are harvested, stems must be hydrated with a hydrating solution. Conditioning using warm water (80–100F, 27–38C) has been suggested. If panicles are not turgid by the time the water cools, place stems in hot water a second time. Two to 3 changes may be necessary for thorough conditioning (Kasperski 1956).

Postharvest

Fresh: Fresh flowers persist only 2–3 days if not well conditioned. This is the most limiting factor to the acceptance of *Buddleia* as a cut flower. Paul Sansone, a grower in Oregon, precuts under water, places the stems in a floral preservative, and then moves them into the cooler. Bob Wollam cuts to a minimum of 18″ (45 cm) and strips and bunches in the field, placing 10–15 stems per bunch, depending on flower size. Ann Trimble of western Kentucky cuts only large stems (>36″, 90 cm) shortly after daybreak and places them into water with ordinary floral preservative. Warm water is good if it is available. She cuts and bunches in the field, doing no more than 50 stems before they are put into water. Hydrating solution is taken to the field so that flowers can be immediately plunged. Flowers persist 7–10 days if properly conditioned.

After field harvest, stems are recut, quick dipped, and placed in a preservative solution in warm water. Stems may be cooled at approximately 38F (3C) for 18–24 hours. White flowers decline more rapidly than other colors. Yellow flowers appear to have the longest vase life.

Dried: Large leaves should be removed and stems hung up to dry in a well-ventilated area. Flowers retain their fragrance even after drying (Bullivant 1989).

Storage: Stems may be stored wet for 1–2 days at 38–40F (3–4C) (Nowak and Rudnicki 1990).

Cultivars

Several dozen have been selected and named, but only a few are easily available and some are more suitable for cut stems than others. Contact your local nursery or a good woody plant distributor. Dirr (1998) has evaluated many cultivars, and although his comments refer to landscape use, his descriptions may be useful for cut flower growers as well. Bob Wollam has been growing and evaluating buddleia cultivars for years; his experiences are even more important to growers, and his favorites are marked as “Wollam favorites.” Ann Trimble notes that lavender and white are far better sellers than her pink cultivars. Heights given will differ, depending on how severely plants are harvested.

White

‘Peace’ has an arching habit, with white flowers and a orange throat. Flowers are 6–14″ (15–36 cm) long.

‘White Bouquet’ bears 8–12″ (20–30 cm) long fragrant flowers with an orange to yellow throat. Foliage is gray-green.

‘White Profusion’ is a strong, upright grower with long panicles of clear white flowers. A Wollam favorite.

Pink, rose, mauve

‘Fortune’ bears long racemes of soft pink flowers, each with a yellow eye.

‘Pink Delight’ is somewhat mixed up in the trade. Plants should be compact, around 6′ (1.8 m), but tend to be taller. Flowers are a rich pink. A Wollam favorite.

‘Summer Beauty’ has gray-green foliage and excellent pink-rose flowers.

‘Summer Rose’ is 8–10′ (2.4–3 m) tall, with large mauve-rose flowers.

Lavender, blue

‘Bonnie’ has light lavender flowers with an orange eye. Vigorous, up to 10′ (3 m) tall and equally wide. Good fragrance.

‘Deep Lavender’ bears lilac-lavender flowers with an orange eye.

‘Ellen’s Blue’ bears deep blue flowers with a yellow eye. Leaves are silvery.

‘Empire Blue’ has rich violet-blue flowers, silvery foliage, and stands about 10′ (3 m) tall. Panicles are 12″ (30 cm) long.

‘Moonshadow’ is smaller than many upright cultivars, with soft lavender flowers on 3–4′ (0.9–1.2 m) tall plants.

‘Orchid Beauty’ has handsome mauve to lavender-blue fragrant flowers but appears to be less vigorous than many others.

Purple, violet, magenta, red

‘Black Knight’ has dark purple, highly scented flowers and grows 8–10′ (2.4–3 m) tall. A Wollam favorite.

‘Dubonnet’ bears rich purple flowers with a light orange throat. The panicles may be up to 14″ (36 cm) long.

‘Potter’s Purple’, an excellent grower with upright stems, produces many deep purple flowers in 10″ (30 cm) panicles. A Wollam favorite.

‘Royal Red’ bears purple-red flowers on 14″ (36 cm) panicles. An excellent “red” cultivar but not the easiest to produce.

Yellow

‘Honeycomb’ has *Buddleia ×weyeriana* parentage and produces excellent yellow flowers. A Wollam favorite.

‘Sun Gold’ is a older than ‘Honeycomb’ but still popular.

Additional Species

Buddleia alternifolia (alternate butterfly-bush) is 10–20′ (3–6 m) tall with an open habit and pendulous stems. The lilac flowers occur in the axils of last year's growth, so they cannot be cut back until after flowering. Very interesting but may not be as useful for cut flowers as *B. davidii*.

Buddleia globosa (orange ball tree) is a terrific useful shrub with spherical orange flower clusters. Flowers on previous year's wood. Hardy only to Zone 7.

Buddleia lindleyana bears little resemblance to normal butterfly-bushes. Plants can reach 12′ (3.6 m) in height and produce purple-violet flowers all season. Not as tidy, and less mite resistant, but worth a look. Hardy only to Zone 7.

Buddleia ×weyeriana, a hybrid between *B. davidii* and *B. globosa*, is hardy in Zones 7–9. The cultivars 'Sun Gold' and 'Golden Glow' bear yellow-orange and pale yellow-orange, fragrant flowers, respectively. If purchasing plants for yellow flowers, include 'Honeycomb' as well.

Pests and Diseases

Three-spotted spider mites can be a serious problem. Gillman et al. (1999) assessed spider mite resistance of *Buddleia* taxa. Results from bioassays and sampling of naturally occurring pest populations in the field identified highly resistant taxa (*Buddleia fallowiana* 'Alba', *B. f.* 'Cornwall Blue') and susceptible taxa (*B. davidii* 'African Queen', *B. lindleyana* 'Gloster').

Few other pests bother butterfly-bush, although nematodes can be a nuisance in the South. Root rot (*Phymatotrichum omnivorum*) has resulted in serious losses in Texas, but it does not appear to be widespread.

Grower Comments

"We are in northern lower Michigan, mostly Zone 5, but sometimes Zone 4 on rare winters. I've been growing buddleia for about 8 years, and it has come back every year. We cut them back to about 6″ in late fall with everything else, and it has worked just fine. At harvest time, I usually dip the stems in boiling water for a few seconds and that seems to help the vase life some. Even when they dry up in a bouquet though, the shape can still be very attractive. The lavenders and purples are the best for me, although I grew a bright cerise for the first time this year and loved it." Phyllis Wells, Wells Family Farm, Williamsburg, Mich.

"We have a few [*Buddleia davidii*] 'Black Knight'. It needs to be picked as soon as it begins to open, early in the day. It will not survive a hot day at the market unless it is well hydrated. When picked fresh and hydrated, it will last 5 days in Oasis™, close to a week in water. I sold some to a florist for a wedding and had to test it in Oasis™ foam for longevity; I was surprised how long it lasted. But it has to be picked at its peak, which, like most flowers is the minute it begins to bloom, not a few days later." Dave Dowling, Farmhouse Flowers, Brookeville, Md.

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Many thanks to Paul Sansone (first edition) and Ann Trimble and Bob Wollam (second edition) for reviewing this section.

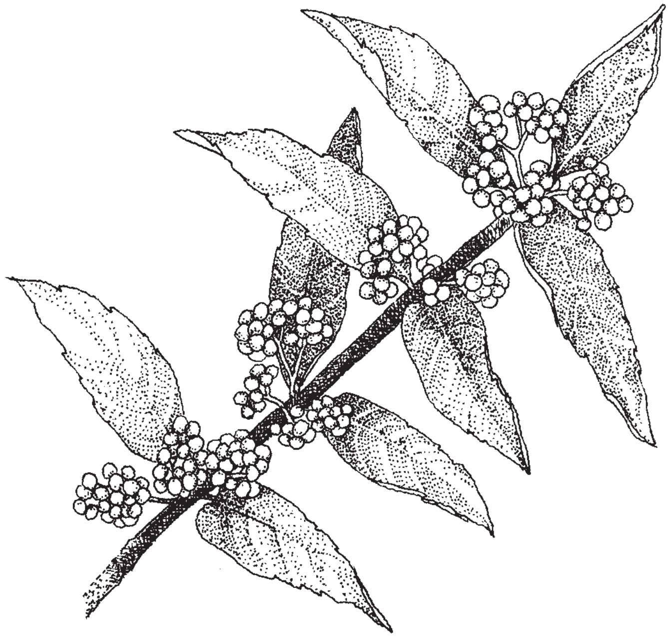
Callicarpa beautyberry Verbenaceae

woody, Zones 5–10 tropics purple, white fruit
4–8′/3–6′ (1.2–2.4 m/0.9–1.8 m)

Noted for their magnificent purple or white fruit in the fall, the beautyberries are easily grown and have great potential as a cut stem—and they are as frustrating a crop to growers as any we have discussed (see “Grower Comments”). Only a few of the approximately 40 species are available to American growers; *Callicarpa americana* and *C. dichotoma* are most useful for the colored fruits. In all species, the magenta or white fruits occur at the nodes in the top ⅓ to ½ of the stem. *Callicarpa americana* (American beautyberry; French mulberry), native from Maryland to Georgia in the East, west to Arkansas and south to Mexico, bears some of the largest (¼″, 6 mm wide) and most ornamental fruit in the genus; its var. *lactea* is a white-flowered form whose white fruit is beautiful initially but discolors as it ages. Species from China and Japan with smaller but no less handsome fruit are also available. *Callicarpa* is in demand by growers because flowers are formed on new wood, and stems may therefore be harvested almost to the ground. In the northern limit of hardiness (Zone 5), plants will die all the way to the ground, reappearing like an herbaceous perennial. Limitations to production of beautyberry are the relative lack of information for the producer and the wholesaler/retailer, the difficulty in removing leaves, and poor shippability.

Propagation

Cuttings: Softwood cuttings root in 7–14 days if placed in clean sand under intermittent mist (Dirr 1998).



Callicarpa dichotoma

Seed: Seed should be stratified for 90 days at 41F (5C) for best germination (Dirr 1998).

Field Performance

Habit: Plants are multistemmed shrubs. Plants reach a height of 4–6′ (1.2–1.5 m) after being cut to within 1′ (30 cm) of the ground the previous winter.

Transplanting: Plants are readily transplanted into well-drained soils in the spring. Irrigation is necessary for good flowering and fruit production. Plants tolerate full sun to partial shade, but full sun provides highest yield of useable stems. Plants reach fruiting stage approximately 2–3 years after transplanting.

Spacing: Cutting back stems in the winter allows for relatively close spacing. If plants are cut back every year, spacing at 2–3′ (60–90 cm) centers can be accomplished. If plants are not cut back, then wider spacing is required.

Fertilization: Excess fertility should be avoided once plants become productive. High rates of nitrogen result in reduced flowering and fruit production.

Harvesting: Harvest by cutting stems 6–12″ (15–30 cm) from the ground. Fruit may fall off; harvest with reasonable care to retain as much fruit as possible.

Yield: After about 2 years in the ground under proper environmental conditions, 15–30 stems are formed. Additional shoots form as plants mature.

Greenhouse Performance

No work has been conducted on forcing beautyberry out of season, but its annual growth rate and habit of fruiting on new wood suggest it could be greenhouse forced. It is likely that long days and warm temperatures enhance flower and fruit production.

Stage of Harvest

Early harvest (early October) may occur when the basal fruit clusters are fully colored and the terminal fruits are still green. Little additional fruit coloration occurs after harvest. Later harvests (mid October to November) are better because all fruit is colored and many leaves have fallen. Some basal fruit will fall off during harvest; this is to be expected. Rough handling or harvesting too late results in significant fruit drop. Harvest before a hard freeze, or the fruit becomes mushy and the stems unsaleable.

Postharvest

Stems should be recut and immersed in hot water. Fruit persists approximately 2 weeks. Stems may be stored at 32–36F (0–2C) for 2–4 days (Vaughan 1988). Remaining foliage should be removed. Work at the University of Georgia showed that if stems are placed for 1–2 hours in a floral preservative, then placed in buckets without liquid, the foliage can be removed more easily approximately 48 hours later. Elizabeth Dean of Wilkerson Mill Gardens in Palmetto, Ga., suggests rolling harvested stems in a lightly moistened paper and storing them in a cooler for 1–3 days to enhance leaf removal and decrease fruit loss: “It is possible to harvest without putting stems in water. Several days storage in a dark cooler makes leaf removal easier.” Once leaves are removed, place the stems back in water and store in a 32–36F (0–2C) cooler.

Additional Species

Callicarpa bodinieri (Bodinier beautyberry) is grown in Europe but is rarely seen in the United States. Native to China, plants are hardy in Zones 5–7. ‘Profusion’ is a heavily fruited Dutch selection with large leaves and violet fruit ⅙" (4 mm) in diameter. Where plants are happy, abundant fruit occurs even on young plants. A white-fruited form also exists, but it too is relatively unavailable to American growers. Not a particularly good plant for the Southeast.

Callicarpa dichotoma (purple beautyberry) is arguably more ornamental than *C. americana*, but fruit is smaller, about ¼" (6 mm) in circumference, and does not encircle the nodes as in its American counterpart. The multistemmed species is relatively fast growing and persistent. Seven-year-old plants in Athens, Ga., produced over 30 marketable stems. Plants are more cold hardy than American beautyberry and grow well in Zones 5–8. The main production difficulty is the removal of the many small leaves, which is labor intensive and if done sloppily, results in a good deal of fruit loss. Postharvest tests at Georgia were disappointing. The fruit falls off rapidly or dries to look like little purple raisins; however, even raisins are handsome to the right eyes. As Elizabeth Dean so aptly states, "The fruit has visual interest dried if one is not expecting perfection; if so, buy plastic." Variety *albifructus* is a white-fruited form that discolors early. 'Early Amethyst' bears many small lilac fruits. 'Issai' appears to be an excellent cultivar, fruiting heavily, even as a young plant.

Callicarpa japonica (Japanese beautyberry) is 4–8′ (1.2–2.4 m) tall and equally wide at maturity. They are not as heavily fruited as *C. americana* or *C. dichotoma*, and some reports suggest the fruit is not as persistent. Plants have about the same hardiness as *C. dichotoma*. 'Leucocarpa' bears white fruit.

Pests and Diseases

Leaf spots (*Atractilina callicarpae*) occur as irregular, rustlike, scattered spots. Fungicide applications prior to fruit coloration may be necessary.

Black mold usually signifies an insect problem. Insects such as aphids secrete honeydew, on which the mold grows. Controlling the insects generally controls the mold.

Grower Comments

"I have a few plants of *Callicarpa dichotoma*. The berries color up, but the leaves are still on the plants. I don't feel like individually pulling the leaves off, so I wait—depending on the weather, when the leaves fall off, usually we only have a couple of days to harvest them. Generally, it freezes too hard, and we lose the berries also. In Seattle it seems the berries stay on most of the winter, looking totally spectacular, but the weather is just mild enough there to make the difference. When I actually do get to harvest them, as long as the leaves have dropped, they need no special conditioning. I've even had the berries dry, making nice winter decorations. But do I think this is a viable crop for us? No." Janet Foss, J. Foss Garden Flowers, Everett, Wash.

"We put in a 200′ row of *Callicarpa dichotoma* 'Issai' several years ago. So far we have not found a way to make money on it except to dig the plants and sell them. The shrubs are beautiful and carefree, but the problem is that the leaves do not hydrate once the stem is cut. We have tried selling them with the leaves on and let the florist pull them off, but that didn't fly. We have tried pulling the leaves off ourselves, but, besides being labor intensive, the stems get all tangled up without the leaves, so when you pull them apart the berries get pulled off. If you wait till the leaves fall off on their own, the berries are starting to rot and will drop. We have tried Hydraflor postharvest to no avail. We have all but given up." Tammy Ford, Perennial Favorites, Leopold, Ind.

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Many thanks to Elizabeth Dean for reviewing this section.

Callistephus chinensis China aster Asteraceae

annual China many colors 1–3′/2′ (0.3–0.9 m/0.6 m)

China asters continue to be offered in various sizes and colors—including pastels, bright blues, and electric reds—and breeders are still bringing plants to the marketplace. Although popular in many circles, including Europe, the main drawbacks of China asters are the relatively low yields and susceptibility to disease. Production has moved mainly to the greenhouse, where more control of the environment is possible. China aster, an annual, should not be confused with perennial asters, which are included under *Aster*.

Propagation

Seed germinates in 3–7 days if placed under intermittent mist at 70–72F (21–22C). Approximately 0.12 oz (3.5 g) of seed yields 1000 plants (Nau 1999). Seed may also be direct sown in the field in early spring at the rate of 0.09 oz per 100′ (10 g per 100 m) for summer production (Kieft 1996). Some cultivars are also propagated vegetatively, from cuttings.

Growing-on

Seedlings should be transplanted to cell packs or 3–4″ (8–10 cm) pots at the first true leaf stage, then grown at 70/60–62F (21/15–17C) day/night until roots are well established. Do not allow plants to become root bound. Maintain plants under long days of approximately 15 hours with incandescent lights when natural short days occur. Fertilize with 100–150 ppm N with potassium or calcium nitrate.

Environmental Factors

Photoperiod: Flowers develop most rapidly when a period of long days is followed by short days (Cockshull 1985). The term given to this plant is a "long-short day" plant. That is, plants are induced to flower under LD, and then develop more rapidly under SD after induction. If plants are provided with continuous LD, they flower more slowly but on longer stems than do those that are exposed only to SD, a useful characteristic for cut flower production. Flowering of laterals is also delayed when plants do not receive SD treatment (Goldsberry et al. 1989). Even though research has shown that only 7 LD are needed for flower initiation (Doorenbos 1959), approximately 4–5 weeks of LD are necessary to adequately "prime" the plant for SD treatment. Flowering is not acceler-

Callistephus chinensis
'Meteor Purple'

ated with less than 4 weeks of LD followed by SD compared with plants that receive only SD. The critical LD photoperiod is approximately 14 hours, and satisfactory LD effects can be obtained by a 16-hour day extension with incandescent lights or with continuous light (Cockshull and Hughes 1969). In summary, research indicates that for pot plant use, 3–4 weeks of LD should be followed by SD for compact, rapidly flowering specimens. For cut flower production, LD could be continued until desired stem length has been achieved. Then, SD will hasten flowering time.

Work at Colorado State University verified much of the older research, as the following table shows (Goldsberry et al. 1988, 1989).

The effect of photoperiod on growth and flowering of cut China asters.

Photoperiod	Days to flower	Stem length (in)^{z}	No. of breaks
continuous SD	49	17.5	5
1 week LD, then SD	51	17.4	5
2 weeks LD, then SD	53	19.5	4
3 weeks LD, then SD	56	23.5	4
4 weeks LD, then SD	57	25.0	4
5 weeks LD, then SD	62	25.2	4

z = multiply (in) by 2.54 to obtain (cm)

In this work, the highest-quality flowers occurred with 3–4 weeks of LD, followed by SD.

Long days also promote leaf expansion, stem extension, and dry matter accumulation but slightly inhibit the formation of lateral breaks (see previous table). The promotion of flower development due to SD inhibits stem elongation.

Temperature: A pronounced interaction between temperature and photoperiod occurs in China asters. Plants grown at 55F (13C) or below flower only if LD are provided but remain as basal rosettes if grown under SD. Raising the temperature to 68F (20C) resulted in 16 days earlier flowering when plants were grown under LD, but the effect was considerably greater when plants were grown under SD (Biebel 1936). In sum, keep the temperatures above 55F (13C) and below 86F (30C). Optimum temperatures are 77F (25C) during the day and 60F (15C) at night.

Field Performance

Field production has been difficult because of the plant's susceptibility to aster yellows virus. The phytoplasm is carried by leafhoppers, which must be controlled (see "Pests and Diseases"). Asters historically have been grown under cloth in the field to reduce the incidence of these hopping bugs. Protective screens must be used at least until plants are budded up; after that time, the disease will not have time to show up.

Scheduling: Flowers of spray asters are generally harvested approximately 3–4 months after transplanting to the field, depending on latitude and temperature. In trials in Maine, plants sown on 20 April flowered in early August (early-flowering cultivars) to mid to late August (later-flowering cultivars). Early flowering in the field may be stimulated by placing seedlings under LD immediately after they come out of the propagation area. For example, seedlings resulting from February and March sowings should receive 4-hour nightbreak lighting and temperatures above 62F (17C) until planted in the field. Since natural photoperiod outside is less than 14 hours, flowering of these field transplants will occur on significantly longer stems than on seedlings grown under natural SD in the greenhouse.

Spacing: Space plants as close as 4 × 4″ (10 × 10 cm), or approximately 9 plants/ft^2 (156 plants/m^2), or up to 1′ (30 cm) apart, depending on cultivar and weed control practices. A spacing of 6 × 6″ (15 × 15 cm), approximately 4 plants/ft^2 (44 plants/m^2), is typical.

Shading: China asters stretch appreciably if grown under shade cloth (Post 1955). This may be useful in the South where shading is used to reduce heat in the field. Use of shade cloth also inhibits the entry of leafhoppers. Cloth for exclusion of hoppers should have approximately 22 threads per inch.

Support: Horizontal plastic mesh or other such support structures should be used to prevent damage from wind or rain.

Yield: Work at the University of Maryland (Healy and Aker 1989) showed yields of approximately 3 flowers per plant when only the main stems were harvested (all lateral shoots included with the main stem) and relatively short stem length, less than 20″ (50 cm) long, with many cultivars of China asters. At the University of Kentucky, yields of approximately 3 stems/ft^2 (32 stems/m^2) were recorded with a spacing of 4 plants/ft^2 (43 plants/m^2). Stems averaged approximately 18″ (45 cm) long (Utami et al. 1990). Although yields are significantly better in coastal California, stems of Matsumoto series were only 12–18″ (30–45 cm) long. When all flowers were harvested separately (laterals and main stem) at Georgia, 22 stems/plant with an average stem length of 15″ (38 cm) occurred during a 3-week period in the summer. For best-quality flowers, disbud lateral stems and remove some of the lower branches.

Greenhouse Performance

China asters may be grown year-round, but prices are traditionally higher in fall and winter. Seed sown 1 August and grown under LD (nightbreak incandescent lights) until flowering results in flowers in late November at 42° latitude. Plant on 4″ (high light) to 8″ (low light) centers (10–20 cm). On a year-round program, Ken Goldsberry of Colorado State University found that at least 5 crops (unpinched) per square foot of bench could be realized under Colorado conditions. He grew single-stem plants in cell packs under LD, then moved them to 6″ (15 cm) pots (3 plants/pot) containing pea gravel when the foliage covered the entire cell pack. Continuous feed and carbon dioxide were applied. China asters are highly sensitive to nightbreak lighting or light drift, and less than 1 fc is effective in stimulating stem elongation; therefore, spotlights or floodlights can effectively light large areas of the greenhouse.

Daylength control is particularly important in southern Florida and southern Texas, where temperatures are always sufficiently warm for growth, but winter daylengths are usually too short to promote stem elongation. Regardless of where asters are grown, LD can be applied by daylength extension (to 14 hours) or nightbreak lighting of at least 4 hours (e.g., 10 p.m. to 2 a.m.).

As in the field, take steps to reduce aphid entry (to reduce aster yellows) in the greenhouse. Use cloths over vents and as entries through doorways.

Temperature: See "Environmental Factors." Temperatures above 80F (27C) should be avoided in the greenhouse.

Scheduling: In Colorado, where night temperatures were 60–62F (15–17C) and days were 70F (21C), asters flowered approximately 4 months from sowing. There was a progressive increase in flowering lateral stems as planting date was delayed from December to March (Goldsberry et al. 1988). At night temperatures of 50F (10C), approximately 5 months are necessary in the fall and winter from seed to flower; 4 months are required in spring and summer. At warmer temperatures, crop time may be slightly reduced, although 14 weeks appears to be as fast as plants can develop (Utami et al. 1990).

Carbon dioxide: Use of CO_2 in English studies showed that 600–900 ppm CO_2 resulted in approximately one week less time on the bench and an increase in stem weight (Cockshull and Hughes 1969). Similar results using 1000 ppm CO_2 continuously resulted in the formation of flower buds 5 days earlier than control (Reekie et al. 1994).

Stage of Harvest

Harvest the terminal stem when outside ray florets begin to open. Achieving a minimum stem length is important. In the greenhouse, aim to produce a minimum stem length of 20–24″ (50–60 cm); the bouquet market needs at least 20″ (50 cm) to use in the mixes.

Bunch size and packaging: Bunch size differs depending on where plants were produced. A "grower's bunch," which may be anything from 10 to 13 stems, is common in Florida. Growers in California use both "grower's bunch" size and 10-stem bunches. Ten-stem bunches are the norm in Holland, Ecuador, and Colombia. Most Dutch growers in California use 10 stems. When orders for mixed colors are filled, asters are usually sold in assorted color boxes with the mix consisting of ⅓ pink, ⅓ red, ⅓ blue.

Postharvest

Fresh: Vase life is 5–7 days, and generally the foliage wilts before the flower declines. Most growers strip the foliage ½ to ⅔ up the stem, since it turns black or yellow so rapidly.

Neck droop may also occur, resulting in shortened vase life. A 10-second pulse in 1000 ppm solution of silver nitrate significantly extended the vase life (Evans and Reid 1990). Asters treated with silver nitrate may be stored up to a week at 33–35F (1–2C). Few growers use silver nitrate because of potential problems, and caution must be used when working with it. 1-MCP and other ethylene-inhibiting products from postharvest manufacturers are more desirable. Flowers do not ship well, and some reduction of vase life can be expected if they are.

Dried: Harvest when flowers are fully open. Allow leaves to remain on stems and hang in small bunches upside down to dry. Flowers may also be dried in a desiccant such as silica gel.

Cultivars

Many cultivars are available from American and European seed companies (one Dutch catalogue alone offers more than 120 different cultivars suitable for cut flowers). The bicolor varieties have had excellent market acceptance and bring strong prices, while yellow and white are often poorly received (white because it shows damage, apricot and yellow because they are perceived as "faded" in the market).

American Beauty Mix produces 3″ (8 cm) wide, double flowers on 2–3′ (60–90 cm) stems in many colors.

'Amour Blue' has double, 3–4″ (8–10 cm) rich purple-blue blooms on a plant 2½–3′ (75–90 cm) tall.

Andrella Super Mix produces single daisy-like blooms, 2½–4″ (6–10 cm) across, in shades of light and dark pink and purple. Plants grow 3–3½′ (0.9–1.1 m) tall.

Astoria series consists of 5 colors and a mix of upright single-flowered asters. Flowers are 2–3″ (5–8 cm) in width; stems are 24–30″ (60–75 cm).

Ball Florist Mix is an old favorite consisting of 3″ (8 cm) wide flowers of white, pink, blue, rose, and purple.

'Bouquet Powderpuffs' has 2–2½″ (5–6 cm) wide, fully double flowers with no yellow center. Plants grow 2–2½′ (60–75 cm) tall. Separate colors are available, including azure, blue, rose, purple, scarlet, and white.

Compliment series has been popular for many years. Flower size is 4″ (10 cm); stem length is about 30″ (75 cm). Available in 6 colors and a mix.

'Crego' bears a many-colored mixture of feathery, 3″ (8 cm) wide flowers on 2′ (60 cm) tall plants.

Crestia series has flowers 2½–3″ (6–8 cm) wide on plants 2–3′ (60–90 cm) tall. The flower is a combination: quill petals in the center, ray petals on the outside.

Daylight series consists of purple, red, rose, violet, and white.

Duchesse series is late to flower and bears peony-like ball-shaped 3–4″ (8–10 cm) wide flowers on 24–30″ (60–75 cm) stems. Available in 6 single colors, 2 bicolors, and 2 mixes.

Early Dawn Choice Mixed (Early Wonder) is a double-flowered series, with 3½″ (8 cm) flowers atop 18″ (24 cm) stems.

Emperor series bears 2½″ (6 cm) wide flowers on 2–3′ (60–90 cm) stems. 'Emperor Carmine' and 'Emperor Red' have carmine and deep red flowers, respectively.

Fan series grows about 2′ (60 cm) tall and bear semi-double flowers with a yellow center. Nine colors and a mix are available. Said to be less susceptible to fusarium wilt.

Florett Strain is available in separate colors, including deep and pale pink, crimson, blue, and a pastel "champagne" color. The 2–3″ (5–8 cm) wide flowers consist of fully double quill forms and are produced on 3′ (90 cm) stems.

Gala series bears 3–4″ (8–10 cm) double flowers on 30–36″ (75–90 cm) upright stems. Eight colors and a mix. Four of the colors received a Fleuroselect Quality Mark in Europe.

Giant Rainbow series includes ‘Crimson’, with deep crimson petals offset by a conspicuous yellow center, and ‘Dark Blue’, a deep violet-blue with contrasting golden-yellow center. Other colors are salmon, blue, pink, lilac, rose, scarlet, white, and a formula mix.

Giant Ray series bears quilled double 5–5½″ (12–14 cm) flowers. Good branching habit, about 2′ (60 cm) tall. Six colors and a mix.

Kamo series has 30″ (75 cm) upright stems, with short-petaled single flowers.

Kurenai Strain is an upright bouquet type with 1½–2″ (4–5 cm) flowers. Colors range from cherry to dark pink to red, with ‘Peppermint Kiss’ thrown in for good measure.

Matador series is similar to Matsumoto, but flowers are slightly smaller. Plants bear strong 2–3′ (60–90 cm) stems with basal branching. Probably better for greenhouse than field production. Nine colors and a mix.

Matsumoto series produces sprays of 2–2½″ (5–6 cm) wide flowers with distinct yellow centers and has become one of the leading series of asters for cut flower production. Mixtures and separate colors are available. Plants have good resistance to fusarium wilt.

Meteor series has large 3–4″ (8–10 cm) flowers on thick stems that are up to 28″ (70 cm) long. Recommended as a greenhouse crop. Colors include carmine-red, rose-pink, purple, yellow, and a mix.

Miss series has shown good uniformity and some tolerance to aster yellows. ‘Miss Europe’ (medium pink), ‘Miss Nippon’ (pale pink), and ‘Miss Mexico’ (dark blue/lavender) have fully double 3–4″ (5–8 cm) wide blooms on 28″ (70 cm) tall plants. Sometimes sold as Irresistible Mix.

Perfection mixture produces 2–3′ (60–90 cm) tall plants and 3–4″ (5–8 cm) wide, fully double flowers with incurved petals.

Pommax series provides 3″ (8 cm) wide double flowers on upright 2–3′ (60–90 cm) stems. Nine separate colors and a mix. Recommended for greenhouse culture.

Pompon series is only about 2′ (60 cm) tall but useful for a short stem program. Ten separate colors and a mix.

Princess series has a well-branched habit with quilled dome-shaped double flowers bearing a light-colored center. Stem length is about 28″ (70 cm). Late summer and fall flowering, available in 11 colors and 2 mixes.

Prinette series has long, thin, curved outer petals and small, tubular center flowers. Flowers are available in pink and red. Plants were Fleuroselect winners.

‘Queen of Market’ grows to 20″ (50 cm) in height with medium-sized round flowers. Available in a mix.

Rainbow mixes may be ordered as single- or double-flowered forms. Flowers generally have a prominent yellow eye and are borne on 2–3′ (60–90 cm) stems.

Serenade series is an early bloomer, with semi-double flowers and spray-type habit, good for filler flowers. Colors include blue, carmine, rose, rose-tipped white, and scarlet. ‘Serenade Light Blue’ provided excellent yield and stem length in trials around the country and was nominated for the ASCFG's 2001 Fresh Cut Flower of the Year. The entire series received high marks in the trials and was noted for its "rich colors and uniform growth" (Dole 2001).

Serene series bears pompon spray flowers on 2′ (60 cm) stems. Plants flower approximately 14 weeks after sowing. Light blue, red, and rose colors are available.

'Sparkler' has double incurved flowers on 2–3′ (60–90 cm) stems. Flowers are mainly available as a mixture.

Standy series is touted as "the most wilt-tolerant aster with tolerance against *Fusarium* and *Verticillium*." The double 3–4″ (8–10 cm) wide flowers occur on stems approximately 30″ (75 cm) tall. Nine colors and a mix.

Starlight series produces large spider-type blooms. Colors are blue, purple, rose, and scarlet.

Super Princess series is 3–3½′ (0.9–1.1 m) tall with quilled petals. The "super" designation refers to its larger flowers and stronger stems (compared to Princess). Numerous cultivars in separate colors include 'Alice' (light blue), 'Hilda' (light yellow), 'Scarletto' (copper-scarlet), and 'Victoria' (scarlet).

Waka series is 2–2½′ (60–75 cm) tall and bears unique single 2½–3″ (6–8 cm) wide flowers with narrow petals in scarlet or pink around a small and unobtrusive central disk.

National field trials

Asters have been evaluated since the inception of the ASCFG's national trials in 1994. The following table (Dole 1995–2002) is a summary of the average stem lengths and yields of asters submitted for trialing. These data are averages over a wide geographical range and must be viewed as guidelines only; individual experience may differ significantly.

Cultivar	Year of trial	Stem length (in)^z	Stems/ plant
Compliment Light Blue	1994	13	3
Compliment Salmon Pink	1994	17	6
Compliment White	1994	15	2
Daylight Purple	2001	16	2
Daylight Red	2001	12	1
Daylight Rose	2001	15	1
Daylight Violet	2001	19	1
Daylight White	2001	13	1
Gala Mix	2001	19	3
Giant Princess Mix	2000	17	4
Matador Mix	1994	15	2
Matsumoto Blue/White	1995	18	4
Matsumoto Formula Mix	1996	16	4
Matsumoto Pink/White	1995	19	6
Matsumoto Lavender	1995	22	5
Meteor Carmine Red	1998	21	6

Meteor Mix	2000	14	5
Meteor Rose	2000	17	7
Meteor Rose Pink	2000	15	6
Meteor Violet Blue	1998	22	6
Serenade Blue	1998	21	8
Serenade Blue/White	2000	17	6
Serenade Carmine	2000	16	5
Serenade Light Blue	2000	17	11
Serenade Red	1998	18	5
Serenade Rose	2000	15	6
Serenade Rose/White	2000	17	8
Serenade Scarlet	2000	16	12
Serenade White	1998	18	5

z = multiply (in) by 2.54 to obtain (cm)

Pests and Diseases

Aster yellows: This disease is caused by an unusual microbe called a phytoplasm. Yellowing of all or part of the plant; distorted, malformed flowers (flowers partly or entirely greenish and yellow); and spindly stems are indications of aster yellows infection. Affected plants may also exhibit considerably increased branching. Leafhoppers pick up the phytoplasm from weeds, and then transmit it to the aster. The best means of control is to reduce or eliminate the population of leafhoppers. Scout your area for leafhopper migrations, and, if at all possible, plant asters only after leafhoppers have moved through your area. Once plants have been infected, they must be discarded. If plants are infected early, the leaves turn yellow while the veins retain their green color. The use of soil sterilants reduces the incidence of the phytoplasm in the soil, but crop rotation should be routinely practiced.

Aster wilt: Plants suddenly wilt, usually near maturity, when attacked by the aster wilt fungus (*Fusarium conglutinans* var. *callistephi*). The stem rots completely at the soil line, and often a streak of blackened tissue extends up one side. The wilt fungus may be carried on the seed, which should be surface sterilized. The advent of wilt-resistant cultivars has greatly reduced the severity of this problem. Verticillium wilt is similar to fusarium wilt.

Aster spotted wilt: This disease causes streaks on the stems or circular patches on the foliage. Infected plants may exhibit increased branching and should be discarded. The wilt organism is spread by thrips, the presence of which must be controlled.

Root rot and rust: *Phytophthora cryptogea* and *Coleosporium solidaginis* result in loss of yield and flower quality, respectively.

Leafhoppers, leafminers, thrips, aphids, and Japanese beetles cause significant damage and reduce the value of the crop. They may also be responsible for the spread of disease. Reflective mulches are presently being trialed in Ventura County, California, and they appear to reduce the populations of leafminers, whiteflies, and aphids. Thrips can wipe out greenhouse crops in the blink of an eye.

Caution: Asters are highly susceptible to some pesticides. Test spray a few plants to determine phytotoxicity.

Grower Comments

"I did a big aster trial this year (52 varieties/colors) and took every precaution. Still we had yellows, probably due to the row cover blowing off one day. [With such] susceptibility, asters are a bit of a pain to grow, but their unmatched beauty and long vase life seem to outweigh the problems." Ginny Kristl, Johnny's Selected Seeds, Albion, Maine.

Related Genera

Perennial asters such as *Aster ericoides* (September aster), *A. novae-angliae* (New England aster) and *A. novi-belgii* (New York aster) are popular cut flowers. Their culture is covered in the section on *Aster*.

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Many thanks to Bob Anderson, Ken Goldsberry, and Will Healy (first edition) and Ginny Kristl, Gay Smith, and Rudolf Sterkel (second edition) for reviewing this section.

Campanula bellflower Campanulaceae

perennial, Zones 3–6 Europe blue 2–3′/3′ (60–90 cm/90 cm)

Only a few of the many bellflowers in the marketplace are useful as cut flowers. Probably the most popular are the peach-leaf bellflower (*Campanula persicifolia*), clustered bellflower (*C. glomerata*), Canterbury bells (*C. medium*), and chimney bellflower (*C. pyramidalis*), and the various hybrids that have recently appeared on the scene. All are more popular in European markets than in American markets. Flower color for all species is typically purple to blue, but cultivars in white and lavender are also available.

Propagation

Seed: Seed is small in all species and should be lightly covered with fine sand or a thin blanket of vermiculite. Germinate at 60–65F (15–18C) under sweat tents or intermittent mist. Seedlings emerge in 14–21 days. Approximately 1/56 to 1/28 oz (0.5–1.0 g) of seed yields 1000 seedlings, depending on species (Kieft 1996).

Division: Divide crowns in spring or after flowering.

Growing-on

If planted in seed flats, seedlings should be transplanted to 3–4″ (8–10 cm) pots or packs when the second set of true leaves emerge. If sown in plugs, sow in large containers (288s or less). Grow at 55–60F (13–15C) until 3–4 leaves emerge, then place in a cold frame or unheated greenhouse for a minimum of 6 weeks. Plant to the field in the fall.

Environmental Factors

Little information is available for cut flower species, but literature concerning flowering of *Campanula carpatica* (Whitman et al. 1998, Armitage and Garner 1999), *C. fragilis* (Zimmer 1985a), and *C. isophylla* (Moe and Heide 1985) provides some useful guidelines to flowering control.

Temperature: All perennial campanulas benefit from a cold treatment, usually supplied by natural winter cold. In recent research, storage of crowns for 12 weeks at 40F (4C) was necessary to induce flowering in *Campanula persicifolia*; cold was not necessary to break dormancy (i.e., leaves were formed) but was needed to induce flowering (Iversen and Weiler 1989). In *C. pyramidalis*, only 6 weeks at 43F (6C) were necessary for 80% of the stems to be vernalized (Zimmer 1985b). In *C. carpatica*, cold is not necessary and does little to enhance flowering or appearance, but it is not detrimental either (Whitman et al. 1998, Armitage and Garner 1999). In work with Canterbury bells (*C. medium*), the longer seedlings were exposed to 40F (4C), the higher the flowering percentage once placed outdoors; also, the best percentages occurred when older plants were cooled compared to young plants (Kim et al. 1997). In general, a cold period of 10–12 weeks at 40F (4C) or below is recommended for most cut flower species (Bartels 1990).

Photoperiod: *Campanula persicifolia* appears to be day neutral, and, once the cold treatment has been satisfied, produces flowers under long or short days (Iversen and Weiler 1989). In other species, however, long days are necessary for flowering after vernalization (Wallensiek 1985, Zimmer 1985a, 1985b). Work with *C. carpatica* showed that a daylength of 15–17 hours results in the greatest flowering, but some cultivars may respond with critical LD of 13–14 hours. Short days should be avoided with with *C. carpatica* because plants may become devernalized (i.e., lose the beneficial effects of cold treatment).

Gibberellic acid: GA does not appear to substitute for either the LD or low temperature requirement of *Campanula*.

Field Performance

Location: Sufficient natural cold is not available in Zones 7b–11. Peach-leaf bellflower does far better in areas of cool summer nights. It performs best on the West Coast and north of Zone 7; production in Zone 7 and warmer results in tall, spindly stems whose quality cannot compete with stems grown further north or from Europe.

Longevity: Plants are long-lived; production continues for at least 3 years. Divide ⅓ of the crop every year.

Spacing: Space plants 12 × 12″ (30 × 30 cm) or as little as 9 × 12″ (23 × 30 cm). Subirrigation is necessary for close spacing. Provide support netting for straight stems.

Forcing: After enough cooling has been provided (see “Environmental Factors”), portable polyethylene frames may be used to raise temperatures for earlier flowering. Work in Holland showed that moveable tunnels used in the winter greatly accelerated flowering, resulting in *Campanula persicifolia* and *C. medium* flowering under the tunnels before the uncovered plants had budded (Wiel 1989). This method can lengthen the harvest time, with little monetary input.

Greenhouse Performance (*Campanula persicifolia*)

Cool crowns for 12 weeks at 40F (4C). The evergreen rosettes are subject to fungal diseases during cooling; using 20–50 fc of incandescent lights for at least 8 hours and applying fungicides during the cold treatment alleviates the problem. Precooled crowns may be planted in 1 gallon (4 l) pots or in ground beds in January at a spacing of 10″ (25 cm) apart, 6″ (15 cm) between rows. Long days (>16 hours) are not necessary but may be applied after cold treatments are completed to produce taller plants (Iversen and Weiler 1989). If greenhouse temperatures are maintained at approximately 60F (15C), flowering occurs about 8 weeks later. If temperatures are 50–55F (10–13C), an additional 1–2 weeks are required. Provide constant fertilization with 75–100 ppm N of a complete fertilizer. Support is necessary for stems of the best quality. Warm temperatures and high nitrogen levels result in tall, spindly plants.

Greenhouse Performance (*Campanula medium*)

With the advent of faster-flowering forms, greenhouse flowering is accelerated. Champion series is grown from seed and, since cold is not required, will flower first year from seed. For single-stem production (best for greenhouse production), plant 4–6″ (10–15 cm) apart; for multiple stems (best for outdoors or cold frame), place 10–12″ (25–30 cm) apart and expect 8–10 stems/plant. Plants should be lit in the winter after 8–10 leaves have emerged with mum lighting from 10 p.m. to 2 a.m. for 6–7 weeks. Approximately 5 months is required from seed to flower at 55–60F (13–15C) (Gillum 2000).

Stage of Harvest

Harvest when 1 or 2 flowers of the inflorescence are open. The best stage of harvest for *Campanula persicifolia* is when the flower buds are colored and considerably swollen (Vaughan 1988); for Champion series, when 2 or 3 buds are open (Gillum 2000).

Postharvest

Fresh: Most species are susceptible to ethylene. Stems persist 8 days in water and 16 days in Carnation Chrysal™, a flower preservative (Blomme and Dambre 1981). Flowers open from bottom to top. Leaves tend to deteriorate before flowers. For Champion series, stems can be stored at 36F (2C) for up to 3 weeks, but 7–10 days is more realistic. The best vase life occurs with 2–6% sucrose solutions; warm water hydration is detrimental (Gillum 2000).

Dried: Flowers do not dry well.

Cultivars (*Campanula persicifolia*)

'Alba' has white flowers and may be seed-propagated.

'Grandiflora' has large, deep blue flowers.

'Moerheimii' bears double, white flowers.

'Telham Beauty', a popular cultivar, produces some of the largest flowers in the species.

Additional Species

Campanula glomerata (clustered bellflower) produces clusters of bell-shaped, violet-blue flowers atop 1–2′ (30–60 cm) stems. Approximately 1/64 to 1/128 oz (0.4–0.2 g) of seed yields 1000 seedlings (Kieft 1996). Cold is also required for flowering. Spacing of 12 × 12″ (30 × 30 cm) is sufficient. Vase life is approximately 9 days in water. 'Acaulis' has pale blue flowers. 'Alba' produces white flowers. 'Joan Elliott' (purple) is a dwarf, vegetatively propagated cultivar that is more suited to the garden than the vase. 'Superba', with large, blue flowers, is among the best cultivars for cut flowers.

Campanula medium (Canterbury bells) has been grown for many years, and new hybrid cultivars, such as the Champion series, have rejuvenated interest. Plants take a long time to flower from seed; some estimates suggest that flowering may require up to a year from seed (Song et al. 1998). Available in a fine range of colors including lavender. Highly recommended by cut flower growers.

Campanula pyramidalis (chimney bellflower) grows to 5′ (1.5 m) tall and is an excellent cut flower. The bell-shaped flowers are clustered together in a pyramidal inflorescence. The species is a lavender-blue but a white form, var. *alba*, is also available. Approximately 1/128 oz (221 mg) of seed yields 1000 seedlings (Kieft 1996). Seed germinates in 3 weeks at 65–70F (18–21C). Plants forced in the field or greenhouse need 11 weeks of cold at 40–45F (4–7C) followed by 15-hour days (Zimmer 1985a).

Pests and Diseases

Aphids should be controlled to reduce problems of sooty mold.

Botrytis and leaf spot can be problems in areas of high summer rains.

Crown rot (*Pellicularia rolfsii*) results in rotting of the crown. It develops under moist soil conditions and warm temperatures. A grayish white discoloration of the base of the stems (*Sclerotinia sclerotiorum*) also occurs, causing plants to decay and fall over.

Sclerotinia rot results in white mold followed by large dark spots on the foliage. The disease usually occurs in humid greenhouses with little air circulation. Similar results occur in dense plantings in the field under rainy weather.

Rust (*Coleosporium campanulae*) can be a serious problem on the underside of *Campanula persicifolia*. The foliage is covered with orange or reddish brown pustules. Leaves dehydrate, and plants are stunted. Other rust-causing organisms are *Puccinia campanulae* and *Aecidium campanulastri*.

Spider mites are worse on plants that are highly fertilized.

Grower Comments

"We have grown 'Champion Blue' for the last 2 years. Plants transplanted to the field in February grew to about 28–30″ in height and started blooming around early April. We found that it was necessary to cut the flowers when they were just opening, as even some partially open flowers did not transport very well. With respect to postharvest, we placed new cuts in Floralife™ and found vase life to be approximately 8–10 days. Our *Campanula* is used for mixed bouquet production." Van Weldon, Wood Duck Farm, Cleveland, Tex.

"I grow *Campanula persicifolia* and have florist customers who love them. I get $7 for a 10-stem bunch. They have an excellent vase life: 10 days to 2 weeks. I use support net; it's not as critical as with some crops, but it will assure nice long, straight stems." Jennifer Judson-Harms, Cricket Park Gardens, New Hampton, Iowa.

"I have been selling *Campanula persicifolia* for 6 years at $7 a bunch to my florists. I treat them as annuals because they don't grow as tall the second year on. I replant plugs every year." Jim Link, Sandgate Flower Farm, Sandgate, Vt.

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Many thanks to Leonard Perry (first edition) and Van Weldon (second edition) for reviewing this section.

Carthamus tinctorius safflower Asteraceae

annual Europe, Asia orange-red 2–3′/2′ (60–90 cm/60 cm)

Safflower has been grown in dry areas of Asia, Africa, and Europe for centuries, for the oil and meal derived from the seeds, and the dye from the flowers. Safflower oil is used in diets for hypertension and heart disease; the meal is fed to livestock; the dye is used in various varnishes and paints. Most published research deals with these economic uses (Veeranna and Rudraradhya 1980, Yazdi-Samadi and Zafar-Ali 1980). Compared to this long agronomic history, the use of safflower for cut flowers is but a blip in time.

Obviously, given all the many safflowers sold over the years, designers and consumers have discerned subtle beauty in each bloom. Beauty is definitely in the eye of the beholder: flowers always seem to appear ragged and bedraggled and in need of tidying up. Not only that, but many of the older cultivars have short spines. And since flowers may be dried, we can be assailed with subtle safflower all year long.

Propagation

Sow seed and cover lightly to permit exposure to light. If placed under mist at 68–72F (20–23C), seed germinates in 10–14 days. Seed are large; approximately 3 oz (84 g) of seed are needed for 1000 transplantable plants (Nau 1999). Seed may be direct sown into the field or bench at the rate of 0.9 oz per 100′ (100 g per 100 m) (Kieft 1996).

Growing-on

Plants should be grown at 65F (18C) night temperature to establish seedlings. Little nutrition is needed at this stage, but fertilization with 50–75 ppm N is beneficial. Plants are ready to transplant to final location in 8–10 weeks. Direct sow seed in early spring, as soon as ground is workable.

Carthamus tinctorius

Environmental Factors

No studies on safflower's responses to the environment could be located. The plants do not appear to have significant photoperiodic responses.

Field Performance

Spacing: If transplanting, space on 6–12″ (15–30 cm) centers.

Shading: In northern areas, grow in full sun. In the South, locate plants in an area of some afternoon shade, or provide approximately 30% shade.

Greenhouse Performance

Plants resulting from seed sown in January can be harvested in early spring (12–16 weeks later). Space transplants as close as 6 × 6″ (15 × 15 cm) or as far as 10 × 10″ (25 × 25 cm). Fertilize with 100–150 ppm N once or twice a week with a nitrate source. Support may be necessary, particularly if a high-density planting is used.

Stage of Harvest

Cut stems when the majority of buds have begun to open and color is clearly visible. If harvested before onset of color, most buds do not open.

Postharvest

Fresh: Flowers persist about one week in water, but the foliage declines more rapidly. With its short vase life and somewhat thorny feel, foliage is often removed at harvest or grading. Plants do not store well, but if storage is necessary, they may be placed in water or preservative at 35–40F (2–4C).

Dried: Flowers may be air-dried.

Cultivars

‘Early Round Leaved’ has rounded leaves and bears 1″ (2.5 cm) wide orange or white flowers on 3–4′ (0.9–1.2 m) stems.

‘Goldtuft’ bears fuzzy golden-orange balls on 2–3′ (60–90 cm) stems. One of the most popular cultivars for cutting.

‘Grenada Orange’ reaches 32–40″ (80–100 cm) in height and is supposedly uniform in germination and harvest time.

‘Lasting Orange’, ‘Lasting Tangerine’, and ‘Lasting White’ are spineless (a definite advantage) and grow 2–3′ (60–90 cm) tall.

‘Orange Ball’ is similar to ‘Lasting Orange’ and also spineless. ‘White Ball’ and ‘Yellow Ball’ are also available.

‘Orange Grenade’ is thornless and not very different from ‘Lasting Orange’ or ‘Orange Ball’. ‘Yellow Grenade’ is almost thornless and can grow 2–2½′ (60–75 cm) tall. Plants produced 7 stems/plant with 19″ (48 cm) stems (Dole 1995). In national trials (Dole 1997), plants of ‘Grenade Mix’ averaged 5 stems/plant with a stem length of 12″ (30 cm).

‘Shiro’ has cream-white flowers that deepen to light yellow as the flowers age.

‘Superior Orange’ averaged 4 stems/plant with a stem length of 23″ (58 cm) (Dole 1999).

‘Tall Splendid Orange’ bears orange-yellow flowers on 3′ (90 cm) stems.

‘Zanzibar’ is a well-branched upright variety, with smaller flowers on 4–5′ (1.2–1.5 m) stems.

Pests and Diseases

Root rots can be a problem in warm climates and poorly drained soils. Aphids are a serious pest.

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Many thanks to Dale Lovejoy for reviewing this section.

Caryopteris ×clandonensis blue beard Verbenaceae

perennial, Zones 5–9 China, Japan blue 2–4′/3′ (0.6–1.2 m/0.9 m)

Caryopteris ×clandonensis is much better known than the annual *C. incana*. Plants are hybrids between *C. incana* and *C. mongolica* and are actually woody shrubs, winter hardy to Zone 5. Flowers range from lavender to dark blue, and numerous cultivars are available. The flowers are not as long-stemmed or as full or whorled as those of *C. incana*, but growers have embraced this crop in recent years. This perennial has terrific potential.

Propagation

Propagation is always vegetative, usually from tip cuttings. Two to 3″ (5–8 cm) cuttings of vegetative shoots may be taken during the summer. Application of low-strength rooting hormones (IBA, NAA) and Hormodin #1™ (1000 ppm IBA in talc) is beneficial. Roots appear in 7–10 days if bottom heat is applied. Plants are also available as plugs from perennial plant nurseries.

Growing-on

See *Caryopteris incana*.

Environmental Factors

See *Caryopteris incana*.

Field Performance

Although they are technically woody shrubs, they may be cut to the ground as soon as spring temperatures warm up. Wait until the sap is beginning to move; cutting to the ground in winter can result in severe plant damage.

Space 15″ (38 cm) apart, with 18–24″ (45–60 cm) between rows. They may grow across each other, but that should not be a problem.

Stage of Harvest

Harvest when buds show color or when the first (lowermost) whorl of flowers is open. Do not allow more than ⅓ of the flowers to open prior to harvesting. Shelf life is similar to *Caryopteris incana*.

Postharvest

A vase life of approximately 10 days is possible; 11 days with STS for 'Blue Mist' was shown by Gast (1997).

Cultivars

'Arthur Simmonds' consists of dull green 1–2″ (2.5–5 cm) long leaves and dark blue flowers on plants 2′ (60 cm) tall.

'Azure' has light blue flowers on a 2½′ (75 cm) tall shrub.

'Blue Mist' has gray-green foliage and light blue flowers.

'Dark Knight' bears the darkest blue flowers of any cultivar. Popular as a cut form and in national field trials, plants averaged 16 stems/plant, with a stem length of 28″ (70 cm) the second year of production (Dole 2000).

'First Choice' has dark green foliage and wonderful dark blue flowers.

'Heavenly Blue' has dark green leaves and deep blue flowers. Seed propagation of this cultivar has resulted in much variation, making it more difficult to distinguish. 'Blue Mist' and 'Dark Knight' may have resulted as sports of 'Heavenly Blue'.

'Kew Blue' resulted from a seedling of 'Arthur Simmonds' and was raised in Kew Gardens. Flowers are a darker blue than 'Arthur Simmonds'.

'Longwood Blue' was selected at Longwood Gardens, Kennett Square, Pa. Plants have silvery foliage, bear sky-blue flowers in late summer, and grow 1½–2′ (45–60 cm) tall.

'Worcester Gold' is easy to distinguish. Grown mainly for its yellow-gold foliage, which contrasts with the average blue flowers. The foliage fades in climates with hot summers but looks wonderful in the spring and early summer.

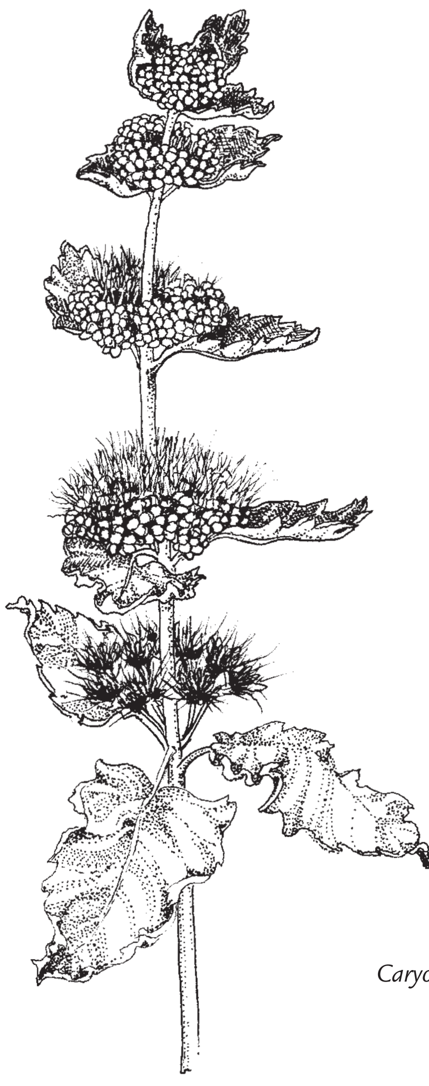
Grower Comments

"It's really popular, easy to sell, and very prolific. More importantly, it has excellent market appreciation [and] ease of cultivation. . . . The market appreciation for the darker blue [cultivars] is higher." Bob Wollam, Wollam Gardens, Jeffersonton, Va.

Caryopteris incana blue spirea Verbenaceae

annual China, Japan blue 2–4′/3′ (0.6–1.2 m/0.9 m)

Plants remain little known, and although we still believe they are quite useful, the market will decide. Plants produce many stems of whorled, lavender-blue flowers and dark green foliage. Flowers are produced in late summer and fall and make fine cut flowers both in the field and the greenhouse. These may still be listed (incorrectly) as *Caryopteris ×bungei*. *Caryopteris incana* is used in traditional Chinese medicine to treat coughs, colds, and rheumatic pains; researchers aim to find the active components (Gao and Han 1997).



Caryopteris incana

Propagation

Seed: Seed sown at 70–75F (21–24C) under high humidity or intermittent mist germinates in approximately 12 days. Transplanting seedlings is most common, but seed may also be direct sown. Approximately 0.03 oz (0.9 g) of seed yields 1000 plants (Nau 1999).

Cuttings: Two to 3″ (5–8 cm) cuttings of vegetative shoots may be taken during the summer. Application of low-strength rooting hormones (IBA, NAA) and Hormodin #1™ (1000 ppm IBA in talc) is beneficial. Roots appear in 7–10 days if bottom heat is applied.

Growing-on

Grow seedlings in low-density plugs, cell packs, or 3″ (8 cm) pots. Fertilize with 50–75 ppm N using calcium nitrate for the first 2–3 weeks followed by 100–150 ppm N of a complete fertilizer. If produced in plugs, allow 5–7 weeks before planting out.

Environmental Factors

Photoperiod: Work at the University of Georgia showed that *Caryopteris* flowers under all photoperiods; however, plants flowered faster under short days (8 hours) than long days (16 hours). Plants were intermediate in their flowering response when grown in 12-hour photoperiods, as the following table shows.

The effect of photoperiod on flowering and stem length of greenhouse-grown *Caryopteris incana*.

Photoperiod (hours)	Days to flower[z]	Stem length (in)[y]
8	72	12.9
12	92	16.6
16	>100	15.3*

z = time from beginning of photoperiod treatment
y = multiply (in) by 2.54 to obtain (cm)
* = measurement taken on 100th day; stem had not flowered

Although the experiment was terminated after 100 days, plants eventually flowered even under long days.

Light intensity: In areas of hot summers and high light intensities, flower stems are longer and less brittle when grown under approximately 55% shade compared to full sun (Armitage and Son 1992). Flowers also have a longer vase life when provided with some shade (see table at "Stage of Harvest").

Temperature: Plants grow rapidly under temperatures of 70–85F (21–29C). Temperatures below 55F (13C) and above 85F (29C) reduce growth and flowering.

Field Performance

Plants yield high numbers of flower stems, but as with many other annuals, subsequent plantings provide high-quality flowers for a longer period of time. Two to 3 successive plantings, approximately 4 weeks apart, have been quite successful.

Yield: On a single planting scheme, crops grown at the University of Georgia trials produced approximately 48 marketable stems/plant with an average stem length of 25.8″ (65.5 cm). Plants were grown at 12 × 12″ (30 × 30 cm) spacing and in both shade and sun.

Shading: In warm, bright summer climates, such as Zones 7–10, the addition of 50–60% shade results in longer, less-brittle flower stems, although no differences in yield occur regardless of shade or sun. At Georgia, both shaded and sun plants yielded approximately 50 stems/plant, but stem lengths were 23″ (58 cm) and 19″ (48 cm), respectively. In the field, it is doubtful that return on investment of shade structures would be strong enough to warrant their use. Shade is not necessary anywhere, and certainly not in areas of cooler summer temperatures. The slight increase in stem length is not sufficient to overcome the potential for weaker stem strength. In the Deep South, however, shade may be useful.

Lateral breaks: For growers planting a single season-long crop, the method of harvest can be a puzzle. Like many other crops, the main stem produces many lateral stems, all of which produce a flower. The dilemma for the cutter is whether to cut the long main stem and sacrifice the laterals, or cut a shorter main stem to allow some of the laterals to flower for subsequent harvest. The former method yields longer but fewer stems; the latter results in many more but shorter stems. The decision must be based on acceptability of certain standards for stem length and is determined by the market. The following table provides an example of the differences between harvesting techniques. If planting successive crops, this discussion is moot, as only the terminals are taken before plants are removed.

The effect of harvesting methods on *Caryopteris incana*. Single planting of 40 plants used for each treatment.

Harvesting method	No. of stems^z	Stem length (in)^y
1. Whole stem cut from base	40	30.8
2. Short terminal cut only, then one	40	16.5
harvest of subsequent laterals	261	22.5

z = from one harvest only (over 1000 lateral stems were harvested from test plants over the season)
y = multiply (in) by 2.54 to obtain (cm)

More labor and time are necessary to harvest by method 2, and market price must dictate its feasibility. In general, more full stems (method 1) are harvested in the "real world" for this and other crops that produce many lateral branches. It is simply a matter of labor.

Greenhouse Performance

Little work has been attempted with this crop in the greenhouse, but preliminary results indicate that plantlets, plugs, or cuttings should be spaced 9–12″ (23–30 cm) apart in well-drained soils. Plants should be grown under long days (>16 hours) until they are 2–2½′ (60–75 cm) tall, then transferred to short days (<12 hours). Such photoperiods are difficult to attain without the use of lighting and blackout material, and such expense may not be warranted. For a winter crop, start seedlings in late summer or early fall while days are still long, then natural short days will occur. Even without photoperiodic manipulation, however, flowering will still occur. Fertilize with 150–200 ppm N every other irrigation, and support plants with greenhouse netting as needed. Preliminary studies in Georgia yielded 40 stems/plant over 3 harvests.

Guideline for Foliar Analyses

At field trials in Athens, Ga., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Numbers are the average of sun- and shade-grown plants and are based on dry weight analysis.

(%)				
N	P	K	Ca	Mg
3.0	0.21	1.47	1.00	0.16
(ppm)				
Fe	Mn	B	Al	Zn
125	80	15	42	57

Stage of Harvest

Stems should be harvested when buds show color or when the first (lowermost) whorl of flowers is open. Later harvesting reduces vase life by approximately 3 days. Once cut, the stem continues to grow, and flowers continue to develop.

Postharvest

Fresh: Stems persist 7–10 days in water and an additional 2–3 days in preservative.

Storage: Stems may be stored at 34–40F (1–4C) for 3–5 days. Stems must be rehydrated immediately after shipping.

Dried: Stems may be air-dried by hanging upside down in a warm well-ventilated area for 7–10 days.

Pests and Diseases

Root rot fungi (*Pythium*, etc.) can be a problem, but no diseases or pests are unique to *Caryopteris*.

Grower Comments

"We grew *Caryopteris incana* . . . with mixed results. On the one hand, it is very prolific and easy to grow, and it blooms in late season when customers are clamoring for something new. It was great in bouquets but wasn't a big seller on its own. Florists were lukewarm about it, and by the time they got used to using it, the bloom time was over. I would consider growing it again, but it is so prolific we don't need a whole 100′ bed of it next time." Tammy Ford, Perennial Favorites, Leopold, Ind.

"Although I still grow [*Caryopteris incana*] and sell it to the florists, it has limited appeal, and therefore I do not grow very much (only one 80′ bed out of 4 acres). . . . One point that I always found interesting about growing this plant is that some small percentage (maybe 5%) are pink rather than blue, and I have periodically seen a few with white whorls." Bob Wollam, Wollam Gardens, Jeffersonton, Va.

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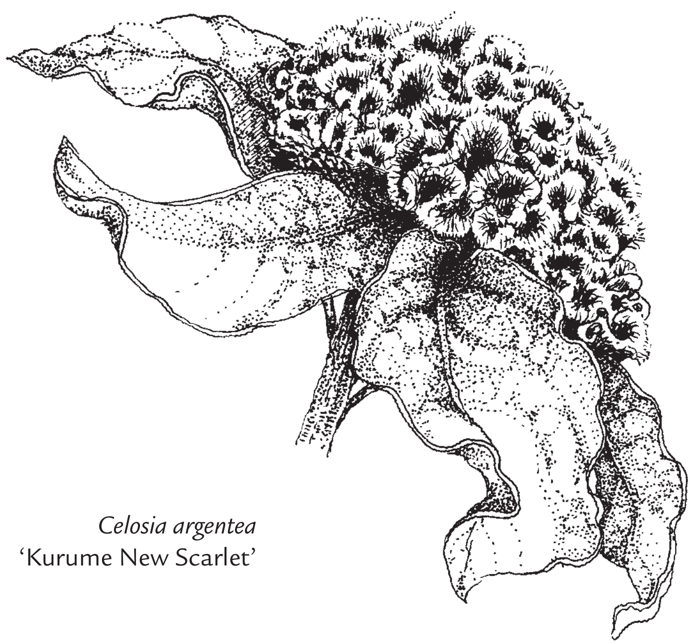
Many thanks to Mindy Storm (first edition), for her help in preparing the material for this crop, and to Bob Wollam (second edition) for reviewing this section.

Celosia argentea cockscomb Amaranthaceae

annual hybrid origin many colors 2–3′/2′ (60–90 cm/60 cm)

Celosia has longed been recognized for its stunning flowers; the name comes from the Greek *keleous* ("burning"), an allusion to their brilliance. While everyone knows what a celosia is, taxonomists, horticulturists, and growers alike have been confused as to how to group the various forms of celosia. All ornamental forms are *Celosia argentea* var. *cristata*, which itself encompasses 4 groups. The most recognizable is the Cristata Group (common cockscomb), whose distorted flower heads make one stare in fascination or in stunned silence. Students remember them more easily when they're referred to as colored brains. The second most common form is the Plumosa Group (prince of Wales feather), with feathery (plumose) spike flowers; they provide a more civilized look and are available in a variety of heights and flower colors. The Spicata Group (wheat celosia) consists of plants that are generally about 3′ (90 cm) tall with long feathery flowers; the silvery rose flowers, borne in slender spires, have become a major flower in the fresh market. Sometimes marketed as flamingo flower, plants are excellent fresh but dry poorly. The Childsii Group is not common in horticultural circles but is characterized by globose heads of flowers; short in stature, they're only occasionally used as cut flowers.



Celosia argentea
'Kurume New Scarlet'

Propagation

Seed count varies with the form, from 34,000 to 39,000 seeds/oz (1200 to 1400 seeds/g). There is a good deal of variability in seed size and germination, even within the various groups. Approximately 0.03 to 0.06 oz (0.9–2 g) of seed yields 1000 seedlings (Nau 1999). Sow seed lightly, and place at 72–80F (22–27C) under mist. Seed has an absolute requirement for light, although light intensity can be very low (Sanjay and Amritphale 1996). Germination should occur in 2–3 days; if you don't see seedlings by 10 days, throw seed out. Direct seeding in the field is not recommended for first planting; it should be done only when temperatures are above 70F (21C). Best accomplished for subsequent plantings.

With the Spicata Group, seeds are occasionally direct sown; 0.13 oz per 100′ (15 g per 100 m) is recommended (Kieft 1996).

Growing-on

Grow seedlings at 62–68F (17–20C) night temperatures and long days (>12 hours). Long days occur in spring, and sowing in early winter—especially if greenhouse temperatures are low—may result in premature flowering. If this is a problem, hanging incandescent lights will help. Do not allow seedlings to dry out. Fertilize with 100–150 ppm N once or twice a week. Plants may be transplanted to the bench or field 4–6 weeks after sowing; however, do not allow plants to become root bound. Celosias do not recover well from stress, and stressing the roots results in poor-quality plants.

Environmental Factors

Photoperiod: *Celosia* is a quantitative short day plant, meaning that although it will flower at any photoperiod, it flowers faster under photoperiods of 14 hours or less (Armitage 1985, Porat et al. 1995). Four to 5 weeks of short days are necessary for most rapid flowering. After 4 weeks, plants may be placed in long days with no detrimental effects of rate or quality of flowering.

Some growers have noted fasciation (deformity in the flowers, and the broadening and flattening of the flower stem at the base of the flower) in *Celosia*, particularly the cockscomb forms. Long days appear to have an influence on fasciation. In one study, 69% of the plants subjected to photoperiods 16 hours or longer produced fasciated stems, whereas only 3% of plants grown at 8-hour photoperiods developed fasciated stems. Those grown under 12-hour conditions were intermediate in their response (Driss-Ecole 1977, 1978). Genetics also plays a role, and since little can be done to change long days in the field, stay away from cultivars highly sensitive to fasciation (unless you like the effect). Unfortunately, such data are not known.

Temperature: Temperature plays a significant role in flowering. Once plants are established, warm temperatures result in faster flowering than cool temperatures (Porat et al. 1995). Temperatures below 50F (10C) result in a significant delay of flowering compared with 80F (27C).

Field Performance

Successive plantings are recommended for crops of the highest quality. Plant transplants in the field as soon as the threat of frost has passed, then plant additional crops 3–4 weeks apart.

Spacing: Plants may be transplanted to a 6 × 6″ (15 × 15 cm) spacing if grown as a single-harvest, single-stem crop. This results in the longest stem lengths, but plants must be planted sequentially for full-season harvesting. Plants may also be grown on 12″ (30 cm) centers, 8 × 12″ (20 × 30 cm), or as far as 18″ (45 cm) apart if plants are to be harvested continuously (single planting only).

Harvesting: Flowers are harvested from early July through late September in most of the United States. The highest percentage of long stems are harvested early in the season.

Yield: Yield is cultivar-dependent. The yield and average stem length for several cultivars follow; only 'Tall Rose Chief' was unsatisfactory in these trials, conducted in Georgia. Plants were on 1′ (30 cm) centers; data indicate multiple harvests on a single planting.

Yield and stem length of *Celosia* Chief series (Cristata Group).

Cultivar	Stems/plant	Stems/ft^{2z}	Stem length (in)^{y}
Carmine Chief	20	14	18.9
Fire Chief	14	11	16.7
Gold Chief	17	12	22.6
Tall Rose Chief	5	3	14.4

z = multiply (stems/ft^2) by 10.76 to obtain (stems/m^2)
y= multiply (in) by 2.54 to obtain (cm)

At the University of Kentucky (Utami et al. 1990), an average of 4.5 stems/ft^2 (48 stems/m^2) were harvested 8–9 weeks after transplanting when 'Red Chief', 'Gold Chief', and 'Fire Chief' were grown as a single-stem crop. In the same work, production for the whole season averaged 12 stems/ft^2 (129 stems/m^2) from crops planted 6″ (15 cm) apart. Over 60% of the stems were 18″ (45 cm) or longer.

Greenhouse Performance

Space plants 8 × 8″ (20 × 20 cm) or on 12″ (30 cm) centers. Use of support netting is desirable. Initially, place plants under 2–3 weeks of long days (>16 hours) and then grow under short days (<14 hours) at 60–62F (15–17C) night temperatures. This is easily accomplished during winter months, when prices are higher. Long days should be applied initially, or plants may flower prematurely on short stems. For best-quality stems, replant every 2–4 weeks. Fertilize with calcium nitrate or potassium nitrate at the rate of 150–200 ppm N with every irrigation. Leach thoroughly every fourth to fifth irrigation.

With the Plumosa Group, Porat et al. (1995) found that pinching seedlings, then maintaining them under LD for the first 3 weeks, prior to SD, increased the number of marketable flowering stems and resulted in inflorescences of desirable length and sufficient quality. According to Ralph Cramer, similar results occur with 'Cramers' Rose Shades' and 'Cramers' Burgundy': that is, pinching results in longer laterals. Pinching appears to be cultivar-dependent, shown by research in Germany where pinched plants of the Cristata Group produced greater yield but smaller inflorescences (Papenhagen 1990). Try pinching some of your plants to determine your preference.

Guideline for Foliar Analyses

At field trials in Athens, Ga., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis.

'Red Chief'

(%)				
N	P	K	Ca	Mg
3.9	0.43	5.06	2.86	1.36
(ppm)				
Fe	Mn	B	Al	Zn
189	261	23	96	182

Stage of Harvest

Flowers should be fully developed on crested forms and 90–100% developed in the plumose form.

Postharvest

Fresh: Flowers of the crested form persist significantly longer than the plumose form. The foliage on both declines rapidly and should be removed as it wilts. A minimum of 7 days may be expected for flowers of *Celosia*. Research conducted in Pennsylvania suggested that flowers of 'Red Rocket' (a crested form) persisted 16 days in tap water and 23 days in distilled water. If 1% or 3% Florever™, a floral preservative, was used, flowers persisted for approximately the same time; if a 0.5% solution was used, they had a vase life of only 9 days (Holcomb et al. 1998). If necessary, flowers may be stored for a few days at 36–41F (2–5C).

Dried: Flowers may be air-dried. Strip foliage and hang upside down in small bunches. The crested form is more popular for dried use than the plumose form. Some growers are doing a good job with Spicata Group cultivars, despite the fact that wheat celosias tends to shatter when dried. Roberts et al. (1998) designed a drying chamber for celosia in which hot air is passed around the hanging flowers and is either exhausted, partially exhausted, or recirculated, controlled by a humidistat. They calculated that over 36,000 bunches of 3- to 10-stem units were dried at a cost of $0.03 per bunch for both fuel and electricity and that waste was reduced from 10% to 0.25%.

Cultivars

Childsii Group (globose forms)

The few cultivars in this group are usually listed as plumosa forms.

Sparkler series bears strong flower stems in many colors. Space closely together for single-stem cut flowers. Carmine, cream, orange, red, yellow, and mixtures are available.

Cristata Group (crested forms)

Bombay series is suitable for greenhouse production, with rapid crop times reported. The flowers are flat, triangular combs atop 24–40″ (60–100 cm) stems. 'Bombay Purple' and 'Bombay Yellow Gold' are Fleuroselect Quality Mark winners. Dark red, velvet, and salmon are also available.

Chief series gained great popularity in the 1990s and was the ASCFG's 2002 Dried Cut Flower of the Year. Flowers are available in red, scarlet, cherry, yellow, gold, and a mix. The red and scarlet strains are more vigorous than other colors. 'Chief Gold' is known for its tall multiple stems; 'Chief Persimmon' has an excellent orange-salmon color and is useful for late summer and fall cropping. Plants grow 2–3′ (60–90 cm) tall. Netting is beneficial but not necessary.

'Cramers' Rose Shades' and 'Cramers' Burgundy' were highly ranked by most growers in the 1997 ASCFG cut flower trials. These should be pinched for longer stem length. Dense direct sowing can also result in tall single-stem plants.

'Fireglow' is suitable for fresh or dried production, with large, deep red crests. Stems are 20–24″ (50–60 cm).

Kurume Strain is 2–3′ (60–90 cm) tall and available in separate colors and a mix. 'Kurume Red Orange' is short but is popular for fall sales. Plants with scarlet flowers are available with either bronzed or green foliage. 'Kurume New Scarlet' was well liked by trialers in 2000 outdoor trials.

'Madras Scarlet' bears many flowers, with the laterals and primaries forming almost simultaneously. Color is an intense red scarlet.

'Prestige Scarlet' has green-bronze foliage and 24″ (60 cm) stems.

'Red Velvet' bears some of the largest flower heads we have seen. The deep crimson heads are at least 10″ (25 cm) across on 2–3′ (60–90 cm) stems. This could be a lethal weapon in the wrong hands. Flowers are excellent for drying.

'Super Crest' was given this singular description: "true giant size cockscomb head but also can boast of a tall, rigid stem." The longer the plants go uncut, the larger the comb size.

Temple Belles series is about 3′ (90 cm) tall, with combs 6–8″ (15–20 cm) wide. 'Temple Belles New Scarlet', 'Temple Belles Dark Rose', and a mix are offered. Ann Trimble from Princeton, Ky., is pleased with the performance of 'Temple Belles' and says that if a broader range of colors becomes available, they may replace the Chief series on her farm.

'Toreador Red' carries large crimson combs on 18–20″ (45–50 cm) stems.

Plumosa Group (plumose forms)

'Apricot Brandy' has large plumes of apricot flowers and performs well in most areas of the country. Plants were developed for use as bedding plants, but the 1.5–2′ (45–60 cm) stem length may be sufficiently long for most cut flower operations.

Century is a basal-branching series with 18–24″ (45–60 cm) stems and 8–12″ (20–30 cm) flower plumes. 'Century Red' is outstanding.

'Forest Fire' bears dense, scarlet plumes atop 2½′ (75 cm) stems. 'Forest Fire Improved' has a longer flowering time and larger plumes than 'Forest Fire'.

Pampas Plume Mix is approximately 3′ (90 cm) tall. Available in shades of yellow and red and gold. Better as a fresh product than a dried.

'Red Fox' has 2′ (60 cm) stems with brilliant carmine plumes.

'Toreador' bears bright red flowers on 2′ (60 cm) tall plants.

Spicata Group (spired forms)

Because of shattering, drying is not recommended, although stems are seen in the dried market.

'Amazon', also from Cramers' Posie Patch, performed well in ASCFG seed trials in 1997. Trialers noted less shattering than other varieties and "millions of blooms." Pinching is recommended. Beautiful plants!

'Enterprise Dark Pink' has a bright pink central plume surrounded by smaller plumes, forming a 6–8″ (15–20 cm) spike. Recommended for greenhouse production as well as for field production in warm climates. 'Enterprise White' bears a central inflorescence of white flowers, surrounded by lateral flowers.

'Flamingo Feather' ('Pink Tassles') has light pink flowers, which sometimes fade to white under high heat. In its introduction, plants grew 3–3½′ (0.9–1.1 m) tall and received some of the highest ratings in trials held across the United States in 1992.

'Flamingo Purple' ('Purple Tassles') is slightly bushier and produces dark foliage and flowers. However, plants don't flower until late summer. Reseeds with gusto.

'Hi-Z' is another introduction from Ralph Cramer of Elizabethtown, Pa. In the 2000 ASCFG trials, evaluators found it easy to grow and "everyone liked it."

'Startrek Rose Pink' did well in 2000 outdoor trials, providing excellent color on 15″ (38 cm) stems.

National field trials

Celosias have been evaluated since the inception of the ASCFG's national trials in 1994. The following table (Dole 1995–2001) is a summary of the average stem lengths and yields of celosias submitted for trialing. These data are averages over a wide geographical range and must be viewed as guidelines only; individual experience may differ significantly.

Cultivar	Year of trial	Stem length (in)^{z}	Stems/ plant
Bombay Purple	1996	16	4
Chief Mix	1994	18	7
Cramers' Amazon	1997	24	39
Cramers' Burgundy	1997	15	7
Cramers' Rose Shades	1997	17	9
Enterprise Wine Red	2000	17	8
Hi-Z	2000	25	12
Kurume New Scarlet	2000	20	6
Pink Candle	1994	17	12
Sparkler Carmine	1994	13	7
Sparkler Cream	1994	11	7
Sparkler Formula Mix	1995	13	12
Sparkler Orange	1994	13	9
Sparkler Red	1994	13	6
Sparkler Wine	1995	20	13
Sparkler Yellow	1994	13	7
Startrek Rose Pink	2000	16	7
Super Crest Burgundy	2000	30	2
Super Crest Mix	2000	26	3
Temple Belles Dark Rose	2000	17	7

z = multiply (in) by 2.54 to obtain (cm)

Pests and Diseases

Botrytis occurs on the flower head in the field during warm, humid conditions or after considerable rainfall. This is particularly true of the crested forms, whose flowers are so tightly produced that water is trapped within the inflorescence.

Leaf spots (*Cercospora*, *Phyllosticta*, *Alternaria*) on the foliage occur more readily during wet seasons. General-purpose fungicides are useful in their control.

Grower Comments

"We harvest 'Amazon' celosia as soon as 10 stems make an acceptable bunch. Wait longer for drying, but don't let it go beige." Ralph Cramer, Cramers' Posie Patch, Elizabethtown, Pa.

"We really love celosias, so we are growing a lot of varieties. My favorite is 'Hi-Z'—we have been cutting on the first planting for a while, although we have been replanting every couple of weeks. I took several samples of various things to a florist; she called back for 'Hi-Z'—she wanted to substitute it for heather." Lynette Lowrance, Broken Gate Farms, Bay City, Tex.

"In western Kentucky, 'Chief Gold' is the strongest-growing celosia. Gold is capable of producing multiple stems of tremendous size at the same time." Ann Trimble, Trimble Field Flowers, Princeton, Ky.

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Many thanks to Bob Anderson (first edition) and Ralph Cramer and Ann Trimble (second edition) for reviewing this section.

Centaurea cornflower Asteraceae

annual/perennial

Centaurea consists of many species with fine cut flower characteristics. *Centaurea* was named for centaurs, the half-man, half-horse creatures of Greek mythology, and sometimes we think a similar mixup occurs with the crop itself. The genus combines a mixed bag of annual and perennial species. Annuals include *Centaurea americana* (American basket flower), *C. cyanus* (bachelor's buttons), and *C. moschata* (sweet sultan) (the scientific name for this last species is now *Amberboa moschata*, but it will be a good number of years before we stop thinking of it as a centaurea, so for now, that is where we will leave it). The perennials *C.*

macrocephala (golden basket flower) and *C. montana* (mountain bluet) are also suitable for cut flowers.

In the eastern half of the country, *Centaurea cyanus* has escaped to clothe the roadsides in a mantle of blue and grows more aggressively than other annuals in the genus. In the Northwest, northern California, and the Northeast, few production problems with any species should be encountered.

All species have small, brown to black bracts at the base of the flower bud, a handsome characteristic that further enhances the cut flower possibilities.

Centaurea americana, *C. cyanus*, *C. moschata* Asteraceae

annual Europe many colors 2–4′/2′ (0.6–1.2 m/0.6 m)

Propagation

Greenhouse: Sow in seed flats or directly to the cutting bench (for greenhouse production). Optimum germination occurs at 60–65F (15–18C) and when seed is covered by ¼ to ½″ (6–13 mm) of medium. Seedlings emerge in 7–14 days under proper germination conditions.

Direct sowing: Seed may be sown directly in early spring, but germination is delayed until temperatures rise. Seed should be covered lightly. Germination occurs in approximately 10 days at 65–75F (18–21C). The various species should be sown at the rates given in the following table (Kieft 1996, Nau 1999).

Species	Direct sown oz (g)/100'	Transplants oz (g)/1000 plants
Centaurea americana	0.5 (15.3)	1.0 (28.4)
Centaurea cyanus	0.3 (9.2)	0.5 (14.2)
Centaurea moschata	0.4 (12.2)	0.5 (14.2)

In Florida and California, seed sown in the open field in fall flowers from February to June. Seed direct sown in early spring in the Midwest and Southeast results in flowering from June to September.

Growing-on

Although most seed is direct sown, many growers transplant seedlings to the field. Transplant seedlings to small containers or place plugs in field when danger of frost has passed.

Plants respond best to short days followed by long days. Planting in early spring generally provides such conditions, but if plants are started in July or August, the lack of natural short days results in short plants, rapid flowering, and low yield. If possible, apply SD for 4–6 weeks prior to putting them in the field.

Environmental Factors

Most of the research on *Centaurea* has been with *Centaurea cyanus*. It is likely, however, that similar results occur with *C. americana* and *C. moschata*.

Photoperiod: *Centaurea* is a long day plant (Laurie and Poesch 1932). Long days are needed for flower induction, but, once induced, flowering continues even under short day conditions, although the rate of flower development is delayed. Approximately 3 weeks of LD are necessary (Kadman-Zahavi and Yahel 1985). Plants flower equally well if provided with nightbreak lighting (30 minutes of light in the middle of the night) or if the daylength is extended to provide a 15-hour day. Since plants are sensitive to LD even in the seedling stage, it is important that they should be provided with SD at the start of production to permit basal branching and a larger plant. Plants grown entirely in LD elongate rapidly, produce few flowers, and can die (Post 1955).

Temperature: Vernalization does not appear to have a significant effect on flowering; however, the literature is somewhat contradictory on this point. One study showed that exposing the seedlings to 10 days of temperatures at 38–50F (3–10C) resulted in a slight acceleration of flowering under LD, but not SD, conditions (Listowski and Jasmanowicz 1973).

Gibberellic acid: GA sprays greatly increase stem elongation but have no effect on flowering, regardless of daylength (Kadman-Zahavi and Yahel 1985). Use caution when applying GA; it can cause flower distortion.

Field Performance

Centaurea cyanus may be produced throughout the country; its flowers are harvested from June to September in the northern tier of states, as early as mid May in the Southeast, and in the winter and spring in California and Florida. The summers are too hot and winters too cold for successful year-round production of *C. americana* and *C. moschata* in Zones 7 and 8.

Spacing: Space seedlings on 6–9″ (15–23 cm) centers.

Yield: *Centaurea americana*, grown in single-planted, multiple-harvested field trials in full sun at the University of Georgia, produced 11–15 stems/plant with an average stem length of 37.8″ (94.5 cm). Stem diameter was approximately ¼″ (6 mm).

Centaurea cyanus produces about 5–12 flowers with an average stem length of 15″ (38 cm). Stems are strong and make excellent cut flowers.

Centaurea moschata, also grown at the University of Georgia in full sun (single planting, multiple harvests), produced 5–8 stems/plant with an average stem length of 18″ (45 cm); the cultivar tested was 'The Bride'. Stem length was unsatisfactory under Georgia conditions, suggesting that field production in areas of hot, humid summers is likely uneconomical. Work done in India showed that flower and seed yields were highly suppressed by deficiencies in nitrogen and phosphorus (Pal and Jana 1997); side dressing with a complete fertilizer in spring will alleviate any problems.

Shading: Cornflowers do best in full sun, even in hot areas of the country. With *Centaurea cyanus*, experiments showed that plants with the greatest southern exposure produced significantly more flowers than plants in rows with a more northerly exposure. Mutual shading results in reduced flowering (Yahel et al. 1972).

Work at the University of Georgia with *Centaurea americana* (see following table) also showed reduced flowering and little difference in stem length when plants were shaded.

The effect of shade on yield and stem length of *Centaurea americana*.

Shade level (%)	Stems/plant	Stem length (in)[z]
0	13.1	38.3
55	7.3	54.0
68	3.0	47.1

z = multiply (in) by 2.54 to obtain (cm)

In more recent field trials of 'Jolly Joker' (Dole 1999), growers reported stem lengths averaging 24.9″ (62.3 cm), with 6.5 stems per plant. Plants performed well under drought conditions, but some lygus bug damage was reported.

Greenhouse Performance

Plants should be grown for 8–12 weeks under SD (winter) conditions or until plants are large enough to support flower development. Maintain temperatures of 50–55F (10–13C). Plants should be fertilized with 100–150 ppm N; do not overfertilize, as plants may become too leafy and lax.

After SD, provide 15- to 16-hour LD either by extending the daylength or by giving a nightbreak for at least 30 minutes. Many growers use 4 hours of nightbreak (11 p.m. to 2 a.m.) with 10–15 fc of incandescent lighting. The following table (Post 1942) shows the effect of temperature and LD provided from October to March; plants were started in August.

The effect of temperature and night lighting on *Centaurea cyanus*.

Temperature	Photoperiod	Flowers/stem
50F (10C)	LD[z]	36.2
50F (10C)	SD	10.4
55F (13C)	LD	67.8
55F (13C)	SD	9.6
60F (15C)	LD	77.8
60F (15C)	SD	34.0

z = all LD provided after 8–10 weeks of SD

The lowest temperature for best flowering is 55F (13C), and the use of long days is essential.

Scheduling: For mid March flowering of *Centaurea cyanus*, sow seed in mid September. For May flowering, sow in early January. Other species may require more time in the greenhouse. If long stem length is not important, Bob Anderson's work describing the fast production of short-stemmed crops, including *C. cyanus*, may be of interest. Seedlings were transferred to 4″ (10 cm) pots at a spacing of 9 plants/ft^2 (100 plants/m^2) and placed under 24-hour HID lighting of 100 $\mu mol m^{-2} s^{-1}$. Ninety percent of the flowers were harvested 14–21 days later. Stem length was 14–20″ (36–50 cm). The system also utilized ebb and flow watering and recirculated nutrient solution (Anderson 1990).

For *Centaurea moschata*, research in Romania showed that yields in the greenhouse were greatest for early sowing or transplanting (11–15 February) compared to later propagation dates. Up to 29 stems/ft^2 (310 stems/m^2) occurred in this work, and time to flower for transplanted seedlings was approximately 15 weeks (Selaru and Drăghici 1989).

Stage of Harvest

All cornflowers should be harvested when flowers are ¼ to ½ open. In the case of multiple flowered stems (i.e., sprays), the uppermost flower may be ¾ open.

Postharvest

Fresh: Flowers persist 6–10 days. They may be stored at 35–41F (2–5C) for 2–3 days, but long-term storage is not recommended.

Dried: Flowers may be air-dried. The fully double forms are best for drying. Retain foliage and hang upside down in a warm, dark area.

Cultivars

Centaurea americana (American basket flower)

'Aloha' has 3″ (8 cm) wide, lilac-rose flowers on 3–4′ (0.9–1.2 m) stems. A white form, 'Aloha Blanca', is also available.

'Jolly Joker' bears 3″ (8 cm) wide, lavender flowers on 4′ (1.2 m) stems. A popular cultivar—some customers appreciate the handsome buds more than the handsome flowers.

'Rose' and 'White' are also listed.

Centaurea cyanus (bachelor's buttons)

Single-flowered:

'Emperor William' is 2–3′ (60–90 cm) tall with marine-blue flowers.

Double-flowered:

Boy series is approximately 3′ (90 cm) tall and most popular for cut flowers. 'Blue Boy' bears light blue flowers, 'Black Boy' has blackish maroon blossoms, and 'Red Boy' produces carmine-red flowers.

Florence series is well-branched, with 18–20″ (45–50 cm) plants. Colors are blue, lavender, pink, red, violet, white, and a mix. Plants are shorter than the Boy series.

Frostie Mix ('Frosted Queen') bears flowers of various colors with petals fringed with white. Plants grow to about 30″ (75 cm) in height.

'Jubilee Gem' has sky-blue flowers but is only about 16″ (40 cm) tall.

'Pinkie' has bright pink flowers.

'Snowman' has creamy white flowers.

Centaurea moschata **(sweet sultan)**

'Antique Lace' grows approximately 2′ (60 cm) tall and bears flowers in pastel shades of pink, lilac, and lavender.

Imperialis Mix offers lavender, lilac, pink, purple, rose, yellow, and white flowers on 2–2½′ (60–75 cm) stems.

'Lucida' has dark red flowers.

var. *suaveolens*, whose correct name is var. *flava*, is often listed as a separate species (*Centaurea suaveolens*). With canary-yellow flowers and stems approximately 2′ (60 cm) tall.

'The Bride' is a 18–24″ (45–60 cm) tall plant with fragrant, clean white flowers.

Pests and Diseases

Aster yellows, spread by leafhoppers, causes one side of the plant to become yellow and flowers to become greenish. Eradicate infected plants and rotate crops.

Botrytis results in desiccation of the tips of some stems and flower buds. Additional air circulation is necessary.

Downy mildew (*Bremia lactucae*) results in pale green to red, irregular spots on the upper side of the foliage and soft, moldy growth beneath. Infected plant parts generally collapse and die. Young plants are particularly susceptible. Remove and destroy infected leaves. Control with wider spacing, better aeration, and appropriate spray solutions.

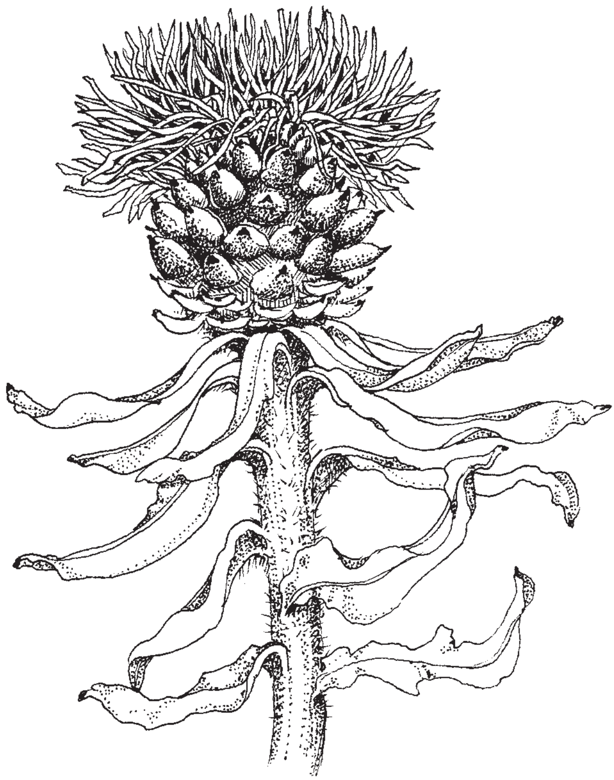
Stem rots caused by *Phytophthora*, *Sclerotinia*, and *Pellicularia* result in significant losses, particularly in cold, waterlogged soils. Use clean soils and sterilized containers.

Aphids and leafhoppers are the worst insect pests of most species of cornflower.

Centaurea macrocephala golden basket flower Asteraceae

perennial, Zones 2–6 Caucasus yellow 3–4′/3′ (0.9–1.2 m/0.9 m)

Golden basket flower, a large-leafed plant, produces abundant large, bright yellow flowers that are particularly useful dried. Common in European markets, they find their way to this country mainly as imports. *Centaurea macrocephala* is a well-known garden plant, and cut flowers have been enjoyed by the home gardener for many years.



Centaurea macrocephala

Propagation

Seed: Germinate under high humidity and 68–72F (20–22C) soil temperature. Research has indicated 86% germination in 5–10 days under the above conditions (Pinnell et al. 1985). Most plants are transplanted to the field, and about 2 oz (56 g) of seed yield 1000 seedlings (Nau 1999). Although transplants are generally more successful, some growers direct sow; a volume of 0.7 oz (20 g) of seed per 100′ (30.5 m) is recommended (Kieft 1996).

Division: Plants may be divided in spring or fall.

Growing-on

Seedlings and small divisions should be transplanted to large cell packs or 4″ (10 cm) pots as soon as they can be handled. Grow at 50–65F (10–15C); avoid temperatures above 75F (24C). Fertilize with 100–150 ppm N from a complete fertilizer; do not exceed 200 ppm N.

Environmental Factors

Temperature: The need for cold in the perennial species of *Centaurea* is not well established. For *Centaurea macrocephala*, cold is likely beneficial if not absolutely necessary.

Photoperiod: Most *Centaurea* species appear to be LD plants and flower more rapidly under daylengths of 14 hours or more; golden basket flower is likely similar.

Field Performance

Location: Plants are more productive and flowers are of a superior quality when grown in areas of cool nights and bright days. Field production is best north of Zone 7. Research results at the University of Georgia, which sees excessive summer temperatures and humidity, have been disappointing.

Longevity: Plants are long-lived perennials. Once established, 3–5 years of production is possible. Production of crops planted from seedlings or small divisions in the fall will be negligible the first season; production peaks in the second to third year from planting.

Spacing: Plants are large and require sufficient space to reduce insect and disease pressure. Space plants 18–24″ (45–60 cm) apart.

Stage of Harvest

Harvest when flowers are ½ to ¾ open. Place in warm water immediately.

Postharvest

Fresh: Flowers may be harvested when the yellow portion is almost entirely emerged. Flowers persist about one week in a preservative solution. The foliage, however, does not persist as long, particularly if a preservative has not been incorporated.

Storage: Flowers may be stored 1–2 weeks at 38–40F (3–4C).

Dried: *Centaurea* flowers may be air-dried and hung upside down. Flowers may also be dried in silica gel (Vaughan 1988). The handsome spherical fruit has shiny brown scales and may be picked immediately after the flower dies. Words of advice from Shelley McGeathy of Hemlock, Mich.: "You can pick the flower when the yellow tuft is just getting full (selling as fresh or dried cut flower). If it is harvested later, either after the tuft is full-blown open or after the pollen appears, the yellow ray flowers will fall out of the pod, and then you can hang the pod to dry. Time to dry for just pods is 10–14 days."

Additional Species

Centaurea crocodyllum is native to Israel and has recently been studied for potential as a cut flower crop (Halevy 2000). Plants have an absolute requirement for LD to flower and must be lit in the winter.

Centaurea dealbata, a fine perennial species with handsome lavender flowers, is quite popular in landscapes and gardens. Plants were evaluated in 2000; in the first year, flowers occurred in early May and June, and problems with weak, short stems and poor yield were noted (Dole 2001).

Centaurea imperialis is sometimes listed as a separate species but is a synonym of *C. moschata*.

Centaurea montana (mountain bluet) is a perennial species with deep blue flowers. Seed requires 7–14 days to germinate at 68–72F (20–22C). No vernalization is required, but LD (4–6 hours of nightbreak incandescent lights) can be used to induce flowering. Weekly spray applications of 25 ppm GA for 9 weeks caused flowering even under SD, although too much GA or too many applications resulted in weak distorted stems (Cox 1986, 1987).

Centaurea pulchra is similar to *C. macrocephala* but has rosy red flowers and is slightly smaller. Unfortunately, plants are difficult to locate. 'Major' has larger flowers than the species.

Pests and Diseases

Stem rots are caused by *Phytophthora cactorum*, *Sclerotinia sclerotiorum*, and *Pellicularia filimentosa*.

Wilt is caused by *Fusarium* spp., similar to the wilt that occurs on annual aster (*Callistephus*).

Spider mites are a major problem in warm summers. Leaf and flower fungal diseases, such as botrytis, are worse if overhead irrigation is used.

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Many thanks to Douglas Cox (first edition) and Shelley McGeathy and Rudolf Sterkel (second edition) for reviewing this section.

Centranthus ruber red valerian Valerianaceae

perennial, Zones 5–7 Europe red, pink, white 2–3′/3′ (60–90 cm/90 cm)

This is a flower—with a certain "country" look about it—that seems to come and go in the marketplace. Not common in cut flower markets (and probably not a smart decision to grow acres of the stuff), but plants are easily grown and readily marketable, bearing terminal clusters of fragrant pink, red, or white flowers.

Propagation

Seed: Germination occurs in 2–3 weeks if seed is placed at 65–70F (18–21C). Approximately 0.12 oz (3.5 g) of seed yields 1000 seedlings (Kieft 1996). Seedlings may be transplanted to final container 4 weeks after sowing (Nau 1999).

Cuttings: Although they are occasionally used by perennial plant growers, terminal stem cuttings are seldom used by commercial cut flower growers.

Growing-on

Grow seedlings at 60–65F (15–18C) under natural daylengths. Apply 50–100 ppm N from a complete fertilizer. Plants may be placed in the field 8–10 weeks after sowing.

Environmental Factors

Plants flower the first year from seed, indicating that a cold treatment is not necessary. They do not perform well where temperature fluctuates a great deal during the year; they are better suited for coastal areas than areas with hot summers or very cold winters. Yield and quality of cut stems were disappointing in Athens, Ga. (Zone 7b).

Field Performance

Few field data are available, but since plants often occur on limestone areas in their native habitat (Armitage 1997), the use of lime in the beds is recommended. Soils rich in nutrients are not necessary and result in tall, rather spindly plants. Eight to 10 flowers/plant should be attainable. Plants should be spaced approximately 12″ (30 cm) apart. Flowers normally occur May through July.

Greenhouse Performance

There is no reason why flowers could not be forced in a greenhouse during the winter. Sow in late summer to early fall, space 9–12″ (23–30 cm) apart, fertilize lightly (100–150 ppm N), and grow at 55/65F (13/18C) night/day temperatures. At least one tier of support, possibly 2, is necessary. If supplemental light is available, plants would no doubt benefit. Flowering occurs 16–18 weeks from sowing (Nau 1999).

Stage of Harvest

Harvest when the first flowers in the inflorescence are fully open. The use of floral preservative is highly recommended.

Postharvest

Fresh: Flowers persist 7–10 days in preservative.

Storage: Not recommended, but flowers may be placed wet at 40F (4C) for 3–5 days. Maqbool and Cameron (1994) worked with storing of bare root plants and found that regrowth of *Centranthus ruber* in the spring was poor when stored at temperatures less than or equal to 28F (⁻2C).

Cultivars

‘Albus’ (white), ‘Coccineus’ (deep red), and ‘Roseus’ (rosy red) are available as separate colors from seed. A mix is also offered.

‘Pretty Betsy’ is a cut flower selection of ‘Coccineus’ that grows 2–3′ (60–90 cm) tall.

‘Rosenrot’ has light red flowers and reaches about 3′ (90 cm). Essentially the same as ‘Roseus’, with perhaps more uniformity of color.

‘Snowcloud’ is a white, somewhat fragrant valerian growing 3′ (90 cm) tall.

Pests and Diseases

No pests and diseases peculiar to *Centranthus* have been noted.

Grower Comments

"I thought they (*Centranthus ruber*) were a nice color, vase-tested well, definitely for smaller bouquet work. They got to about 20″. Not what you'd want for big arrangements, but ok for $6.50 bouquets." Roxana Whitt, Wise Acres, Huntingtown, Md.

"Centranthus is just not that special and not that profitable; it goes to seed very fast, it self-seeds everywhere, florists like it for a while and then they are tired of it." Janet Foss, J. Foss Garden Flowers, Everett, Wash.

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Cirsium japonicum Japanese thistle Asteraceae

perennial, Zones 3–7 Japan red, pink 2–3′/2′ (60–90 cm/60 cm)

It may be debatable, judging from the number sold in this country, but this tough plant may be one of the few useful thistles for fresh cut flowers. Growing any thistle for the cut flower market is an exercise in optimism, but it seems that everything has a market somewhere—and this is the thistle for masochistic consumers. Flowers can be forced most of the year if greenhouse and field production are practiced. The dark green foliage is prickly and will not be a favorite with your harvest crew. The flower heads are dark red or pink. Production is best in areas of cool temperatures, although production in Zone 7 is fair, if not spectacular.

Propagation

Seed: Seed sown under intermittent mist or a sweat tent at 65–68F (18–20C) will germinate in 7–14 days. Approximately 0.12–0.25 oz (3.6–7.2 g) of seed yields 1000 seedlings (Nau 1999). Seed is sometimes direct sown at the rate of 3.0–3.5 oz/1000 ft^2, but germination is inconsistent, and direct sowing is not recommended.

Division: Plants may be divided after 2 years' growth.

Cirsium japonicum

Growing-on

Transplant from 288s to cell packs or 4″ (10 cm) pots after 4 weeks, or as soon as seedlings can be handled. Fertilize sparingly (75 ppm N) for the first 2 weeks then raise to 100–150 ppm N. Grow at 55–60F (13–15C) until ready to transplant to the field (approximately 7 weeks from sowing). Divisions may be planted in 4–6″ (10–15 cm) pots and grown on for 4–6 weeks in a cold frame.

Environmental Factors

Plants do not require a cold period for flowering. Many species of thistle are long day plants, but *Cirsium japonicum* is day neutral.

Field Performance

Longevity: In general, 2–3 years of production are normal. Plants may be divided for rejuvenation.

Spacing: Space plants 12 × 12″ (30 × 30 cm) or 9–12″ (23–30 cm) between plants with 6–9″ (15–23 cm) rows in the bed. Denser spacings of 6–9″ (15–23 cm) centers have also been used (Vita and Agnello 1998).

Yield: Results from work at the University of Georgia are shown in the following table.

Yield and stem length of *Cirsium japonicum*.

Year	Stems/plant	Stems/ft^{2z}	Stem length (in)^{y}
1	8	7.6	27.9
2	13	12.6	38.4

z = multiply (stems/ft^2) by 10.76 to obtain (stems/m^2)
y = multiply (in) by 2.54 to obtain (cm)

Greenhouse Performance

Plants may be forced in heated greenhouses during the fall, winter, and spring. Sowings in July result in flowers by December if grown in 55–65F (13–18C) houses. Flowers continue through April. For best quality, sow seed every 4 weeks. Greenhouse crops generally are used as annuals only.

Guideline for Foliar Analyses

At field trials in Watsonville, Calif., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis.

'Rose Beauty'

(%)				
N	P	K	Ca	Mg
2.6	0.19	2.24	0.60	0.29
(ppm)				
Fe	Mn	B	Al	Zn
462	130	14	208	21

Stage of Harvest

Harvest when the flowers are open. If cut too soon, flowers will not persist well.

Postharvest

Fresh: Flowers persist approximately one week when placed in floral preservative.

Storage: Flowers may be held temporarily at 36–41F (3–5C), but storage is not recommended (Vaughan 1988).

Dried: Flowers may be dried by cutting the flowers as soon as they come into full bloom and hanging upside down. Flowers may be sprayed with clear plastic if any sign of shattering occurs (Kasperski 1956).

Cultivars

'Lilac Beauty' bears lavender flowers on 2–3′ (60–90 cm) stems.

'Pink Beauty' has pink flower heads on 2–2½′ (60–75 cm) stems.

'Rose Beauty' has carmine-red flower heads on 2–2½′ (60–75 cm) stems.

Additional Species

Cirsium helenioides (syn. *C. heterophyllum*) grows up to 5′ (1.5 m) tall and bears solitary purple flowers. Still spiny.

Cirsium rivulare is about 3′ (90 cm) tall and can be a useful fresh or dried cut flower. The lavender to purple blooms are held in clusters and measure 1–2″ (2.5–5 cm) across. Leaves are spiny and not particularly pleasant to handle. 'Atropurpureum' has deeper purple flowers than the species.

Pests and Diseases

Leaf spots (*Cercospora*, *Phyllosticta*) occur as black spots on foliage. More prevalent under humid, wet conditions. Aphids are also a problem.

Grower Comments

"We haven't grown cirsium for a few years, but I think it's a wonderful cut flower. It seems to be an aphid magnet, just like the wild thistles. The larvae of thistle bugs eat the seeds, and they deform the flowers of this thistle also, but even so, every few years when I plant it, it has good market acceptance for me." Janet Foss, J. Foss Garden Flowers, Everett, Wash.

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Clarkia satin flower Onagraceae

annual western North America many colors

16–30″/15″ (40–75 cm/38 cm)

Most taxonomists have rolled everything that was *Godetia* into *Clarkia*, but seed packets and cut flower catalogs will use the names interchangeably; to be sure you get what you want, order by cultivar. We hate to muddy the already murky waters of plant taxonomy for cut flower growers (and most of us seldom use the botanical name anyway in everyday sales and production), but we might as well get the generic name of this plant right—although it will forever remain satin flower in the marketplace. *Clarkia* is an excellent name, after all: we need a good plant to commemorate one of America's great Western explorers, Captain William Clark.

The genus of about 33 species bears showy flowers arranged in racemes or spikes. All species are native to the West Coast of the United States, mainly California and Oregon, and can be greenhouse-grown most anywhere and field-grown in areas of cool summers. They are not particularly suitable for field production in the Midwest, East, or South.

Propagation

Germination occurs within 10 days at 70F (21C) in a sweat tent or under intermittent mist. Approximately 0.03 oz (0.9 g) of seed yields 1000 plants (Nau 1999). Do not direct sow seed.

Growing-on

Seedlings should be grown at 50–60F (10–15C) night temperatures, or spindly growth will result. Warmer day temperatures may be tolerated but should be consistently below 75F (24C). Fertilize sparingly (50–75 ppm N) with a complete fertilizer or potassium nitrate. Supplemental high-intensity discharge lighting accelerates growth of seedlings considerably.

Environmental Factors

Photoperiod: Early observations showed that *Clarkia* did not respond to daylength or temperature for flower bud formation (Post 1955). More recent work revealed that cultivars of the F_1 Grace series are clearly long day plants, even though plants also flower in short days. Plants require less time to flower when grown under long days and supplemental light, as shown in the following table (Anderson and Geneve 1992).

The effect of photoperiod and supplemental light on *Clarkia*.

Photoperiod (hours)	Supplemental light	Time to flower (weeks)	Nodes before flowering
8	no	21	75
8	yes	17	70
20	no	13	37
20	yes	10	32

In this work, the highest quality stems were produced with long days and supplemental light. The supplemental light level was approximately 800 fc from high-pressure sodium lamps (HPS). Not only do LD influence flowering time, they also enhance quality. Work in Italy showed that only 3–6 hours of supplemental light was needed for faster flowering and longer stems (Pascale and di Napoli 1998). Research from Israel also showed that stem lengths are significantly longer when LD (natural days plus 8 hours supplemental light) were applied. Plants grown under natural short days were about 33″ (83 cm) long, while those under LD were over 4′ (1.2 m) tall; interestingly, plants are most responsive to LD at low temperatures, but at 68–78F (20–26C), plants were day neutral (Halevy and Weiss 1991). In areas where natural daylengths are seldom above 12 hours, field lighting with sodium lights during the evening is recommended.

Temperature: *Clarkia* is a cool-season plant and does not tolerate high temperatures. The best temperature for growth is 50–55F (10–13C) nights, with day temperatures below 75F (24C). Greenhouse production at 60–62F (15–17C) nights has been successful in the winter. Halevy and Weiss (1991) showed that overall quality of flowers and stems deteriorates rapidly at temperatures above 75F (24C). Warm temperature is the main reason most summer outdoor production in this country is limited to the West Coast; however, plants may be grown in the East or Midwest if planted in early spring. Cold-acclimated plants transplanted on 5 April in Lexington, Ky., tolerated temperatures of 26F (⁻3C) a few days later and produced flowers in mid June (Anderson and Geneve 1992). Protective row covers could be used to foster earlier plant growth and development.

Gibberellic acid: Plants respond to 100 ppm GA_3 with longer stems, but they are often thinner and bear fewer flowers (Pascale and di Napoli 1998, 1999). GA may be a useful substitute for LD in field production where supplemental lights are not used.

Field Performance

Yield: Commonly, 30 stems per plant. Work over 2 years at the University of Kentucky (Utami 1991) resulted in 25–75 stems per pinched plant spaced on 2′

(60 cm) centers, depending on cultivar. Production was highest when planted no later than 10 April; later plantings were much less successful. Stems were 10–15″ (25–38 cm) long.

In trials in Italy, plugs were planted outdoors from October to July, including spring plantings in March and April. Time between planting and flowering ranged from 180 days for the fall planting, to 75 days for the spring plantings, to 40 days for the summer plantings. The number of flowers on the main stem was constant (10–12), but stem length and diameter decreased from the fall planting to the late summer planting (Pascale and Barbieri 1995). These data reinforce the fact that *Clarkia* should be grown at daylengths greater than 12 hours and temperatures of 68–77F (20–25C).

Spacing: Spacing is dependent on whether plants will be pinched or grown single-stemmed. Unpinched plants should be closely spaced on 4–5″ (10–13 cm) centers. Pinched plants should be spaced at 20–24″ (50–60 cm) in rows 3′ (90 cm) apart. Although stems attain only about 18″ (45 cm) in height, field support is necessary in the East (particularly in areas with heavy spring rains), even with pinched plants. Bamboo stakes (one per plant) or at least one tier of netting should be used. Many growers insist on at least 2 layers of support netting.

Fertilization: Fertilize in field with 200 ppm N from calcium nitrate and 25 ppm magnesium sulfate approximately once every 2–3 weeks to maintain and increase stem strength. Higher frequency of fertilization should be practiced in coastal California areas, lower frequency in eastern sites. Too much fertility results in weak stems and lanky growth; lack of fertilization causes bronzing of the lower foliage and stunting. If nutrition continues to be withheld, plants become unacceptable.

Pinching: Although plants do not require pinching, it results in more flowers and more uniform flowering of axillary shoots. Bob Anderson of the University of Kentucky suggests 2 kinds of pinches. An early pinch is accomplished 3–5 weeks after germination to produce 4–6 lateral (secondary) breaks. In the field, these secondary branches fall over, and the tertiary stems that arise may be harvested with 12–16″ (30–40 cm) stems. A late pinch (actually a disbud), removing the first visible flower buds, allows the upper laterals to develop a spray of short stems, much like a spray mum. According to Anderson, pinching is not necessary under dense spacing (4–6 plants/ft^2, 43–65 plants/m^2). At such a spacing, a yield of 35 stems/ft^2 (376 stems/m^2) was recorded; 75% of the stems were 22–34″ (55–85 cm) long.

Scheduling: *Clarkia* has been grown under high tunnels, planted around 1 May in the North and harvested 10–20 July. All the flowers are harvested within 2 weeks. The first flush of blooms is considered the highest quality. Sequential planting provides season-long flowering.

Protection: If rain during the harvest period is common, some overhead protection, such as shade cloth or single poly, is recommended to reduce the damage. Overhead irrigation or excess rain can result in significant decline in quality.

Greenhouse Performance

Most plants are greenhouse-grown, but successful greenhouse production must occur under long day conditions, high light intensity, and cool temperatures. These conditions may be accomplished in most greenhouses in late winter and early spring. In general, *Clarkia* should be grown at daylengths greater than 12 hours and temperatures of 68–77F (20–25C). In Kentucky, a late January sowing resulted in mid May flowering (Anderson and Geneve 1992). Midwinter production is not possible without high-intensity discharge supplemental lighting. Two to 3 crops may be harvested throughout the winter season with sequential planting.

Single-stem plants may be grown at 8–10 plants/ft^2 (86–107 plants/m^2) for the first 7 weeks if grown under supplemental light. Plants may be finished at 5–6 plants/ft^2 (54–65 plants/m^2) or as little as 2–3 plants/ft^2 (22–32 plants/m^2), which computes to about an 8 × 8″ (20 × 20 cm) spacing.

Flowering begins approximately 10–12 weeks from sowing and continues for about 2 weeks. Yields of 15–30 flowers/plant are not uncommon under such conditions. Plants need support throughout the duration of the crop. Subirrigation is essential, particularly as flower buds form.

If plants are to be pinched, pinch once upon transplanting to the greenhouse bench. Use the same fertility program as for field production.

Guideline for Foliar Analyses

At field trials in Watsonville, Calif., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis.

Grace Mix

(%)				
N	P	K	Ca	Mg
3.2	0.26	4.18	1.03	0.34
(ppm)				
Fe	Mn	B	Al	Zn
189	239	23	96	36

Stage of Harvest

Harvest when the first flowers on the stem are open; 3–6 flowers open is optimum (Tesi et al. 1997). For dried flowers, allow as many flowers to open as possible. Flowers harvested in the tight bud stage (to reduce shipping weight and damage) often do not open without a floral preservative. Vase life is extended when stems are recut under water (Tesi et al. 1997). Relatively poor shippability but an excellent flower for local sales.

Postharvest

Fresh: In water, vase life is approximately 5–10 days, although the fresher the flowers, the better the vase life. Individual flowers may last only 5–6 days, but flower buds continue to open without fading. Therefore, the more flowers present on the stem, the longer the vase life. A vase life of 2 weeks is not uncommon.

A flower solution should be used. Chrysal AVB™ has been shown to be effective (Pascale and Viggiani 1998), but silver thiosulfate (STS) does not significantly improve vase life. Some work with antioxidants has been attempted, but little consistency was noted (Meir et al. 1994). Preservatives enhance vase life by an additional 1–2 days.

Storage: Storage is not recommended, but plants may be kept in water at 36–41F (3–5C) if necessary. This is an excellent plant for local growers, as stems do not ship well dry.

Dried: Strip foliage and hang upside down in a warm, dark, well-ventilated area.

Cultivars

All are cultivars of *Clarkia amoena* (syn. *C. grandiflora*), *C. amoena* subsp. *whitneyi*, or *C. unguiculata* (syn. *C. elegans*).

Single-flowered

'Aurora' has salmon-orange flowers.

'Flamingo' comes in red, lavender, pink, salmon, lavender-pink, and white with a rose eye.

Florist series is semi-tall and available in lavender-pink, red, rose eye, salmon, and white. They were trialed in the ASCFG national field trials in 2001 (Dole 2002).

'Furora' bears crimson-scarlet flowers on 2½′ (75 cm) stems.

'Gloria' produces clear pink flowers.

Grace series is an F_1 hybrid, and although seed is more expensive than open-pollinated forms, uniformity and individual color selection are excellent. The series is particularly attractive for its upright habit and 2–3′ (60–90 cm) height. Available in light pink, rose-pink, salmon, red, lavender, and a formula mix.

'Memoria' bears clean white flowers on 2′ (60 cm) stems.

Double-flowered

'Azaleaflora' mixture is available as a mix or in numerous single colors, including 'Brilliant' (carmine), 'Maidenblush' (bright rose), 'Orange Glory'(orange), 'Ruddigore' (crimson-red), 'Sweetheart' (pink), and 'White Bouquet' (white). Plants generally flower on 1–2′ (30–60 cm) stems.

'Grandiflora' is taller than 'Azaleaflora' but only available as a mixture of colors.

Pests and Diseases

Root rots (*Pythium*, *Phytophthora*, *Rhizoctonia*, etc.) infect seedlings in the propagation area or at transplant. *Rhizoctonia* is very pathogenic and can be lethal 3–7 days after symptoms appear. In the field, the foliage turns pink, then red, and finally the whole plant declines. The pathogen may be seed-borne. Use clean soil and tools, and apply a fungicide as needed.

Rusts have been reported in field plants. Remove and destroy infected plants.

Aster yellows may also occur in field plantings. Rotate crops every 1–2 years.

Aphids and western flower thrips are the most serious pests in the field. Aphids, whiteflies, mites, and thrips are significant problems in the greenhouse.

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Consolida

larkspur Ranunculaceae

annual Mediterranean many colors 2–4′/1′ (0.6–1.2 m/0.3 m)

Larkspur has long been a mainstay for cut flower growers, and the market for larkspur continues strong (although prices fluctuate dramatically) while other plants come and go. Cultivars offer a wide range of colors, and germination is relatively high, even when seed is direct sown. Historically known as annual delphinium, larkspur is in fact closely related to that genus and was for years included under *Delphinium* before being moved to *Consolida*. The species of larkspur used in the cut flower trade are *Consolida ajacis* (syn. *C. ambigua*), *C. orientalis*, and occasionally *C. regalis*. The differences between them are slight: plants of *C. orientalis* are more upright than *C. ajacis*, and the flowers are often in shades of bright pink and purple; plants of *C. ajacis* and *C. regalis* are more branched initially, and flowers are usually light pink or blue. Flowers are generally dried but may also be used in fresh bouquets and arrangements. Some varieties are recommended for use as bouquet fillers, similar to gypsophila.

Propagation

Approximately 9000 seeds/oz (300 seeds/g) is typical, and 0.25 oz (7 g) of seed yields 1000 seedlings (Nau 1999). Most cultivars are direct sown in the field. A volume of 0.3 oz per 100′ (30 g per 100 m) is recommended (Kieft 1996). Seed does not germinate well above 65F (18C) soil temperature (Post 1955) and should be sown in the fall in most parts of the country. Many growers, particularly those in the warmer areas of the country, chill the seed for 7–14 days at 35–40F (2–4C) prior to planting to enhance germination. This is important! In areas south of Zone 5, seed may be sown in the fall without appreciable loss due to winter conditions; however, in very moist winters (e.g., coastal Northwest), seed may rot if planted in the fall. Fresh seed germinates better than old seed.

Seeds do not appear to have an absolute requirement for darkness, but better germination is reported when seeds are completely covered.

In cooler areas, seed may be sown in plugs or other containers and germinated in a 50–55F (10–13C) greenhouse or cold frame; or seed may be chilled at 35F (2C) for 2–3 weeks prior to sowing in the spring. Sow as soon as the ground can be worked. Plugs may be transplanted in early spring for late summer harvest.

Growing-on

If plants are started in the greenhouse, grow at 55F (13C) until ready to plant to the field. Use large plugs (no smaller than a 208-plug tray), or transplant seedlings to final plug container after 3–4 weeks. Fertilize lightly (50–100 ppm N using a nitrate-based fertilizer once a week) while growing at temperatures below 60F (15C).

Environmental Factors

Temperature: Plants of larkspur require a vernalization (cold) period for shoot elongation and flower initiation and development (Bajpal and Nerikar 1959, Post 1955). Vernalization is not effective on the seed. If plants remain below 55F (13C) for 6 weeks, then further development is enhanced: plants will rosette and shoot elongation will occur. Reduced rosetting or flowering occurs above 70F

Consolida ajacis
'Giant Imperial Pink'

(21C). The elongation of the stem and subsequent flowering occur at higher temperatures only if the cool treatment has been satisfied. In the experiment summarized in the upcoming table, seeds were greenhouse-sown in October, and seedlings were grown in the greenhouse at 50F (10C) until 1 January. After 1 January, various treatments were applied. If seedlings are exposed to high temperatures for several days, flower initiation, development and shoot elongation occur rapidly with very poor stem and flower quality.

Photoperiod: Development of the plant is best under long days, which can be satisfied by nightbreak lighting or day extension. Long days (>16 hours) result in longer stems and higher yield than short days. The effect of photoperiod and temperature on larkspur is shown in the following table (Post 1955).

The effect of photoperiod and temperature on yield of larkspur. Seed sown in October, treatments applied after 1 January.

Treatment	50% of flowers cut before . . .	Stems/plant
50F (10C) + LD	17 Apr	16.2
50F ND*	3 May	7.0
55F (13C) + LD	8 Apr	17.0
55F ND	16 Apr	12.0
60F (15C) + LD	21 Mar	20.7
60F ND	12 Mar	12.6

* = natural days

Gibberellic acid: GA accelerates flowering of larkspur (Bose 1965, Lindstrom et al. 1957); however, few growers employ the chemical.

Field Performance

Planting time: Seed may be sown every 2 weeks from September to November in the Midwest. In New York and similar latitudes, initial sowing may be done from 1 to 15 September for spring production. Further south and in California, early to mid October through early November allows for sufficient exposure to the cold. In Florida and the Southwest (Arizona, Texas), planting occurs from mid October to mid November.

Sowing in more northerly environments may be also be accomplished in the fall, but the addition of frost protection cloth such as Remay™ once seeds have germinated makes economic sense. The use of frost cloth is by no means unanimous. Shelley McGeathy, growing in Hemlock, Mich. (Zone 5), considers larkspur to be tough enough to overwinter and uses it to reduce the drying effect of the wind, rather than for cold production. She also recommends a cover crop of oats or the like, sown in fall, which eventually covers any seedlings. The cold kills the oats, not the larkspur seedlings. In years of below-average falls and winters, however, seed may not germinate until temperatures warm up in early spring. If additional hard frosts are expected, put down the cloth. If sowing in the spring, sow early.

Direct sowing is recommended for stronger stems; Zone 5 appears to be the transition area between direct sowing and transplanting (see "Grower Comments").

Spacing: Some growers do not feel spacing is necessary; they practice what they call solid seeding: plants are not spaced out, and because the sowing is so thick, there is no need for support. Additional disease has not been reported, and it is believed that thick rows help to protect from wind. Others do use spacing patterns. If sown more thickly, thin to a 4–6″ (10–15 cm) spacing. Some growers use 3½′ (1.1 m) wide rows, and direct sow 2 lines of plants in the bed (Nakasawa 1990). With most crops, the more dense the spacing, the higher the incidence of disease.

Scheduling: Flowers occur as spring temperatures rise, but approximately 4–5 months are required after sowing.

Shading: Larkspur does not require shading; however, yield and stem quality are not adversely affected under 30% shade.

Yield: Under 10–12″ (25–30 cm) spacing, expect 6 stems/ft^2 (65 stems/m^2) or 500 12-stem bunches per 1000 ft^2 (5 bunches per m^2). At closer spacings, expect higher yield per square foot but lower yield per plant.

Support: Use 1 or 2 tiers of wire or string support (6 × 8″, 15 × 20 cm), particularly if the site is windy. The first tier should be 12–14″ (30–36 cm) off the ground, and the second 18″ (45 cm) above the first (Nakasawa 1990). Growers incorporating very high density plantings use no support, allowing adjacent plants to support each other.

Irrigation: Use drip irrigation if possible.

Greenhouse Performance

Sow or transplant approximately 10″ (25 cm) apart. Maintain 50F (10C) temperatures for 8–10 weeks. After plants are well established, raise temperatures to 55–60F (13–15C) and apply long days by extending the days (>16 hours) or with 2-hour nightbreak lighting using incandescent lamps. Sowing in September results in flowering in early to mid March in the Midwest; for a December sowing, mid April. Sowing after January is not recommended: high greenhouse temperatures usually occur during extension of the flower stem and development of flowers, and quality subsequently declines. Support is necessary for all sowing dates.

Stage of Harvest

For fresh flowers, allow 2–5 basal flowers to open, or up to ⅓ of the stem. Fresh stems are generally bunched in 10–12 stems (heavy) or 20 stems (light). If counting flowers is not feasible, harvest the entire plant at once. For dried flowers, harvest when the majority of flowers are open, with 4 or 5 buds unopened on terminal flower, but before petals drop. Some growers harvest the terminal flower stem for fresh flowers and the laterals for dry flowers, but this practice should be avoided: relegating the laterals for dried material tends to make drieds "inferior," looked upon as second-class stems. Either grow them for fresh or for dried, not both.

Postharvest

Fresh: The vase life of larkspur is approximately 6–8 days. Flowers are highly sensitive to ethylene; silver thiosulfate (STS), if available, is effective in reducing flower drop in larkspur and delphinium (Shillo et al. 1980). Commercial flower preservatives with silver in their makeup are effective treatments for cut stems. Six-hour pretreatment with 1-MCP (1-methylcyclopropene) prolonged vase life as well as did treatments with STS in an ethylene-free environment (Serek et al. 1995). 1-MCP appears to have promise for most ethylene-sensitive crops. Store fresh flowers away from fruit, vegetables, or other drying flowers. If flowers are stored overnight, keep upright in water at 36–41F (3–5C). Keep constantly hydrated; dry storage for fresh flowers is not recommended.

Dried: Larkspurs are excellent for drying and may be air-dried in 10–14 days; forced-air drying requires only about 18 hours at 70–80F (21–27C). Quick drying is recommended for best color retention. Foliage need not be removed. Stems may also be dehydrated with silica gel or other desiccant.

Cultivars

'Blue Cloud' has a more airy, open flower habit than other cultivars and is often used as a filler. The single flowers are violet-blue. 'White Cloud' ('Snow Cloud') is a white form. These appear to be cultivars of *Consolida regalis*.

'Blue Picotee' is an interesting bicolor with white flowers surrounded by a blue picotee edge.

Early Bird series is earlier flowering than the Imperials and is available in blue, lilac, rose, white, and a mix. Stems are 3–4′ (0.9–1.2 m) tall.

'Frosted Skies', a selection of 'Blue Picotee', grows to 4′ (1.2 m); it has mid-blue double flowers, tinged with white.

Giant Florist Strain is basal branching and bears flowers with double floret on 3′ (90 cm) stems. A wide range of colors is available.

Giant Imperial series is the standard of the industry. Plants stand approximately 4′ (1.2 m) tall and are available in numerous colors, including carmine, deep blue ('Blue Spire'), deep rose, light blue, lilac, pink, salmon, white, and a mix. Super Giant Imperial may be as much as 2 weeks earlier than Giant Imperial, with longer stems and larger flower spikes; colors include carmine, white, dark blue, azure-blue, salmon, and a mix.

Messenger series is approximately the same height as the Giant Imperial series but flowers about 2 weeks earlier. Some growers have found this good for sequential planting. Blue, lilac, rose, white, and a mix of colors are available.

'Pink Fantasies' from Gloeckner has big, bright pink flowers. Plants performed well for Janet Foss of Everett, Wash.

QIS series (formerly Sunburst series) has been selected for uniformity and stem quality. Stem lengths are 30–36″ (75–90 cm). Available colors include carmine, dark blue, light pink, lilac, rose, white, and a mix. The label QIS ("Quality in Seed") is available in other cut flowers as well; it was developed by Kieft, whose seed production process includes an aggressive breeding program. Other seed producers have similar programs under different labels.

Rustic series grows 36–40″ (90–100 cm) with single flowers.

Sydney series blooms in 8–12 weeks with uniform fully double flowers. Bred as a greenhouse crop, from Ball Seed Company. The rose color earned Fleuroselect Gold Medal Marks for 2000; the purple and white earned Fleuroselect Quality Marks.

'White Veil' produces wiry stems with small white blossoms.

Pests and Diseases

Botrytis basal rot causes a soft brown basal rot; plants eventually wilt and fall over. Fungicides and aeration are useful preventatives.

Black leaf spot (*Pseudomonas delphinii*) causes irregular, shining, tarlike spots, especially on the upper surface of the foliage. The lower leaves show symptoms first, but petioles, stems, and flowers may also be attacked by this bacterium. Remove infected foliage and destroy. Other leaf spots may be carried on the seed; seed may be treated in 125–130F (52–54C) water for 10 minutes.

Crown rot and root rot (*Sclerotinia delphinii*) result in sudden wilting, stunting, and death of plants. The saying "here today, gone tomorrow" is particularly appropriate for plants afflicted with this fungus, which seems to occur in the weaker-growing colors (and sometimes may be most destructive on a particular color). The fungi live through the winter and are distributed by tools or rain. Crop rotation, soil sterilants, and clean tools relieve the problem.

Cyclamen mites cause blackened buds and downward-cupped, deformed leaves. The "blacks" are distinguished from pseudomonas leaf spot by the deformities caused by the mites. Miticides are useful but not always effective. Aphids and leafminers can also be problems.

Powdery mildew (*Erysiphe* and *Sphaerotheca*) is particularly prevalent during cool, moist seasons. Larkspur, however, is much less susceptible than delphinium. Avoid dense spacing and wet soils when planting.

Slugs can mow down larkspur, especially in the Northwest.

Stem canker (*Fusarium oxysporum* f. *delphinii*) first appears as light brown, water-soaked areas on the stems. Eventually the fungus reaches the crown and invades the vascular tissues. Plants show yellowing of the basal leaves that progresses upward. Fusarium-resistant strains and soil sterilization are useful.

Grower Comments

"We use primarily the Giant Imperial series; I also find 'QIS Light Blue' a very elegant icy color. We tried the Messenger series, which was wonderfully early but wasn't quite as strong as we like to see. [The] trick is not to let [the seedlings] get root bound, so as soon as they have a second leaf, out they go, at least to benches outside, and then in the ground, as quick as you can. To counteract [raising] soil temps, in the field, we use white plastic mulch; it keeps the roots cool and only causes a problem with root rot when you over irrigate." Ruth Merrett, Merrett Farm, Upper Kingsclear, N.B.

"I germinated my larkspur . . . and transferred them to a cold frame. They seem to be doing great, and we have had nighttime temps down into the 20s." Sandy Della Villa, Patch of Paradise, West Henrietta, N.Y.

"I plant early in the spring, after refrigerating the seed for a couple of weeks. It's usually up within 10 days of 50-degree ground temperatures. I then plant every 2 or 3 weeks for successive crops, though here hot summers can ruin the later seedlings because of short stems." Ralph Thurston, Bindweed Farm, Blackfoot, Idaho.

"Larkspur will germinate poorly, if at all, when the soil is above 55F. It also doesn't like to be transplanted, so you may have better luck starting them in small peat pots rather than plugs. If your soil temperature is still below 55F (use a thermometer) and weather predictions are for it to stay that way for a couple of weeks, you're much better off direct seeding it. For direct seeding, I use an Earthway seeder and the "radish" seed plate. Cover the seed ⅛–¼″ since darkness aids germination." Jennifer Judson-Harms, Cricket Park Garden, New Hampton, Iowa.

"I direct seeded larkspur the first week of November; it just sat there and didn't sprout by Christmas. The larkspur may have been slow to start, but now it is up and looks great. Probably the best crop I've had, maybe the month of snow cover melting slowly did the trick. Last year I planted in mid May, it came up but was short." Dave Dowling, Farmhouse Flowers, Brookeville, Md.

"When we seed larkspur, we drop a seed about every inch in the row with 4 rows 12″ apart . . . and we use no support, and we don't thin the row. What we get is tall plants with one flower and minimal branching, nice straight stems, and mostly just leaves, not too many laterals to remove. Larkspur seed is cheap, and direct seeding gives great stem length. We have used as much as 5 lbs of seed per acre, but usually about 4 lbs." Ralph Cramer, Cramers' Posie Patch, Elizabethtown, Pa.

"Plants that have been kept in the tray too long always seem to suffer." Susan O'Connell, Fertile Crescent Farm, Hardwick, Vt.

"I'm in Zone 4, and I direct seed my larkspur in mid April; seed germinates in 3 weeks. I can't count on a fall sowing to come up for me; Zone 5 may be more favorable for that." Julie Marlette, Blue Heron Gardens, Fall Creek, Wis.

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Coreopsis, *Rudbeckia*, *Leucanthemum* — Asteraceae

annual/perennial

There are enough similarities in the production and harvest of these genera (commonly known as tickseed, coneflower, and shasta daisy, respectively) that we decided to group them together. The genus names of the first two are so well known that they are used as common names. Most of the commonly grown members of all genera are perennial; however, many annual cultivars of *Rudbeckia* and one or two of *Coreopsis* are also available. They all grow in full sun, tolerate similar environments, and bear the same type of flowers—that is, they are all "daisies" and sometimes are grown and sold as such. Plants are grown for the colorful flowers; the handsome cones of *Rudbeckia* are also harvested as dry floral items. Plants are field-produced only. In all genera, plants grow as rosettes until they send out a flower stem. Plants themselves remain less than 1′ (30 cm) tall, but flower stems are significantly taller and may require some support, depending on winds and temperatures.

Propagation

Seeds and plugs are available for most daisies. All should be sown under intermittent mist at 70–75F (21–24C). Plants can also be divided after approximately 3 years; division is easiest for *Rudbeckia*, most difficult for *Coreopsis*.

Environmental Factors

Temperature: For *Coreopsis grandiflora*, the need for cold is cultivar specific. For example, 'Sunray' requires approximately 10 weeks of cold (40F, 4C) for flowering, whereas 'Early Sunrise' does not require any cold treatment (Yuan et al. 2000a). For the perennial rudbeckias, cooling is not a requirement, but plants definitely benefit from cold in the field. The annual *Rudbeckia hirta*, however, nei-

Rudbeckia hirta
'Indian Summer'

ther needs nor benefits from cold. For leucanthemums, research with the garden shasta daisy 'Snowcap' showed that 6 weeks of cold of 35–45F (2–7C) were necessary for flower initiation and development (Runkle et al. 2000). It is likely other shasta daisy cultivars have similar requirements.

Photoperiod: All these daises have a requirement for long days. For coreopsis, plants require approximately 3 weeks of LD for flower initiation, after which photoperiod is unimportant. All perennial rudbeckias flower best under LD greater than 13 hours (Yuan et al. 2000b); for shasta daisies, 16-hour daylength appears necessary (Runkle et al. 2000). This is why all these daisies flower in the summer, as natural photoperiods lengthen.

Field Performance

Yield: Plants are productive 3–5 years. All daisies can be planted in early spring; perennial daisies benefit from being planted in early fall. For the perennials, yield is minimal the first year (although *Coreopsis* 'Early Sunrise' flowers well the first year if spring-planted). Harvesting can occur the second year and in subsequent summers.

Spacing: Spacing of 12–18″ (30–45 cm) may be used for all genera.

Longevity: All perennial daisies require division after 3–4 years, or plants become unproductive. Coreopsis and shasta daisies require division more often than rudbeckias.

Support: Use of side supports or netting may be useful if winds are high; otherwise the stems are self-supporting.

Greenhouse Performance

We are not aware of cut flower production in the greenhouse; however, the use of cold-treated plugs or field roots in combination with proper photoperiod manipulation will yield flowers (Yuan et al. 2000a, 2000b). In general, cool plugs at 40 (4C) for 8–12 weeks, then grow at 55–62F (13–17C) under winter light conditions (SD) until a sufficient root system and leaves fill the container. Long days may be applied by extending daylength through supplemental lighting or using nightbreak incandescent lighting for 3–4 hours per night. Turn lights off no later than when color first appears on the buds. High-intensity discharge lamps are recommended during winter months for more vigorous growth, although the economics of their installation may not be favorable. Greenhouse forcing temperatures should be around 50–55F (10–13C) for best-quality stems. Flowers may be forced faster at warmer temperatures, but stems will be less robust.

Stage of Harvest

Harvest all daisies when the flowers are starting to open (Vaughan 1988).

Postharvest

Vase life for most daisies is 7–10 days in a floral preservative; some species will persist even longer. Ethylene is not a significant problem with flowers in the aster family, so anti-ethylene products are not recommended.

Cut stems can be stored at 36–41F (2–5C), but storage is not recommended.

Cultivars

Coreopsis grandiflora

'Badengold' bears bright yellow flowers. Early to flower.

'Double Sunburst' grows to 24″ (60 cm) with 2″ (5 cm) double flowers.

'Early Sunrise' was an All-American Selection in 1989. Plants are easily raised from seed and bear bright yellow semi-double flowers 2″ (5 cm) wide. Short-lived but excellent for a couple of years.

'Mayfield Giant' is an old cultivar with 2–3″ (5–8 cm) wide gold-yellow flowers. Grows 2–3′ (60–90 cm) tall.

'Ruby Throat' bears yellow flowers with a deep claret throat.

'Schnittgold' ('Gold Cut') produces golden-yellow flowers.

'Sunburst' (sometimes called 'Improved Mayfield Giants') is about 2′ (60 cm) tall with large semi-double golden-yellow flowers.

'Sunray' is an exceptional selection that bears 2″ (5 cm) wide double flowers for 8–12 weeks on 2′ (60 cm) plants.

Rudbeckia fulgida

'Goldsturm', a selection of var. *sullivantii* and one of the most popular plants in the perennial trade, is occasionally used for cut flowers. It is a little short, but if stem length is not a problem, it should be grown for performance alone. The dark green foliage contrasts beautifully with the 3–4″ (8–10 cm) wide deep yellow flowers. The center consists of a nearly black cone. The popularity of 'Goldsturm' created a demand that vegetative propagation could not meet. In response, growers resorted to seed propagation, and it is therefore unlikely there are many true 'Goldsturm' out there. Flowers in mid summer to fall.

Additional Species

Perennials

Coreopsis lanceolata (lance-leaf coreopsis) is similar to *C. grandiflora*, differing in vegetative characteristics but quite similar in flower. Useful cultivars for cut flowers include 'Brown Eyes', an excellent long-lived selection with single yellow flowers and a maroon ring near the center, and 'Goldfink', which produces many 2″ (5 cm) wide single yellow flowers with an orange center. Should be raised from cuttings or divisions. Zones 3–8.

Rudbeckia laciniata (cutleaf coneflower) and *R. nitida* are large plants, growing well over 5′ (1.5 m) tall under favorable conditions, that flower in late summer and fall. They differ in minor ways, and it is best to obtain named cultivars if growing them as cuts. The blooms are 2–3½″ (5–9 cm) wide and consist of drooping yellow ray flowers surrounding a green cylindrical disk. 'Golden Glow' grows 3–5′ (0.9–1.5 m) tall and bears large, fully double lemon-yellow flowers; unfortunately, they are often covered with aphids, to which this cultivar is most prone. 'Goldquelle' ('Gold Fountain', 'Gold Drop') bears double yellow flowers and is a clump-former, growing 3–4′ (0.9–1.2 m) tall. In full sun, stems are sufficiently strong to support the heavy flowers; in shady areas, they fall like cooked spaghetti. 'Herbstsonne' ('Autumn Sun') grows up to 7′ (2.1 m) tall and is one of the finest coneflowers in cultivation, producing dozens of cut stems in late August through October. Dozens of long, drooping sulphur-yellow petals surround a green cylindrical disk. In the North, the stems usually don't require staking; in the South, staking should be considered. Zones 3–9.

Rudbeckia triloba (three-lobed coneflower) grows 3–5′ (0.9–1.5 m) tall and produces dozens of flower stems with 3–6 flowers per stem. The flowers are much smaller than those of the perennial species just mentioned, but many more are produced. Plants are short-lived, persisting 2–3 years at most, but they reseed prolifically. Zones 3–10. Purchased seed may germinate at a higher percentage if they are put in a seed flat or plugs and cooled at 40F (4C) for about a month.

Annuals

Coreopsis tinctoria (plains coreopsis) is a seed-propagated annual with multi-colored flowers on 1–2′ (30–60 cm) plants. Home Mix has 30″ (75 cm) stems with small, brown-red flowers with yellow tips. Good for filler.

Rudbeckia hirta (black-eyed susan), grown for years as a garden plant, is also a useful cut flower. Plants are true annuals and often fall apart midseason, but they can be resown in late spring and early summer for a second crop. Cultivars are many, including 'Indian Summer', the ASCFG's 2000 Fresh Cut Flower of the Year, whose ease of production, long vase life, and high consumer ratings make it a favorite with growers across the country; large (6″, 15 cm) flowers are produced on wiry stems up to 3′ (90 cm) tall. 'Gloriosa' ('Gloriosa Double Flowered', 'Double Orange'), an All-American Selection in 1981, is an old-fashioned form with equally large semi-double and double flowers in orange and rust shades; the large plants are 3–5′ (0.9–1.5 m) tall. 'Goldilocks' is a semi-double to double daisy, 18–24″ (45–60 cm) tall, with 3–4″ (8–10 cm) wide golden-yellow flowers; the doubleness is quite attractive, if you like double daisies, but flowers are even more susceptible to disease from summer rain and humidity. (Retailers look upon double rudbeckias as yellow dahlias.) 'Irish Eyes' is distinguished by the green center, surrounded by orange petals. 'Marmalade', another old standard, provides large golden-yellow flowers with a contrasting dark disk; plants grow 2½–3′ (75–90 cm) tall. 'Prairie Sun' has a green center and bicolor yellow petals—an outstanding cultivar. 'Rustic Colors' are just that, a mix of bronze, gold, mahogany, and yellow with a contrasting black center; plants range from 2′ (60 cm; sometimes called 'Rustic Dwarf') to 3½′ (110 cm) tall. 'Sonora' carries 5″ (13 cm) bicolor flowers, mahogany-red at center and golden-yellow beyond, on 15–20″ (40–50 cm) plants.

Pests and Diseases

The normal complement of insects devours these daises, particularly aphids and thrips.

Diseases include rot (*Sclerotium*), bacterial blights, botrytis, downy and powdery mildews, and verticillium wilt (Perry 1998).

Coreopsis must be divided regularly; overcrowding results in death. Also, if stems are not cut and flowers go to seed, yield and longevity will suffer. Remove all flowers, even if they will be used as compost.

Grower Comments

"My favorite is *Rudbeckia triloba*. This is a native American flower, but reselected seeds producing quality cut flowers are available. This flower lasts 2 weeks plus in a vase; never in all the years I've grown it has a bunch ever ended up on the compost heap. This flower sells! From the time we start selling in the spring, people ask when it will be ready." Janet Foss, J. Foss Garden Flowers, Everett, Wash.

"Grasshoppers have been the bane of my existence since becoming a flower grower. They love sunflowers and rudbeckias, so be sure to cut those as soon as the petals start to peel away from the face of the flower. They will open nicely in a day or two." Lynn Byczynski, Growing for Market, Lawrence, Kans.

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Cornus dogwood Cornaceae

woody

The diversity of dogwoods is extraordinary, from noble flowering landscape trees to shrubs best known for lighting up the winter landscape. The flowers are occasionally used for cuts (see *Cornus florida*), but their poor stem length and lack of vase life and shippability limit their popularity in the market. Dogwoods are most valued as cuts for the deciduous winter stems of the colored-stem forms (*C. alba*, *C. sericea*), harvested at the peak of color in late fall or winter.

Cornus alba red-stem dogwood Cornaceae

woody, Zones 2–6 Asia colored stems 8–10′/5–10′ (2.4–3 m/1.5–3 m)

Propagation

Cuttings: Hardwood cuttings have been successfully taken in early spring, dipped with a rooting hormone, and rooted with bottom heat. Softwood and hardwood cuttings root readily any time of year, but a 1000-ppm IBA dip should be used on cuttings taken in June and July. Hardwood cuttings, about 8–10″ (20–25 cm) long, can also be stuck directly into the field in late winter–early spring (Dirr 1998).

Seed: Seed should be stratified for 60–90 days at 41F (5C) (Dirr 1998).

Field Performance

Culture: For best stem color, plant in full sun and in areas where constant moisture may be maintained. Plants are normally found in the wild in wet, swampy areas. Neither *Cornus alba* nor *C. sericea* perform well in the South. Susceptibility to canker and poor stem coloration limit their usefulness south of Zone 6.

Habit: Plants are multistemmed shrubs with horizontal branches. The one-year-old stems are relatively unbranched, making them particularly suitable for cutting. Plants spread readily by underground stems.

Transplanting: Growers may direct-stick long cuttings or transplant rooted cuttings in the spring or fall.

Spacing: Plants may be grown as large masses; the only concern is to allow room for efficient harvesting. Stoloniferous growth eventually results in close spacing.

Fertilization: Reduce nitrogen fertilization in late summer. Excess fertilization, particularly nitrogen, results in soft growth and retards leaf drop and the development of stem coloration.

Harvesting: All stems should be cut close to the ground by late winter to allow new growth in the spring. New stems have the most brilliant color in the spring and in the winter. The best color occurs in late winter on one-year-old stems.

Yield: A massed planting can become a thicket, particularly if mismanaged. Three-year-old plants should yield approximately 25 stems.

Stage of Harvest

Stems are best harvested after the foliage has fallen in the fall and can be harvested until foliage emerges in spring. If foliage is removed, stems may be harvested whenever sufficient stem color has developed. Stems can be sorted by height; Huey Kinzie of Stoney Point Flowers in western Wisconsin bunches in lengths of 1–2′ (30–60 cm), 3–5′ (0.9–1.5 m), and 5–6′ (1.5–1.8 m), each longer bunch demanding a significantly higher price.

Postharvest

The highest demand appears to be in October to December; demand is quite limited the rest of the year. Stems may be stored in a humid area at 28F (⁻2C). Cold storage enhances stem color. When placed in water, branch color persists and some flowering may also occur.

Cultivars

Many cultivars are available, most differing only in their foliar characteristics. Few have more desirable stem color than the species. ‘Bloodgood’ has excellent showy red stems; ‘Kesselringii’ produces purple-black stems; and ‘Sibirica’ bears bright coral-red stems.

A few cultivars also bear handsome leaves, which may have potential as cut foliage. 'Argenteo-marginata' (also sold as 'Elegantissima') has gray-green leaves with irregular, creamy white margins; 'Spaethii' produces green foliage with strong yellow borders.

Pests and Diseases

Many fungi enjoy the delicacies of dogwood including those that cause canker, leaf blight, leaf spot, twig blight, and mildews. Crown canker and twig blight can be particularly devastating to *Cornus alba*.

Crown canker is caused by *Phytophthora cactorum*. Leaves curl and shrivel; later, twigs and even large branches die. Plants grown under stress (dry conditions, high temperatures) are more susceptible to canker. Plants may be treated in the early stages of infection, but once severely infected, plants eventually die. Cull badly affected plants. Rotate plants regularly to reduce the incidence of canker.

Twig blight is caused by several fungi; application of fungicides to the foliage and stems helps the problem.

Scale and bagworms also debilitate plants.

Cornus florida flowering dogwood Cornaceae

woody, Zones 5–9 Massachusetts to Florida white
10–20′/20′ (3–6 m/6 m)

This plant offers something in all seasons for the designer: in spring, lovely flowers; in summer, handsome foliage; in fall, red fruits and colored leaves; and in winter, unusual buds. Since few flowers are sold during the natural flowering time outdoors, flowering dogwoods are sometimes forced. Generally, they are cut as a budded branch, and stems are stored and then forced for winter bloom.

Propagation

Budding: Most cultivars are budded on seedling understock in July and August.

Cuttings: Collect softwood cuttings immediately after flowering. Treat with a quick dip of 1000 ppm IBA, and root in peat/perlite medium under intermittent mist (Dirr 1998).

Seed: Seed requires 100–130 days at 41F (5C) for germination (Dirr 1998).

Field Performance

Culture: Plants tolerate partial shade, although full sun is acceptable, and many more flower buds are formed. Foliage is more handsome in partial shade than in full sun. Acid soils, even moisture, and a cool root run are essential for maximum growth. Mulch is helpful, and good drainage is an absolute necessity.

Habit: Plants are usually grown as a low-branched tree, but when cut, they may become more shrubby in appearance.

Transplanting: Usually transplanted to the field as budded whips or 1- to 2-year-old seedlings.

Spacing: No data are available, but a 5–7′ (1.5–2.1 m) spacing should allow for sufficient room as long as branches are pruned annually.

Harvesting: Harvest long branches back to a node, allowing approximately ⅓ of the branch to remain.

Stage of Harvest

Forcing: Cut when buds are swollen. This may be accomplished 4–6 weeks prior to normal flowering time outdoors (Kasperski 1956). Place stems in water at 65–70F (18–21C). Use an acid preservative and change regularly. Flowers on stems cut in mid March require 2–4 weeks to open (Munroe 1991).

Cut flowers: Harvest when the bracts are beginning to open but prior to pollen formation in the flower. Place the stems immediately in a floral preservative to reduce bacterial and fungal growth.

Buds: Buds form in late summer and early fall. As soon as they are swollen, budded stems may be cut and used immediately.

Postharvest

Kasperski (1956) suggested that fresh flowers persisted 7–10 days if branches were split or crushed, although little evidence on the benefit of crushing stems has been recorded, and few growers "hack and whack" today. Condition by immediately placing stems in warm water (100F, 38C).

Cultivars

For cut stems, usually the species, grown from seed, is used; pink-flowered forms are vegetatively propagated. Dozens of cultivars have been selected for the landscape trade, however, and while they are more expensive, they may be useful in broadening the offerings of the niche grower. Dirr (1998) lists 90 taxa of flowering dogwood; some are notable for their variegated or colorful foliage, others for their large flowers, double flowers, or pink to red flowers.

Pests and Diseases

Plants are susceptible to several pests and diseases, among them borer, leaf, and petal spots. The more stress a tree is under, the more likely damage will occur. Dogwood anthracnose (*Discula*) has been a major concern for nursery growers in the North and Middle Atlantic states. Symptoms include irregular, purple-rimmed leaf spotting or tan blotches; infected leaves that stay on branches after normal leaf fall; die-back of twigs; water sprout formation; and infection of bracts under rainy conditions (Dirr 1998). Trees are killed within 3 years of infection.

Additional Species

Cornus mas (cornelian cherry dogwood) can be grown for its flowers and fruit. Plants grow 15–25′ (4.5–7.5 m) tall and 15–20′ (4.5–6 m) wide. Bright yellow flowers, which occur in ¾″ (2 cm) wide inflorescences, appear in late winter in the South and early spring in the North. Harvest when flowers are open or when fruit has begun to turn red, but before the fruit begins to fall. The fruit ripens irregularly; some may be yellow, others red. Flowers persist 7–10 days and will store in the cooler for up to 2 weeks. The ½″ (13 mm) wide fruit, formed during the summer, is a bright cherry-red. Trees perform best in the North and are hardy in Zones 4–7.

Cornus sanguinea (bloodtwig dogwood) has mediocre reddish stems, brighter on the side toward the sun, but several better cultivars are available. One, 'Midwinter Fire', is reddish at the base, changing to orange and yellow toward the tips during the winter; needs to be cut back for best color.

Cornus sericea (syn. *C. stolonifera*) is grown for its colorful stems. Some authorities believe it to be a subspecies of *C. alba*, which it resembles; indeed, few differences in habit or culture exist between these species. The species is highly susceptible to canker, hardy in Zones 2–7. Several cultivars of *C. sericea* enhance the offerings of the grower. 'Cardinal' bears cherry-red stems. 'Flaviramea' is a marvelous form with bright yellow stems; if grown well, it is unbeatable for color. 'Silver and Gold' is a branch sport (chimera) of 'Flaviramea' and bears yellow stems; potentially useful for its irregular, creamy-margined foliage as well.

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Many thanks to Huey Kinzie for reviewing this section.

Cosmos bipinnatus lace cosmos Asteraceae

annual Mexico many colors 3–5′/2′ (0.9–1.5 m/0.6 m)

Cosmos is a common bedding plant; most plants used in American landscapes are either the dwarf sulphur cosmos (*Cosmos sulphureus*) or lace cosmos (*C. bipinnatus*). Sulphur cosmos is sometimes used as a cut flower, but lace cosmos is more popular, being taller and available in numerous colors.

Cosmos bipinnatus
'Daydream'

Propagation

Seed emerges in 7–10 days if germinated at 70–72F (21–22C) under intermittent mist. Seed should be lightly covered for best germination. Approximately 0.5 oz (14 g) of seed yields 1000 seedlings (Nau 1999). Direct sowing cosmos has become more popular every year, particularly for a second or third sowing. Sow at the rate of 0.45 oz per 100′ (50 g per 100 m) (Kieft 1996), but field temperatures must be above 60F (15C) for best results.

Growing-on

Plants should be grown at 60–65F (15–18C). Low nitrogen fertilization is recommended. Apply 50–100 ppm N during the growing-on stage; higher nutrition results in tall, spindly growth. Green plants may be planted out 4–6 weeks after sowing.

Environmental Factors

Photoperiod: *Cosmos bipinnatus* is a quantitative short day plant (Molder and Owens 1974). This means that, although plants flower more rapidly under short days than under long days, they eventually flower under all photoperiods. It may seem to make little sense initially that cosmos is a SD plant that flowers in the summer; however, the optimum photoperiod for flowering is less than 14 hours. Only when daylengths are greater than 14 hours is flower development delayed. Under LD, flower buds appear sporadically. The following table (Wittwer and Bukovac 1959) illustrates the effect of photoperiod on 'Sensation'.

The effect of photoperiod on *Cosmos bipinnatus* 'Sensation'.

Photoperiod	Plants in flower (%)	Days to visible bud	No. of nodes	Height (in)^{z}
9 hours	100	47	12	37.0
18 hours	75	56	12	39.8

z = multiply (in) by 2.54 to obtain (cm)

Temperature: *Cosmos* is a heat-loving plant and grows and flowers well at temperatures above 60F (15C). Temperatures below 55F (13C) inhibit growth and flowering.

Plant age: As plants mature, the need for short days decreases; therefore, older plants are more likely to flower under long day conditions than young plants. Plants with 6–8 leaf pairs are sufficiently mature to flower regardless of photoperiod (Molder and Owens 1974).

Gibberellic acid: GA_3 substitutes for short day treatments (Molder and Owens 1974). Approximately 100 ppm GA will substitute for the need for SD; that is, if plants are grown under LD (>14-hour photoperiod), and given GA, they will flower as rapidly as if grown under SD conditions (Wittwer and Bukovac 1959).

The effect of photoperiod and gibberellic acid on *Cosmos bipinnatus* 'Sensation'.

Photoperiod, GA treatment	Plants in flower (%)	Days to visible bud	No. of nodes	Height (in)^z
9 hours + 100 ppm GA	100	46	12	45.6
18 hours + 100 ppm GA	100	46	12	48.4

z = multiply (in) by 2.54 to obtain (cm)

Care must be taken when applying GA, however, as results have shown that GA is not as efficient as SD treatment, nor are GA-induced flowers as large as those induced under SD (Molder and Owens 1974). Plants treated with GA have elongated internodes and generally are of inferior quality. Seldom used by commercial growers except perhaps those in the far North or South, where summer photoperiods of less than 14 hours are difficult to attain.

Field Performance

Space plants 9–12″ (23–30 cm) apart; support mesh is necessary, especially if wind is a problem. Some growers plant on 8″ (20 cm) centers and find that plants support each other; however, excessively dense plantings can encourage disease. Sequential planting (planting every 2–4 weeks) results in better-quality stems and less disease than harvesting from the same plants throughout the season. This is highly recommended in the South. Cosmos are less prone to deer browsing than many other annuals; this is thought to be because they produce repulsive odors when attacked (Ball 1997). As with most crops, the degree of deer resistance is dependent on deer population and availability of food.

Fertilize with a granular 10-10-10 fertilizer or an application of 200 ppm N using a complete soluble fertilizer in early spring, when plants are placed in the field. Repeat in mid summer, but do not over-fertilize, or lanky, leafy plants will result.

In order to encourage long stems, some growers pinch early, near the base of the plant. When Chas Gill of Bowdoinham, Maine, sets out cosmos, he prefers to pinch the plants to the first set of nodes; alternatively, he waits until the plants are about 18″ (45 cm) tall, then trims them with hedge shears to 10–12″ (25–30 cm). He finds that plants so treated have a better branching habit and harvest is easier.

Greenhouse Performance

Space plants 6–9″ (15–23 cm) apart. Apply LD (>14 hours) until plants have approximately 6 leaf pairs. Apply SD for most rapid flowering at that time. Remember that SD only have to be less than 14 hours. If stems are too short, continue LD for a longer period of time. Maintain temperatures of 60–65F (15–18C) or higher if accelerated flowering is desired. Provide as much light as possible.

If short stems are needed, paclobutrazol (Bonzi™) at 150 ppm is effective (Mohd et al. 1988) and daminozide (B-Nine™) is also effective. Sprays can be applied early, but they should be used only if necessary, as flower size is generally reduced as well. However, if B-Nine™ was applied late (just before flower stem elongation), the tendency of flowers to droop is reduced and little flower size reduction occurs (Samata et al. 1974).

Fertilize newly transplanted plants in the bench with 50–75 ppm N using potassium nitrate and continue with weekly applications of 150–200 ppm N from a complete soluble fertilizer. Do not overapply nutrients.

Stage of Harvest

Flowers may be harvested in colored bud, particularly if flowers are to be shipped or used for a wedding or other event where stems are already sold. Some growers harvest when petals (ray flowers) on the first flower are just opening but have not yet flattened out. If flowers are to be dried, allow the outer row of petals to fully open. Stage of harvest is quite important (see “Grower Comments”).

Postharvest

Fresh: Vase life is only about 4–6 days in water but can be extended with floral preservatives. Gast (1998) looked at several cultivars of cosmos and showed that a vase life of approximately 7–9 days is possible.

Storage: Store stems at 36–40F (2–4C) for 3–4 days only if necessary. Storage is not recommended.

Dried: *Cosmos* can be dried in silica gel (2–3 days) or borax (4–6 days).

Cultivars

‘Bright Lights’ is a mix of 30–36″ (75–90 cm) tall reds, oranges, and yellows.

Campus series grows to 3–5′ (0.9–1.5 m) and comes in apricot and lemon-yellow. Might be useful for fall designs.

‘Candystripe’ has white, rose, or red flowers with crimson markings on the petals. Plants are 2½–3′ (75–90 cm) tall.

‘Collarette’ is a mixture of different colors of semi-double flowers, although single flowers are also present. Plants are 2–3′ (60–90 cm) tall.

‘Daydream’ produces handsome, pale pink flowers with a deep rose center on 3′ (90 cm) stems.

Giant Tetra series produces flower stems 40–48″ (1–1.2 m) tall. Varieties include ‘Elysee’ (white), ‘Louvre’ (early, pink), and ‘Opera’ (appleblossom-pink).

'Klondyke' occurs in mixed colors and grows 3–5′ (0.9–1.5 m) tall.

'Picotee' is a mix of flowers ranging from white with red edges to red with faint white markings. Plants grow 3–4′ (0.9–1.2 m) tall.

Pied Piper series bears flowers with rolled petals and a yellow center. Stems are approximately 36″ (90 cm) long.

'Pink Fairytales' bears sprays of pink and white daisy-like flowers on 2–3′ (60–90 cm) stems.

Polidor Mix has 3′ (90 cm) stems with semi-double 2″ (5 cm) wide flowers in a mix of red, gold, and orange.

Psyche Mix has burgundy shades of semi-double daisies on 40–48″ (1–1.2 m) stems. Some people love it, others miss the old-time singleness of flowers.

'Radiance' has rose-crimson flowers.

'Sea Shells' comes in a color mix and consists of interesting flowers with tubular petals and fluted edges. Most decorative.

Sensation (Early Sensation) series bears 3″ (8 cm) wide flowers in many colors. Plants generally grow 3–5′ (0.9–1.5 m) tall. 'Dazzler' has fiery red flowers on 3′ (90 cm) stems; 'Gloria', rose flowers with a carmine zone; and 'Purity' bears large, white flowers. In national trials, 'Sensation Purity Superior' produced 12 stems/plant with an average stem length of 30″ (75 cm) (Dole 1995). A long-time favorite of cut flower growers.

Sonata is an outstanding series, with many bright colors and large flowers.

'Summer Garden' is a pale yellow with a touch of pink in the center. Plants grow about 4′ (1.2 m) tall, with stiff stems of 24″ (60 cm). Highly daylength sensitive and difficult to flower in the spring.

'Vega' is said to be an early-flowering form, although it has not been tested widely enough to verify. Produces 3″ (8 cm) flowers in shades of rose, pink, and white, on 3′ (90 cm) stems.

Versailles series is a particularly good cut flower selection, although not as tall as some of the newer offerings, with large, single flowers with crimson rings. Originally available only in lilac-rose, now joined by carmine, blush-pink, lilac-pink with crimson, pink, and white forms. Cultivars evaluated in national trials averaged approximately 16 stems/plant with an average stem length of 17½″ (44 cm); 'Versailles Carmine' was particularly well-received (Dole 1995).

'Yellow Garden' bears pastel yellow flowers on 3′ (90 cm) stems. Tends to fade in bright light.

Additional Species

Cosmos atrosanguineus (chocolate cosmos) bears single, occasionally double flowers of purple to red, and is not as vigorous or as floriferous as other species. In fact, the dark color of the flowers gets lost among other more sturdy, bigger plants. The petals are velvet, the color is chocolate-maroon. But the real kicker is that as you stick your nose closer, the unmistakable smell of chocolate fills your head. Plants grow 2–3′ (60–90 cm) tall with 2″ (5 cm) wide flowers.

Plants grow from swollen tuberous roots; they are short-lived perennials in some areas, but for most of the United States, they should be treated as annuals.

Greenhouse studies in England (Kanellos and Pearson 2000) provided some useful information on the response of chocolate cosmos to temperature and photoperiod. When temperatures were raised from about 54F (12C) to around 80F (27C), plants emerged 17 days faster and plant height doubled, but flowers were smaller. Increasing temperatures had only a small influence on flowering time. Flowering was advanced by LD; plants grown at a 17-hour photoperiod flowered 33 days faster than those at 8 hours and were far bigger and stockier. Long days and temperatures of 62–70F (17–21C) seem to make sense.

Cosmos sulphureus is a good cut flower, but stem length may be too short, depending on your market. Photoperiod is more critical with this species. They are obligate SD plants, meaning that they must see SD (<14 hours) for optimum flowering to occur (Biebel 1936). 'Diablo' and the Sunny series are less responsive to photoperiod. They were bred as bedding plants but may still be useful cuts.

Pests and Diseases

Bacterial wilt (*Pseudomonas solanacearum*) results in sudden wilting and collapse of the plants. Plants shrivel and dry up in 2–3 days. Infected plants should be destroyed immediately. Because bacteria can overwinter, crop rotation should also be practiced.

Canker (*Diaporthe stewartii*) usually affects stems and branches at blooming time. The lesions are first dark brown and later ash gray. Remove and destroy infected plants.

Root and stem rots are particularly damaging in southern states and in areas where plants are overwatered. Soil drenches with appropriate fungicides are useful.

Aphids, Japanese beetles, and leafhoppers are the most common pests on *Cosmos*.

Grower Comments

"One problem with cosmos is that if you wait until it looks good to cut, its vase life is already half shot. If you cut it in the bud, it will open, but customers don't know that." Ralph Thurston, Bindweed Farm, Blackfoot, Idaho.

"I once did a wedding of only cosmos—1000 stems! I used all the 'Versailles' varieties—it was beautiful. We cut them in colored bud the night before and put them in preservative in an air-conditioned room. The next day they opened immediately in regular day temperatures of 80F or more." Pat Bowman, Cape May Cut Flowers, Cape May, N.J.

"Cosmos is one of those flowers that needs to be picked every day. If you can't sell them that day, you need to deadhead them so you know the flower you pick tomorrow is a new one. I figure each day blooming in the garden is at least one less day of vase life." Dave Dowling, Farmhouse Flowers, Brookeville, Md.

"Cosmos is one of our bigger crops. We transplant plugs into black plastic on 8″ centers. We do not stake as plants support each other. We put 15 stems per bunch and retail them for $5 a bunch. In order to encourage long stems our initial cuts are made deep into the plant; this may cause panic at first, but be patient—long stems are bound to follow. We tried 'Versailles' but it was too short. . . . We mainly grew Sensation varieties and 'Psyche', a double variety, I love it." Linda Gill, Kennebec Flower Farm, Bowdoinham, Maine.

"I've grown *Cosmos bipinnatus* 'Summer Garden' a few times and I can't get it to flower until fall. It seems to be very daylength sensitive." Betsy Hitt, Peregrine Farm, Graham, N.C.

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Many thanks to Chas Gill and Pat Bowman for reviewing this section.

Crocosmia hybrids montbretia Iridaceae

bulb, Zones 5–9 hybrid origin many colors 2–2½′/2′ (60–75 cm/60 cm)

This genus contains about 7 species, but the main cut flower forms are hybrids, sometimes referred to as *Crocosmia* ×*crocosmiiflora* (and still sold as *Montbretia*, although that name is no longer valid). An underused cut, crocosmias provide flowers on thin, spike-like inflorescences (racemes); the flowers are 1½–2″ (2.5–5 cm) long and occur in many handsome colors. The fruit too is highly ornamental, and plants are often left in the field so that the fruiting stem rather than the flowering stem may be harvested in late summer and fall. The fruit vary in color, although most start greenish and turn maroon and rust in September and October. Plants are easily cold hardy to Zone 5 and have been left in the ground in Zone 4 with success.

Propagation

Plants emerge from corms, and 1- to 2-year-old corms may be purchased from specialty suppliers. Seeds require approximately 2 years to reach flowering size.

Growing-on

Place corms or plantlets immediately to the field, at a depth of about 2″ (5 cm) below the soil. In more northerly zones, corms may be planted as deep as 6″ (15 cm) below the soil. Emergence will be less uniform with deeper planting.

Field Performance

Spacing: Space plants (corms) approximately 6″ (15 cm) apart. In coastal areas, particularly the West Coast, corms multiply rapidly and colonize the area. Most cormels (new corms), however, are too small to flower.

Planting time: South of Zone 5, corms may be planted in January. The effect of different planting times in Zone 7b, Athens, Ga., is shown in the following table (Armitage and Laushman 1990).

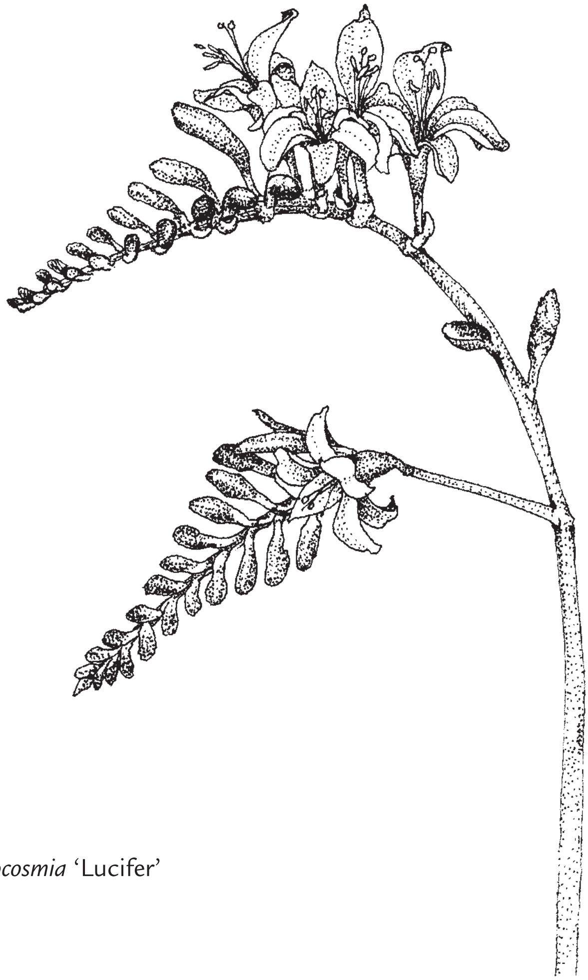
The effect of planting date on *Crocosmia*.

Month planted	Flw/corm	First harvest	Harvest duration (days)	Stem length (in)^{z}
Jan	1.3	2 Jul	30	25.7
Feb	0.8	15 Jul	25	20.2
Mar	0.8	21 Jul	21	20.0

z = multiply (in) by 2.54 to obtain (cm)

Later planting extends flowering time but does not significantly affect yield. Stem length, however, is reduced as corms are planted later in the season. North of Zone 5, corms may be planted as soon as field conditions warrant.

Longevity: North of Zone 5, corms should be lifted in the fall (similar to gladiolus), graded, and replanted in the spring; however, Susan O'Connell of Fertile Crescent Farm, Hardwick, Vt., reports that she has 100% return from corms in



Crocosmia 'Lucifer'

her Zone 4 farm, without any special treatment. Longevity in Zone 7b is shown in the following table (Armitage and Laushman 1990).

Longevity of *Crocosmia* in Athens, Ga.

Year	Stems/corm	Stem length (in)^z	Stem width (mm)^y
1	0.9	22.2	4.9
2	1.2	16.0	4.7
3	2.0	20.0	4.5

z = multiply (in) by 2.54 to obtain (cm)
y = divide (mm) by 25.4 to obtain (in)

Corms did not produce well in the fourth year; therefore, treat crocosmia as a 2–3 year crop where corms overwinter. Corms are inexpensive and are often replanted each year. In southern and coastal climates, crocosmia is a 2–5 year crop. In areas of the West Coast, plants are considered almost invasive.

Stage of Harvest

Pods: Kent Miles of Seymour, Ill., has been harvesting crocosmia for many years: "For our market in this area, we can get a better price per bunch as fresh pods than as fresh blooms. So we wait and harvest the fresh pod stems in the fall —10 per bunch." He has higher success when he plants in the spring, compared to the fall; fall-planted material suffers with the wetness of the soil and the cold temperatures in Zone 5: "We now know to lift in fall, store, replant in spring."

Flowers: The first few flower buds at the base should be showing color but need not be open (Vaughan 1988). If harvesting stems with fruit, do not allow the fruit to open.

Postharvest

Fresh: Flowers and pods should be handled similarly. Fresh stems persist 7–10 days. They are sensitive to ethylene and must be stored away from fruits and vegetables (Vaughan 1988). Flower buds and pods are fragile, so handle cut stems with care.

Storage: Stems may be stored dry for up to 4 days at 34–37F (1–3C), although storage in water is recommended (Vaughan 1988).

Dried: Flowers may be air-dried upside down in small bunches in a warm, dry place. The strap-like leaves are also useful and provide a fresh look to a dried arrangement. If bunches are hung with plenty of air circulation, they retain their original color (Bullivant 1989).

Cultivars

Only a few of the many cultivars seem to have found their way into cut flower markets. The parentage of many of them is not known; all are thought to be hybrids. Most were bred in England and may be difficult to obtain.

'A. E. Amos' is a brilliant orange-red but has not performed particularly well in north Georgia.

'Bressingham Beacon' produces many orange and yellow bicolored flower sprays on dark stems. Stunning.

'Bressingham Blaze' has intense orange-red flowers on 2–3′ (60–90 cm) tall plants.

'Citronella' ('Citrinum') has small, pretty, orange-yellow flowers above light green foliage.

'Emberglow' produces reddish burnt-orange flowers atop 2–3′ (60–90 cm) plants.

'Emily McKenzie', introduced in the mid 1950s, is truly impressive and still difficult to beat for vibrant color. The large orange petals contrast beautifully with the crimson throat.

'Firebird' bears fiery orange-red flowers with a bright yellow throat.

'James Coey' has deep red flowers with yellow centers. Not as vigorous as some of the new cultivars.

'Jenny Bloom' is a vigorous selection with butter-yellow flowers on 2–3′ (60–90 cm) plants.

'Lucifer' is exceptional, the standard by which all other cultivars are measured. It has been grown in the United States for years, covered with scarlet-red flowers each summer, and has proven its value over and over.

'Météore' bears red and yellow bicolored flowers in mid summer. About 2′ (60 cm) tall.

'Norwich Canary' is a late-flowered form with bright yellow flowers on 2′ (60 cm) plants.

'Plaizar' is about 2½′ (75 cm) tall with bright yellow-orange outward-facing flowers.

'Solfatare', one of the oldest hybrids, was bred in the late 1800s by the French nursery Lemoine. It is 2′ (60 cm) tall with apricot-yellow flowers and dark green leaves.

'Spitfire' is a large plant with stunning orange-red flowers with a yellow throat.

'Star of the East' is not as cold hardy as other cultivars but has handsome apricot flowers on 2–3′ (60–90 cm) stems.

'Venus' is only 18–24″ (45–60 cm) tall and produces peach-yellow flowers on darkened stems.

'Vulcan' is also relatively short, compared to 'Lucifer', and bears scarlet-orange flowers.

'Walburton Yellow' has golden-yellow, upward-facing flowers. 'Walburton Red' has fire-engine-red flowers.

Grower Comments

"Regarding planting depth for crocosmia, in my experience 1″ of soil cover is plenty. At deeper depths, corm sprouting is highly variable and prolonged." Paul Sansone, Here & Now Garden, Gales Creek, Ore.

"They don't seem very prolific—I get a stem or two from each corm each year. They seem to 'settle in,' though, and I think they will continue to produce more and more. The open blooms are very fragile, and break off easily. Buds continue to open, but a rough customer in my crocosmia bucket can do a lot of damage very quickly. My vote for a vibrant orange that stops them dead in their tracks is *Crocosmia* 'Lucifer'. Bright deep orange color, and when arranged with giant 'Sungold' sunflowers, customers are powerless. Their wallets jump out of their pockets as if under a spell." Susan O'Connell, Fertile Crescent Farm, Hardwick, Vt.

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Many thanks to Kent Miles and Paul Sansone for reviewing this section.

Dahlia hybrids — Asteraceae

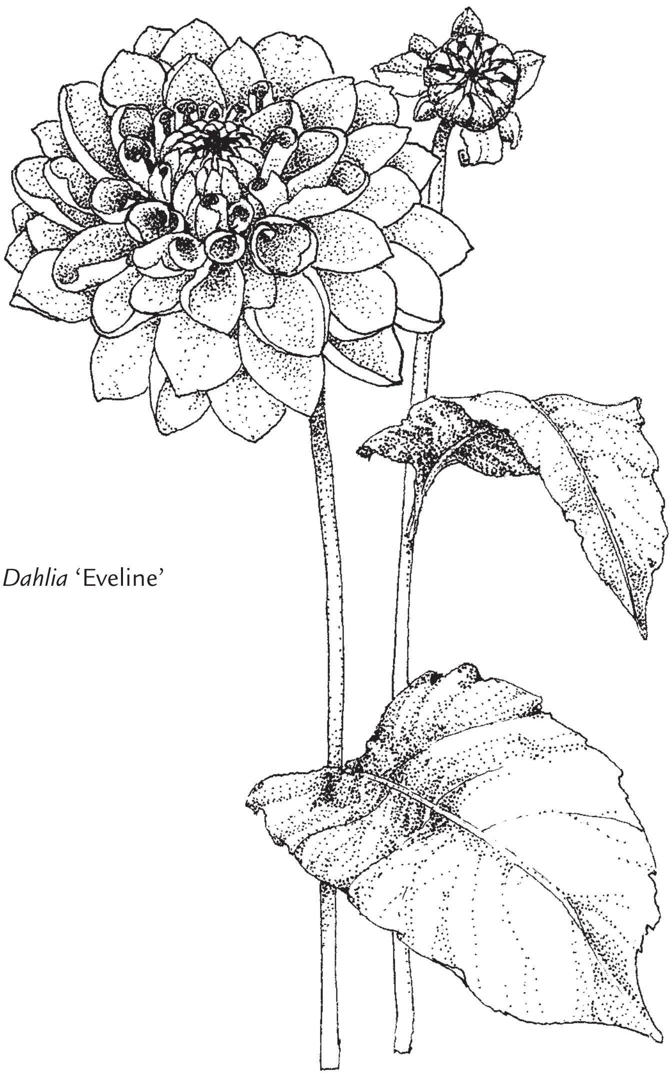
bulb, Zones 7–10 hybrid origin many colors 2–5′/3′ (0.6–1.5 m/0.9 m)

Dahlias continue to be popular and are field-produced from Oregon to Minnesota to Florida as well as in Europe and Japan. Today's cultivars, hybrids all, originally resulted from crosses of *Dahlia pinnata* and *D. coccinea*, and probably other species. Plants emerge from tuberous roots and bear tall, often hollow stems, opposite leaves, and terminal inflorescences. Although many colors and flower shapes occur (see "Cultivars"), most are classified as single (in which showy florets surround a central disk of smaller, yellow florets) or double (in which the colored florets predominate). Doubles are most common in cut flower use. Tubers must be lifted in northern states but may remain in the ground for up to 3 years in Zones 7–10. Flowers do not ship particularly well, making dahlias a good product for the local market.

Propagation

Most growers purchase roots from specialty suppliers, but dahlias may be propagated by seed, tubers, or stem cuttings. For seed germination, maintain 80–85F (27–29C), cover lightly, and place in an area of high humidity. Germination occurs in 10–12 days. Terminal cuttings can be taken from actively growing plants; however, the best results arise from tubers forced in the greenhouse in the winter. New shoots appear in about 2 weeks when greenhouse temperatures remain at 50–60F (10–15C). Select 2- or 3-node cuttings and place in a well-drained medium in a humid environment at 65–72F (18–22C). Roots should appear at the bottom of the pot in 3–4 weeks. Tubers may be divided, but tubers themselves cannot produce new buds. A piece of the old stem with a bud attached must be taken with each piece of tuber. Phil Clark, a small grower in Camden, Maine, works with dug tubers in the spring:

> Around the end of February or beginning of March, the tubers are brought out of storage. Up to that point they have been wintering in our cellar in plastic shoeboxes [filled with] vermiculite. The first thing I do is add a tablespoon of water to the vermiculite and introduce them to a warm area



Dahlia 'Eveline'

[because] I have consistently found that some dahlia tubers with an eye fail to sprout or send out feeder roots. In approximately 2 weeks, many of the tubers will begin to sprout (some varieties may take quite a bit longer). The tubers with sprouts are immediately potted up. The ones that haven't are monitored weekly and potted when ready. They all have their own timetable. Even tubers of the same variety will send up sprouts at different times. After several weeks, the tubers that didn't sprout are discarded. That way you don't plant tubers that will never come up!

Growing-on

Transplant seedlings or cuttings to 4–6″ (10–15 cm) pots and grow at 60–68F (15–20C). Plants may be placed in the field as soon as danger of frost has passed. Place tubers in the ground as soon as soil temperatures remain above freezing.

Environmental Factors

Photoperiod: Daylength has a direct influence on flowering and tuber formation. Long days (approximately 14 hours, depending on cultivar) cause faster flower initiation, but if daylengths are very short (8 hours), flowers usually fail to open. A large volume of research on various cultivars suggests that the percentage of flowering plants and the total production of flowers are optimized in daylengths of 13–15 hours (Konishi and Inaba 1964, Durso and De Hertogh 1977). Daylengths below 11 hours and greater than 16 hours had a deleterious effect. Some older cultivars fail to flower when daylengths are greater than 16 hours (Konishi and Inaba 1964, 1966). Short days (12 hours or less) result in tuber formation for most cultivars (Moser and Hess 1968, Zimmerman and Hitchcock 1929).

Temperature: The optimum temperature range for vegetative shoot development is 55–77F (13–25C), but optimum temperature for flower initiation and development is 50–59F (10–15C) (Dole and Wilkins 1999). Night temperatures between 50 and 86F (10 and 30C) do not affect flower initiation, but flower development proceeds more slowly at cooler temperatures (Mastalerz 1976). The greatest influence of cold temperatures is the breaking of tuber dormancy. If tubers spend at least 40 days at 32F (0C), dormancy is broken and normal shoot production occurs (Konishi and Inaba 1967).

Field Performance

Planting: Place tubers or started plants in the field after all threat of frost. Late frosts check the emerging foliage and result in significantly delayed flowering. Unsprouted tubers may be planted earlier, but if planted when the soil is too cold, sprouting is delayed. The size of the tuber appears to have little to do with the resulting plant.

Weed control: Research in Oregon (Maul 1999) showed that the herbicides containing the active ingredients oryzalin, isoxaben, or prodamine, alone or in combination (oryzalin and isoxaben, oryzalin and prodamine) significantly reduced weed populations when combined with hoeing. No phytotoxicity was noted. The combination of oryzalin and isoxaben (44 ml + 7 g/1000 ft^2) resulted in best control.

Spacing: Space 2′ (60 cm) apart. More dense spacing results in tangled stems and poor air circulation—and greater disease problems. Planting up to 3′ (90 cm) apart results in more flowers and less disease but is an uneconomical use of space. In areas of cool temperatures and low humidity (e.g., coastal Northwest), closer spacing can be used without fear of disease, but don't get greedy.

Support: Unless excellent wind support is available, all plants used for cutting require some support to keep the plants from falling over, such as 4′ (1.2 m) bamboo canes (each plant is usually provided with 3 canes, forming a triangle, with the plants tied into the triangle), wire cages, a single stake per plant, rebar, or 2–3′ (60–90 cm) tall wire runs.

Mulch: Dahlias are shallow-rooted, and a root mulch should be liberally applied. Pine straw, bark, peat moss, manures, or lawn clippings may be used.

Nutrition: Side dress with a complete granular fertilizer, such as 10-10-10, when tubers begin to sprout. Liquid fertilizer (300–600 ppm N) once every 2 weeks is sufficient in most climates.

Pinching: Pinching the terminal shoot encourages the development of the many side shoots, meaning more flowers are produced more rapidly, although flowering is delayed by 1–2 weeks. Pinch approximately 2″ (5 cm) of growth when plants are about 2′ (60 cm) tall. Some growers want to harvest the central flower, which is the largest and earliest; you must weigh the benefit of the price obtained for the earlier, larger flower against the cost of delay of axillary flowers.

Disbudding: Most varieties bear flowers with small side buds beneath the center bud (like a chrysanthemum). Removal of the lateral flower buds yields larger flowers; allowing them to remain results in a spray inflorescence. Disbudding requires significant labor and some skill.

Yield: Yield is highly dependent on cultivar; however, yields of 20 flowers per plant are not uncommon. Flowers are generally harvested in early summer and may continue to flower until frost.

Longevity: In the South, where tubers are left in the ground, 3-year production from the same tuber is not uncommon. If tubers are lifted and stored properly, they may be used indefinitely.

Lifting tubers: In northern states and Canada, tubers should be lifted after the first frost. Lift, clean, and store dry tubers in a well-ventilated room at 45–50F (7–10C). Clean the tubers well, using a brush if necessary to get rid of soil. Refer to *Zantedeschia* for additional guidelines on lifting tubers.

Greenhouse Performance

With proper manipulation of photoperiod and temperature, dahlias may be forced year-round. When tubers arrive, plant immediately. If unable to plant, place tubers in cooler in the shipping containers at 45–50F (7–10C).

Planting: Plant in ground beds or large containers around 12″ (30 cm) in diameter. Water in well, and keep soils moist.

Light and photoperiod: High light levels are required for best dahlia growth, and winter production often requires supplemental lighting. Shade may be needed for summer production. Provide daylengths of 11–14 hours; never allow daylengths to fall below 8 hours. Long days of 16 hours may delay flowering of newer cultivars but will not likely be detrimental otherwise (De Hertogh 1996).

Temperature: Provide minimum night temperatures of 62–65F (17–18C); day temperatures of 73–77F (23–26C) are recommended. Avoid temperatures greater than 80F (27C), or quality will be reduced. The crop may be slowed down if temperature is lowered to 55F (13C). This is particularly useful when flower buds are in color, before the market is ready.

Pinching: As with other field-grown plants, dahlias may be pinched for additional flower production. Nonpinched plants may be more closely spaced than pinched plants.

Scheduling: Depending on cultivar, plants flower 9–13 weeks from planting the tuber. The later the planting date, the more rapid the flowering.

Stage of Harvest

Dahlias should be harvested when the flowers are 75% to fully open, but before the outer petals begin to decline. If cut too early, dahlias fail to open, even in opening solutions. Flowers that do eventually open are often of poor quality. After harvest, immerse stems in warm water (130F, 54C) (Nowak and Rudnicki 1990).

Postharvest

Fresh: Dahlias persist 3–5 days in water, 7–10 days if an opening solution is used (Nowak and Rudnicki 1990, Vaughan 1988). Harvest in the morning, and place stems immediately in hydrating solution. Some growers immediately put the cut stems in hot water, then allow the water to cool, before arranging.

Dried: Dahlias are best dried in silica gel or sand; they shrink when air-dried. In sand, flowers take several days and up to 4 weeks to dry (Vaughan 1988).

Storage: Flowers can be stored wet at 37–40F (3–4C) and about 80% humidity, but storage should be avoided whenever possible.

Shipping: Always ship in water or preservative.

Cultivars

Dahlias are divided into various classes, some of which may be more useful in a particular market than others. Check with your supplier.

Single dahlias	Single row of ray petals.
Anemone-flowered	Usually disk flowers and ray flowers of different colors.
Collarette	One or more series of ray flowers. Above each series is a ring of florets (the collarette) only ½ the length of the rays and usually of a different color. May be single-, peony-, or double-flowered.
Peony-flowered	Usually 2 or 3 series of ray flowers and a single disk.
Decorative	Flower heads fully double, showing no central disk. A popular cut class.
Pompon	Similar to doubles but smaller.
Cactus	Flower heads fully double. The margins of the flowers are thin and elongated.

Pests and Diseases

Dahlias are subject to viruses, insects, and a host of disease organisms. Slugs find them particularly tasty. Growing dahlias requires a preventative spray program for mildews, leaf spots, and Japanese beetles. Southern growers, in particular, must spray conscientiously, especially after afternoon thunderstorms.

Grower Comments

"Last year we planted dahlias in raised beds, covered with white plastic, and 2 layers of netting. After planting the tubers, set your posts at opposite ends of the bed. Run one layer of net about 6–8″ above the bed. Then, run one more layer of net about 12″ above the first layer of net. As the dahlias grow, raise the net to support the plant. I found that using this method rather than tomato cages (cost and space prohibitive), or using a fence, allowed for straighter growing stems and much easier access to the blooming flowers." Joseph Caputi, Charlotte's Garden, Louisa, Va.

"I have never staked my dahlias; I cut stems that are 24–30″ plus, every time I pick. This keeps the dahlias at a good height. If I have trouble with a dahlia that falls down or whatever, I quit growing it and find something else. If it doesn't last in a vase for me, if I have to disbud too much, if the stem can't hold the weight of the flower, if they shatter, etc., I discard it. Many reputable dahlia tuber producers have already done this for you, if you select tubers they recommend for cutting." Janet Foss, J. Foss Garden Flowers, Everett, Wash.

"On poppies and dahlias—dip in hot water for a few seconds when you get back to the packing shed, then into cool hydration solution (50% Hydraflor 100) and hold in cooler." Ray Gray, Sunset Flowers of New Zealand, Oregon City, Ore.

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Many thanks to Ken and Suzy Cook (first edition) and Phillip Clark and Howard Lubbers (second edition) for reviewing this section.

Delphinium hybrids — Ranunculaceae

perennial, Zones 2–7 — hybrid origin — many colors — 3–4′/3′ (0.9–1.2 m/0.9 m)

A mainstay in the cut flower industry, delphiniums have been grown for years in North America, South America, and Europe. Current offerings are hybrids, mainly from *Delphinium elatum* and *D. grandiflorum*. They will continue to be popular, although the market fluctuates from year to year. In the southern states, delphiniums are field-planted in fall for spring flowering and treated as an annual; in the North, plants may be in production for up to 3 years.

Two main forms of delphiniums are found in the trade. Elatum hybrids are generally double-flowered and densely flowered—the classic form of cut delphiniums. Belladonna (Bellamosa) hybrids are usually single to semi-double flowered, looser, and more open than the elatums.

Significant differences occur between delphiniums and larkspurs (*Consolida* spp.), although the names are often used interchangeably. Consumers may be allowed to get them mixed up, but we, as an industry, should not. We are tired of reading about larkspurs being called delphiniums because someone thinks they sound better that way. Let's get it right. For information about larkspurs, see *Consolida*.

Propagation

Seed: Lightly cover the seed and chill it (35–40F, 2–4C) for 2–4 weeks, after which temperatures of 65–70F (18–21C) may be used for germination (Carpenter and Boucher 1992). If prechilled, seeds germinate in 8–15 days. Nonprechilled seed will germinate erratically, continuing 2–3 weeks. Plugs are usually available and are recommended.

Cuttings: Take 3–4″ (8–10 cm) long terminal cuttings of new shoots arising from the base of the plant. The base of the cutting should be solid, not hollow. They will root in 3–4 weeks under mist or in a sweat tent in a sand/peat or peat/perlite mixture.

Tissue culture: Many hybrids are now produced from tissue culture and made available to the grower as plugs.

Delphinium 'King Arthur'

Growing-on

Grow seedlings at 50–55F (10–13C) in the greenhouse or in cold frames and transplant when large enough to handle. Cuttings should be transplanted to 4–5″ (10–13 cm) pots as soon as rooted and grown until ready for planting. For northern growers, seed sown in January will be ready for transplanting in March or April; for southern growers, seed should be sown in July for plants to be moved outdoors by October. Growers in coastal, central, and northern California, Oregon, and Washington can plant out as late as June for flowering in September. Summer temperatures are too warm in other parts of the country to attempt such late plantings.

Environmental Factors

Temperature: In general, cool nights, temperate days, and lots of light are recommended for growing delphiniums. Plants benefit from, but do not have an absolute requirement for, cold temperatures. That is, plants will flower the first year from seed without being exposed to chilling temperatures, but flower yield and quality will be enhanced if chilling is provided. Approximately 6 weeks at temperatures of 35–40F (2–4C) satisfy the vernalization requirements of most delphiniums (Wilkins 1985, Ogasawara et al. 1996); therefore, fall planting is recommended for most areas of the country. Temperatures above 70F (21C) reduce flower yield and size. Night temperatures of 55–60F (13–15C) are optimum for growth.

Photoperiod: Long days hasten flowering, increase stem length, and improve quality in most delphiniums, particularly the belladonna forms (Wilkins 1985). Long days provided by nightbreak lighting from 10 p.m. to 2 a.m. reduced days to flower and increased yield in greenhouse-grown delphiniums (Garner et al. 1997). High light levels in the winter are even more important than long days, especially in northern climates.

Field Performance

Spacing: If used as an annual, plant at a density of as little as 9 × 9″ (23 × 23 cm) or up to approximately 1 × 1′ (30 × 30 cm); if more than one year of production is anticipated, plant up to 12 × 18″ (30 × 45 cm). If crops are planted in the fall and again in the spring, harvest time is staggered over a longer period of time.

Yield: The first year (after the first winter), 5–6 flowering stems/plant should be realized from Elatum hybrids. Up to 12 shorter stems may be harvested from belladonna types.

Irrigation: Hollow stems remain on the plant after harvesting; overhead irrigation must therefore be avoided, or stem rot could become a serious problem.

Support: Support may be necessary for the Elatum hybrids but not generally for the Belladonna hybrids. As temperatures rise, however, stems tend to fall over; support is useful for late harvests.

Forcing: Plastic greenhouses, tunnels, or frames can be used over the outdoor crop in late February; flowering occurs approximately 30–40 days earlier than in nature.

Greenhouse Performance

Seedlings or cuttings transplanted in August may be flowered in a cool greenhouse by January. Incandescent nightbreak lighting or daylength extension lighting (>14 hours) will accelerate flowering, although plants will still flower under natural SD if light intensity is sufficiently high. In northern latitudes, high-intensity discharge lamps are highly recommended. Two to 3 croppings may be cut from each plant. Harvesting will finish when cool greenhouse temperatures can no longer be maintained. Avoid temperatures above 75F (24C); long spindly stems result otherwise. Similarly, fertilizer concentrations greater than 100–150 ppm N should be avoided. Use at least one layer of support netting.

Temperature in the greenhouse is important. Trying to raise high-quality flowers when average day/night temperatures are consistently above 75F (24C) is difficult. Effective greenhouse cooling is essential to maintaining quality material. A study in Japan used air conditioning for a small section of a greenhouse to keep seedlings sown in May at around 68F (20C)—at least 18F (10C) lower than the control. They used the AC until temperatures cooled in the fall, when seedlings were transplanted to final beds. Those that were cooled produced high-quality flowers in January; those that were not bolted earlier and were of poor quality (Hirai and Mori 1999). Expense was not considered.

Elatum forms should yield a minimum of 4 stems/plant per year for a period of 3 years, in a good greenhouse environment, belladonnas 6–8 stems/plant per year.

Pinching plants may be an effective means of lengthening harvest time (Armitage 1995). Garner et al. (1997) found that pinching delayed flowering, but yield was not significantly different under natural SD. In LD, yield was enhanced by pinching.

Guideline for Foliar Analyses

At field trials in Watsonville, Calif., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis.

'Pacific Giant'

(%)				
N	P	K	Ca	Mg
3.2	0.33	3.52	2.86	0.70
(ppm)				
Fe	Mn	B	Al	Zn
617	59	18	517	35

Stage of Harvest

Harvest stems of Elatum hybrids when ¼ to ⅓ of the flowers on the stem are open, Belladonna hybrids when 75–90% of the flowers are open. Immediately after cutting, place flowers in a clean bucket containing a solution of silver thiosulphate, if available, for at least 4 hours. Don't place the bucket in a cooler during this time. Then put the flowers in a bucket, also containing a bactericide, until ready for shipment.

Postharvest

Fresh: Delphiniums are very sensitive to ethylene, which causes flower drop, incomplete flower-setting, and a short postharvest life. A good deal of research has been conducted in recent years on flower treatments. Flowers of delphinium are sensitive to ethylene and if not treated with STS, they shatter readily (Song et al. 1995). Various products have been tested, and although vase life in water is 6–8 days (Wilkins 1985), it is significantly enhanced by pulsing cut stems with a preservative containing silver thiosulfate (STS). 1-MCP is also effective.

Bacteria also reduce vase life by obstructing water uptake and causing slimy stems, which are much less attractive to buyers. Using a bactericide in the postharvest mix lessens this problem; many products from America and from Europe are available.

Stems may be stored upright in water for 1–2 days at 38–41F (3–6C). Plants exhibit a geotropic response, and stems should be stored upright whenever possible (Nowak and Rudnicki 1990).

Dried: Most dried "delphiniums" are actually larkspur. True delphiniums may be dried if cut before the bottom flowers drop. If picked after that time, ⅔ of the flowers will end up as confetti. After leaves have been stripped, the inflorescence should be hung in small bunches upside down. When the flowers feel papery, they should be stood upright to finish drying. The closed flowers may partially open again, providing a more natural look (Bullivant 1989).

Cultivars

Dozens of cultivars, many of them European introductions, are available through seed producers and perennial plant growers.

Belladonna hybrids

Arrow series is not yet proven commercially, but it is being tested in Holland and should soon make its way to America. 'Janny Arrow', with single sky-blue flowers, is the latest of the 12 colors.

Bella series has plants in blue and light blue.

'Belladonna' bears light blue flowers and is very similar to the garden variety 'Clivendon Beauty'; 'Bellamosum' has deep blue flowers. Both are old-fashioned cultivars, yet still quite popular.

'Blue Shadow' is an excellent cultivar for warm areas. Plants are 2–3′ tall (60–90 cm), and the leaves are deep green. Recommended for areas of California, Florida, and others where soil temperatures are a little too warm for high-quality delphiniums. Plants also appear to have good resistance to powdery mildew.

'Casa Blanca' produces white flowers.

'Oriental Blue' bears blue flowers and appears to be a good form, particularly for southern growers.

'Volkerfrieden' ('International Peace') bears vibrant blue flowers on 3–4′ (0.9–1.2 m) stems. Plants flush up to 3 times a year and may be planted as close as 9″ (23 cm) apart or about 2 plants/ft^2 (22 plants/m^2) in the greenhouse. A standard in the industry.

Elatum hybrids

Aurora series is available in blue or lavender, each with a white eye. Plants grow about 4′ (1.2 m) tall.

'Clear Springs' is considered a more compact 2½–3½′ (75–110 cm) series. Greenhouse production requires one layer of netting; field production can be accomplished with none. Growers in the ASCFG's 1998 National Seed Trials reported good production even throughout a hot summer. Includes lavender, light blue, mid-blue, rose-pink, white, and a mix. An improvement over Pacific Giant.

Magic Fountain series probably derived from the Pacific Giant group of delphiniums. They are 2–3′ (60–90 cm) tall and are offered by many seed producers.

Pacific Giant series (Giant Pacific Court hybrids) are 4–5′ (1.2–1.5 m) tall with flowers of various colors, including 'Astolat' (lavender-pink), 'Black Knight' (dark purple), 'Galahad' (white), and 'King Arthur' (dark blue). All have double flowers, often with the center (bee) a different color than the rest of the flower, and most are available from seed.

'Princess Caroline' provides immense flowers of salmon-pink. Almost too big.

'Red Caroline', a selection of 'Princess Caroline', bears red flowers on 28–36″ (70–90 cm) stems.

Additional Species

Delphinium cardinale 'Scarlet Butterfly' has scarlet-red flowers; 'Yellow Butterfly' bears bright yellow flowers. Beverly Hills series grows 4–5′ (1.2–1.5 m) tall and is available from seed or in plugs, in salmon, scarlet, or yellow flowers. Susceptible to overwatering and powdery mildew.

Delphinium nudicaule has orange-red flowers, and *D. semibarbatum* (syn. *D. zalil*) has yellow blossoms. Neither has the classic style and grace of the hybrids, but they may find a niche in the delphinium market. They are available from seed.

Delphinium yunnanense is from the Yunnan province of China. 'Blue Bouquet', with droopy inflorescences of gentian-blue flowers, may be a form of it or a hybrid involving it. Pretty, and a little different from other blue delphiniums.

Pests and Diseases

Black spot (*Pseudomonas delphinii*) results in large black spots on stems and leaves. Good air circulation and low humidity are helpful in reducing incidence of the disease. Cull infected plants.

Phoma xanthina is common and causes regular, brown-black, round or oblong spots on the leaves.

Crown rot (*Sclerotium rolfsii* var. *delphinii*) causes the plant to wilt and fall over. Apply a general fungicide when plants are young.

Powdery mildew can be a serious problem in the field and the greenhouse, especially when the weather is wet and cloudy.

Viruses result in misshapen shoots and stunted growth. Yellow spots, which become necrotic, also can appear on the foliage. Control of thrips and aphids is essential.

Caterpillars and slugs in the field, and thrips and aphids in both the greenhouse and field, can also cause significant headaches.

Grower Comments

"I grow a lot of delphinium. I plant them mainly in the fall and a backup lot in the spring. I treat them as annuals because we pick them so heavily. I grow them in the ground and in black cloth. If you use black cloth, they need a mulch to deflect the heat. Delphinium are very sensitive to slugs; in my experience, they do best when planted far from grassy paths that may be hosts to slugs. I use wire meshing about 2′ from the ground to keep the stems straight, as we get a strong crosswind in the evening. I grow mostly Pacific Giants, as they produce wonderful long stems and also lots of shorter stems for the florists who prefer those. My choice for a bee is always white, mainly because the flower is sharper and it does not bleed if watered overhead. We compost heavily and feed them with chicken manure after every flush. I dry every stem I don't sell fresh." Joan Thorndike, Le Mera Gardens, Ashland, Ore.

"I think 'Oriental Blue' is the best bellamosa type, hands down." Frank Arnosky, Texas Specialty Cut Flowers, Blanco, Tex.

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Many thanks to Jack Graham (first edition) and Jeff McGrew (second edition) for reviewing this section.

Dianthus barbatus sweet william Caryophyllaceae

biennial, Zones 3–7 southern Europe many colors
1–2′/2′ (30–60 cm/60 cm)

Although technically a biennial (plants flower after 2 years, then die), sweet william may reseed itself and persist more than 2 years. Plants require a cold period in order to flower and are therefore often planted in the fall. New colors and cultivars more suited to cut flower production are constantly being introduced.

Propagation

Seed: Approximately 0.06 oz (2 g) of seed is needed for 1000 transplants (Nau 1999). Plants for spring flowering are sometimes direct sown in July through September at 0.1 oz/100 ft (0.1 g/m) (Kieft 1996), but transplants are more common. Seed sown at 65–70F (18–21C) under intermittent mist or a sweat tent germinates in 7–10 days (Nau 1999). Cover seed very lightly or not at all.

Cuttings: Plants may be propagated by stem cuttings, but for economic reasons, this is seldom practiced.

Growing-on

Plants raised in the greenhouse should be sown in late summer and grown at 55–60F (13–15C) if possible. Fertilize with 100–150 ppm N using a balanced fertilizer. Plants should be ready to place in the field in 4–8 weeks.

Environmental Factors

Temperature: Most cultivars of sweet william require vernalization, and seedlings seldom flower well without exposure to chilling. This is not the case with *Dianthus* hybrids (‘Bouquet Purple’, for example, which see), or with bedding plant forms, such as Ideal or Telstar series. Flower initiation occurs only after the cold treatment has been fulfilled. The cold treatment consists of 40F (4C) temperatures, but the length of time for vernalization varies considerably among cultivars. Interspecific hybridization has resulted in vernalization times of 3–12 weeks; however, seedlings must be established prior to the onset of cold: usually 8–12 weeks are needed before they are responsive to the cold. Unrooted cuttings can be vernalized during the rooting process, but results are contradictory. The use of supplemental light to enhance the rooting of cuttings reduces the amount of chilling needed. If temperatures above 100F (38C) occur immediately after the cold treatment, the benefit of the cold treatment disappears (devernalization) (Cockshull 1985, Takeda 1996).

Photoperiod: Photoperiod has little effect on flowering if plants are vernalized. If plants have not been vernalized sufficiently, then LD accelerates flowering slightly and may produce a higher percentage of flowering plants (Cockshull 1985). If plants have received no cold, flower buds will initiate in SD during the winter (Takeda 1996).

Field Performance

Yields of 4–10 stems/plant are not uncommon. Transplants should be placed in the field early enough for plants to establish themselves before cold weather arrives. If direct sown, seedlings should be thinned to 6–8″ (15–20 cm) in the row (Post 1955). If planted in the spring or summer, flowering will not occur until the following spring.

Greenhouse Performance

Because sweet william is a cool-loving plant, the greenhouse may be maintained at 45–50F (7–10C); it is therefore relatively inexpensive to force sweet william into flower. Plants (seedlings or cuttings) should be grown for 8–12 weeks at 55–60F (13–15C) before applying the necessary cold treatment. When plants have sufficient roots and 6–12 leaf pairs, temperatures should be reduced to 40–45F (4–7C) and maintained. Plants flower as temperatures increase in the spring.

Stage of Harvest

Harvest when 10–20% of the flowers in the inflorescence are open.

Postharvest

Fresh: The use of STS and 1-MCP enhances vase life. The vase life of flowers treated with 1-MCP was up to 4 times greater than control plants (Serek et al. 1995). Flowers persist 7–10 days.

Storage: Flowers may be stored dry at 34–36F (1–2C) or wet at 40F (4C) for 7–10 days. Few differences have been seen between wet and dry storage (Bang et al. 1996); however, treatment with an ethylene inhibitor is recommended.

Cultivars

Single and double forms are available, nearly all from seed. Time from sowing to harvest is approximately 40 weeks. Hybrid cultivars, with *Dianthus barbatus* as one of the parents, are listed separately. All cultivars are 18–24″ (45–60 cm) tall unless otherwise noted and available in single or mixed colors.

'Diadem' bears single, crimson flowers with a pale eye.

Double Mix consists of double flowers in a wide range of colors.

Electron Mix includes red, rose, pink, lavender, salmon, and white on 24–30″ (60–75 cm) stems. Flower heads are about 3½″ (9 cm) across.

'Giant White' produces large, white flowers.

'Harlequin' grows 2′ (60 cm) tall and bears flowers that change from rose to pink as they mature.

Messenger series is an early-flowering mixture of single flowers.

'Newport Pink' is an exceptional cultivar with deep salmon-pink, single flowers.

'Nigricans' has dark crimson, single flowers with bronze foliage.

Parachute series consists of early single-flowered forms. Red with green leaves, red with bronze foliage, and white-flowered selections are available.

'Pride of Park Avenue' is a mix of 18–24″ (45–60 cm) tall flowers with excellent yields and field performance.

'Super Duplex' bears double flowers in a mix of colors.

Hybrids

Many hybrids of *Dianthus barbatus* with other species have been bred as bedding and pot plants, including such well-known series as Telstar, Princess, and Ideal. They are excellent bedding and landscape plants but, because of stem length, have not been used for cut flower production, particularly in the field; however, a few excellent cultivars of *Dianthus* hybrids are quite useful for cut flowers. Although none require vernalization, growing them with cool temperatures is recommended.

'Amazon Neon', the first color offered in the Amazon series, looks to be a winner. Blooms first year from seed, but treat as a short-lived perennial in subsequent years.

'Bouquet Purple' is an excellent landscape and cut flower selection. Recommendations by Katz and Kreidermacher (2000) suggest a spacing of 3–4 plants/ft^2 (32 plants/m^2). If planted in the fall, crop time in coastal California is 14–18 weeks from sowing, for spring plantings, 12–13 weeks. Flower stems are taller when fall-planted. In trials at the University of Georgia, plants performed well when transplanted in October. Watch for more colors.

Cinderella Mix is hardy in Zones 5–9. Stem length is 18–36″ (45–90 cm). Colors include rose, salmon, pink, carmine, scarlet, and carmine with eye. It has a great deal of *Dianthus barbatus* in its parentage but still blooms the first year from seed.

'First Love' produces flowers that change from white to soft pink and finally to rose-pink. Plants do not require cold to flower and can be forced year-round, although temperatures above 80F (27C) should be avoided; to produce sufficiently tall plants, they are generally greenhouse-grown at 55/65F (13/18C) night/day temperatures. Plants are spaced 9″ (23 cm) apart and flower 100–110 days from sowing.

'Hollandia', a seed-propagated variety, performs best in cool summer conditions when grown as an annual. The mix contains single flowers in purple, red, pink, white, and bicolor. Flower stems are 24–30″ (60–75 cm).

Melody series blooms first year from seed but can be grown as a perennial. Plants come in blush-pink (flowers open white and then deepen), pink (an All-American Selection), and white. Plants performed well in trials in Georgia and have been a popular landscape and cut flower cultivar.

Miss series is seed-propagated and generally sown in late summer or fall for spring flowering and planted to the field or greenhouse when plants have about 6 leaves. Plants require cold temperatures for best performance; therefore, temperatures in the greenhouse should be lowered to about 40F (4C) when plants have produced 10–15 leaves. Maintain cool temperatures for 40–50 days, followed by 45/65F (7/18C) night/day conditions. In the field, plants can withstand $^{-}$15F ($^{-}$26C) if properly acclimated. 'Miss Biwako' bears rose-red flowers on 2′ (60 cm) stems, 'Miss Kobe' has magenta-purple blooms, and 'Miss Kyoto' produces pink flowers.

'Oeschberg' grows to 20″ (50 cm) with purple-red flowers.

'Provencal' is a mix that can be sown in January for June cutting. Greenhouse stems will reach 24″ (60 cm); field plants may be shorter.

'Rainbow Loveliness' is a seed variety with 18–24″(45–60 cm) stems. The fringed flowers are lilac, carmine, pink, white, or bicolor.

Additional Species

Dianthus caryophyllus (carnation) is greenhouse-grown throughout the world but is not included in the context of this "specialty" book. Five spray types in the Gipsy series, however, are available: 'Gipsy' (lavender-pink), 'Giant' (larger but otherwise similar to 'Gipsy'), 'Pink', 'Bright Eye' (white with dark pink eye), and 'Dark Eyes' (large carmine eye). They may be planted outdoors in areas of moderate winters or grown in a cool greenhouse.

Dianthus knappii (yellow pink—an oxymoron?) is occasionally used as a cut flower. Sometimes sold as 'Yellow Beauty'.

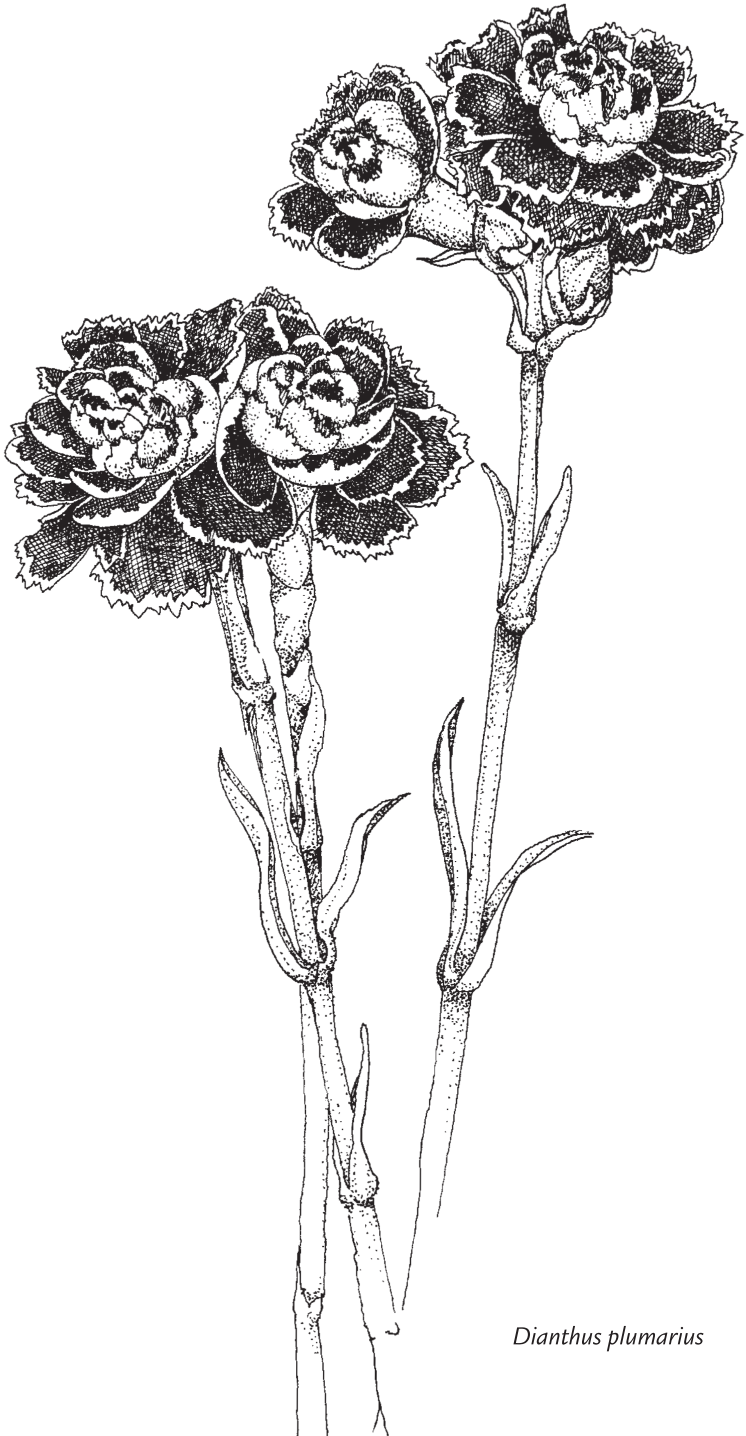
Dianthus plumarius (cottage pink) is also grown as a cut. Cultivars are available mainly in white ('Musgrave's White') and pink ('Spring Beauty').

Pests and Diseases

Many diseases of carnations also infect sweet william. Do not grow sweet william and greenhouse carnations in the same bench. In the field, several diseases are particularly destructive to sweet william.

Rust (*Puccinia arenariae*) can be a serious disease and is particularly destructive to the lower foliage.

Wilt (*Fusarium oxysporum* var. *barbati*) manifests itself in a yellowing of new growth. Leaves point downward, and plants are stunted. Remove infected plants, and sterilize infected soil.



Dianthus plumarius

Grower Comments

"'Hollandia' grew beautifully for me, producing many stems per plant. When I thought about how much I saved not having to have a whole row of young plants not producing for a whole year, and no die back over winter, the seed seems cheap. The plants all produced flowers for me last year—beautiful colors, highly fragrant." Susan O'Connell, Fertile Crescent Farm, Hardwick, Vt.

"A couple years ago I grew 'Provencal'—they look like sweet william and are annual-blooming like 'Hollandia'—but the unique thing about this strain was that it bloomed all winter without protection; it went through a couple of 20-degree spells, a few inches of snow, and still kept blooming. Because the weather was pretty hard on the blooms, they weren't what I would consider sellable, but if they had been in a cold frame with top cover they would have been really nice. Even as they were, without any special treatment, they lasted 2 weeks in a vase. They grew about 18″ tall, but in a greenhouse they will grow 24″ tall. I mention this for those who are looking for crops for their cold frames." Janet Foss, J. Foss Garden Flowers, Everett, Wash.

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Digitalis purpurea foxglove Scrophulariaceae

biennial, Zones 4–8 Europe purple 1–4′/2′ (0.3–1.2 m/0.6 m)

This is an underused cut flower, and we don't know why. It is easy to propagate, easy to grow, tolerates cold, and produces spike-like flowers. That it is a biennial (requires a cold treatment, needs a winter to produce flowers) may keep some growers from producing it, but once in the rotation, plants can be harvested every year. The genus is best known for *Digitalis purpurea*, the common foxglove, but a few more species, true perennials, deserve to be looked at as cut flower crops.

Digitalis purpurea is the source of digitalin, the powerful drug used for heart diseases. It was introduced into the *London Pharmacopoeia* in 1650, and the British physician William Withering published a clinical report on its usefulness in 1785; but for centuries prior, all sorts of fabulous medicinal properties were attributed to these plants. In the 13th century, leaves were used to treat "scrofulous complaints," and this is thought to be the origin of the family name.

Propagation

Plants are always propagated by seed. Seed is small and should not be covered. Sow at approximately 70F (21C). Direct sowing is not recommended; significant reduction in germination will occur. Plugs may also be purchased.

Growing-on

Grow young plants on at 58–62F (14–17C) night temperatures, the cooler the temperatures the better. Plants grow fine for 4–6 weeks in containers as small as a 72-pack flat to as large as 4″ (10 cm) pot; they may be transplanted to the field in September–October. The popular 'Foxy' does not require cool temperatures to flower and can be started in a greenhouse in the winter for transplanting to the field in early spring. Grow on 'Foxy' at 48–55F (9–13C).

Environmental Factors

Seed requires light to germinate; do not cover them. Foxgloves need a cold treatment for best flower production; if no cold is provided, some plants will flower (under long days), but the population will be uneven and a poor crop will result. The cold is usually provided by winter temperatures imposed on the plants. In Zones 4–8, natural winters suffice for flowering; in Zones 3 and 4, plants should be cooled in a greenhouse or cold frame prior to planting out for summer production. In mild winters, Zone 8 plants may not receive sufficient cold. Vince-Prue (1975) suggested that a temperature below 46F (8C) was needed for several weeks. Work at Georgia with noncooled plants showed that long days (nightbreak lighting) could substitute for the cold but that the crop was not uniform; no flowering occurred under short days if cooling was not provided.

Field Performance

Location: All foxgloves perform better with afternoon shade. Full sun in the winter and early spring is not a problem but will result in wilt and poor flower stems if harvests persist into the summer.

Transplants: Place transplants in the field in the fall, early enough so that they have time to grow before the onset of freezing temperatures. If placed in the ground too late, some plants will die. In Zone 4 and below, plants cooled in the greenhouse or cold frame will flower the same summer; otherwise, they will not flower until the following year.

Spacing: Place plants 12–15″ (30–38 cm) apart. Stake only if winds are a problem.

Yield: Mature plants should yield 2–4 stems/plant. A second flush of shorter flowers may occur in more northerly latitudes. In Zones 6–8, some small secondary flowers may form, but their value is marginal. It is probably better to replace the foxgloves after first flowering with a different crop.

Greenhouse Performance

Little forcing is done; however, the plugs may be cooled for 8 weeks, then placed in the greenhouse in large containers or in ground beds. Plants will flower regardless of photoperiod. If LD are provided, a higher percentage of flowering plants will occur. Force at temperatures of 55–65F (13–18C). Flowers occur approximately 12 weeks after transplanting to the greenhouse.

Stage of Harvest

Harvest when 2–3 lower flowers are beginning to open, or as late as when ½ the flowers are open (Dole and Wilkins 1999).

Postharvest

Cut flowers should be immediately rehydrated and cooled. Fresh flowers persist for approximately 7 days.

Cultivars

All but 'Foxy' should be treated as biennials.

'Alba', a good, clean white form of the species, is particularly sought after.

'Apricot Beauty' is about 4′ (1.2 m) tall with handsome apricot-orange flowers.

Excelsior hybrids produce their flowers around the entire flower stalk and are held more upright than those of the species. The 2–3″ (5–8 cm) flowers are almost horizontal, allowing an easier view of the handsome markings. Plants grow 5–7′ (1.5–2.1 m) tall. A dwarf Excelsior mix with 2′ (60 cm) tall stems is also available.

'Foxy' is only 1–2′ (30–60 cm) tall but has more side shoots than others. Flowers in a mixture of colors are produced the first year from seed.

Giant Shirley hybrids are 4–5′ (1.2–1.5 m) in height, with the potential of reaching up to 8′ (2.4 m). The large bell-shaped flowers are densely packed and usually mottled in shades of pink.

'Snow Thimble' is a pure white cultivar.

'Sutton's Apricot' bears large flowers in fabulous shades of apricot and salmon.

Additional Species

Most are hardy in Zones 5–8, but some will overwinter to Zone 4. Few have been tested for postharvest or other characteristics, but all are available to the cut flower grower. All are true perennials, not biennials.

Digitalis ferruginea (rusty foxglove) has rusty red and white flowers on 3–4′ (0.9–1.2 m) flower stems. Unusual, may have potential as a cut flower.

Digitalis grandiflora (syn. *D. ambigua*; large-flowered foxglove) is a perennial species and among the best performers in the genus. The 2″ (5 cm) long pendant flowers, pale yellowish on the outside and netted with brown on the inside, are mainly borne on one side of the inflorescence. The more we see this plant, the more we are taken with its understated charm and tough disposition. Excellent heat tolerance. Seed germinates rapidly at 70–75F (21–24C) and high humidity.

Digitalis lanata (Grecian foxglove) has 1″ (2.5 cm) long pale flowers held in an erect, dense inflorescence. The flowers are almost white with purplish netting within. Only 1–2′ (30–60 cm) tall, and, unlike other species mentioned here, the lower lip of its flower is longer than the other flower segments. Flowers are interesting, and few buyers have seen them.

Digitalis lutea (yellow foxglove) also bears yellow flowers, but they are much smaller (¾″, 2 cm) and more numerous than those of *D. grandiflora*. A tough perennial but not as heat tolerant as *D. grandiflora* and seldom grown in the South.

Digitalis ×*mertonensis* (strawberry foxglove) is a hybrid that produces handsome, pale strawberry-red flowers on short (1–2′, 30–60 cm) plants. Good-looking foliage as well.

Digitalis viridiflora (green foxglove) is more interesting than colorful. If designers need a greenish yellow flower that complements green foliage in the bouquet, this may be worth growing. Plants are 2–3′ (60–90 cm) tall.

Pests and Diseases

Aphids and thrips can be very troublesome. Preventative programs must begin as soon as temperatures rise above 50F (10C). In hot weather, plants will succumb to root rot organisms; if plants have already flowered once, simply remove them.

Grower Comments

"Large digitalis is harder to get and as desirable as large delphiniums (in my market area) and priced approximately the same. . . . Aphids can be a problem if you don't watch closely. One spring I just had a major blowout; didn't know anything could multiply that fast. Foxglove seed was very easy to start. Whatever system you use to grow plants, put the seed on top of the media. Took a few days to come up, and I swear it was 110% germ. The seeds are tiny, so very easy to get it too thick." Ann Trimble, Trimble Field Flowers, Princeton, Ky.

"I have grown digitalis every year I've been in business and tried most of them. I've finally narrowed down to growing just 'Alba'. The 'Alba' is sown in July, and the plugs are put out in Sepember and covered with row cover. The initial flush the next June is the best, and while we have been able to keep the plants producing shorter spikes in July and August, I think we'll plow them down sometime in July and plant something else, like late sunflowers. We easily sell the initial stems for $7.50 per bunch to florist and $1 each at the farmers' market. Our biggest problem is thrips! If we don't spray for them (it's the only insect I spray for on this farm), then we don't have any stems to sell at all." Bob Wollam, Wollam Gardens, Jeffersonton, Va.

"Here in northern Michigan, we grow 'Foxy' foxglove every year, starting it around the 21st of February. It is one of the first to bloom in the spring, usually in June in cool summers; we have it all summer long. We don't cover the seed when trying to germinate it, and it has a cooler germination temperature than many, at 65–70 degrees. 'Foxy' is grown as an annual for us—they are much nicer if new each year. As a cut flower, they do seem to last well if picked when only a few blossoms are open on the bottom. They sell medium well as a bunch, but we mostly use them in our mixed bouquets." Phyllis Wells, Wells Family Farm, Williamsburg, Mich.

"We started ['Foxy'] in March last year, and they bloomed for us July, August, and September. Stems were way too short, about 12–16″, and flower tubes spaced too far apart. We will not use this one again. We grew Shirleys . . . and Exclesior hybrids that should bloom for us this year. Shirleys planted the year before did dandy for us!" Michelle Smith, Blossoms, Inc, Fletcher, N.C.

Reading

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Echinacea purpurea purple coneflower Asteraceae

perennial, Zones 3–8 eastern United States purple

3–4′/3′ (0.9–1.2 m/0.9 m)

Native from the Great Plains to Georgia to Louisiana, the species may be cultivated over a wide range of environmental conditions. Drooping, mauve-purple ray flowers surround a copper-brown cylindrical disk atop 3–4′ (0.9–1.2 m) stems. They may be sold fresh as cut flowers, but often the petals are removed and the disk is sold as a dried flower.

As a supplement for combating colds and flu, *Echinacea*, particularly *Echinacea angustifolia*, has become a bit of a medical celebrity. The chemical, pharmacological, and clinical applications of *Echinacea* have been the subject of more than 350 scientific studies, which have proven coneflower's tissue-regenerative, anti-inflammatory, and immuno-stimulatory properties; and interest in the plant's ability to help in the treatment of cancer, AIDS, and other debilitating diseases continues. More and more these plants are cultivated for their medicinal rather than their ornamental uses.

Echinacea purpurea 'Bright Star'

Propagation

Seed: Seed germinates in 15–20 days if sown at 70–75F (21–24C) and in the light under mist or a sweat tent (Pinnell et al. 1985). Cooler temperatures result in slower and less uniform germination. Approximately 0.25 oz (7 g) of seed yields 1000 seedlings (Nau 1999).

Seeds of *Echinacea* can go into a deep dormancy. Priming in an aerated solution of distilled water containing 50 mM potassium nitrate for 6 days enhanced uniformity and rate of germination (Samfield et al. 1991); and GA_3 was also found to enhance uniformity and rate if included in the priming substrate (Pill and Haynes 1996). Stratification at 40F (4C) for 4 weeks increases uniformity and germination percentage, and reduces the time to germination (Bratcher et al. 1993); and acid scarification enhanced germination of *Echinacea angustifolia* seeds (Feghahati and Reese 1994). Stratification should be routinely practiced.

Division: Plants may be carefully divided in the spring or fall. Division may be accomplished every 3 years.

Cuttings: In early spring, take root cuttings 1–3″ (2.5–8 cm) in length and insert upright in a loose sand/peat mix (60/40, v/v). A mild concentration of rooting hormone is also useful. Cuttings may also be laid flat and barely covered with medium.

Growing-on

If seedlings are grown in plugs, grow for 4–6 weeks in full sun at 60–65F (15–18C) before transplanting to cell packs, 4″ (10 cm) pots, or field. Fertilize with 50–100 ppm N constant liquid feed using a complete fertilizer. If grown in seed flats, transplant to cell packs as soon as seedlings can be handled without damage (approximately 5–6 weeks).

Divisions and root cuttings should be sorted to size; large propagules may be transplanted directly to the field, smaller ones may be placed in pots or cell packs and grown on in the greenhouse or cold frame.

Environmental Factors

Cold is not necessary for flower initiation and development, although stem length and yield are greater when at least 6 weeks of temperatures at 40F (4C) are provided. When plants are grown to force flowers in the greenhouse, cooling the seedlings or plugs results in accelerated flowering. Plants require a LD for flowering, and flower more completely with nightbreak lighting (2–4 hours), cyclic lighting, or daylength extension between 12 and 16 hours (Finical et al. 1998). Little difference in stem length occurs between northern and southern plantings.

Field Performance

Longevity: Expect 3–5 years of performance.

Spacing: Space plants as close as 15 × 15″ (38 × 38 cm) to as much as 2 × 2′ (60 × 60 cm). Plants spaced closer than 15″ (38 cm) centers are more prone to foliar disease. If spaced greater than 2′ (60 cm) apart, plants may require support. Research in Burlington, Vt., resulted in 15 stems/plant at a spacing of 2 × 2′ (60 × 60 cm) (Perry 1989). The average stem length was approximately 31″ (78 cm).

Greenhouse Performance

Few crops are forced for cut flowers in the greenhouse; however, work by Finical et al. (1998) provides guidelines for forcing flowers during winter months. They suggest growing-on plants at 68F (20C) under LD (>14 hours or night interruption) until at least 4 leaves have formed. Temperatures may then be set to time the crop. If forced at 63F (17C), 17–18 weeks are required; if forced at 73F (23C), flowering occurs in 14–15 weeks. Long days are necessary (14 hours or NI) until flower buds are visible. The difficulty in forcing is the tall, thin stems that result. Reducing the number of hours of exposure to incandescent lamps is recommended, and the cooler the forcing temperature (we recommend 50–55F, 10–13C), the stronger the stems. More time is needed at cooler temperatures, but better stems result. Sumagic™ (15 ppm), A-Rest™ (100 ppm), B-Nine™ (5000 ppm), or other growth regulators can be applied once flowers begin to bolt; Bonzi™ appears to be ineffective (Finical et al. 1998).

Stage of Harvest

If sold as fresh flowers, harvest when petals are expanding and place in preservative. If used as a disk flower only, additional time on the plant is useful to color the disk and to allow easier removal of the petals. Place at 40F (4C) after harvest.

Postharvest

Fresh: Petals of the species (not necessarily the cultivars) tend to droop regardless of the time of harvest; this detracts from the beauty of the flower, and consumers may think the flower is wilted. Flowers last 7–10 days in preservative solution.

Dried: Once petals are removed, the disk may be hung to dry and will last indefinitely.

Cultivars

Many of the cultivars differ only slightly in the color of the ray flowers (petals), and the angle at which the ray flowers are held in relation to the disk; those that are held at right angles are more appropriate as fresh cuts. Yellows, oranges, and other unheard of colors will hit the marketplace in the next few years.

'Abendsonne' has lighter, more cerise-pink flowers than the species.

'Alba' has creamy white flowers that contrast well with the copper-brown cone. Plants may be propagated from seed.

'Amado' bears 4″ (10 cm) white flowers on 36″ (90 cm) stems.

'Bravado' has 4–5″ (10–13 cm) rosy red flowers with excellent horizontal ray flowers.

'Bressingham Hybrids' is a seed strain of 'Robert Bloom'. Plants vary slightly from light rose to red and are excellent garden performers.

'Bright Star' ('Starbright', 'Starlight') is a rose-colored, free-flowering cultivar that has performed well throughout the country. Plants are 2.5–3′ (75–90 cm) tall and seed-propagated, so significant variability occurs.

'Dwarf Star' is a little shorter than 'Bright Star' and yields shorter stems for bouquet work. Seldom offered but a good plant.

'Kim's Knee-Hi' and 'Kim's Mop Head' are dwarf forms with purple and white flowers, respectively. Not useful if long stems are desired.

'Magnus' is a fine, 3′ (90 cm) tall cultivar with large, deep purple flowers. Horizontal ray flowers are its claim to fame; but plants are seed-propagated and therefore variable, and many flowers do not hold out their petals.

'Overton' is a seed-propagated form with drooping, rosy pink ray flowers.

'Robert Bloom' bears 4–5″ (10–13 cm) wide purple-rose flowers with upright petals on 3′ (90 cm) stems. More commonly available in Europe than in the United States.

'Ruby Giant' is vegetatively propagated and has 4″ (10 cm) flowers on 36″ (90 cm) stems.

'Ruby Star' grows to 36–40″ (90–100 cm) with carmine-red petals.

'The King' is 4–5′ (1.2–1.5 m) tall with rose-red flowers 4–5″ (10–13 cm) in diameter.

'White Lustre' differs from 'White Swan' by having more-horizontal ray flowers and a center a little more bronze-orange. Plants are often vegetatively propagated and so are more uniform.

'White Swan' is a seed-propagated white form with drooping ray flowers.

Additional Species

Echinacea angustifolia is a western species with a similar cone, but the petals are straplike and are not useful as fresh flowers.

Echinacea pallida (pale coneflower) has narrow, drooping petals and is most useful as a dried cone.

Echinacea paradoxa is the yellow purple coneflower, a paradox for sure. The ray flowers are yellow and outward-facing, and stems stand upright. Mimo Davis and Kelly Anderson of WildThang Farms in Ashland, Mo., think this species has great potential as a cut flower.

Echinacea tennesseensis (Tennessee coneflower) has dark mauve, upturned ray petals and a greenish pink center. It has some potential for drying but probably not as good as cultivars of *E. purpurea*, and it is on the Federal Endangered Species list, so its availability is severely limited.

Pests and Diseases

Leaf spots (*Cercospora rudbeckiae*, *Septoria lepachydis*) result in marginal necrosis followed by blackening of leaves. Treat with a general-purpose foliar fungicide.

Grower Comments

"The disks of our native *Echinacea purpurea* are coppery red, rather than brown. The color and intensity of the disk make it appear to glow, and it is excellent as a fresh cut, lasting about 2 weeks in the vase. Remove all foliage when bunching. The disk does turn brown when dried. Even when fresh, however, the disks of other species (*E. pallida*, *E. tennesseensis*) are brown and therefore not so useful as fresh cuts." Mimo Davis and Kelly Anderson, Wild Thang Farms, Ashland, Mo.

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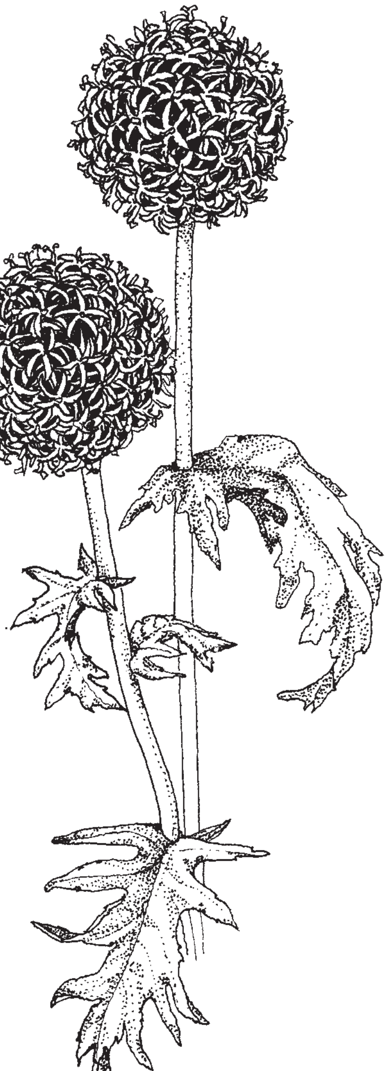
Many thanks to Leonard Perry (first edition) and Mimo Davis and Kelly Anderson (second edition) for reviewing this section.

Echinops bannaticus globe thistle Asteraceae

perennial, Zones 3–8 southern Europe blue 3–5′/3′ (0.9–1.5 m/0.9 m)

Echinops bannaticus is the proper name for *E. ritro*, but since nobody pays much attention to botanical names anyway, it will likely continue to be grown and sold as *E. ritro*. Grown for the globular, metallic-blue flowers, the species is useful as a fresh and dried cut flower. The foliage, green on top and gray-green beneath, has pointed lobes but is not prickly like other thistles. The flower heads consist of many individual flowers, each surrounded by bristly bracts; they are coarse and can be difficult to handle.



Echinops bannaticus

Propagation

Seed: Sow seed in a greenhouse under mist or sweat tent at 65–70F (18–21C). Seed germinates in 14–21 days and may be transplanted to 4″ (10 cm) containers 2–3 weeks later. Approximately 1 oz (28 g) of seed yields 1000 seedlings (Nau 1999).

Division: Divide plants in spring or in summer after flowering. A portion of the root must accompany the vegetative division. Plantlets occur naturally around the main stem.

Root cuttings: Take a 1–2″ (2.5–5 cm) long piece of healthy root in the spring, and place vertically in rooting medium in a warm, moist location. New shoots appear in 2–3 weeks.

Growing-on

Temperature in the greenhouse should be 55–65F (13–18C). Avoid temperatures above 70F (21C). Fertilize plantlets with 50–100 ppm N until large enough to transplant to the field (6–8 weeks). If plants are left in the greenhouse longer than 8 weeks, transplant to a larger container to minimize root restriction.

Environmental Factors

Temperature: Cold is necessary for best flowering. Plants will not flower uniformly unless a cold treatment is provided, usually by natural winter cooling. Most rapid development occurs if crowns are provided with at least 6 weeks at 40F (Iversen and Weiler 1989). Hot summers, such as those experienced in the South, reduce the quality of stems and flowers, particularly the intensity of the blue color; a hot spell during the summer in the Midwest or Northeast has little effect on the color. Cooler summers intensify the color and reduce foliar chlorosis—but also reduce stem length. Its cold hardiness makes this plant useful as far north as the prairie provinces of Canada.

Photoperiod: After vernalization, plants flower most rapidly under LD (>16 hours). Plants will also be taller under LD than SD (8 hours) (Iversen and Weiler 1989).

Field Performance

Longevity: Globe thistle is a long-lived perennial and will be productive for many years. Commercial growers can expect 3–5 years of flower production; some report up to 10 years of production.

Longevity of *Echinops bannaticus*. Fall-planted, spacing 2' (60 cm), full sun.

Year	Stems/plant	Stems/ft^{2z}	Stem length (in)^{y}	Stem width (mm)^{x}
1	1	0.4	27.0	6.5
2	4	1.0	38.4	7.2
3	5	1.3	38.3	6.8
4	7	1.8	33.2	6.4

z = multiply (stems/ft^2) by 10.76 to obtain (stems/m^2)
y = multiply (in) by 2.54 to obtain (cm)
x = divide (mm) by 25.4 to obtain (in)

Shelley McGeathy of McGeathy Farms reported stem lengths of 30–46″ (0.75–1.2 m) under full sun in Hemlock, Mich.

Spacing: Plants grow 3–5′ (0.9–1.5 m) tall and equally wide over time. If plants are to remain in the ground longer than 3 years, space 2′ (60 cm) apart. If plants are to be removed in 3 years or less, spacing may be reduced to 18″ (45 cm) centers.

Shading: In the North, shade is not needed or recommended; plants are normally grown in full sun. Afternoon shade is beneficial in the South (Zone 7 and below); the addition of shade cloth (up to 55%) increases yield and stem length, as well as providing protection from winds and rain.

Shade level (%)	Stems/plant	Stem length (in)[z]
0	5	33
55	7	43
67	6	36

z = multiply (in) by 2.54 to obtain (cm)

Greenhouse Performance

For best greenhouse production, cool potted crowns for 6 weeks at 40F (4C) followed by 12 weeks in the greenhouse at 60F (15C) under 16- to 24-hour photoperiod (Iversen and Weiler 1989). Nightbreak lighting (2–3 hours) with 40-watt incandescent lamps may be used to provide LD. Cool plants to 50F (10C) a few weeks prior to harvest to enhance blue color.

Stage of Harvest

Flowers should be harvested when ½ to ¾ of the globe has turned blue. Flowers on inflorescences harvested too early fail to open (Gast and Inch 2000). Leaves decline more rapidly than the flowers. If harvested for dried flower use, flowers should be harvested when the globe has turned blue but before the individual flowers begin to open.

Postharvest

Fresh: Flowers persist 6–12 days in water; foliage persists only about 5 days.

Storage: Placing flowers in a 40F (4C) cooler intensifies color. Stems may be stored wet for 7–10 days.

Dried: Air dry by hanging bunches upside down. Do not strip leaves. If harvested after the individual flowers begin to open, the globe will shatter.

Cultivars

'Taplow Blue' has more intense blue flowers than the species. It is the most popular cultivar of the genus and is often sold as a selection of *Echinops ritro*.

'Veitch's Blue' is similar and more common in Europe than in America.

Additional Species

Echinops exaltatus (syn. *E. commutatus*) and *E. sphaerocephalus* grow up to 7′ (2.1 m) in height. They have prickly leaves, green on the upper side, gray beneath, with gray stems and large dusty whitish flower heads. 'Arctic Glow' has large white flowers on reddish stems. Differences between the two species have more to do with leaf shape than with their usefulness as cuts.

Pests and Diseases

Crown rot (*Pellicularia rolfsii*) infects roots and crown, often the result of waterlogged soils.

European corn borer has become more of a problem, particularly in the Midwest.

Grower Comments

"After harvest, we clean up the field by mowing off any remaining vegetation. Plants will begin to green up again." Shelley McGeathy, McGeathy Farms, Hemlock, Mich.

"Each stem [of *Echinops sphaerocephalus*] will branch out and have 5–10 blooms on it, which makes an excellent filler for large bouquets. The stems are grayish green and cobwebby, and develop maroon striping before they flower. Your average gladiolus customer may not want these on her dining room table, but I like to carry something striking and unusual. And even if I didn't sell a single stem, they would be worth the effort just for the attention they draw." Susan O'Connell, Fertile Crescent Farm, Hardwick, Vt.

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Many thanks to Shelley McGeathy for reviewing this section.

Emilia javanica tassel flower Asteraceae

annual tropics scarlet, orange 1½–2′/2′ (45–60 cm/60 cm)

This species, sometimes sold as *Cacalia javanica*, makes a colorful filler. Plants bear numerous fuzzy, scarlet and orange flowers, ½″ (13 mm) wide, on 12–15″ (30–38 cm) stems. Each main stem produces many lateral flower stems, and each lateral may be used as a short-stemmed (6–8″, 15–20 cm) filler. Although plants are annuals, they self-sow prolifically.

Propagation

Direct sowing is recommended. Seed may be direct sown, in fall in the South or in early spring in the North, at the rate of 0.09 oz per 100′ (10 g per 100 m) (Kieft 1996). If not direct sown, 0.03 oz (0.9 g) yields 1000 plants (Nau 1999). Direct-sown seed should germinate in 10–14 days; in a 68–72F (20–22C) mist bench in the greenhouse, expect germination in 7–10 days.

Growing-on

Plantlets produced in the greenhouse should be grown at 55–60F (13–15C) night temperatures and fertilized with no more than 100 ppm N prior to setting out in the field or greenhouse. Plants are large enough to transplant in approximately 8 weeks.

Environmental Factors

Based on trials at the University of Georgia, *Emilia* appears to have little photoperiodic sensitivity. Plants also continue to flower in heat and humidity, showing that such conditions do not inhibit flower initiation or development.

Field Performance

Spacing: Space plants 6 × 6″ (15 × 15 cm) or as far apart as 10 × 12″ (25 × 30 cm). They fill in readily.

Yield: In trials at Athens, Ga., we were overwhelmed by the number of flower stems produced in a single season. Students revolted at the sight of yet another 5000 *Emilia* stems awaiting their gentle harvest, by hand—only *Cirsium* and *Eryngium* were viewed with more dislike. In our trials, plants produced over 100 stems/plant with an average length of 17.7″ (44.3 cm); each stem carried approximately 7 small flowers. Flowers are produced continuously, so plants lend themselves well to mechanical harvesting. If mechanical harvesting is employed, yield would be significantly reduced; labor costs, however, would plunge: cutting one stem at a time is a never-ending process. To be honest, how much *Emilia* can one use?

Greenhouse Performance

Plants are seldom produced commercially as cut flowers in the greenhouse. If one is determined to produce these in the greenhouse, high light conditions, warm temperatures, and moderate fertility practices (100 ppm N) should be maintained.

Stage of Harvest

Harvest stems when the first flower is fully open. Not all flowers on the individual stem may open.

Postharvest

Fresh: Flowers persist 3–6 days in plain water. Short stems persist longer than long stems; water does not move well through the longer stems. If needed, store in water in 35F (2C) rooms.

Dried: Flowers may be air-dried, but some of the color is lost.

Cultivars

None available, but seed-grown plants result in scarlet and orange flowers.

Additional Species

Emilia coccinea, *E. flammea*, and *E. sagittata* are synonyms of *E. javanica*.

Emilia sonchifolia differs slightly from *E. javanica*; it has toothed or wavy margins, and the flowers are usually rose or purple. 'Scarlet Magic' is likely a selection of *E. sonchifolia*. Both *E. sonchifolia* and *E. javanica* are naturalized in southern Florida.

Pests and Diseases

The only problem in field trials in Georgia was the incidence of botrytis (*Botrytis cinerea*) during times of heavy rains.

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Eremurus foxtail lily Asphodelaceae

perennial, Zones 5–7 Asia many colors 3–6′/2′ (0.9–1.8 m/0.6 m)

Foxtail lilies are native to the drier regions of western and central Asia, occurring in areas with long, hot summers and fall-spring rains. Excellent cut flowers, they are grown successfully on the West Coast and in the Northeast. Their compact rhizome has 1 or 2 central buds (crown buds), and long fleshy roots radiate from all sides. The inflorescences consist of hundreds of small individual flowers borne on unbranched racemes. Few plants are as impressive as a foxtail lily in flower. They come into flower in early summer to fall and are always in demand from high-end wholesalers and retailers. Plants are winter hardy to Zones 4 and 5.

Propagation

Seed can be used. Pretreat seeds in warm (86F, 30C), moist conditions for 30–60 days, then germinate them at 35F (2C) in the dark. If seeds are pretreated, germination occurs within 6 weeks (Zimmer 1985). It can take up to 5 years from seed to flowering rhizome; vegetative propagation by division, in contrast, results in new flowers in about 2 years. Rhizomes behave like gladioli corms; that is, the old root dies while a new one is formed each year. After the foliage disappears, the rhizome can be lifted and divided. If the rhizomes are left in the ground for many years, the roots become highly tangled and are difficult to lift.

Dividing rhizomes: Rhizomes are dug for overwintering purposes or for division, in the summer. After clearing the weeds and spraying a nontranslocatable foliage killer, dig the rhizomes with a small subsoiler. The rhizomes are very brittle; allow them to dry for a couple of days; when they are limp, they are less prone to handling damage. Grade them (singles and so forth), soak in a fungicide, and place them in bins with dry peat moss at 55–60F (13–15C) (definitely below 70F, 21C). Allow them to remain dormant until mid September, and plant them early enough to have roots develop in the field before winter sets in. This process is not for everyone; it may make more sense to let someone else do this. For most growers, buying well-developed rhizomes from a reputable supplier makes the most sense.

Growing-on

Plant rhizomes in the fall. They need a thoroughly drained, rich soil and will not do well in heavy clays. Since rhizomes can be infected with viruses spread through cutting tools, new stock should be reintroduced after 2–3 years.

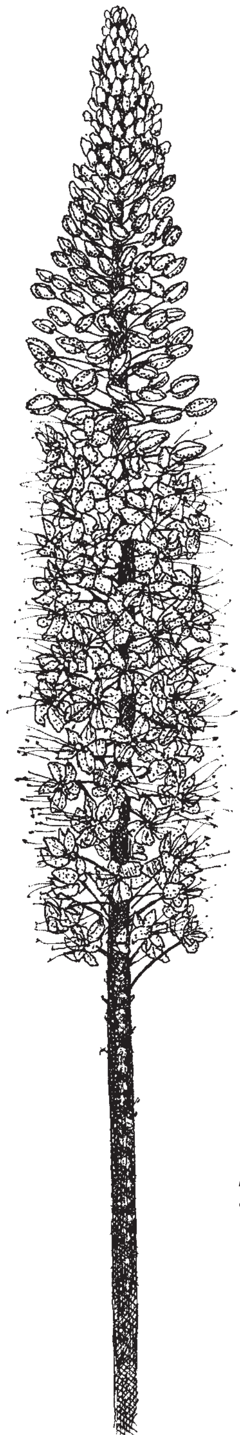
Environmental Factors

Flowers initiate during the winter and cold is necessary. Previous research suggested 16–18 weeks at temperatures less than 50F (10C) was required for flowering and leaf development (Zimmer 1985).

Photoperiod is unimportant.

Field Performance

Planting: Dig a hole that easily accommodates the long, fleshy tentacle roots. Fill in gently so as not to damage the roots. Mulch plants as soon as the leaves emerge in the spring: spring frosts can be deadly. Plant the crowns about 2–4″ (5–10 cm) deep, and do not allow them to dry out. If the rhizomes appear to be



Eremurus ×*isabellinus*
'Rosalind'

dried out, soak them for a few hours prior to planting. Choose a site in full sun out of prevailing winds. Avoid wet areas. Mulch in the fall to prevent winter damage. Rhizomes can double in size in a single year.

Yield: Two to 3 stems per mature rhizome can be realized.

Spacing: Space rhizomes 3½–4′ (1.1–1.2 m) apart, with 4–6″ (10–15 cm) of soil above the nose, in raised hills; leave 1–2′ (30–60 cm) between rows.

Greenhouse Performance

Rhizomes can be forced in the greenhouse after rhizomes are cooled, then grown on at 50–55F (10–13C). Plant in ground beds and provide suitable support for the tall stems. Crop time is approximately 17 weeks (Dole and Wilkins 1999).

Stage of Harvest

Jan Roozen of Choice Bulbs in Mt. Vernon, Wash., cuts stems when the bottom flowers are becoming colored but not fully open. This is the best stage if stems need to be stored in a cooler. If harvested too open, they cannot be stored for any length of time, and if too tight, they will not open. Some experimentation is necessary. If sold fresh for immediate consumption, stems are harvested when about ½ the flowers are open (Dole and Wilkins 1999).

Postharvest

Store stems at 36F (2C) to inhibit additional flower opening. Flowers persist up to 3 weeks in a properly vented cooler. *Eremurus* should be shipped and stored upright: the stems are geotropic (they bend upward if laid on their sides). Postharvest treatments with a biocide and ethylene inhibitor (STS) have been shown to benefit postharvest life (Nowak and Rudnicki 1990).

Species and Cultivars

Eremurus himalaicus, a 3–5′ (0.9–1.5 m) tall white-flowered species, is a parent in many hybrids. One of the earliest to flower.

Eremurus ×*isabellinus* (syn. *E.* ×*shelfordii*) bears 3–4′ (0.9–1.2 m) long racemes in shades of yellow, pink, white, and copper in summer. These free-flowering hybrids are the result of crossing *E. stenophyllus* and *E. olgae*, a medium to tall, white-flowered species. Cultivars include 'Isobel' (rosy orange), 'Moonlight' (pale yellow), 'Rosalind' (bright rose), and 'White Beauty' (clear white).

Eremurus robustus is the most stately species, growing 8–10′ (2.4–3.0 m) and bearing long spike-like inflorescences crowded with fragrant peachy pink flowers. Exceptional, among the finest forms for cuts. 'Albus' is a white-flowered selection.

Eremurus stenophyllus (syn. *E. bungei*) is one of the shorter species, growing to 2–3′ (60–90 cm), but as lovely as any. Plants produce bright yellow flowers that open slowly, resulting in a full-flowered spike. All the few cultivars have flowers in yellow shades.

Ruiter hybrids are the preferred cultivars for cut flower production. They are usually sold in mixed colors but include such single colors as 'Cleopatra' (orange with red midribs on the flowers), 'Copperboy' (yellow), 'Oase' (pale pink), 'Obelisk' (white-tinged green), 'Odessa' (yellowish green), 'Romance' (salmon-pink), and 'Sahara' (coral-pink).

Pests and Diseases

Botrytis is a serious problem and fungicide applications may be necessary. Aphids, slugs (put out bait early), and thrips can be a problem. Because plants are large and persistent, weeds can be a nuisance.

Grower Comments

"Eremurus are very slow for me from seed. Time to bloom depends on variety and is probably 3–7 years. I recommend buying the spidery tubers, which can exceed 24″ across. My favorite is probably the 9-foot-tall pink *Eremurus robustus*. I do love the 4-plus-foot-tall, May-blooming, white *E. himalaicus*, as it is my earliest and easier to use in arrangements." Kelly O'Neill, Wet Rock Gardens, Springfield, Ore.

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Many thanks to Jan Roozen for reviewing this section.

Eryngium planum sea holly Apiaceae

perennial, Zones 3–7 eastern Europe blue 2–4′/3′ (0.6–1.2 m/0.9 m)

As striking as the blue stems, blue flowers, and exotic-looking inflorescence of *Eryngium* are, the demand for sea holly fluctuates. Several of the available species are difficult to handle, and some ship poorly, but these things are true of many cut flowers, particularly the problem of fluctuating demand. Most sea hollies tolerate saline conditions and are cold hardy throughout the country. Some people complain that the flowers are malodorous. The few people growing this crop may find significant profit if and when demand rises.

Eryngium planum, one of the smaller-flowered sea hollies, is as useful and decorative as any, even the larger-flowered forms. It is also one of the most economical sea hollies to ship: the relatively small flowers allow more stems to be placed in the shipping container. The small blue flowers are arranged in a tight globose head, and each inflorescence is subtended by bracts, which turn metallic blue in the summer.

Propagation

Seed: If possible, collect ripe seed from stock plants and sow immediately in a loose mixture of sand and vermiculite or other seed medium. Seed enters a dormancy phase rapidly after harvest, and purchased seed takes many months for germination. In the following work (Pinnell et al. 1985), seed was germinated under intermittent mist at 70–72F (21–22C).

Germination of *Eryngium planum* over time.

Age of seed	Germination (%)
fresh	55
1 month	48
2 months	32
3 months	6
4 months	5
5 months	0
6 months	1

For purchased seed, sow in seed trays; cover lightly with soil; and place in a cold frame, unheated greenhouse, or outside under snow. Germination occurs the next spring. Another season of warmth and cold, however, is necessary to germinate all viable seed. Approximately 0.7–1 oz (9–28 g) of seed yields 1000 seedlings (Nau 1999). *Eryngium alpinum* (alpine sea holly) germinates less uniformly and more slowly than *E. planum*.

Division: Plantlets are formed at the base of plants and may be carefully removed.

Cuttings: Root cuttings are an excellent means of propagation. Remove sections of mature root, 2–4″ (4–10 cm) long, and plant upright in containers of porous medium. Place containers at 68–75F (20–24C) and keep moist.

Growing-on

Grow at 55–60F (13–15C) and avoid temperatures above 75F (24C) to minimize stretching. Fertilize sparingly (50–100 ppm N) until large enough to transplant to the field or bench. Seed-propagated material may be transplanted 5–8 weeks after emergence. Medium to large divisions should be grown for 3–4 weeks before placing in the field; small divisions can be placed in growing-on beds for a year before being placed in the production area. Plantlets tolerate full sun in the greenhouse in winter, spring, and fall, but shade is necessary in the summer.

Environmental Factors

Cold is necessary for flowering, and temperatures of 40F (4C) or below may be provided by winter, cold frames, or unheated greenhouses. Hot summers are tolerated, but the metallic blue color of the flowers, stems, and bracts is not as intense as those grown under cool summer nights. Plants grown north of Zone 5 are of high quality, but stem lengths are shorter than those grown further south. *Eryngium* is sensitive to overwatering; well-drained soils are a must.

Field Performance

Longevity: Sea holly is a long-lived perennial, and flower production continues for many years. For commercial growers, 3–5 years of production are easily obtainable. Yield declines after approximately 3 years, although stem length and diameter are not seriously affected over time, as the following table shows.

Longevity of *Eryngium planum*. Fall-planted, spacing 2' (60 cm), full sun.

Year	Stems/plant	Stems/ft^{2z}	Stem length (in)^{y}	Stem width (mm)^{x}
1	3	0.6	30.4	9.1
2	6	1.4	32.4	9.4
3	9	2.1	36.2	9.2
4	6	1.5	37.0	8.9
5	5	1.3	37.1	8.9

z = multiply (stems/ft^2) by 10.8 to obtain (stems/m^2)
y = multiply (in) by 2.54 to obtain (cm)
x = divide (mm) by 25.4 to obtain (in)

Spacing: Plants grow 2–4′ (0.6–1.2 m) tall with equal spread. If plants are to remain in production for more than 3 years, space 2′ (60 cm) apart. If plants are to be removed at the end of the third year, spacing may be reduced to 18″ (45 cm) centers.

Shading: Plants are usually grown in full sun in the North but are occasionally shaded in the South. Work at the University of Georgia showed that yield was significantly reduced as plants were covered by 0, 55, or 67% shade (7, 5, and 1 stems/plant, respectively); stem length was only slightly increased. Shade cloth protects against damage by wind and rain, but the decrease in yield is too great to warrant its use.

Guideline for Foliar Analyses

At field trials in Athens, Ga., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis.

(%)				
N	P	K	Ca	Mg
4.05	0.63	3.36	1.19	0.47
(ppm)				
Fe	Mn	B	Al	Zn
257	84	28	83	61

Stage of Harvest

Flowers should be harvested when the entire flower head, including bracts, turns blue.

Postharvest

Fresh: Flowers persist 10–12 days; foliage lasts only 5–8 days.

Storage: Placing flowers in 40F (4C) coolers intensifies color. Stems may be stored 7–10 days at 38–40F (3–4C).

Dried: Air drying is successful, but drying in silica gel or other desiccant preserves more color.

Cultivars

'Blue Cap' ('Blaukappe') bears deep blue flowers on 2′ (60 cm) tall plants.

'Blue Diamond' is a dwarf form selected for the deep blue flowers. Not much different from the next form.

'Blue Dwarf' ('Blauer Zwerg') is similar to *Eryngium planum* but grows only 15–18″ (38–45 cm) high.

'Blue Ribbon' has larger flowers, appearing to be double blue. Plants grow about 2′ (60 cm) tall.

'Sapphire Blue' has large blue flowers on strong 28″ (70 cm) stems.

'Silver Stone' has creamy white flowers and stands 3–4′ (0.9–1.2 m) tall.

Additional Species

Eryngium alpinum (alpine sea holly), the most popular species in Europe, bears larger bracts than *E. planum* and is more ornamental. Shipping quality is not as good, however. 'Amethyst' is 2½–3′ (75–90 cm) tall with metallic, light blue bracts and serrated foliage. 'Blue Star' has been popular because it has been one of the few cultivars available from seed, even though half the seed may never come up; plants grow 2–3′ (60–90 cm) tall and bear large lavender-blue involucres. 'Opal' is 2′ (60 cm) tall and bears more silvery blue flowers than 'Amethyst'.

'Slieve Donard' has handsome light blue bracts around dark blue flowers. 'Superbum' has large dark blue flowers on 2–3′ (60–90 cm) stems.

Eryngium amethystinum is popular in the United States.

Eryngium bourgatii is also used for cut flowers.

Eryngium giganteum (Miss Willmott's ghost) is a biennial that provides large gray flowers the second year from seeding. Quite eye-catching in a ghost-like way. Seldom used in this country, but then again, not much cut sea holly is seen in this country anyway, so perhaps worth a small space.

Eryngium yuccifolium (rattlesnake master) is also grown as a cut flower. People who grow it find demand is excellent.

Pests and Diseases

Leaf spots are common; treat with a general-purpose foliar fungicide.

Grower Comments

"I like sea holly very much, even though it smells pretty bad. When the stems are tall and straight it works really well in bouquets. If they have flopped over and gotten a bit twisted, I just bunch several stems and sell it straight. It always sells, and I can get $2 per stem for the twisted stuff, more for the straight beauties. I have grown *Eryngium planum* from seed. Also got some *E. p.* 'Blaukappe'. My seeded stuff did not require netting, 'Blaukappe' should have been netted. It's the first year with the 'Blaukappe', though, and I think that they'll be straighter and taller next year. In my experience, *Eryngium* takes 2 years to establish itself [and needs] to be lifted and rejuvenated on the third or fourth year. It does dry beautifully. Looks great in artichoke bouquets." Debbie Barber, Double Decker Farm, Hillsdale, N.Y.

"I have *Eryngium alpinum* and *E. giganteum*. I love *alpinum*; it is very challenging for me to grow, but it sells well. *Eryngium giganteum* is okay; it's easy enough, just very prickly." Janet Foss, J. Foss Garden Flowers, Everett, Wash.

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Many thanks to Tom Wikstrom for reviewing this section.

Euphorbia marginata snow-on-the-mountain Euphorbiaceae

annual North America white bracts 2–4′/3′ (0.6–1.2 m/0.9 m)

The long-lasting cut stems are most useful in bouquets: well-branched plants have variegated or entirely white upper foliage, and the inconsequential flowers

Eryngium alpinum

are surrounded by large, white bracts. The sap causes severe dermatitis in sensitive individuals; gloves and long-sleeved shirts should be worn when harvesting. Eyes too are highly sensitive to the sap (Eke et al. 2000), and firsthand evidence suggests that caution, as well as eye protection, is essential (see comments by Hartenfeld). If sap solution has been handled, workers should be warned not to rub their eyes.

Propagation

Sow seed at the rate of approximately 1 oz (28 g) for 1000 plants (Seals 1991) at 60–68F (15–20C) under intermittent mist. Although seed may emerge in 10–14 days, germination is erratic and may require 1–2 months. For field germination, seed approximately 0.7 oz (20 g) per 100′ (30.5 m) (Kieft 1996). In southern latitudes, 3 or 4 successive sowings, 2 weeks apart, may be recommended; in northern latitudes, with their early frosts and long summer photoperiods, 2 successive sowings are the limit, suggests Ginny Kristl of Albion, Maine.

Growing-on

Seed germinated in the greenhouse or frame should be grown at 60F (15C) and fertilized with 75–100 ppm N. Plants may be transplanted to the field in 4–6 weeks.

Environmental Factors

Photoperiod: Snow-on-the-mountain is a short day species. Flowers are initiated under short days, and vegetative growth occurs under long days. However, SD are not exactly short. Daylengths of 14 hours can still result in flowering; more than 14 hours inhibits flowering.

Temperature: Stems are thicker and flowers larger when average temperatures remain below 75F (24C). High temperatures result in poor initiation and spindly stems.

Field Performance

Yield: The goal of 5–10 stems per plant is not unrealistic.

Spacing: Space plants 6 × 6″ (15 × 15 cm), 6 × 9″ (15 × 23 cm), or 9 × 9″ (23 × 23 cm). No shade is necessary.

Plants are of a better quality when night temperatures remain below 75F (24C), although we have seen some outstanding material in Raleigh, N.C. If plants are produced in the South (Zones 7–10), they should be scheduled to flower in late summer and fall. The following data were submitted by Ginny Kristl of Johnny’s Selected Seeds, Albion, Maine.

Euphorbia marginata

Growth of *Euphorbia marginata* and cultivars in the North. Seeds were sown *in situ* 28 May, germinated 7 June.

	First flower	Peak bloom	Spread (in)^z	Height (in)^z	Uniformity (1–5)	Rating (1–5)
species	23 Aug	1 Sep	28–32	46–53	3.0	3.5
Icicle	23 Aug	1 Sep	30–32	43–49	2.5	3.0
Kilimanjaro	4 Aug	24 Aug	24–27	34–40	4.0	4.0
Summer Icicle	23 Aug	1 Sep	30–37	42–52	2.5	3.5

z = multiply (in) by 2.54 to obtain (cm)

All taxa had similar stem strength and bract diameters of about 3½″ (9 cm). Ginny noted that standout performer 'Kilimanjaro' was also excellent in terms of flower yield and showed variegation almost 3 weeks earlier than the others (although earliness to flower and to show variegation are not necessarily benefits).

Greenhouse Performance

Plant in ground beds or raised beds at 6 × 6″ (15 × 15 cm) or 6 × 9″ (15 × 23 cm) spacing. Fertilize with approximately 100 ppm N and grow plants under long days (14- to 16-hour photoperiod) for 6–8 weeks. If flowers are desired, provide shorter days (<14-hour photoperiod) when stems are 1–2′ (30–60 cm) long.

Stage of Harvest

Cut stems when bracts are fully colored but before the flowers are fully open. The flowers themselves are small; when they are open, stamens are easily visible. At that stage, vase life will be reduced.

Postharvest

Fresh: Bracts and flowers persist 7–10 days. The foliage does not remain fresh as long as the bracts and flowers do. Many florists remove the foliage prior to making an arrangement Stems benefit from being cut/recut under water. The milky sap can be quite troublesome, but if stems are cut under water, the latex coagulates. Searing the latex with flame or immersing the cut ends in alcohol or boiling water also rids the stems of latex.

Storage: Storage is not recommended, but temperatures of 42–55F (6–13C) can be used.

Cultivars

'Chameleon' is a favorite of some cut flower growers.

'Icicle', with 3–4′ (0.9–1.2 m) stems, is relatively early to color.

'Kilimanjaro' bears stems around 3′ (90 cm) in height. Bracts are white. Plants are less photoperiodic than others. Foliage may become variegated under short day conditions.

'Summer Icicle' appears to be identical to 'Icicle'.

Additional Species

Euphorbia dulcis (chameleon plant) has been used occasionally as a filler. The purple foliage and greenish flowers of its cultivar 'Chameleon' may have some potential for Northern growers, but stems are short, vase life mediocre, and vigor is not outstanding. Absolutely useless in the South.

Euphorbia fulgens (scarlet plume) is a common greenhouse-produced cut flower with scarlet blooms. Plants require SD for flowering and initiate with 12-

hour photoperiods at 68F (20C). They are excellent cut flowers, mainly imported from Europe. Short days provided on 1 August, 1 September, and 1 October resulted in plants that flowered on 20 September, 30 October, and 15 December, respectively (Post 1955, Runger 1985).

Pests and Diseases

Few problems occur with *Euphorbia marginata*, although warm temperatures result in root rots, botrytis, and other stress-related infections. Damping off of seedlings occurs in cool weather. Plants grown north of Zone 7 appear to have fewer problems than those further south.

Grower Comments

"After inadvertently splashing a very *diluted* solution of sap into my eyes, I wound up in the emergency room, couldn't see for 2 days, and lost a week of work at the height of the cutting season. I no longer grow *Euphorbia marginata*." Jeff Hartenfeld, Hart Farm, Solsberry, Ind.

"I grow *Euphorbia marginata* from seed. [It] grows 4′ tall and is quite a hit at market. The sap is mildly irritating to sensitive skin, and after a long day messing with it at market, I have felt a slight burn on my hands and arms, but it didn't last too long." Tom Wikstrom, Happy Trowels Farm, Ogden, Utah.

"Although it can be a great cut, it can go down if cared for improperly, and once florists have this problem, they don't seem to want to try it again. The only way I could get *Euphorbia* not to go down . . . was to cut it under water. I also cut it early, while stems were still stiff; the stems absolutely have to be cut under water. I also wore long-sleeved shirts, and I would recommend gloves." Ralph Thurston, Bindweed Farm, Blackfoot, Idaho.

"We have had trouble with damping off, but if you sterilize your soil (we heat ours), the success rate is great and damping off is not a problem. You must take cut stems inside within 10 minutes of picking, sear (we use a candle), and then put into water with Floralife™. I would cut the stems at various lengths that I thought I would use for that day, and after searing, I put them directly into the bouquet jars arranged as filler." Phyllis Wells, Wells Family Farm, Williamsburg, Mich.

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Many thanks to Ginny Kristl and Jeff Hartenfeld for reviewing this section.

Eustoma grandiflorum lisianthus, prairie gentian Gentianaceae

annual Nebraska, Colorado, Texas many colors
2–3′/2′ (60–90 cm/60 cm)

This great cut flower has come a long way from its humble origins on the western plains, and growers, sellers, and consumers are wild about it. Perhaps Dave Lines of Dave Lines' Cut Flowers says it best: "Many of us feel passionately that its customer acceptance and popularity will continue to soar. Lisianthus is without doubt the best cut flower that has come along in years. Customers love them and particularly appreciate their beauty and long vase life."

Now among the most important greenhouse cut flowers, this North American species continues to be crossed by American, Dutch, Japanese, and Israeli breeders and shows no sign of losing popularity in world markets. The blue flower color of the species has been complemented by cultivars with flowers of white, pink, yellow, red, and purple, and various combinations thereof. Though plants are biennials in their native habitat, they may be treated as annuals in the field; however, some growers find that overwintered plants produce the best crop the following spring. Flower production is challenging, particularly in warm climates, and the environment plays a major role in plant development and flower initiation.

Propagation

Seed: Plants are raised almost exclusively from seed by specialist propagators; terminal cuttings are only occasionally used because they tend to flower irregularly. For the small- to medium-sized operation, mature plugs should be purchased; however, if seed propagation is attempted, sow seed on top of medium (do not cover) at 70–75F (21–24C). Germination usually occurs in 10–15 days. Chilling seed at around 35F (2C) for 11–15 days dramatically increases germination (Ecker et al. 1994), but for most commercial seed, germination is not seen as a problem. Seed is small, with approximately 600,000 seeds/oz (22,000 seeds/g), 20,000 pelleted seeds/oz (715/g). For 1000 plants, only about 1/256 oz (110 mg) is needed (Nau 1999). Pelleted seed is available for most cultivars.

Cuttings: Not recommended unless stock plants are available. Terminal cuttings root under mist in approximately 2 weeks at 75F (24C). Stock plants should be maintained under LD (>12 hours) for maximum cutting production. Some plants, once established from cuttings, are shorter and weaker and have fewer flowers than those propagated from seed (Roh et al. 1989).

Growing-on

Two distinct growing phases occur, according to the plant's response to temperature. In the first phase, growth occurs slowly; seedlings require up to 3

Eustoma grandiflorum
'Heidi Pink'

months to form approximately 3–5 leaf pairs. During the seedling stage, maintain temperatures of 45–65F (7–18C). This ensures subsequent stem elongation, taller flower stems, and increased flower number (Roh 1999). Temperatures above 70F (21C), particularly at night, result in rosetting of the plants, something that must be avoided like the plague. If rosetting occurs, flowering is significantly delayed, and flowers are generally second-rate. Rosetting of the seedlings can be reversed (with difficulty) by application of 55F (13C) temperatures and LD for 4 weeks (Ohkawa et al. 1996), but it is far better to try to keep temperatures below 70F (21C). Research has shown that cooling the seedlings for 5 weeks at 54F (12C) prior to greenhouse planting accelerated flowering by 10 days (Sclomo and Halevy 1987). The seedling stage continues until 4 or 5 leaf pairs have formed and usually takes about 90 days. If possible, short days (<12 hours) should be maintained during the seedling phase, but photoperiod is less important than temperature. High-intensity lighting during the seedling phase to accelerate the growth of seedlings has been unsuccessful. This stage is often handled by plug specialists, so that the grower can obtain seedlings with 4 or 5 leaf pairs ready to plant in the greenhouse or field. Research in Japan (Ohta et al. 1999) showed that incorporating chitosan (poly-(1→4-)-$^{\beta}$- D-glucoseamine) in the soil mix at seeding significantly enhanced growth and flowering.

Second is the stem elongation (bolting) stage, which includes flowering and lasts for about 3 months. Night temperatures of 65–70F (18–21C) and LD are recommended.

Environmental Factors

Photoperiod: Lisianthus is a quantitative long day plant (that is, plants will flower faster under LD, but will eventually flower regardless of photoperiod) (Tsukada et al. 1982, Roh et al. 1989). Even under 8-hour days, plants form flowers (Halevy and Kofranek 1984); however, the effects of LD are relatively small. Under conditions of natural daylength, plants required 151 days to flower; plants provided with 20-hour LD treatments for 2–3 months flowered in approximately 120 days. Application of LD once flower buds were visible had no effect on flowering (Huh et al. 1998). When 30–45 long days were applied beginning when seedlings were 90 days old, flowering was not accelerated (Tsukada et al. 1982). These data show that LD are beneficial if applied early in the elongation stage and that, to significantly accelerate growth, LD should be given continuously until budding. The difference between growth and flowering under natural fall and winter conditions compared to LD conditions (nightbreak lighting or day extension) is minimal. Temperature is far more important.

Light intensity: Although light intensity does not accelerate flowering, an increase in flower number occurs when high-intensity sodium lights are used to supplement winter light (Grueber et al. 1984). Plants are more vigorous and produce more flowers in areas of high natural light intensity. Also the color of flowers produced under high light is less intense than under low light conditions (Kawabata et al. 1995). Additional HID light does not accelerate the seedling stage, and the additional heat from the lights at that stage may be detrimental.

Temperature: Temperatures above 72F (22C) in the greenhouse should be avoided in the seedling stage. Exposing germinating seedlings to high temperatures for as little as 3 days has been shown to reduce stem elongation, and more than 14 days of high temperature completely inhibited elongation even when plants were subsequently grown at lower temperatures (Ohkawa et al. 1991). Once the fourth or fifth leaf pair is formed, temperatures of 80F (27C) can be tolerated without negatively affecting flower quality.

Field Performance

Most lisianthus worldwide are greenhouse-produced; however, significant field production in the United States is accomplished. Field production in Maryland (Gill et al. 1998) has been reviewed and provides excellent information for much of the country; the planting schedule that follows is based on methods used in La Plata, Md., by Dave Lines. Plugs received by 1 March are moved up to 48-cell packs and planted out in raised beds, using an 8 × 8″ (20 × 20 cm) spacing. Three plantings are accomplished, and plants are overwintered.

Plant to field	1st harvest*	2nd harvest**
previous year's overwintered[z]	15 Jun	1 Aug
15 Apr	1 Jul	15 Aug
15 May	15 Jul	1 Sep
15 Jun	1 Aug	15 Sep

z = 20–40% survival; average stem length of overwintered stems was >2' (60 cm)
* = average length of non-overwintered stems was 16–24" (40–60 cm); harvest dates spread out over 3–4 weeks
** = average length of non-overwintered stems was 8–16" (20–40 cm); harvest dates spread out over 3–4 weeks

Flowers are susceptible to numerous diseases and must be protected from rain. Rain will cause spotting on fully developed flower petals, especially on darker colors, and those flowers should be removed before sale. Good drainage is essential: plant in raised beds if drainage is suspect or in areas where summer rains are plentiful. Uniform irrigation is necessary after transplanting to the field; drying out at this stage reduces yield and quality. At least one tier of support is recommended; 2 tiers of support netting are often used.

Do not accept rosetted seedlings; they have been grown too warm in the seedling stage and will give nothing but headaches. Plug sizes of 288 are common when placing seedlings in the field; plants should have at least 4 leaf pairs, but the larger the better for transplanting. Growing-on plugs in the greenhouse to fill 48-cell trays results in better establishment in the field and faster harvests.

Work in Kentucky showed that plugs moved up to cell packs (48 cells/tray) could be planted to the field as soon as threat of frost was passed. Approximately 4–6 weeks were necessary from transplant to the field until the first flowers were harvested. Yield was 3–4 stems/plant over 3–4 weeks, and stem length was 15–30″ (38–75 cm) (White-Mays 1992).

After the harvest, cut the plants back to stimulate a second harvest. The second harvest occurs 6–8 weeks after the first and will be about 30% of the initial harvest. Some growers plant seedlings about 3 weeks apart to allow for successive harvests.

Nutrition: A slow-release fertilizer (usually a 3-month formulation) can be provided immediately after transplanting to the field. If applying nitrogen, use a nitrate form. Potassium should be equal to nitrogen (e.g., 15-0-15), and supplemental calcium is recommended (Gill et al. 1998).

Shading: All sorts of claims are made about shading. In areas of bright summer sun, shading may increase stem length, but we are not convinced that the additional stem length makes up for the reduction in flower number or stem diameter. If shading is employed, approximately 30% shade should do the job; some growers use up to 70% shade, which seems way too high to us. *Eustoma grandiflorum* is a species of the prairies, where full sun is common. Try shading if stem length in the field is a problem; otherwise, the only protection should be for rain and inclement weather.

Overwintering: The key benefit to overwintering is that plants produce multiple stems the next spring, each with greater stem length and diameter than those produced from annual cropping. The quality and yield can be so much better that many growers do all they can to overwinter their plants. Some protect by using row covers or a hoop house (Gill et al. 1998), although growers in areas south of Zone 7 will likely not need to use protection. Overwintering also brings on additional stem and soil pathogens. Reduce problems by cutting back plants to 2–4″ (5–10 cm) and removing debris. Cleanliness is a must. Survival rate depends on severity of winter, protection methods, incidence of disease, and rodent problems. Plant losses that occur during attempts at overwintering may negate the increased value.

Greenhouse Performance

Winter greenhouse production, centered in northern or alpine areas of the world, provides flowers that can command excellent prices; however, the long time needed between sowing and flowering (up to 6 months) limits the usefulness of self-sowing the crop for greenhouse operators. The details of producing seedlings were discussed earlier; obviously, unless one has an overwhelming desire for masochism, mature plugs should be purchased from reputable seedling producers. Some large growers do the entire job themselves, particularly in areas of cool night temperatures, and once a schedule has been established, weekly sowings are the norm.

Place plugs in ground beds on 4–9″ (10–23 cm) centers; alternatively, place 1 or 2 plants per 4″ (10 cm) pot or 3–5 per 6″ (15 cm) pot. One tier of support is usually needed. Natural daylength is appropriate, but LD (>12 hours) can accelerate flowering. Additional flowers may be formed if HID sodium or metal halide lamps are used, but it is questionable whether this is cost-effective. Day temperatures of 78–86F (26–30C) and 65F (18C) nights result in faster flowering than 68–75F (20–24C) days and 55F (13C) nights (Halevy and Kofranek 1984). Pinching results in shorter stems and delayed flowering and is not recommended for cut flower cultivars (Dennis et al. 1989). One to 2 months are required between visible flower bud and open flower, depending on temperature. When plants are grown well, more than 10 flower buds are formed from the 4–6 upper shoots.

Nutrition: Lisianthus thrives in a higher pH than most crops. Maintaining a pH of 6.5 to 7.0 is highly recommended; a pH lower than 6.0 causes significant problems. The use of a nitrate form of nitrogen is recommended, particularly at lower pH values (Alt 1993). Excessive pH (>7.0) can result in reduced flower color intensity; a 7% increase in pH can reduce flower intensity by up to 10% (Griesbach 1992). Maintain high levels of fertility; underfertilization reduces growth. The major deficient nutrient appears to be calcium, which shows up as tip burn on young leaves; foliar application of calcium fertilizers helps prevent the problem. Tissue and soil analysis is recommended.

Stage of Harvest

Smaller flower buds can be removed as the terminal starts to open. Many growers find that best results occur when the central bud is removed, so that more flowers will be open simultaneously. Harvest when one flower is fully colored (e.g., when the white flower is totally white, not partially green). The flower need not be fully open.

Postharvest

Fresh: Postharvest life is excellent, 10–15 days. Small buds often fail to develop after harvesting, and flowers (particularly blue and pink flowers) fade badly in low light conditions; if placed in high light, these conditions become less severe (Kawabata 1995). A 25% decrease in light intensity results in a 40% decrease in color intensity (Griesbach 1992).

Preservatives are effective in lengthening postharvest life and should be used. Several solutions have been tested, with varying results. Ethylene production in cut flowers was shown to peak approximately 12 days after harvest; flowers are far more sensitive to ethylene as they age than when they open (Ichimura et al. 1998). Interestingly, Song et al. (1994) found that pretreating stems with STS or Chrysal AVB™ prior to placing in preservatives had little effect on longevity but resulted in more flowers opening in the vase. Other research showed that treatment with 0.1 mM STS for 24 hours before placing in distilled water increased the vase life significantly. Sucrose too has been studied and recommended as an alternative to STS. Continuous use of a solution of 20 g/l plus hydroxyquinoline (HQS, an antimicrobial agent) increased the pigment coloration and extended the vase life (Ichimura 1998). Continuous use of 4% sucrose solutions plus antimicrobial agents resulted in stems persisting for 30 days, each flower lasting approximately 13 days (Grueber et al. 1984). Another recipe, consisting of 10% sugar, citric acid, and antimicrobial agents, pulsed for 24 hours, resulted in 13-day postharvest life and opening of all flower buds on the cut stem. All this seems very confusing! In general, 2–4% sugar solutions used continuously have proven successful, as has pulsing with up to 10% sugar in combination with antimicrobial agents (8-HQC). Anti-ethylene compounds are probably not warranted.

Cultivars

The recent avalanche of cultivars reflects the interest and importance of this crop to the florist trade. Cultivars make be classified into early (winter flowering), mid (spring flowering), and late season (summer flowering).

Single flowers

Early season (winter flowering):

Polestar is intermediate in timing between Ventura and Heidi. Eight separate colors.

Tyrol series flowers early, with 1½–2″ (4–5 cm) flowers in white to rose-pink to deep blue shades. Noted for uniformity and vigor (Dole 1998).

Ventura is 3 weeks earlier than Heidi, on 30″ (75 cm) flowering stems. Eight colors.

'Winter Pink' is used for the short days of winter production.

Mid season (spring flowering):

Heidi series bears sprays of single flowers atop 2–2½′ (60–75 cm) stems. Nine separate colors plus a mix are offered. 'Heidi Wine Red Improved' has deeper colored flowers than its predecessor.

Malibu series can finish 2 weeks earlier than Heidi. Eight colors.

Royal series is earlier than some others and is available in pink, light purple, purple, violet, and white.

Late season (summer flowering):

Flamenco series was developed to follow Heidi and Echo during higher temperatures and longer days. Plants bear long stems about 2 weeks after Heidi. Thirteen separate colors plus a mix are available.

Laguna series carries 40–45″ (1–1.1 m) stems and includes 'Blue Blush', 'Deep Blue', 'Deep Rose', and 'Pink Rim'.

Mirage series appears to be daylength neutral. Flowers are 2½–3″ (6–8 cm) wide. 'Blue Rim', 'Light Pink', and 'Pure White' are available.

'Red Glass' is very nearly red, with 12–18″ (30–45 cm) stems.

Double flowers

Early season (winter flowering):

Avila series flowers under low light and lower temperatures than Echo. Five colors are available, including 'Avila Deep Rose'.

Mid season (spring flowering):

Balboa series was bred to flower during longer daylengths and warmer temperatures and appears to be a good choice for the field. In Maryland, flowers were harvested 11–14 weeks after transplanting and provided 22″ (56 cm) stems (Gill et al. 1998). Longer stems occur in the greenhouse. 'Blue', 'Blue Blush', and 'Blue Rim' are available from plugs.

'Blue Rose' has double blue flowers on 18–24″ (45–60 cm) stems.

Candy series was bred for moderate temperatures and low light conditions.

'Double Up Pink' carries delicate pink, fully double flowers on 30–36″ (75–90 cm) stems.

Echo series is nearly 100% double and flowers a little earlier than some of the single mid-season forms. Available in chiffon blue ('Misty Blue'), light blue, mid-blue, picotee blue, picotee pink, pink, white, and a mix. Cut stems are approximately 2′ (60 cm) long. Still one of the most popular doubles, and the ASCFG's 2002 Fresh Cut Flower of the Year.

Late season (summer flowering):

Catalina series exhibits less rosetting and larger flowers on 40–45″ (1–1.1 m) stems. Recommended for field production.

Mariachi's round-petaled flowers are carried on 20–26″ (50–66 cm) stems. Colors include 'Lime Green', 'Orchid', 'Yellow', and 3 picotee forms. Good for field and greenhouse production.

National field trials

Lisianthus has been evaluated since the inception of the ASCFG's national trials in 1994. The following table (Dole 1995–2001) is a summary of the average stem lengths and yields of eustoma submitted for trialing. These data are averages over a wide geographical range and must be viewed as guidelines only; individual experience may differ significantly.

Cultivar	Year of trial	Stem length (in)^z	Stems/ plant
Avila Ivory	2000	20	2
Balboa Blue	2000	17	3
Catalina Yellow	2000	16	2
Double Up Pink	1994	12	2
Flamenco Blue Rim	2000	14	2
Flamenco Purple Rose	2000	17	2
Heidi Champagne	2000	18	2
Heidi Mix	1996	18	3
Laguna Blue Blush	2000	16	2
Malibu Blue Blush	1998	13	5
Malibu Blue Rim	1998	14	6
Malibu Deep Blue	1998	13	9
Malibu Lilac	1998	17	6
Malibu White	1998	16	6
Mirage Blue Rim	1998	20	6
Mirage Light Pink Rim	1998	22	5
Mirage Pure White Rim	1998	21	5
Sentinel Porcelain	1994	11	2
Tyrol Blue	1997	12	3
Tyrol Blue Rim	1997	19	5
Tyrol Rose	1997	15	3
Tyrol Rose Pink	1997	17	4
Tyrol White	1997	17	3

z = multiply (in) by 2.54 to obtain (cm)

Pests and Diseases

The major problem in the greenhouse occurs during the long seedling stage. Seedlings develop so slowly that plants may be inadvertently overwatered, allowing water molds such as *Pythium* and *Rhizoctonia* to strike. Attention to watering is very important during the seedling stage. In the field, poor drainage is a serious problem. Stem blight, caused by *Sclerotium rolfsii* has also been isolated (McGovern et al. 2000). Where drainage has not been improved, heavy summer rains often result in root rots. This can be particularly devastating in hot, humid summers; raised beds or well-drained fields are recommended in such areas. *Fusarium*, *Alternaria*, *Botrytis*, and other fungi can also be present on lisianthus. Drenching the seedlings and the production beds with a fungicide is highly recommended, and good management practices, such as crop rotation, are a must.

Tomato spotted wilt virus and impatiens necrotic spot virus (mainly spread by thrips), bean yellow mosaic virus (aphids), tobacco mosaic virus (humans), and tomato yellow leaf curl virus (whiteflies) have been reported on lisianthus. Symptoms vary with the causal virus but include yellowing, mottling or chlorosis of the foliage, lack of flowering, and leaf distortion. Affected plants must be destroyed.

Aphids, thrips, and whiteflies also cause significant damage on their own, besides being vectors for the spread of viral diseases.

Grower Comments

"I grow my lissies in the field in full sun, and get about a 20″ plant with Echo. I sell at the farmers' market, and that stem length is fine with my customers. I cut out the first bloom with as little as a 4″ stem and sell them. They look great bunched in pint jars and make a pretty bouquet." Julie Marlette, Blue Heron Gardens, Fall Creek, Wis.

"When raised beds are covered with white-on-black plastic, increased natural light reflectivity helps increase plant vigor, stem diameter, and stem length." Dave Lines, Dave Lines' Cut Flowers, La Plata, Md.

"We grow the lisianthus [in] hoops all summer [with] a shade cloth on the hoop. We use about 70% shade. Our overwintered crop of lisianthus is in its second week of blooming [28 June], and the smallest stems per plant are 40″, the taller ones are 48″; there are 7–10 stems per plant, all saleable [at] $18 to $20 for a 10-stem bunch." Mimo Davis, WildThang Farms, Ashland, Mo.

"Lisianthus are a bit susceptible to root rots. Pull a few plants and take a good look at the roots. A healthy root system [has] lots of fine, white root hairs. It is definitely worthwhile to have a disease analysis done." Laurie Constable, Avalon Flowers, Santa Barbara, Calif.

"I use both Rootshield® and Clearys 3336®. I mix [them together] and water in every lisianthus plug when we plant in the field. The plugs have also been lightly drenched in the watering process while the plugs are growing-on. I always plant lissies in a new bed—I have about 2 more years before every annual bed will have had lisianthus—and I know that drenching is a must." Bob Wollam, Wollam Gardens, Jeffersonton, Va.

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Many thanks to Philip Katz and Dave Lines for reviewing this section.

Freesia ×hybrida

Iridaceae

bulb, greenhouse hybrid origin many colors
12–15″/9″ (30–38 cm/23 cm)

Precooled freesias are still produced in Florida as a winter crop, but nearly all current production occurs under protected structures, largely in California and the Northeast. Although significant field production occurred in southern California from the 1950s through the 1970s, problems with disease and insects reduced outdoor productivity. Freesias are native to the Cape Province of South Africa; thus, for optimum flowering, they require a warm, dry storage followed by cool soil temperatures (Imanishi 1993). For year-round forcing, a soil-cooling system is required. In their native habitat, corms initiate growth in the fall and flower in winter at temperatures around 46–50F (8–10C).

Propagation

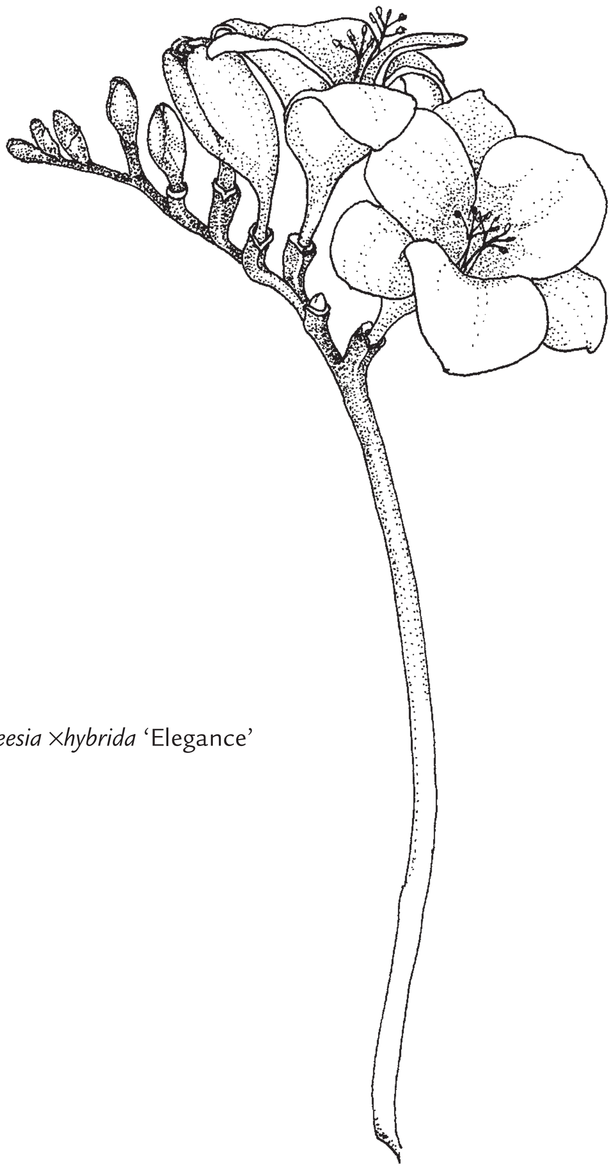
Seed: Seed sown at 60–66F (15–19C) soil temperature in the dark germinate in approximately 3 weeks and may be transplanted to pots or flats 1–2 weeks later (Gilbertson-Ferriss 1985).

Corms: Most growers purchase prepared corms produced by specialists in Holland.

Environmental Factors

Temperature: Bulb specialists pretreat corms for at least 3 months at 86F (30C) prior to shipping (De Hertogh 2001). Corms must therefore be ordered well in advance.

Flowering: Plants are similar to *Alstroemeria* in that soil temperature is the main trigger for flower initiation and development. Freesias initiate flowers at 40–68F (4–20C), but 54–60F (12–15C) is optimal (Heide 1965). Air temperatures above 62F (17C) should be avoided. Although research has suggested that tempera-



Freesia ×hybrida 'Elegance'

tures greater than 61F (16C) hasten flower stem development once flowers have initiated, the time savings is often offset by a reduction in flower quality. Abnormal inflorescences develop: the flowers are more widely spaced on the spike, fewer flowers occur per spike, and flower stems are shorter (Gilbertson-Ferriss and Wilkins 1978). The crop is best forced at 54–60F (12–15C).

Photoperiod: Temperature is more important than photoperiod, particularly as temperatures increase (Heide 1965). Research has shown that flower initiation is enhanced by SD, while flower development (stage after initiation) is enhanced by LD (Gilbertson-Ferriss and Wilkins 1978). Short days increase the number of flowers per raceme, the stem length, and the number of lateral flower stems (DeLint 1969, Gilbertson-Ferriss and Wilkins 1978). Most growers, however, do not consider photoperiod a major factor.

Greenhouse Performance (corms)

Planting: If corms cannot be planted immediately upon arrival, store at 55F (13C), high relative humidity, and no ventilation, but only for a maximum of 3 weeks (De Hertogh 1996). Plant 5/7 cm corms with the tops approximately 2″ (5 cm) below the surface in well-drained, fluoride-free soil. Never use superphosphate or water that contains fluorine. A pH of 6.5–7.2 is recommended (De Hertogh 2001). Space corms about 2–3″ (5–8 cm) apart, which is approximately 90–110 corms/100 ft^2 (10–12 corms/m^2) (De Hertogh 2001). Provide at least 2 layers of mesh support system over the bed.

Planting time: The planting date depends on the prevailing soil temperatures. Warm temperatures of 55–63F (13–17C) can be maintained by under-bench heating to delay flower initiation for the first 3–4 weeks, or until 5–7 leaves are visible. At this time, air temperatures can be up to 70F (21C) days and 65F (18C) nights. Then, air temperatures should be lowered and soil temperatures maintained at 50–55F (10–13C). Low soil temperatures limit production to winter months in much of the country unless a soil-cooling system is used when temperatures become warm. Warmer temperatures cause problems (see "Environmental Factors").

Light intensity: Provide as much light as possible (2500–5000 fc) by keeping the covering clean. Most crops are grown in glass or acrylic houses, as double polyhouses do not offer sufficient light in the winter months. In areas where winter light is poor (e.g., the Northwest), supplemental lighting enhances flower quality. In the relatively bright winter light area of southwestern Ontario, supplemental lighting did not enhance flower quality (Blom and Piott 1992). As temperatures begin to rise, a light shading for spring flowering is recommended.

Fertilization: Once well rooted, fertilize twice with 100 ppm nitrogen, and then raise fertility no higher than 200 ppm nitrogen.

Carbon dioxide: CO_2 at 1000 ppm is effective during daylight hours.

Flowering time: Flowering generally starts 110–120 days after corms are planted and persists for 4 weeks (De Hertogh 1996). Planting of corms must be staggered for a long season of flower production.

Greenhouse Performance (seedlings)

Seedlings can be used from plugs and transplanted when they are 2–3″ (5–8 cm) tall (4–5 weeks from sowing) and grown at 70F (21C) days and 65F (18C) nights until 6–8 leaves are visible (Gilbertson-Ferriss 1985). Lower temperatures to continuous 50–55F (10–13C) soil temperatures for flower initiation and development. Follow cultural practices as outlined for corms.

Stage of Harvest

For local markets, harvest when first flower is open and at least 2 additional flowers are showing color (De Hertogh 2001). For wholesale markets, flowers may be picked sufficiently early in the bud stage so they may be sold when they are in the balloon stage, showing color only. John LaSalle, who has been growing freesias in Whately, Mass., for many years, harvests a slightly shorter first cut (than used in Dutch markets), then picks 1 or 2 second-cut side shoots and bunches them to sell in retail shops and grocery stores, or as bouquets with greens and baby's breath added.

Postharvest

Fresh: Flowers last approximately one week (Vaughan 1988). Freesias are susceptible to ethylene and should be kept away from fruit or other ethylene sources. A treatment with 1-MCP is effective (De Hertogh 2001), as is an 18-hour pulse with a sugar solution carried out in the dark at 70F (21C) and 85% relative humidity (Evans and Reid 1990). Such treatments will increase flower size and allow more flowers to open. Immature flowers (cut before the first flower has opened) should be held in a preservative solution containing 4% sucrose at 50–70F (10–21C) to open flowers well (Evans and Reid 1990). Always avoid fluoridated water.

Storage: Avoid storage of fresh cut flowers when possible. Botrytis can occur in coolers in as little as 3 days. For the short term, flowers may be stored dry at 32–35F (0–2C) and 95% relative humidity (Nowak and Rudnicki 1990). They can be held longer in water at 33–35F (1–2C). Stems also benefit from a pulse of 200 ppm 8-HQC plus 20% sucrose for 24 hours at 70F (21C) and 60% relative humidity prior to shipping (Woodson 1987). Ship wet if at all possible.

Dried: Freesias may be dried with silica gel desiccant (Vaughan 1988). They do not air dry well.

Cultivars

Cultivars with single or double flowers are available in an array of colors. Some of the more common include 'Blue Heaven' (blue), 'Dukaat' (yellow), 'Elegance' (white), 'Golden Wave' (double yellow), and 'Volante' (double white). Consult a bulb specialist for the best cultivars for your area.

Pests and Diseases

Botrytis and aphids, the most common pests, are best treated with an IPM program. For botrytis on blooms, apply some heat and ventilate the greenhouse. Some fungicides are effective, but others may disfigure open flowers. Do a small experimental spray prior to treating the entire crop. Dip corms on arrival into an appropriate fungicide to reduce incidence of botrytis and apply proper aphicides when necessary. Thrips, especially in late plantings, can be a large problem.

Physiological disorders

"Thumbing" describes an inflorescence in which the lowermost 2 or 3 flowers are unevenly spaced along the spike, and the spike is nearly straight. Warm temperatures during floral induction is thought to be the cause; provide shade to reduce the temperature.

Leaf scorch appears to be a fluoride problem. Reduce the use of phosphorus sources.

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Many thanks to August De Hertogh, John LaSalle, and Roy Snow for reviewing this section.

Gladiolus — Iridaceae

bulb

Glads are well established as a mainstream cut flower, and a staggering volume of spikes are produced in this country as well as in Europe, South America, and Israel. Two main types of gladioli are used: standard types produce one spike per corm, with up to 30 large flowers per spike; miniatures may produce several stems per corm. The largest production areas are in Florida, California, and Michigan. The need for large, bold stems in everyday flower arranging and funerals is declining, and while the market for standard glads is reasonably strong, other forms or species must be examined. The new "orchidola" glads are useful for their shorter stems, shorter production time, and "different" look. Some old-fashioned species also have charm and practicality, including *Gladiolus callianthus*, *G. communis* subsp. *byzantinus*, and *G. tristis*.

Gladiolus callianthus Abyssinian glad Iridaceae

bulb, Zones 7–10 Ethiopia white with purple throat
3–4′/3′ (0.9–1.2 m/0.9 m)

Gladiolus callianthus (syn. *Acidanthera bicolor*) is an excellent fragrant cut flower. Approximately 5 flowers, 3″ (8 cm) wide, are formed on the spike, and they open from bottom to top. The "bulb" is a small tunicated corm, about ½″ (13 mm) wide. Shelf life is reasonable, if not exceptional. Treat as an annual in most areas of the country.

Environmental Factors

Photoperiod: Photoperiod likely has an effect on flowering time, and LD may be beneficial.

Temperature: Temperature affects the rate of development and crop timing (see under *Gladiolus* hybrids). Abyssinian glad does not require cold for flowering, and temperatures below 40F (4C) should be avoided.

Field Performance

Spacing: Space 3–4″, up to 16 corms/ft^2 (8–10 cm, 170 corms/m^2).

Longevity: Yield is reduced significantly after the first year, although stem length and diameter are not adversely affected, as shown in the following table (Armitage and Laushman 1990).

Longevity of *Gladiolus callianthus* 'Muralis'. Fall-planted, Athens, Ga.

Year	Scapes/corm	Stem length (in)^z	Stem width (mm)^y
1	1.2	28.6	8.0
2	0.6	32.2	7.5
3	0.5	34.4	7.5

z = multiply (in) by 2.54 to obtain (cm)
y = divide (mm) by 25.4 to obtain (in)

If corms are to be replanted (not recommended), lift in late fall and overwinter in dry, 60–65F (15–18C) conditions in a well-ventilated area. In Zones 7b and south, corms may be left in the ground, but yield declines each season. Corms are inexpensive and should be replanted every year.

Planting time: In the North, corms may be field-planted after the last frost date. In the South, corms may be planted in the fall. Plants normally flower in late summer in the South, fall in the North. When corms were planted at different times between November and March, differences in yield and stem quality were minimal (Armitage and Laushman 1990).

The effect of planting date on *Gladiolus callianthus* 'Muralis'.

Month planted	Corm survival (%)	Flw/ corm	First harvest	Stem length (in)^z	Stem width (mm)^y
Nov	98	1.2	2 Jul	28.9	8.2
Feb	97	1.3	2 Jul	28.3	8.5
Mar	84	0.8	11 Jul	28.1	7.7

z = multiply (in) by 2.54 to obtain (cm)
y = divide (mm) by 25.4 to obtain (in)

The harvest lasted approximately 22 days, regardless of planting date.

Guideline for Foliar Analyses

At field trials in Athens, Ga., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis.

(%)				
N	P	K	Ca	Mg
2.5	0.29	1.54	0.47	0.16
(ppm)				
Fe	Mn	B	Al	Zn
110	32	15	27	50

Calcium deficiency during production results in brittle stems that break when harvested, a disorder known as topple.

Stage of Harvest

Harvest when 1 or 2 flowers are open; other flowers will open in a preservative solution. The earlier the preservative is applied, the longer the vase life.

Postharvest

Fresh: Flowers persist 5–7 days at room temperature in a commercial preservative. Most commercial preservative solutions are effective and should be used for rehydration of stems.

Storage: Flowers may be stored in an upright position for 6–8 days at 36–41F (3–5C). Lower temperatures result in injury and prevent flower opening. Leaving lights on in the storage area helps to open buds.

Stem tips of Abyssinian glad bend if placed on their sides and therefore should be maintained upright unless refrigerated throughout the market chain. The problem is not as severe as with standard hybrid gladioli (see "Postharvest" under *Gladiolus* hybrids, which are closely related—and more studied).

Cultivars

'Muralis' has larger flowers and stronger stems than the species.

Additional Species

Gladiolus communis subsp. *byzantinus* (syn. *G. byzantinus*; Byzantine gladiolus) bears brilliant rusty red flowers. Quite different, has naturalized in the South.

Pests and Diseases

Rust and thrips, which disfigure the foliage, are common problems. Voles and other rodents can be serious pests. Problems inherent with hybrid gladiolus production should be considered when producing this species.

Grower Comments

"Acidanthera is a great cut [but] harvest period is very compressed. I plant 3 or 4 plantings 2–3 weeks apart. Spacing about 6 × 6″. Probably could go closer. Problems that may crop up are thrips (of course) and rust. Basically, it is cultured like gladiolus." Paul Shumaker, Never Should Have Started Farm, Bangor, Pa.

"Our acidanthera 'Muralis' has been selling to a local florist for $6.50 per bunch of 10 and to an art gallery owner in the trendy/pricey Berkshires for $15 per bunch. They are blooming now and have huge, gorgeous flowers. But we find we can't wholesale them because 1) you have to pick after the first 1 or 2 flowers are open, and they'd get crushed if you tried to bunch them tightly or pack them for shipping, and 2) storing in our cooler, which cycles between 33 and 39F, damages the buds. They are beautiful, long-lasting, and heavenly scented, and the customers love them." Alice Vigliani, Maple Ridge Peony Farm, Conway, Mass.

Gladiolus hybrids

Iridaceae

bulb, Zones 8–10 hybrid origin many colors 1–3′/1′ (30–60 cm/30 cm)

Propagation

All flowers are produced from corms by specialist propagators. Corms are usually harvested when dormant, and the degree of dormancy depends on where they were harvested and on the cultivar. In general, corms are placed, after digging, at 100F (38C) for a few days, and then in a 41F (5C) cooler for up to 5 months (Cohat 1993, Jean et al. 1997). With *Gladiolus tristis*, corms stored 3 or 6 weeks at 41F (5C) and 90% relative humidity flowered 20 or 11 days earlier, respectively, than those that were not stored. The corms stored 6 weeks flowered 35 days longer than those given other treatments (Gonzalez et al. 1998). Some growers use the same corm for up to 3 years, but most replant each year.

Environmental Factors

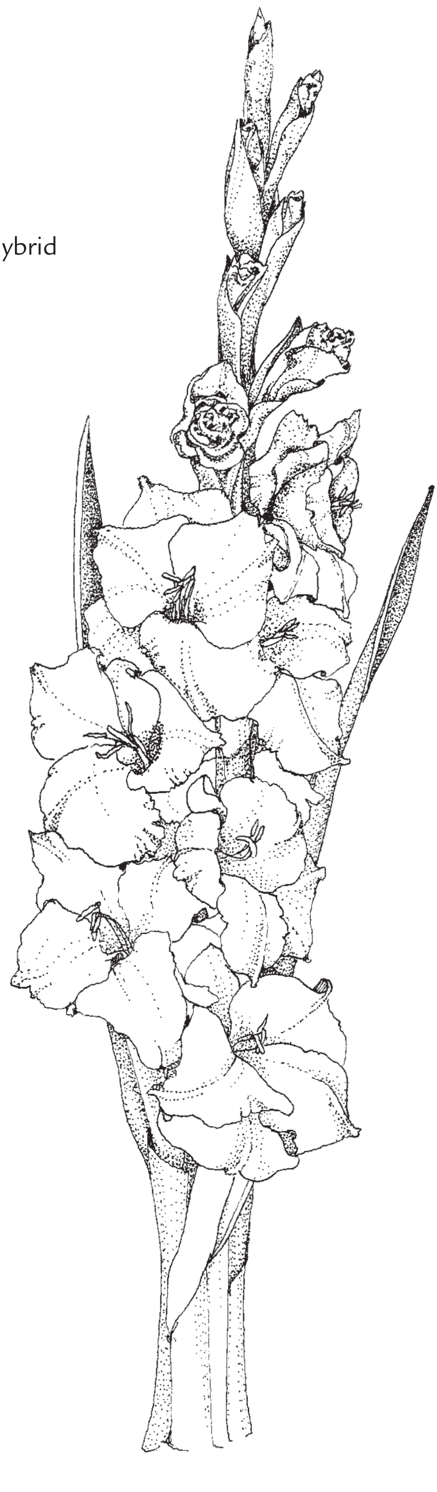
All gladioli are vegetative when planted, and flowers are initiated after a certain number of leaves are formed. The number of leaves formed differs from cultivar to cultivar, and the exact time of flower development depends on water balance, light, and temperature. The flowering shoot emerges after the last leaf; 8–10 leaves are formed in most cultivars. Gladioli that do not flower are said to be blind. Blind mature gladioli are plants in which the flowers were formed but aborted, a phenomenon known as blasting. Blasting is a result of poor light conditions or the drying out of developing plants.

Light and photoperiod: Low light and short days during winter production increase the incidence of flower blasting. Plants are most sensitive to low light and SD during the first to fifth leaf stage (reduced flower percentage) and the fourth to sixth leaf stage (increased flower blasting). Long days, either natural or by applying nightbreak lighting in the greenhouse or field, reduce the incidence of blindness and improve the length and quality of the spikes (Shillo and Halevy 1976, McKay et al. 1981). Long days, however, may delay flowering in some cultivars. Corm development continues during SD but is arrested when LD are applied and does not continue until after flowering (Shillo and Halevy 1981). Supplemental light of 460 fc for 12 hours significantly reduced bud abortion during winter forcing. Once 3 leaves have appeared, the plants are responsive to supplemental light (Zhang 1995).

In summary, high light and long days are best for flower production of gladioli. During winter production, a day extension of 4–5 hours or a nightbreak of 2–4 hours is used in the field or greenhouse (McKay et al. 1981, Shillo and Halevy 1981). Miniature and standard cultivars also respond positively to supplemental photoperiodic lighting (Halevy 1985).

Temperature: Temperature is the most important environmental factor: it affects the rate of floral development, and therefore, the rate of flowering. Summer-grown gladioli bloom in about 70 days, while the same cultivars require approximately 130 days to flower in the winter. Low night temperatures of 33–

Gladiolus hybrid



38F (1–3C) cause flower blasting when light intensities are low. Chilling during the day appears to inhibit flowering but does not cause blasting. Blasting caused by high temperature is usually the result of poor water balance (plants dry out) and not temperature per se.

Water: Water stress affects the developing flowers much more than the corm; therefore, drying out causes more flower blasting than actual damage to the plant itself. The stages immediately after planting and the 4- to 7-leaf stage (when flowers are developing) are the most sensitive to water stress.

Field Performance

Corm size: Use large corms. Nearly all published research has shown that larger corms result in faster sprouting, taller plants, more shoots, and thicker stems than smaller ones (Mohanty et al. 1994, Kalasareddi et al. 1998). If forcing in the winter or under low light, it is particularly important to use the biggest (i.e., #1 size) corms. Smaller sizes may be used for summer production.

Planting: Plant when frost is no longer a danger. In the Midwest, corms may be planted as soon as the ground can be worked. Place as close as 2″ (5 cm) apart, with as little as 2″ (5 cm) to as much as 5″ (13 cm) of soil above. Although corms may be planted "corm to corm," the probability of disease increases with dense plantings. For production of cormels, a planting density of 6 × 6″ (15 × 15 cm) is recommended (Bahar and Korkut 1998).

Soil: Fresh or fumigated soils should be used, and 2- to 3-year crop rotations are most important. Soil pH of 6.0–6.5 is best, and well-drained soils are necessary to reduce root and foliar problems.

Scheduling: Depending on cultivar and time of year, flowering occurs 60–100 days from planting (De Hertogh 1996). Howard Lubbers of Holland, Mich., suggests that up to 5 plantings may be conducted, starting 1 April and each month thereafter until 15 June.

Weeding: Weeds have a serious impact on flower yield and stem length. Weeds should be controlled before the 3-leaf stage to allow for good-quality cut flowers (Cheong et al. 2000).

Fertilization: Plants in sandy soils require more frequent fertilization than those in heavier soils. For sturdier stems, a complete fertilizer, such as 5-10-10 or 5-15-5, should be applied before planting and as a side dressing about one month later. An additional side dressing may be used when the spikes are visible but is probably not needed in clay-loam soils.

Photoperiodic control: For growers producing a winter field crop, incandescent lights should be strung over the plants to provide long days. Sixty- or 100-watt bulbs spaced at a distance to provide 10–20 fc during the night are most effective. Provide 13-hour days by lighting from one hour before dusk until about 10 p.m. to midnight, depending on natural daylength. Nightbreak lighting and cyclic lighting may also be used.

Digging corms: Corms may be removed after the foliage has declined (about 8 weeks after flowering) or after first frost. Remove foliage and place no more than 4 layers of corms in trays with screen or slat bottoms. Cure at 75–85F (24–

29C) for 10–15 days. After curing, store corms at 40F (4C), 70–75% relative humidity. To avoid problems of digging, curing, and storage, purchase new corms annually.

Greenhouse Performance

Plant corms in ground beds at a spacing of 5–8 corms per running foot (15–25 per running meter). In greenhouse work in South America, a planting density of 25 corms/m^2 produced the best stem length and yield compared to 15, 35, or 45 plants/m^2 (Klasman et al. 1995). The number of cormels produced was also greatest at that density.

Provide LD (13–15 hours) with incandescent lights (10–20 fc) during late fall, winter, and early spring production. Temperatures should be maintained at 70/65F (21/18C) day/night throughout the crop. Higher temperatures may be used to accelerate leaf emergence, therefore flowering, but high temperatures are not necessary for high-quality flowers. Flowers occur 60–75 days after planting, depending on cultivar. Fertilize with liquid (nitrate forms of nitrogen are best) or granular fertilizers at planting and again after 3–4 leaves have emerged.

Stage of Harvest

Cut when 1–5 flowers on the spike are showing color. For local distribution, cut when bottom flower is thumb-sized to fully open. When bunching, position the stems so that the flowers are on the outside of the bunch.

Postharvest

Fresh: Cut stems respond well to being placed in a preservative solution containing up to 20% sugar and a germicide; sugar (4%) and HQC (250 ppm) appears to be a good combination for flower shelf life (Zhou et al. 1995, De et al. 1996). Allow stems to remain in solution overnight at 70F (21C). Use warm, deionized water for rehydration; deionized water is best for gladioli because they are susceptible to fluoride levels as low as 0.25 ppm. Stems should be placed at 68–76F (20–25C) for maximum bud opening.

The tips of gladioli stems are very prone to bending if placed on their sides. Unless they can be refrigerated throughout the market chain, they must remain upright during storage and transport.

Storage: Stems may be stored dry if conditioned with 10% sucrose solution plus STS at 68F (20C) for 24 hours. Older research suggested that flowers should be stored at 40–42F (4–6C) to prevent chill injury, but recent research (Nell and Reid 2000) has shown that flowers can be stored at 33–35C (1–3C), wrapped in moisture-proof paper and placed in polyethylene bags. After storage, recut stems and place in an opening solution until flowers reach the desired flowering stage (Nowak and Rudnicki 1984).

Wet storage is easier to accomplish if stems are placed in a floral preservative. Stems should be stored at 33–38F (1–3C) (Nowak and Rudnicki 1990).

Corms may be stored by growers after curing and cleaning. Corms are placed at about 40F (4C) for 60–90 days (Pirone 1970).

Cultivars

Many standard, hybrid, and miniature gladioli are available. Discuss optimum cultivars with a reputable bulb salesperson.

The North American Gladiolus Council classifies glads into miniature (under 2½″, 6 cm), small-flowered (under 3½″, 9 cm), medium-flowered (under 4½″, 11 cm), large-flowered (under 5½″, 14 cm), and giant-flowered (over 5½″, 14 cm).

Pests and Diseases

Insects

The main insect-type pests are thrips, red spider mites, aphids, and wire worms.

Gladiolus thrips are most prevalent and damaging. They feed by rasping the foliage and flowers; surfaces of infected tissue appear whitish gray. They feed mainly in cloudy weather, seldom in full sunlight. Infected flowers are discolored and spotted and eventually dry up as if burned (Pirone 1970). Corms may also be attacked and become sticky from the sap that oozes out as a result of the infestation. Apply an insecticide early in the growing season. If possible, refrain from spraying when flowers are open.

Wire worms (the larvae of click beetles) feed on the corms and roots, boring holes in the base of the foliage. They are reddish brown, long, and narrow, with a hard, many-jointed shell (Pirone 1970). Infestations are more common and debilitating in heavy soils that lack adequate drainage. Well-drained light soils reduce the presence of wire worms, and most soil insecticidal drenches are effective.

Diseases

Botrytis dry rot, corm rot, hard rot, leaf and flower spot, fusarium rot, and viruses affect gladioli.

Botrytis gladiolorum, which causes botrytis dry rot, is the most common cause of corm rot and leaf and flower spot in glads. The foliage turns brown so suddenly, it appears as if the field has been burned. Infected spikes may appear healthy at harvest but rot in transit. Control methods include fungicides, roguing, and planting in a well-drained field.

Corm rots can be caused by many organisms. *Penicillium gladioli* causes red-brown sunken, corky lesions and is usually introduced through physical injury. Handle the corms carefully to avoid wounding; if corms are dug, proper curing procedures should include covering any wounded tissue. *Fusarium oxysporum* f. *gladioli*, which causes fusarium dry rot of corms, is the most serious storage disease organism of gladioli corms. Infected areas appear as concentric water-soaked sunken spots, varying in color from very light brown to tan (Pirone 1970). Treatments vary from plunging cormels in hot water (128F, 53C) to roguing infected plants. Where infection has occurred, it is essential that soils be well drained and sterilized, and that drying and curing time be accomplished prior to storage.

Leaf and flower spotting caused by *Curvularia trifolii* f. *gladioli* shows up as oval, tan spots on the leaves and stems. The spots may grow from pinhead size to 1″ (2.5 cm) in diameter in a few days. Spots may be seen on both sides of the leaf, and black powdery spores occur in the middle of the lesions. Flowers fail to open when the disease is advanced. Foliar fungicide may have to be applied every week to control the disease.

Viruses include cucumber mosaic and tobacco mosaic virus. Streaking of the foliage and flowers is a common symptom of infection. Most viruses are transmitted by aphids, leafhoppers, or infected tools. Control viruses by disinfecting tools and controlling the insects. Viruses are carried over from one season to the next in the corms; therefore, infected corms should be discarded.

Grower Comments

"My experience is limited, but the mini-glad Nanus 'Atom' was terrific for me. Red with a paintstroke of white around the edges and a lavender tickle in the throat. Excellent stems, with about 50% giving a second smaller and later shoot. If you're planting 5000–6000, you'll cut 'em all, and the second shoot will come with the first cutting. On my smaller scale, I can cut the first and leave the second. I also tried Nanus 'Impressive' and only got a few blooms. But they were indeed so 'impressive' that I'm trying them again this year, thinking that perhaps I planted too deep. These were a deep shell-pink with a bicolor coral- and white-painted throat." Karen Hanley, Stork Road Farm, North Creek, N.Y.

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Many thanks to Howard Lubbers for reviewing this section.

Gomphrena globosa globe amaranth Amaranthaceae

annual Mediterranean many colors 2–3′/2′ (60–90 cm/60 cm)

Gomphrena globosa is widely used as a dried flower. Excellent selections of it and *G. haageana*, and hybrids between them, in various colors and sizes, have been offered. Plants are a mixed blessing: they are extraordinarily heat tolerant yet grow like weeds—sometimes a little too exuberantly. Take the tongue-in-cheek comments of one of America's fine cut flower growers, Frank Arnosky of Texas Specialty Cut Flowers, who has perhaps seen more of these amaranths than most of us:

> Gomphrena likes it hot because it originally grew in Hades' garden at the gates of hell. Hades kidnapped Persephone, the daughter of Demeter, while she was out picking flowers (of course). Zeus worked out a compromise to get Persephone back for at least half of the year (summer). Hades was none too happy about it. He decided to curse Demeter, the goddess of agriculture and fertility, by sending gomphrena seeds up with Persephone. Of course they grew like hell, and since then, all of us who farm flowers for a living share in Hades' curse. Gomphrena grows best here in Texas because our climate most closely matches that of gomphrena's native environment.

Frank's version of the story notwithstanding, plants probably came over to this country with some of the first settlers and have been part of the cut flower scene for a long time. They are easy to grow and may be harvested mechanically.

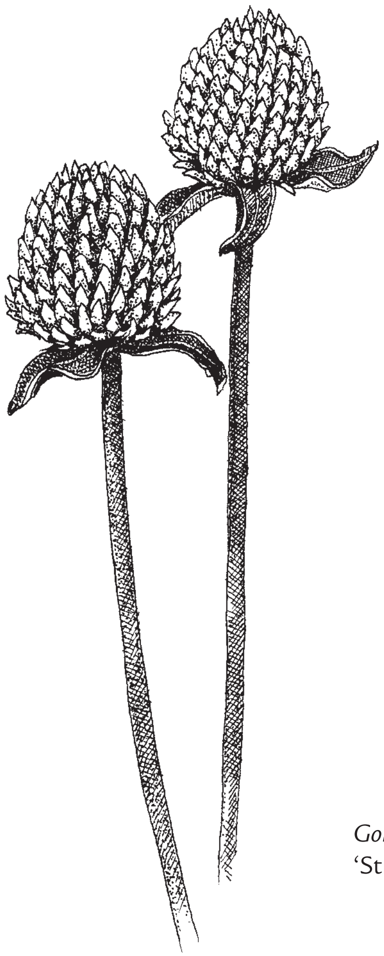
Propagation

It is ludicrous not to purchase clean seed—few things are as messy as uncleaned gomphrena seed. *Gomphrena globosa* has approximately 19,000 clean seeds/oz (700 seeds/g), but there are only about 8000 (300) uncleaned seeds for the same weight. *Gomphrena haageana* has 11,000 clean seeds/oz (400/g). Although more expensive, greater percentages and more uniform germination can be expected from properly cleaned seed. Various other treatments can improve erratic seed emergence. Germination is approximately doubled by scarification; always purchase scarified seed if available. Seed may also be separated by size for higher germination (the larger the seed, the better the germination), and "high-tech" seed is recommended. Use 1.5–2 oz (42–56 g) of clean seed for 1000 seedlings (Nau 1999).

Germination occurs in as little as 4–5 days in a sweat chamber at 78–80F (26–27C) or may take as long as 10 days when sown in the greenhouse at 70–72F (21–22C) under mist. One grower has had successful and rapid germination at temperatures as high as 100F (38C). No difference in germination between light and dark conditions has been shown. Because untreated seed germinates so erratically, direct sowing is not recommended; however, if direct sowing is to be accomplished, use clean, scarified, and, preferably, sized seed.

Growing-on

Grow seedlings at 65F (18C) nights, 70F (21C) days for most rapid growth. Capillary mats and temperatures of 70–72F (21–22C) are useful for growing-on seedlings after the first flush of germination. Capillary mats also minimize damping off, a problem common to overwatered plants. Seedlings from open packs may be transplanted to cell packs or small containers about 3 weeks from sowing



Gomphrena
'Strawberry Fields'

and planted to the field 4–5 weeks later. Transplant prior to flowering. If grown in plugs, allow 4–6 weeks (in a 200-cell pack) before transplanting to container or field, depending on size of plug.

Fertilize seedlings initially with 50–100 ppm N; over 50% of the nitrogen should be in the nitrate form. As seedlings grow more actively, fertility may be increased to 100–150 ppm N and K. Overfertilizing results in tall, soft growth, which transplants poorly.

Environmental Factors

Photoperiod: Flowering occurs as plants mature, regardless of photoperiod. Flowers initiate as the plant produces additional nodes; the number of nodes is directly affected by light intensity and temperature.

Temperature: Plants grow and flower more rapidly as temperatures rise above 70F (21C); temperatures below 65F (18C) result in slow growth and reduced flowering. Their tolerance of warm, humid weather makes these excellent plants for the Midwest and Southeast.

Field Performance

Spacing: Gomphrena behaves like most other field crops, in that as spacing is increased, yield per plant increases but yield/ft^2 decreases. For example, research in India showed that as spacing increased from 9 × 12″ (23 × 30 cm) to 9 × 24″ (23 × 60 cm), plant width, number of branches per plant, and number and weight of flowers per plant increased but the highest yield/unit area was at the densest spacing (Jhon and Paul 1992). The same holds true in Sioux City, Iowa, or Waynesville, N.C. Our work in Athens suggested that plants be grown on approximately 6–9″ (15–23 cm) centers, although wider spacing may reduce disease incidence. Some growers plant a double row on ridges 16″ (40 cm) apart. Two rows are planted 8″ (20 cm) apart on top of each ridge. This computes to approximately 16,000 plants/acre (39,500 plants/hectare). No pinching or support is necessary.

Harvesting: Yield is often measured in dry weight per acre or plant. An average of ½ to ¾ pound of dried stems per plant occurred at Woodcreek Farm in Ohio; red cultivars yielded up to 1 lb/plant. Flowers may be picked all summer long from single spring plantings. Little mechanical harvesting is done, but it is a crop that lends itself to such a practice: although fewer stems/plant would be harvested compared with hand harvesting, the labor savings would outweigh the value of the lost stems.

Shelley McGeathy obtains stem lengths of 10–12″ (25–30 cm) in Michigan (Zone 5). Work at the University of Georgia (Zone 7) in which stems of *Gomphrena* 'Strawberry Fields' were hand-harvested resulted in approximately 58 stems/plant with an average stem length over the entire season of 15″ (38 cm). Distribution of yield is shown in the following table.

Yield and percentage of total stems on *Gomphrena* 'Strawberry Fields'. Based on 50 plants.

Week no.	No. of stems	Percentage of harvest
19–22	230	7.4
23–26	265	8.5
27–30	200	6.4
31–34	678	21.8
35–38	1050	33.7
39–42	696	22.4

Stem quality: The length of stems is not as critical a quality in *Gomphrena* as it is with other cut flower genera because fresh flowers are normally used in wreaths and table designs, where short stems are useful. Stem length cannot be ignored, however, and breeding efforts have concentrated on flower color and shape as well as on longer, stronger stems. The distribution of stem length from field trials at the University of Georgia is provided in the following table.

Stem length of *Gomphrena* 'Strawberry Fields'.

Week no.	Stem length (in)^{z}
19–22	12
23–26	14
27–30	15
31–34	16
35–38	18
39–42	15

^{z} multiply (in) by 2.54 to obtain (cm)

Shading: Shading is not recommended for these full-sun plants.

Greenhouse Performance

Gomphrena is seldom grown in the greenhouse for cut flower production; however, if grown in the greenhouse, use 63–65F (17–18C) nights and 70F (21C) days. Allow as much light penetration as possible and fertilize at 200 ppm N with nitrate nitrogen. Space on 6–9″ (15–23 cm) centers or grow in containers.

Stage of Harvest

Harvest when flowers are in color but before fully open. If stems are mechanically harvested, select only those flowers that are swollen and nearly fully colored. If harvested for drying, allow flowers to open completely.

Postharvest

Fresh: Fresh flowers persist approximately one week.

Dried: Most flowers grown in the United States are used for drying. Flowers may be air-dried and held indefinitely. Hang upside down in small bunches; leaves need not be stripped prior to drying. To prevent mold, reduce field moisture as much as possible, use good air circulation, and reduce humidity. Stems are sometimes treated with glycerine, but this is more costly than air drying.

Storage: Storage of fresh flowers is not recommended. Store at 36–41F (3–4C) only if necessary.

Additional Species

Gomphrena haageana (golden amaranth), native to India, has a longer, less rounded flower and is an attractive yellow-orange color. Cultivation is similar to *G. globosa*.

Cultivars

Most of the recent cut flowers selections are likely hybrids between *Gomphrena globosa* and *G. haageana*; however, bedding plant cultivars of *G. globosa* are also available (e.g., Buddy, Gnome series). Only 12–14″ (30–36 cm) tall, they cannot be recommended for cut flower production unless short-stem forms are in demand.

'All Around Purple' performed exceptionally well in national field trials in 2001. Plants averaged 11 stems per plant with a stem length of approximately 16″ (40 cm). Nominated for Cut Flower of the Year by the ASCFG (Dole 2002).

'Bicolor Rose' has rose and white flowers and strong, upright stems. Excellent, among the best of the recent cultivars. In national field trials, 'Bicolor Rose' was a hit for just about all trialers, receiving some of the highest scores that year; stems averaged 16″ (40 cm) with over 50 stems per plant reported (Dole 1996).

'Flashing Light' bears large red flowers on 16–18″ (40–45 cm) plants. Probably a selection of *Gomphrena haageana* and quite similar to 'Strawberry Fields'.

QIS series enjoyed enormous popularity in the late 1990s and early 2000s. Available in purple, red (which has had some excellent reviews), and several other colors. 'QIS Carmine' was the ASCFG's 1999 Dried Cut Flower of the Year.

'Strawberry Fields' was a standard for cut gomphrena, and although it has been superseded by others, it is still a fine selection. The long stems bear deep red flowers, which hold their color exceptionally well when dried. Probably a selection of *Gomphrena haageana*.

Pests and Diseases

Several leaf-spotting fungi, the worst being *Cercospora gomphrenae*, occur on globe amaranth in the southern United States. It is also host to several viral diseases; particularly unwelcome is the impatiens form of tomato spotted wilted virus (TMSV-I), first found in Georgia in the early 1990s (Ruter and Gitaitis 1993). Seed-borne pathogens, such as *Colletotrichum dematium* (part of the *Anthracnose* complex) and *Phoma* spp., reduce seed germination (Chou and Wu 1995).

Pests include aphids, thrips, and two-spotted spider mite. The good news is that gomphrena is quite resistant to elevated levels of ozone (Findley et al. 1997), so it can be a weed almost anywhere.

Grower Comments

"Seed is the least expensive part of production, and therefore I am willing to pay more for better seed. I do not pick continuously, rather one time and the entire plant. I do this when the central or primary flower shows signs of age. I have picked it too late, and it shattered horribly in the barn." Tom Wikstrom, Happy Trowels Farm, Ogden, Utah.

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Many thanks to Ralph Cramer and Mike Wallace (first edition) and Ralph Cramer, Shelley McGeathy, and Frank Arnosky (second edition) for reviewing this section.

Goniolimon tataricum German statice Plumbaginaceae

perennial, Zones 6–8 Asia lavender 2–2½′/2′ (60–75 cm/60 cm)

Although it is chiefly applied to *Goniolimon tataricum* (once known as *Limonium tataricum*), German statice serves as the common name for many species, such as *L. latifolium* and *L. altaica*, and hybrids between them. In general, plants have glossy green leathery leaves, and the flowers are faintly to strongly malodorous. They grow as rosettes, and the flower stems arise in early to mid summer with clouds of lavender to light blue. They do not have the vigor or the stem length of *Limonium* hybrids, such as 'Misty Blue'.

Unfortunately the market for many dried flowers, and particularly for German statice, has declined in the last few years. The comments submitted by Mary Ellen and Bob Schultz, long-time statice growers in Montana, are typical:

> We've been growing German statice for 10-plus years, and in that time frame, the market has been on a continuous decline, more or less following the dried flower market decline. We periodically call around to other German statice growers, and the story seems to be the same. Besides the general dried flower market shift, one of the principal problems from our perspective has been with large growers that give little attention to quality and sell it cheap. Time and again we'd get samples from big volume grow-

> ers, where the product was totally faded and brown and smashed-packed into boxes. We believe most of this product goes to the discount hobby/craft stores, where quality seems to be a secondary concern. The fallout is, of course, that this practice establishes a very bad reputation for the product in general and puts the onus on the better producers to convince buyers there is better product out there—but it necessarily costs more too.

Much of the field information presented in this section is from work at the University of Georgia with *Limonium altaica* (altaica statice), but it is pertinent to *Goniolimon tataricum* and German statice in general.

Propagation

Seed: Seed is difficult to locate but not particularly difficult to germinate. Sow seed lightly and place under mist or sweat tent at 70–72F (21–22C). Germination occurs in 12–21 days.

Division: Seed or explants are preferable; however, plants may be cut apart carefully, retaining as much root system on plantlets as possible. Plantlets recover slowly, and little production occurs the first year from division. Spring division is best if plantlets are to be replanted immediately. Otherwise, divide in fall and grow in the greenhouse for 3–4 weeks; overwinter in cold frames or unheated greenhouses.

Cuttings: The best method of vegetative propagation is by root cuttings. Cut 1–3″ (2.5–8 cm) long pieces of the fleshy roots. The thickest roots may be placed upright in sandy soil; the thinner ones may be placed horizontally and covered lightly. Cuttings are most successful in early spring, but fall cuttings may also be used.

Growing-on

Grow seedlings and small divisions in the greenhouse, under full light and 55–60F (13–15C) night temperatures, for 6–8 weeks or until ready for transplanting. Large root divisions may be placed immediately in nursery beds, but smaller divisions require growing in the greenhouse or cold frame. Little or no flower production occurs the first year from seed. Flowers are cut when 75% of the inflorescences are open (Hodgkin 1992).

Environmental Factors

Cold treatment is necessary for best flower production. Hot summers have no detrimental effect on yield or quality, although flower color is more striking under cool nights. No photoperiodic response has been reported, although LD appear to accelerate flowering.

German statice produces few flowers the first season from seed, indicating that a vernalization period is probably necessary. Therefore, it appears that cool temperatures, followed by warm temperatures and LD should be recommended for flowering in perennial statice.

Field Performance

Longevity: German statice can stay in production for 3 years without any decline in yield. Work with *Limonium altaica* in the Georgia trials suggested 4–5 years of cutting was possible.

Spacing: Plants can be spaced as widely as 2 × 2′ (60 × 60 cm), but 1′ (30 cm) centers are adequate. Tight spacing can be a problem if foliar diseases or botrytis is present. The wider the spacing, the less the disease pressure.

Shading: Grow under full sun. Light shade may result in longer stems; however, stem diameter is not as strong.

Guideline for Foliar Analyses

At field trials in Athens, Ga., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis for *Limonium altaica*, a species similar to German statice.

(%)				
N	P	K	Ca	Mg
3.85	0.40	3.60	0.48	0.40
(ppm)				
Fe	Mn	B	Al	Zn
129	47	22	102	36

Stage of Harvest

Flowers are cut when 75–80% of the inflorescences are open (Hodgkin 1992). Harvesting too early results in poor opening and small flower heads, although earlier harvesting and placing stems in an opening solution can help reduce the offensive smell. Harvesting too late results in discoloration and poor vase life. Place stems in floral preservative or sugar immediately after harvesting.

Postharvest

Fresh: Flowers persist in preservative for up to 2 weeks.

Dried: Hang stems upside down in a cool, well-ventilated room. Dried flowers last 1–2 years.

Pests and Diseases

See *Limonium*.

Reading

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Gypsophila paniculata baby's breath Caryophyllaceae

perennial, Zones 3–7 northern Asia, Europe white

2–4′/3′ (0.6–1.2 m/0.9 m)

A mainstay of the cut flower industry, baby's breath is grown for its airy panicle of flowers. Production occurs in the field and year-round in greenhouses. Some cultivars have been selected for their double flowers, some for their gray-green foliage. In warmer areas of the country, such as Florida, gypsophila is grown as an annual; in Michigan, California, and overseas, it is produced as a perennial.

Propagation

Seed: Seed is used for the species and a few cultivars ('Snowflake', for one), but most cultivars are propagated vegetatively; with seed, the quality of resultant plants varies. If seed is used, 0.06–0.12 oz (1.8–3.5 g) yields 1000 plants (Nau 1999).

Grafting: Double-flowered cultivars were grafted on the rootstock of the more vigorous, single *Gypsophila paniculata*. The practice is very labor intensive and expensive and has all but disappeared.

Cuttings: Vegetative cuttings taken in the summer root in 10–14 days under mist and warm temperatures. Cuttings are more uniform and healthy, and flower production is equal to that of grafted plants.

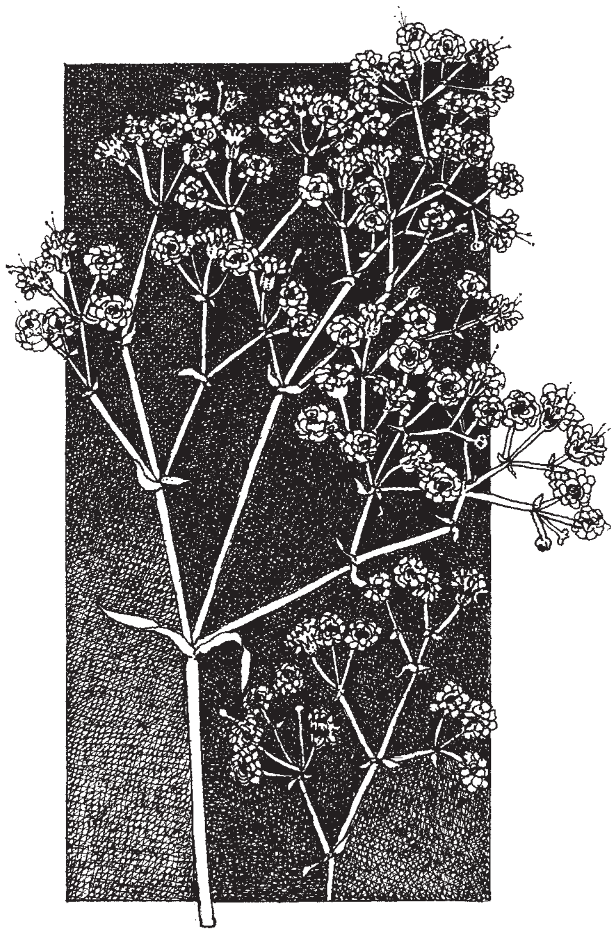
Tissue culture: Most commercial propagation is done by stem tip culture.

Growing-on

Plants should be grown under short days, high light, and cool temperatures of 50–55F (10–13C)—but only until plants are large enough to be planted to the field or greenhouse bench. At an early stage of development, cool temperatures result in better branching than warmer (65–70F, 18–21C) temperatures.

Environmental Factors

Photoperiod: *Gypsophila* species are long day plants; flowering is inhibited by short days. Under SD and low temperatures, plants form a rosette of leaves. For most cultivars, the critical photoperiod for flowering is 12–14 hours (Krogt 1982); however, longer daylengths are commonly used. Plants must have at least 12 nodes before LD are perceived (Kusey et al. 1981). Under normal growing conditions, this occurs 3–5 weeks after transplanting. The more LD cycles received, the more flowers produced. Approximately 56 cycles are needed by



Gypsophila paniculata 'Bristol Fairy'

'Bristol Fairy', fewer (about 28 cycles) by 'Bridal Veil', for maximum flower yield and stem elongation (Hicklenton et al. 1993a, 1993b). Also, the longer the photoperiod, the earlier the flowering (Shillo 1985). Stem length and quality are greatest at 16- to 18-hour photoperiods (Kusey et al. 1981, Karagüzel and Altan 1999). Work in Holland with many different sources of light showed that incandescent lamps were best for forcing flowers, particularly during winter months, and the higher the light intensity (up to 2 moles m-2s-1), the more rapid the rate of stem elongation (Graaf-van der Zande and de Blacquiere 1997).

Temperature: Cooling young plants prior to application of LD makes the plants receptive to subsequent photoperiod and temperature treatments.

Rooted cuttings cooled at 32–35F (0–2C) in the dark for 7 weeks become vernalized (Shillo 1985), as do plants cooled under SD conditions and temperatures of 52/41F (11/5C) day/night for 8 weeks (Davies et al. 1996). Temperatures can be as high as 50–54F (10–12C) for 7 weeks if sufficient light is provided (Shillo 1985). The cool treatment is not a requirement for flowering; however, it results in plants flowering regardless of daylength. Using precooled clumps allows flower production in cool greenhouses under natural winter daylengths and promotes winter flowering of field-grown plants in warm climates, such as Florida. Plants that have been cooled have more flowers under LD compared with those that have not been cooled. If plants are grown under warm temperatures and never see cool temperatures, they will not flower under SD; under LD, will flower rapidly but quality will not be optimum.

Once precooled and subsequently grown on the bench or in the field, plants will flower at 55F (13C), but flowering is significantly delayed compared with plants grown under warmer temperatures (Shillo and Halevy 1982, Moe 1988). GA application may be used to grow plants at 55F (13C), but in general, day temperatures should be maintained by setting venting temperature to 70–75F (21–24C).

Carbon dioxide: CO_2 is effective in promoting growth and development (Shillo 1985).

Light intensity: The number of flowers increases with an increase in light intensity. Lack of light is often a limiting factor in northern greenhouse during the winter.

Gibberellic acid: GA is used to help with bolting. It does not substitute for LD (Shillo 1985); however, if GA (500 ppm) is applied, plants respond to LD even below 55F (13C). Do not spray more than once a week.

Field Performance

Natural flowering is from late spring through late summer, with 2 or 3 flowering flushes obtained. In California, flowering starts in early spring and continues into the fall but significantly declines in the winter. Yield of 5–6 stems/plant is normal in winter production; 20–25 stems/plant occur under field conditions in the summer, depending on cultivar. An earlier crop may be forced in the field, with plastic frames to warm air and soil, and incandescent or HID lamps to provide 16-hour days. Stems of plants produced in the South are usually shorter than those grown in the North, where summer photoperiods are longer.

Spacing: Plant on 18–24″ (45–60 cm) centers with 1–2′ (30–60 cm) between rows. Approximately 0.4–0.6 plants/ft^2 (5–6 plants/m^2) is recommended.

Longevity: Plants may be kept in production in temperate zones for 2–3 years, although, if desired, precooled plants may be set out every year from March to June. In Florida, precooled clumps are planted from September to February for winter and early spring production. After flowering, plants are removed. Some cultivars exhibit a strong apical dominance and should be pinched close to the ground in the spring to encourage additional shoots.

Shading: Shading is not necessary.

Soil: Soil must be well drained for best production; plants do poorly if placed where the water table is high. Soil low in calcium and magnesium should be liberally fertilized with dolomitic lime; gypsophila absorbs large amounts of those elements (see “Guideline for Foliar Analyses”).

Timing: When high temperatures above 80F (27C) and LD of 14–16 hours occur, the time between planting and harvesting can be as short as 60 days, but quality is poor. Under cooler temperatures and LD, up to 120 days are required, but quality is significantly better. Under SD and low temperatures, flowering will not occur unless daylength, temperature, or light intensity is changed.

Greenhouse Performance

Gypsophila is produced year-round, but greenhouse culture is mainly for winter and spring production.

Cuttings: Cuttings may be planted in August and September and grown at 60–70F (15–21C) until plants have at least 12 nodes (3–5 weeks). Double-row spacing may be used, in which plants are spaced 18–20″ (45–51 cm) apart and rows are 3–3½′ (0.9–1.1 m) apart.

Long days of at least 16 hours should then be provided at least until flower stalks are visible. Continuous lighting (24 hours) is better than 16-hour lighting, but nightbreak lighting and cyclic lighting may also be used. Incandescent bulbs are best for photoperiodic lighting. Do not allow temperatures to drop below 55F (13C). If precooled crowns or cuttings are used, LD treatments are not necessary for flowering, but weaker stems may result.

Light: In northern climates, the use of sodium HID during early development enhances subsequent flower yield and quality (Hicklenton 1987). Approximately 6 weeks of high-pressure sodium lighting (600 fc) applied after pinching resulted in flowers approximately 10 weeks after pinching (Hicklenton 1986). The number of flowering stems and quality of stems and flowers are highly correlated to light intensity in northern climates. In the South, high-intensity lighting is not as useful as in the North.

Fertilization: Except for magnesium and calcium, nutritional requirements of gypsophila are not high. The use of 100–150 ppm N and K once or twice a week is sufficient.

Guideline for Foliar Analyses

At field trials in Athens, Ga., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis.

'Bristol Fairy'

(%)				
N	P	K	Ca	Mg
3.72	0.68	2.15	5.32	1.30
(ppm)				
Fe	Mn	B	Al	Zn
287	70	29	159	76

Stage of Harvest

For the local fresh flower market, stems can be cut when 80% of the flowers are open, but for shipping, fewer than 30% of the flowers are open when cut (Doi et al. 1999a). For drying, 80–90% of the flowers should be open. For immediate local sale of fresh flowers, 80–90% flowers open is also appropriate. Plants may also be harvested in tight bud (5–10% open) if placed in a bud-opening solution (see "Postharvest"). Most gypsophila is sold by weight (e.g., 11 oz per bunch, 300 g per bunch) or in 10 stems per bunch, minimum.

Postharvest

Fresh: To open tight buds so that plants can be shipped with about 40% open flowers, stems should be immediately placed in a solution containing 2–4 mM silver (STS), 4% sugar, and a bactericide (such as 8-HQS), and placed under approximately 90% relative humidity and bright light (Doorn et al. 1992). Temperatures should be 62–68F (17–20C). Using this or a similar regime results in open flowers, but with no flower browning, even if temperatures rise (Doi et al. 1999b). Gypsophila is sensitive to ethylene (Doorn et al. 1992) and bacterial contamination; use of silver thiosulfate (STS) and a germicide is recommended. Using a combination STS/preservative solution is a one-solution system for postharvest treatment. Treatments may be pulsed for 30 minutes or held overnight in the solution if necessary. Other work with various chemicals shows that an anti-ethylene agent is necessary if plants are to be shipped. 1-MCP inhibited the effects of ethylene on open flowers, but was of no benefit to subsequent flowers (Newman et al. 1998).

Dried: Two methods are commonly used. In the first method, flowers are air-dried upright in a container of water, with the water just covering the cut ends, at a room temperature of 50F (10C) (Vaughan 1988).

In the second method, flowers are dried in a solution of 1 part glycerine to 2 parts water (Moe 1988). The plants can be removed from the glycerine solution when beads of moisture form on the leaf surface (Vaughan 1988). Stems should then be dried upside down in a well-ventilated room.

Storage: Stems should not be stored dry more than 2–3 days unless absolutely necessary: the incidence of botrytis under storage conditions is high; however, if fungicides are applied and good air movement is present in the cooler, stems with 50% of flowers open persist up to 3 weeks if held at 33–35F (1–2C).

Cultivars

Fewer than half a dozen of the many available cultivars provide more than 90% of the gypsophila sold by florists.

'Arbel' and 'Tavor' are less sensitive to daylength and will flower with photoperiods as short as 11 hours. They flower rapidly but have strong apical dominance and must be pinched.

'Bristol Fairy' is the traditional double white-flowered baby's breath and grows about 2′ (60 cm) tall. Less widely grown, superseded by 'Perfecta'.

Festival series is seed-propagated. Both 'Festival Pink' and 'Festival White' are only 12–18″ (30–45 cm) tall and bear both single and double flowers.

'Flamingo', a popular double pink, is vigorous, attaining heights of 3–4′ (0.9–1.2 m). Yields are low compared to 'Perfecta'.

'Gilboa' and 'Golan' are part of the Magic series from Danziger. Rapid flowering, even under lower temperatures, and strong stems.

'Lucky Stars' has single white flowers.

'Million Stars' has enjoyed success among gypsophila growers. Plants attain the same size as 'Perfecta', but the smaller flowers tend to be more terminal, providing a fuller look and less tangling, a major concern when using gypsophila in bouquet work because it slows things down and side shoots are torn off. The buds tend to open more evenly, and the crop time is shorter than 'Perfecta'. Stem lengths of 24–30″ (60–75 cm).

'New Hope' is similar to 'Perfecta' with bright white, slightly smaller flowers. It too is less prone to tangle. Flower stems are 24–28″ (60–70 cm) and grow relatively straight.

'Perfecta' has long been the worldwide standard, having replaced 'Bristol Fairy'. Plants are about 4′ (1.2 m) tall and equally wide, with larger white double flowers and more vigor than 'Bristol Fairy'. It is in jeopardy of being superseded by 'Million Stars'.

'Pink Fairy', a pink version of 'Bristol Fairy', is about 18″ (45 cm) tall.

'Pink Star' has bright pink flowers on 18″ (45 cm), compact plants.

'Red Sea' bears double rose-pink flowers on 3–4′ (0.9–1.2 m) stems.

'Rosy Veil' is a paler form of 'Pink Star'.

'Single White' is as the name implies. About 3′ (90 cm) tall.

'Snowball' has bigger flowers than 'Perfecta' and a slightly faster growth rate.

'Snowflake' ('Schneeflocke') consists of pure white double flowers. Also sold as 'Double Snowflake'.

'Viette's Dwarf', from Viette's Nursery in Virginia, is only 12–18″ (30–45 cm) tall with pinkish double flowers. Terrific for short stems.

'Virgo' stands 3–4′ (0.9–1.2 m) tall and carries mostly double white flowers.

'Yukinko' is a fast-flowering cultivar, less sensitive to daylength than 'Perfecta'. Also less sensitive to hot weather, thus useful for summer production.

Additional Species

Gypsophila elegans may be used as a short-stemmed filler. The stems are only 9–15″ (23–38 cm) long, but the many pink or creamy white flowers fill the plant. May be propagated from seed or cuttings. Treat plants as an annual crop.

Gypsophila oldhamiana bears pink to deep pink, fragrant flowers in a large, 9–12″ (23–30 cm) long panicle. Plants are native to northeast Asia and Korea and are hardy to Zone 5.

Pests and Diseases

Crown gall (*Agrobacterium gypsophilae*) results in soft, nodular galls about 1″ (2.5 cm) in diameter. Much more prevalent on grafted plants than on plants propagated from cuttings or seed because it is often spread with grafting knives. Avoid propagation from infected plants, and dip plants and knives in a bacterial solution.

Blight from *Botrytis cinerea* causes ash-gray spots to develop on buds and stems.

Damping off (*Pythium debaryanum*, *Pellicularia filamentosa*) results in rotting at the soil line followed by stem rot and topple.

Red spider mites and thrips can be a problem, particularly in perennial crops.

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Many thanks to Whiting Preston, Bob Pollioni, and Peter Hicklenton (first edition) and Gay Smith (second edition) for reviewing this section.

Helianthus annuus annual sunflower Asteraceae

annual western U.S., Midwest red, gold, yellow, bicolor
4–7′/3′ (1.2–2.1 m/0.9 m)

So many sunflowers, so little time. The lowly sunflower of the 1980s was the star of the 1990s. From coffee cups to T-shirts, placemats to aprons, the sunflower shone everywhere. Sunflowers in hotel lobbies, in wedding bouquets, dried in potpourri—you couldn't escape them. While the excitement of the sunflower has waned a bit, plants are still grown for cuts by the acre, under protection and under the noonday sun. Of course, the economic importance of sunflowers is felt much further than the cut flower industry: they are among the most important crops in the world for their oil and forage properties. The annual sunflower is native from Minnesota to Washington and California, and cultivars suitable for cutting have emerged from the greenhouses of Japanese, European, and United States breeders. Plants are relatively easy to grow, and flowers are prolifically produced.

Propagation

All plants are produced from seed; there are approximately 920–1840 seeds/oz (32–65 seeds/g), depending on species and cultivar. If plants are to be direct sown, use 0.7 oz per 100′ (67 g per 100 m) (Kieft 1996). Approximately 1.5 oz (42 g) of seed yields 1000 plants when direct sown (Nau 1999).

Greenhouse: Although sunflower seed is usually direct sown, seed may be greenhouse sown at 70–75F (21–24C) in final containers (72-cell plugs or small

Helianthus annuus
'Sunrich Orange'

pots) 3–4 weeks prior to placing in the field. Do not sow too early, or plants become lanky and will not transplant well.

Field: Most seed is direct sown 9–12″ (23–30 cm) apart in the field after all threat of frost has passed; some growers direct seed as close as 6″ (15 cm) apart when using nonbranched forms. The danger of dense planting is the lack of air movement and the subsequent potential for disease. For best germination and growth, soil should be at least 50F (10C) before sowing and well drained.

Growing-on

If plants are to be grown outdoors, seedlings should be held in the greenhouse for no more than 3 weeks prior to planting in the field. Provide full light, high fertility levels (150–200 ppm N), and good air movement.

Environmental Factors

Photoperiod: Plants show a remarkable cultivar-dependent response to photoperiod (Shuster 1985), but most appear to be day-neutral or flower somewhat faster under short days. The critical photoperiod is between 11 and 13 hours. One reason for the increased popularity of sunflowers was the breeding of day-neutral cultivars.

Temperature: Warm temperatures result in faster flower development than cool temperatures. Temperatures below 50F (10C) slow development significantly; temperatures of 65–75F (18–24C) appear optimal for growth and development of cut flower cultivars. People sometimes attribute faster summer flowering to photoperiod (concluding that sunflowers must be LD), but the faster flowering is simply a function of warmer summer temperatures. For earlier flowering, wait 2–3 weeks as temperatures warm up rather start plants too early in spring. Similarly, if plants are started in late summer as temperature decreases, flowering will be delayed.

Gibberellic acid: The use of gibberellic acid shortens the vegetative stage and slightly accelerates flowering (Shuster 1985).

Field Performance

Spacing: Space seed or transplants as close as 9″ (23 cm) or as wide as 24″ (60 cm) apart. A 20 × 20″ (50 × 50 cm) spacing is reasonable for branching forms or larger cultivars; less can be used for nonbranching and smaller ones. The closer together, the less chance of branching; therefore, if cultivars are said to be well branched, space them out accordingly. A plant density of 30,000 to 40,000 plants per acre (75,000–100,000 plants/hectare) is reasonable.

Fertilization: Sunflowers are heavy feeders, and plants should be fed at least 3 times a season. Side dress with granular 10-10-10 or liquid feed of 20-5-30 at 200 ppm N with a complete soluble fertilizer.

Support: Some cultivars can grow 8′ (2.4 m) tall and may fall over from the weight of the heavy foliage and flowers. Stems of newer cultivars are sufficiently strong to carry the flowers under calm conditions but support may be necessary in windy areas.

Planting: Sequential planting, as often as every week (Deep South) to every 3 weeks, is useful to take advantage of long terminal flower stems. Laterals are shorter, and flowers are smaller after the terminal has been cut.

Pinching and harvesting: Cultivars that are naturally basal branching do not need to be pinched; they do fine on their own, at a 20 × 20″ (50 × 50 cm) spacing. For standard cultivars, the primary flower is the largest and of higher quality, with a longer stem than the axillary shoots. Pinching promotes uniformly developing side shoots with consistent flowers, albeit smaller than the terminal would have been; each flower in the resulting spray formation can be used where smaller flowers and stems are useful. If longer stems are desired, pinch early, when plants have 4–6 leaf pairs. Multiflora cultivars are especially suited to being pinched. The resulting side shoots will be long-stemmed with intermediate-sized flower heads, but shorter than single-stemmed flowers (Dole and Wilkins 1999).

Greenhouse Performance

Sunflowers may be produced during the winter in the greenhouse if market price and demand so warrant. Supplemental light (use HID lamps) may be necessary in northern greenhouses.

For single-stem production, sow seed directly in the bench at 6 × 9″ (15 × 23 cm) spacing or in a 6–8″ (15–20 cm) container. For branching varieties, spacing at 20 × 20″ (50 × 50 cm) is recommended in the greenhouse. According to Dole and Wilkins (1999), greenhouse-grown cuts can be planted in 1801 bedding plant flats for quick crops. The size of the flower head and the thickness of the stem will vary with the number of plants per flat; 10–18 plants per flat provide 2–3′ (60–90 cm) stems with 3–4″ (8–10 cm) wide flower heads. The small volume of soil limits the size of the plants and decreases crop time compared with field production but requires that plants be irrigated frequently. Stems are generally harvestable 8–9 weeks from sowing seed.

For tallest plants, grow under long days for 4–6 weeks, then change to short days (12 hours or less), but photoperiod manipulation is not necessary for flowering, especially if plants are grown at a dense spacing. Plants may be grown under natural photoperiod throughout. Fertilize with a constant liquid feed of 100–150 ppm N or once a week with 300 ppm N. In all cases, fertilize lightly (100 ppm N) when seedlings have emerged. Maintain 50–55F (10–13C) night temperatures and 65–70F (18–21C) day temperatures. Liquid rates of 150 ppm nitrogen, 15 ppm phosphorus, 200 ppm potassium, 4 ppm calcium, and 50 ppm magnesium have shown excellent results in greenhouse production (Heaton and Denny 1999). An excellent article on nutrient deficiencies was written by Brian Whipker and his colleagues (2000).

Plants must be supported with stakes or strong netting. With newer cultivars, a crop time of 13 weeks in winter, 11 weeks in summer is common; however, some growers report crop times as little as 6 weeks from sowing.

Stage of Harvest

Some growers have been successful in harvesting tight, when yellow petals (ray flowers) were barely visible; others wait until 1 or 2 petals lift off the disk; and some will wait until the flowers are almost completely open. Put in preservative immediately. The most important considerations are that the center should still be "tight" and dark and that no petals should have started to curl back.

Flower deformities: The subject of deformed flowers comes up whenever sunflowers are discussed. Blooms are distorted, half-opened, or stunted—some look like trolls, others are missing significant flower parts. Some years are worse than others, and some areas of the country are more affected than others, yet it seems like deformities have always been present.

Some deformities can be attributed to insects, particularly aphids, sunflower midges, lygus bugs (see "Grower Comments"), and thrips; proper insect control goes a long way to reducing the problem in this case. Extremes of temperatures (too cool, too hot) during flower initiation can be blamed when some of the flowers are deformed but subsequent ones are not; cold is a more common problem than heat. Anything that interferes with good root growth—clay soil, poor nutrition practices, root rots—may influence flower structure. Finally, some cultivars are genetically unsuited to your area; if you find one is worse than the others, don't grow it.

Postharvest

Fresh: Flowers remain fresh in a flower preservative, such as Floralife™, for 7–9 days (Gast 1998). The foliage declines more rapidly than the flower and should be stripped immediately. Pollenless cultivars exhibit longer vase life and offer consumers flowers that don't drop pollen or irritate allergies. Recutting and immediately plunging the stems in warm water reduces the tendency of some cultivars to droop. Drooping of the heads indicates either blocked stems or other reasons for poor water transit to the flower. Stems can be pretreated for 15–30 minutes in a solution of clean water plus 0.02% detergent (Tween-20™, Triton X-100™, or even some dishwashing solution) (Nell and Reid 2000).

Storage: Flowers may be stored at 36–41F (3–5C) for up to one week. Flowers picked too tight and stored cool may not open properly.

Dried: Flowers air dry well. Some growers have had great success with silica gel (see "Grower Comments").

Dyeing: Some growers have experimented with dyeing sunflowers using commercial dyes, sometimes mixed together, yielding flowers in varying shades of brown, orange, and red. These novelty items were hot sellers at local farmers' markets. No accounting for taste—if there is a market for painted sunflowers, who are we to argue?

Cultivars

Describing sunflower cultivars is like describing rocks: they are infinitely different to a geologist but sort of look the same to the rest of the world. Many have been trialed in Texas (Arnosky 2000), Connecticut (Shashok and McAvoy 1997), Kansas (Gast 1995), and nationally (Dole 1995–2001). Some are grown for the natural branching, others are best as single stems. Many of the newer cultivars are pollenless, and most of these are F_1 hybrids, providing far better uniformity and vigor than the older cultivars. There are far too many sunflowers claiming to be the best this or the most colorful that. Here are a few descriptions—you be the judge.

'Abendsonne' is 7–8′ (2.1–2.4 m) tall with yellow flowers around a bronze center.

'Apricot Twist' has a yellow center surrounded by apricot petals. Pollenless flowers. Grows to 5′ (1.5 m).

'Autumn Beauty' can grow to 6′ (1.8 m), with flowers of bronze, yellow, and mahogany. Flowers are 6″ (15 cm) wide. Two harvests can be taken.

'Bellezza d'Autunno' produces 4″ (10 cm) flower heads with light cream to deep mahogany petals. Plants grow to 6′ (1.8 m) in height.

'Claret' is multibranched about ⅔ up the 5–6′ (1.5–1.8 m) tall plant. Flowers are 4–5″ (10–13 cm) wide, overlapping red petals surrounding a dark center. The dark green leaves are attached to the stems with red petioles. Winner of the Royal Horticultural Society's Award of Garden Merit.

'Color Fashion' has yellow and bronze petals with yellow and orange tips, plants grow to 5½′ (1.7 m) tall.

'Cutting Gold' produces large heads on 3½′ (1.1 m) nonbranching stems. Flowers have golden-yellow petals with a dark center, similar to 'Sunbright'.

'Del Sol' carries medium-sized heads on 3′ (90 cm) single-stemmed plants.

'Double Shine' was very popular in the 1999 ASCFG Seed Trials for its sturdy 20–28″ (50–70 cm) tall stems, large flower heads, and long vase life.

'Double Sun Gold' averaged 6′ (1.8 m) in Connecticut trials.

'Elite Sun' is similar to 'Sunbright', with uniform flowering.

'Evening Sun' is tall enough to play in the NBA, at 7′ (2.1 m). The 6″ (15 cm) flowers are a mix of red and bronze shades with dark centers.

'Eversun Deep Yellow' is traditional-looking and disease resistant, according to 1997 trials. Large flower heads on 40″ (1 m) stems were common. 'Eversun 2001' has more uniformity and improved stem quality.

Fantasia Mix is an F_1 mixture in single, semi-double, and double flowers.

'Florenza' is a red and yellow bicolor form, producing flowers up to 5″ (12 cm) in diameter.

'Floristan' is a distinctive bicolor (dark red with yellow tips). They were well received by participants in the 1994 ASCFG Seed Trials. Branching plants are about 3′ (90 cm) tall.

'Full Sun' is 3–4′ (0.9–1.2 m) tall and bears gold-yellow flowers. It is day-neutral and does not produce pollen.

'Giant Sungold', a branching variety, has 8″ (20 cm) wide double flowers with golden-yellow petals.

'Goldburst' is an excellent cultivar with 3–4″ (8–10 cm) wide, golden, double flowers on 4–6′ (1.2–1.8 m) stems. In national trials in 1992, it scored higher than any other tested.

'Golden Glory' is similar to 'Sunbright', but taller and with lighter-colored centers. Flower heads have been reported as large as 18″ (45 cm) across.

'Golden Pheasant' has double flowers with golden-orange florets. Plants grow 3½′ (1.1 m) tall.

'Hallo' is a productive 5′ (1.5 m) plant with dense side branches up to 3′ (90 cm) long. Flowers are single with a dark brown disk.

'Happy Face' bears golden-yellow ray florets with a greenish yellow disc; flowers are about 4″ (10 cm) in diameter.

'Henry Wilde', Oscar's little brother, grows 6–8′ (1.8–2.4 m) tall, branching with 6″ (15 cm) golden-petaled flowers with dark centers.

'Holiday' has 4′ (1.2 m) plants with golden-yellow flowers 6–8″ (15–20 cm) wide. A traditional sunflower color and form.

'Ikarus' was the darling of 2000, carrying light lemon-yellow flowers on 24–26″ (60–66 cm) stems. Under favorable conditions, plants can grow nearly 4′ (1.2 m) tall. Almost pollenless flowers have a dark velvet eye. It is basal branching, forming long side shoots. To encourage optimal branching, plant 20 × 20″ (50 × 50 cm).

'Inca Jewels' is said to be heat and drought tolerant, with multicolored gold to burgundy to orange petals. Plants grow 5–7′ (1.5–2.1 m) tall.

'Indian Blanket' bears double and semi-double flowers in mixes of red, lemon, cream, and bicolors. The branching plants are about 5½′ (1.7 m) tall.

'Jade' has interesting lime-green flowers. Pollenless and single, the flowers are borne on branching 4′ (1.2 m) plants.

'Joker' is a pollenless bicolor, full double to semi-double, with petals curling around the disk. Plants can grow to 6′ (1.8 m).

'Moonbright' is floriferous with uniform flowering of pale yellow blooms with a dark disk. Averaged almost 3½′ (1.1 m) in ASCFG trials.

'Moonwalker' has creamy, pale yellow petals and produces many flowers per plant.

'Moulin Rouge' bears pollenless flowers with velvet burgundy petals. Many growers consider this similar to 'Prado Red'. Postharvest life has been disappointing, but the flowers are beautiful.

'Music Box' has been called a good cut flower, although stems are only 24–30″ (60–75 cm) long. Flowers are creamy yellow and gold to mahogany red with dark brown centers.

'Pacino' is a pot plant variety, producing bright yellow flowers on branched 12–16″ (30–40 cm) stems.

'Prado Red' and 'Prado Gold' are branched forms, which produce smaller flowers useful for bouquets. 'Prado Gold' is quite handsome, with overlapping petals. 'Prado Red' is pollenless and also offers dark bronzy red on stems and leaves.

'Premiere Cream Yellow' is an early-flowering cultivar with small leaves and creamy yellow pollenless flowers. The centers are black. Plants are about 3′ (90 cm) tall.

Provence Mixture is a branching variety, about 6′ (1.8 m) tall.

'Purple Sun' is an F_1 variety with 5″ (13 cm) flowers and black to purple pollenless center, growing to 6′ (1.8 m).

'Red Treasures' is not as tall as some varieties but has been called valuable for its branching. It bears 3″ (8 cm) yellow and orange flowers.

'Ring of Fire' grows 2–4′ (0.6–1.2 m) with contrasting bronze and yellow petals. Approximate flowering time is 10 weeks from sowing.

'Ruby Eclipse' ('Strawberry Blonde') has pollenless flowers in shades of ruby-red to pale pink with pale lemon tips and a dark center.

'Shine' is a semi-double variety, branching, with yellow-orange flowers.

'Silverleaf' is disease resistant and tolerant of extreme temperatures. Flowers have long yellow ray florets and chocolate disks. Plants grow 4–6′ (1.2–1.8 m) tall.

'Sonja' ('Sonia') bears nice small golden-orange flowers with brown centers. Plants grow about 3′ (90 cm) tall. A branching form. Approximate flowering time is 8–9 weeks from sowing.

'Soraya' (formerly 'Large Flowered Orange') has upward-facing, almost pollenless flowers and a branching habit. An All-America Selection, it bears orange flowers with a dark center and can yield up to 15 stems/plant. Approximate flowering time is 13 weeks from sowing.

'Starburst Aura' is a starburst-type, semi-double yellow flower with a small green center. Plants can grow to 6′ (1.8 m).

'Sunbeam' has a light green pollenless center and golden-yellow petals. Grows to 5′ (1.5 m) and flowers early. Inconsistent petaling has been reported. Few laterals were produced.

'Sunbright' is a uniform F_1 hybrid with 4–5″ (10–13 cm) wide pollenless flowers. Among the earliest pollenless cultivars developed and still one of the best—so good, in fact that it was the ASCFG's 2001 Fresh Cut Flower of the Year. In vase life trials, it remained fresh for 11 days, significantly longer than other cultivars in the same test (Gast 1997).

'Sunbright Supreme' has 30″ (75 cm) flowering stems. Pollenless flowers have bright yellow petals and a dark brown center. Some cold tolerance.

'Sundance Kid', a pot plant variety, may not be tall enough for cut production but is useful for small settings.

'Sundown' is about 5′ (1.5 m) tall with strong yellow and red bicolor flower heads.

'Sunny', an early-flowerer, carries single golden-yellow flowers with a dark center on 5–6′ (1.5–1.8 m) stems.

'Sunray' is very early flowering, almost 2 weeks earlier than the standard 'Sunbright'.

'Sunrich Lemon' is a pollenless, day-neutral F_1 hybrid. Flowers are more yellow than lemon, but they contrast well with the black center. Plants flower earlier than 'Sunbright'.

'Sunrich Orange' has 4″ (10 cm) wide pollenless flowers, deep golden petals surrounding a black center. Day-neutral. Plants grow 3–4′ (0.9–1.2 m) tall.

'Sunrise' bears lemon-yellow flowers on 5′ (1.5 m) plants.

'Superior Gold' is similar to 'Superior Sunset' but is a brighter yellow and flowers a little earlier. Not quite as tough in the vase as 'Superior Sunset'. The gaps between the petals are considered undesirable by some.

‘Superior Sunset’ produces large 8–10″ (20–25 cm) flowers with yellow-orange petals. Some people really like this cultivar.

‘Tangina’ has golden-orange ray florets around a dark center; flowers are about 2″ (5 cm) wide.

‘Tiffany’ produces bright orange pollenless flowers on 3–4′ (0.9–1.2 m) unbranched stems. The flowers consist of short petals around a relatively large disk.

Tiger’s Eye Mix flowered early in Connecticut. Good lateral branching provided additional harvests.

‘Valentine’ has little pollen in its lemon-yellow flowers on 30″ (75 cm) stems.

‘Velvet Queen’ grows to 5′ (1.5 m), with velvety-crimson flowers. Well branched.

‘Watermelon Shades’ is a branching variety in a mix of bright petal colors.

‘Zebulon’ produces 30″ (75 cm) tall, single stems with bright yellow flowers.

National field trials

Sunflowers have been evaluated since the inception of the ASCFG’s national trials in 1994. The following table (Dole 1995–2001) is a summary of the average stem lengths and yields of sunflowers submitted for trialing. These data are averages over a wide geographical range and must be viewed as guidelines only; individual experience may differ significantly.

Cultivar	Year of trial	Stem length	Stems/ plant (in)^z
Cutting Gold	1995	42	3
Del Sol	1997	35	3
Double Shine	1999	28	5
Eversun Deep Yellow	1997	41	2
Floristan	1994	24	6
Golden Glory	2000	38	2
Holiday	1994	29	5
Ikarus	1999	25	5
Moonbright	1995	44	3
Prado Gold	1998	32	4
Prado Gold Imp.	1999	24	5
Prado Red	1998	32	4
Ring of Fire	1999	22	6
Sonja	1994	19	7
Soraya	1998	38	4
Sunbeam	1994	66	2
Sunbright	1994	44	3
Sunbright Supreme	1999	30	2
Sunrich Lemon	1994	37	1
Valentine	1994	32	5

z = multiply (in) by 2.54 to obtain (cm)

Additional Species

Helianthus decapetalus (thinleaf sunflower) has smaller flowers than *H. annuus* and may bear multiple flowers per stem. 'Italian White' has creamy white flowers with a contrasting black center but has not been a particularly good cut flower. Variety *multiflorus* is excellent for cut flower production, bearing numerous, single light yellow flowers on 4–6′ (1.2–1.8 m) tall plants; it is a perennial in most areas of the country. 'Soleil d'Or' is a good cut flower, with semi-double primrose-yellow flowers.

Helianthus debilis 'Vanilla Ice' has creamy lemon-yellow 4″ (10 cm) flowers with black centers on branching 4′ (1.2 m) plants.

Helianthus maximiliani, native to Texas, Missouri, and north to southern Canada, bears yellow flowers in late September and October. The very tall plants (up to 9′, 3 m) can be used to lengthen the season. They are perennial (Zone 4) and can be invasive.

Helianthus salicifolius (willow-leaf sunflower) and *H. angustifolius* (swamp sunflower) are both perennial forms of sunflowers (Zones 6–9). The plants are 4–7′ (1.2–2.1 m) tall and produce many small yellow single daisy-like flowers on short branched stems. The stem length on the individual flowers is too short to be considered a mainstream cut flower, and the blooms are much smaller than those of *H. annuus*; however, some people may find a market for them. 'First Light' and 'Lemon Queen' (*H. salicifolius*) both produce light yellow flowers, on 3′ (0.9 m) and 4′ (1.2 m) tall plants, respectively.

Pests and Diseases

Aphids are the most common pest of sunflowers. Control with aphicides if necessary.

Caterpillar species prefer sunflowers and can quickly damage and defoliate plants. The larvae of other moths tunnel through flower heads. The female headclipper weevil is well named: it girdles the stem just below the flower head and lays eggs on the head (Stevens et al. 1993). The heads often fall off, leaving growers wondering who cut the flowers off their plants. The weevils are rare, and although damage can occasionally be significant, it is usually limited.

Cutworms are the larvae of moths. The eggs are laid on grass or weeds, and the worms burrow into the ground. They feed at night on the surface, cutting off the plants near the ground or damaging them so they wilt and die. They can also crawl up the plant and munch on leaves and even the flowers. Cutworms are extremely destructive, killing far more plants than they can possibly consume. To prevent infestation, clean up weeds and keep grass mowed. Sprays containing carbaryl (e.g., Sevin™) have also been effective.

Grasshoppers can be a terrible scourge, particularly in dry seasons. They eat foliage and flowers and seem to appear just before harvest. Control early with bait.

Leaf spots, caused by *Alternaria* and other fungal genera, result in brown to black spotting of the foliage. Alternating fungicides provides some control.

Downy mildew can be a serious pathogen, particularly under moist, cool conditions.

Lygus bug is partly responsible for deformities in the flower head, gaps in the petal rings, and contortions where you don't want them. The nymphs are light green and somewhat resemble aphids. There may be 2 or 3 generations a season. Reduce weeds and apply a general insecticide while plants are young.

Midges can lay eggs and burrow into the flower head. They are destructive while feeding, then emerge and return to the soil, where they overwinter. They are quite small, the adult is only about 1/8″ (3.2 mm) long.

Powdery mildew (*Erysiphe cichoracearum*) causes white, powdery growth, particularly on the undersides of leaves. This can be quite severe, depending on cultivar and seasonal weather. Use of appropriate fungicides or sulfur is recommended.

Stem rot (*Sclerotinia sclerotiorum*) normally affects plants when they are several feet tall. The thick, white, feltlike growth occurs on the stems, and the tissue beneath becomes discolored. The disease is worse in hot, wet summers. Destroy infected plants, pasteurize the soil, and rotate crops every other year. Avoid close spacings and moist conditions.

Rust, in the form of red-brown pustules, affects the undersides of leaves and causes the foliage to dry up and fall. Several organisms cause rust, but the main fungus is *Puccinia helianthi*. Destroy infected tissue.

Wilt symptoms are caused by various organisms (*Plasmopara*, *Verticillium*) and cause young plants to wilt and die. Older plants may survive, but the leaves may be mottled with mosaic patterns of light yellow. Pasteurize soil and rotate crops. Do not put sunflowers in the same area more than 2 years in a row.

Grower Comments

"We grow about 2500 stems a week, and we plant every week for 28 weeks, starting with transplants sown March 15. We plant them 4 rows in a 4′ bed, 1′ between the rows, 1′ between the plants in the row. If you want smaller flowers, just decrease the spacing. . . . I think if we gave our 'Sundown' sunflower plants a lot of room, they would be more branching, but we spaced them close (1 × 1′) and they went straight up. They did have a cluster of buds at the top, and these buds continue to bloom out after the main flower goes. For us, the necks were significantly stronger than other reds. We don't even grow any other reds now because of that weakness." Frank Arnosky, Texas Specialty Cut Flowers, Blanco, Tex.

"With all the erratic weather this year, sunflowers have been the trouper. We are growing just about every one you can think of. Actually, we have almost decided to change our name to Broken Gate Sunflower Farm." Lynette Lowrance, Broken Gate Farms, Bay City, Tex.

"Lygus bugs and sunflower midges [cause] deformities. Short of perfectly timed spraying, I am not sure there's anything you can do. Since the field that suffered most is bordered by alfalfa, which often draws lygus bugs, I believe that the sunflower midge is not the culprit, in my area." Ralph Thurston, Bindweed Farm, Blackfoot, Idaho.

"The 'Sunbright Supreme' began blooming on June 27 and peaked today. We cut the deformed and unsellable central blooms off at least 60% of the plants today." Cheryl Shuett, 4 Friends Flower Farm, Pickens, S.C.

"'Sunbright Supreme' bailed me out so far this season! It bloomed about 10 days earlier and had no problems [with deformities] of any sort." Susan O'Connell, Fertile Crescent Farm, Hardwick, Vt.

"We've noticed a big difference in droop propensity dependent upon cultivar. We no longer grow the branching-type sunflower cultivars because of this characteristic. We currently grow almost exclusively 'Sunrich Orange', largely because of the very strong stems. Even these on occasion will get the 'droop,' but not often, and only a very few at a time. . . . We started dyeing ['Sunbright' and 'Sunrich Orange'] as part of our fall collection. Our farmers' market customers went wild over them. We tried several colors, as you never know how it is going to turn out. The dyes are taken up better and faster when the solution is very warm. You can reuse the same dye for about a week, or until it is all gone." Tammy Ford, Perennial Favorites, Leopold, Ind.

"I dry lots of sunflowers in silica—all small types, as the center would never dry on the very large ones. I bury them face down for about a week. They are best used where they have support for the petals in arrangements, as they reabsorb humidity and droop if unsupported. Spraying with clear acrylic helps keep them nice." Karen Yasui, Petalland, Tullahoma, Tenn.

"I dry my 'Sunrich' by hanging them upside down on the drying rack." Julie Marlette, Blue Heron Gardens, Fall Creek, Wis.

"Concerning dyeing of sunflowers, we take a $1 sunflower and send it through our dehydration-rehydration process (which are words we use with customers who ask how we do it), and the words alone up the price of the sunflower to $1.50 a stem, $12.50 a bunch. We do this only for farmers' market; our florists consistently do not liked dyed flowers." Mimo Davis, WildThang Farms, Ashland, Mo.

"If you are really obsessed with finding the ultimate red sunnie, absorption dye is also an interesting alternative, as long as it doesn't offend your sense of aesthetics. Shameless marketer that I am, we had great fun with red 'Giant Sungold'—they were spectacular and walked out faster than we could produce them, at the market and wholesale level." Ruth Merrett, Merrett Farms, Upper Kingsclear, N.B.

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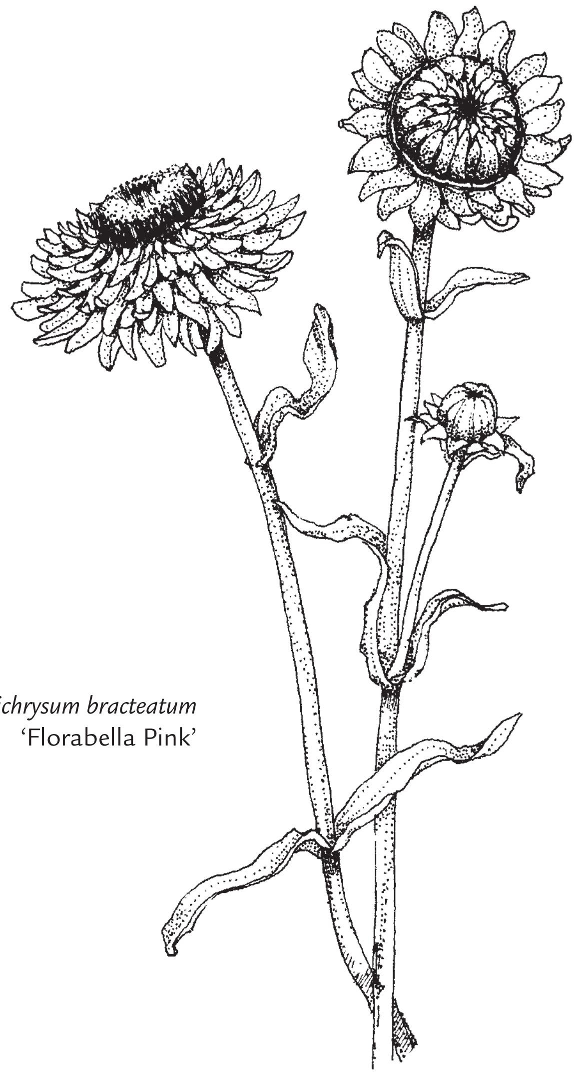
Helichrysum bracteatum strawflower Asteraceae

annual Australia many colors 15–30″/2′ (38–75 cm/60 cm)

The genus consists of about 300 species of annuals, perennials, subshrubs, and shrubs, most native to Australia and South Africa. The flowers are surrounded by dry, papery ornamental bracts and are easily dried. Taxonomic rumblings have been rolling over *Helichrysum*, and some authorities have placed the Australian members in a separate genus, *Bracteantha*. This includes the popular strawflower, *Helichrysum bracteatum* (now known as *B. bracteata*, or even *Xerochrysum bracteatum*), while *H. rosmarinifolium* (rosemary strawflower) has been transferred to *Ozothamnus*. Common names for flowers of the genus include strawflower, everlasting, and immortelle. So for now, let's leave these plants under *Helichrysum*, with the understanding that if *Bracteantha*, or *Ozothamnus*, or *Xerochrysum* is listed on someone's availability list, it is the same thing.

Propagation

Seed may be started at 70–75F (21–24C) in a sweat tent and lightly covered. Germination occurs in 7–10 days, and seedlings may be transplanted in 3–4 weeks. Approximately 0.03 oz (0.9 g) of seed yields 1000 plants (Nau 1999). If direct sown in the field, use 0.2 oz per 100′ (20 g per 100 m) (Kieft 1996).



Helichrysum bracteatum
'Florabella Pink'

Growing-on

Provide seedlings with 60F (15C) night temperatures, 65–70F (18–21C) day temperatures. If sown in open flats, transplant to cells or small pots 3–4 weeks from sowing. If germinated in plugs, maintain the plug for 5–6 weeks before transplanting to the field. Fertilize with 75–100 ppm N with a complete fertilizer. Overfertilization results in tall, lanky seedlings. Maintain low moisture levels; plants are susceptible to overwatering and should be allowed to dry out. Transplant to the field or final greenhouse spacing when plants are still vegetative or in small flower bud; do not transplant with flowers.

Environmental Factors

Photoperiod: Long days result in faster flowering, but flowering occurs regardless of photoperiod. Flowering is mainly a result of light intensity and temperature. Growth is more rapid, and therefore flowering occurs faster, under full sun and warm temperatures.

Temperature: Temperatures below 55F (13C) result in slow growth and additional problems with root rot fungi. Temperatures of 70–75F (21–24C) are optimum for growth and flowering.

Field Performance

Spacing: Space on 10–12″ (25–30 cm) centers.

Support: Plants, particularly tetraploids, require at least one tier of support.

Planting: Sequentially direct sow or transplant every 2–4 weeks. The main flower head may be removed to harvest the resulting laterals. With sequential planting, only the first 2–4 lateral flowers are harvested; subsequent flower stems are disregarded. If only a single planting occurs, lateral stems eventually become too short for high-quality stems.

Location: Plants are not tolerant of poorly drained soils or areas of heavy rainfall. Warm temperatures in combination with wet weather result in root rots and foliar spotting. Plants do better for a longer period of time in areas of dry summers (California, Arizona) than in areas of high moisture (Southeast); sequential plantings are a must in such challenging locales.

Greenhouse Performance

Place on 6–9″ (15–23 cm) centers; maintain 65–75F (18–24C) temperatures and high light intensity.

Stage of Harvest

Cut when flowers are unfolding and centers are visible. Always harvest before flowers are fully open (Bullivant 1989). If picked open, petals turn backward as they dry, resulting in a particularly ugly blossom.

Postharvest

Fresh: Fresh flowers persist 7–10 days.

Storage: Storage of fresh flowers is not recommended; store at 36–41F (3–5C) if necessary.

Dried: When dried, flowers persist indefinitely. Strip leaves and hang in tight bunches upside down in a warm, well-ventilated area. Flower heads themselves may be wired singly and dried straight up. Leave ½–1″ (1.3–2.5 cm) of stem and stand them in a shallow container to dry.

Cultivars

Ball Florists series is a tetraploid series growing 2–3′ (60–90 cm) tall with little basal branching. Bronze, gold, purple, red, white, and a mix are available.

Bikini series grows only 18–24″ (45–60 cm), shorter than most cultivars, and is available in gold, red, and a mix.

Double Giant Florist series has 3″ (8 cm) double flowers in a wide variety of colors.

Double Pastel Mix grows to about 3′ (90 cm) with pale pink, clear yellow, bright salmon, and apricot flowers.

Dwarf Mixture is also on the short end—about 18″ (45 cm)—but is recommended for dried bouquets.

Finest Mixed is about 3′ (90 cm) tall with colors ranging from salmon-rose to golden-yellow to purple and white.

'Flaming Ball' has dark reddish flowers.

Florabella series was developed for the landscape, but if 12–18″ (30–45 cm) stems are not a problem, it provides excellent colors on strong, compact plants. Other landscape forms produce excellent flowers but are probably too short.

Giant Flowered series has rounded flowers, about 2½″ (6 cm) wide. Plants grow 24–30″ (60–75 cm).

King Size series bears double flowers on 2½–3′ (75–90 cm) stems. Available in sulphur-yellow, orange, red, rose, and white. King Mix is a reselection with larger flowers.

var. *monstrosum*, the most common variety in the trade, has double flowers and has been selected in numerous colors and heights. Often sold as Monster series. In national field trials, plants averaged 7 stems/plant, but they were only 7–12″ (18–30 cm) long (Dole 1997).

'Moreska' produces early 2–2½′ (60–75 cm) stems with flowers in gold, deep rose, pink, white, yellow, and tangerine.

'Paper Daisy' produces many 1″ (2.5 cm) wide, yellow flowers on 15–18″ (38–45 cm) stems.

'Perfect Jewels' has large 3″ (8 cm) wide flowers on vigorous stems.

Salsa Mix contains hot, spicy colors.

Standard series grows approximately 3′ (90 cm) tall and has double flowers in single colors or as a mix. Pink, red, purple, yellow, orange, salmon, and white flowers are available. Seed is less expensive than some other series but has not been as aggressively selected.

Swiss Giants Mixed bears large double flowers on 36″ (90 cm) stems.

Victorian Pastels Mix is a mix of pale, soft colors.

Additional Species

A few "minor" species of *Helichrysum* are available through specialty sources. In general, they are native to Australia, New Zealand, or South Africa and are best suited to the Pacific Northwest, northern California, or the Northeast. High temperatures and high humidity are not to their liking.

Helichrysum cassianum has single to semi-double pink flowers and grows approximately 1½–2′ (40–60 cm) tall. 'Rose Beauty' has rose-pink flowers. Germination is erratic and slow, and seed order should be double that of *H. bracteatum*.

Helichrysum subulifolium, although relatively difficult to find, grows 1½–2′ tall (30–45 cm) and bears many clear yellow flowers. 'Golden Sun' bears 1″ (2.5 cm) wide bright yellow flowers on 24″ (60 cm) stems. Unlike *H. bracteatum*, they should be harvested when flowers are fully open.

Helichrysum thianshanicum 'Golden Baby' has silvery gray foliage and yellow to orange double flowers on 12″ (30 cm) stems. Better grown for the foliage than the forgettable flower. Plants require excellent drainage and relatively high fertility levels. Perennial in warmer areas of the country.

Related Genera

Ozothamnus is closely related to *Helichrysum*. The main species used for cut flowers is *Ozothamnus diosmifolius* (syn. *Helichrysum diosmifolium*; rice flower), a large shrubby plant native to Australia and harvested from natural stands there (Turnbull and Beal 1998). Cultivated production is becoming more common. Plants require mild winters and warm summers; cut flower production in this country has been limited to coastal California.

Pests and Diseases

Aster leafhoppers suck the juice from the plant and transmit aster yellows disease.

Root and stem rot fungi result in loss of plants in areas of poor drainage and high rainfall. Sclerotinia rot (*Sclerotinia sclerotiorum*) has been reported (Takeuchi and Horie 1999). Wilt (*Verticillium albo-atrum*) may cause severe damage, particularly in California.

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Many thanks to Maureen Charde for reviewing this section.

Helleborus orientalis Lenten rose Ranunculaceae

perennial, Zones 4–9 Asia Minor white, purple
12–18″/12″ (30–45 cm/30 cm)

Lenten rose has not been used a great deal for cut flowers, mainly because of limited availability and the cost of new plants. Once established, however, all hellebores are persistent and produce for many years.

Propagation

Propagation from purchased seed is difficult and exacting. Sow seeds in well-drained medium and place at 75–80F (24–27C) for 7 weeks. Move tray to approximately 32F (0C) for 8 weeks and then raise temperature slowly to 40F (4C). Germination should commence at that temperature, after which soil temperature may be elevated to 50–55F (10–13C) until germination is complete.

Mother Nature, however, has no such difficulties and is much more efficient than most growers. Seedlings may be found under the plant litter at the base of 2- to 3-year-old plants. Gentle removal and subsequent transplanting provides abundant plants. In the field, we have seen growers simply remove mature flower heads, lay them in rows over well-prepared soil, and cover them lightly with compost. The next spring, thousands of seedlings appear.

If necessary, roots of mature plants may also be divided in the spring, but large clumps will result only if plants remain undisturbed.

Growing-on

If propagated from seedlings in the field, gently remove the seedlings and place where desired. Seedlings can be transplanted to small containers, grown during the summer in a shaded area outdoors, and transplanted in the fall.

Environmental Factors

Temperature: Cold temperatures are beneficial for growth and flowering. Flowers initiate in the fall, and cold temperature appears necessary to break dormancy.

Field Performance

Yield: Flowers may be harvested no earlier than the second year, but once plants are established, flowers may be harvested every year. Approximately 2–6 stems per plant, each bearing 3–6 flowers, can be harvested without damage to the plant. Stems are 12–15″ (30–38 cm) long.

Spacing: We recommend 12–18″ (30–45 cm) spacing.

Helleborus orientalis

Stage of Harvest

Flowers persist a long time, opening in late winter to early spring and essentially "drying" on the plant. For fresh flowers, cut when stamens become visible. For drying, flowers can be cut any time but are also useful later when the follicles (seed capsules) become visible in the inside of the flower.

Postharvest

Flowers persist 10–14 days in the vase.

Cultivars

Since all plants are propagated from seed, a good deal of variability occurs in flower color. White, lavender, purple, and bicolor flowers occur in any population. Breeding work has yielded new and single colors; however, numbers are low, and prices are high.

Additional Species

Helleborus foetidus (stinking hellebore) bears small flowers and long finger-like foliage. Stems can be a little longer than *H. orientalis*, but flowers are smaller and occur in chartreuse only.

Helleborus niger (Christmas rose) produces beautiful clean white flowers. Plants are shorter and more difficult to establish than *H. orientalis*.

Pests and Diseases

Few problems occur with *Helleborus*, but black spot and crown rot are possible (Perry 1998).

Grower Comments

"I have been selling [hellebores] for a couple of years, mostly orientalis. They have a wonderful long vase life, 10-plus days easy, and I give no special treatment other than Floralife™. I have cut early in the season, when they are mauve, or waited 'til they turn chartreuse in late April–May. They command a good price: $1.50 and up per stem—and basically are completely maintenance free. Mine are well established at the base of very large trees and reseed freely, with basically no irrigation. They bloom for the big day—February 14—and grow where most other things would not." Lisa Ziegler, Ziegler Garden, Newport News, Va.

"Hellebore flowers hang way over, so they don't make the greatest cut flower, since—unless you are lying on the ground and looking up into it—you can't see that lovely color. I dry mine in silica gel and then use them in wreaths. The foetidus variety does last for weeks and weeks in a vase and may be worth marketing. I doubt we could sell it here in the Northwest, but maybe in other parts of the country." Sally Senior, Queen Bee Flowers & Gardens, Portland, Ore.

"We sell hellebores in a 5-stem bunch, 12–16″ in length, $5 to $12 a bunch. Lasts up to 2 weeks." Leon Carrier, PlantMasters, Laytonsville, Md.

Reading

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Hydrangea hortensia Hydrangeaceae

woody

Approximately 80 species occur, many with potential as cut flowers, either fresh or dried. The most popular is *Hydrangea macrophylla* (bigleaf hydrangea). Long staples of landscape horticulture, these mopheads, as they are also known, have become the darlings of the florist industry. Other useful species of this fine genus include *H. arborescens* (smooth hydrangea), *H. paniculata* (panicle hydrangea), and *H. quercifolia* (oakleaf hydrangea). All have undergone significant selection, and many cultivars are available.

Hydrangea macrophylla bigleaf hydrangea Hydrangeaceae

woody, Zones 5–8 hybrid origin many colors 3–5′/5′ (0.9–1.5 m/1.5 m)

The buying public has become enamored with hydrangeas of all kinds, in the garden, in commercial landscapes, and in vases and bouquets. Mopheads have always had a place in cut flower coolers, but broadened demand and choice of cultivars have enhanced the reasons a grower should invest capital and time in a crop that requires 2–3 years before the first flower is cut. Inflorescences consist of showy sterile flowers and small fertile flowers. When the head is made up mostly of sterile flowers, and the fertile ones are hardly noticed, the rounded flower head is referred to as a mophead; when only the outer ring of the inflorescence consists of sterile flowers, and the center is flattened, the head is referred to as a lacecap. The fullness of the mopheads has made that form most popular in the cut flower trade.

Propagation

In general, 1- or 2-node softwood cuttings are used from May to early July in most areas of the country. Don Mitchell of Flora Pacifica in southern Oregon developed his own method of propagation, the "box" method, which he shares as follows. Take tip cuttings (usually in April and May) and with a sharp knife, cut and remove about 50% of the leaf tissue. Dip the entire cutting in a mild systemic fungicide, allow the excess to drain, then dip the stem end in rooting hor-

Hydrangea macrophylla

mone solution. Place the cuttings in a waxed cardboard box, close the lid, and place the box in an undisturbed location at room temperature (55–75F, 13–24C is ideal). In approximately 10–15 days the cuttings should be calloused, with small roots starting. Plant these cuttings in 4″ pots in a protected area until fully rooted and ready to harden off.

Paul and Jhon (1992) found that only 27–33% of control cuttings rooted, and that the use of IBA, regardless of node numbers, resulted in far better rooting, with more roots per cutting and longer roots than cuttings receiving no dip. The greatest number of roots (about 21) were produced by 1- or 2-node cuttings treated with 1500 ppm IBA. Dirr (1998) recommends 1000 ppm KIBA and media consisting of 3 parts perlite to 1 part peat under mist; roots occur in 10–20 days.

Growing-on

Pot up rooted cuttings in well-drained medium. Plants may be grown on in large containers. Most cultivars flower on the previous years' wood and require at least 2 years to flower.

Environmental Factors

Most research on flowering centered on how to force containerized hydrangeas as gift plants for Mother's Day or Easter. The resulting forcing schedules were attempts to simulate what happens naturally. Essentially, hydrangeas begin flower initiation in late summer and fall, as photoperiod shortens and temperatures fall. As plants go into winter, leaves fall off and flowers are completely formed. Winter cold is necessary to break the dormancy of latent buds; plants flower as temperatures warm up. In greenhouse forcing, flower induction, initiation, and development are done under 8-hour photoperiods at night temperatures below 65F (18C) (Dole and Wilkins 1999). Plants are moved into cold storage areas, where leaves abscise naturally or with the help of ethylene gas or an ethylene-inducing chemical, such as 2-butyne-1,4-diol (Blom and Smith 1994). Defoliation is necessary; otherwise, botrytis will spread rapidly in the cooler and seriously damage plant quality. Without a chilling period, flowers will abort in most cultivars (Guo et al. 1995). A common cooling regime is around 40F (4C) for 6–8 weeks, although less time and colder temperatures can be used. Upon removal from the cooler, plants are placed into final containers and forced around 60–62F (15–17C) (Bailey 1989).

Field Performance

Most hydrangeas grown for cut flowers are field-produced, so nature provides the environment necessary for flower initiation, breaking dormancy, and flower formation.

Spacing: Spacing varies, 3–4′ (0.9–1.2 m) between plants and 5–8′ (1.5–2.4 m) between rows. The more stems removed, the closer the spacer can be; however, too dense a planting results in thinner stems and more disease problems. At Flora Pacifica, plants are spaced 3′ (90 cm) apart in 8′ (2.4 m) rows.

Harvesting: Flowers are generally harvested so that 2–4 nodes remain on the stem. Many flowers are dried, and stem length for dried flowers is not as important as it is in other plants. Most fresh cuts are harvested with stem length of 18–30″ (45–75 cm); for dried flowers, 6–12″ (15–30 cm) stems are adequate. At Flora Pacifica, harvesters cut alternate rows back to about knee height on alternate years. They find that this opens up the field for better air circulation and keeps the plants at manageable heights. In southern Oregon, flower size can be too big for fresh cuts, and this method of cutting also helps to keep flower size smaller.

Support: Not all growers use support; those that do recommend using supports along the rows to a height of 18–24″ (45–60 cm).

Shade: Hydrangeas perform best when provided with afternoon shade; the further south one grows hydrangeas, the more important shade becomes. Even in the Northwest, some shade is used. Natural shade is preferred, but shade cloth over frames is also useful. Recommendations of 30–50% have been made. White hydrangeas appear to need more shade; around 40–50% would be appropriate. In some areas, shade is employed only when the daytime temperature reaches 85F (29C) and above.

Flower color: The concentration of free aluminum in the soil can strongly affect flower color. The concentration of aluminum is highest in acid soils and lowest in alkaline soils. In general, blue flowers will occur in acid soils, pink in alkaline soils. In greenhouse-forcing cultivars, Blom and Piott (1992) suggested that application of aluminum sulphate (approximately 0.5 oz/6″ pot, 14 g/15 cm pot) induced blue coloration. Not all flowers have sufficient pigment to change colors, however, and many will remain the same color regardless of aluminum or pH.

Greenhouse Performance

Most cultivars require a cold treatment before flowering, although new cultivars for which no cold is necessary have been selected. Hydrangeas (and other woodies) are particularly good candidates for outdoor "moveable" greenhouses or tunnels, in which in-field plantings can be covered and forced when prices are at their peak. If noncooled hydrangeas are moved into a greenhouse in the fall, provide about 6 weeks of 40–45F (4–7C) in the greenhouse, cooler, or outdoors. Plants are usually in containers, so they can be moved in or out of the greenhouse as needed. Flowers can be harvested, depending on cultivar, 4–8 weeks after temperatures are raised.

Stage of Harvest

Fresh: Cut flowers when they are completely open. But keep in mind Don Mitchell's experience: "Sometimes we have 'gotta have' customers, who have to have hydrangeas before they are ready. [We've] cut them with considerable white showing on the inflorescence, and they still make a good cut flower, though in my opinion not the best."

Dried: Hydrangeas for drying are not ready for harvest until about 1 September, depending on locale. Generally, they are not ready to harvest until the true flowers in the center of the colorful inflorescence have dropped off and the flowers feel rubbery (not papery) to the touch. With experience, a harvester can readily tell by the feel of the flowers. If harvested too soon, they shrivel into the unattractive product sometimes creatively marketed as "crinkles."

Postharvest

Fresh: Defoliate and bunch in groups of 10 in the field. As soon as practical get them to the barn and place them in buckets with about 5–7″ (13–18 cm) of hot water (110–120F, 43–49C) and immediately place them in a 34–36F (1–2C) cooler. They should remain in the cooler at least 8 hours or until they are shipped. Don Mitchell finds that hydrangeas conditioned in this way ship well and considers floral preservative optional. Customers should be told to recut the stems and immediately put them in similarly heated water (110–120F, 43–49C). Using this procedure, completely wilted flowers will revive and become turgid. Vase life of conditioned flowers is easily 7–14 days. A word of caution to florists: hydrangeas need lots of water and do not do well in floral foam; the stem needs to be in water.

Dried: Mopheads are far better for drying than lacecaps, lacecaps dry poorly. Wait until flowers feel somewhat leathery or rubbery before harvesting. If cut too early, the petals shrivel. When flowers are harvested as outlined earlier, they can be stripped of leaves and bunched in threes using a rubber band. Hang upside down on a drying rack, in a warm, dry, dark place. A barn loft or an attic work fine. It is the combination of repeated drying and rehydration as well as sunlight that causes the loss of color. Don Mitchell has found that if placed in a dryer, the flowers will dry overnight, and the stems may take 2 or 3 days. Add fans for ventilation and a dehumidifier to reduce humidity. Direct sunlight results in discoloration; dampness results in flowers turning brown. Some growers, such as J. B. Barzo-Reinke of Small Pleasures Farm in Bandon, Ore., dry thousands of flowers in 2 days in a 20 × 16′ room.

And Don Mitchell has the last word on drying: "I have no idea where this idea originated, that you need to place hydrangeas in a vase of water to dry. Other than perhaps a backyard operation, this is pure bunk. Try drying 100,000 hydrangeas in vases of water! I understand Martha Stewart suggested putting vodka in the water to increase uptake. I say, drink the vodka and hang the hydrangeas!"

Cultivars

'Ayesha' bears pink or blue semi-double flowers.

'Deutschland' has pink flowers. Good hydrangea for outside cultivation.

'Dooley' has handsome blue flowers and is distinguished by having many flower buds on the flowering stem. If a late frost kills the terminal buds, the additional buds will subsequently develop.

'Glowing Embers' is floriferous, but stems are short. The mostly red main flowers on the top of the bush do not dry well (they tend to be muddy-looking); however, the more protected flowers develop an attractive buttery yellow-green color. One of Don Mitchell's top 5.

'Green Shadow' produces greenish red flowers in summer, dried in autumn.

'Hamburg', Don Mitchell's favorite, is excellent for early fresh cut flowers and drying. It has good-sized flower heads (6–10″, 15–25 cm), and the individual florets are fairly large. Flowers develop nice burgundy tinges as they mature.

'Kuhnert', another of Don Mitchell's top 5, is an excellent mid-blue hydrangea with small flowers (6–8″, 15–20 cm) that also dries well. In southern Oregon, plants flower all winter, though with all the heavy rain, the flowers are of poor quality.

'Nikko Blue' is a popular small-flowered blue hydrangea. Perfect for florists who prefer small flowers.

'Red Star' is late-bloomer with mid-blue flowers. Good as a fresh cut, with large (8–12″, 20–30 cm) flower heads. As a dried flower, it tends to have a floppy head; however, the blue color seems to hold with much less burgundy coloration than 'Hamburg'. In Don Mitchell's top 5.

'Regula' is a nice white that flowers later in the season and continues on into the winter. It is a good fresh cut, and the mature flowers turn an attractive green. In Don Mitchell's top 5.

'Romantic Fantasy' is a picotee form, red-violet with a white edge.

Old wood, new wood

Hydrangea macrophylla produces flower buds on stems in late summer and fall. These buds go through the winter, which breaks their dormancy, then go on to form flowers next spring, on "old wood." Outdoors, when plants are pruned hard in winter (after the buds have set), or late frosts kill back stems, or deer eat the plants to the ground, flowering is nil or very sparse. Plants are still healthy and a few flowers may form, but flowering is significantly diminished. Plants that flower on old wood flush only once a season. This is also why plants forced in the greenhouse must undergo a cold treatment on the old wood, or flowering is unsatisfactory.

A few cultivars seem to be able to flower without cold. Buds are formed on developing stems ("new wood"), and cold is not necessary for flowering. Butterfly-bush and deciduous hollies also flower on new wood; with such plants, greenhouse forcing is significantly easier, and additional flushes may occur throughout the season. Very few cultivars of *Hydrangea macrophylla* that bloom on new wood are available in adequate numbers, although a few, such as 'Endless Summer' and 'PennyMac', are being investigated and may prove useful.

Additional Species

Several species can be used for cut flowers; some bloom early, others do not bloom until the fall. Hydrangeas, as cuts, have been looked at as a possible alternative source of income for row crop farmers (Wolfe and Dunwell 1999), but in general, literature on growing a diverse range of *Hydrangea* species as cuts is scanty. Products like hydrangeas and peonies fit well into a niche market.

Hydrangea arborescens is hardy in Zones 4–9. 'Annabelle', the most readily available cultivar, bears large, 10–12″ (25–30 cm) wide, creamy white flowers in late June through September. Plants flower on new wood and, therefore, may be cut to the ground in late winter; the resulting growth will produce sufficient flowers for cutting. A second flush of flowers is possible in southern climates in September if the first flush is removed by early July. The inflorescences are excellent for drying.

Hydrangea paniculata is hardy in Zones 3–8, the hardiest of all hydrangeas, and also flowers on new wood. 'Grandiflora' (PG, peegee hydrangea) is very common and bears large panicles of white, sterile flowers in early to mid summer.

The panicles are usually 6–8″ (15–20 cm) long but can reach 12–18″ (30–45 cm) in length if branches are selectively pruned; such large inflorescences may be too big for the cut flower market. 'Kyushu' has white pyramidal plumes of flowers from late June to late summer. 'Praecox' is similar to 'Grandiflora' but flowers approximately 2 weeks earlier. 'Tardiva' bears numerous sterile flowers on a 6″ (15 cm) long inflorescence; its late-flowering habit (late September) makes it a useful option for extending the hydrangea market. 'White Diamond' and 'Pink Diamond' have become quite popular as easy-to-grow cut flower candidates. 'Unique' produces white flowers in July–September, which dry to pink in September–October. See Dirr (1998) for additional cultivars.

Hydrangea quercifolia (oakleaf hydrangea) is a stoloniferous shrub with few branches when young but significant branching at maturity. White flowers are formed in long terminal panicles on old wood. The outer showy flowers are sterile, the inner nonornamental ones, fertile. Plants are hardy in Zones 6–9, marginal, at best, in Zone 5 and below. Cultivars include 'Alice' (long panicles), 'Snowflake' (double flowers), and 'Snow Queen' (heavier flowers than the species); all are better candidates than the species for cut flowers. Needs shade.

Pests and Diseases

Bud blight, leaf spots, rust, mildew, and assorted thrips, aphids, and whiteflies have all been known to associate with hydrangeas. Slugs and snails are particularly nasty pests, and botrytis is a serious problem. Petal spotting, in which distinct, multiple purple spots (like chicken pox) occur on the flowers, has been reported (Leite and Barreto 2000); J. B. Barzo-Reinke actually points affected plants out to her customers: she finds that they love her "printed mops."

Grower Comments

"My hydrangeas are planted in rows 7′ apart, plants 4′ apart in the rows. I trim back to 2 or 3 nodes every winter. This gives me lots of nice long stems for cut flower production. I have been using 33% shade but am changing to 50% this year." Ray Gray, Sunset Flowers of New Zealand, Oregon City, Ore.

"I'm selling to a wholesaler for $4/5 stems. These are somewhat small, 30″ stems, from tree PGs set out this spring. Larger stems I would sell for $1/stem. They liked them cut about half green, half white." Ron Smith, R. Smith Farm, Renfew, Pa.

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Many thanks to J. B. Barzo-Reinke, Don Mitchell, and Bob Wollam for reviewing this section.

Hypericum

Clusiaceae

perennial, Zones 5–7 Europe, North Africa fruit

2–3′/2′ (60–90 cm/60 cm)

The species used for cut fruit production are *Hypericum androsaemum* (tutsan) and a related hybrid, *H.* ×*inodorum*. The former bears rounded, fleshy red fruit; the latter has elliptical, orange-red fruit. Most cultivars in use are hybrids between the two. The hybrids are based on fruit color and size, all varieties of which have found acceptance in the marketplace. Stems are being produced around the world and are imported into the United States year-round. Susceptibility to rust has made American growers more reliant on overseas material.

Propagation

Plants can be grown from seed, rooted from terminal cuttings, or purchased as bare root plants. Cultivars do not come true from seed. Bare root plants, if shipped dormant, must be "sweated" (placed in a hot, moist environment prior to planting) to break dormancy or shipped after dormancy has been broken. Some cultivars are patented and must be purchased from a licensed propagator; these newer cultivars are always identified by a plant patent number. Cultivars without plant patent numbers can be propagated without a royalty payment.

Growing-on

If small plantlets are received, transplant to larger containers until ready for transplanting to the field or greenhouse. Grow on at 55–65C (13–18C) in bright light. Plants can be placed in the field when roots fill the container.

Environmental Factors

Plants are long day and respond by flowering when daylength is greater than 14 hours; some recommendations suggest that daylength should be extended to 18–20 hours. This is possible in the greenhouse; however, fruit still forms under natural daylengths in most of the country. Plants produce more fruit at northern latitudes, where daylengths are naturally longer than those at southern latitudes. Lighting in the field to provide 18- to 20-hour daylengths may prove useful. Lighting programs in this case would be started before dusk.

Field Performance

Planting: Plant to the field when roots are well developed. Spacing on 18–24″ (45–60 cm) centers is sufficient. As daylength increases, flowers and fruit are produced. Outdoors, stems are harvested in late summer. Areas for high-quality production are limited in the United States. *Hypericum androsaemum* does poorly in areas of hot, humid conditions, being highly susceptible to fungi under such environments. Plants are cold hardy to about Zone 5, but winter damage can be significant if plants are not protected.

Pinching: Plants should be pinched when cuttings are starting to elongate, leaving at least 3 leaf pairs.

Fertilization: Reduce N fertilization when the first shoots are branching, to reduce lateral growth. Reduce irrigation when the berries are ripening, to prevent bursting.

Yield: Production in the first flush is approximately 2 stems/plant; the second flush is about 6 stems/plant, and additional flushes may be as high as 15 stems per mature plant (Bartels 2000).

Overwintering: Hypericum is essentially a woody shrub, and any stems remaining after harvest should be left uncut (similar to other woodies). Winter kill is always related to desiccation from wind without snow cover; after the ground has frozen, plants can be mulched to increase winter survival in colder zones without snow cover. Plants should be cut back to 1″ (2.5 cm) after they have begun to sprout in spring.

Greenhouse Performance

Year-round demand has resulted in increased cultivation under protection. Plants may be grown in winter conditions if long days (>14 hours, up to 20 hours) and warm temperatures (65–75F, 18–24C) are provided. Data concerning yield, fertility, and spacing are few.

Stage of Harvest

Harvest stems close to the ground when fruit is fully colored. Stems are usually sold in bundles of 5–10.

Postharvest

Stems have a vase life of 9–14 days (Anon. 2001). Leaves deteriorate before the fruit. Treat stems immediately after cutting.

Cultivars

'Albury Purple', a cultivar of *Hypericum androsaemum*, has bronzed purple foliage with a round red berry, surrounded by purple bracts. Plants are cut for the foliage and the fruit.

'Annebel', a hybrid between *Hypericum androsaemum* and *H.* ×*inodorum*, bears a rounded fruit of brown-red.

'Autumn Blaze', a cultivar of *Hypericum androsaemum*, bears brown-black fruit. Very similar to 'Excellent Flair' but sets fruit approximately 2 weeks later and is more rust prone.

'Dolly Parton' has pink fruit. Individual berries, twice as large as other cultivars, seem to require the even daylength of the equator and the bright light of higher elevations; the fruit reportedly occurs consistently only in Ecuador or Peru.

Flair series, the most prevalent of available groups, has greatly encouraged the production and sale of the species. ‘Excellent Flair’ (red-brown fruit), the standby cultivar, grows 3–4′ (0.9–1.2 m) tall and has good rust resistance. Others include ‘Candy Flair’ (pink), ‘Envy Flair’ (red), ‘Jade Flair’ (green), and ‘Pinky Flair’ (pink).

‘Glacier’ has variegated foliage, green and white with some pink. Must be grown in shade or cool coastal conditions.

Magical series includes ‘Magical Beauty’ (salmon), ‘Magical Dream’ (green), and ‘Magical Flame’ (deep red).

‘October Revolution’ is late to set but finally produces small red-brown fruit with a pointed shape. Good rust resistance.

‘Rheingold’ is comparable to ‘Annebel’ (similar parentage) with earlier, slightly smaller, more pointed, oval brown-red fruit. Plants are vigorous growers with good rust resistance.

‘Summer’ is also a hybrid with very early, dark red fruit. Rust resistance appears to be marginal.

Pests and Diseases

Aphids and whiteflies can be a problem early in the growing season. Timely control will prevent the loss of stem length that can occur if new growth becomes stunted.

Hypericum rust (*Melampsora hypericorum*) shows up as yellow spots on top of the leaves and as orange spots beneath. Heavy infection can cause brown or dead leaves. Rust spores can spread rapidly via wind, rain, and clothes. Remove dead leaves, keep the beds clean, and apply a fungicide early in the plant cycle. Paul Sansone of Here & Now Garden in Gales Creek, Ore., has further suggestions: “Each spring a copper spray [is] applied when plants are dormant. . . . If chemical control is used, apply systemic control early, when the second or third sets of leaves have emerged, and again 30 days later. Nonchemical control can be achieved with foliar sprays of compost tea. Rust tends to appear when hot dry weather settles in. [Control] by shifting to overhead irrigation and soaking plants daily with ½″ of water.”

Nematodes have been reported as a serious problem.

Root rots appear frequently in hot, humid weather.

Reading

Anon. 2001. Dutch hypericum produces large berries, profits. *Flower News* (Sept. 8): 4.

Bartels, G. 2000. *Bartels Cultural Guide*. Bartels Stek, Aalsmeer, The Netherlands.

Many thanks to Paul Sansone for reviewing this section.

Ilex deciduous holly Aquifoliaceae

woody, Zones 3–9 North America fruit 6–10′/6′ (1.8–3 m/1.8 m)

Hollies have been vigorously bred and selected, and with the dozens of species and hundreds of cultivars available in the nursery trade, one would expect to find some in cut flower markets. But the many species native to China and Japan usually bear evergreen, often spiny foliage that is of limited value for cut sales; the evergreen species also tend to be less cold hardy than deciduous species, and while they may occasionally be seen in local markets, little widespread interest has developed. The deciduous species, by contrast, such as *Ilex decidua*, *I. verticillata*, and *I. serrata* and hybrids, have been in cut flower markets for years, and enjoy such poetic names as winterberry, coralberry, sparkleberry, and possumhaw. The stems are cherished for their berrylike fruits (drupes), which are harvested for the Christmas and Easter markets. Most hollies are dioecious, meaning that plants are either male or female. Only the female plants bear fruit, but some males are necessary for pollination; approximately one male plant for every 20 females is sufficient. Generally, any male holly can pollinate any female if flowering times overlap.

Propagation

Cuttings: Softwood cuttings root easily. Treat June or July cuttings with a quick dip of 1000–3000 ppm IBA, stick in peat/perlite medium, and place under intermittent mist. Ninety to 100% rooting occurs in 6–8 weeks (Dirr 1998).

Seed: Seed exhibits a deep dormancy, and patience is a must. Some seed may require up to 18 months. Remove the mealy outside layers of the fruit and sow the hard seeds (nutlets) in a suitable medium. Place at 70–75F (21–24C) in a humid area (Dirr 1998).

Growing-on

Plants are slow-growing and generally grown in containers. Acid conditions (pH 4.5–6.5) and moderate fertility levels are recommended. They can be transplanted to the field as rooted cuttings in the spring, but fibrous roots dry out rapidly and significant losses may occur. To reduce losses, use 1 gallon (4 l) containerized plants.

Field Performance

Habit: Plants are oval to rounded in shape and tend to form large multistemmed clumps. The foliage is deciduous but persists into late fall.

Spacing: Plants can grow 10–15′ (3–4.5 m) wide if left undisturbed; spacing of 20 × 20′ (6 × 6 m) has been used to facilitate mechanical harvesting. With selective cutting, denser spacing may be provided to produce mass plantings. Some growers space as densely as 4′ (1.2 m) apart and 10′ (3 m) between rows. Wider spacing allows more stems/plant but fewer stems/ft^2. With large plantings, spacing should be dictated by the equipment available for cultivating and harvesting.

Ilex verticillata
'Winter Red'

Harvesting: Flower buds are set a year prior to flowering; severe harvesting therefore retards subsequent fruiting. If plants are cut back severely, approximately 3 years are necessary before plants can be reharvested. Mechanical mowing of 15–18″ (38–45 cm) stems is also practiced (Eisel 1989). Harvesting is generally accomplished after the leaves have fallen—most retailers don't want to mess with pulling off leaves. Stems are generally sold by the pound, so harvested material needs to be weighed prior to boxing.

Soils: Plants are native to swampy areas and can be grown with the entire root system submerged. Plants are also adaptable to "normal" field conditions. Drainage is not as important with these species as with other woody plants.

Wild material: Some people still simply harvest from the wild. This is not the place to get into ecological and ethical discussions on the benefits or detriments of such practices; however, there is no doubt that commercial cultivars bear larger stems and more fruit and will bring a better price than wild-collected stems. Also, cultivation practice such as watering, appropriate fertility, and plant management invariably improve production and yield. Last but not least, the "gatherers," with their lack of overhead, tend to price their material too cheap, hurting the market in general.

Stage of Harvest

Branches should be harvested before the fruit reaches maturity (Eisel 1989). While it's not necessary to remove the foliage from holly branches, some wholesalers believe the fruit is more ornamental when the branches are defoliated. If stems are to be defoliated, defoliation must be done prior to shipping.

Postharvest

Abscission of foliage: A problem occurs when some, but not all, of the leaves and fruits abscise, resulting in an unattractive branch. Storage of cut branches in high-humidity chambers helps in the removal of foliage, whether foliage is finally removed mechanically or by hand. Tammy and John Ford, excellent growers in south-central Indiana, share their experience: "We cut early to mid November but will leave the stems in the field as long as possible until 1) we have orders to fill or 2) a hard freeze is forecast. The holly will take a few light frosts okay, but a hard freeze [decreases] the longevity of the berries after cutting. After cutting, we like to store the stems, for a few days at least, in plastic bags in the cooler. This helps to loosen the leaves if some are still hanging tight. When you pull them from the cooler, a good shake will drop most of the leaves, and the rest pull off very easily. We try to remove the majority of the leaves, but if there are a few tight ones, we won't worry about it—figure they'll be loosened by the time they reach their destination."

Banko and Stefani (1999) compared combinations, concentrations, and timing of chemical defoliants. Using *Ilex verticillata* 'Winter Red', they found that the most promising chemicals were Dropp™ (thidiazuron) and Harvade™ (dimethipin); other chemicals resulted in premature berry softening and drop. A single application of Harvade™ at 1600 ppm provided reasonably good defoliation (71%) and minimal berry drop (1%), with little additional loss of berries from the stems during a 3-month storage period.

Storage: Stems should be stored dry (Eisel 1989). Branches may be stored at 32F (0C) for 1–3 weeks in moisture-retentive boxes (Nowak and Rudnicki 1990).

Species and Cultivars

Ilex decidua (possumhaw) is fall-fruiting with scarlet-red berries. Plants grow 7–15′ (2.1–4.5) tall and about 10′ (3 m) wide at maturity. Plants are hardy in Zones 5–9, although differences among cultivars occur. Useful cultivars include 'Byers Golden' (yellow fruit); 'Council Fire' (orange fruit); 'Red Cascade' (red fruit); 'Sentry' (red fruit); 'Sundance' (orange-red fruit); and 'Warren's Red' (red fruit). 'Red Escort' is a good male form.

Ilex serrata (fine-tooth holly) bears ¼″ (6 mm) wide fruit and generally grows about 6–8′ (1.8–2.4 m) tall. The abundant fruit ripens early and is showy. Unfortunately, the fruit on many selections does not hold well and fades on the side facing the sun. Cultivars include 'Leucocarpa' (white fruit) and 'Xanthocarpa' (yellow fruit).

Ilex verticillata cultivars are available by the dozen, most with red fruit but a few with yellow and orange-red fruit (see Dirr 1998 for discussion). 'Jim Dandy', 'Southern Gentleman', 'Raritan Chief', or 'Rhett Butler' are good male forms. 'Berry Nice' has vivid large fruit. 'Cacapon' produces an abundance of truly red fruit on 6–8′ (1.5–2.4 m) tall plants. 'Christmas Gem', introduced by Jenkins Nursery in Maryland, bears dark red fruit. 'Chrysocarpa' bears yellow fruit but does not fruit as heavily as many of the red-fruited forms. 'Maryland Beauty', another Jenkins introduction, is a heavy producer. 'Shaver' has perhaps the largest fruit of all selections; the fruit is orange-red and produced on upright-growing plants. 'Sunset' bears bright red fruit that is slightly longer than that of 'Winter Red'. 'Tiasquam' produces excellent, persistent red fruit. 'Winter Gold', a branch sport of 'Winter Red', produces ¼″ (6 mm) wide, pinkish orange fruit. 'Winter Red', introduced by Simpson Nursery in Indiana, has performed exceptionally well in trials at the University of Georgia and many other sites; bright red fruit, ⅜″ (10 mm) wide, is borne in great profusion and maintained through the winter.

Ilex verticillata × *I. serrata* crosses have resulted in some useful cultivars; however, they are less suitable than *I. verticillata* forms for cut fruit. The fruit, in general, is slightly smaller than *I. verticillata* forms and usually less persistent. 'Autumn Glow' is 6–8′ (1.8–2.4 m) tall and produces red fruit that fades on the side facing the sun by Christmas. 'Bonfire' is a vigorous grower with red fruit. 'Sparkleberry' is one of the best cultivars, bearing persistent, brilliant red fruit, often throughout the winter. Use 'Apollo' as the male form.

Pests and Diseases

Tar spot (*Rhytisma concavum*) results in yellow spots on the foliage in spring, which turn reddish brown in summer and black in fall. Treat with a fungicide in early spring.

Spittlebugs can be a problem. Ruter and Bramen (1999) found that the number of adult spittlebugs per plant varied, by species, from 0 to 28, while the number of damaged tops per plant ranged from 0 to 62. *Ilex cassine* and *I. opaca* and hybrids of these species were the most susceptible; *I. cornuta*, *I. glabra*, *I. verticillata*, and *I. vomitoria* and their hybrids were least susceptible.

Leaf spots, caused by numerous fungi, result in small, brown to black spots on the foliage. Increasing the vigor of the plants by reducing stress (keeping them well watered and so forth) will reduce the incidence of leaf spotting.

Powdery mildew is sometimes a problem, particularly in the South. Fungicides may be necessary.

Grower Comments

"*Ilex verticillata* is always sold here with the leaves removed. I think it's important to keep the humidity pretty high, but not enough to harm the berries—we use a method similar to this for bittersweet. [If] they dry out too much the leaves never come off and are even difficult to pull off." Janet Foss, J. Foss Garden Flowers, Everett, Wash.

"I just bunch the stuff up at 10 branches to the bunch and store it outside on the ground." Jim Link, Sandgate Flower Farm, Sandgate, Vt.

"Cultivars of *Ilex verticillata* like 'Winter Red' are significantly different from wild populations. They are very heavily berried, and the berries are very persistent. The price to a wholesaler is $5 to $8/lb; somewhat more, $12/lb, to high-end florists and restaurants in Louisville; and as much as $12 to $14/lb retail (at late season farmers' markets). A single stem of 'Winter Red' may weigh as much as 2 lbs or more! 'Winter Red' stems are too bulky to be bunched! We pack 5 lbs in a box for our wholesale customers. A 3–6′ stem carries a lot of heft if covered with berries." Tammy Ford, Perennial Favorites, Leopold, Ind.

Reading

Banko, T. J and M. Stefani. 1999. Defoliating deciduous hollies grown for the cut floral market. *Holly Society Journal* 17(4):14–18

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Nowak, J., and R. M. Rudnicki. 1990. *Postharvest Handling and Storage of Cut Flowers, Florist Greens, and Potted Plants*. Timber Press, Portland, Ore.

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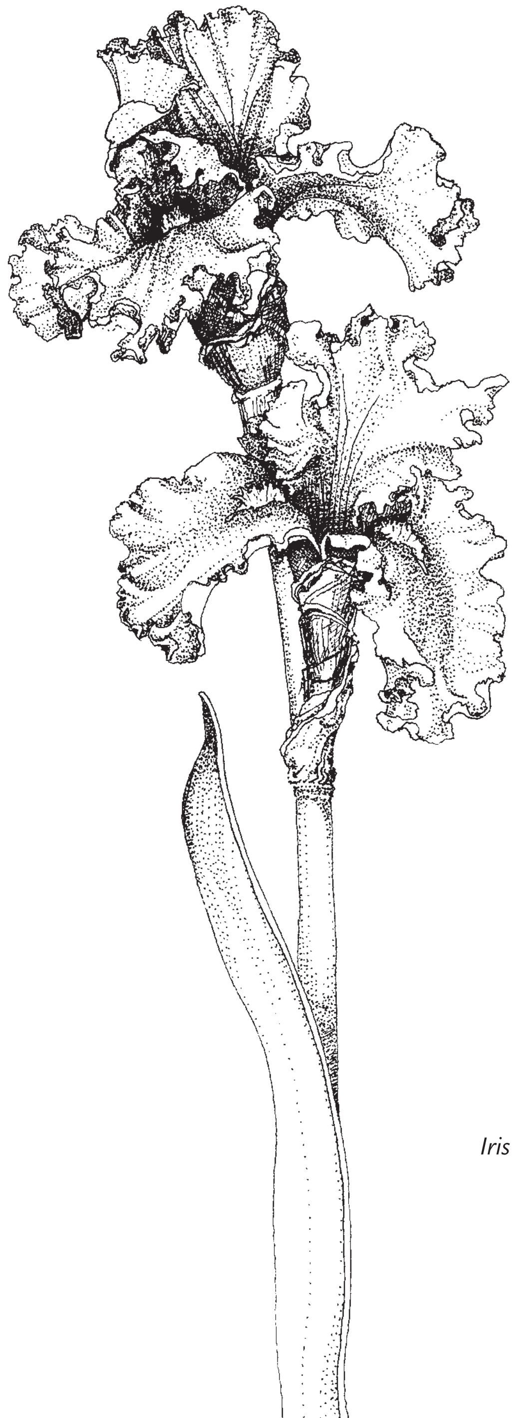
Iris Iridaceae

bulb/perennial

It is hard to argue with the beauty of an iris flower, regardless of the species or cultivar. Japanese iris, Siberian iris, Louisiana iris, and the ubiquitous bearded iris are all beautiful, but they are not commonly found in floral markets. They all are easy to grow and bear handsome flowers, but their limited shelf life tends to make them local items only. That in itself is not a problem as long as the consumer realizes that vase life is not one of their headier characteristics. No worry about overseas competition with most irises.

Bulbous iris are forced year-round and are the most widely grown. The most popular form of the bulbous iris is the Dutch iris (*Iris xiphium*); English iris (*Iris latifolia*) is occasionally grown.



Iris (bearded form)

Iris xiphium group

Dutch iris — Iridaceae

bulb/perennial, Zones 8–10 — hybrid origin — many colors

1.5–2′/1′ (45–60 cm/30 cm)

Dutch iris are the most sought after because of their hybrid vigor, diversity of color, ease of flowering, and shelf life. In the United States they are more commonly grown as a greenhouse crop, but field production is possible in the southern states and on the West Coast (Zones 8–10). Iris bulbs can be found from as small as 6/7 cm to 10+ cm in diameter. The smaller sizes (6/7, 7/8, and 8/9) are used for garden and outdoor forcing; the 8/9, 9/10, and 10+ cm are used for greenhouse forcing. The larger sizes respond better to cold treatments and produce longer stems.

Propagation

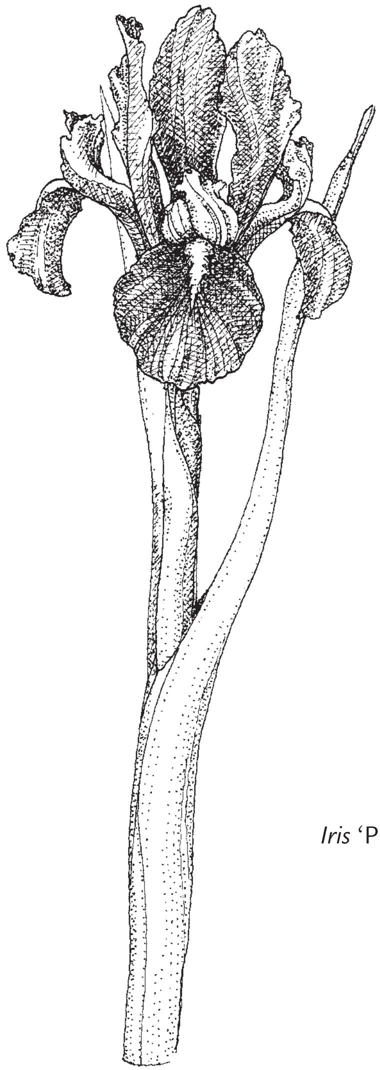
Dutch iris are true bulbs, and offsets are formed after flowering. Bulb growers in Holland propagate iris bulbs by replanting the offsets or clusters in the fall. All bulbs graded over 6 cm for the small bulbous group and over 8 cm in the large bulbous group are made available to the commercial trade. France also produces a considerable number of bulbs; they are harvested earlier and can therefore be cold treated and forced earlier than the bulbs grown in Holland.

Cut flower growers may propagate their own clusters. Offsets may be divided, cleaned, sized, and replanted each summer. Most growers, however, treat the bulbs as annuals and discard them each year. This is particularly true for greenhouse production. Bulbs should be immediately planted upon arrival.

Environmental Factors

Temperature: Dutch iris do poorly above 70F (21C) for extended periods of time. Recommended greenhouse temperatures are 62F (17C) days and 53F (11C) nights. This limits the time bulbs can be forced in the field or greenhouse in many parts of the country. In the East, greenhouse forcing is difficult during the summer months without excellent soil-cooling facilities; on the West Coast, more production during the summer is possible.

Warm temperatures after digging are necessary for successful flower forcing. The temperatures provided and the durations the temperatures are applied depend on where the bulbs are grown and when they are lifted. When lifted from warm soils, the heat requirement is partially fulfilled. Warm storage recommendations differ for various areas but are given for approximately 2 weeks. For example, bulbs grown in Holland may be stored at 86–95F (30–35C) for 2 weeks followed by 3 days at 110F (43C); in western Washington, bulbs are stored 2 weeks at 90F (32C); in the United Kingdom 86F (30C) for 2 weeks followed by 3 days of 110F (43C) are satisfactory (Rees 1985). The most common treatment, however, is 2–3 weeks at 86F (30C); this appears to be the optimum combination to make an iris bulb go dormant. Most iris varieties can be kept dormant up to one year at 86F (30C), allowing bulb suppliers to make cold-treated bulbs avail-



Iris 'Purple Sensation'

able to growers on a year-round basis; bulbs used for this purpose are said to be retarded. Bulbs that must be immediately placed in cold storage (for early forcing) receive a treatment of ethylene gas or banana gas, which boosts the flowering performance of the bulbs, especially the ones that are must be planted early.

After the heat treatment, low temperatures are necessary for flower initiation. These treatments are nearly always provided by the bulb supplier; however, forcers with proper equipment for temperature treatment may do their own. Various cold treatments are used, depending on the variety of bulb, the climate, and the greenhouse conditions under which the bulbs are grown. Generally cold treatments are done in a combination: 1–2 weeks of 62F (17C) followed by 6–11 weeks of 48F (9C). In the spring and toward the summer, these cooling periods are shorter.

Light: Bulbs produce more flowers of better quality under high light conditions. In the winter, provide clean greenhouses and supplemental light if appropriate; in the summer, houses may have to be shaded to maintain optimum temperatures.

Photoperiod/CO_2: No photoperiodic response or benefit of supplemental CO_2 is evident.

Field Performance

Bulb size: Bulb size should be greater than 8/9 cm for optimum flowering (De Hertogh 1996); however, optimum bulb size varies with cultivar.

Spacing: Different cultivars require different spacing. Bulbs in the Ideal Group, for example, may be planted at high densities of 21–24 bulbs/ft^2 (230–260 bulbs/m^2), whereas those in the Small Bulb Group are spaced at 10–12 bulbs/ft^2 (110–130 bulbs/m^2) (Buschman 2000). This computes to as wide as 4″ (10 cm) apart to as close as bulb to bulb. There is no hard and fast rule for spacing; however, some cultivars can be planted closer together without adversely affecting yield or quality. Denser spacings are more appropriate in greenhouse production than field production.

Bulbs should be planted 4–5″ (10–13 cm) below the soil surface (De Hertogh 1996). If planted too shallow, bulbs dry out more quickly and stems are more likely to topple in winds.

Planting time: Bulbs should be planted when soil temperature is 60F (15C) (De Hertogh 1996). The optimum growing temperatures for field production is 60–62C (15–17C). Soil temperatures should be no higher than 68F (20C), air temperature no higher than 77F (25C). In mild climates, bulbs planted in the fall produce flowers in late spring and summer. Information concerning planting time on 5 cultivars of Dutch iris, planted approximately 6″ (15 cm) apart at Athens, Ga. (Zone 7b), follows (Armitage and Laushman 1990).

The effect of planting date on Dutch iris^z.

Month planted	Stems/ bulb	First harvest	Harvest duration (days)	Stem length (in)^y	Stem width (mm)^x
Nov	0.84	15 Apr	15	16.2	9.5
Dec	0.89	13 Apr	17	15.0	9.5
Jan	0.94	24 Apr	14	14.7	9.3
Feb	0.80	30 Apr	13	12.3	7.5
Mar	0.73	20 May	15	11.2	7.4

z = data are averages of ‘Blue Ideal’, ‘Blue Ribbon’, ‘White Wedgwood’, ‘White Bell’, and ‘White Cloud’
y = multiply (in) by 2.54 to obtain (cm)
x = divide (mm) by 25.4 to obtain (in)

Notice that little difference in yield occurred between November and January plantings. Harvest was delayed after December, however, and stem length and diameter were reduced as planting was delayed. It is obvious that, at least in Zone 7b, planting after January cannot be recommended: the rising soil and air temperatures, March through June, reduce quality.

Longevity: Most growers replace bulbs annually, and even in areas where bulbs may be perennialized, late frosts can devastate emerging flowers. In areas where no frost occurs, bulbs must be precooled.

Greenhouse Performance

Planting time: Plant bulbs every week in beds or crates for as long as quality can be maintained.

Bulb size: In general, a large bulb size is preferable, and for most cultivars a circumference of 9/10 cm is recommended. But some cultivars—'Crown Jewel', 'Golden Beauty', 'Purple Sensation', and 'Yellow Queen', for example—naturally produce smaller bulbs, and the maximum circumference for this Small Bulb Group is 8 cm (Buschman 2000). Whatever the cultivar, a less than optimal bulb size increases the incidence of flower blindness.

Bulb depth: Plant by pushing ¾ of the bulb ("thumbing in") into loosened soil, then cover with 3–4″ (8–10 cm) of soil. If planted too shallow, the bulbs are more likely to be affected by drying out. Some growers in northern areas place a thin plastic film over the beds for the first 4 weeks after planting to maintain a high relative humidity and soil temperature around 62F (17C) (Buschman 2000).

Spacing: See "Field Performance." Depending on the cultivars, spacing of the bulbs for greenhouse production should be no higher than 20 bulbs/ft^2 (about 220 bulbs/m^2).

Temperature: Maintaining soil temperatures below 68F (20C) is the most important measurement. The optimum soil temperature is 62–65F (16–18C). Use 55F (13C) night temperature and 60–63F (15–17C) day temperatures when possible; the optimum greenhouse temperature appears to be 60F (15C). To reduce flowering time, bulbs can be grown as high as 65F (18C) for the first 3–4 weeks; however, temperatures should be lowered to 55–60 (13–15C) after that time. Avoid average temperatures above 65F (18C), particularly under short days or time of low light (De Hertogh 1996). Low night temperatures (near 50F, 10C) enhances postharvest life (Nowak and Rudnicki 1990); the lowest temperature is 41F (5C).

Light: In temperate areas, low light increases the incidence of flower blasting (see "Pests and Diseases"). Add more light or reduce temperatures to 50–55F (10–13C).

Fertilization: Fertilize weekly with calcium nitrate at approximately 200 ppm N.

Scheduling: Harvest occurs 6–8 weeks after planting in greenhouse. The following table provides scheduling guidelines for the various groups of Dutch iris (see "Cultivars") based on "normal" greenhouse production.

Ideal Group	50–60 days
Prof. Blaauw Group	60–80 days
Blue Magic Group	65–85 days
Tingitana Group	70–90 days
Small Bulb Group	60–85 days
Miscellaneous Group	55–75 days

Stage of Harvest

Cut all Dutch iris when the tight flower has fully emerged from the sheath. In the fall and winter, wait until the colored tip is about 1½″ (4 cm) long. In the spring, only about ½″ (13 mm) of colored tip is needed (Buschman 2000). This is referred to as the pencil stage, when a pencil of color is visible. Some cultivars need to be harvested more open than others; this is learned by experience. Harvest by pulling the entire plant, bulb and all. After harvesting, the bulbs are removed, as are yellow or disfigured leaf tips, and stems are sorted by stem length for uniformity and bunched in groups of 10. The bulbs are usually discarded.

Postharvest

Fresh: After harvesting, place immediately into a cooler at approximately 35F (2C) for precooling. Be sure the stems and flowers are dry to prevent fungal disease. The cooler should be set at approximately 80% humidity to keep flowers from dehydrating. If bunches are limp, place them in water in the cooler. Flowers are not sensitive to ethylene, and anti-ethylene agents do little to extend vase life. Vase life is 3–6 days.

Storage: Store for as short a period as possible. Flowers may be stored dry at 31–32F (⁻1–0C) upright for no more than a week (Sacalis 1989) or stored wet upright for 5–10 days at 33F (1C). However, be careful that the cooler does not freeze the product. Prolonged storage time results in failure of flowers to open (Evans and Reid 1990).

If flowers are conditioned in a solution containing 1.5 oz/5 gallons citric acid and 1.5 oz/5 gallons sucrose for 12 hours at 68F (20C), the vase life of dry shipped flowers improves; the retailer or consumer should rehydrate iris in warm water (100F, 38C) for 3 hours (Nowak and Rudnicki 1990).

Cultivars

The International Flower Bulb Center (Buschman 2000) has separated cultivars into 6 main groups, shown here. Consult wholesale bulb catalog or the Holland Bulb Forcer's Guide (De Hertogh 1996) for more details.

Bulb group	Color	Max. bulb size[z]	Plant height (in)[y]
Ideal Group			
Blue Diamond	deep blue	10	26
Ideal	light blue	10	26
White Wedgwood	white	10	26
Prof. Blaauw Group			
Prof. Blaauw	deep blue	10	30
White Bridge	white	10	28
White Cloud	white	10	30
Blue Magic Group			
Blue Magic	violet	10	24
Casablanca	white	10	32
Madonna	blue	10	24
Mercedes	blue	10	24
Pickwick	white-violet	10	24
Tingitana Group			
Acapulco	purple	10	30
Holland Knight	violet/purple	10	32
Hong Kong	dark purple	10	30
Paris	violet	10	32
Small Bulb Group			
Crown Jewel	yellow	8	26
Frans Hals	bronze/yellow	8	26
Golden Beauty	yellow	8	28
Golden Harvest	yellow	8	24
Oriental Beauty	yellow/blue	8	28
Purple Jacket	purple	8	24
Purple Sensation	purple	8	24
Romano	yellow/blue	8	24
Royal Yellow	yellow	8	32
Sapphire Beauty	blue	8	26
Symphony	yellow/white	8	26
White van Vliet	white	8	24
Yellow Queen	yellow	7	28
Miscellaneous Group			
Apollo*	yellow/white	10	32
Atlantis	light blue	10	30
Blue King	blue	10	32
Deep River	blue	10	28

(continued)

Bulb group	Color	Max. bulb size^{z}	Plant height (in)^{y}
Hildegarde	light blue	10	32
Holland Lilac	lilac	10	30
Holland Sapphire	dark blue	10+	32
Miss America	purple	10	30
Nova Blue	light blue	10	32
Nova Sun	yellow/white	10	32
Saturnus*	white	10	32
Telstar*	blue/violet	10	28
White Giant	white	10	32

z = bulb size in (cm)
y = multiply (in) by 2.54 to obtain (cm)
* = triploid

'Blue Magic' and members of the Miscellaneous Group make up almost 95% of all commercially produced cut flowers. Most cultivars in the Miscellaneous Group are hybrids, and some of them are triploids; they open well and have an excellent vase life.

Additional Species

With so many cultivars and species of *Iris* available, it is naive to believe that only bulbous iris are used as cut flowers. Without doubt, bearded iris, Siberian iris, Japanese iris, Louisiana iris, and others are sold, mostly in farmers' markets and occasionally through florists; their beauty is unquestioned, but their market is limited by the perception that they have a short vase life.

Ray Schreiner of Schreiner's Iris Gardens in Salem, Ore., strongly disagrees that 3–4 days of vase life for bearded iris is generous. He says that if flowers are picked at the right time, they persist a week or longer. Newer cultivars are bred to have 10–12 flowers per stem and should be harvested when 1 or 2 flowers are open on the stem. After harvesting, remove spent flowers (should be only 1 or 2 of those), cut to size for uniformity for bunching, or simply incorporate in bouquets, where their beauty can be appreciated. Spent flowers should be removed throughout the life of the cut stem for optimum vase life. In summary, there is no end to the colors, sizes, flowers, and fruit (particularly in the Japanese iris) that can be harvested within the genus *Iris*, but attention to recutting stems and water levels in the final containers and removing spent flowers is critical. For most growers, vase life is best for local consumption. This is actually a plus for incorporating more diversity and thinking about off-season forcing of some of these "garden" forms; they ship poorly and will not be coming in from overseas.

Pests and Diseases

Dipping the bulbs in a fungicide (e.g., benomyl or thiabenzadole) immediately before planting is recommended to reduce fungal infection. Dipping for approximately 15 minutes at the normal concentration should be sufficient.

Bulb rot (*Fusarium oxysporum*), crown rot (*Sclerotium rolfsii*), gray mold (*Botrytis*), rhizoctonia (*Rhizoctonia solani*), root rot (*Pythium ultimum*) and blue mold (*Penicillium*) are all caused by fungi. Dipping the bulbs and good environmental sanitation practices will reduce the incidence of these problems. Soft rot (*Erwinia carotovora*) is a bacterial disease, easily recognized by the unpleasant odor and mushy feel of affected bulbs. There is no chemical defense against erwinia. Further infestation can be controlled only by lowering temperatures and salt levels (no fertilizing) and by reducing the amount of water. Sterile soil in greenhouse forcing is highly recommended.

Bud blasting is a physiological problem in which the flower bud develops but fails to open. Ultimately the flower bud becomes limp and dries out. Bud blasting can occur at any time. The cause appears to be insufficient light combined with temperatures that are too high. It can be caused by too high a planting density and a sudden drop in temperature, or by a root infection in which water is not taken up efficiently. Bud blasting is a far greater problem in winter months; provide as much light as possible and reduce temperatures during dull periods. Another factor is high humidity levels in the greenhouse in the winter months. When temperatures are cold outside and the heaters in the greenhouse are running, humidity levels increase dramatically, especially if irrigation recently took place. Venting the greenhouse slightly by turning just one fan on or cracking the roof vents (even though heaters are running) can reduce the humidity. It might seem like a waste of energy, but it is a lot cheaper than losing flowers to blasting or blindness.

Grower Comments

"We have found that the tall bearded iris flowers last 1–2 days in the vase, then become unsightly and have to be picked off, by which time others on the stem have opened (a little like *Hemerocallis*). Japanese iris (*Iris kaempferi*) makes what I think is the most beautiful cut flower, each of the 2 buds lasts 2 days in the vase. Culture is difficult and opening the flower in the vase makes it too difficult for us to grow commercially. It's a real niche flower, most appropriate to sell to designers. Siberian iris (*I. sibirica*) is a substitute for Dutch iris (the florist's iris), but the blossoms are even shorter lived (2 days for each). I prefer their look to that of Dutch iris. They can be also grown for their seed pods. We don't grow Dutch iris because they are not hardy in our Zone [3–4]." Ed Pincus, Third Branch Flower, Roxbury, Vt.

"I am not an expert but I have been growing Louisiana iris for about 4 years. They have the entire color range represented, including blues, yellows, and reds. I started growing Louisiana iris in a swampy section of my property, and they really took off. They generally don't make long-lasting cuts. However, I have taken them to sell at the local farmers' market. Like most iris, they do best if harvested in the pencil stage. If your iris are in a location they like (they need plenty of water, fertilizer, and organic matter in the planting beds), each stem should produce 3 or 4 blooms, which will open from the top down the stem. My farmers' market customers are used to picking off the spent flowers. In my area these are considered unusual cuts, and I get $1.50 to $2.00 per stem. Most of my customers buy them in bouquets though not in straight bunches." Kate Sparks, Lilies and Lavender, Doylestown, Pa.

Reading

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Many thanks to Mark Hommes and Ray Schreiner for reviewing this section.

Lathyrus odoratus sweet pea Papilionaceae

annual Sicily, Crete many colors vine

The history of the popularity of ornamental horticulture is reflected in the history of the popularity of the sweet pea, *Lathyrus odoratus*, once a foundation of the traditional English garden. Sweet peas were introduced there around 1699 and were first offered for sale in catalogs in 1730. The Invincible series of sweet peas, which first appeared in England in 1866, were introduced to America in 1870; they were intended to be grown as sweet pea hedges and screens and used for their fragrance in bouquets. By the turn of the century, over 130 cultivars had been bred. Interestingly, while most "peas" are edible, the sweet pea is poisonous. A medical term, lathyrism, is used to describe the convulsions, leg paralysis, and unconsciousness associated with eating sweet pea seeds. Fortunately, a lot of seeds must be eaten, and few cases have occurred.

There's renewed interest in this plant, which still win hands down in the cut flower fragrance category. Sweet peas are now grown under elaborate systems in greenhouses, mainly in the West, and are field-grown where climates allow. With

Lathyrus odoratus
'Mammoth Mix'

low light requirements and tolerance of lower temperatures, sweet peas are ideal for low-cost winter production. Plants are vines, growing on strings, trellises, or walls, and are most popular in May and June for wedding flowers.

Propagation

Soaking sweet pea seed is always recommended. Soak seed for approximately 24 hours prior to planting, and change the water once, whether seeds are to be germinated in a greenhouse or *in situ* outdoors.

If sowing in a greenhouse, germination takes 10–21 days at 60F (15C). If plants are eventually going to be placed outdoors, seed is usually sown in plugs or peat pots, 2 seeds in a 4″ (10 cm) peat pots. Place pots at 68F (20C) until the plants are 2–3″ (5–8 cm) tall.

If sowing *in situ*, sow as soon as weather allows. Steve Houck of Accent Gardens in Boulder, Colo., sows seed in March (sometimes even on a nice day in February); it germinates by April.

Growing-on

Lower the temperature in the greenhouse to 48–50F (9–10C). For indoor production, presoaked seeds can be direct sown in ground beds, placing 2 or 3 seeds per hole. The greenhouse must be warm (around 68F, 20C) for uniform germination. Seedlings may be thinned to one plant at this time. When plants are 2–3″ (5–8 cm) tall, lower the greenhouse temperature to 50F (10C).

When plants are sufficiently tall (approximately 6″, 15 cm), tie them to bamboo canes. Sweet peas can be grown naturally or, as is the case with most cut flower growers, using a modified cordon culture. In the natural system, plants are allowed to grow up the supporting structures, and no pinching is done; this provides more flowers but of smaller size and of less value.

The cordon system is more labor intensive, requiring the selection of a leader stem and subsequent pinching of side shoots; this results in fewer shoots but significantly larger and showier flowers. The selection of a leader stem is done early in the growing-on phase for greenhouse production (plants around 6″, 15 cm tall), and prior to placing plants outdoors for field culture. Pinch to one branch per plant, allowing the leader to grow. Train stems to grow up lengths of twine, bamboo stakes, trellis, or netting. Plants should not be subjected to temperatures below 32F (0C) or above 60F (15C).

Environmental Factors

The major limiting factor to widespread production of sweet peas is their poor tolerance to heat. Temperatures should not exceed 70F (21C) for any length of time, and therefore most outdoor production is limited to areas of cool summers. Greenhouse production can be carried out if temperatures can be maintained around 60F (15C) or lower during the winter. Photoperiod has little influence on flowering; high light levels in the winter, combined with cool temperatures, are recommended. Low light levels result in smaller flowers, bud abortion, and fewer flowers per stem.

Field Performance

For earliest flowering regardless of location, plants should be started and grown on in a greenhouse or cold frame. Two to 3 weeks before planting in the field, the crop should be placed in a cold frame or in a cold greenhouse where temperatures are held above freezing. Once planted outdoors, spacing varies; Ethan Kayes of Kansas City used a spacing of one plant every 4–6″ (10–15 cm). Plants should always be kept off the ground, first by tying them to their stakes and later by weaving the vines in and out of support netting, which will help to reduce powdery mildew and a variety of stem rots. Side shoots may be removed as they appear; in general, when the vines are 3–4′ (0.9–1.2 m), lateral branches should be pinched off. This will produce longer stems with a greater number of flowers per stem. Kayes (1993) allowed that, while the process may seem tedious, they spent only 15–20 minutes 3 times a week.

If started outdoors, thin seedlings to an appropriate spacing, and train either to a single leader or let grow naturally.

Fertilization: Because the soil temperature during most of the production cycle is below 60F (15C), nitrate should be the source of nitrogen. Kayes (1993) recommended no more than 5% of the total nitrogen applied should be in the ammonia form. He used fertilizer with an analysis of 150 ppm N, 100 ppm P, 150 ppm K, 100 ppm Ca, and 50 ppm of Mg. In addition, some production problems, such as bud drop, may be reduced by inoculating the sweet peas with a commercial legume bacteria. Several growers recommend mulching to keep roots cool.

Yield: Steve Houck harvested about 3 bunches of sweet peas per plant (based on 10–15 stems/bunch) and shared a useful hint: "I planted seeds or plants in east-west rows in 5-gallon buckets. The trellis was always on the north side in the buckets, which facilitated the harvest [because] the flowers always [leaned] toward the south. This really made a difference with the speed of harvest and [we had] fewer broken stems."

Greenhouse Performance

Yields are higher and quality is usually better (less breakage, longer, fuller stems) when sweet peas are greenhouse-produced compared to outdoor production. Greenhouse temperatures are more easily controlled than those outdoors. Planting so that a bed is near the cool pads makes sense. Houck started his August planting near the pad, and subsequent plantings were moved further from the pads during the winter. As spring approached, he would pull out the August planting and replant for the last crop in May.

Steve grows sweet peas by the natural trellising method in his greenhouse. Details vary among growers, but his comments are excellent guidelines. He sowed seeds in 200-cell plug trays in September and transplanted about 4 weeks later into Dutch bulb crates. In general, he planted 3 sweet peas per bulb crate and ran them against the wall on netting. The netting was also on the north side of the planting. The drainage was enhanced by sitting the crate on gravel on the greenhouse floor. The sweet peas performed better in the crates than in a ground bed, but many growers use ground beds quite successfully. Houck grew the plants at 48F (9C) during the winter and kept them trellised; they began blooming in late February or March. Temperatures above 55F (13C) resulted in spindly stems and poor flowering.

Houck fertilized with 350 ppm N and 300 ppm K, alternating with a complete 20-18-20. He harvested 4.8 bunches per plant (each bunch this time with 10–12 stems), about 440 bunches during the greenhouse season.

Stage of Harvest

Harvest sweet peas when 2 or 3 flowers start to show color and stems are about 12″ (30 cm) long. Cut the stems or snap the stem with the fingers near the base. Bunch and place cut bunches immediately in floral preservative.

Postharvest

Sweet peas are highly sensitive to ethylene, and use of silver thiosulfate (STS), if available, as a postharvest treatment is highly recommended. Untreated sweet peas last about 3 days; a one-hour pulse of STS at 200 ppm can increase the shelf life to 12 days (Kayes 1993).

Storage: Sweet peas should be sold as soon as possible; however, if storage is necessary, place the stems in a 35F (2C) cooler. If stored more than 24 hours, supply about 12 hours of incandescent light in the cooler.

Cultivars

'America' is an heirloom variety valued for its fragrance and wavy red and white striping.

'Annie Gilroy' produces cerise-pink flowers on 5–6′ (1.5–1.8 m) stems.

'Cupani', purported to be the "original" sweet pea, is extremely fragrant. Plants grow 4–5′ (1.2–1.5 m).

Cuthbertson Floridbunda Mix, a spring-flowerer that grows 5–6′ (1.5–1.8 m), is used for both spring greenhouse production and field production. Reasonably heat tolerant.

Early Multiflora Gigantea series has large, early flowers on 60–74″ (1.5–1.8 m) stems. The series includes 'Chloe' (navy blue), 'Eleanor' (mid-blue), 'Gloria' (deep rose-pink), 'Grace' (lavender), 'Lily' (white), 'Marilyn' (scarlet-cerise), 'Susie' (salmon-pink), and a mix.

Late Spencer types appear in an almost infinite variety of flower form, size, and color, including such classics as 'Noel Sutton', a favorite of the floral industry and a Gold Medal winner in England, with violet, ruffled-edge flowers; 'Mrs. R. Bolton', with large, deep almond-pink flowers; 'Air Warden Improved', with bicolor flowers of red and yellow; 'Leamington', with lilac flowers; and the crimson flowers of 'Winston Churchill'. This group performs best in areas of cool summers.

Mammoth series is a spring-flowering group, considered an improvement over Early Multiflora Gigantea and recommended for its heat resistance, large flowers, and long stems. It comes in a mix of colors ranging from scarlet to rose-pink to navy blue to lavender, plus a mix. Reasonably heat tolerant.

Old Spice series bears highly fragrant flowers on 60–74″ (1.5–1.8 m) stems.

'Painted Lady' is an old sweet pea cultivar. The bicolor flowers are small, but flowers are early and have a pleasant fragrance.

Royal series flowers in spring to early summer, between Early Multiflora Gigantea and the Late Spencer types. Colors include blue, crimson, lavender, navy blue, rose-pink, salmon, scarlet, white, and a mix.

Unwin's Striped Mix is an unusual mix of flower shapes and colors, in blends of scarlet, purple, and deep scarlet.

Winter Elegance series is available in 7 colors: 'White', 'Scarlet', 'Pink-Diana', 'Rose', 'Deep Rose', 'Salmon Cream Pink', and 'Lavender'. Tolerant of cool temperatures (55F, 13C), Winter Elegance is ideal for December–January harvesting, and, if a grower sows by early August, a crop can be sold during the Christmas season.

Pests and Diseases

Seedlings in the field are susceptible to slug damage: be sure to get them off the ground as soon as possible. Thrips and aphids can be destructive. Aphids can carry various viruses, causing symptoms such as mottling, yellowing, and color breaks in the flowers. Root rots (*Thielaviopsis*, *Rhizoctonia*) cause discolored stem bases and eventual decay; control by using sterile media and fungicides.

Grower Comments

"Last year I used the Mammoth mix with good success. Stems averaged 17″ with comparative blossom size. I liked the fast-and-furious crop time: direct seeded April 12, first bunches sold June 23. Ground replanted to sunflowers July 25. Biggest marketing problem was the lack of white blooms in the mix—only about 1%. Although they were trellised, harvest was slow. I sold to distributors for $3 for 12-stem bunch, and $4 on my florist route. The market saturated before the crop diminished, and later sales were slow." Joanne Harrison, Harrison Flowers, Hood River, Ore.

Reading

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Many thanks to Steve Houck for reviewing this section

Lavatera trimestris mallow Malvaceae

annual Mediterranean white, pink 2–2½′/2′ (60–75 cm/60 cm)

Mallow bears some of the most handsome cut flowers in the plant kingdom. The 3–4″ (8–10 cm) wide flowers are normally rose-pink, but some separate colors are available. Given the number of diseases that affect mallow in wet, hot summers, the West Coast of the United States is more suitable for production than the East Coast.

Propagation

Seed sown under mist or sweat tent at 70–72F (21–22C) germinates in 7–14 days. Approximately 0.5 oz (14 g) of seed yields 1000 plants (Nau 1999). Seed is also direct sown after threat of frost. Sow at the rate of 0.5 oz per 100′ (60 g per 100 m) (Kieft 1996). Thin to 12″ (30 cm) apart or more in the rows.

Growing-on

Grow at 60F (15C) night temperature, 65–70F (18–21C) during the day. Fertilize sparingly (50–75 ppm N) with a nitrate-type fertilizer. Overwatering results in proliferation of root rot organisms; maintain plants on the dry side of moist.

Environmental Factors

Photoperiod: Flower initiation and development are not dependent on photoperiod.

Temperature: Warm temperatures result in more rapid growth and flowering; however, cool night temperatures of 55–60F (13–15C) produce higher-quality plants and flowers than nights above 70F (21C).

Humidity: Plants are susceptible to numerous foliar diseases and should not be grown in areas of high humidity (e.g., Southeast) without an aggressive spray program for pests and diseases. Mallow has been trialed at the University of Georgia on 3 separate occasions, and each time has ended in a dismal, disease-ridden and pest-infested failure.

Field Performance

Spacing: Space plants 18–24″ (45–60 cm) apart. Although plants can be spaced as closely as 12″ (30 cm) centers, wider spacing helps reduce disease and insect pressure.

Yield: An average of 10 stems/plant is not uncommon.

Greenhouse Performance

Cut flower production is seldom accomplished in the greenhouse; however, if mallow is produced under cover, grow 12″ (30 cm) apart at 58–60F (14–15C) night temperatures, 70–75F (21–24C) during the day. Fertilize with 100–150 ppm N constant liquid feed or with 300 ppm N once a week.

Stage of Harvest

Cut when the flowers are uncurling or when they have just begun to open. Harvest before flowers lie flat.

Lavatera trimestris 'Mont Rose'

Postharvest

Flowers persist approximately one week; storage is not recommended. Flowers do not dry well.

Cultivars

Beauty Mix produces strong stems in pink, rose, salmon, and white. Quite a popular mix.

'Easter Parade' is 24–30″ (60–75 cm) tall, with 3–4″ (8–10 cm) trumpet-shaped flowers in pink, plum, and white.

'Loveliness' produces bright flowers of carmine-rose.

'Mont Blanc' has white flowers and grows 2–3′ (60–90 cm) tall.

'Mont Rose' bears pink flowers.

'Ruby Regis' has cerise-pink flowers on 30″ (75 cm) stems.

'Silver Cup' has salmon-rose flowers with dark veins.

'Tanagra', a tetraploid cultivar, has 4–5″ (10–13 cm) wide, deep rose flowers on plants 2–3′ (60–90 cm) tall.

National field trials

Mallow was evaluated in the ASCFG's national trials. The following table (Dole 1995–1997) is a summary of the average stem lengths and yields of plants submitted for trialing. These data are averages over a wide geographical range and must be viewed as guidelines only; individual experience may differ significantly.

Cultivar	Year of trial	Stem length (in)[z]	Stems/plant
Pink Beauty	1994	16	7
Rose Beauty	1994	8	3
Salmon Beauty	1996	14	11
White Beauty	1994	20	11

z = multiply (in) by 2.54 to obtain (cm)

Additional Species

Lavatera thuringiaca, a half-hardy perennial, bears rose flowers on 4′ (1.2 m) tall plants. 'Barnsley' is 6–8′ (1.8–2.4 m) tall and bears handsome pink fringed flowers.

Pests and Diseases

Leaf spots, caused by at least 5 fungi, are very common. Leaf and stem blights (from 3 fungi) and rust are common, particularly in warm climates.

Aphids, spider mites, and western flower thrips also enjoy dining on lavatera. In fact, mallow seems to be a preferred appetizer for most beasties in the field and greenhouse.

Grower Comments

"We produce about 500 bunches per annum as field production and will likely do a greenhouse crop later this spring." Martin Connaughton, Wilderness Flowers, Santa Fe, N.M.

"I love the silver cup (pink) lavatera—lovely hollyhock-type blooms that make the older ladies nostalgic. Limited sales, as it is delicate, and doesn't hold up well in transit and in the heat." Susan O'Connell, Fertile Crescent Farm, Hardwick, Vt.

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Liatris spicata gayfeather Asteraceae

bulb, Zones 3–9 North America purple, white 2–4′/2′ (0.6–1.2 m/0.6 m)

Liatris is grown throughout the world and has become a mainstay in florists' coolers and designers' arrangements. In the United States, it is difficult to compete with overseas production; however, fresh liatris will always have a place in the local market. Approximately 30 species and over 10 hybrid forms are known. *Liatris spicata* is most commonly produced, but *L. aspera* (button gayfeather), *L. pycnostachya* (tall gayfeather), and other species are also excellent cut flowers. Using different species and colors helps to extend the harvest time.

Propagation

Liatris corms (often referred to as tubers) may be divided and replanted in the field or greenhouse. Allow to cure (place in warm, well-ventilated area) for 3–7 days after dividing. Small offsets from the corm (bulbils) can also be used for propagation (Choi et al. 1999).

Seed may be sown in soilless media at 75–78F (24–26C) and high humidity. However, the time required from seed to harvest (approximately 12 months) versus from corm to harvest (approximately 8 weeks) should be taken into account when deciding which method is more profitable.

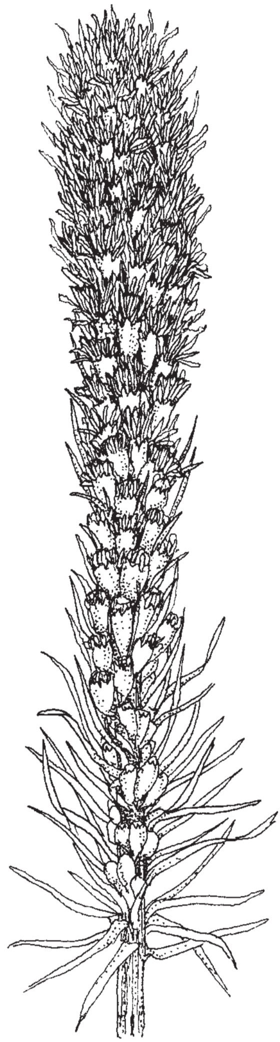
Cuttings from newly emerged stems may be rooted in approximately 21 days. Vegetatively produced corms are more productive than those grown from seed (Salac and Fitzgerald 1983).

Environmental Factors

Temperature: Cold temperatures are essential for flowering in liatris. Storage of corms at 28–36F ($^{-}$2–2C) for 8–15 weeks results in a majority of corms flowering. Prolonged cooling also reduces the time to flower when forced in the greenhouse. For example, corms stored 3 weeks at 32F (0C) flowered in 99 days from planting in the greenhouse, while corms stored 15 weeks flowered in 72 days (Moe and Berland 1986).

Gibberellic acid: Soaking corms for one hour in 500 ppm GA_3 after 5 weeks cold storage resulted in 100% flowering (Zieslin 1985). Use of GA may partially substitute for the cold treatment. Cold treatment/GA dip combinations are particularly useful for early forcing dates.

Ethephon: Preliminary work showed that preplant application of approximately 1000 ppm ethephon resulted in more flowering shoots (Banon et al.



Liatris spicata

1998). High applications may result in many small shoots—useful perhaps for pot plants but not for cut flowers.

Photoperiod: Flower initiation occurs regardless of photoperiod; however, plants respond to LD through accelerated flowering and longer stems. If corms are provided a sufficient cooling period, LD result in accelerated flowering. However, if plants receive a short cooling period, then SD enhances flowering (Berland 1983). Similar interactions with forcing temperature were found if corms were forced in the greenhouse. At cool forcing temperatures of 55F (13C), LD hastened flowering; but at warmer forcing temperatures, photoperiod had little effect, or sometimes SD resulted in more reproductive than vegetative shoots (Evans 1994). For greatest flower acceleration, LD (14 hours) should be applied in the first 5 weeks after emergence of the foliage. Long days also result in greater stem elongation regardless of cooling treatments or forcing (Espinosa et al. 1991).

Studies have shown that continuous LD after emergence reduced the number of flowers per corm (Zieslin and Geller 1983). A short period of SD prior to application of LD may be useful to increase the number of flowers (Espinosa et al. 1991). When all is said and done, it appears that temperature and photoperiod influence flowering mainly during the first 5 weeks of development.

Field Performance

Orientation and terminal bud removal: Research showed that planting the corms on their sides or upside down resulted in a delay of flowering and reduced the length of shoots, the proportion of the shoot bearing flowers, and the shoot diameter, compared to upright corms. Removing the terminal bud delayed flowering by about 11 days but resulted in approximately 3 flowering shoots compared to one for the intact corm (Evans 1992). Some find this to be a profitable method for growing liatris (see "Grower Comments").

Spacing: Plant corms 2–4″ (5–10 cm) apart, about 6–8 corms per ft^2 (65–86 corms per m^2), and 2–3″ (5–8 cm) beneath the soil surface.

Corm size: Small corms result in poor yield and short stems. In general, the larger the corm, the more rapid the flowering and the higher the percentage of flowering corms (Waithaka and Wanjao 1982). Use of 6/8 or 8/10 cm circumference corms is recommended.

Planting and harvest time: Typically, planting in northern climates (Zone 5 and colder) is accomplished in early spring, usually April. Corms planted in April are generally harvested in July, the white forms usually a week or so earlier than the purple forms. Stored frozen corms may be planted in the field at any time; however, differences in yield and stem length occur. The effect of different planting times in Zone 7b, Athens, Ga., is shown in the following table (Armitage and Laushman 1990).

The effect of planting date on *Liatris spicata*.

Month planted	Flw/ corm	First harvest	Harvest duration (days)	Stem length (in)^z	Stem width (mm)^y
Nov	2.2	1 Jul	14	25.0	7.1
Dec	1.2	1 Jul	15	22.8	6.9
Jan	2.0	8 Jul	14	20.0	6.9
Feb	3.4	12 Jul	12	26.5	7.9
Mar	4.5	21 Jul	15	28.9	6.0

z = multiply (in) by 2.54 to obtain (cm)
y = divide (mm) by 25.4 to obtain (in)

Three weeks' extension of flowering occurred when planting was delayed until March, but this was likely due to the increase in number of weeks of cold storage. No difference in harvest duration occurred due to planting date, nor did any differences occur in subsequent years of production.

Longevity: Liatris can be considered perennial (at least 3 years of production) in most of the country. Continued corm growth from year to year results in increased yield and stem length each year. Three years are often needed for best stem length, as the following table of work done at Athens, Ga., shows (Armitage and Laushman 1990).

Longevity of *Liatris spicata*.

Year	Flw/corm	Stem length (in)^z
1	2.7	24.7
2	8.0	30.0
3	15.0	39.2

z = multiply (in) by 2.54 to obtain (cm)

Liatris spicata may be productive for up to 5 years although partial replacement after 3 years is recommended. Work with *L. pycnostachya*, however, showed that maximum production was 3 years (Armitage 1987).

Support: Support is necessary, especially after the first year. Use 2 layers of floriculture netting. If stems topple, flowers turn up and become distorted.

Grading: Stems are generally graded by stem length. Kent Miles of Botanicals by K&V in Seymour, Ill., sells 3 grades: short (20–24″, 50–60 cm), medium (26–36″, 66–90 cm), and long (>36″, 90 cm).

Greenhouse Performance

Use large corms for greenhouse forcing, which may be accomplished year-round. Pot 3 corms in 6–8″ (15–20 cm) pots or in ground beds, using sterilized soils to reduce soil fungi. Maintain soil temperatures as close to 60F (15C) as possible and place under short days (8–10 hours) for first 2–3 weeks after emergence. Fertilize with 100–150 ppm N after foliar emergence. Provide LD (14–16 hours) by extending the day or with nightbreak lighting after SD for maximum stem elongation and most rapid flowering. Use temperatures of 65–68F (18–20C) for forcing. Flowers may be harvested 60–70 days after emergence, depending on light intensity and temperature.

Guideline for Foliar Analyses

At field trials in Athens, Ga., and Watsonville, Calif., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Numbers are averages for both sites and are based on dry weight analysis.

(%)				
N	P	K	Ca	Mg
3.0	0.20	1.73	1.30	0.43
(ppm)				
Fe	Mn	B	Al	Zn
207	170	27	59	90

Stage of Harvest

Inflorescences may be harvested when 3–4 flowers have opened if stems are pulsed in a bud-opening solution. If no preservative is used after harvesting, stems should be harvested when at least ½ the flowers are open. Flowers should be harvested in the morning, preferably before noon.

Postharvest

Fresh: Flowers treated with preservatives persist 7–12 days (Salac and Fitzgerald 1983). The foliage may decline more rapidly. Lower foliage must be removed prior to placing cut stems in solution. Shipping occurs dry or wet.

A 24- to 72-hour pulse in a bud-opening solution that includes 5% sucrose is recommended for tight cut flowers (Borochov and Karten-Paz 1984, Sacalis 1989).

Storage: Stems may be stored about one week in water at 32–35F (0–2C) after pulsing, about 5 days dry (Vaughan 1988). Good air circulation is necessary in the storage room because liatris is susceptible to botrytis. For long-term transport, flowers may be cut in tight bud stage and opened after arrival in a preservative solution or a solution of 1 ppm 8-HQC and 50 g/l sucrose (Nowak and Rudnicki 1990).

Dried: Allow all flowers on spike to open. Strip leaves and air dry by hanging upside down in a well-ventilated area (Bullivant 1989).

Cultivars

The only flower colors are purple and white. Purple colors are best filled by the species itself or 'Floristan Purple'. Other garden forms such as 'Kobold' may be too short (12–18″, 30–45 cm) for cut flower production.

var. *alba* is white and similar to the species except for flower color.

'Floristan White' is excellent, with creamy white flowers. The Floristan series may be raised from seed.

'Gloriosa' is a vigorous purple cultivar but not readily available in the United States.

Additional Species

Liatris aspera (button gayfeather, rough gayfeather) has recently been discovered by growers and retailers. The lilac flowers are rounded and spaced well apart. People also enjoy the greenish to lilac cone-like flower buds; stems may be harvested even before the flowers open. Another excellent North American native, it grows from North Dakota to Ontario and Ohio in the North, and Texas and Florida in the South.

Liatris callilepis is a synonym for *L. spicata*, and plants should be treated the same. Some bulb specialists sell vegetatively propagated plants as *L. callilepis* and seed-propagated material as *L. spicata*.

Liatris pycnostachya (tall gayfeather, Kansas gayfeather) is a taller, coarser plant than *L. spicata*. In trials in Georgia, stems were over 3′ (90 cm) tall and plants persisted only 3 years. 'Eureka', a selection developed by the University of Nebraska and the U.S. Soil Conservation Service, is not nationally available.

Liatris scariosa (tall gayfeather) also has a place in a cut flower program. The flowers are more button-like than *L. spicata* and provide a handsome stem. 'September Glory' has purple flowers that open almost simultaneously; 'White Spires' has white flowers.

Pests and Diseases

Leaf spots (*Phyllostricta liatridis*, *Septoria liatridis*) occur as brown to black spots on the foliage. Fungicides may be applied when plants are young.

Rusts may infect plants. Certain grasses and pine trees act as alternate hosts for liatris rust (*Coleosporium laciniariae*, *Puccinia liatridis*). Destroy infected plants.

Grower Comments

"A wholesaler showed me something called 'spray liatris,' new to him last season. It's apparently regular purple *Liatris spicata* that has been pinched or topped, to force it to form 10–20 side shoots. The story he had was that a grower in Ecuador had problems in a liatris field, so he mowed it down and forgot about it. Later he found that the stems had branched nicely, so he sold it as spray liatris. He was the only source for it. My wholesaler paid $4.50 for a 5-stem bunch. It looked like the stems had been cut about 6–8″ from the ground." Ron Smith, R. Smith Farm, Renfew, Pa.

"I grow the common stuff, which is sold as spicata and alba. I treat them as quasi annuals. I dig them every fall and store the undivided tubers/corms in a refrigerator. The following season I plant every 3 weeks until the end of July. I divide the tubers as I plant, cutting them into halves and quarters if needed. Nothing fancy, but it works well. Figure on 50–60 days from planting to harvest with the later plantings." Paul Shumaker, Never Should Have Started Farm, Bangor, Pa.

"As cheap as liatris corms are, I use them instead of seed. You have to decide if your time and space are worth the wait for flowers from seeds. I plant the corms about 3″ on center." Dave Dowling, Farmhouse Flowers, Brookeville, Md.

"There are two button-type liatris. *Liatris scariosa* (my favorite liatris) has buttons that stand slightly away from the stems on short pedicels. It has rich burgundy buds that open to the typical liatris lilac. *Liatris aspera* has buttons about the same size, only they are more tightly next to the stem; they are more distinctly spiral around the stem, but their buds are lilac as are the flowers." Kelly Anderson, WildThang Farms, Ashland, Mo.

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Many thanks Jack Zonneveld (first edition) and Kelly Anderson, Mimo Davis, and Kent Miles (second edition) for reviewing this section.

Lilium hybrids lily Liliaceae

bulb, Zones 3–7 hybrid origin many colors 3–8′/2′ (0.9–2.4 m/0.6 m)

Lilies, major cut flowers in global markets, are predominantly grown under cover. The huge number of hybrid lilies bred for the cut flower market are sold under 3 group names, Asiatic, Oriental, and LA lilies—taxonomically, *Lilium ×elegans*, *L. speciosum*, and *L. longiflorum* × Asiatic hybrids, respectively. Additionally, hybrids between Oriental and Trumpet (OT) lilies are appearing on the market. So much hybridization has occurred as to render these categories dubious at best (Beattie and White 1993), but they do work as shorthand references to the appearance of the flowers and foliage. In contrast to Oriental hybrids, Asiatic hybrids are earlier to flower, have smaller leaves, are often shorter, and—generally but not always—have upward-facing flowers; they are available in a wide color range and are more tolerant of a range of soil and fertility types. Orientals are taller than Asiatics and have larger flowers (often outward-facing or nodding) with much wider, more succulent leaves along the stem; the flowers are generally more fragrant than those of Asiatics, most of which have no fragrance. The LA hybrids will differ depending on the percentage of Asiatic in the parentage. Some of the original LA's (e.g., Royal series) were too similar to Asiatics and demanded too high a price for the small difference seen in flowering. They have come a long way. Now more varieties are available, with better bud count and prices that are on a par with Asiatics; in fact, some Asiatic customers are switching to LA varieties. Breeding of all lily groups continues unabated, and hybridization among groups continues. Expect many additional combinations to hit the market, and know that, with the constant breeding, hybrid cultivars have only a 3- to 5-year life span in the market.

Propagation

The majority of lilies used for cut flowers are produced either in the Netherlands or in the northwestern United States. Hybridizers propagate by scaling, offsets, and seed.

Lilium 'Acapulco' (Oriental hybrid)

Growing-on

Bulbs should be given a 10- to 20-second preplant dip in a fungicide solution to control the root rot complex associated with lilies (see “Pests and Diseases”). After treatment, immediately plant the bulbs in the field or greenhouse.

Environmental Factors

Temperature: All lilies require cold temperatures for flowering (bulb vernalization). Lilies harvested in late summer and fall are precooled at 35F (2C) for 6–8 weeks in moist peat moss. For later plantings, bulbs may be frozen at 30F ($^{-}$1C) after being precooled. Problems can occur, particularly if bulbs are allowed to dry out. Sealing the bulbs in plastic bags and keeping them in peat moss is a common practice to maintain humidity around the bulbs. Bulbs that have been dried out are susceptible to floral abortion and abscission later in the growth cycle. Small differences in storage temperature are recommended for the different bulb groups. For example, some exporters feel that Orientals should be stored at 29F ($^{-}$1.5C) and Asiatic and LA hybrids at 28F ($^{-}$2C). Most growers don’t have that degree of sophistication in their coolers, thus it is best to allow the distributor to do it. Long-term storage of all lilies at a lower temperature than recommended (25F, $^{-}$4C) can lead to freezer burn, which manifests itself when the plant is being forced, resulting in twisted foliage and buds and sometimes bud abortion.

Koike and Imanishi (1993) determined that precooling bulbs at 33F (1C) for 4–6 weeks followed by storage at 28F ($^{-}$2C) resulted in excellent flower count and quality. They also found that long-term storage of bulbs at 25F ($^{-}$4C) did not affect quality but delayed flowering. Planting frozen bulbs during hot summer months reduced quality.

Light intensity: Lilies require high light for optimal flowering, particularly if forced in the greenhouse during the winter months. Low light levels result in flower bud abortion, abscission (bud drop), and taller plants.

Photoperiod: In Oriental and LA lilies, flowering can be accelerated by LD given to shoots after emergence, but LD are not effective for Asiatic lilies (Roh 1999). Application of LD can substitute for the cold requirement in Easter lilies (*Lilium longiflorum*) (Wilkins 1980), but the relationship between photoperiod and vernalization has not been established for the other groups of bulbs.

Field Performance

Bulb size: Large bulb sizes are preferable over smaller sizes, but differences between species and cultivars occur. Bulbs from 4/5″ (10/12 cm) to 8/9″ (20/22 cm) in circumference are used.

Spacing: Spacing depends on the size of the bulb circumference and the flower group. Generally, bulbs are placed about 4–6″ (10–15 cm) apart, with 2″ (5 cm) of soil above the nose.

Planting time: Lilies are generally planted in the fall. Properly cooled bulbs may be planted year-round, depending on the local weather patterns.

Longevity: Most growers treat lilies as annuals, replanting after each crop regardless of locale. Longevity depends on temperature, fertility, light, and the amount of stem leaves allowed to remain on the plant after harvest. Bulbs planted in USDA Zones 8–10 are always treated as annuals.

Greenhouse Performance

Bulb size: Use large bulb sizes for greenhouse forcing. Mark Hommes of Bulbmark, Inc., recommends the following sizes (all given in centimeters) for greenhouse production:

	Asiatics	Orientals	LA's
spring/summer	12/14	14/16 or 16/18	12/14 or 14/16
fall/winter	12/14 or 14/16	16/18	12/14 or 14/16

Generally, smaller bulb sizes have fewer flowers and are prone to abscission. Bulbs used for greenhouse forcing must receive 6 weeks (LA lilies), 6–9 weeks (Asiatic), and 9 weeks (Oriental) of cold moist treatment (Roh 1999). For later forcings and year-round flowering, bulbs should be frozen at 28–30F (⁻2–⁻1C) after being precooled for 6–8 weeks (De Hertogh 1996). Temperatures should not fall below 28F (⁻2C), or freezing injury to the bulbs may occur.

Arrival: On arrival, bulbs should be planted immediately in sterile ground beds in well-drained media lacking superphosphate at a pH of 6.8–7.0. All cultivars can be forced for the spring (March through June) while some may be forced during the winter (December through March). Four crops may be produced on a year-round basis. In warm months (for year-round forcers) bulbs are often rooted for about 2 weeks in the cases; they are then planted in crates and stacked on pallets in the cooler, where they remain for a week at 50–60F (10–15C) before being moved to the greenhouse. In such cases, pay close attention to the moisture level in the growing medium.

Planting density: Plant bulbs with at least 2″ (5 cm) of media above the nose. Bulbs are planted in the ground or in standard bulb crates. Mark Hommes recommends the following planting densities, based on bulb size.

	Bulb crate		Square foot	
	12/14	14/16	12/14	14/16
Asiatic	22	19	8½	7½
Oriental	17	14	6½	5½
LA	21	18	8	7

Under high temperatures and high light conditions (e.g., summer), the planting density may be increased up to 2 bulbs per crate. Under low light and low temperatures, the planting density may be decreased by 2 bulbs per crate. Many growers plant in bulb crates because bulbs can be preplanted, cooled in place, and then moved to the greenhouse.

After planting in crates, beds, or other containers, lilies should be supported with grow wire. This is especially important during the rapid growth of summer, when the stems of the plants are not as firm as they would be in early spring.

Light intensity: High light is necessary for greenhouse forcing. It is often insufficient during the winter; therefore, supplemental light is useful for areas of low light, particularly in the Northwest. Low light is a major cause of bud drop. Orientals need more light (and heat) than Asiatics and LA hybrids. During high light conditions in late spring and summer, shading may be required.

Temperature: Large fluctuations in temperatures should be avoided; forcing temperatures of 55–65F (13–18C) are optimal. Avoid prolonged temperatures above 70F (21C). During warm seasons, use mulch to reduce soil temperatures.

Nutrition: Fertilize with calcium nitrate and potassium nitrate (2 lbs and 1 lb per 100 gallons water, respectively) once a week (De Hertogh 1996).

Scheduling: Asiatic lilies require 8–12 weeks in the greenhouse, and normally require 30–35 days to flower after reaching visible buds. LA's also need 8–12 weeks. Oriental lilies need 12–16 weeks in the greenhouse and normally require 50–55 days from visible bud to open flower (De Hertogh 1996).

Guideline for Foliar Analyses

At field trials in Watsonville, Calif., foliage was sampled from vigorously growing healthy Asiatic lilies when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis.

(%)				
N	P	K	Ca	Mg
2.0	0.12	2.51	1.09	0.30
(ppm)				
Fe	Mn	B	Al	Zn
63	30	17	60	25

Stage of Harvest

Cut when the first flower is fully colored but not yet open. Open flowers are easily damaged in transit.

Postharvest

Fresh: The vase life of most cut lily flowers is 5–9 days, depending on cultivar and environmental conditions. Son and Suh (1999) found that ethylene production from 'Casa Blanca' lily rises steeply from the fifth day after flowering, also that ethylene production was higher from stamens and pistils than from the tepals. STS pretreatment significantly enhanced vase life (Ranwala and Miller 2002).

Pulsing stems for approximately 20 minutes with a preservative containing STS extends vase life. Longer pulse times with more dilute STS are also effective. After pulsing, place stems in preservative solutions. Placing stems in a combination of STS and 10% sugar for 24 hours followed by placement in 50 ppm GA_3 greatly increases vase life of 'Enchantment' lilies (Evans and Reid 1990).

Vacuum cooling, similar to that used for vegetables, is effective as long as adequate water is sprayed on the flowers prior to their going into the apparatus. No weight loss occurred, and the vase life of the flowers was extended (Brosnan and Sun 2001).

Storage: Lilies may be stored dry at 33F (1C) for up to 4 weeks if initially pulsed for 24 hours with STS and 10% sucrose. Flowers should be wrapped in polyethylene film to reduce water loss during storage. Do not store more than 3 days without chemical pretreatment. For wet storage, flowers are cut at bud stage, conditioned as above, and placed in containers of water at 32–34F (0–1C). Flowers may be stored up to 4 weeks (Nowak and Rudnicki 1990).

Cultivars

The numbers of cultivars are many and continually changing. Consult a reputable bulb distributor who specializes in lilies for cut flowers. A good deal of effort has been expended in the last 10 years to breed dwarf cultivars for pot plant use; stay away from these if stem length is important. Here are some excellent cut flower cultivars planted for bulb production in Holland in 2001, sent in by Ben Kneppers of Zabo Plant and Mark Hommes. The list will be different each year.

Orientals	Asiatics	LA's	Longiflorum
Stargazer	Pollyanna	Bestseller	Snow Queen
Siberia	Navona	Royal Sea	White Fox
Casa Blanca	Brunello	Royal Song	Gelria
Sorbonne	Vivaldi	Algarve	Lorina
Simplon	Gironde	Aladdin Dazzle	Pausini
Acapulco	Elite	Royal Trinity	S. Coeur
Merostar	Dreamland	Dazzle	White Elegance
Marco Polo	Nova Cento	Canillo	Snowcap
Tiber	Prato	Brandizzi	White America
Barbaresco	Marrakesh	Moneymaker	Como

Additional Species

Lilium auratum (goldband lily) is an excellent cut flower. The best variety is var. *platyphyllum*, which has fragrant outward-facing white flowers with a band of gold on the inside.

Lilium formosanum (Formosa lily) has demonstrated excellent stem strength and vigorous growth during field trials in Georgia. The fruit are also large and useful for cutting. Its advantages are ease of growth, ease of propagation (seeds sown in summer will flower the following summer), and stem strength. Disadvantages are lack of "exciting" colors and susceptibility to lily mosaic virus.

Lilium longiflorum (Easter lily) also produces good cut flowers. See the previous table for top cut cultivars.

Pests and Diseases

Root rot complex (*Fusarium*, *Pythium*, *Rhizoctonia*) discolors and rots roots. Bulbs should be dipped in appropriate fungicides for 10–30 seconds prior to planting. Because of the different fungi involved, it is necessary to alternate fungicides or use a combination of fungicides. Check with local extension agents concerning the availability of chemicals.

Botrytis, the lily's biggest enemy, can devastate a crop in no time. Preventative spraying against botrytis is highly recommended, especially in climates with high humidity levels.

Lily mosaic virus was a serious disease, but efforts to clean up propagation stock, particularly on greenhouse-grown material, have paid off, and its incidence has been considerably reduced. Where present, yellowing and mottling appear on the leaves, which may become twisted and distorted. Aphids spread the disease from plant to plant. Discard bulbs if virus is present.

Physiological disorders

Bud abscission: Low light intensity is the most common reason for flower bud abortion, but not the only one. Improper cold storage conditions or lack of moisture in the first week after planting can cause similar problems. When cold bulbs are planted in warm soil, it is critical to have ample water in the ground. Do not allow the soil to dry out. Also, be certain bulbs are completely thawed after moving out of frozen storage. Do not touch them if they are still even slightly frozen. It is even better to open the bags or crates and let them sit in a cool place for a couple of days; a little sprouting is not a problem.

Leaf scorch: Leaf scorch is normally associated with fluoride toxicity. Maintaining media free of fluoride and a pH near 7.0 reduces the problem. Beside fluoride toxicity, leaf scorch can become a problem when lilies are grown at very high temperatures and during the winter months in greenhouses when bulbs are used from the previous harvest. Generally, leaf scorch occurs when the plant evaporates more water than it is able to take up through its root system. Larger bulbs are more susceptible then small bulbs. Certain varieties are more tolerant of leaf scorch than others. To help reduce problems with leaf scorch, spray with calcium chloride (1%), lower day temperature in greenhouse, and, if possible, preroot your bulbs for at least 2 weeks at 53F (12C) before moving containers or trays into the greenhouse.

Flower abortion and flower abscission result from high temperatures and low light intensity, respectively.

Grower Comments

"We are growing lilies in bulb crates in the greenhouse, and they have come out great! We figured cheaper than pots, maybe less soil—6–8 bulbs per crate. We grew 'Black Beauty' for Valentine's Day, and they came up great—5 buds, with [stems] 48″ on average. We will be trying more like this in just a few weeks!" Michelle Smith, Blossoms, Inc., Fletcher, N.C.

"We don't have problems with petals dropping on their own, but petals will snap off if bent backward, and they do show crease lines and bruises if handled roughly. Orientals are much tougher and can take the rough treatment some florists give them. Sell your lilies in bud stage, and tell the customers to treat them carefully when selecting from your display." Dave Dowling, Farmhouse Flowers, Brookeville, Md.

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Many thanks to Gus De Hertogh, John Dole, and Mark Hommes for reviewing this section.

Limonium statice Plumbaginaceae

annual/perennial

Statice is a mainstay of the cut flower industry, grown worldwide in fields and greenhouses, and since South American growers saw the sense in adding specialty flowers to their roses and carnations, statice has grown in volume. Many species are used in the cut flower trade, the most common being annual statice (*Limonium sinuatum*) and the free-flowering statice hybrids. As more statice is grown, marginal species such as *L. tetragonum* (syn. *L. sinense*; confetti statice) are gaining favor as cut flowers. The popularity of German statice (*Goniolimon tataricum*, which see) has declined with the advent of *Limonium* hybrids.

Limonium hybrids statice Plumbaginaceae

annual/perennial

These are the backbone of statice today. They are often, but not always, hybrids between *Limonium latifolium* and *L. bellidifolium* (Caspia statice) and produce outstanding lacy flower heads on spikes up to 4′ (1.2 m) tall. Large-scale production is the norm, particularly of the Misty series, in the United States, Colombia, and Ecuador. Plants persist 3–4 years without problem, and flowering occurs at 60–65F (15–18C) nights. Plants of the Misty series produce up to 20 stems/plant about 4 months after planting (Jenkins 1992).

Following the work of Garner and Armitage (1996), in which directed sprays of 400 ppm of GA_3 influenced yield and accelerated flowering, gibberellic acid is routinely used to promote flowering and substitute for LD in the winter. Applications of 500 ppm are equally effective. Plants should be sprayed at weekly intervals for 3–4 weeks, starting when plants are young, or once growth begins after a harvest. GA can have unforeseen consequences, so do a little experimenting on your own before spraying the entire crop.

In Central America, the bunch weight for these types is 12.5 oz (350 g). The stem length standard for ‘Beltlaard’, Diamond series, ‘Misty’, and ‘Ocean Blue’, is 30″ (75 cm); in California, bunches of ‘Misty’ can be longer than 40″ (1 m).

Postharvest life of hybrids in plain water is usually only 4–5 days, although using a wetting agent in the water can be helpful (Burge et al. 1998). Sugar is the additive of choice. Work with ‘Fantasia’ showed that 20 g/l of sucrose, combined with a quaternary ammonium disinfectant solution, such as Physan™, extended vase life to 17 days and promoted bud opening (Doi and Reid 1995). A 12-hour pulse treatment of 100 g/l sucrose (with Physan™) partially substituted for the continuous sugar supply. Ichimura (1998) found that pulsing with 20g/l sucrose alone had little effect but was effective if combined with 10 mM α-aminoisobutyric acid (AIB).

Malodorous smell is a continual problem. *Limonium altaica*, *Goniolimon tataricum* (German statice), and even the hybrids produce a smell some say reminds them of cat urine, or something equally unpleasant. A few olfactory-challenged people find that the hybrids are not malodorous at all, while others run away holding their noses. This does little to enhance sales. The Emille Group (*L. altaica*) and the Misty series seem to be less offensive than the others. Cutting stems when only about 30% of the flowers are open and placing in an opening solution (such as sugar and a biocide) in a well-ventilated room before shipping reduces the odor. The smell will be worse if botrytis is present, or if the flowers are old, or if they’re cut and packed in bunches with humidity. According to industry specialist Gay Smith, some supermarkets have banned statice from bouquets because the stuff stinks so badly (heats up and sweats in the bunch or gets botrytis from the water sloshing in the wet pack, wrapped in nonperforated bouquet sleeves).

Cultivars

Representative hybrids include 'Beltlaard' (less upright than 'Saint Pierre'), 'Fantasia', and 'Saint Pierre', and the Misty series. The Supreme varieties of the Misty series were bred in southern California for superior performance in southern climates, but flowering appears to be especially strong in cool conditions; they produce 6–7 cut flowers the first year, 10 or more the second. Misty colors include blue, pink, rose, and white.

'Ocean Blue' is compact, growing 3–3½′ (0.9–1.1 m) with light blue flowers. Appears to be a good grower with many useful lateral stems.

'Supreme Bluenight' produces many stems of blue flowers.

'Topian Blue' and 'Splash Blue' are relatively new to the statice market.

Limonium perezii

Perez statice, seafoam statice Plumbaginaceae
perennial, Zones 8–11 Canary Islands blue, white
1–2′/1′ (30–60 cm/30 cm)

Seafoam statice has large, leathery basal leaves and produces coarse, blue and white inflorescences. According to Gay Smith, it is a slow wholesale seller because people are looking for more stems per bunch, especially for bouquet work; *Limonium perezii* has compound laterals, so it only takes 3–6 stems to make a beefy bunch. Drainage must be excellent if plants are to be perennial, which they are to Zone 7 with mulch; and they can be grown as annuals in most of the United States (they are almost weeds in southern California).

Propagation

Seed germinates in 5–14 days if planted at 70–72F (21–22C). Purchase clean (rubbed) seed. Although a little more expensive, clean seed facilitates seeding and reduces frustration. If seed is soaked in water for 24 hours prior to sowing, germination is enhanced (Kieft 1996). Approximately 0.12 oz (3.5 g) of seed yields 1000 seedlings. Division may be tried, particularly if plants are perennial.

Growing-on

Transplant to cell packs or 4″ (10 cm) pots as soon as seedlings can be handled. Fertilize with 75–100 ppm N using potassium nitrate or a complete fertilizer and maintain temperatures at approximately 65F (18C). Plants may be placed in the field as soon as threat of frost has passed. Expect 8–10 weeks from seed to field transplant.

Environmental Factors

Likely LD and warm temperatures promote flowering, similar to annual statice (*Limonium sinuatum*, which see). If sown early, plants produce some flowers the first year.

Field Performance

Plants perform better in Mediterranean climates than in eastern or southeastern climes. First-year results from trials at the University of Georgia resulted in only 5 stems/plant, averaging 20″ (50 cm), the minimum stem length for bouquet work. Plants did not overwinter.

Guideline for Foliar Analyses

At field trials in Athens, Ga., and Watsonville, Calif., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Numbers are averages for both sites and are based on dry weight analysis.

(%)				
N	P	K	Ca	Mg
3.28	0.42	2.26	0.61	0.55
(ppm)				
Fe	Mn	B	Al	Zn
105	78	17	71	181

Stage of Harvest

Harvest when approximately 80% of the flower head has opened.

Postharvest

Fresh: All statice is sensitive to ethylene and benefits from pretreatment with STS or 1-MCP. A vase solution containing 10% sugar pulse (12 hours) is highly effective in extending the vase life (Nell and Reid 2000). Flowers persist 10–14 days if properly treated and placed in fresh flower food.

Storage: Plants may be stored dry for 4–5 days at 35–38F (2–3C).

Dried: Flowers may be air-dried upside down in a well-ventilated room.

Cultivars

'Atlantis', a seed-propagated cultivar, has darker blue flowers than the species. Plants grow 2–3′ (60–90 cm) tall.

Limonium sinuatum annual statice Plumbaginaceae

annual Mediterranean many colors 18–24″/2′ (45–60 cm/60 cm)

Among the most popular cut flowers in the world, annual or sinuata statice continues to be produced in vast quantities. Breeding of annual statice has provided myriad hybrids of various strains and colors, suitable for both drying and fresh use. Flowers may be grown everywhere in the United States, although California and Florida are the leading producers.

Propagation

Approximately 10,000 clean seeds/oz occur. At "normal" germination percentages, 0.25 oz (7 g) produces 1000 seedlings (Nau 1999). Clean seed is more expensive than unprocessed seed but is easier to handle and germinates more rapidly. Seed should be sown and covered lightly or left exposed to ensure that light reaches the seed. Seed provided with 70F (21C) germinates in 5–14 days, depending on cultivar, and may be transplanted in 3 weeks. Large plugs or transplants may be placed in the field 6–8 weeks after sowing.

Growing-on

Provide 60F (15C) temperatures for 1–2 weeks after cotyledons emerge to encourage rooting. Plants flower more rapidly and are of better quality if subjected to a cold treatment (vernalized) when young and should initially be grown at temperatures of 50–55F (10–13C) (Krizek and Semeniuk 1972). This is best accomplished in a cool greenhouse, although work using 8 weeks in a 40F (4C) illuminated storage area was also successful, as long as light was present (Katsutani et al. 1998). Twelve hours of photosynthetic light (about 300 fc) should be provided in the cold chambers (Shillo 1976). The seedling is most responsive to vernalization; cold treatment of seeds is ineffective. Plants should be cooled from the cotyledon to the 5-leaf stage, which requires 5–8 weeks, although waiting until 15 leaves have expanded before cooling was equally effective (Katsutani et al. 1998). Some growers germinate seed in the greenhouse and then place seedling or plug flats in cold frames for cool temperature treatment. As daylength increases, the length of the cold treatment can be decreased. If seedlings are vernalized under LD, however, flowering is also enhanced (Shillo 1976). Fertilize seedlings with 50–100 ppm N and K.

Environmental Factors

Photoperiod: Long days promote earlier flowering, greater percentage of flowering plants, and higher yields; they are most effective after plants have been cooled and are actively growing. The optimum photoperiod is greater than 13 hours (Shillo and Zamski 1985), but around 12 hours seems sufficient. This is borne out by the fact that LD have little effect in the tropics. Growers in Ecuador

Limonium sinuatum
'Sunset Blue'

and Colombia, however, routinely light their crops in the field. If LD are provided during the seedling stage, the length of the vernalization may be reduced. Long days without vernalization are relatively ineffective. Long days applied to actively growing plants induce a greater percentage of flowering plants regardless of temperature compared with short days, but LD applied to seedlings have little effect if not accompanied by cool temperatures. Plants will still flower under SD of winter, but yield, flowering time, and stem length may be negatively affected.

Temperature: A cold treatment hastens flower initiation. High temperatures promote leaf initiation, leaf growth, and stem elongation but inhibit flowering. This explains why nonvernalized plants placed under warm field conditions grow well but have poor yield. Researchers at Beltsville, Md., placed seedlings in controlled temperature chambers for 6 weeks (Krizek and Semeniuk 1972). They showed that plants grown at 80/75F (29/24C) day/night temperature formed a vegetative rosette that persisted approximately 4 months. Day/night temperatures of 70/64F (21/18C) resulted in only 20% flowering plants, but temperatures below 65F (18C) caused flower initiation in all plants. The optimum temperatures were 60/55F (15/13C) day/night. In general, blue-flowered cultivars have the greatest cold requirement (lower temperature and longer duration), followed by lavender, pink, white, and yellow (Semeniuk and Krizek 1973).

In summary, high temperature during the seedling stage is the chief constraint to flowering. Temperatures of 50–55F (10–13C) should be applied at the seedling stage for 3–8 weeks depending on season and cultivar. This treatment may occur naturally in the field with spring-planted crops or may be applied artificially in coolers for summer-planted crops.

The length of precooling varies with the season. This was shown in Israel, where plants are cropped throughout the winter; in fall plantings, a maximum flowering response was obtained with 8 weeks of precooling, but in early spring plantings, only 3 weeks precooling was necessary (Shillo 1977). The reduction in precooling time in the spring plantings can likely be attributed to cooler night temperatures when plants were young and longer photoperiods as plants matured.

After vernalization is completed, high temperatures speed flower development but should not be applied immediately after planting. In practical terms, this means that precooled plants should not immediately be transplanted to 80–90F (27–32C) fields; transplanting in the spring is recommended. An optimum temperature regime for early and profuse flowering is 73/60F (23/15C) day/night temperatures (Semeniuk and Krizek 1973).

Gibberellic acid: Gibberellic acid (GA_3) has been used to reduce the need for precooling in annual statice. Work in Florida and Israel has shown that application of GA_3 partially overcomes the precooling requirement. The following table (Wilfret and Raulston 1975) shows the influence of GA on 'Midnight Blue' statice; notice that it is relatively ineffective if the precooling requirements have been satisfied.

The effect of GA on flowering of 'Midnight Blue' statice.

No. of days of precooling	GA applied	Plants in flower (%)
0	no	40
	yes	83
6	no	42
	yes	94
12	no	72
	yes	100
28	no	95
	yes	100

The table shows that as more precooling was applied, GA became less effective, but with 0–12 days of precooling, the application of GA was effective in promoting flowering. GA does not appear to be useful if plants have had no precooling or if precooling has been saturated.

GA is routinely applied to most statice, including the hybrids. The optimum application time appears to be 12 weeks after seeding (Wilfret and Raulston 1975) or about 3 weeks after planting (KunYang et al. 1995); the optimum concentration is 500 ppm. GA should not be applied when plants are budded. An application in the amount of 10 ml/plant is effective. Work by Wilfret and Raulston (1975) showed that 'Iceberg' and 'Midnight Blue' flowered in 134 and 160 days from seed, respectively, with a GA application, but required 238 and 229 days without GA.

Field Performance

Soil: Annual statice prefers soil high in lime: pH 6.5–7.5.

Spacing: Space either on 1′ (30 cm) centers or 10 × 12″ (25 × 30 cm). Plants may be grown in rows that are 12–14″ (30–36 cm) wide, allowing for 2–3 staggered rows per bed. Space plants 14–16″ (35–40 cm) apart down the length of the bed. Wider spacing is also effective. In India, the greatest plant height and spread occurred at spacings of 2 × 1′ (60 × 30 cm), the closest spacing in the work (Ramesh and Kiranjeet 1997). Neither support nor pinching is necessary.

Scheduling: The first harvest occurs in the South approximately 3–5 months after sowing; in the North 4–6 months may be necessary. Place in the field after danger of frost has passed but before night temperatures rise above 55–60F (13–15C). In northern California, plant from October to January for April to October production. Harvest is heavy for the first 4–6 weeks and levels off as plants mature.

Plants may be planted at 2-week or monthly intervals; precooling (see "Environmental Factors") or gibberellic acid application is recommended. The longer days of summer reduce the need for such additional inputs, but in areas where temperatures seldom go below 55F (13C), the use of GA is warranted, particularly in shorter daylength times of the year. Plants will begin to flower 6–10 weeks after transplanting. In warm winter areas, continuous cropping may be accomplished by sowing at 2- to 4-week intervals.

Yield: In northern California, approximately 20 stems/plant are produced from April to October. This translates to approximately 25,000 bunches (12 stems/bunch) per acre from 15,000 plants. At Watsonville, Calif., stems were harvested from week 14 to week 39 (April to September), but the highest yield was between weeks 21 and 26 (week 25 alone yielded 12,000 bunches); distribution of total yield by month is shown in the following table.

Month	Yield (%)
Apr	5
May	22
Jun	26
Jul	20
Aug	14
Sep	13

Research at the University of Georgia using hand-harvest methods resulted in 22 stems/plant between mid June and August with the Fortress series. Distribution patterns from these plantings are shown in the following table. The results are similar, although harvesting lasts for many more weeks in California than in Georgia.

Week no.	Yield (%)
23	7
24	8
25	13
26	15
27	14
28	13
29	13
30	10
31	7

Statice is often sold by the pound, and yields of 10,000–40,000 lbs/acre (2100–8650 kg/hectare), depending on cultivar and environment, may be expected. In Central America, grading is done by weight, and the standard for grading is the blue/purple at 450 grams/bunch. Other colors are bunched to appear to be the same size as purple bunches but not specifically the same weight. The idea is that it would take a ton of stems to get 450 grams of pink or yellow. Growers use the blue as a benchmark size.

Stem quality: At Georgia, stem lengths ranged from less than 12″ (30 cm) to greater than 30″ (75 cm) for the Fortress series. Longer and thicker stems occurred during initial harvest dates compared with later harvests. In general, blue-flowered stems were thicker than average, yellow-flowered stems thinner than average.

Greenhouse Performance

Space seedlings 10 × 10″ (25 × 25 cm) and grow in a greenhouse at 50–55F (10–13C) to initiate flowers (see "Environmental Factors"). Cool temperatures must be maintained for at least 6 weeks. After the cool treatment, temperatures may be raised to 60/70F (15/21C) night/day. In the absence of cool temperatures, a spray of 500 ppm gibberellic acid may be applied when plants are 6–8″ (15–20 cm) across. Maintain plants under photoperiods of approximately 16 hours, using incandescent nightbreak lighting or daylength extension. Fertilize with a nitrate-N fertilizer at 100 ppm each irrigation when plants are grown cool, and raise fertility levels when temperatures are raised.

Plants sown in November and January will flower in March and May, respectively, depending on cultivar and location.

Guideline for Foliar Analyses

At field trials in Athens, Ga., and Watsonville, Calif., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis. Numbers shown are the average of 'Heavenly Blue' (Georgia) and 'Fortress Blue' and 'Fortress Yellow' (California).

(%)				
N	P	K	Ca	Mg
3.5	0.66	3.11	0.57	0.92
(ppm)				
Fe	Mn	B	Al	Zn
159	117	20	105	70

Stage of Harvest

Harvest when the individual flowers are mostly open and showing color. The white of the flowers (petals) should be visible and the rest of the flower color (sepals) well developed. The most common packing color assortment for U.S. wholesalers is 75% purple, 5% blue, 5% pink, 5% lavender, 5% yellow, and 5% white. Peach, with its high color variation, is less important. "Rainbow statice" bunches sell well as consumer bunches, but growers say they need about 20% higher prices to cover the bunching costs.

Postharvest

Fresh: Flowers persist approximately 2 weeks in water without any particular care. Stems must be dry prior to shipping, or botrytis will take hold.

Storage: Stems may be stored dry at 36–41F (3–5C) for 2 weeks.

Dried: Strip the large, fleshy leaves and hang upside down in a warm, well-ventilated area. The drying barn must be dark, or the color of stems and flowers will rapidly decline. Stems remain green if dried too rapidly.

Cultivars

Many cultivars are available, and more are developed each year. Tissue culture sinuata remains a hot item; all vegetative material is more expensive and recommended for protected culture only. Wholesalers usually have no problem selling to retailers, who will pay considerably more for tissue-cultured cultivars, until the market floods in with cheap material.

Arrow series is one of a relatively new group of vegetatively propagated annual statice, mostly available from tissue culture. Plants grow up to 3′ (90 cm) tall and bear 4–5″ (10–13 cm) flower heads. Available in dark blue and lavender.

'Blue River' has intense blue flowers with somewhat shorter stems than Fortress.

Blue Waves Mixed and Pink Waves Mixed contain shades of each color on heavy-flowering plants.

Compindi series is useful for fresh or dried production. Colors include white, deep blue, light blue, and rose.

Excellent series comes into production more rapidly than others, and uniformity of its many colors is excellent. Colors include deep yellow, light blue, purple, sky blue, and shades of rose, pink, and salmon.

Forever series includes blue, gold, lavender, and rose and is used for both fresh and dried production. 'Forever Gold', 'Forever Lavender', 'Forever Moonlight', and 'Forever Silver' are available.

Fortress series has long been popular for cut flower production. Individual colors are apricot, dark blue, light blue ('Heavenly Blue'), purple, rose, white, and yellow, most with a white center cup. Interestingly, some retailers have been known to reject Fortress bunches, thinking the inner white petal cup is some kind of problem.

Friendly series has round stems rather than the more common flat stems of most sinuata. 'Friendly Yellow' is now available.

'Kampf's Blue Improved' has rich, dark blue flowers.

'Lavandin' bears clear lavender flowers and appears to resist sunburn better than other cultivars.

'Market Grower Blue' produces tall, uniformly blue flowers.

'Midnight Blue' has uniform, rich, dark blue flowers.

New Era series (vegetatively propagated) consists of plants with 4–5″ (10–13 cm) flowers with good color consistency on 3–3½′ (0.9–1.1 m) stems. Flowers in about 8 weeks. Available in light pink ('Appleblossom') and lavender.

New Wonder series (vegetatively propagated) is a triploid form that produces large 5″ (13 cm) flower heads on strong 3–3½′ (0.9–1.1 m) stems. High yields and good disease resistance have been reported. Available in dark lavender, lavender, pink, pink-rose bicolor, and deep pink.

'Oriental Blue' has been a standard cultivar for cut flower production for many years. The rich, deep blue color is consistent and uniform.

Pacific Strain is available as a mix or in individual colors, including 'American Beauty' (deep rose), 'Apricot Beauty', 'Gold Coast' (deep yellow), 'Heavenly Blue', 'Iceberg' (white), 'Roselight' (rose-pink), and 'Twilight' (lavender-pink). Names change like the weather. Some growers, particularly in the Northwest, claim that yield for Pacific Strain is significantly higher than for Fortress. Sometimes known as the Standard series or the Splendor series.

'Pastel Shades' is a mixture of lavender and purple shades on 2–3′ (60–90 cm) stems. 'Sophia' consists of rose and pale pink flowers and is part of the series.

Petite Bouquet Mix is short (12″, 30 cm) but is used as a cut. Drought tolerant. Mix includes blue, white, salmon, and yellow.

'Purple Monarch' bears rich purple flowers.

QIS series (formerly Sunburst series) has proven to be excellent for greenhouse and field production. The series has uniform colors, is fast-flowering, and grows 2½′ (75 cm) tall. Colors include apricot, dark blue, pale blue, lilac, purple, red, rose (earlier than other cultivars), white, and yellow. Sometimes referred to as QIS Rainbow Formula Mix.

'Rose Strike' has rose-pink shades and a loose flower habit.

'Sirima' is a mix of pale pink to mauve to clear rose to lilac and lavender. Grows to 24″ (60 cm).

Soiree series is relatively new and includes apricot, rose, purple, light blue, white, deep blue, and a mix.

Splendor series appears to be a "mix and match" selection of existing (see Pacific Strain especially) but perhaps improved cultivars. As far as we can determine, 'Carmine Rose' is 'American Beauty', 'Chamois' is 'Apricot Beauty', 'Dark Blue' is 'Kampf's Blue', 'Golden Yellow' is 'Gold Coast', 'Midnight Blue' is 'Market Grower Blue', 'Rosea Splendens' is 'Roselight', 'Sky Blue' is 'Heavenly Blue', and 'White' is 'Iceberg'. And of course, there is a Splendor Mixed.

Sunset series bears flowers in fall colors, shades of blue, yellow, orange, salmon, rose, and apricot.

Supreme series produces uniform stems to about 26″ (66 cm). Colors include apricot, deep blue, light blue, rose, white, and yellow.

'Swan Lake', a selection from 'QIS White', bears double white flowers.

Turbo series is known for its pastel shades, early flowering habit, and long stems. Plants grow 2½′ (75 cm) tall. Colors are blue, carmine, peach, purple, white, and yellow.

Wings series is a tissue-cultured series of statice recommended for greenhouse, unheated greenhouse, or plastic tunnel only as long as plants are kept free from frost. More botrytis resistant and quite popular in Europe and South America. Excellent colors, strong stems, high yield, and more flower per leaf ratio make this a fine series. Nearly 24 named cultivars are available, such as 'Blue

Wings', 'Cherry Wings', 'Cobalt Wings', 'Polar Wings Improved', 'Purple Wings', 'Royal Wings', 'Silver Wings' (white flowers with a yellow crown), 'Starlight Wings', and 'Velvet Wings'.

National field trials

Annual statice has been evaluated since the inception of the ASCFG's national trials in 1994. The following table (Dole 1995–2000) is a summary of the average stem lengths and yields of plants submitted for trialing. These data are averages over a wide geographical range and must be viewed as guidelines only; individual experience may differ significantly.

Cultivar	Year of trial	Stem length (in)^z	Stems/ plant
Compindi Deep Blue	1994	18	11
Compindi Light Blue	1995	13	10
Compindi Rose	1994	14	18
Excellent Formula Mix	1995	17	14
Excellent Light Pink	1995	17	15
Fortress Apricot	1998	19	11
Fortress Dark Blue	1998	18	11
Fortress Heavenly Blue	1998	19	12
Fortress Purple	1998	17	12
Fortress Rose	1998	19	11
Fortress White	1998	21	12
Fortress Yellow	1998	21	15
Mello Yellow	1999	13	7
Pastel Shades	1994	14	12
QIS Dark Blue XL	1995	16	20
QIS Soft Pastel Shades	1995	15	16
QIS White	1994	22	16

z = multiply (in) by 2.54 to obtain (cm)

Grower Comments

"We have grown the QIS variety with good success, both as a fresh cut and as a dried flower. Colors that are most requested [in Michigan] are dark blue, sky blue, rose (really more a hot-pink, raspberry color), white, and more and more requests for yellow. We have had it bloom from mid July until the beginning of October. Have had it shut down on us as early as mid August, usually when it gets cooler and rainy. We have grown it in rows with 12–14″ spacing." Shelley McGeathy, McGeathy Farms, Hemlock, Mich.

"I have had very spotty results with my statice. I have read it likes it on the dry side, but last year, when it rained every day and was much wetter and cooler than most, I had the best year ever! I believe tarnished plant bug has been the cause of a lot of my statice troubles, and last year there were fewer TPB, hence more blooms." Susan O'Connell, Fertile Crescent Farm, Hardwick, Vt.

"Favorite color is the market rose. I am using last year's now for mixing into Valentine and Mother's Day bouquets. It starts blooming here in New Hampshire, Zone 5, about mid July and I cut it up to frost. I get about 5 good harvests, which means going down one side of the 4′ wide row and cutting all that is open. Then up the other side. It's backbreaking, somewhat, but I sell a lot of it bunched up all by itself." Heather Warren, Warren Farm, Barrington, N.H.

"Statice needs an adequate cool period to get good stem length. We seeded ours February 16 in a warm greenhouse, got it hardened off and transplanted to the field early, while the weather is quite cool. We usually try to have it in the field by late March or early April here in Zone 6. If you have it out real early and there's a *real* cold snap coming, you can cover it with Remay™ till the weather is back to normal. We plant it into black plastic mulch, and this year we plan on pulling up the mulch about 4 weeks after transplanting, while we still can without yanking the plants out of the soil. I always hated this crop because I could never make money on it consistently, but since I learned about the cool thing, I like it a lot." Ralph Cramer, Cramers' Posie Patch, Elizabethtown, Pa.

Limonium tetragonum

confetti statice, yellow statice — Plumbaginaceae

annual — China, Korea, Japan — yellow, white — 2–3′/2′ (60–90 cm/60 cm)

This upright yellow statice, long known as *Limonium sinense*, has been grown on and off for years, but it never seems to have caught on. It is very different from the yellow sinuata statice and is dyed all sorts of colors. Plants hit the California market in a big way in the late 1980s but have never been very good sellers in the U.S. market. It is one of the most handsome species in the trade but lacks vigor and is susceptible to disease. Relatively little is grown in South America.

Propagation is from seed or tissue culture and growing-on is similar to German statice (*Goniolimon tataricum*, which see). In Spain, greenhouse night temperatures of 55F (13C) advanced the onset of flowering by 6 weeks compared to an unheated greenhouse and also resulted in increased inflorescence width (Lopez et al. 1996). Provide a minimum of 18″ (45 cm) centers to minimize disease pressure.

Cultivars

Diamond series is a new form, and its diversity of color (not just yellow) suggests that it is a hybrid. Plants appear to have a low susceptibility to mildew and other fungi, allowing for field production as well as greenhouse growing. Yearly productivity is 20–25 stems/plant. Best planting time in the greenhouse is from November until March; outdoor plantings can begin as soon as the risk of night frost has passed. Available in white, yellow, pink, deep pink ('Festival Diamond), and light pink ('Granada Diamond').

'Stardust' performed excellently in field trials at the University of Georgia, and it has been grown successfully in California and Ecuador. The handsome flowers are light yellow with white eyes, and plants are perennial at least as far as Zone 7b (north Georgia). Harvest begins in early June and continues until early August. First-year yields at Georgia were 10 stems/plant at 13.5″ (33.8 cm) in length; the second-year yields were 20 stems/plant and stem length was 18.7″ (46.8 cm). In the third year, yield fell back to 10 stems/plant, but stem length increased to 20.1″ (50.2 cm).

Additional Species

Limonium altaica is best known for its toughness even in outdoor beds, and for its relative resistance to downy mildew. Plants are not as well known in the United States, mostly because there are so many other statice available, and it may seem there is no overwhelming reason to seek out this species; however, plants tend to hold their color better than the Mistys or 'Beltlaard'. 'Emille', 'Pink Emille', and 'Tall Emille', bred by Miyoshi in Japan, are excellent older cultivars, although a little short, producing rosy lavender, pink, and lavender flowers, respectively. 'Emille' and 'Pink Emille' grow approximately 2–2½′ (60–75 cm) tall; 'Tall Emille' reaches about 3′ (90 cm) in height. Standards for the Emille cultivars appear to be at least 2′ (60 cm), or a 9 oz (250 g) bunch, and their flowers give off a less obnoxious odor than many statice. 'Montana' grows to about 3′ (90 cm) and is suitable for outdoor production, with an annual yield of 20–30 stems/plant; the dark blue flowers do not shatter after harvest, and plants do not appear to be daylength sensitive.

Limonium bellidifolium (syn. *L. caspium*) is the true Caspia statice. Seldom used as a cut any more, although it has been an important parent in hybrid statices like the Misty series. 'Dazzling Blue' (also known as 'Spangle') has light blue flowers and grows to a little over 3′ (1 m).

Limonium bonduellii are half-hardy annual or perennial plants. Flowers are yellow, borne on 1–2′ (30–60 cm) tall flower stems and known by their spiny bracts. Plants are marginally tall enough to be included in a cut flower program. Sometimes yellow-flowering plants listed under *L. sinuatum* are actually this species.

Limonium gmelinii (Siberian statice) bears lilac-blue flowers on 2′ (60 cm) stems. Hardy to Zone 4 (maybe 3), flowers are formed in mid summer starting the second year.

Limonium otolepis produces sterile and flowering branches from a tight rosette in spring and summer. Flowers are lavender to blue. In Italy, 17 flowers per plant were recorded the second year from seed. Monthly yield of 8 flowers per plant in July of the third year was noted. A 16-hour photoperiod had little effect on earliness to flower or on yield (Guda et al. 1998).

Limonium peregrinum (syn. *L. roseum*) does best in a greenhouse. Plants have been grown in New Zealand but not many other areas. It is a little short, but the pink to rose flowers are beautiful and eye-catching. The inflorescence, comprised of many individual flowers, remains decorative long after the petals have deteriorated. Vase life is very long, up to 40 days in water. Sugar increased the number of flower buds that opened and the length of time open flowers were present on the inflorescence, but reduced vase life to 20–25 days (Lewis and Borst 1993). Storage also reduces vase life.

Limonium suworowii (syn. *Psylliostachys suworowii*; rat tail statice, Russian statice) is an excellent flower for drying, with a terminal spike of lavender flowers up to 1′ (30 cm) long. The flower stems are 2–2½′ (60–75 cm) long. Harvest in full flower (no less than 80% open) and hang upside down with leaves remaining. Plants are best grown in a cool greenhouse in the Southeast but may be produced in the field in winter in Florida and California. They are not tolerant of warm summer conditions and should be avoided as an outdoor summer cut flower in the Midwest and Southeast.

Pests and Diseases

Botrytis, a serious problem, is exacerbated by high humidity and/or cool temperatures. Biological control from *Tricoderma hamatum* in combination with fungicidal application is effective (Diaz et al. 1999). Using warm water heating around the plants usually eliminates fungal disease.

Root rots, caused by water molds, are a common problem, particularly in warm, wet weather. Use a fungicidal drench when transplanting to the field. Yellow-colored cultivars are more sensitive to root rots than other colors are. Fungal root rot as a result of wet soils can decimate all statice species. Maintaining good drainage is essential.

Leaf spots are caused by at least 5 fungal species. Spray regularly with general foliar fungicide and pick off infected leaves when spots first appear. Powdery mildew and downy mildew are serious problems in statice production. Keep leaves and ground free of standing water.

Rust can also be a serious problem. Rust never sleeps.

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Many thanks to Fran Foley (first edition) and Gay Smith (second edition) for reviewing this section.

Lobelia

Campanulaceae

annual/perennial

Lobelia consists of over 250 species of annual and perennial herbaceous plants native in many parts of the world, but the American species are most numerous and colorful. *Lobelia cardinalis* (cardinal flower), the most popular, has been used as a parent in many outstanding hybrids; *L. siphilitica* (big blue lobelia) and other species are also useful as cuts. In general, plants reach 2–4′ (0.6–1.2 m) in height and spread to 2′ (0.6 m).

Considerable breeding has produced hybrid strains (*Lobelia* ×*speciosa*, *L.* ×*gerardii*) with dark stems and brilliant scarlet or purple flowers. They provide outstanding color on upright rigid stems. All lobelias, including the hybrids, are short-lived and must be replaced or divided at least every 3 years. Many are native to stream banks and other areas of moist soil and prefer a rich, moist, but well-drained location in the field. In the Northeast and Northwest, plants tolerate full sun or partial shade, but in the Midwest and South, some shade is beneficial. Regardless of where they are grown, a light (½–1″, 1.5–2.5 cm deep) winter mulch is beneficial. If mulched heavily, plants die. Remove mulch early in the spring.

Plants tolerate full sun as long as moisture levels are maintained. Dry sun is not a good combination. Too much shade, however, greatly eliminates vigor and reduces yield.

Propagation

Some lobelias may be propagated from seed or division; others must be divided. Seed is tiny and should be lightly covered to ensure it does not dry out. Seeds germinate in 10–14 days under 70–72F (21–22C) conditions using intermittent mist.

Growing-on

Transplant seedlings from trays or seed flats to larger containers, such as 72-cell trays or 4″ (10 cm) pots, as soon as they can be handled without damage. Seedlings are slow to fill out, and approximately 8–10 weeks may be required from seed to transplant. Grow on at 62F (17C) nights and slightly warmer days. Set out in the field when roots fill the container, approximately 3–4 weeks from transplanting.

Environmental Factors

Work with the hybrid ‘Compliment Scarlet’ showed that while plants do not require cold, 6 weeks of 41F (5C) resulted in more vigorous plants and more uniform flowering. When cold was provided, photoperiod was unimportant. When cold was not provided, plants required long days of at least 14 hours (Frane et al. 2000).

Field Performance

Yield: For most locales, yield will be minimal the first year and increase over 2–3 years. Yield varies, from 1 to 4 or 5 stems per plant.

Spacing: Plants can be spaced 12–18″ (30–45 cm) apart.

Greenhouse Performance

Lobelias can be forced in the off season if plugs are cooled for 6 weeks at 40F (4C) then placed under long days at 68–72F (17–22C) after cooling has been completed. Long days may be accomplished through daylength extension or a 4-hour nightbreak using incandescent lights. Flowering time ranges from 85 days at 59F (15C) to 39 days at 80F (27C) after transplanting (Frane et al. 2000). In general, the cooler the temperature the better the quality of stem.

Cultivars

Many of the following are hybrids, often referred to as *Lobelia ×speciosa*, a catch-all name for the numerous hybrids developed from *L. splendens* (syn. *L. fulgens*; Mexican lobelia), *L. cardinalis*, and *L. siphilitica*. These hybrids are longer lived and more tolerant of soil types and moisture. They don't have the winter hardiness of *L. cardinalis* or *L. siphilitica*, but some are most glorious plants and worth a try even if they flower only for a single year. Most are winter hardy to Zone 5 at best, many only to Zone 6.

'Bees' Flame' bears vermilion-red flowers and beet-red foliage and can reach heights of 5′ (1.5 m). Absolutely magnificent in moist, partially shaded conditions.

'Brightness' is 3–4′ (0.9–1.2 m) tall with bright cherry-red flowers atop dark bronze foliage.

Compliment series, available from seed, is mid-sized and probably the most popular group of lobelias for cut flowers. Hardy to Zone 4, flower colors include deep red, scarlet, violet, and a mix.

'Cranberry Crowns' bears cranberry-red flowers and grows about 2′ (60 cm) tall.

'Dark Crusader' provides dark purple foliage in combination with blood-red flowers.

Fan series consists of burgundy, scarlet, and deep rose flowers. Plants are only about 2′ (60 cm) tall.

'Illumination' bears large spikes of exceptionally bright, deep scarlet flowers over bronze foliage.

'Pink Flamingo' has rich rosy-pink flowers in late summer.

'Queen Victoria' is the most popular cardinal flower with brilliant red flowers over bronze foliage. In flower, plants grow 3–4′ (0.9–1.2 m) tall. Not as cold hardy (Zone 6) as most cultivars.

'Royal Robe' bears deep red flowers with maroon leaves.

'Ruby Slippers' produces bright garnet-red flowers on robust plants.

'Russian Princess' has bright reddish purple flowers with purple foliage.
'Wildwood Splendor' produces large lavender flowers in late summer.

Additional Species

Lobelia siphilitica (big blue lobelia) flowers later than *L. cardinalis*, and flowers persist about 4 weeks. Constant moisture and partial shade are necessary for optimum performance; plants are short-lived and should be divided and moved every 2–3 years. Few cultivars have been bred; however, 'Blue Peter' has light blue flowers on a 3′ (90 cm) plant and may prove more perennial than others.

Pests and Diseases

Lobelias are susceptible to crown and root rots (*Pythium*) and botrytis. Pests include fungus gnat larvae, plant bugs, red-banded leaf roller, southern root-knot nematodes, slugs, and thrips.

Reading

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Lunaria annua honesty Brassicaceae

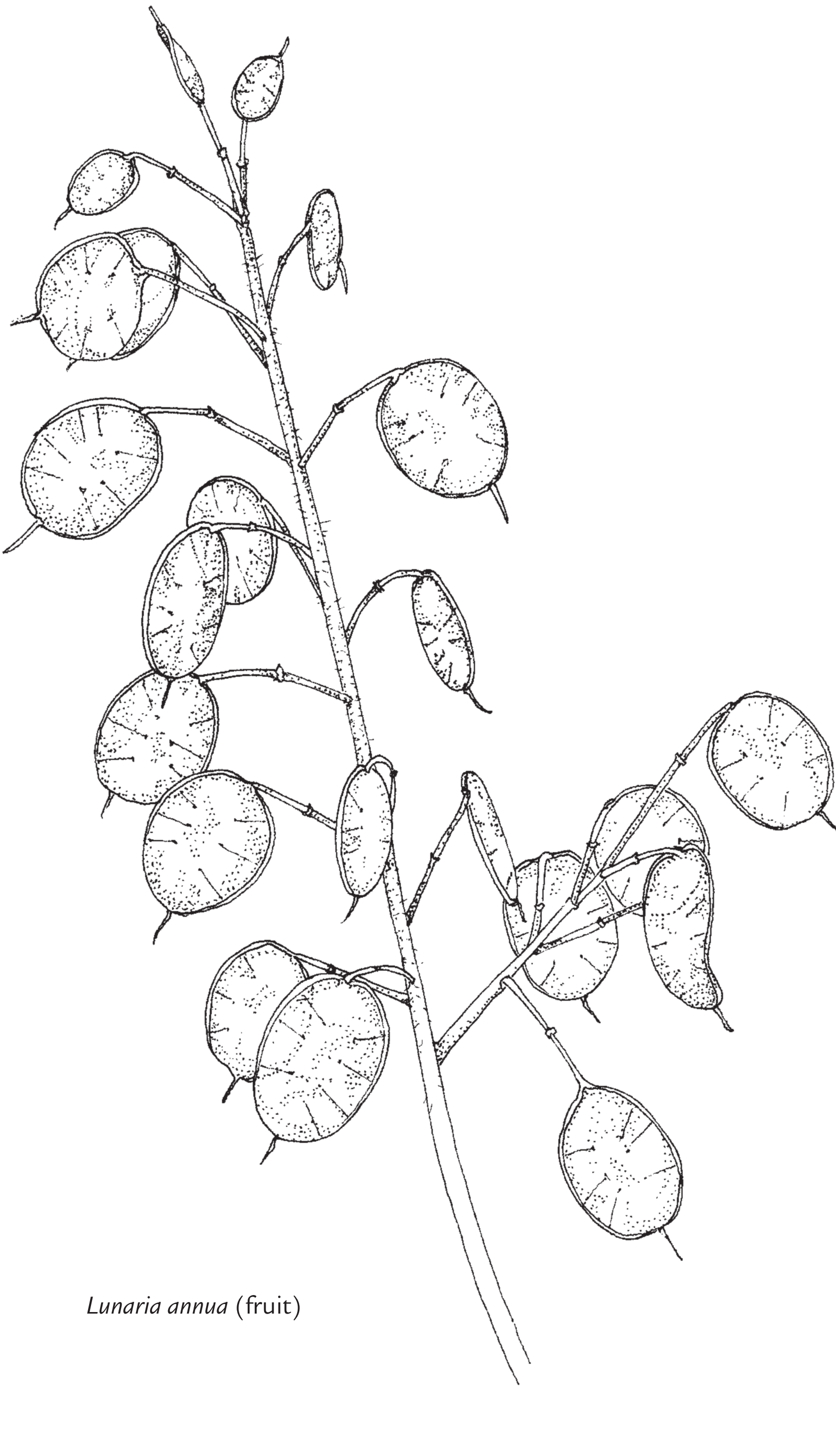
biennial Europe violet, white 2–3′/2′ (60–90 cm/60 cm)

Lunaria annua is grown as a biennial; however, plants will reseed if allowed to do so, so they need not be replanted each year. Interest in the species as an industrial crop developed from the discovery that it has a seed oil content of 30–40%, with high levels of erucic and nervonic acids (Cromack 1998). The flowers, although handsome, are of little value as cut flowers because of their tendency to shatter, but the slim, round, transparent fruits, which form rapidly after flowering, are excellent dried material (and give the species its other common name, money plant).

Propagation

Seed should be direct sown at the rate of 0.7 oz per 100′ (80 g per 100 m) (Kieft 1996). Seed may be sown in the fall in mild climates, very early spring in harsher climes. If sown in the fall, expect germination in late winter; spring sowings germinate in the field in 2–3 weeks.

Although usually direct sown, seed may be sown in the greenhouse at 65–70F (18–21C) under intermittent mist and will germinate in 10–14 days. Approximately 1 oz (28 g) of seed yields 1000 seedlings (Nau 1999). Plantlets, grown in open pack, may be transplanted in 3–4 weeks. If grown in plugs, transplant to the



Lunaria annua (fruit)

field or 4″ (10 cm) containers after 6–8 weeks. Transplant with care; they decline if roughly handled.

Growing-on

Grow at 60F (15C) night temperatures. Fertilize with 100 ppm N, using a complete fertilizer.

Environmental Factors

Photoperiod: Plants require a cold treatment (vernalization) for proper flowering. Although the main trigger to flowering is cold temperature, LD (16 hours) after vernalization result in faster flowering than SD (8 hours) (Wellensiek 1985). Once vernalized, however, plants will flower regardless of photoperiod.

Light intensity: High light intensity results in faster flowering after vernalization.

Temperature: Approximately 10 weeks of cold temperatures (40F, 4C) are necessary for flowering. Seedlings should be at least 6 weeks old before vernalization is applied. If vernalization is not sufficiently long or cold, some plants do not flower and lateral flowers predominate. Under optimal vernalization conditions, lateral and terminal flowers occur side by side. Seed vernalization has a partial effect on flower induction (Wellensiek 1985).

Field Performance

Spacing: Space transplants or thin seedlings to 10 × 18″ (25 × 45 cm) or 12 × 12″ (30 × 30 cm) spacing. One-year-old transplants may be purchased and planted at the proper spacing. Partial shade is useful in hot climates, full sun in more temperate areas.

Fertilization: Apply side dressings of granular fertilizer such as 8-8-8 in the spring and summer, or apply 500–700 ppm N once a week with a water-soluble fertilizer.

Greenhouse Performance

Using one-year-old precooled plants only, grow in 6–8″ (15–20 cm) containers or space 9″ (23 cm) apart in a greenhouse bench. After approximately 3 weeks in the greenhouse, use incandescent lights to provide 16-hour days until flower buds are visible. Fertilize with a water-soluble fertilizer (100–150 ppm N) with each irrigation. Support may be necessary.

Stage of Harvest

Harvest the pods when they are fully developed. Pods may be green, translucent, or purple (var. *purpurea*) as they dry naturally on the plant. Strip the main leaves but allow the finer ones to remain. Bunch and hang upside down in a warm, dark place for 4–5 weeks. The pods are ready when the papery covering is easily removed.

Postharvest

The flowers, which are generally harvested in May and June, may be cut for fresh arrangements and persist a maximum of 3–5 days. The seed pods, once air-dried, should persist indefinitely.

Cultivars

Seeds of white-, red- and purple-flowered cultivars are available, but they all produce the same color and shape of fruit. If the color could be retained, the purple fruits of var. *purpurea* would be a welcome market addition. A cultivar with variegated foliage, var. *folio-variegata*, is also found.

Additional Species

Lunaria rediviva (perennial honesty) bears elliptical seed pods. The plants, once established, are perennial and persist 3–5 years. The fruit is not considered to be as ornamental as the biennial form, an unfortunate misconception.

Pests and Diseases

Numerous fungal species (*Alternaria oleracea*, *Helminthosporium lunariae*) attack the foliage or pods, resulting in brown to black spotting of the infected areas. Application of a general fungicide can reduce the damage. Root rots from *Phytophthora* and *Rhizoctonia* spp. also occur. Waterlogged soils result in *Phytophthora* infections. Club root, in which the feeder roots are destroyed and the main roots develop abnormally, is a result of *Plasmodiophora brassicae*; fungicidal drenches have been effective against it.

Leaf rollers, thrips, and aphids are the major insect pests.

Grower Comments

"I did sell it to upper-end shops, with repeat sales. I remember one designer telling me that she loved the pure white color, and although it looked very frail, it held up well to all her abuse.The pods work well as a fresh green cut. Green has been a color that everyone couldn't get enough of over the past few years, and these things really fit right in. I also cut the green pods to dry. They hold the green color really well. I let them get just a little more mature to dry, so the pod will survive, but not so mature that it becomes brown and comes apart." Bev Schaeffer, Schaeffer Flowers, Conestoga, Pa.

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Many thanks to Bev Schaeffer for reviewing this section.

Lysimachia clethroides gooseneck loosestrife Primulaceae

perennial, Zones 3–8 China, Japan white 2–2½′/3′ (30–45 cm/90 cm)

The genus consists of many excellent garden, landscape, and cut flower species, but gooseneck loosestrife is probably the best known. Plants are easily grown and can spread rapidly. Flower stem production is excellent as far south as Zone 7, but in Zone 8 in the Southeast and Southwest, flower are smaller and stems are thinner. Flowers appear in late spring (Zone 7) or summer (Zone 7 and colder).

Propagation

Division: Division is the most common means of propagation; plants roam freely, and the rhizomes may be easily divided after flowering.

Seed: Seed (not always easy to obtain) should be barely covered and placed at 65–68F (18–20C). Germination is erratic.

Growing-on

Transplant to cell packs, plugs, or 4″ (10 cm) pots as soon as seedlings can be handled. Grow at 50–60F (10–15C) for 6–8 weeks with as much light as possible. Fertilize lightly with 50–100 ppm N of a complete fertilizer. Transplant to field in fall or early spring.

Environmental Factors

Cold is not necessary to break dormancy in rhizomes, although shoots from noncooled roots emerge significantly slower and flowering is greatly delayed compared to cooled roots; 10 weeks of case-cooling at 39–40 (3–4C) yields most rapid emergence and flower production (Lewis et al. 1999). Plants grown in continuous short day conditions did not flower, and at least 10 weeks of long day (nightbreak lighting) were needed for optimal development and flowering under greenhouse conditions (Lewis et al. 2000).

Lysimachia clethroides

Field Performance

Spacing: Plant on 12″ (30 cm) centers. Plants fill in rapidly and, within 2 years, cover the planting area. Support netting is necessary.

Yield: Two-year yields and stem lengths are shown in the following table. Yields and stem length in the second year were much better than the first. Stem length in California was longer than in Georgia for both years; however, yield was almost double in Georgia in year 2.

Two-year yields and stem lengths in Athens, Ga., and Watsonville, Calif.

		Georgia		California	
Year	Shade level (%)	Stems/ plant	Stem length (in)^z	Stems/ plant	Stem length (in)^z
1	0	12	15.8*	8	27.0
2	0	39	27.6	20	42.0
2	55	30	34.9	*	*

z = multiply (in) by 2.54 to obtain (cm)
* = plants in California were not grown in shade

In the third year at Athens, Ga., plants spread with wild abandon and yield rose astronomically. Yield for the original 48 plants was 6030 stems, an average of 126 stems/original plant! Stem length averaged 40″ (1 m) in the full sun. We thought the place would be carried away with loosestrife.

Shade: As the data in the preceding table from the University of Georgia show, although plants grown under 55% shade had longer stems, yield was reduced by 9 stems/plant. Stem diameters were unaffected.

Field problems: Ron Smith, of Renfrew, Pa. (Zones 5 and 6), acknowledges the extreme aggressiveness of the plants but telegraphs their good points: "very productive, easy pest control, good demand; and a bunch of 10 stems, 30″ (75 cm), is easy to handle and hardly takes up any space." But then he gets to the "almost-fatal flaw": "[Their] season starts just before July 4, and lasts for 2–3 weeks in July, the slowest time of the year. I've tried cutting back the stems at various times and heights, in order to delay bloom time, but the secondary stems that result are always weaker and smaller."

Greenhouse Performance

Greenhouse production is not uncommon in Europe and on the west coast of Canada and the United States. Some of the finest material we have seen comes from Gerard Smit in Abbotsford, B.C., who rotates lysimachia along with astilbes, phlox, solidago, and peonies in rolling "moveable" greenhouses. Production is also excellent in standard greenhouse structures elsewhere.

Lewis et al. (1999, 2000) provides useful guidelines for winter greenhouse production. She suggests case-cooling the rhizomes for 10 weeks at 40F (4C), then potting up in containers or beds. Stems emerge in approximately 2 weeks at 68F (20C). More than 10 weeks cooling resulted in shorter stems with little decrease in forcing time, as seen in the following table (Garner and Lewis 1999).

The effect of cooling rhizomes on flowering, yield, and stem length of *Lysimachia clethroides*.

Cooling duration at 40F (4C)	Greenhouse days to flower	Stems/ plant	Stem length (in)[z]
0	170	1.4	37
4	170	3.2	40
6	165	3.7	41
8	150	4.4	44
10	140	4.0	47
12	135	2.7	33

z = multiply (in) by 2.54 to obtain (cm)

She suggests that LD be applied through incandescent nightbreak lighting from 10 p.m. to 2 a.m. approximately 6 weeks after emergence. If LD are applied at emergence, flowering is faster than if plants do not receive LD until plants have grown in natural SD for 6–8 weeks; however, stem strength, yield, and raceme length are of poorer quality. First flowers open 15–22 weeks after cooling, depending on light and photoperiod regime (Lewis et al. 1999, 2000).

Supplemental light is recommended if winter light is low, for example in the Midwest and Northwest.

Day/night temperatures of approximately 68/65F (20/18C) provided excellent results; however, cooler temperatures of 65/60F (18/15C) day/night have also been successful (Iversen and Weiler 1994). The cooler the temperatures, the longer the forcing time.

Scheduling: The following chart provides several schedules suggested by Garner and Lewis (1999) for forcing gooseneck loosestrife in the greenhouse.

Stage of Harvest

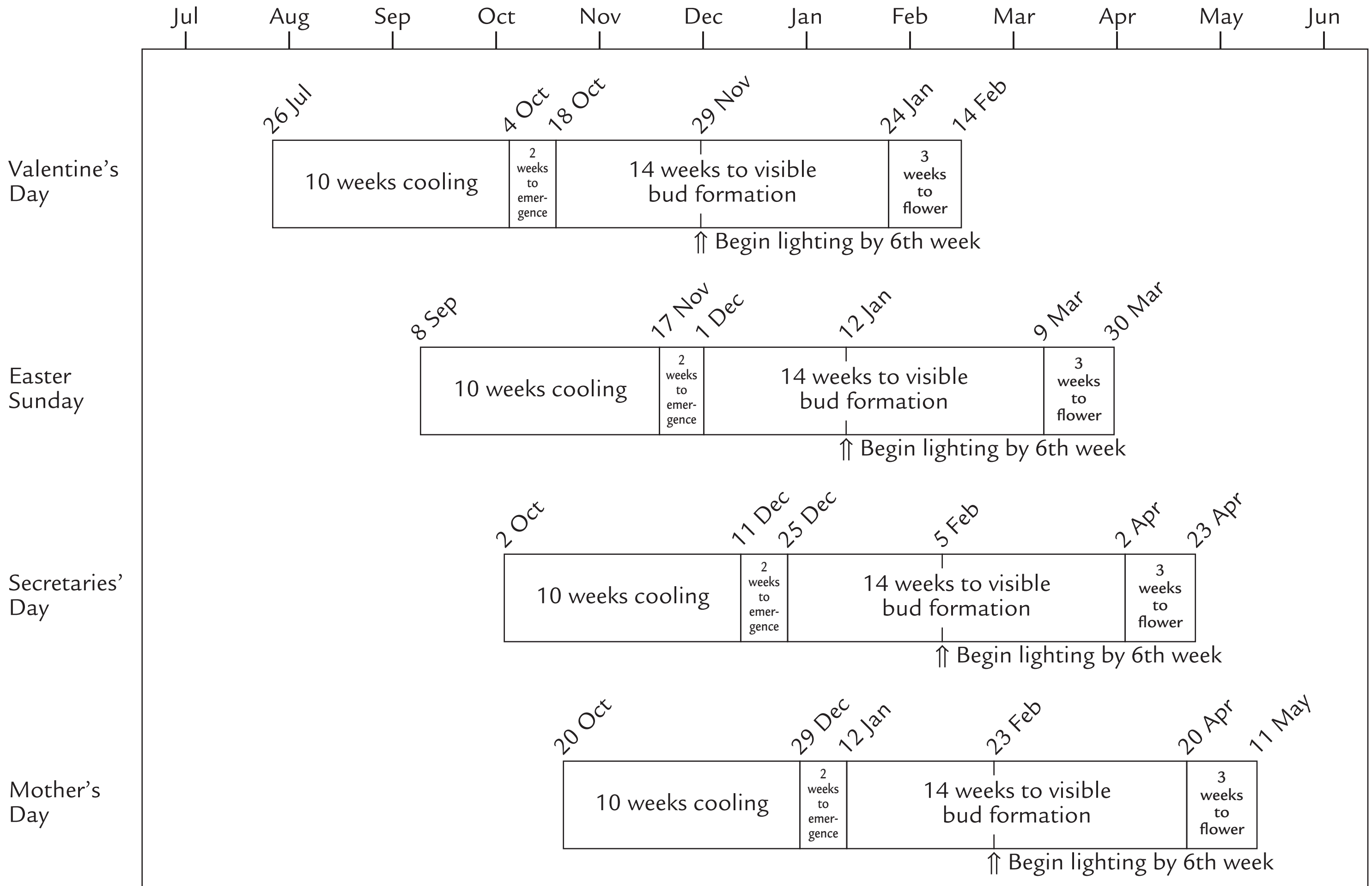
Harvest when flowers in the inflorescence are ⅓ to ½ open. This occurs when about 10 flowers are open. If placed in a complete preservative (e.g., Floralife™), flowers may be harvested when the majority of flower buds are white but not open.

Postharvest

Fresh: Work conducted at the University of Georgia showed that flowers cut at the proper stage of harvest persisted 12 days in Floralife™ and Rogard™ but lasted only 5 days in water. Various concentrations of STS were ineffective. Sugar concentrations were better than water but not as effective as the floral preservatives tested—the differences were like night and day.

Storage: Store flowers at 36–41F (3–5C) whenever possible.

Greenhouse schedules for *Lysimachia clethroides*.



Additional Species

Lysimachia ephemera is similar in that the flowers are elongated and white, without the distinctive "gooseneck." They are also much less aggressive: their yield is far less, and the flowers provide much less "flower power." A poor performer south of Zone 7a and north of Zone 5.

Lysimachia punctata (yellow loosestrife) is a useful cut, with yellow flowers borne in whorls in the nodes along the stem. Plants are about 2′ (60 cm) tall.

Lysimachia purpurea has only recently been tried as a cut flower. Flowers are rusty purple and stand about 2½′ (75 cm) tall. May have potential.

Lysimachia vulgaris (also known as yellow loosestrife) has ½″ (13 mm) wide, yellow flowers with orange dots clustered in panicles (like *Phlox paniculata*). Plants are 2–3′ (60–90 cm) tall.

Pests and Diseases

Few problems occur if plants are provided with well-drained soils and full sun exposure.

Grower Comments

"We started both [*Lysimachia clethroides*] and [*L. punctata*] for perennial sales. They are prolific and aggressive growers. Punctata is excellent in the vase in its early blossoming—less shattering. The foliage fills the vase nicely too, and here in the Northeast, it's one of the earliest bloomers. Gooseneck loosestrife is perhaps my favorite cut flower. It lasts up to 2 weeks in the vase and the foliage is wonderful." Karen Hanley, Stork Road Farm, Reading, Pa.

Reading

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Matthiola incana stock Brassicaceae

annual Mediterranean many colors 2–3′/2′ (60–90 cm/60 cm)

Stocks have long been a favorite cut flower for their form, color, and fragrance. Requiring cool temperatures for optimum flowering and quality, they are usually seen in northern flower-producing areas and the West Coast. Breeders have been steadily increasing the percentage of double flowers from a sowing, but additional work to stabilize doubleness and fragrance in flowers is still necessary. The greater the percentage of double flowers, the more profitable the crop will be. Doubleness has been genetically linked with light green leaves when grown at 50F (10C), and it is theoretically possible to select for 100% double flowers in some seed strains if started in the greenhouse. Unless cultivars have been selected for doubleness, most are still 50–60% double.

Propagation

There are about 19,000 seeds/oz (630 seeds/g), depending on cultivar. Seed sown at 60–68F (15–20C) germinates in 5–12 days. Approximately 0.25–0.5 oz (7–14 g) of seed yields 1000 seedlings (Nau 1999). Direct sowing is not recommended for everyone, unless water management can be perfectly maintained. If sown in open packs, transplant to 3–4″ (8–10 cm) containers 14–21 days from sowing. If grown in plugs, grow for 4–6 weeks.

Growing-on

If produced in plugs, apply 75–100 ppm N fertilizer at each irrigation. Temperatures of 50–55F (10–13C) should be applied as soon as plants are removed from the propagation area. Plants may be placed in the field in fall or early spring after 8–10 weeks in the greenhouse.

Environmental Factors

Temperature is the main environmental factor affecting flowering in stock, although photoperiod and juvenility also influence flowering time.

Temperature: Although great diversity exists in the response of different cultivars, high temperature generally delays flowering while low temperature promotes it (Roberts and Struckmeyer 1939, Howland 1944). Most cultivars ('Column', 'Bismarck', 'Avalanche', e.g.) fail to initiate flowers at temperatures above 65F (18C), and those that do ('Brilliant') are usually later and produce more leaves than when grown below 60F (15C).

Late-flowering types require lower temperatures for a longer period of time than those classified as early-flowering types. In general, early-flowering types require fewer than 10 days at 50–55F (10–15C); about 3 weeks may be necessary for late-flowering cultivars. Although floral initiation occurs rapidly, low temperatures should be maintained for an additional 15–20 days after floral initiation.

Photoperiod: Long days provided before or during the cold treatment usually result in faster flowering at a lower leaf number compared to SD (Post 1942, Biswas and Rogers 1963, Heide 1963). Long days can partially substitute for cold in some cultivars and result in earlier flowering where temperature treatments

Matthiola incana
'QIS White'

are not fully satisfied (Biswas and Rogers 1963, Heide 1963). Long day treatments may be provided by daylength extension or nightbreak lighting.

Juvenility: The timing of the application of cold treatment varies with cultivar. In general, cultivars classified as early flowering have a short juvenile period and form few leaves; those classified as late flowering have a longer juvenile period and form more leaves before the first flower bud (Cockshull 1985). Some flowering types and their response to cold treatment are shown in the following table (Post 1942, Kohl 1958, Heide 1963).

The effect of application time of cold treatment (50–55F, 10–13C for 14–21 days) depends on age and cultivar.

Cultivar	Flowering type	Juvenility (days from sowing)	No. of mature leaves at time of cold	Days to visible bud	No. of leaves at visible bud
Brilliant	early	15	2	40	16
Column	medium	38	10	70	*
Avalanche	late	57	*	86	42

* = no data available

With most cultivars, regardless of flowering classification, the older the plant, the shorter the period of cold treatment needed. Vernalization of seed is of no benefit (Howland 1944).

Chemical control: Work with GA_3 has shown some acceleration of flowering, but results are inconsistent. Application of prohexadione-calcium (PCa), a GA inhibitor, resulted in faster flowering (Hisamatsu et al. 1999) but is still highly experimental.

Field Performance

Stocks can be field-grown successfully only in areas of mild winters and/or cool summers, such as Texas, Arizona, the West Coast, and parts of Florida. Selectability is less important in the field, and the higher cost of selectable seed cannot usually be justified. If a high percentage of doubles are desired, then seedlings must be transplanted after selection in the greenhouse.

Spacing: Space plants on 6–10″ (15–25 cm) centers. A dense spacing such as 6 × 8″ (15 × 20 cm) increases yield/ft^2, but the potential for disease and insect problems is also increased. Direct sowings may be as close as 3″ (8 cm) apart, but some thinning of seedlings must be done. Too dense a planting results in thin stems and additional disease pressure.

Support: Netting is seldom used for stock production. It is necessary only where temperatures are too high. Night temperatures should remain around 50F (10C) during the duration of the crop. If temperatures are consistently above 70F (21C), support may be necessary.

Greenhouse Performance

Stocks may be greenhouse-grown in the winter in all Midwestern and northern areas. Plants are generally sown in plugs and transplanted to final beds or containers. They are best grown in approximately 220-cell plugs and transplanted just as the root ball forms; do not allow the seedling to become root bound. Transplant approximately 25 days after sowing from a 220-cell plug pack (Goto et al. 1999). Plants grow best in a glass greenhouse, but work in Canada using 3-

year polyethylene showed that when energy savings were considered, growing stocks under poly resulted in saleable crops (Dansereau et al. 1998).

Spacing: Greenhouse spacing as dense as 3 × 6″ (8 × 15 cm) or as wide as 1′ (30 cm) centers is used. A spacing of 6 plants/ft^2 (65 plants/m^2) is common. Two tiers of support are recommended (Nau 1990).

Fertilization: Nutrition is critical for best growth and flowering. Stocks are sensitive to potassium deficiency, and fertilizers such as potassium nitrate are most effective. Potassium deficiency causes leaves to die from the tip and margin to the base. Older leaves are most sensitive, and the symptoms are most visible at flowering time. Overfertilization can also be a problem. High applications of nitrogen result in soft, thin stems and should be avoided.

Temperature: Seedlings should be grown at 60–65F (15–18C) until they have approximately 8–10 leaves (10–30 days, depending on cultivar) prior to lowering temperatures for the cold treatment. The length of this "warm" temperature influences the ultimate stem length (Post 1955). Seedlings started at low temperatures are dwarfed.

Work with day/night temperature difference (DIF) showed that a positive DIF (day temp > night temp) resulted in taller plants than a constant temperature, but negative DIF resulted in suppressed growth (Ito et al. 1997). Negative DIF is useful in the seedling stage, to reduce stretching and maintain compact growth, but should be avoided during later growth. Night temperatures of 50F (10C) should be applied for a minimum of 3 weeks but preferably for 6 weeks. Once the cold treatment has been applied, temperatures should remain around 55–60F (13–15C) for the duration of the crop. Flower buds form after the 15th leaf on early-flowered cultivars if conditions are favorable. Temperatures above 65F (18C) result in weaker, taller plants and necessitate the use of support netting.

Light and photoperiod: Long days, using incandescent lights as a 4-hour nightbreak or day extension (16 hours), are useful during or after the cold period. Incandescent lights, however, cause excessive elongation of the stem and should not be applied after the appearance of color on the flower buds (Post 1955).

Scheduling: In the Midwest, holiday crops may be scheduled as shown in the following table (Nau 1990). All cultivars used should be selectable.

Sowing times for holiday crops in the Chicago area (Zone 5). Night/day temperatures 45–50/55–60F (7–10/13–15C).

Flowering for . . .	Sow seed on . . .
Christmas	15 Jul
Valentine's Day	1 Sep
Easter (late March)	1 Oct
Mother's Day	15 Dec
June weddings	25 Feb

Approximately 6–7 months are necessary for flowering in January to March unless supplemental lighting is used at the temperatures given earlier.

With cultivars such as the Vegmo series, winter production (November December planting) requires about 4 months; spring production (January–March planting), 3 months; summer production (April–July planting), 2½ months; fall production (August–October planting), 2–3 months.

With later sowings, it is more difficult to maintain cool temperatures, and quality may suffer. Crop time can be significantly reduced if temperatures are raised; however, quality is also reduced.

Stage of Harvest

Stems should be harvested when ½ the flowers in the inflorescences are open. Stems should be immediately placed in preservative and out of the sun. Do not allow cut stems to remain out of water or in the heat, for postharvest life will be significantly reduced. Do not crush stems. Retailers generally expect the lower ⅔ of the flowers to be open.

Postharvest

Fresh: If stems are recut frequently and kept away from excessive heat, fresh flowers persist 7–10 days in a preservative. Pretreating the stems after cutting with sugar (7%) and STS, even combined with GA_3, increased subsequent vase life by only 2 days when later placed in water. Placing the stems in 1% sugar plus a biocide (HQC) without a pretreatment added 4 days, and the two in combination added 5 days to subsequent vase life after storage (Young et al. 1996).

Dried: Harvest flowers when fully open and hang in small bunches (3–5 stems) in a warm place. If dried rapidly, stocks retain their fragrance.

Storage: Stems may be stored dry for 2 days, although wet storage is recommended. Storage temperatures should be 36–41F (3–5C). Prolonged refrigeration results in loss of fragrance. Hold stocks in the dark to avoid stem elongation and curving of the growing tip.

Cultivars

Selectability

The ability to distinguish double-flowered seedlings from single-flowered ones is an important issue in stock breeding. Double forms are gray-green and generally less vigorous than single forms, but removing the singles is a difficult job at best, and almost impossible if seeds are direct sown in the field.

The currently accepted method of selection is to expose the seedlings to 41F (5C) for 5–7 days. Seedlings should be watered thoroughly one day prior to exposure, which is accomplished 15–20 days after sowing. After removal from the cold, the double-flowered forms appear yellow and chlorotic within a couple of days, while the single-flowered forms remain green and vigorous, and have smoother leaf margins. Selection should be done early in the morning and out of full sun: cotyledon color is easier to differentiate in the shade than in sunlight. The good-looking ones are then discarded, and the chlorotic ones remain. They will green up in a few days. As breeding becomes more refined, selectability will become a thing of the past, and cultivars will be 90–100% double without selection. A few cultivars have already attained nonselectable double status; many more will be introduced in the future.

Selectability is more important in greenhouse-grown crops than in the field; however, if plants are to be transplanted rather than direct sown, selectable cultivars can be used successfully. Selectable cultivars are more expensive and nearly always used in the greenhouse, because of higher costs of greenhouse forcing.

Field cultivars

Almost without exception, cultivars recommended for field culture are less expensive and less hybridized than those used for greenhouse production. They are usually nonselectable for doubleness. Confusion reigns in catalogs: the cultivars may be listed separately or they may be lumped together, as column stocks, excelsior stocks, mammoth stocks, or a strain of stocks. Many breeders and distributors have their own numbered strains, such as No. 21 Lilac Heart (Ball).

These field cultivars offer strong stems and 50–60% double flowers. Individual colors include ‘American Beauty’ (carmine-red), ‘Appleblossom’, ‘Avalanche’ (white), ‘Illusion’ (red with yellow eye), ‘Malmaison Pink’ (pastel salmon-pink), ‘Pacific Blue’ (mid-blue), ‘Sweetheart Pink’, and ‘White Christmas’. Numbered and colored strains (e.g., Apricot) and Giant Excelsior Strain are also offered in this potpourri. Height of the flowering plants is 2–3′ (60–90 cm).

Goddess series grows 2–3′ (60–90 cm) tall and is offered in orchid, white, and yellow.

Miracle series bears flowers of blue, crimson, gold, lavender, white, and yellow.

Trysomic series is said to be 85% double in a mix of carmine, lilac, lavender, white, rose-pink, yellow, and purple. Height is about 15″ (38 cm).

‘White Beach’ provides double white flowers.

Greenhouse cultivars

All are selectable.

Frolic series flowers with less cold and is therefore a little earlier than many others. Available in 7 colors and a mix and grows 2–3′ (60–90 cm) tall.

Glory series flowers a little earlier than Xmas series. Bred in cherry, lavender, pink, rose, and white.

Joy series has flowers in lavender, light pink, red, white, and a mix.

Lucinda series provides uniformity of germination and flowering and comes in white, cream, light rose, dark rose, red, lavender, and deep blue.

Mid Cheerful series is later than Cheerful. Plants require more cooling to flower but potentially produce a longer flower stalk with closely spaced florets. ‘Mid Cheerful White’ and ‘Mid Cheerful Yellow’ are available.

Nordic series, bred especially for northern greenhouse conditions, is offered in 7 colors.

Vegmo series offers 13 colors including white ('Aida'), dark blue ('Debora'), pink ('Lena'), deep rose ('Nabucco'), and brick-red ('Siberia'). Final height is 2–2½′ (60–75 cm) and seedlings are 100% selectable.

Wonder series bears nonbranching, 2–3′ (60–90 cm) tall flower stems and is 60–90% double. 'White Wonder' and 'Snow Wonder' have similar flowers but differently shaped foliage.

Xmas series grows 3′ (90 cm) tall; bears nonbranching, mostly double flowers; and is early to flower. Blue, purple ('Xmas Ocean'), red, rouge, pink, rose, ruby, white, and violet are available. What do you think an Xmas Ocean is, anyway?

Cultivars for greenhouse and field

Cheerful series grows 2–3′ (60–90 cm) tall. Minimum cold is necessary. Available in a limited number of colors, mainly white and yellow, and a mix. Its high percentage of doubleness makes it more popular in the greenhouse.

Goldcut series is available in dark blue, light blue, ruby-red, rose, rosy red, white, yellow, and a mix. Plants are about 30″ (75 cm) tall.

QIS series is available in 10 colors. One hundred percent selectable. Best performance in the greenhouse.

Regal series is said to require no selection and claims 95% doubleness. 'Regal White' is most common.

Ultra Strain has been selected for doubleness. Plants are 2–2½′ (60–75 cm) tall. 'Crispy' and 'Madonna' are early and midseason white selections, respectively.

Pests and Diseases

Bacterial rot (*Xanthomonas incanae*) produces a green water-soaked line on the stem of the seedling. The stem later turns dark brown and cracks, and the plant dies. Older plants may also be infected. When stems of older plants are cut open, a yellow liquid is clearly visible. The bacterial spores can overwinter on debris and can be spread in irrigation water and through cultivation equipment. Problems are greater in heavy soils and where overhead irrigation is employed. The bacteria can also be seed-borne; to control, soak seeds in 130F (54C) water for 10 minutes.

Club rot (*Plasmodiophora brassicae*), also known as slime mold, affects many plants in the Brassicaceae. Main roots develop abnormally and form swellings similar to crown galls; feeder roots are often destroyed and slimy in appearance. Plants die without flowering. Fungicides have been effective, but discarding infected plants may be the best solution.

Damping off of seedlings is caused by soil fungi, which may be controlled with sterile soilless mixes and other standard sanitary procedures.

Downy mildew (*Peronospora parasitica*) results in pale green spots on the upper surface of the leaves and downy mold on the lower surface. Foliage wilts, plants are stunted, and flowers develop poorly, if at all. Avoid crowding the plants and provide as much ventilation as possible. Placing warm water pipes around and over the crop reduces mildew considerably. Sterilize all media.

Verticillium wilt (*Verticillium albo-atrum*) results in yellow basal leaves and severe stunting. Vascular tissues are often discolored, and flowering is inhibited. Crop rotation and soil sterilization are essential to breaking the wilt cycle.

Diamondback moths, flea beetles, and springtails are serious pests and cause significant damage to foliage and flowers.

Aphids and thrips can also plague stock plantings.

Physiological disorders

Short plants develop when the temperature is too low during the seedling stage. Sow seed when soil temperature is above 60F (15C).

Blind plants, which fail to form flowers, likely result from an insufficient period of time below 60F (15C) or too long a period above 80F (27C). This was more of a problem with earlier types than with current cultivars; however, if sown between late February and late July, blindness can still be a major headache.

"Skips" are flowers with blank areas in the middle of the inflorescence. This problem, which is more prevalent in northern growing areas, may be attributable to low light levels just after flowers have initiated.

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Many thanks to Jim Nau (first edition) and Bill Borchard and Blair Winner (second edition) for reviewing this section.

Narcissus daffodil Amaryllidaceae

bulb, Zones 3–9 Spain, Portugal many colors
18–24″/12″ (45–60 cm/30 cm)

Narcissus is forced for cut flowers for Valentine's Day through Mother's Day and may be produced in the greenhouse or field. Hundreds of cultivars are available, some far more expensive than others; registered cultivars have been divided into 11 classes, depending on parentage and morphological characteristics such as length of the trumpet or cup. Most cultivars used for cut flowers belong to the trumpet (class I) or large-cupped (class II) narcissus, but any classification can provide useable flowers. The tazetta forms (class VIII; paperwhites), which require no cold for forcing, are chiefly greenhouse-grown and may be field-produced only in nearly frost-free areas of the country.

Environmental Factors

Most daffodils require a warm-cool-warm temperature sequence: the initial warmth occurs in the summer for flower initiation, and the winter cool results in subsequent rapid growth and synchronous flowering once warm weather recurs in the spring. Generally, bulbs are planted in pots or bulb crates, then stored at a temperature around 48F (9C) for about 120 days prior to warm temperatures for flower emergence. Daffodils are not as critical in their temperature requirements as tulips (which see); planted bulbs may be stored in cold frames or under straw mulch outdoors to achieve these temperatures, but more uniformity and better timing are gained with controlled temperature facilities. For proper timing of forced cut flowers, bulbs must be stored in such facilities.

Field Performance

Bulb size: Use double-nosed daffodils or 4½–6½″ (12–16 cm) rounds. Its shape makes it difficult to measure the circumference of the bulb.

Planting: Plant with 4–6″ (10–15 cm) of soil above the nose. Plant approximately 6″ (15 cm) apart.

Narcissus
'Holland Sensation'

Planting time: In climatic Zones 4 and 5, plant in September and early October; Zones 6 and 7, in October and early November; Zones 7 and 8, November and early December. In areas with little cold temperature (e.g., Florida, coastal California), precooled bulbs that are cooled 8–10 weeks at 40F (4C) should be planted in early December (De Hertogh 1996).

Longevity: In all but the warmest areas, daffodils will perennialize. Well-maintained bulbs should be productive 3–5 years. At that time bulbs are lifted and separated.

Timing: Using both early- and late-flowering cultivars makes for a longer flowering period. Proper selection of cultivars can provide up to 8 weeks of harvest. Flowering begins in February in the South for *Narcissus cyclamineus* and other early species and early, small-flowered cultivars like 'February Gold', and continues through late April for large-cupped cultivars. In the North, flowering is up to 4 weeks later.

Harvesting: Daffodils are often pulled rather than cut to ensure longest stem length.

Stem length: The difference in stem length between northern- and southern-grown bulbs is not nearly as large for daffodils as for tulips (which see). This is because cold is not as necessary for stem extension in daffodils as it is in tulips.

Fertilization: Apply 2–3 pounds of a complete granular fertilizer, such as 3-9-18 or 5-10-20, per 100′ (2.5 kg per 100 m) immediately after planting (De Hertogh 1996).

Greenhouse Performance

Most forcers treat daffodils as they do tulips (which see). If coolers are not sensitive, allow bulbs to remain at 40–48F (4–9C) for about 16 weeks. With better coolers, however, a more specialized cooling cycle can be established. For the Valentine's Day market, bulbs are usually panned in October; stored at 48F (9C) until roots are visible through the drainage holes; transferred to 41F (5C) until shoots are 1–2″ (2.5–5 cm) tall; and then placed at 33–35F (1–2C) until they are moved to the greenhouse bench. The total time in the cooler is about 17 weeks, depending on cultivar, with a minimum cooling time of 15 and maximum around 20 weeks (De Hertogh 1996).

This method works well but requires a good deal of cooler space and does not allow for additional turns once plants are moved into the greenhouse. Dole (1996) suggested a delayed potting method, in which the bulbs are cooled dry for the first 8 weeks then potted up as normal for the last 8 weeks of cooling time. Cooler space needed for the dry bulbs is minimal, and when pots are removed for greenhouse forcing, additional dry cooled bulbs may be potted to take their place. In this method, the cooler should remain at 41F (5C) whenever dry bulbs are present.

The greenhouse temperature for forcing should be around 60F (15C), but time in the greenhouse (usually around 2–3 weeks) depends on cultivar and time of year. For market times before Valentine's, precooled bulbs must be purchased.

If height control is required, application of ethephon at 1000–2000 ppm is applied in the greenhouse when plants are about 3″ (8 cm) tall (De Hertogh 1996). A second application may be required 3–5 days later. Seldom used for cuts.

Stage of Harvest

Single, large flowers should be harvested when closed, but with color showing. This is known as the gooseneck stage. Flowers should be at a 90–120° angle from the stem.

For double-flowered cultivars, harvest when flowers are just beginning to open.

Stems are packed 10 to a bunch.

Postharvest

Fresh: Fresh flowers have a vase life of 4–6 days. Preservatives do not generally enhance the vase life of daffodils.

Storage: Flowers may be stored wet or dry. For dry storage, pack in polyethylene and store in open boxes in a cold room. Flowers may be kept 10 days at 32–33F (0–1C), 8 days at 36–38F (2–3C), or 1–2 days at 50F (10C) (Nowak and Rudnicki 1990). Flowers should be kept upright. If flowers arrive bent, they may be wrapped tightly in wet paper and placed in water under direct overhead light (Vaughan 1988). They also may be stored in 100% nitrogen for several weeks without loss of quality (Nell and Reid 2000).

Hardening: Daffodils secrete a mucus that is detrimental to roses, carnations, freesias, tulips, and many other cut flowers. If daffodils are used in arrangements or stored with other flowers, they should be placed by themselves for 12–24 hours in clear water. Change the water at least once, and wash the stems upon removal. If freshly cut flowers must be placed with other flowers, put daffodils in a bleach solution containing 5–7 drops of bleach per quart (liter) of water for 1–5 hours (De Hertogh 1996). Rinse stems and place with other flowers.

Cultivars

Cultivars are far too many to list, and there are no particularly bad ones. Choice is based on earliness, color, stem length, fragrance, and cost. Consult a bulb specialist for best cultivars for your area.

Pests and Diseases

Basal rot (*Fusarium*) infects the basal plate of the bulb and results in brown-colored decay. Cull infected bulbs and use a preplant dip of benomyl on others. The best preventative methods are excellent drainage and proper dry storage of bulbs.

Fire, manifested as reddish brown spots on leaves, flowers, and occasionally on bulbs, can be troublesome. The spots are somewhat elongated parallel to the veins. The disease occurs more often in warm, humid climates and after 2–3 days of rainy weather. Sprays of various fungicides (benomyl, mancozeb, iprodione) and smokes (exotherm) are useful.

Aphids and bulb mites are the most serious pests for commercial growers of cut daffodils.

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Many thanks to Brent Heath (first edition) and Mark Hommes (second edition) for reviewing this section.

Nigella damascena love-in-a-mist Ranunculaceae

annual Mediterranean blue, white 1½–2′/1′ (45–60 cm/30 cm)

Nigella has handsome foliage and flowers, and although the cut flowers have been considerably successful on the local level, plants are mainly grown for the attractive seed pods. Pods may be used fresh or dried in arrangements or potpourri.

Propagation

Sow seed directly to the field or bench. Approximately 0.25 oz (7 g) of seed yields 1000 seedlings (Nau 1999). If sown directly to the field, sow at the rate of 0.1 oz per 100′ (9.5 g per 100 m) (Kieft 1996). Germination occurs in 10–14 days. When sown in the greenhouse, maintain 60F (15C). In southern locations (Zone 7 and warmer), sowing may be accomplished in the fall, similar to larkspur. Fall sowing is also done in Zone 6, although germination may be marginal. In general, fall sowing results in longer stem length than spring sowing.

Growing-on

Grow plants at temperatures of 60–65F (15–18C) and apply 50–100 ppm N at each irrigation. Photoperiod has little effect on growth.

Nigella damascena 'Miss Jekyll'

Environmental Factors

Flowers are formed as plants mature and reach a certain number of nodes. Warm temperatures accelerate growth and flowering, but temperatures above 80F (27C) should be avoided. Photoperiod has little effect on flowering. High temperatures and lack of water result in reduced stem length.

Field Performance

Spacing: Space plants or thin seedlings to 6–9″ (15–23 cm) centers. When using successive sowings, use dense spacings. The tighter the spacing, the greater the opportunity of obtaining large terminal flowers; however, the tighter the spacing, the greater the opportunity for disease. Use common sense.

Planting time: Sow or transplant 3 or 4 times every 2–3 weeks early in the season for best fruit production. Hot summer temperatures will reduce stem length. The best pods are from the terminal flowers. Those from the laterals are smaller and less saleable; however, many growers clear cut the stems and still find an acceptable market for all the pods.

Fertilization: Side dress with a granular fertilizer, such as 10-10-10 or 8-8-8, approximately 3 weeks after direct sowing or transplanting to the field. Soluble fertilization may also be used at the rate of 300–500 ppm N applied every week.

Shading: In the South, shading (up to 30% shade) is useful: longer stems result.

Greenhouse Performance

Temperature: Plants may be produced with cool temperatures of 55–60F (13–15C) and bright light.

Scheduling: Seed sown in fall or early spring results in flowering plants approximately 9–12 weeks later.

Supplemental light: Use of HID (not incandescent) lights can greatly enhance stem strength and yield.

Stage of Harvest

Flowers: Harvest when the flowers are fully colored but before the petals have totally separated from the center.

Seed pods: The correct stage of maturity of the pods is debatable. Some growers harvest pods when they begin to turn purple-bronze; however, Kate van Ummersen, an Oregon grower, emphatically takes bronze coloration to be a sign of tardy harvest and poor quality. She suggests that pods should be fully developed, slightly before the pod starts to split; this stage, she contends, results in the most vibrant green and purple colors.

Postharvest

Fresh: Flowers persist 7–10 days, particularly if a preservative is used and water is replaced often. Store at 36–41F (3–5C) only if necessary. Pods are also sold fresh.

Dried: Flowers may be dried if harvested when fully open. Pods, harvested when they are green or purple, are air-dried and persist indefinitely. If harvested when fully developed, but still vibrant green, they dry well in the dark. This is also true for the pods of *Nigella orientalis*. Drying in the light causes bronzing. Removal of the finely divided foliage is usually not necessary.

Cultivars

These differ mainly in flower color; only a few show improvements in fruit size and color.

'Albion' bears double white flowers and deep green-purple pods.

'Cramers' Plum' has plum-colored pods with no stripes. Useful both for fresh and dried sales. Plants averaged 11″ (28 cm) long with 8 stems per plant in national trials (Dole 1998); according to its developer, Ralph Cramer, if sowing had been accomplished in the fall rather than the spring, stems would be closer to 22″ (55 cm) long.

'Dwarf Moody Blue' is only 6–9″ (15–23 cm) tall with blue flowers.

'Miss Jekyll' has semi-double flowers in sky blue. Also found in white ('Miss Jekyll White'), as well as dark blue and rose.

'Mulberry Rose' produces double pale pink flowers on 24″ (60 cm) stems.

'Oxford Blue' bears large double, dark blue flowers.

Persian Jewels is a mixture of mauve, purple, and white flowers.

'Red Jewel' produces deep rose flowers.

Additional Species

Several additional species are available, mainly for the unusual pods they produce.

Nigella arvensis bears pale mauve-blue flowers and ferny foliage.

Nigella ciliaris 'Pinwheel' has yellow flowers followed by pinwheel-like pods. It resembles the better-known *N. orientalis*.

Nigella hispanica (fennel flower) is about 2′ (60 cm) tall and bears deep blue flowers with blood-red stamens. The 1–2″ (2.5–5 cm) wide flowers are similar to those of *N. damascena*, except they don't have the spider-like extensions (involucres) at the base. The lack of these spidery structures makes for a cleaner look, but some consumers may miss it—after all, that's one reason love-in-a-mist is so misty. The fruit, which is not as inflated as *N. damascena*, is longer than wide and topped by a crown of 5 spreading styles, further helping to differentiate this species from *N. damascena*. 'Curiosity' grows 28–36″ (70–90 cm) with violet-blue flowers and spider-like pods. 'Exotic' has velvety petals on single flowers and dark purple stamens.

Nigella orientalis (Asian nigella) differs considerably, mainly by producing smaller yellow flowers with red spots. The "spiders" are also absent. The inflated fruit is united in the middle and divergent above. 'Transformer' bears yellow flowers and curious seed pods that are excellent for cutting and drying. Closely spaced plants result in unbranched 18–24″ (45–60 cm) stems.

Nigella sativa has bluish white flowers and grows about 18″ (45 cm) tall. The seeds of this species are the culinary spice black cumin.

Pests and Diseases

Damping off, aphids, and spider mites can be serious problems.

Grower Comments

"[I have] a tractor-mounted Planet Jr™ seeder. For *Nigella damascena*, I use the #12 hole (second-shallowest notch) and plant 4 rows per 4′ bed, 4.7 oz/1000 ft (440 g/1000 m). For *N. orientalis*, I use the #23 hole (third-shallowest notch) and plant 4 rows per 4′ bed, 4.0 oz/1000 ft (374 g/1000 m)." Kate van Ummersen, Sterling Flowers, Brooks, Ore.

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Many thanks to Don Mitchell (first edition) and Ralph Cramer and Kate van Ummersen (second edition) for reviewing this section.

Ornithogalum arabicum Arabian star flower Liliaceae

bulb, Zones 8–10 Mediterranean white 18–24″/18″ (45–60 cm/45 cm)

Clusters of creamy white flowers with black centers are borne on long stems. Plants lack winter hardiness and have poor heat tolerance, so, although production is common in Mediterranean countries, it is limited to the West Coast in this country.The genus is bulging with many fine species, but cut flower production usually involves *Ornithogalum arabicum* and *O. thyrsoides* (chincherinchee); *O. saundersiae* has a small but useful market. Other species sometimes mentioned, such as *O. nutans* (nodding star-of-Bethlehem) and *O. dubium* (orange star flower) are more often used as garden plants and pot plants, respectively. Be careful, all parts of plant are poisonous.

Environmental Factors

Photoperiod: No effects of photoperiod have been observed.

Temperature: Temperature is important for flower and scape development. Under natural conditions, flower development occurs after the foliage has died down. Bulbs can be programmed for immediate flowering or treated with warm

Ornithogalum thyrsoides

temperatures to retard flowering in order to extend the harvest. Bulbs can either be programmed for immediate flowering or can be placed at 86–91F (30–33C) to retard development (Shimada et al. 1995).

Bulb storage temperatures: Storage regimes for *Ornithogalum arabicum* vary; a few are provided here.

1. 68F (20C) after harvest until 1 November, then hold at 55F (13C) for 30 days prior to planting (Shoub and Halevy 1971).
2. 77F (25C) after harvest until 1 November, then hold at 63F (17C) for 30 days prior to planting (De Hertogh and Le Nard 1993).
3. For fastest development, 86F (30C) for 12 weeks, then 68F (20C) for 4 weeks, then hold at 55F (13C) 8 weeks before flowering (Shimada et al. 1995).
4. To retard flowering, store at 86–91F (30–33C) for several months (Shimada et al. 1995), follow with holding temperatures provided in scenario 1 or 2.

Greenhouse forcing temperatures: After programming, a greenhouse cycle of 70/50F (21/10C) day/night temperature requires about 21 weeks to flower (Dole and Wilkins 1999), 72/64F (22/18C) requires approximately 13–14 weeks, 79/72F (26/22C). Highest quality flowers result from greenhouse temperatures of 55–62F (13–17C).

Field Performance

Bulb size: Large bulbs of 5½–6½″ (14/16 cm) circumference yield the greatest percentage of flowering plants. Bulbs below 3″ (8 cm) fail to flower, and only about 30% of 4½″ (11 cm) circumference bulbs flower; the following table has additional details (Shoub and Halevy 1971).

Bulb size and yield of *Ornithogalum*.

Bulb weight (g)	Bulb circumference (cm)	Stems per 100 bulbs	Flowers per inflorescence
6–8	7–8	0	0
8–13	8–9	5	13–19
12–22	9–11	20–30	18–23
20–60	11–15	70–95	22–26
50–100	15–20	100–120	25–29

Larger bulb sizes also result in increased flowers per inflorescence; however, very large bulbs tend to split and should be avoided. John LaSalle of Whately, Mass., gets good flowers from 16/18 cm bulbs and better flowers from larger bulbs; he also notes that the larger bulbs tend to flower faster. From 12/14 cm bulbs, he gets small flowers.

Spacing: Place bulbs 6–9″ (15–23 cm) apart and cover with 4″ (10 cm) of soil.

Longevity: Bulbs persist 1–2 years, depending on location. On the West Coast or in Mediterranean climates, they may be left in the ground for 2 years, but are generally treated as annuals. If grown in the East, bulbs must be lifted each year and treated as annuals. Trials in Georgia were disappointing: the majority of bulbs failed to survive, and of those that did, flower production was poor. Plants are essentially xerophytic, and the cold winter temperatures in combination with rain in the winter and summer were likely to blame for the poor performance.

Greenhouse Performance

Most production is under protection. Purchase prepared bulbs (see "Environmental Factors") for winter and spring flowering. Place bulbs 6″ (15 cm) apart in 8–10″ (20–25 cm) pots, bulb crates, or ground beds. The temperature and duration of storage has a direct influence on flowering time (see "Environmental Factors" and section on *Ornithogalum thyrsoides*). Fertilize with 75–100 ppm N from calcium nitrate after planting. Greenhouse temperatures vary, but temperatures of 68–70F (20–21C) for 3–4 weeks followed by 58–62F (14–17C) until flowering have been successful. Treat bulbs as annuals, digging them up every year, but be sure they're dried down well before storing. Bulbs must have minimum storage temperature of 60F (15C) with good air movement.

Provide the highest light possible, particularly in the winter, and plant in well-drained soils at approximately 5.5–6.0 pH.

Guideline for Foliar Analyses

At field trials in Watsonville, Calif., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis.

(%)				
N	P	K	Ca	Mg
2.0	0.25	3.59	2.08	0.30
(ppm)				
Fe	Mn	B	Al	Zn
82	10	24	60	37

Stage of Harvest

If flowers are to be shipped long distances, harvest no later than when the first flower is open. Approximately ¼ of the flowers may be open for local sales. Place 10 per bunch and hold them in water, if possible.

Postharvest

Fresh: Flowers have excellent vase life and persist over 2 weeks. Preservative is not necessary. Unopened flowers continue to open even in plain water.

Storage: Flowers of various species of *Ornithogalum* may be stored dry at 40F (4C) for 4–6 weeks in moisture-retentive boxes (Rees 1985).

Dried: Flowering stems may be dried by desiccation. A equal mixture of borax and fine sand is best for drying. Place a thin layer of the borax/sand mixture in a container and lay the flowers on the layer. Gently pour desiccant over the stems, enough to cover them. Cover the container. Drying takes 4–10 days (Vaughan 1988).

Additional Species

Ornithogalum saundersiae bears 2–3′ (0.6–0.9 m) stems that terminate in white flowers with dark eyes. A better choice for eastern growers than *O. arabicum*—it is far more tolerant of cold winters and hot summers.

Ornithogalum thyrsoides (chincherinchee) is native to South Africa and bears 12–30 pure white flowers on each 15–20″ (38–51 cm) stem. As with *O. arabicum*, bulb storage regimes vary, depending on whether flowers are required immediately or delay of flowering is desired. Three possible scenarios follow.

1. 86F (30C) for 8 weeks after bulb harvest, then hold at 63F (17C) for 30 days prior to planting (De Hertogh and Gallitano 1997).
2. 41F (5C) for 14 weeks after bulb harvest and hold until planting (van Vuuren and Holtzhausen 1992).
3. To retard flowering, 86–95F (30–35C) for several months. Follow with 41F (5C) for 6–14 weeks (length of storage decreases as length of heat retardation increases) prior to planting (Shoub and Halevy 1971, van Vuuren and Holtzhausen 1992).

For greenhouse production, 50–60F (10–15C) is used after planting.

For outdoor planting, plant in February–March for flowering in early June. An average of 1.5 inflorescences are produced by 4–5 cm bulbs; 8–10 cm bulbs produced 4 inflorescences per bulb (Rees 1985). Flowers should be harvested when the first flower opens. Stems are pulled, not cut. Postharvest treatments are similar to *Ornithogalum arabicum*. Cultivars include double-flowered 'Mount Blanc' and 'Mount Everest'. An excellent cut flower species.

Ornithogalum umbellatum (star-of-Bethlehem) carries 10–20 star-shaped white flowers with green stripes on 12″ (30 cm) stems. Bulbs spread rapidly and can be considered perennial in much of the Southeast. This is one of the few useful ornithogalums for the eastern half of the country. Unfortunately the common name, star-of-Bethlehem, is also used for *O. arabicum*. Do not confuse the pair when ordering bulbs; they are very different.

Pests and Diseases

Leaf spots occasionally detract from the foliage, and root rots may occur in wet soils.

Ornithogalum mosaic virus results in finely mottled light and dark green foliage. More conspicuous mottling of gray and yellow occurs as the foliage matures. The virus is spread by aphids and is best controlled by controlling the aphid population.

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Many thanks to John LaSalle for reviewing this section.

Paeonia hybrids

peony — Ranunculaceae

perennial, Zones 2–7 — China, Japan — many colors

2–3′/3′ (60–90 cm/90 cm)

Modern hybrid peonies are the result of persistent breeding and include both herbaceous (bush) peonies (the result of crossings between *Paeonia lactiflora*, *P. officinalis*, *P. mollis*, and others) and tree peonies (*P. suffruticosa*, *P. lutea*, etc.). Most cut flower production in this country involves the herbaceous forms; flowers of tree peonies are mainly harvested overseas.

Herbaceous peonies have long enjoyed popularity for their cut flowers and were farmed on hundreds of acres in the Midwest during the 1930s. They are making a comeback. A minimum of 5 years is needed before peonies become profitable. Capital during the first 3 years is spent on plants, soil improvements, cultivating, and overhead expenses. Only during the following 2 years will plants produce sufficient stems to realize a profit.

All growth originates from an underground crown. The stem buds or eyes are formed at the top of the crown and are the beginning of the next year's growth. Single- and double-flowering cultivars, and early-, mid- and late-flowering cultivars are available.

Paeonia ‘Bowl of Beauty’
(Japanese pink lactiflora)

Propagation

Plants are purchased as divided crowns and transplanted directly to the field. Five-eyed pieces are best, although 3-eyed pieces readily develop into flowering size (Stimart 1989). It takes propagators 3–5 years to produce transplants. Remove threadlike roots prior to planting. Planting is best done in the fall; early spring planting is appropriate if fall-harvested roots were cold stored during the winter.

Environmental Factors

Photoperiod: Buds of peonies are vegetative in early summer; flower initiation commences in July and August, depending on cultivar. Both terminal and lateral buds are initiated by late fall, before the onset of dormancy. Peonies go dormant as early as late August, but most cultivars persist until late October. Short days do not trigger dormancy as in other perennials, and experiments have shown that plants go dormant regardless of photoperiod (Wilkins and Halevy 1985).

Temperature: No exact data are available concerning optimum length of cold or temperature necessary to break dormancy. Although peonies flower in northern latitudes where freezing temperatures occur, they also perform well in central California and northern Georgia, where frost is not a constant guest in winter. From the authors' point of view, however, the more persistent the winter cold, the better the production. This does not mean freezing temperatures are necessary, but persistent soil cold (<40F, 4C) is beneficial. Flower bud dormancy may be broken with as little as 4 weeks at 43F (6C), but increasing time to 6 weeks or lowering temperature to just above freezing for 4 weeks increases the number of flowering shoots (Wilkins and Halevy 1985). Stimart (1992) states that approximately 600 hours at 32–36F (0–2C) are necessary to break dormancy.

Work with prechilling and growing-on temperatures for tree peonies was conducted in Japan by Aoki (1992). He determined that prechilling 2-year-old dormant plants for 10 days at 60F (15C) prior to chilling at 40F (4C) for 7 weeks caused acceleration of sprouting and flowering. When initial growing temperatures (after chilling) were low (day/night 62/52F, 17/11C), flowering percentages were high, regardless of prechilling. Plants that were forced at constant 62F (17C) compared to constant 55F (13C) flowered 15 days faster, but cut flower quality was much reduced. Work in China (ZhiMin et al. 1999) showed that tree peonies had better root growth and nutrient absorption in a soilless substrate than when soil alone was used, and that a substrate temperature of 53–65F (12–18C) was considered optimal for growth and development.

In general, for all peonies, flower production declines as temperatures rise, and temperatures above 70F (21C) result in more rapid decline of flowers.

Field Performance

Planting: The buds (eyes) of the rootstock should not be planted deeper than 2″ (5 cm) below the soil surface. Deep planting inhibits flowering (Nehrling and Nehrling 1960). Planting should be accomplished in the fall. Janet Foss of J. Foss

Garden Flowers in western Washington plants peonies very shallow—with the pink buds just at the soil line, often showing a bit. She goes on to say that growers in eastern Washington plant the eyes much deeper. The difference is temperature: "On the western side of the state, deep plantings don't get enough cold to promote flowering, but shallow plantings do. Many peonies here [western Washington] fail to bloom if planted too deep, and even after 10 years they have failed to adjust themselves to the correct depth to promote blooms."

Mulching: Mulch is often used to provide some winter protection, particularly in newly planted root divisions; however, cold is seldom an overwintering problem. Mulch also may help to keep roots cooler and delay flowering. In general, overzealous mulching will not hurt plants if done for a year or so; however, continuous mulching causes a buildup, reducing oxygen and water penetration to the roots, and soon the roots are buried too deeply. Some suggest that the roots will eventually find their own proper depth, but Bernie Van Essendelft, a peony grower in North Carolina, states that mulching or planting too deep causes the plant to move eye development from the crown up to the stem, especially on 'Sarah Bernhardt'. The result is fewer blooms and weaker stems. He plants no deeper than 1″ (2.5 cm). Most peony growers caution against mulch (especially bark), as too thick a mulch may reduce flowering and promote fungal disease.

Spacing: Plants should be planted no closer than 18″ (45 cm) apart; 24″ (60 cm) is not uncommon (Kneppers 2001). If row planting is used, 2–3′ (60–90 cm) spacing between plants and 4′ (1 m) wide rows are common (Stimart 1989). Closer spacing reduces longevity.

Disbudding: Lateral flowers are often disbudded to increase the size of the primary flower and to provide longer stems; disbud approximately 3 weeks prior to blooming. Alternatively, terminal flower buds are removed, resulting in a spray of lateral flowers. The best time to disbud is when the buds are easy to reach and are the size of a small pea. According to Roy Snow of United Flower Growers in Burnaby, B.C., "All peonies sold through the Vancouver Flower Auction have to be disbudded or they are sold as second grade." In 2000 the auction sold about 90,000 stems of peonies, all disbudded.

However, not everybody agrees that disbudding means better quality. As Ed Pincus, a Vermont grower, puts it,"The market demands it, so you disbud." He also provides a contrary argument: "The side buds give the peony a different look that some prefer, and in any case they can be disbudded after sale. On some varieties the side buds will blossom on the cut stem, extending bloom time. On 'Ann Cousins' and other varieties, the side buds are fairly long (12″), and if you are willing to give up the main bud, you can get 2 or 3 12″ stems without cutting any of the plant's foliage."

Longevity: Two- to 3-year-old transplants require an additional 2–4 years before any significant harvest occurs. Plants are kept in the field for 10–15 years, and 30-year longevity is not uncommon. Flower production peaks in the third through tenth year in the North. In southern areas, plants may have to be rotated a little earlier. Divide or replace plants when yield is significantly less than the previous year.

Shading: Peonies should be planted in full sun but will tolerate partial shade, particularly in the South. Reduction in flower number and size is indicative of too much shade.

Fertilization: Side dress peonies (e.g., 8-8-8) in the fall and again in the spring, after stems have emerged. A pH of approximately 6.0 is recommended.

Forcing: Flowering is advanced by covering the beds with plastic or tunnels in late winter.

Failure to flower: Sometimes no buds appear at all, and sometimes buds appear but flowers do not develop. The reasons and possible solutions follow (American Peony Society 1995).

No buds appear:	
1. Plants too young and immature.	Allow them to mature.
2. Planted too deep or too shallow.	Examine, and if eyes are more than 3" (8 cm) below ground, lift and replant.
3. Clumps too large and too old.	Divide the clump if it stops flowering (after 3–10 years), leaving 3 eyes per division.
4. Too much nitrogen.	Cut down on frequency or concentration of fertilizer.
5. Moved and divided too often.	If the clump is flowering well, it should not be moved. Clumps can remain in place well over 10 years.
6. Too much shade.	Move to sunny location.
Buds appear but flowers do not develop:	
1. Buds killed by late frost.	Better luck next year. Plant later cultivars.
2. Buds killed by disease. They usually turn black and die.	Spray fungicide as directed for botrytis.
3. Buds attacked by thrips. They open partially, turn brown and fall.	Spray as directed.
4. Buds waterlogged due to excessive rain.	Plant singles or Japanese forms. Bagging buds will help.
5. Plants undernourished.	Fertilize with 8-8-8 and bonemeal.
6. Excessively hot weather.	Plant early-flowering cultivars.

Yield: Depending on cultivar, 8–12 flower stems/plant can be realized once plants are mature. Karen Gast at Kansas State University evaluated yield and vase life of dozens of cultivars over approximately 10 years. Cultivars that consistently produced excellent yield are listed in the following table (Gast 1998). Karen notes that Kansas is on the southern end of peony production and believes that yields would be higher in cooler climates.

	Cultivar	Stems/plant
White	Henry Sass	5.8
	Lois Kelsey	6.6
Pink	Edulis Superba	5.1
	Hermione	5.0
	Mrs. Franklin D. Roosevelt	5.6
	Reine Hortense	5.0
	Sarah Bernhardt	20.2
	Therese	6.6
	Walter Faxon	9.4
Red	David Harum	6.4
	Felix Supreme	13.4
	Grover Cleveland	5.0
	Karl Rosenfield	7.8
	Louis van Houtte	8.8
	Philippe Rivoire	7.6
	Richard Carvel	13.4

Cut only ⅓ of the harvestable stems, and allow as much foliage to remain on the plant as possible (Post 1955). Leaving behind some stems is good for the health of the plant; removal of too much foliage reduces vigor and results in poorer production in subsequent years. Growers who do elect to cut all stems aggressively must replace plants more often. Stem length depends on cultivar and the duration of cold. Stem length in Fremont, Calif., averaged 10″ (25 cm); in Pantego, N.C., 18″ (45 cm); in the upper Midwest, 2–3′ (60–90 cm) (Stimart 1989).

Greenhouse Performance

Plants in which dormancy has been broken with cold temperatures can be forced in the greenhouse in 8 weeks at 60–65F (15–18C) night temperatures (Wilkins and Halevy 1985). Crowns dug from the field on 1 November in Minnesota were stored at 32–40F (0–4C) until the cold treatment had been satisfied (late December), then placed in a 65F (18C) greenhouse; shoots emerged and flowering occurred without problem.

Since flowers initiate before the onset of dormancy, it is possible that plants simply must attain a certain size or leaf area to stimulate the formation of additional flower buds. Another possible environmental signal to force initiation of new buds may be the lessening of daylength, since peonies are generally vegetative in summer but have finished initiation of terminal and lateral buds by September (Wilkins and Halevy 1985). If additional flower buds were forced early, then plants would still likely require a dormant period and then a cold treatment to overcome the dormancy. Most forced peonies are replanted or discarded after flowering.

Stage of Harvest

Stage of harvest is tricky with peonies—all growers agree that skilled pickers are essential. As a general rule of thumb, flowers should be harvested when the first true color appears on top of the tight bud, but researchers have come up with bud maturity indices that offer more precision. ChaeKyu (1998) broke flower development into 3 stages: in stage 1 the margin of the calyx was showing color, in stage 2 the calyx had started to open and petals could be seen, and in stage 3 the petals were obviously puffy. Harvesting in stage 2 was recommended. In 2001, Gast et al. determined additional stages of development using 8 cultivars. Flowers were separated into grades based on firmness, amount of lifted petals, amount of center showing, color shift, angle of guard petals, bud length, and brightness of petal color. As expected, vase life varied by cultivar.

Double-flowered types should be further developed than single forms, and red cultivars should be more developed than whites (Post 1955).

Postharvest

Fresh: Work by ChaeKyu (1998) showed that pulsing the cut stems in a 20% sucrose solution for 24 hours provided the best opening and longevity of the flower. Flowers may persist up to 10 days if harvested in the bud stage, but if already open, they persist only 5 days (Vaughan 1988). Fresh flowers are best maintained at 36–41F (3–5C) at all times. Gast (1999, 2000) measured vase life of numerous cultivars in water and the floral preservative Floralife™ at the rate of 4 tablespoons per gallon of water. In general, her results showed that floral preservative was not useful in all cases; however, it did result in larger flowers in the vase for some cultivars. Interestingly, the way in which the flowers declined differed too: in water, the petals fell off; in the preservative, they wilted. This study suggests that all preservatives should be trialed prior to widespread use.

Dried: Flowers harvested when first showing color or at loose calyx stage may be stored dry at 32–34F (0–1C) for up to 4 weeks (Wilkins and Halevy 1985, Heuser and Evensen 1986). Lower leaves should be removed from the cut stem. Flowers may be air-dried, although they tend to shrink considerably. When flowers are almost dry, smooth out the outer petals until the flower regains its original shape (Bullivant 1989). Flowers may also be dried in a microwave. Cover with warm silica gel and microwave for 1–3½ minutes, depending on the fleshiness of the flowers. Freeze-drying of peonies has also been recommended.

Storage: Flowers may be stored dry after being placed in water for 2–3 hours at 36F (2C). Remove from the water and stand upright in 32–36F (0–2C) at 75–80% humidity. Storage of up to 4 weeks is reported (Stimart 1992, Gast 1999), but that is too long for most cultivars. However long they are held, flowers must be dry, or fungal growth sets in.

Cultivars

Many cultivars and forms are available from specialist peony producers. The American Peony Society divides the flowers of herbaceous peonies into 4 different forms (American Peony Society 1995).

Single	Five or more petals are arranged around a center made up of stamens with pollen-bearing anthers.
Japanese	Really a double form, characterized by 5 or more petals around a center made up of stamens with non-pollen-bearing anthers (staminodes). When the stamens in the center have been transformed into narrow petal-like structures (petaloids), the bloom is said to be anemone-flowered.
Semi-double	Five or more outer petals are arranged around a center consisting of broad petals and stamens with pollen-bearing anthers. There may be a distinct center of stamens or they may occur in rings, intermixed among the petals. Either way, the stamens are always clearly visible and prominent.
Double	Five or more outer petals occur, but the bulk of the flower is the stamens, transformed into petals. Often no trace of the stamens remains; sometimes they may be present or partially petaloid. In double types, stamens are not a prominent part of the flower.

As cut flowers, doubles enjoy the greatest market, followed by semi-doubles and then singles and Japanese. Without doubt, white is the favorite color of buyers and should be planted more heavily than others. Pink is the next most requested color, followed by red. Bicolors are useful but more of a fad than a mainstay. If growing fully doubles in the South, select early and midseason cultivars to reduce disease problems.

According to Alice Vigliani, a peony grower in Massachusetts, factors that make a cultivar good for cut flower production include stem length and strength; number of side buds (ease of disbudding); hardness of bud when it can be cut (the harder the bud, the easier to ship wholesale without it opening too much before getting to the end user); number of harvestable stems per plant; vase life (doubles last longer than Japanese or singles); and disease resistance (botrytis).

The following cultivars are recommended for cut flower production by Alice Vigliani (V) of Massachusetts, Paul Sansone (S) of Oregon, and Bernie Van Essendelft (E) of North Carolina. The color given is the predominant color in the flower, not necessarily the only color; some flowers are flecked, spotted, edged, or blushed with additional colors.

White	'Bowl of Cream' (double) (E), 'Charlie's White' (double) (V, E), 'Festiva Maxima' (double) (V, S, E), 'Henry Sass' (double) (E), 'Marie Lemoine' (double) (S)
Pink	'Angel Cheeks' (double) (V), 'Cytherea' (semi-double) (S), 'Duchesse d'Orléans' (double) (S), 'Honor' (single) (S), 'James Pillow' (double) (V), 'Monsieur Jules Elie' (double) (V, S, E), 'Raspberry Sundae' (double) (V), 'Reine Hortense' (double) (E), 'Roselette' (single) (S), 'Sarah Bernhardt' (double) (S, E)
Red	'Big Ben' (double) (E), 'Charm' (Japanese) (V), 'Felix Crousse' (double) (S, E), 'Felix Supreme' (double) (V, E), 'Kansas' (double) (E), 'Nippon Beauty' (Japanese) (S), 'Red Charm' (double) (E), 'Red Red Rose' (semi-double) (S), 'Richard Carvel' (double) (V)
Coral	'Coral Charm' (semi-double) (S)
Lavender	'Rivida' (single) (S)
Bicolor	'Gay Paree' (pink/white, Japanese) (V), 'Largo' (pink/yellow, Japanese) (V), 'Top Brass' (white/pink/yellow, double) (V).

Pests and Diseases

Botrytis or gray mold (*Botrytis paeoniae*) affects flowers, particularly double forms, during periods of wet weather. Botrytis can infect the entire plant, causing it to turn black. Control by removing any infected parts in summer and fall. Apply preventative fungicides in early spring when leaves begin to unfurl; a second application may be applied 10–14 days later. If additional sprays are needed, apply at 10- to 14-day intervals.

Leaf spots, caused by numerous fungal species, result in spots of varying sizes and colors. Red spots or measles (*Cladosporium paeoniae*) occur as small, circular, discolored spots that eventually run together. The undersurface becomes light brown, the upper, dark purple. Remove all infected tissue as soon as spots are visible. Apply general foliar fungicide as above.

Root rots caused by soil-inhabiting fungi cause decay at the base of the plant.

Stem rot (*Sclerotinia sclerotiorum*) results in sudden wilt and stem rot. The large, black sclerotia develop inside the infected stems. Remove and dispose of infected plants.

Northern root-knot nematodes (*Meloidogyne* spp.) can be particularly destructive. Nematicides and soil fumigation are useful, but if infestation is severe, the only solutions may be to plant where peonies have never been grown or to relocate the nursery.

Viral organisms can cause ringspot—circular areas consisting of concentric bands of alternating dark and light green. Unlike other viruses, plants are not dwarfed. Dwarfing of plants is caused by leaf curl virus, Lemoine virus, and crown elongation virus. Control all viral diseases by removal and disposal of affected plants.

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Papaver nudicaule

Iceland poppy | Papaveraceae
perennial, Zones 2–7 | subarctic regions | many colors
1–2½′/1′ (30–75 cm/30 cm)

This northern species, grown for its colorful flowers, is becoming more popular in designs. Breeders have provided some outstanding cultivars with incredible colors, including white, pale yellow, burnt orange, raspberry, salmon, egg-yolk-yellow, and apricot.

Propagation

All plants are grown from seed, yet germination is erratic (often less than 50%) and is a major limitation to the crop. When sown at 65–75F (18–24C), seeds germinate in 7–12 days (Nau 1999). Do not cover seeds. Some growers start plants in 392-cell trays the last 2 weeks of August, then bump them up to 72s, and plant around mid November, depending on latitude. It may be more profitable to purchase started plugs when available.

Growing-on

Transplant seedlings to containers in about 3 weeks from sowing, or when the seedlings can be handled. Plugs are available, and an intermediate transplant prior to placing in the field or greenhouse is recommended. Grow on at 45–55F (10–13C).

Environmental Factors

Iceland poppies do poorly in temperatures above 70F (21C). Plants can be flowered at warm temperatures, but plant quality and flower size is reduced as temperatures rise. No photoperiodic effect is known.

Field Performance

In the South (Zones 7 and 8), plant in late fall (October) for early spring production; to be safe, plant them out in an unheated greenhouse to avoid winter injury and death. In the North, plants will not do well if planted in the fall unless protected. In the spring, place in the field as soon as the ground can be worked.

Plants generally produce 10–15 flower stems per plant before warm temperatures reduce their usefulness. Plants can be harvested as long as summer nights remain below 60F (15C). Stem length varies, 18–28″ (45–70 cm).

Greenhouse Performance

Plants are produced in greenhouse conditions for winter production when cool temperatures can be maintained. Propagate and grow on as just described. Production occurs in ground beds or 6″ (15 cm) containers. Multiple plants per container can be used successfully. Temperature should be maintained below 60F (15C) whenever possible. Crop time is 15–17 weeks from seed (Nau 1999). Supplemental lighting enhances growth and flowering, particularly at northern latitudes.

Stage of Harvest

Harvest flowers at colored bud stage (when fuzzy sheaths split open and color is showing). Some flowers fail to open if cut too early; it may be necessary to cut twice a day. Harvest stems by giving them a sharp tug to the side; some growers find this method reduces decay and crown rot. Scald stems in hot water to reduce latex flow each time they are cut (see "Grower Comments").

Postharvest

Flowers persist 5–7 days (Vaughan 1988). Storage is not recommended; stems and petals are too thin.

Cultivars

'Champagne Bubbles' is an F_1 hybrid with 3″ (8 cm) wide flowers in white, orange, pink, and yellow shades. Stem length is about 15″ (38 cm).

'Flamenco' offers a mixture of flowers in pastel pink shades with white fluted edges.

Highlight Mixed offers a wide range of early-flowering halo and pastel types.

Kelmscott Strain is 12–18″ (30–45 cm) tall and consists of mostly pastel colors.

'Meadow Pastels' is a mix of both pastel and bright colors, in shades of rose, pink, white, yellow, orange, and cream and bicolors. Plants grow to 24″ (60 cm).

Monarch Mix bears flowers up to 2″ (5 cm) wide in many bright colors.

'Party Fun' produces sturdy upright stems with 4″ (10 cm) wide flowers in a wide range of colors. Plants stand 12–15″ (30–38 cm).

'Popsicle' has 3–4″ (8–10 cm) wide flowers in an assortment of colors.

'Red Sails' bears 5″ (13 cm) wide orange-scarlet flowers on 30″ (75 cm) tall plants.

San Remo Mix is a lesser-known variety, with red, orange, rose, yellow, and white flowers on 24″ (60 cm) plants.

'Solar Fire Orange' is especially useful as a cut flower, growing nearly 2′ (60 cm) tall. One of the few choices in a single color; the bright orange flowers are eye-catching.

'Summer Promise' contains both solid and bicolor 2–3″ (5–8 cm) wide flowers on 2′ (60 cm) stems.

Temptress series provides long-stemmed flowers in numerous colors. A favorite among growers (see "Grower Comments").

Wonderland Mix is more compact than the type and bears flowers 2–3″ (5–8 cm) in diameter. 'Wonderland Orange' has bright orange flowers 3″ (8 cm) wide.

Additional Species

Papaver somniferum (opium poppy) is grown for the seed capsules, used in dried arrangements. Opium is made from the sap of the green seed capsules and was known by the Greeks and Egyptians several centuries before the birth of Christ. Cut flower growers have been producing opium poppy for the decorative pods for years. Laws about growing this plant are changing in the United States; since some states frown on fields of opium poppy, a fruitful discussion with local law enforcement prior to planting is a fine idea.

Seeds can be direct sown in the fall or early spring. Flowers are beautiful, but their vase life is minimal and they are seldom harvested. Capsules are harvested green when an appropriate size is attained, then dried. Plants are less stringent in their need for cool temperatures, and capsules are harvested into the summer; however, warm temperatures result in decline of additional flowers.

Select cultivars whose capsules are sufficiently large and whose stem length is long enough. 'Black Cloud' has almost 4″ (10 cm) double, ruffled flowers in a rich dark purple red. 'Hens and Chickens' bears 3–4″ (8–10 cm) lavender flowers, followed by many small seed pods; plants grow to 2′ (60 cm) in height. 'Oase' has fringed double scarlet flowers with a contrasting white blotch. 'The Giant' bears lilac flowers followed by large 1–2″ (2.5–5 cm) seed pods. 'White Cloud' is about 36″ (90 cm) tall and has 4″ (10 cm) double, ruffled flowers.

Pests and Diseases

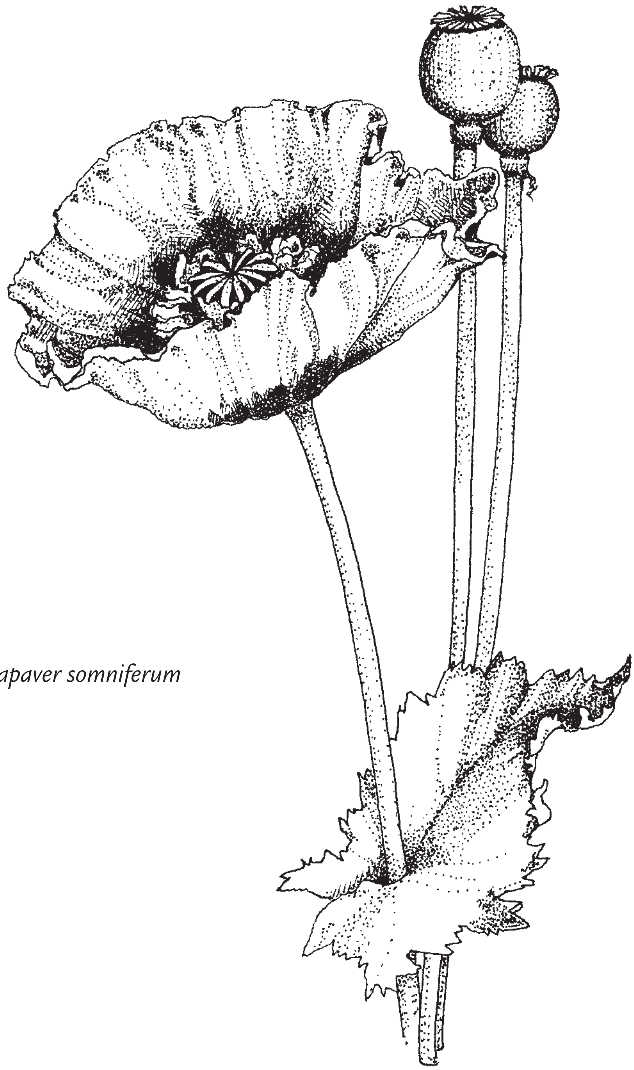
Southern blight (*Sclerotinia*) can be a problem, especially with over-wet conditions. It results in crown rot, which shows up as a fuzzy white fungus.

Grower Comments

"My best results with poppies is to cut just as the bud is starting to split. When you get them back to the barn, recut a tiny amount from the bottom of the stem, dip a half inch or so in boiling water for a few seconds, and plunge stems into several inches of cold water. Each time the stems are recut, the treatment needs to be repeated. On Icelandics we receive from New Zealand, the treatment appears to be the same. They are shipped dry with the sepals bursting and there is evidence of 'cooked' stems on the end centimeter or so." Ray Gray, Sunset Flowers of New Zealand, Oregon City, Ore.

"I grew Temptress poppies outside last year, and they did last better than other Iceland poppies. I tried them several times in the house, and they definitely lasted longer than other Icelands I've tried. Overall I do think they are the best cut flower poppies I've ever tried, and the price is fair." Janet Foss, J. Foss Garden Flowers, Everett, Wash.

"I grow [*Papaver somniferum*] for the pods, which I sell green. We sell in 12-pod bunches. That might be 5–10 stems, depending on the branching. We don't count little pods. The stems are about 3′. I grow Icelandic for the flowers. These are scalded and are about 12–28″ long. . . . I love Temptress because I get 15–20″



Papaver somniferum

stems and great colors. Salmon is the most popular. Germination was poor, and next year I'm ordering plugs. I've grown 'Champagne Bubbles', and the blooms are bigger, but the stems aren't as long. We treat every stem by scalding the bottom half inch for 20 seconds. I have been getting more than a week in the vase, but my farmhouse is cold. I planted mine in November and production started early March in my hoophouse. We cut twice a day when they open and put them in the cooler. They store there very well, although sometimes a few never open. With all this said, these flowers are still my favorite to grow in the winter/spring." Bob Wollam, Wollam Gardens, Jeffersonton, Va.

"I grow 'Temptress' poppies every year. I have also tried other varieties such as 'San Remo' [and] 'Meadow Pastels' . . . but 'Temptress' is the best quality and most productive. We treat our cut stems in boiling water to stop sap flow. We stick the whole bunch in the water up to about 2″ deep for 20 seconds. You will know you have done it long enough when you see a light grayish ring at the water level after treating. A flame can be used but is not really effective with large amounts. When we sell them, we tell our customers to flame the ends if they cut the stems to another length." Frank Arnosky, Texas Specialty Cut Flowers, Blanco, Tex.

Reading

Nau, J. 1999. *Ball Culture Guide*. 3rd ed. Ball Publishing, Batavia, Ill.
Vaughan, M. J. 1988. *The Complete Book of Cut Flower Care*. Timber Press, Portland, Ore.

Phlox paniculata

summer phlox — Polemoniaceae
perennial, Zones 3–8 — North America — many colors
3–4′/3′ (0.9–1.2 m/0.9 m)

Phlox has long been used as a cut flower for its vigorous growth, wide selection of flower colors, and large inflorescences. It is a popular stem for fillers in bouquets, and the fragrance of the flowers only increases demand. Two major problems still plague summer phlox: the incidence of powdery mildew on many cultivars and the premature shattering of flowers after harvest. Less mildew-susceptible cultivars and species such as spotted phlox (*Phlox maculata*) are being incorporated into cut flower programs.

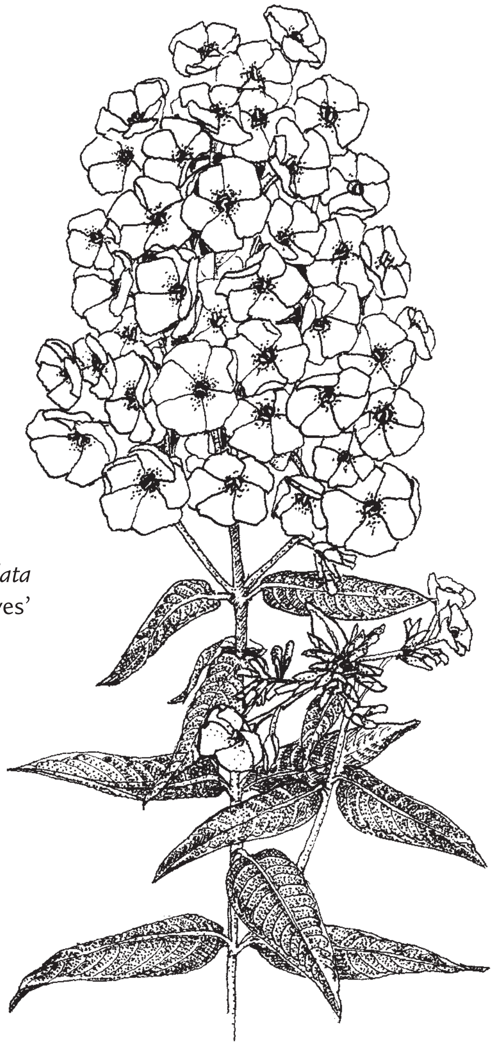
Propagation

Propagation is accomplished by perennial growers from root cuttings, stem cuttings, or division. For cut flower production, stem cuttings rooted in plug trays and 1- to 2-year-old transplants are most popular. Cuttings root in 2–3 weeks in well-drained medium and warm soil temperatures. Bare-root material is mainly used in the nursery business, although some cut flower growers also use this method of propagation.

Growing-on

Propagules are usually placed in the field directly, with little or no additional growing time necessary. If bare-rooted plants are received too early, they may be stored in moist sphagnum moss at 40F (4C). If potted plants are received too early, they may be placed in 45–55F (7–13C) greenhouses until ready to plant out.

Planting in the fall is best for cut flower growers; planting in early spring is acceptable.



Phlox paniculata
'Bright Eyes'

Environmental Factors

Temperature: Garner and Armitage (2000) worked with greenhouse forcing of 'Ice Cap' and 'Red Eyes'. Plants were kept in a cooler for 0, 4, 8, or 12 weeks at 40F (4C) with incandescent light inside the cooler for 12 hours. When they came out of the cooler, they were placed under long days using extended lighting or nightbreak lighting with incandescent lamps. Regardless of the kind of LD incandescent lighting they received, plants that were cooled flowered earlier, with longer stems and higher yields, than uncooled plants. The following table shows that as cooling increased, time to flower decreased and stem length and yield increased.

Weeks in cooler	Flowering time in gh* using extended days	Stem length(in)^z	Stems/ plant
0	118	17	2
4	98	18	3
8	92	19	5
12	87	22	6
16	79	24	7

z = multiply (in) by 2.54 to obtain (cm)
* = greenhouse

Similarly, in work with *Phlox paniculata* 'Fairy's Petticoat', no cold treatment was necessary to break dormancy, but cold resulted in accelerated flower development and taller plants (Iversen 1989). In the field, cooling is provided by winter temperatures; in the greenhouse, a cooler or cold greenhouse is necessary.

Photoperiod: Under normal growing conditions, summer phlox is a long day plant; the critical photoperiod is between 8 and 16 hours. All plants of 'Fairy's Petticoat' flowered when provided with 16- and 24-hour days, but no flowering occurred under 8 hours, regardless of cold treatment (Iversen 1989, Runkle 1998, Garner and Armitage 2000). In the field, photoperiods longer than 10 hours initiate the flowering process.

In the greenhouse, incandescent lamps are used to extend daylength or as nightbreak lighting. Extended day lighting using incandescent lighting was more effective than nightbreak lighting in increasing stem length, although yields and flowering time were similar, regardless of cooling. Regardless of the length of cooling, plants of 'Ice Cap' exposed to extended day lighting in the greenhouse flowered more quickly and had longer stems and usually a higher yield than those exposed to nightbreak lighting.

High-intensity discharge (HID) lamps are another way to provide LD. Interestingly, if HID lighting (which provided far more cumulative light to the plants than incandescent light) was used, the high light substituted for cold and the effect of cooling was insignificant. As the following table shows, HID lights caused faster flowering, higher yields, and longer stems than either extended day or nightbreak lighting using incandescent lamps.

Weeks in cooler	Flowering time in gh using HID light	Stem length (in)^z	Stems/ plant
0	64	26	7
4	61	35	8
8	59	37	10
12	62	37	11
16	57	38	13

z = multiply (in) by 2.54 to obtain (cm)

Field Performance

Spacing: Space plants as close as 10 × 10″ (25 × 25 cm) or as wide as 18″ (45 cm) centers; these compute to 1.4 plants/ft^2 (15 plants/m^2) and 0.45 plants/ft^2 (5 plants/m^2), respectively. Sufficient spacing promotes good air movement, a necessity for reducing the incidence of powdery mildew. European recommendations suggest a spacing of 1.5 plants/ft^2 (16 plants/m^2).

Support: Use one or 2 layers of support.

Yield: The first harvest, after fall planting, results in 3–6 stems/plant. Yield increases the second year to 5–10 stems, depending on cultivar. The following table provides data from consecutive harvests in Watsonville, Calif.

Two-year yields and stem lengths of *Phlox paniculata*.

Cultivar	Year	Stems/plant	Stem length (in)[z]
Amethyst	1	12	17
	2	10	44
Bright Eyes	1	4	17
	2	6	38
Lilac Time	1	5	27
	2	8	48
Snowdrift	1	6	24
	2	8	45

z = multiply (in) by 2.54 to obtain (cm)

This table demonstrates the effect of maturity on *Phlox*. Summer phlox is a clump-forming species; as plants mature, the additional vigor is translated into longer and stronger stems, not necessarily significant additional yield.

Greenhouse Performance

Greenhouse spacing is more dense than field spacing. We planted phlox in bulb crates, at a spacing of 2 plants/ft^2 (22 plants/m^2); European recommendations suggest a spacing as dense as 8 × 8″ (20 × 20 cm), which works out to approximately 2.2 plants/ft^2 (24 plants/m^2).

Garner and Armitage (2000) found that flowering stems from rooted cuttings were generally longer than those from one-year-old transplants, although transplants yielded more stems over a given period of time than did cuttings. They found, however, that terminal shoots from vegetative cuttings could easily be rooted in about 3 weeks, and results suggested that an efficient programmed production could be developed using rooted terminal cuttings. Cuttings may also be placed at denser spacings, increasing yield efficiencies. For patented material, it makes sense to purchase rooted cuttings in plugs from a distributor. The use of cutting or graded transplants provides more uniformity than bare-root material and is recommended for greenhouse forcing.

If bare-root material is used, 2- to 3-year-old roots are best. Root divisions generally require 6–8 weeks to become established in the container or bed. Plants may be purchased or dug, but for more uniform flowering, the roots should always be cooled. If roots are dug on 15 August, cold storage can begin on 15 October. After cooling roots and crown at 40F (4C), forcing can begin on 1 December by placing plants under long days (incandescent lamps at 20–50 fc). Use good ventilation and fungicides to reduce incidence of disease. At 60F (15C), plants flower in approximately 12–15 weeks (Iversen 1989). Fertilize with a complete fertilizer at 150–250 ppm N every irrigation or with 500 ppm N once a week.

Stage of Harvest

Harvest as early as when 2 flowers are open (Bartels 2000), or as late as when ½ the flowers are open on the inflorescence (Nowak and Rudnicki 1990). Flowers are sensitive to ethylene and must be stored where ethylene is not present. Normal recommendations call for the use of an anti-ethylene agent after harvest, although results have been inconsistent. An antibacterial agent is also recommended. Leave approximately 2″ (5 cm) of stem behind to encourage regrowth. The next flush should occur in 10–12 weeks, depending on the environment.

Postharvest

Fresh: Flowers persist 5–7 days in floral preservative.

Storage: Stems may be stored wet at 38F (3C) for 1–3 days (Nowak and Rudnicki 1990).

Dried: Flowers do not dry well.

Cultivars

Pink

'Bright Eyes', among the most popular cultivars, has pale pink flowers with a crimson eye.

'Dresden China' produces pastel pink flowers with a deep rose-pink eye.

'Eva Cullum' has large heads of clear pink flowers with a dark red eye. Plants are only 2–2½′ (60–75 cm) tall.

'Fairest One' has wonderful, full salmon-pink blooms with a red eye.

'Fairy's Petticoat' bears large heads of pale pink flowers with darker eyes.

'Miss Candy' bears dark pink flowers with darker eyes.

'Miss Pepper' has pink flowers with a white eye. More often recommended for landscape use.

'Rose Joy' has rosy pink flowers and stands approximately 3′ (90 cm) tall.

'Windsor' produces deep pink flowers with a magenta eye.

Purple, lavender

'Amethyst' bears purple flowers on 3–4′ (0.9–1.2 m) stems.
'Ann' is a late bloomer with large, lavender flower heads.
'Lilac Time' has lilac flowers with a white eye on 3–4′ (0.9–1.2 m) tall plants.
'Progress' has pale violet blossoms with a darker eye.
'The King' is approximately 3′ (90 cm) tall and bears deep purple flowers.
'The Prince' has light violet flowers.

Salmon, red

'Othello' has deep red flowers with a long blooming time.
'Sir John Falstaff' bears large inflorescences of salmon-pink.
'Starfire' has striking, cherry-red flowers.
'Tenor' produces large, red flower heads.

White

'Blue Ice' is only 2½′ (75 cm) tall and bears white flowers with a blue eye.

'David' can grow to 4′ (1.2 m) and is more mildew resistant than many. Not entirely resistant, however.

'Ice Cap' has been an excellent performer with high yield and clean white flowers.

'Mount Fuji' ('Mt. Fujiyama') bears large, pure white flower heads. Mildew sensitive.

'Prime Minister' produces white flowers with a red eye and grows 3′ (90 cm) tall.

'Snowdrift' ('Schneerausch') bears white flowers on 3–4′ (0.9–1.2 m) tall plants.

'White Admiral' has large, clear, white flower heads.

Additional Species

These may be better cut flower species for areas where mildew is a problem.

Phlox ×arendsii (Arend's phlox) is a hybrid between *P. paniculata* and *P. divaricata* (woodland phlox). *Phlox divaricata* is only 12–15″ (30–38 cm) tall but is not as susceptible to mildew as *P. paniculata* is. Arend's phlox may provide a robust plant with good disease resistance and is a potentially good hybrid for Midwest and southern growers. Cultivars include 'Anja' (red-purple), 'Hilde' (lavender), and 'Suzanne' (white with a red eye).

Phlox maculata (spotted phlox) is rapidly gaining popularity as a cut flower. Plants are less susceptible to powdery mildew than *P. paniculata* but are not as vigorous or tall. Stems 2–3′ (60–90 cm) tall may be harvested. Cultivars include 'Alpha' (rose-pink with the hint of a darker eye), 'Delta' (white with a pink eye), 'Miss Lingard' (white with a pale yellow eye), 'Omega' (white with a lilac eye), and 'Rosalinde' (dark pink).

Pests and Diseases

Leaf spots are caused by many different fungi. Dark brown, circular spots up to ¼″ (6 mm) in diameter with light gray centers occur, followed by leaves that dry up and die prematurely. Use of sulfur helps reduce the incidence of leaf spots.

Powdery mildew (*Erysiphe cichoracearum*, *Sphaerotheca humuli*) occurs as a white coating on the foliage. The fungi do not cause permanent damage, but the leaves become terribly discolored. Use of fungicides is essential starting around mid June.

Crown rot (*Puccinia*, *Sclerotium*, *Thielaviopsis*) can result in significant losses. Sterilizing soils inhibits these soil-borne fungi.

Mites, thrips, and nematodes feed on phlox and may be controlled with appropriate spray materials. In the case of stem nematodes, plants should be discarded, soil disinfected, and crops rotated.

Reading

Bartels, G. 2000. *Bartels Cultural Guide*. Bartels Stek, Aalsmeer, The Netherlands.

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Iversen, R. 1989. Greenhouse forcing of herbaceous garden perennials. Ph.D. diss., Cornell Univ., Ithaca, N.Y.

Nowak, J., and R. M. Rudnicki. 1990. *Postharvest Handling and Storage of Cut Flowers, Florist Greens, and Potted Plants*. Timber Press, Portland, Ore.

Runkle, E. S., R. D. Heins, A. C. Cameron, and W. H. Carlson. 1998. Flowering of *Phlox paniculata* is influenced by photoperiod and cold treatment. *HortScience* 33(7):1172–1174.

Physalis alkekengi Chinese lantern Solanaceae

annual China, Japan orange fruit 12–15″/15″ (30–38 cm/38 cm)

Physalis consists of approximately 100 species, the best known of which is *Physalis alkekengi* (syn. *P. franchetii*, *P. alkekengi* var. *franchetii*; Chinese lantern), for the inflated, bright orange calyces that surround the fruit. When harvested and dried, the calyx persists for years. Plants may reseed themselves in many areas and act like perennials.

Propagation

Best germination occurs when seed is chilled 4–6 weeks at 40F (4C) then placed at 60–70F (15–21C). Approximately 0.12 oz (3.5 g) of seed yields 1000 seedlings (Nau 1999). Germination may require as little as 7 days and as many as 30. Fresh seed may be sown at 60–70F (15–21C) without stratification, but if stored for any length of time, moist stratification at 40F (4C) reduces germination time and increases uniformity.

Physalis alkekengi

Growing-on

Transplant to 3–4″ (8–10 cm) containers from the open seed pack approximately 3 weeks from sowing. Grow seedlings in plug flats for 4–6 weeks at 55–60F (13–15C). Fertilize once or twice per week with 150–200 ppm N from a balanced fertilizer. Over-fertilization and warm temperatures result in leggy plants with poor stem strength. Transplant to the field 8–12 weeks after sowing.

Environmental Factors

Chinese lanterns flower as plants mature. No evidence suggests that photoperiod is necessary for flower initiation. Warm temperatures and bright light result in faster flowering. Temperatures below 80F (27C) are best for production of largest fruit. Consistently high temperatures (above 80F, 27C) result in fewer flowers and small, poorly colored fruit.

Field Performance

Spacing: Space on 1′ (30 cm) centers or 12 × 18″ (30 × 45 cm). Sufficient space allows for expansion of the fruit and proper coloration.

Irrigation: Plants are heavy water users and should not be allowed to dry out, especially when fruit is being formed.

Fertilization: Side dress in the spring with a balanced fertilizer (20-10-20, 10-10-10) and also when plants are in flower but before fruits have matured.

Stage of Harvest

Harvest when the fruit is fully colored.

Postharvest

Fresh: If the fruit is used fresh, expect 12–20 days of vase life.

Storage: Store stems bearing fruit in water at 36–41F (3–5C) if necessary. Recut the stems when first placed in storage.

Dried: Strip leaves and hang stems containing fruit, or place fruit and stems horizontally in a box or other container. They are gourmet food for mice, so keep boxes sealed if mice are a problem.

Cultivars

'Gigantea' has larger fruit than the species but is not easy to locate.

Pests and Diseases

Several diseases occur on Chinese lanterns, but if grown in favorable environments, diseases are seldom serious.

Bacterial wilt (*Pseudomonas solanacearum*) results in rapid deterioration of the foliage. Plants should be discarded and plant rotation practiced.

Leaf spotting by various species of *Phyllosticta* may be controlled by general foliar fungicides at 10- to 14-day intervals.

Skeletonizing of the fruit by various insects and fungi occurs if the fruit is left on the plant too long. The problem is worse in high-density plantings, where air circulation is poor, fruit remains wet, and light seldom penetrates. Using landscape fabric around the plants helps keep fruit off the ground.

Reading

Nau, J. 1999. *Ball Culture Guide*. 3rd ed. Ball Publishing, Batavia, Ill.

Physostegia virginiana obedient plant Lamiaceae

perennial, Zones 3–9 North America purple-pink
3–4′/3′ (0.9–1.2 m/0.9 m)

Physostegia virginiana is a popular cut flower in Europe and Japan and in some North American markets. The whorled flowers are held in upright spikes above opposite, slightly toothed foliage, and the rhizomatous plants spread freely and rapidly, particularly in rich soil. Its common name is derived from the notion that flowers supposedly retain the position into which they are pushed, a useful characteristic for floral arrangers and decorators. Never, ever works for us.

Propagation

Seed: Germination is erratic and may take from 3 weeks to many months. For best uniformity, sow seed in moist seed flats or plugs and place at 35–40F (2–4C) for approximately 6 weeks. Remove from cold and place in 70–72F (21–22C) greenhouse. Germination occurs in 7–14 days; approximately 0.12 oz (3.5 g) of seed yields 1000 seedlings (Nau 1999).

Division: The easiest method of propagation is to divide plants in the spring, retaining roots with each propagule. Plants may be divided after one year in the field.

Cuttings: Stem cuttings may be rooted under warm substrate conditions. To increase the number of branches for cuttings, BA can be sprayed. Bessler (1995) suggested applications of 10 ppm 3 times weekly for 5 weeks. Root cuttings are also successful.

Growing-on

Large divisions may be transplanted directly to the field; small divisions should be placed in 4–5″ (10–13 cm) pots for additional growth. Grow seedlings and divisions at 50–60F (10–15C) in cold frames or cool greenhouses until ready for transplant to the field. Plants grow more rapidly at 70F (21C), but internode elongation may occur. Fertilize sparingly with 100 ppm N using calcium nitrate and potassium nitrate.

Environmental Factors

Temperature: Work with *Physostegia virginiana* 'Alba' demonstrated that cold is not necessary to break dormancy of the rhizome; however, the cold normally associated with winter temperatures seems to synchronize flower development. Plants given a 12-week cold treatment were taller than those provided with 6 weeks of cold (Iversen 1989).

Photoperiod: Physostegia is a long day plant, the critical daylength lying between 12 and 16 hours (Cantino 1982, Deneke and Beattie 1989). If provided with LD, plants flowered regardless of presence or absence of a cold treatment; however, when plants were provided with 12 weeks at 40F (4C), 80% flowered. This shows that cold can substitute for LD, an occurrence not uncommon in

Physostegia virginiana

LD plants. The critical photoperiod is probably shorter for 'Alba' than 'Bouquet Rose'. 'Alba' flowers in late June and July in north Georgia, while 'Bouquet Rose' does not flower until late August and continues through mid September.

Field Performance

Longevity: Obedient plant is long-lived and may be expected to produce well for 3–5 years. Plants become very dense after 2–3 years of production, however, and should then be divided and rejuvenated.

Longevity of *Physostegia virginiana* 'Alba'. Spacing 1' (30 cm).

Year	Stems/plant (in)^z	Stem length (in)^z	Stem width
1	13	29.4	0.30
2	26	30.9	0.30
3	14	29.0	0.26

z = multiply (in) by 2.54 to obtain (cm)

Yield was significantly reduced in the third year for 'Alba', but not for 'Bouquet Rose'.

Longevity of *Physostegia virginiana* 'Bouquet Rose'.

Year	Stems/plant (in)^z	Stem length (in)^z	Stem width
1	12	40.2	0.34
2	24	63.6	0.35
3	30	76.2	0.35

z = multiply (in) by 2.54 to obtain (cm)

Stem lengths are considerably longer with 'Bouquet Rose' than 'Alba' at the same spacing.

The effect of cultivar on stem length. Spacing 2' (60 cm).

		Stem length (%)		
Cultivar	Stem length (in)^z	<2'^{y}	2–3'	>3'
Alba	30.9	11.6	54.1	34.3
Bouquet Rose	63.6	0.4	1.9	97.7

z = multiply (in) by 2.54 to obtain (cm)
y = multiply (ft) by 30 to obtain (cm)

Various cultivars of *Physostegia virginiana* were trialed in Watsonville, Calif.; the results follow.

Yield and stem length of *Physostegia virginiana*.

Cultivar	Year	Stems/plant	Stem length (in)^z
Bouquet Rose	1	17	33
	2	25	54
Summer Snow	1	10	22
	2	16	46
Summer Spire	1	18	27
	2	20	52

z = multiply (in) by 2.54 to obtain (cm)

In general, yield and stem length were excellent, but less so in California than in Georgia.

Spacing: Plants may be spaced 1 × 1′ (30 × 30 cm), but because plants fill in rapidly, yield declines after 3 years. Spacing at 18–24″ (45–60 cm) centers is best for tall cultivars such as 'Bouquet Rose' and 'Summer Snow', but 'Alba' may be planted on 12″ (30 cm) centers to increase yield.

The effect of spacing on yield and stem quality of *Physostegia virginiana* 'Alba'. Second season in production.

Spacing (in)^z	Stems/plant	Stems/ft^{2y}	Stem length (in)^z
12	26	26	37.4
24	43	10	35.6
36	50	6	33.9

z = multiply (in) by 2.54 to obtain (cm)
y = multiply (stems/ft^2) by 10.76 to obtain (stems/m^2)

Spacing also affected the distribution of stem lengths: spacing plants greater than 2′ (60 cm) apart resulted in fewer long stems.

Greenhouse Performance

For more uniform flowering, plugs or bare root plants should be provided with 6 weeks at 40F (4C). Cold is not necessary if uniformity is of little importance. Space rhizomes in 6–8″ (15–20 cm) pots or a 9 × 12″ (23 × 30 cm) spacing in greenhouse beds. Provide 16-hour LD and 60F (15C) average temperature once cooled rhizomes are in the greenhouse. In Pennsylvania (Beattie et al. 1989), 'Summer Snow' flowered in 10 weeks, 'Vivid' in 15 weeks under 75/62F (24/17C) day/night temperatures. Under New York conditions, flowering will begin in approximately 12 weeks (Iversen 1989). Work conducted in the winter in Finland showed that 16 weeks was required (Sarkka 1991).

Guideline for Foliar Analyses

At field trials in Athens, Ga., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis.

'Alba'

(%)				
N	P	K	Ca	Mg
2.72	0.32	1.25	1.00	0.37
(ppm)				
Fe	Mn	B	Al	Zn
242	66	27	50	198

Stage of Harvest

Flowers may be cut when the spikes are fully elongated but before individual flowers are open, although allowing 3 or 4 flowers to open does not reduce shelf life significantly. Harvesting when more basal flowers are already declining reduces shelf life by 3–4 days. Pink flowers have better shelf life than white flowers: the white flowers turn brown as they decline and become unsightly; pink flowers abscise in the same manner, but the browning is significantly less visible.

Postharvest

Fresh: Even though stems appear relatively resilient, they should go into preservative immediately; plunge them in preservative in the field to increase longevity. Place stems in cooler at around 40F (4C) as soon as possible. The use of pulses of silver thiosulfate (STS) and 5% sucrose reduces shattering significantly. Too much STS (>2 mM) results in browning of petals and leaf margins. Flowers persist about 6 days without preservative or STS treatment, but with proper treatment (STS, preservative, sugar) a vase life of 14 days is realistic. Work with *Physostegia purpurea* showed that flowers stored dry for one week at 32F (0C) and treated with preservative and STS persisted 8 days compared with a 4-day vase life when stems were not treated once removed from cold storage (Kelly and Starman 1990). The same study showed that if flowers were held dry at relatively warm temperatures (72F, 22C), vase life was not affected unless flowers remained warm and dry for up to 8 hours.

Dried: Flowers do not dry well.

Cultivars

'Alba' (var. *alba*) has milky white flowers on 2′ (0.6 m) stems. Flowers are produced 4–6 weeks earlier than pink cultivars.

'Bouquet Rose' ('Rose Bouquet') has rose-pink flowers on 3–5′ (0.9–1.5 m) stems.

'Miss Manners', a dwarf form, stands about 16″ (40 cm) tall. It is less invasive than other varieties.

'Red Beauty' has rose-lavender flowers.

'Rosea' flowers a little earlier than 'Bouquet Rose' and bears rose-pink flowers on 3′ (90 cm) stems.

'Summer Snow' is the most popular white-flowered form with 3–4′ (0.9–1.2 m) tall, white spikes in early to late summer. Flowers appear about the same time as pink cultivars and are taller than var. *alba.*

'Summer Spire' has pink-red flowers on 3–3½′ (0.9–1.1 m) stems.

'Vivid' is the most popular garden form with 12–15″ (30–38 cm) stems and vivid purple flowers. The short stems make it more difficult to market, however.

Additional Species

Physostegia purpurea, which bears purple-magenta flowers, is native to the southwestern United States and has become naturalized across the southern states. May have potential for its relatively early flowering: in South Carolina, flowers are harvested in late April and May. Combining *P. purpurea* and *P. virginiana* allows for a longer harvest of flowers.

Pests and Diseases

Crown rot (*Pellicularia rolfsii*, *Sclerotinia* spp.) invades through roots or lower stem wounds and causes rapid wilting. Sterilizing soil prior to planting offers the best control. Rust (*Puccinia*), downy mildew (*Plasmopara*), and stem rot (*Sclerotinia*) also occur (Perry 1998).

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Many thanks to John Kelley for reviewing this section.

Platycodon grandiflorus balloonflower Campanulaceae

perennial, Zones 3–8 China, Japan blue 2½–3′/2′ (75–90 cm/60 cm)

Balloonflower has never become a mainstream cut flower crop, perhaps because of the time required to establish the plants, the height of the mature plant, or the tendency of the foliage to yellow. The unique bulging flower buds and lovely blue flowers have gained plants their followers as cut flowers, however. Starman et al. (1995) studied field production of balloonflower and concluded that mature plants, combining high yield with long stems, could be highly profitable.

Propagation

Seed: Most material grown for cut flowers is still seed-propagated. Approximately 0.06 oz (2 g) of seed yields 1000 plants. Seed sown at 68–70F (20–21C) germinates in 1–2 weeks, and seedlings can be transplanted approximately 2 weeks later (Nau 1999).

Division: Plants have long tap roots and do not divide well. The crown may be carefully divided as long as sufficient root is taken with the section; if replanted immediately, few problems occur. Division may be accomplished in the spring after the foliage has emerged. Do not divide more than once every 3 years.

Growing-on

Three to 5 weeks are needed to transplant to final container from sowing, depending on whether seedlings are in open trays or plugs. Temperatures of 62–68F (17–20C) are recommended for growing-on. Temperatures below 55F (13C) may result in leaf yellowing and unacceptable slow growth. Plants may be planted out to the field in 10–13 weeks, or when the roots reach the bottom of the container. Planting in the fall or early spring is recommended.

Environmental Factors

Temperature: Plants grown from seed require no cold treatment to flower; plants that have been divided require a cold treatment to break crown dormancy

Platycodon grandiflorus

(Iversen 1989). At least 6 weeks at 40F (4C) are necessary; 12 weeks result in more rapid flowering. Goi et al. (1994) stored quiescent crowns for up to 30 weeks as low as 32F (0C) and were able to have flowering plants all season.

Research with 'Astra Blue' and other pot plant cultivars suggests that greenhouse temperatures of 68–72F (20–22C) result in rapid flowering and excellent branching; however, fresh weight and leaf area at flowering increased with decreasing temperatures (Park et al. 1998). Plants of 'Sentimental Blue', another pot cultivar, flowered 133–149 days from sowing at 62/60F (17/15C) day/night. Supplemental light and LD did not influence the number of days to flower but increased the number of shoots and flowers (Song et al. 1993).

In the field, plants tolerate outdoor temperatures as far south as north Florida and north to New England.

Photoperiod: Plants are day neutral (Iversen 1989), but a 4-hour night interruption during the forcing phase may result in flowering one week earlier. In the field, photoperiod is not used.

Field Performance

Spacing: Space plants as wide as 12″ (30 cm) centers to as dense as 9″ (23 cm) centers. This is equal to 100 plants/100 ft^2 (1080 plants/100 m^2) and 180 plants/100 ft^2 (1750 plants/100 m^2), respectively. Plants will form large clumps within 3 years.

Yield: Approximately 5 flower stems are formed after the first winter, up to 15 stems on mature, well-developed specimens. Flowering occurs in mid to late summer and continues for about 4 weeks. Plants will rebloom on side shoots after cutting but with shorter stem lengths.

Longevity: Plants are long lived and should remain productive 5–8 years.

Support: Stems of the species and other tall cultivars require support. This is a necessity in the South and recommended in the North.

Weed control: Because balloonflower is so late in emerging, herbicides such as Roundup™ can be applied in the spring (before emergence) to control overwintering and early spring weeds.

Greenhouse Performance

If forcing bare-root material, plant one-year-old roots in ground beds (12″, 30 cm centers) or in deep pots, 6–7″ (15–18 cm) in diameter. Provide 6 weeks of 40F (4C) cold treatment; be sure that the medium remains moist. The cold treatment may be given in an unheated greenhouse, cold frame, or cold storage chamber. After 6 weeks, plants should be placed in 60F (15C) houses. Balloonflower is notoriously slow to emerge in the field or greenhouse; don't give up too early: stem emergence will occur in about 4 weeks (Iversen and Weiler 1994). An additional 9 weeks are necessary for flowering.

If growing from seed, no cold treatment is necessary. Transplant seedlings in ground beds or final containers. Natural photoperiod is sufficient, although LD (nightbreak lighting or extended days) may result in slightly faster flowering. Supplemental lighting with HID lamps during low light months will improve quality but may not be economical. Keep temperatures warm; below 55F (13C), leaves will turn yellow, and plants will be stunted. Work with pot plant cultivars suggested 12–13 weeks at 64F (18C), 10–11 weeks at 70F (21C), and 9–10 weeks at 75F (24C). Expect an additional 2–3 weeks for cut flower cultivars. Approximately 30 days are necessary between visible flower bud and open flower (Iversen 1989).

Stage of Harvest

Harvest when 2–3 flowers are open on the flower stem (Nowak and Rudnicki 1990).

Postharvest

Flowers persist 5–8 days in preservative.

Cultivars

'Albus' has white flowers with yellow veins on 3′ (90 cm) stems.

'Double Blue' bears deep double flowers on 2′ (60 cm) tall plants, but who wants double balloonflowers?

Florists series, available in dark blue, pink, and white, was developed for the specialty cut flower trade.

Fuji series is a seed-propagated strain bred for cut flowers. Flowers are available in pink, white, and blue. Plants grow 2–3′ (60–90 cm) tall.

'Hakone Double Blue', a tall double-flowered form, is also available from seed.

'Komachi' is a flowerless flower: the buds swell but never open. Interesting enough and may find a following, but don't bet the farm on it. A white form is also available, and likely other cultivars with similar flower habit will be developed.

'Misato Purple' grows 15–18″ (38–45 cm) tall and provides dark purple flowers.

'Shell Pink' may be grown from seed and bears shell-pink flowers on 2–2½′ (60–75 cm) stems.

Pests and Diseases

Aphids and whiteflies can be a problem, as can earwigs, who chew through the bud and live within.

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Many thanks to Dave Dowling for reviewing this section.

Polianthes tuberosa tuberose Agavaceae

bulb, Zones 7–10 Mexico white 2–4′/2′ (0.6–1.2 m/0.6 m)

Tuberoses have been cultivated for years and are well known for their sweet, heavy fragrance. The fragrance is sometimes considered too overpowering for use in confined areas, although historically, flowers were forced in European hothouses and used to decorate churches. The oil in tuberose is extracted for use in perfumery; approximately 1150 grams of flowers yield 1 gram of oil (Royal Horticultural Society 1992). The species itself no longer exists and is found only as a cultigen, that is, a plant solely represented by a cultivar(s), in this case, with single or double flowers. Up to 24 waxy-white, 2½″ (6 cm) long flowers occur along an erect, open spike. Rootstalks consist of tender bulb-like tubers and must be lifted north of Zone 7b (north Georgia), although if adequate mulch is employed, growers in Zone 7a may leave bulbs in the ground. If tubers are lifted in the fall, store around 45F (7C) in a dry area and replant in spring after danger of frost is passed. Growers in the Northwest and coastal California may also leave bulbs in the ground. Since they don't ship particularly well, tuberoses have become desirable local items, particularly popular for farmers' markets.

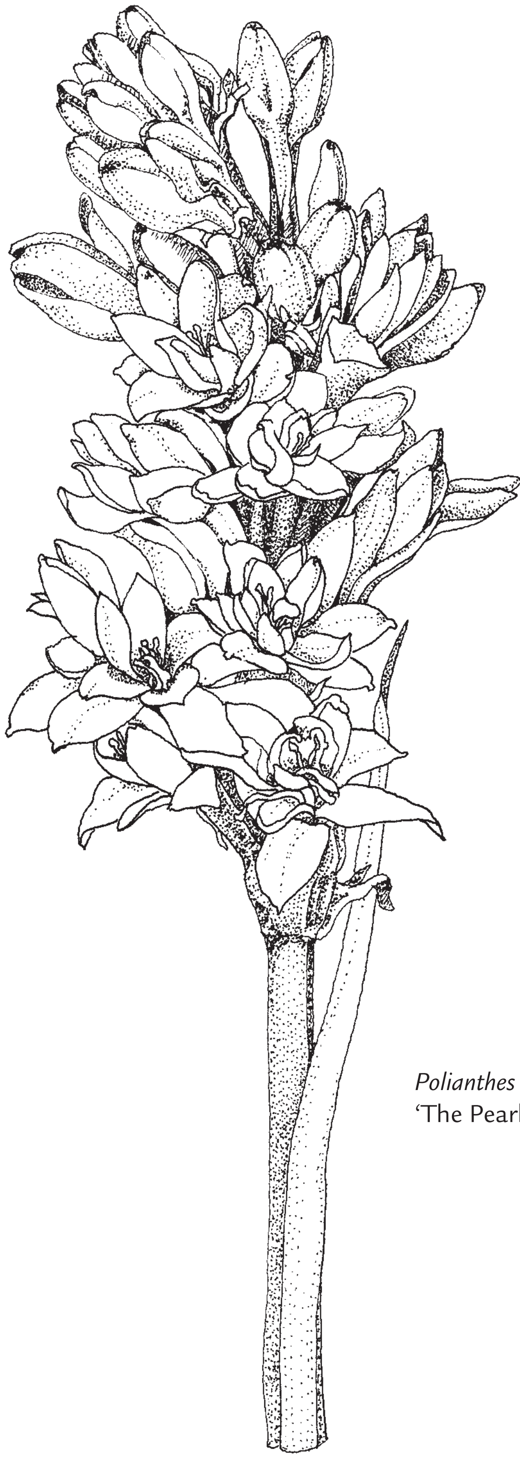
Propagation

Tubers come in all sizes, including singles and clumps—that is simply the nature of the beast. They may be split after flowering and separated by size. They are also split and graded by the distributor, or the grower may split them after receiving from the distributor. Tuberoses increase naturally, and large offsets may flower the following year. Smaller ones can be placed together in nursery rows for an additional year if they overwinter, but this is hardly worth the time if they are dug every year.

Environmental Factors

Photoperiod: No photoperiodic effects have been reported.

Temperature: Tuberoses grow best at a minimum temperature of 68F (20C). They do continue to flower even when air temperatures fall below 50F (10C);



Polianthes tuberosa
'The Pearl'

however, warm temperatures are necessary for flower bud initiation, continued differentiation, and development (Kosugi and Kimura 1961). For growers in the North (Zone 5 and colder), the use of polyhouses to build up heat earlier may be essential. Tuberoses perform best under hot summers; 90F (32C) is not too warm for this crop.

Field Performance

Tuber size: A great diversity in tuber size is available. The smaller sizes may flower in the southern United States but are of little use in the North. Large tubers emerge slower but flower faster than smaller ones. In general, 10+ cm bulbs will flower the first year. Plant 9–12″ (23–30 cm) apart and cover with 2–3″ (5–8 cm) of soil. They may be planted as clumps, in which case tubers may be placed almost cheek by jowl.

Planting time: Tubers must be planted after danger of frost, in northern areas usually around late April, and can be planted all season. In areas of mild winters, they may be planted in the fall or early winter. In the North, there is no reason why tubers can't be started early in moveable polyhouses or tunnels; this may help to bring in flowers significantly earlier.

To be on the safe side, plant no earlier than February, even in mild climates, if no protection is provided. Once established, bulbs can tolerate occasional freezing temperatures in the winter. The effect of different planting times in Zone 7b, Athens, Ga., is shown in the following table (Armitage and Laushman 1990).

The effect of planting date on tuberose cultivars.

Month planted	Flw/ tuber	First harvest	Harvest duration (days)	Stem length (in)^z	Stem diameter (mm)^y
'Mexican Single'					
Feb	0.8	2 Jul	87	43.7	8.3
Mar	1.1	22 Jul	67	36.9	7.4
'The Pearl'					
Feb	0.9	16 Jul	73	33.2	8.9
Mar	1.1	1 Aug	58	35.0	9.3

z = multiply (in) by 2.54 to obtain (cm)
y = divide (mm) by 25.4 to obtain (in)

Notice the duration of harvest: well over 8 weeks. Carolyne Anderson of Clark, Mo. (Zone 5–6), plants at 2-week intervals from April through July and harvests flowers from 15 July through frost. In northerly climates, earlier planting (e.g., March) is possible, but beds may require frost covers for the first 6–8 weeks.

Longevity: If tubers remain in the ground (assuming they are hardy for the area), tuberoses may be harvested for at least 3 years without division. The dead foliage may be used as a mulch in the winter. Remove mulch as soon as possible in the spring. Yield does not decline until the fourth year; therefore, lifting and dividing should be accomplished during the third or fourth year. Stem length may decline after the first year.

Nutrition: Tuberoses are heavy feeders, and side dressing of a complete fertilizer is recommended.

Greenhouse Performance

Warm temperatures around 68–75F (20–24C) are necessary to force tubers, which should be planted in ground beds. In one report, tubers of single-flowered cultivars planted on 1 April flowered on 10 August, 132 days from planting, when the average temperature was approximately 68F (20C) (Kosugi and Kimura 1961). Double forms are generally 3–4 weeks earlier under greenhouse conditions than the singles. Check with the bulb supplier for the availability of bulbs for winter forcing. Although bulbs received in the spring may be dry-stored at 40–50F (4–10C) until ready to plant, properly stored bulbs should be received at the appropriate time from the supplier.

Stage of Harvest

Harvest when 2–3 flowers are open on the flower stalk and others are showing color. If necessary, stems may be cut with as many as ½ to ¾ of the flowers open, but the bottom flowers must not have started to fade.

Postharvest

Fresh: Fresh flowers have a vase life of about 9 days, during which time 44% of the buds open (Reid and Dodge 1997). Storage reduces vase life significantly. Faded flowers should be removed and stems recut as necessary. A flower preservative is useful for additional postharvest life. High concentrations of ethylene are deleterious, but treatment with an anti-ethylene agent is likely not warranted. Single flowers appear to persist longer than doubles because the inner row of petals on double flowers darkens rapidly, thus discoloring the whole flower. Petals of single flowers also discolor but not as quickly.

Dried: Single flowers do not dry well, doubles are only slightly better.

Storage: Optimal temperature to store cut tuberose is 32–41F (0–5C), but storage of flowers is not recommended. Reid and Dodge (1997) found that the vase life of flowers stored wet (stems in a solution of 250 ppm 8-HQC and 2% sucrose) was no better than dry stored flowers (wrapped in newsprint and polyethylene to reduce water loss); when they expanded their research to determine if dry storage at 35F (2C) could be used in combination with different pretreatments, storage duration, and vase solutions, the results were quite interesting.

The effect of vase solutions, dry storage at 35F (2C), and chemical pretreatments on keeping quality of cut tuberose flowers.

Pretreatment	Dry storage (days)	Vase solution	Open florets (%)	Vase life (days)
none	0	HQC 250 ppm	34.3 b[z]	6 c
none	0	HQC + 2% sucr.	50.5 a	9 b
20% sucrose	0	HQC + 2% sucr.	57.5 a	11 a
1 umol STS	0	HQC + 2% sucr.	39.5 b	8 b
none	6	HQC + 2% sucr.	19.0 c	5 c
1 umol STS	6	HQC + 2% sucr.	33.3 b	6 c
20% sucrose	6	HQC + 2% sucr.	50.1 a	11 c

z = means with the same letter are not significantly different using Duncan's Multiple Range Test (5%)

The table shows that STS actually decreases vase life of tuberose; however, a pretreatment of 20% sucrose enhanced vase life regardless of storage methods. And for growers and shippers, a 20% sucrose pretreatment essentially overcame the negative effects of 6 days of cold storage. Most important, the work shows the importance of using a proper preservative when florists are unboxing the stems.

Storage of tubers must be attended to carefully. They must be dried before storage, or stored in a well-ventilated area to allow for drying. Temperatures of 70–80F (21–27C) will speed the process of drying before storing at 45–50F (7–10C).

Cultivars

'Chula', a recent offering, is a single white form, but there does not appear to be a great deal of difference between it and 'Mexican Single'.

'Mexican Single', the old standby, has waxy-white single flowers closely spaced on the flower stalk. An excellent cut flower.

'The Pearl' is the most popular double-flowered form, with twice the number of petals as singles.

Pests and Diseases

Few problems affect tuberose, but that doesn't mean there aren't some sad tales out there. If conditions are too wet, especially when flowers are forming or opening, then flowers may be speckled with brown spots, probably the result of botrytis. Begin spraying with a fungicide as buds swell. Thrips can be a major problem in open flowers, causing damage with their sucking mouth parts. If field conditions are too wet, tubers disintegrate over the winter; therefore, good drainage is important.

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Many thanks to Carolyne Anderson and Craig Schaafsma for reviewing this section.

Ranunculus asiaticus Ranunculaceae

bulb, Zones 8–10 Mediterranean many colors 1–2′/9″ (30–60 cm/23 cm)

Many species of buttercups are found in gardens and along roadsides, but this is the species that provides the color in bouquets from Saskatchewan to Singapore. Shyness is not one of its qualities, and its bold colors brighten up any arrangement. Plants do have one drawback: they are intolerant of extremes of heat or cold and can be grown outdoors only in areas with a Mediterranean climate, such as southern and central coastal California. Some southern growers have had moderate success with it as a winter crop; however, winter rains result in a high incidence of rotted tubers, especially where drainage is not sufficient. Flowering generally takes place from late September and continues through March, depending on prevailing temperatures. Most stems emanate from winter greenhouses, where production can take place anywhere cool temperatures and bright light occur. Ranunculus is a good companion crop for carnations or *Anemone coronaria* in the greenhouse.

Propagation

Tubers: Tubers may be purchased from bulb suppliers. Yield is directly proportional to tuber size; however, the start of flowering and full bloom occur at the same time regardless of tuber size. Also, as expected, tuber yields per mother tuber were highest from the largest mother tubers (Piskornik 1997). In general, tubers smaller than 3/5 cm will not flower adequately.

Tuber viability is always a question when purchasing tubers. Umiel et al. (1992) developed a viability test for tubers anyone can do. Immerse dry tubers in running tap water for 2–12 hours (6 hours is sufficient), and follow this with a 20-minute soak in an aqueous solution of Captan™ (0.25%). Plant the swollen tubers in a tray containing wet vermiculite (5:1 vermiculite:water, by volume) and incubate for 2 weeks at 62F (17C). After this, remove the tubers from the tray. Those that have produced roots and shoots are viable.

Ranunculus asiaticus 'Tecolote'

Soaking tubers: Traditional wisdom has been to soak tuber for 2–4 hours to hasten germination and rooting, but Mike Mellano Sr. of Mellano & Company has a better method. He spreads the tubers out on a screen and mists them, soaking them but allowing the water to pass through the screen to a trough below. This minimizes the risk of spreading bacteria or fungi from infected tubers to healthy ones. He cautions that the screen must be high enough so that no water splashes back up from the trough. He suggests doing the same with any kind of preplant soak, including fungicides.

Seed: Seed, if sown at 50–60F (10–15C), will germinate in 15–20 days. For the commercial flower grower, purchasing plugs from specialist plug growers is more sensible. Plugs may be planted immediately or grown on in a 45–55F (7–13C) greenhouse until ready for planting.

Environmental Factors

Temperature: As for freesia and alstroemeria, soil temperature is very important, particularly in the Southeast and Southwest, where warm temperatures are the norm. Ranunculus are cool-loving plants and perform poorly if temperatures exceed 60F (15C) for any length of time. Night temperatures of 45–50F (7–10C) are preferable (Horovitz 1985). Cold temperatures of 34–36F (1–2C) have been used on presprouted tubers (tubers soaked in water for 24 hours) to accelerate flowering. Research in France showed that when soaked tubers were given a 14-day treatment of 36F (2C), the time between planting and the production of the first 3 flowers was shortened by 4 weeks (Horovitz 1985). More recent work in Italy found that storing tubers for 30 days at 50F (10C) resulted in faster flowering (126 days from planting tubers), compared with those stored at 36F (2C) (170 days) or those not cooled at all (190 days) (Guda and Scordo 1989). Frank Arnosky suggests that 10 days is the maximum storage time for his operation; longer than that, and tubers begin to rot.

Before exposing tubers to cool temperatures, they should first be stored at 55–60F (13–15C) for 8–10 days. Frank has been growing ranunculus for years in Blanco County, Tex., hardly a “normal” location for these cold-loving plants. He has found that soil temperatures must be below 70F (21C), or prechilled tubers will go dormant and begin to rot. For him, patience is important: tubers are not normally planted until late October or November.

Photoperiod: The highest percentage of tubers flower when placed under short day treatments (12 hours or less). Although long day treatments (>12 hours) accelerate flowering and flower quality, yields may not be as high. Long days also result in greater tuberization. If plants are placed under 14-hour days or longer, all the plants produce tubers but fewer than 40% produce flowers (Horovitz 1985).

Field Performance

Tuber size: Best results occur with 5/6 cm tubers, although 3/5 cm tubers will flower. In ranunculus, bigger is better; buying smaller tubers is a false economy.

As Mike Mellano Sr. says, "If you figure your bulb cost relative to flower production and quality, the bigger bulbs are better."

Planting depth: Plant tubers with eyes up, approximately 1–2″ (2.5–5 cm) below soil surface. The claw-like appendages should be on the bottom. Increasing planting depth delayed emergence and reduced the percentage of emerging plants. The number of developing shoots, leaves, and flowering stems were negatively correlated with planting depth. Tubers of ranunculus, when planted deeply, formed new tubers above the deep planting depth closer to the ground surface (Hagiladi et al. 1992).

Spacing: It is better to be conservative on spacing; crowding tubers invariably results in botrytis and tuber rot. If using 3/5 cm tubers, plant approximately 5 tubers/ft^2 (54 tubers/m^2) or approximately 4″ (10 cm) apart. The largest tubers should be planted about 8″ (20 cm) apart (De Hertogh 1996).

Yield: Depending on cultivar and tuber size, 3–5 marketable stems per tuber is not uncommon. For the Victoria series, 4–6 stems/tuber were obtained the first year from plugs.

Longevity: Tubers are inexpensive and are usually treated as annuals. If grown from seed, they are always treated as annuals.

Greenhouse Performance

Ranunculus are usually produced in greenhouses or clear plastic houses but can also be forced in unheated cold frames in the South. Plant tubers (or plugs) in a very well-drained soil in a raised bed. Planting can be started when soil temperatures are below 70F (21C) (September–November) and continued until January. Maintain 45–50F (7–10C) night, 60F (15C) day temperatures and provide as much light as possible. Do not allow temperatures to exceed 60F (15C) for any length of time. If plants are grown too warm or if they dry out excessively, leaves are yellow and short-stemmed, and flowers are smaller in diameter. Soil-cooling equipment may prove to be cost beneficial. Maintain plants under natural photoperiod or as little as 8 hours of light. Avoid long days caused by light drift in the winter.

Plants and even flower buds can endure freezing temperatures, probably as low as 23F (⁻5C). In the South, when plants are forced in unheated cold frames, a floating row cover provides adequate protection from harsh weather.

Fertilize plants weekly with approximately 200 ppm N and leach often to reduce soluble salts (Horovitz 1985). Application of 50 or 100 ppm gibberellic acid 2 months after planting, and again 3 weeks later, advanced flowering and the number of flowers produced (Pascale and Scognamiglio 1998). Drip irrigation reduces disease on foliage and tubers; avoid overhead irrigation.

Tubers flower 60–90 days from planting, depending on whether they have been soaked and/or vernalized prior to planting. Seed-grown plants flower 4–6 months from sowing. The lengthy time required for flowering from seed often dictates that seed cultivars be purchased as plugs.

Stage of Harvest

Cut flowers when buds show color and are about to open (Nowak and Rudnicki 1990). For local markets, flowers can be allowed to fully open.

Postharvest

Fresh: Flowers persist in preservative for 7–10 days at cool room temperatures around 60F (15C). Work by Kenza et al. (2000) found that flower quality was not improved by treatments with aminooxyacetic acid (AOA) or silver thiosulfate (STS). This indicates that ethylene is not an important regulator of senescence in cut ranunculus and that no special precautions are needed to keep the flowers from contact with ethylene.

Dried: Flowers may be air-dried by first stripping leaves and hanging upside down in small bunches. Drying by microwave is also practiced (Vaughan 1988).

Storage: Flowers should be stored only if necessary at 34–36F (1–2C) in water/preservative (Vaughan 1988). They do not store well dry.

Cultivars

La Bella series has been highly successful, producing fully double flowers in many colors. Arnosky harvests 10 and more flowers per tuber.

'Tecolote' has been used for cutting for many years. Plants bear double flowers 3–4″ (8–10 cm) wide, and some singles, in a range of colors.

Victoria series is an F_1 hybrid strain with excellent uniformity and flower shades. Available from seed or plugs.

Pests and Diseases

Crown rot (*Botrytis*) affects tubers. Provide good ventilation and do not plant too closely or use overhead irrigation.

Southern blight (*Sclerotium*) can be a serious disease, particularly in dark, moist conditions. Older leaves develop fuzzy white growth that moves into the crown. Good airflow and removal of infected leaves is essential.

Various water molds, such as *Pythium* and *Phytophthora*, result from poor drainage. Tubers and roots are susceptible to these fungi. Be sure soils are exceptionally well drained.

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Many thanks to Bob Pollioni (first edition) and Frank Arnosky and Mike Mellano Sr. (second edition) for reviewing this section.

Salix willow Salicaceae

woody, Zones 3–8 worldwide contorted, colorful stems
6–20′/20′ (1.8–6 m/6 m)

Willows, among the most common cut woody stems, are easy to propagate and fill an important niche in the cut branch market. They are grown for their contorted stems (*Salix matsudana* 'Tortuosa'), flattened stems (*S. sachalinensis* 'Sekka', the fantail willow much sought after by arrangers), and colored stems (*S. alba* 'Britzensis', 'Vitellina')—or a combination of these (*S.* ×*erythroflexuosa* 'Golden Curls', 'Scarlet Curls'). Stem colors range from red to yellow, and several fast-growing species and cultivars with twisted stem shapes are now available.

They are also grown for their male catkins (pussy willows), but Mel Heath of Bridge Farm Nursery in Maryland, who has been growing salix for about 6 years, says pussy willows may not be worth the space, attention, water, fertilizer, and labor required, particularly on a small scale. He has found that prices are low, volumes for individual customers are low, and plants take up a lot of space. He makes the excellent point, however, that those same arguments could be applied to any plant in this book, so listen to Mel and choose your crops wisely.

Propagation

Cuttings: Easily propagated by soft and hardwood cuttings any time of year. Cut and stick.

Seed: Seed has no dormancy and germinates in 12–24 hours if provided with a moist environment (Dirr 1998).

Growing-on

After rooting, transplant to a 6″ (15 cm) pot or 1 gallon (4 l) container until plants are large enough to transplant to the field.

Environmental Factors

Stems are most contorted and colored forms most colorful when young. Cool temperatures in late fall and winter and high light intensity result in more colorful stems.

Field Performance

All species grown for colored stems need to be cut back hard in late winter and early spring for best form and color in the fall and winter.

Stage of Harvest

Harvest leafless stems at peak of color.

Postharvest

When stems are cut, place immediately in water. Remove foliage. Stems may be stored dry at 30F (⁻1C). Plunge pussy willow stems in water upon harvesting and store in a 35–40F (2–4C) cooler.

Species and Cultivars

Species grown for male catkins (pussy willows)

Salix caprea (goat willow) and *S. discolor*, the true pussy willow, are closely related and often confused with each other. *Salix discolor* has brown branches and almost white lower leaf surfaces. The catkins of *S. caprea*, a 15–25′ (4.5–7.5 m) tall tree, are 1–2″ (2.5–5 cm) long and appear in March and early April. It is a better species for catkins than *S. discolor* because of the latter species' susceptibility to canker. Neither species is long lasting in the field.

Salix chaenomeloides (Japanese pussy willow) grows 10′ (3 m) tall in a couple of years. The large red flower buds are the best part of the plant, even better than the pink to rosy catkins. Vigorous, well worth a try.

Salix gracilistyla (rosegold pussy willow) has rosy catkins.

Salix melanostachys (black pussy willow) is an interesting 10′ (3 m) tall shrub. In winter, the stems take on a purplish hue, and in the spring the catkins are

Salix chaenomeloides

purple-black, finally showing off red stamens, which later turn yellow. The stems and catkins are beautiful, but production of useable stems has been inconsistent due to inconsistent spacing of the catkins.

Species grown for contorted and/or colorful stems

Salix alba (white willow), a common landscape plant, is of little value as a cut stem. But its colored-stem forms, particularly 'Britzensis' (coral bark willow) and 'Vitellina' (yellow bark willow), are quite beautiful and highly functional for cut stems in late fall and winter.

Salix ×erythroflexuosa 'Golden Curls' is a cross between *S. alba* 'Tristis' and *S. matsudana* 'Tortuosa'; its stems are slightly contorted and golden-yellow in the winter. 'Scarlet Curls' is similar but with red winter stems.

Salix matsudana (Hankow willow) is best known for the cultivar 'Tortuosa', the common contorted willow harvested by the truckload. Short-lived in the heat but an effective persistent plant elsewhere.

Pests and Diseases

All willows are fast-growing and short-lived. The wood is weak, and maintenance and upkeep are necessary to keep plants productive.

Physiological disorders

The biggest complaint we hear about growing pussy willows is the inconsistent spacing of the buds (later the catkins). In some stems, they are equally spaced along the entire length; in others, half the stem will have no buds at all. This is likely attributable to changes in soil moisture, fertility, or temperatures while the buds are forming in the summer and fall. Very difficult to forecast.

Grower Comments

"Black pussy willow (*Salix melanostachys*) grew slower than most salix but are now fully growing together in rows and are 4′ tall (after being cut back to about 18″ each winter). We've had very dry years recently, and the plants just haven't made very good cuts. When you cut them they are branched, and the catkin is beautiful—black with a red fuzzy end—on reddish stems. But so few of my stems have been really nice. Also, in the few years when I did have good stems I found only very special florists knew how to design with them." Bob Wollam, Wollam Gardens, Jeffersonton, Va.

"We have black pussy willow on the farm. The market potential is very promising, but they are too short and have too many twigs without the black buds (look like red dogwood.). We found out that with willows, if you cut it to the ground (6–12″) you get very heavy twigs in the next season and very tall ones—we got 8–10′. If you cut it just about 2–3′ at pruning, you will get many more twigs that are not as heavy as the first ones, and about 4–6′ in length." Shlomo Danieli, Blooming of Beloit, Beloit, Wis.

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Many thanks to Mel Heath for reviewing this section.

Salvia sage Lamiaceae

annual/perennial

Hundreds of species of sage have been grown over the years by gardeners, landscapers, greenhouse operators, and nurserymen, but only a few have been used in the cut flower trade. Some reasons for their general exclusion are obvious: lack of sufficient stem length, flower shatter, malodorous foliage, and poor yield; however, many salvia species have cut flower potential for bouquet work as well as bunches and arrangements. A few are perennial, some are obvious annuals, and others are "temperennials," depending on the latitude. Their ornamental properties are waiting to be exploited.

Salvia leucantha Mexican bush sage, velvet sage Lamiaceae

annual Mexico purple, white 2–4′/3′ (0.6–1.2 m/0.9 m)

This species is among the most useful salvias for cut flower production. Plants are relatively easy to grow in both field and greenhouse, the foliage is handsome, and flower production is excellent—a high-impact show. Flowers are seldom seen from overseas growers.

Propagation

Velvet sage is easily propagated by terminal cuttings taken before flower buds have formed. Approximately 2–3″ (5–8 cm) long cuttings may be rooted in a 1:2 ratio of a peat/perlite mix in 7–10 days if placed at 70–75F (21–24C) and humid conditions. A sweat tent or similar means of maintaining high humidity is better than intermittent mist. Plants may also be dug out of the field in the fall and overwintered in cool (40F, 4C) greenhouses (Wollam 1997). Cuttings may be taken from these plants in late winter and spring. If overwintering for stock plant use, provide long days to inhibit flower initiation.

Growing-on

Once plants are rooted, they may be transplanted to small containers prior to planting out in the field. Place plants at 55–62F (13–17C) under long days (>12 hours) and fertilize with 150–200 ppm N once or twice a week. If roots are well formed, plants may be transplanted to the field immediately once the threat of frost has passed.

Environmental Factors

Photoperiod: Velvet sage is a short day plant, which helps to explain why flowers occur in the fall. Long days result in vegetative development and long stems; short days are necessary for both flower initiation and development (Armitage 1989). This plant was in full flower in December in Quito, Ecuador, where photoperiod is essentially 12 hours year-round, suggesting that the length of the dark period need not be greater than 12 hours. In areas of early frosts, such as the Northeast, there may be insufficient time for flower development.

Temperature: Warm temperatures are best for flower development. Plants are particularly vigorous in warm summers. Cool temperatures in late summer result in fewer flowers on smaller plants.

Field Performance

Spacing: Velvet sage is a large, vigorous plant; therefore, spacing less than 15″ (38 cm) apart should be avoided, as should spacing greater than 3′ (90 cm) centers, not only because yield/ft^2 is reduced, but also because the brittle stems need surrounding plants for support. Bob Wollam grows his on 2′ (60 cm) spacing in 2 rows on a 3½′ (1.1 m) bed. Work at the University of Georgia showed that wide spacing resulted in more stems/plant than close spacing, but stems/ft^2 decreased (Armitage 1987).

The effect of spacing on yield of *Salvia leucantha*.

Spacing (in)^z	Stems/plant	Stems/ft^{2y}
24	125	32
36	180	20
48	180	12

z = multiply (in) by 2.54 to obtain (cm)
y = multiply (stems/ft^2) by 10.8 to obtain (stems/m^2)

Lateral stems: Lateral stems form after the terminal has been harvested. Harvesting the entire stem (laterals and all) at once is easier and less expensive, and provides the greatest stem length; however, if stem length is not a major issue, harvesting the terminal stem about halfway down and then allowing the laterals to flower will provide significantly higher yield. It's your choice.

Support: Plants are woody at the base and can grow to 5′ (1.5 m) tall and almost as wide. The main stems are sufficiently strong without support, but the secondary flower stems are brittle. Netting can be used, but cutting would be time consuming and unacceptable breakage of stems might occur. Wind damage can be a problem, and planting a windbreak makes sense (Wollam 1997). Plants eventually fall on themselves, acting as their own support system.

Flowering time: Velvet sage is a fall-flowering salvia, and unless lights are employed outdoors, plants flower in September and October, regardless of planting date. This can be a serious limitation to growers in the North, particularly those north of Zone 6. Early frosts can be painful, and Bob Wollam (1997) suggests overnight water sprays to reduce frost injury.

Greenhouse Performance

Salvia leucantha is an excellent plant for greenhouse production. Flowering is easy to control, and forcing may take place year-round using a chrysanthemum schedule.

Space rooted cuttings 12 × 12″ (25 × 25 cm) or 12 × 18″ (25 × 45 cm) apart in ground beds or in large containers. Closer spacing may be used, but air movement is reduced. Place cuttings under long days (>14 hours) and fertilize with 200 ppm N of a balanced fertilizer, such as 20-10-20. Calcium nitrate and potassium nitrate should be rotated in the winter. For the first crop, a single pinch when the shoots are about 4″ (10 cm) long is useful but not necessary. Once the new shoots are 4–6″ (10–15 cm) long, place plants under short days (12 hours) until the flower buds are colored. Short days must be maintained until flower buds have colored; long days interrupt the development of the flowers (Armitage 1989). Maintain 60–63F (15–17C) night temperatures and 70–75F (21–24C) day temperatures. Reduce night temperatures to 55F (13C) about one week prior to harvesting (when flower buds are colored).

Harvest all stems from a single planting over a period of one week; do not wait for laterals to form as in the field. Yield is reduced compared to the field, but harvesting is easier and subsequent plantings allow for extended harvests throughout the season. Place stems immediately in water with floral preservative. The leaves wilt readily and must be protected from heat and stress.

Crop time is 11–15 weeks from planting. This includes 3–5 weeks LD and 8–10 weeks SD until harvest. These times vary with season and location.

Stage of Harvest

Flowers should be harvested when the white petals (corolla) emerge from the purple sepals (calyx) on the first 3 or 4 basal flowers. This generally occurs outdoors any time from the first 2 weeks of September to the last 2 weeks in October.

Postharvest

Fresh: Hydrate immediately in the field. Recut once indoors. Flowers persist approximately 7 days in water (Gast and Inch 2000). The flowers tend to shatter, particularly if stems are out of water for any length of time. Using STS, if available, as a 30-minute pulse prior to placing in preservative solution adds an additional 3–4 days.

Storage: Stems do not store well dry; the foliage declines more rapidly than the flowers. They may be stored wet for 3–4 days at 35–40F (2–4C).

Dried: Flowers are air-dried and make good dried flowers. The application of silica gel or glycerine may be useful.

Cultivars

'Midnight', the name of choice for the cultivar with entirely purple flowers, is also known as 'Blue on Blue' and 'Purple on Purple'.

'Santa Barbara' is a dwarf form, growing only about ½ as tall as the species itself. May be useful if shorter stems are desired.

Additional Species

Salvia farinacea (mealy-cup sage) bears Wedgwood-blue flowers on 2′ (60 cm) stems. Seed germinates in 2–3 weeks at 70–72F (21–22C). Numerous colors have been bred; all are useful for cuts, but none have outstanding stem length or stem strength. 'Argent' ('Silver'), an older form with silver-white flowers, does not stand out from other plantings as well as the blue and violet forms; in national field trials, 14 stems/plant with an average stem length of 15″ (38 cm) were produced (Dole 1998). 'Blue Bedder' is one of the standards in the industry; plants are productive and sufficiently tall, and provide handsome dark blue flowers. 'Cirrus' is about 15″ (38 cm) tall with white flowers on silver-white flower stems; more compact and slightly whiter flowers than 'Argent'. 'Rhea' is a 12″ (25 cm) compact form with dark blue to violet flowers. 'Strata' can be an interesting addition to the garden, bearing bicolored blue and white flowers. It comes off as rather washed-out, not knowing whether it wants to be blue or white, and being neither; all the same, this cultivar was honored with Europe's Fleuroselect award and was a 1996 All-American Selection in the United States. 'Victoria' is by far the most common cultivar, with large intense violet-blue flowers. Bigger and more vivid than 'Rhea', 'Victoria' produces deep violet-blue flowers that are useful fresh or dried. In national field trials, 8 stems per plant with an average stem length of 15″ (38 cm) were produced (Dole 1998). Recommended: most mealy-cup sage cut in this country is either 'Victoria' or 'Blue Bedder'. 'Reference' has bicolor flowers, similar but not as well known as 'Strata'; in national field trials, 7 stems/plant with an average stem length of 15″ (38 cm) were produced (Dole 1997).

Salvia guaranitica (anise-scented sage) grows 3′ (90 cm) tall and bears dozens of dark blue flowers. Untested but has potential. This outstanding sage begins to flower in early to mid summer and continues all season. The dark green leaves are 4–6″ (10–15 cm) long and sparsely hairy. They don't have much smell when crushed, and do not smell like anise. Flowers are held in whorls of 3–8; the corolla (the petals) can be up to 3″ (8 cm) long, and the calyx (sepals) may be a different color. Hardy to Zone 6. 'Argentina Skies' has flowers of pastel blue, much more muted than those of the species; beautiful but not quite as floriferous as the type. 'Black and Blue' is a huge subshrub with hairy leaves and large dark blue flowers with almost black sepals; plants often reach 5–6′ (1.5–1.8 m) in height. 'Blue Ensign' has large light blue petals with green sepals. 'Costa Rica Blue' may be the same as 'Black and Blue', which may be the same as 'Late Blooming Giant'. They are all big, flower later than the species, and have darker calyces than the corollas. 'Purple Majesty', a hybrid between *S. guaranitica* and *S. gesneraeflora* (a red-flowered Mexican species) is at least 5′ (1.8 m) tall and 3′ (90 cm) wide with deep purple flowers. Hardy to Zone 7b. 'Purple Splendor' is smaller than 'Purple Majesty'; it too has dark violet-blue sepals, but its leaves are smooth.

Salvia 'Indigo Spires', a tall-growing blue-flowering sage, is among the most vigorous and floriferous hybrids (*Salvia farinacea* × *S. longispicata*) available. In flower, plants easily grow 3–4′ (0.9–1.2 m) tall and bloom for many months; as fall settles in, the flower color becomes more intense, and the spires live up to their name. Unfortunately for northern growers, it is hardy only to about Zone 7b, but for those who grow it, the best advice is to plant and get out of the way. Cut the flowers back occasionally for repeat bloom. Flowers for months at a time, and is perennial to Zone 7.

Salvia splendens (annual sage) is occasionally used. Colors include white, salmon, and purple, but red is the predominant color. Propagate by seed. Dozens of cultivars—taller ones include 'Bonfire', with 26″ (66 cm) stems, and 'Flare', 18″ (45 cm). A new selection, 'Faye Chappell' (syn. *S. splendens* subsp. *van houttei*), has bright scarlet flowers held on 2–3′ (60–90 cm) stems. Quite outstanding.

Salvia ×*superba* (perennial hybrid sage) produces dozens of 18–24″ (45–60 cm) long, blue to violet-blue flowers. 'Blue Queen' (violet-blue), 'Lubecca' (purple), and 'May Night' (indigo) are useful for cutting. Propagate cultivars by terminal cuttings; seed is available for *S.* ×*superba*. Very closely related to *S. nemorosa*, another species worth a try for its straight thick stems.

Salvia viridis (green sage, clary; not to be confused with *S. sclarea*, clary sage) is the namesake of all salvias in the Greek language: until the early 1980s, it was known as *S. horminum*, and *horminum* is ancient Greek for sage. Plants have brightly colored, veined bracts and dry well. Harvest when the bracts feel firm and papery, remove large leaves, and hang upside down. Quite different from other large-flowered forms, simple to raise and grow, and worth trying, for the interest alone; however, stems are only 12–15″ (30–38 cm) long. Plants are native to the Mediterranean and do not tolerate extremes of temperature or humidity. Better in the North than in the South. Many cultivars available, all raised from seed. 'Alba' has white bracts. 'Bluebeard' produces pale violet bracts with darker veins. 'Claryssa' is a dwarf form with a mix of purple, pink, and white bracts. Marble Arch series is available in blue, rose, and white. In national field trials, 'Marble Arch Blue' produced 18 stems/plant with an average stem length of 14″ (36 cm); the rose and white form produced 19 and 20 stems per plant with lengths of 18″ (45 cm) and 14″ (36 cm), respectively (Dole 2000). 'Oxford Blue' bears blue-purple bracts. 'Pink Sundae' has rosy carmine bracts with darker veins; similar to 'Purpurea'. 'Purpurea' is quite common and has rosy red to purple bracts. 'Rose Bouquet' has pink bracts. 'Violacea' bears violet bracts with darker veins. 'White Swan', with clean white bracts, is essentially the same as 'Alba'.

Pests and Diseases

Few pests and diseases occur on velvet sage. Aphids can be a problem. Perennial sages grown north of Zone 7 are seldom troubled with disease; however, if grown in areas of hot, humid summers, root rot may be common.

Grower Comments

"*Salvia leucantha* is marginally hardy for me in Zone 7b. I have taken cuttings as late as early June and had good-sized plants to cut in September–October." Alex Hitt, Peregrine Farm, Graham, N.C.

"I have tried many [*Salvia farinacea*] cultivars, and the only ones I grow are 'Victoria' (it's productive, very blue, and tall enough for use in small bouquet work) and 'Blue Bedder' (which is tall and the industry standard in the salvia department)." Bob Wollam, Wollam Gardens, Jeffersonton, Va.

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Many thanks to Bob Wollam for reviewing this section.

Scabiosa pincushion flower Dipsacaceae

annual/perennial

Both annual and perennial species of the genus are used as cut flowers, nearly all field-grown. The annual forms are more often seen in mixed bouquets and as fillers; their range of flower colors adds diversity on a season-long schedule. Perennial cultivars usually bear larger flowers but are available in limited color selection only.

Scabiosa atropurpurea pincushion flower Dipsacaceae

annual southern Europe blue 2–3′/2′ (60–90 cm/60 cm)

The tufted appearance of this species' flower heads recalls a velvet pincushion, and the flowers' dark color also signifies death, accounting for another of its common names, mournful widow. According to Joan Thorndike of Ashland, Ore., plants with purple flowers are known as *la viuda* ("the widow"). The erect branched stems stand upright, without need of support. The fully double flowers are sweetly fragrant; they form in late spring and continue through the summer. They are borne singly on long flower stems, and are purple to crimson, but other colors have been bred. At the base of the flowers are the whitish overlapping bracts, one of the ways to distinguish the genus from others in the family. Compared to the more common perennial forms of *Scabiosa*, particularly *Scabiosa caucasica*, some cultivars of this annual are more tolerant of heat and can be grown further south. *Scabiosa atropurpurea* may not be a big money maker, but it's terrific for wedding work (including boutonnieres) and other specialized functions.

Propagation

Seed: Seed is often direct sown to the field after the threat of frost has disappeared. Sow 0.5 oz per 100′ (50 g per 100 m) (Kieft 1996); if transplants are used, 0.5 oz (14 g) of seed yields 1000 seedlings (Nau 1999). Seed should be covered lightly, if at all, because light enhances germination. Seed germinates in 10–12 days at 65–70F (18–21C).

Growing-on

If sown in the greenhouse, grow plugs or trays at 50–55F (10–13C) for 10–12 weeks from seeding. Warmer temperatures accelerate growth, but plants tend to stretch. Fertilize lightly (50–100 ppm N) with potassium and calcium nitrate.

Environmental Factors

Photoperiod: *Scabiosa atropurpurea* is a long day plant. Flowering during the winter is enhanced with incandescent lights, either by daylength extension or by nightbreak lighting (Wilkins and Halevy 1985).

Temperature: Temperatures below 55F (13C) are best for plant growth. The combination of cool growing temperatures and LD significantly reduces flowering time. Well-rosetted (i.e., older) plants are more responsive to cool/LD conditions than seedlings (Wilkins and Halevy 1985).

Field Performance

Seed or transplant on 9–15″ (23–38 cm) centers in full sun (Post 1955). The yield in trials at Athens, Ga., was 14 stems/plant with an average stem length of 27.8″ (70 cm) from 3 to 20 July. Many more flowers were produced after that time, but stem length averaged only 15″ (38 cm). Plants can reach 4′ (1.2 m) in height. Successive plantings (every 2–4 weeks until mid summer) are necessary for optimum stem length and flower quality. Flowering occurs as days lengthen and temperatures increase. Netting should be used to avoid flopping and bent stems;

once the netting is up, harvesting becomes more labor intensive. Plants are generally low in maintenance, hardly affected by fertility or insects and diseases, and they keep producing generously all season long.

Plants can be overwintered, but they should be replanted every year. Self-sown seedlings are generally haphazard in performance and color; however, if seeds are collected, germination is good, and the random hybridization that results can yield some very different offspring, some outstanding.

Greenhouse Performance

Scabiosa atropurpurea is seldom greenhouse-grown: quality is poor under warm conditions and so too is financial return. For an early spring crop, seedlings may be grown at 55–60F (13–15C) until rosettes have formed (10–12 weeks after sowing). Reduce night temperature to 50F (10C) and keep days as cool as possible. Long days (>16 hours) using 10–20 fc of incandescent light should be used throughout the crop cycle. Warmer temperatures result in thin stems. Flowering occurs approximately 4 months from sowing.

Stage of Harvest

Harvest the flower when the center has just started to unfurl.

Postharvest

Fresh: Flowers persist 5–7 days in water, an additional 3–5 days with flower preservative.

Cultivars

'Ace of Spades' is a terrific plant, with dark purple to almost black, honey-fragrant blooms. About 2½′ (75 cm) tall. Everyone enjoys this one.

Double Giant Mixture has 2″ (5 cm) double flowers in pink, white, lilac, red, and blue.

'Imperial Giants' comes in a mixture of colors and grows 2–3′ (60–90 cm) tall. Some people detect a fragrance, but that is very subjective.

'Perfect Lilac' and 'Perfect White' both grow to about 2′ (60 cm).

QIS Formula series is available in separate colors (dark blue, salmon-pink, scarlet, and burgundy-red) and as a mix. Plants are 3′ (90 cm) tall. The upright growth and uniformity of flowering are most useful for cut flower growers. Stem yield in national trials of QIS Formula Mix averaged 17 stems/plant with 19″ (48 cm) stem length; many growers loved them and sold all they produced, others found problems with lodging after rain or wind, and crooked stems (Dole 2000).

Scabiosa caucasica perennial scabious Dipsacaceae

perennial, Zones 3–7 Caucasus blue, white 2–2½′/2′ (60–75 cm/60 cm)

This species is the most popular scabious used for cut flowers.

Propagation

Seed: Seed sown at 65–70F (18–21C) under intermittent mist or sweat tents germinates in 10–18 days. Approximately 1 oz (28 g) of seed yield 1000 seedlings (Nau 1999). Seed is not direct sown.

Division: Plants may be divided after 2–3 years in the field.

Growing-on

Transplant to flats (50–96 cells per tray) in the greenhouse 3–4 weeks after sowing. Fertilize with 75–100 ppm N for the first 2 weeks, then raise to 125 ppm N with a complete fertilizer. Grow on at 55–58F (13–14C) until ready to transplant to the field. Plants are ready to transplant as soon as they can be put in the ground without damage, approximately 6–10 weeks from sowing. Plants that have been divided may be moved immediately to 4″ (10 cm) pots for 2–3 weeks prior to planting in the field, or planted directly.

Environmental Factors

Temperature: *Scabiosa caucasica* appears to have a critical temperature and photoperiod for flowering. Under winter and SD conditions, temperatures above 65F (18C) inhibit stem elongation (Post 1955). This species requires some cooling at temperatures below 40–45F (4–7C), whereas the annual *S. atropurpurea* (which see) does not.

Photoperiod: Flowering occurs more rapidly under LD. Larger plants are more responsive to LD treatments than seedlings.

Field Performance

Plants produce more flowers of higher quality in areas of cool summers and cold winters. Quality of the cut flowers declines south of Zone 7, although precooled plants may be used for winter production in Florida.

Spacing: Space plants 18 × 18″ (45 × 45 cm) or 12 × 12″ (30 × 30 cm). Spacing as wide as 2′ (60 cm) centers has also been used.

Yield: In Burlington, Vt., 13 stems/plant were harvested from 2-year-old plants of *Scabiosa caucasica* ‘Fama’ spaced 2′ (60 cm) apart (Perry 1989). The average stem length was 27″ (67 cm). Plants of ‘Fama’ trialed nationally averaged 26 stems/plant with a stem length 18″ (45 cm) in its first year (Dole 1997), but longer stem length would be expected the second year.

Longevity: Plants are productive for 3–5 years, but 2–3 years are normal.

Shading: Not necessary.

Scabiosa caucasica 'Alba'

Forcing: Field plants covered with clear single plastic were forced earlier than uncovered plants. Night temperatures of 40–43F (4–6C) were provided (Plomacher 1980).

Greenhouse Performance

Plants forced for winter production should be sown in July and August and grown under SD at 50–55F (10–13C) for 4–6 weeks. Long days (>14 hours), by day extension or nightbreak lighting with 4 hours of incandescent lights, should then be provided. Flowering occurs 8–12 weeks after the beginning of LD treatment. Night temperatures below 55F (13C) must be maintained; otherwise, weak stems result.

Guideline for Foliar Analyses

At field trials in Watsonville, Calif., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis.

'Fama'

(%)				
N	P	K	Ca	Mg
2.81	0.22	2.11	0.20	0.36
(ppm)				
Fe	Mn	B	Al	Zn
400	116	27	332	19

Stage of Harvest

Flowers may be harvested as soon as flower color is visible.

Postharvest

Fresh: Fresh flowers remain viable for 5–8 days.
Storage: Flowers may be held wet at 36–41F (3–5C).
Dried: Flowers do not dry well.

Cultivars

White forms tend to have thinner stems than the blue forms.

'Alba', a white-flowered form, comes true from seed but is otherwise similar to the species. Does not continue to produce flowers as long as 'Fama'.

'Blue Perfection' ('Perfecta Blue') has fringed, lavender-blue flowers and stands 2′ (60 cm) tall. A selection of var. *perfecta* ('Perfecta'), which has large fringed flowers in shades of blue.

'Bressingham White', with 3–4″ (8–10 cm) wide flowers of clear white on 3′ (90 cm) stems, has effectively replaced 'Miss Willmott', an older white cultivar.

'Compliment' ('Kompliment') is 20–24″ (50–60 cm) tall with dark lavender flowers.

'Fama' has large dark, lavender-blue flowers with a silver center on 18″ (45 cm) stems. The flower color and plant habit are excellent. Most popular as a cut flower (see comments by Thorndike).

'House Hybrids' ('Isaac House Hybrids') is a mixture of blue and white shades. They arose from selections made at Isaac House in Bristol, England, and are parents to many of the more recent selections.

'Miss Willmott' has white flowers on 2–2½′ (60–75 cm) stems.

'Moerheim Blue' has large blue flowers, darker than the species.

'Perfecta' has lavender-blue flowers on 2–3′ (60–90 cm) stems; 'Perfecta Alba' has cream-white flowers, larger than 'Alba', with fringed petals; 'Perfecta Lilac' has 2–3″ (5–8 cm) lilac flowers on 20″ (50 cm) stems.

'Stafa' bears dark blue flowers on 2–2½′ (60–75 cm) stems.

Additional Species

Scabiosa columbaria differs from *S. caucasica* by being shorter but more than makes up for the lack of height in early and persistent flowering. The best selection is 'Butterfly Blue', whose lavender-blue flowers begin in late spring and continue for months. 'Pink Mist' has lavender-pink flowers, quite respectable but not as good a performer. Neither has the stem length needed to impress the florist, but yield is outstanding.

Scabiosa lucida has 1–1½″ (2.5–4 cm) wide rosy lilac flowers that appear in late spring and flower for 6–8 weeks. Plants are only 1–2′ (30–60 cm) tall.

Scabiosa ochroleuca (cream scabious) has creamy yellow flowers and makes a good, although short-lived, species for cut flower production. Under proper conditions, plants grow 4′ (1.2 m) tall.

Scabiosa prolifera (Carmel daisy) is an annual occasionally used as a cut flower. Plants grow about 2′ (60 cm) tall with 2″ (5 cm) wide creamy white flowers, sometimes blushed with lilac. The seed heads are also ornamental. Useful dried and fresh.

Scabiosa stellata (drumstick plant) is grown for its seed heads, which may be dried. An interesting novelty item. Direct seed at 0.2 oz per 100′ (20 g per 100 m) (Kieft 1996). 'Ping Pong' has 2″ (5 cm) white flowers that develop into star-shaped heads.

Pests and Diseases

Powdery mildew (*Erysiphe polygoni*), root rot (*Phymatotrichum omnivorum*), and stem rot (*Sclerotinia sclerotiorum*) are fungal diseases that infect scabious. Fungal sprays and sterilized soils offer some protection.

Beet curly top virus results in foliar deformation. Dispose of plants at first sign of infection.

Grower Comments

"'Fama' I call my queen. She is tireless! Once she starts blooming, she just gets completely into the task at hand and will not quit, even after frost has hit the field and we are all tired of looking at her, picking her, and trying to find a companion flower for her! The flower comes in variations of lavender; the stem is strong, though not always straight (which provides just the right amount of character), and seems to thrive on being cut. We can't sell it for all that much money, but the demand is steady throughout the whole picking season." Joan Thorndike, Le Mera Gardens, Ashland, Ore.

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Many thanks to Mary Ellen Schultz and Joan Thorndike for reviewing this section.

Solidago hybrids, ×*Solidaster* goldenrod, golden aster Asteraceae

perennial, Zones 3–8 North America yellow 2–3′/3′ (60–90 cm/90 cm)

The entry in the first edition of this book began like this: "To refer to *Solidago* as a useful plant 5 years ago would bring chuckles at best, or outright derision. . . . Market resistance to goldenrod is declining, albeit slowly, and sales potential is strengthening." Goldenrod is now a mainstream cut flower, produced in the field and the greenhouse, wherever cut flowers are grown. Florists and designers incorporate them in mixed bouquets and arrangements. Plants exhibit ease of culture, high yield, and excellent vase life.

×*Solidaster* (golden aster; the × is silent) is an intergeneric cross between *Solidago* and *Aster*. Some field production of ×*Solidaster luteus* took place; however,

Solidago 'Baby Gold'

the exceptional breeding with *Solidago* has virtually eliminated ×*Solidaster* as a cut flower. Its only cultivar is 'Lemore', bred in 1948, with light yellow to lemon-yellow flowers. The information provided here refers to both genera.

Propagation

At least 90% of the world's production involves hybrids propagated from cuttings or through tissue culture. All popular cultivars are available as plugs. Renewal in the field and greenhouse should occur after 2–3 years.

Seed: Seeds of numerous taxa (not hybrids) may be sown at 68–72F (20–22C) and germinate in 2–3 weeks. Seed is small; approximately 1/50 oz (0.6 g) of seed is needed for 1000 seedlings, depending on species (Kieft 1996). With seed of *Solidago petiolaris*, a goldenrod native to Oklahoma, 10 weeks of stratification at 41F (5C) significantly enhanced germination (Bratcher et al. 1993).

Cuttings: Terminal cuttings may be rooted any time but preferably prior to flower initiation.

Division: Field-grown plants may be divided after 2–3 years.

Growing-on

During the vegetative period (seedlings or small plugs), grow at 55–60F (13–15C) night and 60–65F (15–18C) day temperature with 100 ppm N using a complete fertilizer. Plants should be grown in LD (>14 hours). Plugs and divisions may be placed in 4″ (10 cm) pots and grown for 2–3 weeks under LD prior to planting out. Plants may be field planted when green in the fall or early spring. For pinched plant production, pinch after about 3 weeks growth in the greenhouse.

Environmental Factors

Temperature: No cool treatment is necessary for flowering.

Photoperiod: Solidago in general and the hybrids specifically are sensitive to photoperiod. Paradoxically, although they require about 14 hours of light for flower production, they are nevertheless referred to as short day plants. This is because, as shown by research on *Solidago canadensis*, one of the parents of the hybrids, even though flowers initiate when plants are provided with 14 hours of light, they remain vegetative under 16-hour photoperiods, resulting in them being categorized as SD plants; very short photoperiods (8 hours) result in flower abortion and dormancy, while 12-hour photoperiods result in poorly developed inflorescences (Schwabe 1986). Thus, in the field in the annual cycle of changing daylengths, vegetative growth and shoot elongation are promoted by LD; then as days shorten in late summer, flowering occurs; and finally as autumnal equinox is approached and passed, dormancy ensues. Plants grow taller under LD; application of SD inhibits stem extension. For the cut flower hybrids, if daylength is regulated when appropriate, year-round production is possible, assuming light intensity during the day is sufficient. In the vegetative growing period, long days of at least 16 hours are recommended (Bartels 2001).

Different species may exhibit somewhat differing responses to photoperiod. Roncancio et al. (1996) showed that floral induction of ×*Solidaster luteus* was more rapid and prolific in photoperiods of 16 hours or more, suggesting that this species should be classified as quantitative LD plants. Observing plants in outdoor situations will suggest whether plants will benefit from LD or SD treatment. Those that flower in the fall (e.g., *Solidago canadensis*) are likely SD plants; those that flower in summer may be LD or day neutral.

Field Performance

Large acreages of goldenrod are field-produced, usually with subirrigation and support systems. Production time is approximately 3 months from planting to harvesting.

Spacing: Grow plants on 8 or 10″ (20 or 25 cm) centers, which results in 144–225 plants/100 ft^2 (15–24 plants/m^2) if growing a pinched crop. Closer spacing may be employed for unpinched plants; however, disease susceptibility caused by decreased air movement must be taken into account.

Longevity: To maintain quality, replant crop every 2–3 years.

Pinch: Both pinched and unpinched crops are possible. Pinching is more common under natural field conditions, where lighting is not used. If pinching is to be done, it should be accomplished 3–4 weeks after planting in the field or the greenhouse. Leave at least 4–8 leaves on the plant. Pinch a whole block at once to get uniform regrowth. Spacing should be increased if plants are pinched. Pinching and pruning (removing thin stems) are recommended after the first year in the field.

Lighting: Lighting for photoperiodic response is generally done under greenhouse conditions; however, lights may be used in the field as well (see “Greenhouse Performance”).

Support: Not necessary the first year but recommended for taller cultivars in subsequent years.

Yield: Dutch production suggests yields of approximately 37 stems per 100 ft^2 or 350 per 100 m^2 (Anon. 1998b). The following table provides consecutive yields of *Solidago* ‘Strahlenkrone’ from Athens, Ga., and Watsonville, Calif.

Yields and stem quality of *Solidago* ‘Strahlenkrone’.

	Stems/ plant	Stem length (in)^z	Stem width (mm)^y
Year 1			
Georgia	7	17.5	4.7
California	5	27.0	5.0
Year 2			
Georgia only	44	19.6	4.5
Year 3			
Georgia only	17	20.3	4.3

z = multiply (in) by 2.54 to obtain (cm)
y = divide (mm) by 25.4 to obtain (in)

Shade: Shading results in higher incidence of disease and lower yield, and does not benefit stem length or diameter. Second-year data with ‘Strahlenkrone’ showed that shade resulted in 22 stems/plant (44 stems in sun) and average stem length of 16.9″ (42 cm). In the sun, stems lengths were 19.6″ (49 cm), and no difference in stem widths occurred. Obviously, shade is not recommended.

Greenhouse Performance

In the greenhouse or under protected culture, flowers can be forced in the winter and spring by manipulating temperature and photoperiod lighting. Use at least 2 layers of support.

Temperature: Grow at 55–60F (13–15C) night and 60–65F (15–18C) day temperature. If grown too warm (>80F, 27C), flowering is delayed and quality is reduced. 'Tara' may be more heat tolerant than 'Toto' or 'Yellow Submarine' (Anon. 1998a).

Spacing: In general, plants are not pinched in the greenhouse and can be spaced as close as 5″ (13 cm) centers, 5½ plants/ft^2 (60 plants/m^2) or as wide as 6″ (15 cm) centers, 4 plants/ft^2 (45 plants/m^2). More space is given for pinched crops: 1½–2 plants/ft^2 (16–21 plants/m^2). Spacing is determined by yield, air movement, and disease control measures.

Fertilization: Cuttings may be grown at 65F (18C) and fertilized with 100 ppm N.

Lighting: Long days (>16 hours) should initially be applied for approximately 5 weeks to extend stem length and delay flowering. Cyclic lighting (at least 6 minutes per half hour) or daylength extension can be used. This should be done until the plants reach a height of at least 12–15″ (30–38 cm). After lighting, plants will begin to set flowers. Crop time is 10–14 weeks from planting of cuttings, depending on temperature and cultivar. Under this system, 3 flushes of flowers may be possible. If pinching, allow approximately 2 weeks additional time.

Guideline for Foliar Analyses

At field trials, Athens, Ga., and Watsonville, Calif., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis.

'Strahlenkrone' (Ga.)

(%)				
N	P	K	Ca	Mg
3.6	0.46	3.82	0.87	0.30
(ppm)				
Fe	Mn	B	Al	Zn
202	115	24	43	68

'Super' (Calif.)

(%)				
N	P	K	Ca	Mg
2.7	0.27	4.71	1.23	0.43
(ppm)				
Fe	Mn	B	Al	Zn
200	282	30	43	25

Although nitrogen and phosphorus were relatively low for 'Super' in California trials, the resulting stems were of excellent quality.

Magnesium deficiency has been shown to produce yellow leaves and poor-quality stems. This may occur when under conditions of high soil pH and high calcium: the calcium can take the place of the Mg in the soil, and the available Mg will not be available.

Stage of Harvest

Harvest the inflorescence when ½ the flowers are open (Nowak and Rudnicki 1990) or as early as when about ¼ of the flowers have opened (Bartels 2001). After harvesting, all plants should be cut back to just above ground level. Harvest time for the entire crop should be completed in about a week.

Postharvest

Fresh: The most important consideration is to place cut stems immediately in a rehydrating solution containing a bactericide. Stems will persist 5–6 days in water, significantly longer with various preservatives. Research has shown considerable enhancement of vase life with 0.5 mM cobalt sulfate + 2% sucrose (Patil and Reddy 1997) or 0.4% aluminum sulfate (Ryagi et al. 1996). Leaf yellowing was retarded by pulsing with 45 mM of a formulation of soluble benzyladenine (Philosoph-Hadas et al. 1997).

Storage: Flowers may be stored dry for up to 5 days at 36–41F (3–5C) (Vaughan 1988).

Dried: Cut when flowers are fully open, then dry standing up (Bullivant 1989).

Cultivars

'Baby Gold', a dwarf form, is more often used as a garden plant than a cut flower. The flower color is excellent, however, and the flowers hold up well. Research in Burlington, Vt., on 2-year-old plants showed 21 stems/plant (spacing 2 × 2′, 60 × 60 cm) with an average stem length of 24″ (60 cm) (Perry 1989).

'Golden Gate' has dark yellow flowers.

'Golden Lime' has a free branching habit and numerous side branches.

'Praecox', a selection of *Solidago virgaurea*, bears bright yellow flowers. Early summer and fall flowering occur. Popular in Europe.

'Strahlenkrone', an exceptional yellow cultivar, grows about 2–2½′ (60–75 cm) tall.

'Super' has lemon-yellow flowers on 2–3′ (60–90 cm) stems. This is one of the most handsome goldenrods we have seen, but, unfortunately, is highly susceptible to rust and intolerant of poor drainage. Losses in our trials were close to 100%.

'Tara' has mid-yellow plume-shaped flowers and robust habit.

'Tara Gold' has golden-yellow flowers.

'Toto' produces deep yellow flowers.

'Yellow Submarine' bears lemon-yellow, open, spreading blooms. Excellent performer.

Additional Species

Solidago caesia (wreath goldenrod) has dark yellow flowers with 3′ (90 cm) tall bluish wiry stems. Flowers occur in the fall and may be used to extend goldenrod flowering time. This unusual goldenrod may find a niche in the cut flower market.

Solidago odora (sweet goldenrod) has yellow flowers on 3′ (90 cm) stems. The benefit of this species is its fragrant foliage, which smells like anise when crushed.

Solidago rugosa 'Fireworks' and *S. sphacelata* 'Golden Fleece' are exceptional yet underused goldenrods. 'Fireworks' performed very well in trials as a garden plant (Hawke 2000).

Pests and Diseases

Powdery mildew (*Erysiphe polygoni*) is a white fungus on the undersides of the leaves and the stems. Downy mildew can also be a severe problem. Work done by Hawke (2000) at the Chicago Botanic Garden with different goldenrod taxa suggested that *Solidago caesia*, *S. flexicaulis*, *S. graminifolia*, *S. sphacelata* 'Golden Fleece', and *S.* 'Peter Pan' were less susceptible to powdery mildew than others tested. These data may be useful for breeding some disease resistance into the hybrid cut flower forms.

Rust (*Coleosporium asterum*) is the most serious disease of goldenrod. Rust-colored pustules cover the foliage and stems in late summer. Because pine trees act as an intermediate host, plant well away from stands of pine trees. No effective control is known, although spraying with zinc-based fungicides appears to provide some control.

Leafminers, whiteflies, and spider mites are pests of *Solidago*.

Leaf yellowing is not uncommon and may be related to high pH, low soil temperatures, or mineral imbalance. An application of 1.8–2.0% zinc sprayed every 10 days has been shown to reduce leaf yellowing (Bartels 2001).

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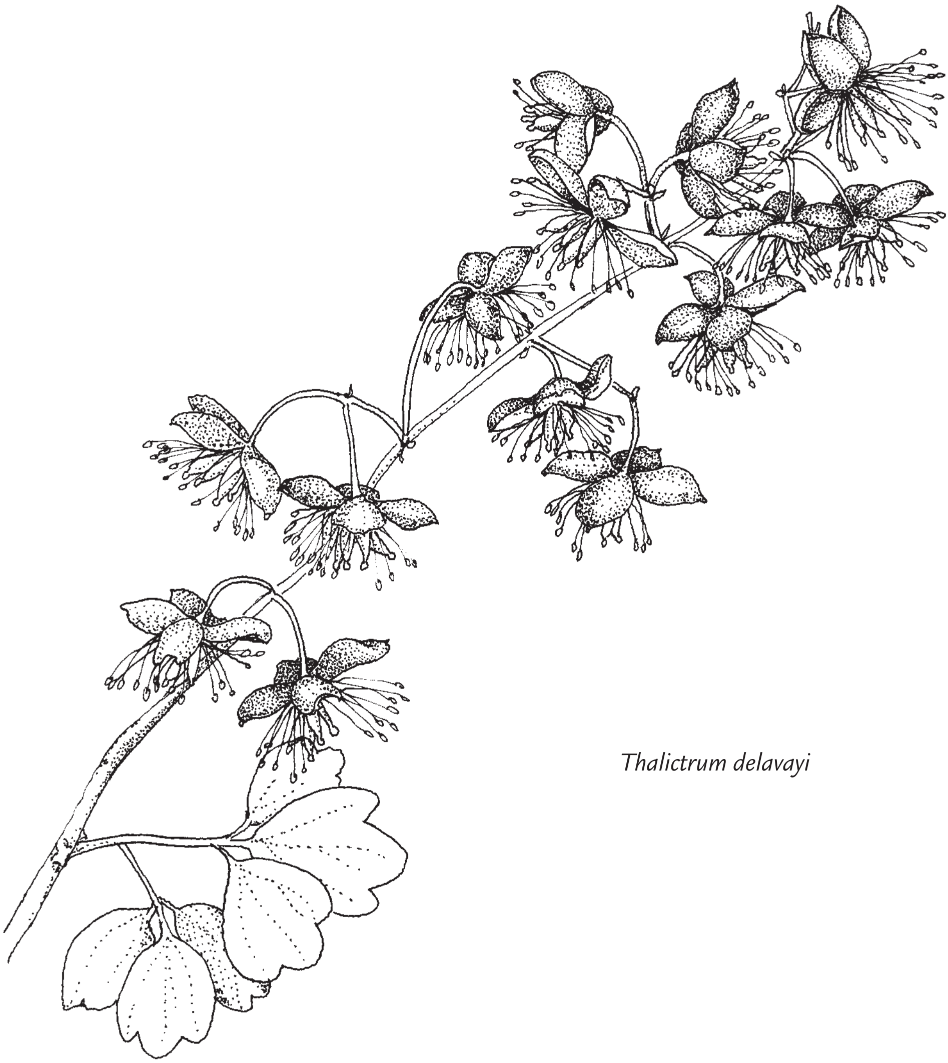
Many thanks to Jeff McGrew for reviewing this section.

Thalictrum meadow-rue Ranunculaceae

perennial, Zones 3–7 western China white/mauve
3–6′/3′ (0.9–1.8 m/0.9 m)

Plants bear small but delicate flowers that are useful as fillers and are occasionally substituted for baby's breath. Flowers of all meadow-rue consist mainly of stamens and tend to shatter; double-flowered forms reduce the problem.

Several species are useful for cut flowers, the most common being Yunnan meadow-rue (*Thalictrum delavayi*) and columbine meadow-rue (*T. aquilegifolium*),



Thalictrum delavayi

although lavender mist (*T. rochebruneanum*) has its followers. *Thalictrum delavayi* has fern-like foliage and lilac flowers on thin-stemmed plants that are usually at least 3′ (90 cm) tall; the flowers consist of lilac sepals and hundreds of yellow stamens. A fair amount of research has been conducted on this species, particularly on 'Hewitt's Double', a double-flowered cultivar that is much less prone to shatter. With fuller flowers in purple and white, *T. aquilegifolium* is common in cut flower markets and an excellent species for the South; seed and plants are easier to obtain than those of *T. delavayi*.

Propagation

Seed: Seeds benefit from chilling at approximately 40F (4C) for at least 2 weeks. Seeds of *Thalictrum aquilegifolium* germinated at 74–93% compared with 16% of unchilled seeds (YongGu et al. 1996). After chilling, sow thinly on fine medium at 60–65F (15–18C); seeds normally germinate within 2–3 weeks. Approximately 0.33 (10 g) of seed yields 1000 seedlings (Kieft 1996).

Division: The storage organ for *Thalictrum* is the crown, and plants may be divided every 2–3 years.

Growing-on

Transplant seedlings when they are large enough to handle. In general, 2-year-old crowns are used. Divisions and seedlings should be grown at 55F (13C) for 6–8 weeks before placing in the field. Fertilize with 100 ppm N using a complete fertilizer. Larger divisions may be planted immediately in the field.

Environmental Factors

Crowns of 'Hewitt's Double' benefit from a cooling period. Plants were cooled for up to 15 weeks at 45F (8C), and sufficient cooling was obtained after 6 weeks; however, when removed from storage, the time to flower on the bench was reduced for each storage time (Huang et al. 1999).

Weeks of cooling	Days to flower after removal
0	190
3	175
6	140
9	130
12	120
15	115

Plants respond to LD (11–13.5 hours); incandescent lights result in decreased time to flower.

Field Performance

The earliest meadow-rue to flower is *Thalictrum aquilegifolium* (early spring), the latest is *T. rochebruneanum* (as late as mid summer). Limited data are available on field performance; however, nylon or wire mesh must be used to separate the flowers from each other, otherwise they can become terribly entangled and damage occurs to flowers and to those trying to extricate them. To discourage tangling, do not space plants closer than 15 × 15″ (38 × 38 cm). Harvest flowers after one full winter in the field. Crop time from sowing to harvest is approximately 18 months. Crowns planted in the fall will flower the first season, but yield may be disappointing. Yield increases the second year.

Stage of Harvest

Harvest flowers when most are open. Unopened flowers do not develop well if cut in bud stage.

Postharvest

Fresh: Since flowers consist mainly of sepals, they tend to shatter rapidly. Flowers are sensitive to ethylene, and STS products enhance the vase life. Pulsing with 0.2 mM silver increased vase life of 'Hewitt's Double' from about 4 days in water to 11 days in STS (Hansen et al. 1996). Thalictrum is recommended as a local item.

Storage: Storage is not recommended. If necessary, store at 36–41F (3–5C) for up to one week (Vaughan 1988).

Dried: Harvest in full flower, strip foliage, and dry standing up to maintain shape. Flowers retain their color for only a few months, but they are useful fillers for large arrangements. Stems may also be hung upside down to dry (Bullivant 1989).

Cultivars

Thalictrum aquilegifolium

'Atropurpureum' has dark purple stems and stamens. The variety listed as 'Purpureum' is likely the same; however, the stems are not as highly colored.

'Roseum' bears handsome light pink to pale rose flowers.

'Thundercloud' has deep purple flowers and larger flower heads than the type.

'White Cloud' is the best of the white-flowered forms, with large, white flowers.

Thalictrum delavayi

'Hewitt's Double' bears flowers that consist of lilac sepals and creamy yellow stamens produced in a 2–3′ (60–90 cm) long inflorescence (panicle).

Additional Species

Thalictrum dipterocarpum (also known as Yunnan meadow-rue) is so similar to *T. delavayi* that plants are often offered under this name. Field culture is the same for both.

Thalictrum flavum (yellow meadow-rue) grows aggressively to about 5′ (1.5 m) and produces balls of yellow flowers. Some people find that the color is not bright enough and that the smell is disagreeable. 'Glaucum' has blue-green foliage.

Thalictrum rochebruneanum (lavender mist) grows 6–7′ (1.8–2.1 m) tall with deep blue flowers in early to mid summer held on strong self-supporting stems.

Excellent potential as a local product for a filler or bouquets. Susan Minnich produces lavender mist in Massachusetts, where it grows 7′ (2.1 m) or more without support netting. She grows them about 2′ (60 cm) apart in damp soil under partly shady conditions, and fertilizes plants in spring and again later in the season. She has no problems with tangling when growing or cutting it, but keeps stems separated at market to avoid tangling. She sells only direct to consumer. It sells like crazy at markets—people either love it or hate it. Plants are slow-growing, one reason they are not seen as often as others.

Grower Comments

"The biggest problem with thalictrum is the bloom time, especially when cutting is very short; some types we harvest for less than a week (these are the ones that seem the best for cutting!)." Janet Foss, J. Foss Garden Flowers, Everett, Wash.

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Many thanks to Susan Minnich and Ralph Thurston for reviewing this section.

Trachelium caeruleum throatwort Campanulaceae

annual Mediterranean blue, white 2–3′/2′ (60–90 cm/60 cm)

The generic name comes from *trachelos* ("neck"), for these plants were supposed to be useful against diseases of the throat; perhaps more soothing treatments, like a cup of homemade soup, are to be recommended before chewing on trachelium leaves. A much preferable common name is veil of flowers. Plants are grown by the acre in greenhouses in the United States, Holland, and South America, and in the field in coastal California. They are widely branched toward the top of the plant and bear lavender, dark blue, or white terminal flower clusters consisting of dozens of small tubular flowers, each measuring less than ¼″ (6 mm) across. Plants are excellent subjects for cut flowers and will overwinter in areas of Florida, the Gulf Coast, and California.

Propagation

Always propagated from seed, and although raw seed is available, it is very tiny and seldom used. Pelleted seed is available, by seed count, and is recommended. Sown under intermittent mist in the greenhouse at 62–70F (17–21C), seed germinates in 14–21 days. Do not bury deeply, as light promotes germination. If sowing in open flats in the greenhouse, seedlings may be transplanted to plug trays (up to 200 cells) after the first set of true leaves are visible. Alternatively, seed may be sown in plug trays. In general, because approximately 10–12 weeks are needed between sowing and transplanting to plugs, most growers purchase plugs from commercial propagators. Direct sowing to the field is seldom practiced, due to inconsistent germination.

Growing-on

Grow seedlings in plugs or pots at 55/60F (13/15C) night/days. Fertilize with 50–100 ppm N solution of a complete fertilizer when 2 true leaves have expanded. Raise temperatures gradually but no higher than 75F (24C). Increase fertilizer to 200 ppm N every other watering. As plants reach 3 or 4 leaves, reduce greenhouse temperature to 60–62F (15–17C). Plants may be transplanted when large enough to handle.

Environmental Factors

Photoperiod: Plants flower faster under long days of at least 14 hours (Armitage 1988). Short days inhibit flowering.

Temperature: Plants are Mediterranean in origin and do not respond well to large fluctuations in seasonal temperature. During greenhouse growing, temperatures of 60–70F (15–21C) appear to be optimum. Field production is best in areas of cool nights and warm days.

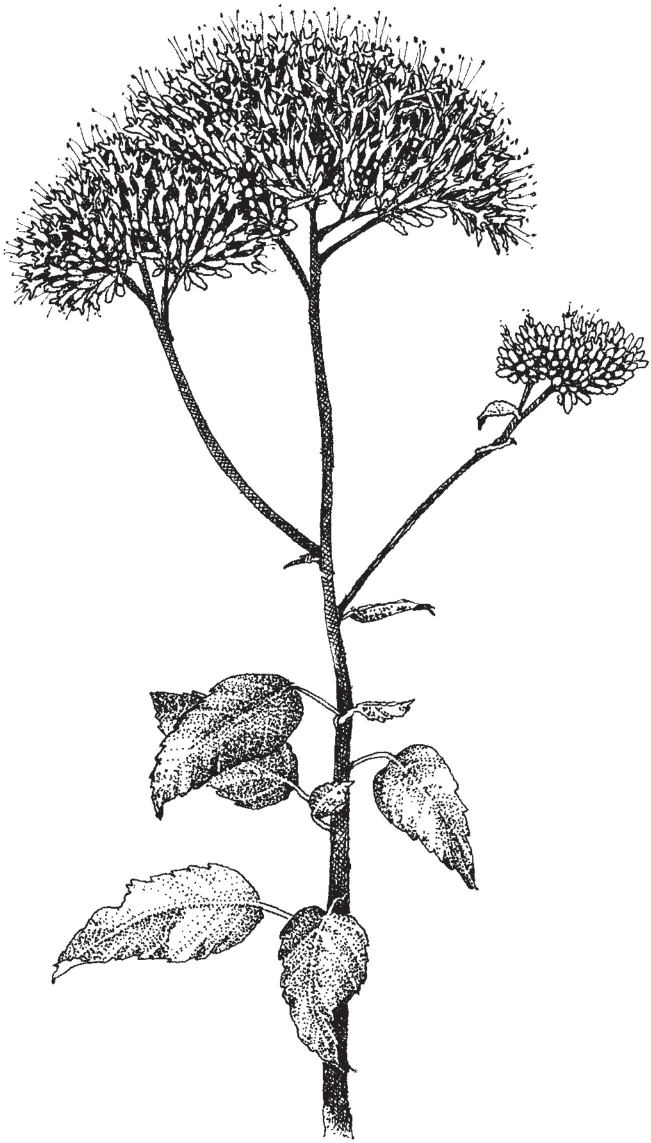
Field Performance

Plants may be field-grown in the summer in the Northwest and coastal California, but they do poorly in high heat, and therefore suffer in summers in the southern half of the country and in many areas of the Midwest. Performance in the fall, winter, and early spring is excellent in south Georgia and Florida.

Spacing: Space plants 9–18″ (23–45 cm) apart; the wider the spacing, the more breaks and the greater the yield/plant.

Support: Two tiers of support netting may be useful, however, netting is mainly recommended where high winds are a factor.

Overwintering: Plants should be considered annual in most of the country, and even in “mild” winters, overwintering in the field is questionable at best.



Trachelium caeruleum
'Lake Sunset Improved'

Overwintering depends on more than low temperatures, such as duration of cold, humidity, wind, and snow cover. Temperatures of 28F (⁻2C) for a single night are sufficient to damage mature plants and to kill plugs. At 20–25F (⁻7–⁻4C), most plants are killed. Even plants that survive mild winters will likely have to be cut back to the ground in the spring.

Greenhouse Performance

Most production is under protection; comparatively little is accomplished in the open field.

Temperature: Plants should be grown cool initially for good root development. Grow seedlings in plugs or pots at 55/60F (13/15C) night/days. Raise temperatures gradually but no higher than 75F (24C).

Spacing: Fertilize with 50–100 ppm N solution of a complete fertilizer when 2 true leaves have expanded. Grow plants in ground beds, 12″ (30 cm) or as little as 9″ (23 cm) apart. Some production occurs in 6″ (15 cm) pots, spaced pot to pot.

Fertilization: Fertilize with 100–200 ppm N during the fall and winter.

Light and temperature: Grow with bright light and 55–60F (13–15C) night temperatures and 65–70F (18–21C) day temperatures. Warmer temperatures result in faster growth and flowering but also cause thinner stems and more open inflorescences. Work in Spain showed that heating the greenhouse to 55F (13C) with 18-hour days and continuous fertilization resulted in flowering 8 weeks earlier and a significant increase in stem quality, compared with unheated houses under natural photoperiods (Lopez et al. 1996).

Supplemental light: Supplemental light (sodium or metal halide) accelerates growth and flowering if used during the day and is highly recommended (Armitage 1988). Place plants under 14- to 20-hour day conditions. Use either HID lamps (350–450 fc) or fluorescent lamps, depending on latitude. In northern latitudes, HID lamps may be necessary because natural light is too low for good-quality plants. If light intensity is sufficient but daylength too low, mum lighting (10–20 fc) can be used. Lighting generally starts about 3 weeks after transplanting (van Hee 1994).

Incandescent lamps are the most inefficient means of producing light; fluorescent lights are far more efficient. Costs of installation, however, are quite different. Ben-Tal and Wallerstein (1999) studied the use of fluorescent lamps to provide 16-hour days and concluded that they were 44% cheaper and accelerated flowering equally with incandescent light. Although the fixtures cost 16 times more, they lasted 10 times longer.

Carbon dioxide: Elevating CO_2 has positive effects on flowering. Reekie et al. (1994) found that raising CO_2 to 1000 ppm advanced flower opening by affecting flower initiation. Plant size was also increased.

Support: One to 2 tiers should be used with greenhouse-grown crops. Plants require 5–7 months to flower from seed.

Scheduling: Transplanting from September to January would provide flowers after 14–18 weeks; in February to May, after 12–13 weeks, and during June to August, as low as 10–12 weeks in a sunny area (southern California).

Stage of Harvest

Harvest the stem when ¼ to ⅓ of the flowers are open (Bredmose 1987). If harvested too early, the flowers will not open (van Hee 1994). Most growers prefer to harvest the entire stem at once (called untopped), including the main flower and laterals, whereas others prefer to top off the main stem and harvest laterals later. With the former method, associated labor costs are lower and stems are longer and of a higher quality; however, yield is markedly reduced. Dirks (1996) studied the economics of both systems and found that costs per stem in the untopped harvest was higher, because of lower yields, but that the topped system resulted in many thinner, poorer quality stems. We recommend cutting everything at once.

Postharvest

Fresh: Fresh flowers, if harvested at the proper stage, persist approximately 2 weeks in water. The addition of STS resulted in an additional 1–2 days but is not mandatory (Bredmose 1987).

Storage: Store in water at 40F (4C) for approximately 24 hours.

Shipping: If properly precooled and if temperatures are maintained at 36–40F (2–4C) during shipping, flowers may be shipped dry with excellent results.

Dried: Flowers may be air-dried but lose much of their color.

Cultivars

Many available cultivars, but they don't offer a great deal of diversity.

'Blue Wonder' is a spring-flowering selection with mid-blue flowers.

Devotion series comes in blue, white, and purple. Plants are naturally 30–36″ (75–90 cm) tall, but because they respond well to growth regulator application, they have been mainly used for pots and large containers.

Hamer series was bred especially for cut flower production. 'Hamer Blue Umbrella' is a dark blue, green-leaved standard variety. 'Hamer Dafne' bears flat umbels of dark pink flowers. 'Hamer Eris' produces silvery blue flowers. 'Hamer Helios' bears pure white flowers. 'Hamer Pallas' is an improved 'Blue Umbrella' and is said to have a short harvest period. 'Hamer Pandora' has purple flowers and dark stems.

Lake series produces plants that grow to 28–40″ (70–100 cm) with white or lavender to purple flowers. 'Lake Avalon' is a somewhat washed-out pink. 'Lake Forest' (mid-blue) is an excellent later-flowering form, flowering from fall into spring. 'Lake Powell Improved' has white flowers; white tends to discolor earlier than darker colors and has limited market appeal. Plants are about 2 weeks earlier to flower than its predecessor. 'Lake Sunset Improved' is burgundy-red and seems to flower almost year-round. 'Lake Sunset' (prior to being "improved") was slightly earlier than other Lakes. Best under some protection; in national field trials, 'Lake Sunset' produced 4 flowers per stem when planted outdoors (Dole 2001). 'Lake Superior Improved' has darker purple flowers, stems, and leaves. A favorite in some markets.

'Merii Blue' has mid-blue flowers.

'Midnight Blue' is said to be heat and stress tolerant and quite uniform.

'Summer Blue Wonder' produces light blue umbels in the summer.

'Summer Lake Superior' also flowers in the summer but with darker blue flowers. The Summer series was bred for optimal performance under high light and high temperature.

'Umbrella Blue' has lavender-blue flowers and is similar to the species, perhaps a little more compact.

'Umbrella White' bears creamy white flowers. The flowers decline more readily than the blue forms, showing petal blackening.

Pests and Diseases

A tospovirus, transmitted by western flower thrips, causes leaf scorch and blackening of stems. Whiteflies can also be an occasional pest. Many problems are caused by hot temperatures and high humidity, resulting in premature flowering and botrytis, respectively. Susceptibility to root nematodes, particularly *Paratylenchus bukowinensis*, has also been noted (Brinkman et al. 1995).

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Many thanks to Philip Katz, Jeroen Ravensbergen, and Jim Rider for reviewing this section.

Triteleia brodiaea Liliaceae

bulb, Zones 6–9 California blue 9–15″/6″ (23–38 cm/15 cm)

Although the species commonly used for cut flowers were recently transferred from *Brodiaea* to the genus *Triteleia*, flowers and corms are often still sold as brodiaeas. The flip-flop of botanical names has occurred with *Chrysanthemum* and many other genera, and we will get used to it. *Triteleia laxa*, the species of choice and by far the most common, bears the largest inflorescences of the genus. The 2–5″ (5–13 cm) wide inflorescence consists of 15–25 deep blue tubular flowers. The individual flowers are up to 1½″ (4 cm) across, about 1″ (2.5 cm) long, and carried on 2–3″ (5–8 cm) long pedicels.

Flowers of brodiaea are easy to grow, inexpensive, and have reasonable vase life, but they are not often seen at local florists; their diminutive size and lack of easy availability perhaps contributes to this lack of visibility. Also, as Jan Roozen of Choice Bulb Farm in Mount Vernon, Wash., notes, his part of the country is "lousy with agapanthus at that time of year." And agapanthus provide the same color with bigger, more showy flowers.

Propagation

One- to 2-year-old corms can be purchased from reliable bulb suppliers. Seed can be purchased but requires 2 years to reach flowering size.

Growing-on

Corms should be immediately planted in the field. Seedlings may be grown on in beds, pans, or 4–5″ (10–13 cm) pots in the greenhouse or propagation field. In favorable environments (e.g., Northwest), they multiply rapidly, increasing threefold in 2–3 years. If propagating from corms, treat like gladioli and discard the mother corm.

Environmental Factors

Growth is affected by soil temperature. A sunny location where the soil warms up quickly in the spring is best. Photoperiod has little effect on flowering.

Treatment of corms with 20 ppm ethylene for 7 days resulted in reduction of time to sprouting and first flowering. The treatment also increased the number of flowers per inflorescence and the fresh weight of daughter corms. The length of the scape, however, was not affected (Han et al. 1990).

Field Performance

Corm size: Corms 5/6 or 7/8 cm in circumference are recommended (De Hertogh 1996).

Spacing: Space corms 3–6″ (8–15 cm) apart and 4–5″ (10–13 cm) below the surface.

Planting time: Corms may be planted in early spring north of Zone 6, in the fall south of Zone 6. Ruth Merrett of New Brunswick (Zone 4b) has had excellent stem lengths for 4 years in a row; she plants early and then covers crop with Remay™ to maintain corms above freezing.

In Zone 7b (Athens, Ga.), no difference in yield of corms planted after November was found. Few growth and flower differences occurred for any date, although yield was slightly reduced when planted as early as November. As the following table shows, planting time did not affect initial harvest date (Armitage and Laushman 1990).

The effect of planting date on *Triteleia laxa*.

Month planted	Flw/ corm	First harvest	Harvest duration (days)	Stem length (in)[z]	Stem width (mm)[y]
Nov	0.8	27 May	7	8.7	4.7
Dec	1.4	21 May	13	12.0	3.9
Jan	1.0	29 May	8	9.9	2.7
Feb	1.3	27 May	13	11.7	3.1

z = multiply (in) by 2.54 to obtain (cm)
y = divide (mm) by 25.4 to obtain (in)

Northern growers must wait until the ground thaws prior to planting. Corms may be lifted, cleaned, and sorted to size after the foliage has disappeared or in the fall after the first freeze.

Longevity: In field tests in Georgia, corms persisted 2 years; summer temperatures in north Georgia, combined with evening rainstorms, likely reduced corm numbers in the third year. Triteleias should be treated as a 1- or 2-year crop east of the Rocky Mountains. Corms are sufficiently inexpensive to make annual renewal an option.

Planting zones: Corms overwintered as far north as Nova Scotia (Zone 5) but are not normally overwintered north of Zone 6 (De Hertogh 1996). Flowering time and stem lengths were 20 July/16″ (40 cm) in Nova Scotia (Zone 5), 25 June/14″ (36 cm) in East Lansing, Mich. (Zone 5), 20 June/14″ (36 cm) in Washington, D.C. (Zone 7), and 2 May/10″ (25 cm) in Baton Rouge, La. (Zone 9).

Greenhouse Performance

Data from California for flowers forced in greenhouses at 65/40F (18/4C) day/night temperatures are of interest. Without any ethylene treatment, corms required 104 days to sprout and 274 days to flower; with 20 ppm ethylene treatment for 7 days, corms sprouted in 78 days and flowered in 228 days (Han et al. 1990). Drip irrigation, starting when the stems are 4″ (10 cm) tall and continuing until buds form, usually results in taller stems and larger flowers.

Stage of Harvest

Some growers harvest when only one flower is open; however, 4–6 flowers can be open with no loss in quality. If insect pollination can be avoided (e.g., if plants are greenhouse-grown), allow approximately 15 flowers to open prior to harvesting for local sales (Nowak and Rudnicki 1990). Harvesting in bud stage and cold storage are not recommended.

Postharvest

Fresh: Flowers persist 10–14 days in water (Vaughan 1988), 1–2 additional days if preservative is used. Stems must be recut at each step of the postharvest chain. The bottom white portion of the stem should be removed. Stems may be stored dry for up to 4 days at 36–41F (3–5C) if necessary, although if stems are in water, they can be stored significantly longer without significant loss in vase life.

Dried: Flowers do not dry well.

Species and Cultivars

Triteleia californica (syn. *Brodiaea californica*) bears dark blue to mid-blue flowers. Plants are only 12–15″ (30–38 cm) tall. Stems and flowers enjoy an excellent vase life.

Triteleia 'Corrina' is 20–26″ (50–66 cm) tall and has purplish flowers.

Triteleia hyacinthina has pale blue, almost ghost-like flowers. 'Royal Blue' has double lilac flowers.

Triteleia laxa (Ithuriel's sword), the most common species, is as good as any cultivar and probably better. It is taller than most cultivars and bears more and larger flowers. Unfortunately, this species has been around for so long that some of the stock has weakened. 'Alba' produces white flowers.

Triteleia 'Queen Fabiola', a probable hybrid between *Triteleia laxa* and *T. peduncularis*, is properly classified as *T.* ×*tubergenii*. Regardless of its taxonomic niche, it bears excellent dark blue flowers and is the principal cultivar available. The blue color is most intense in cool climates but fades as temperatures increase. Stems are 14–20″ (36–50 cm) tall.

Pests and Diseases

Plants (corms) require excellent drainage or root and corm rots occur. Application of soil fungicide 1–2 weeks prior to planting reduces incidence of rot organisms.

Reading

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Many thanks to Ruth Merrett and Jan Roozen for reviewing this section.

Tulipa tulip Liliaceae

bulb, Zones 3–7 Asia Minor many colors 12–30″/12″ (30–75 cm/30 cm)

The origin of the modern tulip is not known, although a long period of cultivation and selection occurred in Turkey and Iran prior to its introduction to Europe in the 16th century. Garden tulips have been divided into many different classes, based on parentage, flowering time (early, late), and flower form (single, double, lily-flowered, parrot). Major forms of tulips used for cut flowers include Darwin, Triumph, Rembrandt, Double, and Peony- and Lily-flowered. Essentially all bulbs come from Holland, and many flowers are also produced there. Flowers are produced mainly for the early spring market (outdoor production) or in early January under greenhouse conditions. Greenhouse production generally requires controlled-temperature forcing chambers, and, while all pre-greenhouse treatment may be accomplished outside in cold frames, controlled-temperature facilities are necessary to meet a particular marketing period. A recent trend in bulb production, particularly tulips, is hydroponic production; and at least for the near future, this is how much of the greenhouse forcing will be accomplished. For forcers growing bulbs in outdoor beds, the market may be affected slightly by cultural techniques, but the market date and flower quality essentially are under control of prevailing temperatures.

Environmental Factors

Like daffodils, tulips require an annual warm–cool–warm temperature sequence. In the field, this begins with warm summer temperatures, with winter and spring completing the sequence. The initial warm temperatures result in leaf differentiation and flower initiation. The cool treatment (13–20 weeks) causes acceleration of flowering, uniformity of flowering within the population, and sufficiently long flower stems (Rees 1985). The final warm treatment is necessary to force the flower to elongate and open. Research has been conducted on many cultivars, and optimal cooling and greenhouse forcing times have been determined for greenhouse-forced bulbs (De Hertogh 1996). In general, the optimum greenhouse temperatures are 63–68F (17–20C) (Rees 1985).

Tulipa 'Fantasy'
(parrot form)

Field Performance

Bulb size: The only factor that is unequivocally related to flowering is bulb circumference. Bulbs below a critical size (depending on cultivar) will form only a single leaf and will not flower until the following year. Use 10/11 to 12+ cm circumference bulbs, depending on cultivar (De Hertogh 1996).

Planting: Place bulbs with 5–6″ (13–15 cm) of media above the nose. Plant approximately 6″ (15 cm) apart.

Planting time: In most areas of the country, non-precooled bulbs should be planted in the fall. In the South (Zones 6 and 7b, e.g., north Georgia), plant in October to November; in the North (Zone 6 and lower) in September and early October. In the Deep South (e.g., Florida, south Texas, southern California), bulbs must be precooled (8–10 weeks at 40–45F, 4–7C) and planted in late November through December.

Longevity: In all but the most northern states and provinces (Zone 4 and lower), tulips should be treated as annuals, although perhaps a couple of years' production may be realized. In more northern areas, Darwin, Scheepers, and Fosteriana hybrids provide some perennial performance.

Timing: The length of time tulips may be harvested depends on the use of early-, mid- and late-season cultivars. Also important is the length of winter temperatures below 45F (7C) and the rate of spring warming. If temperatures rise quickly in the spring, harvest time is shorter. Trials conducted in different areas of the country provided the following results (De Hertogh 1996).

Average of 4-year cut tulip trials in various areas.

Location (Zone)	Earliest harvest date	Harvest duration (days)
College Station, Tex. (8)	18 Feb	48
Pomona, Calif. (9)	26 Feb	64
Corvallis, Ore. (9)	12 Mar	64
Clemson, S.C. (7)	14 Mar	38
Ames, Iowa (5)	10 Apr	40
East Lansing, Mich. (5)	15 Apr	40
St. Paul, Minn. (4)	27 Apr	30
Hamilton, Ont. (5)	1 May	32
Edmonton, Alb. (3)	15 May	33

Notice that the duration of harvest is greatest in areas where less variation in temperatures occur (Northwest). In areas with "short springs," harvest time is shortest. The beginning of harvest coincides with spring warming.

Stem length: Cold is necessary for stem extension, therefore less cold equals shorter stems. Stems are shorter in warmer areas than in areas with cold winters (i.e., longer in the North than the South).

Greenhouse Performance

Maturity of bulbs: Tulips go through well-defined stages of maturation; prior to cooling, the dry bulb develops 4 vegetative leaves, then the petals, stamens, and finally the female organs (gynoecium). At this point, the bulb is said to have reached stage G. It is imperative that the bulbs have reached stage G before bulb cooling commences. For early forcing, a random sample of bulbs should be dissected to determine that the G stage has been reached. For the early-flowering periods (prior to Valentine's Day), bulbs should be stored at 63F (17C) for 1–5 weeks prior to rooting in cold temperatures (De Hertogh and Le Nard 1993).

In most cases, bulbs may be planted immediately upon arrival and stored in controlled facilities for the appropriate number of cold weeks for the cultivar used. For the Valentine's Day market, bulbs are usually panned in October, stored at 48F (9C) until roots are visible through the drainage holes, transferred to 41F (5C) until shoots are 1–2″ (2.5–5 cm) tall, and then placed at 33–35F (1–2C) until they are moved to the greenhouse bench. The total amount of time in the cooler depends on cultivar; 16–17 weeks are optimum for most, 15 is minimum, and 20–22 weeks is maximum (De Hertogh 1996). The greenhouse temperature and time in greenhouse (2–3 weeks) also depend on cultivar, locale, and time of year. For market times before Valentine's, precooled bulbs must be used. For those interested in forcing in the greenhouse, the *Holland Bulb Forcer's Guide* by Gus De Hertogh (1996) provides specifics on cultivars and is essential reading.

One of the limitations to greenhouse forcing is the need for cooler space for bulbs. Dole (1996) suggested a delayed potting method in which the bulbs are cooled dry for the first 8 weeks, then potted up as normal for the last 6 weeks of cooling time. Cooler space needed for the dry bulbs is minimal, and when pots are removed for greenhouse forcing, additional dry cooled bulbs may be potted to take their place. In this method, the cooler should remain at 41F (5C) for the entire time that dry bulbs are present in the cooler.

Stage of Harvest

Harvest Darwin tulips when 50% of the flower is colored; others should be cut when nearly the entire flower is colored. Tulips must be harvested several times a day for optimum postharvest life. They are usually wrapped in 10-stem bunches.

Postharvest

Fresh: Sexton et al. (2000) concluded that tulip senescence does not involve primary regulation by ethylene. Neither addition of silver thiosulfate nor aminoethoxyvinylglycine (AVG) delayed the time to abscission. Flowers persist 3–4 days in the opening stage, and a further week after they open (Vaughan 1988).

Storage: Growers must wrap bunches after grading. If they are shipped immediately, they may be placed vertically in water. Cevallos and Reid (2001) found no significant differences between the vase life of flowers stored dry and flowers stored in water when storage temperatures were 32–50F (0–10C); however, the vase life after wet storage at temperatures of 54F (12C) and greater was significantly higher than vase life after dry storage at those temperatures.

Stem stretch: Stems continue to grow for the first 24 hours in water, and flowers bend toward the light. Growth regulators have been effective in reducing growth and bending after harvest. The addition of 20 or 50 mg GA_3/l to a preservative solution containing 8-hydroxyquinoline citrate and sucrose significantly prolonged the vase life of tulip cultivars. GA_3 also reduced the excessive stem elongation that occurs in cut tulips kept in water. The addition of 25 or 50 mg Ethrel™ (ethephon)/l to the preservative solution containing GA_3 completely inhibited stem elongation during vase life and had no effect on flower longevity (Pisulewski et al. 1989).

Wholesalers should store tightly wrapped stems horizontally at 32–35F (0–2C) (De Hertogh 1996). If placed in water, recut about ¼″ (6 mm) of the stem base and place in 6–8″ (15–20 cm) of cooled water. If flowers arrive bent, they may be straightened by wrapping them in wet paper and placing in water with light directly above (Vaughan 1988).

Do not place tulips with daffodils. Daffodils exude a mucous substance that is toxic to many other species (Doorn 1998). Tulips and daffodils may be mixed if daffodils have been allowed to stand in water in separate containers for 24 hours (see *Narcissus*).

Cultivars

Many, many are used. Contact your bulb distributor for up-to-date cultivar listings and availability. Roy Snow of the United Flower Growers auction in Burnaby, B.C., shares these most popular cultivars: 'Angelique' (double pink), 'Apricot Beauty' (apricot), 'Bastogne' (red), 'Blenda' (pink and white), 'Christmas Marvel' (hot pink), 'Don Quichottee' (hot pink), 'Gander' (hot pink), 'Gander's Rhapsody' (light pink), 'Ile de France' (red), 'Inzel' (white), 'Leen van der Mark' (red and yellow), 'Monte Carlo' (double yellow), 'Negrita' (purple), 'Upstar' (double pink and white), 'White Dream' (white), and 'Yokohama' (yellow).

Roy also mentions some interesting newer varieties: 'Double Price' (extremely double purple), 'Jan Reus' (burgundy), 'Orange Monarch' (orange), 'Princess Irene' (orange with red stripes), 'Purple Prince' (purple), 'Rocco' (parrot red), 'Top Parrot' (parrot red), 'Washington' (red and yellow), 'Weber's Parrot' (parrot pink and green), 'Winterberg' (cream), and 'Zurel' (purple and white striped).

Pests and Diseases

Sterilize beds whenever possible to reduce incidence of soil-borne diseases, such as those caused by *Rhizoctonia* and *Pythium*.

Gray mold (*Botrytis*) affects flower petals and stems. Crop rotation and use of fungicides help combat the problem. Avoid overhead irrigation.

Basal rot (*Fusarium oxysporum*) results in red foliage, few roots, and rotted bulbs. This problem must be controlled by the bulb grower and should never enter the grower's field. Always check bulbs on arrival for a whitish mold and a foul smell. Infected bulbs feel soft beneath the outer covering, and some may feel very light. If more than 10% of the bulbs are infected, the whole lot may have to be discarded.

Blue mold (*Penicillium*) is generally not serious, but bulbs should be dusted with a fungicide if placed in dry storage or drenched if immediately planted (De Hertogh 1996).

Flower rot often occurs on double-flowered forms that have been watered overhead and have not dried out. Provide good ventilation, particularly for double flowers.

Physiological disorders

Flower abortion during early stages of development can be caused by excessively high temperatures during transportation of the bulbs from Holland or ethylene exposure at any point during forcing (Charles-Edwards and Rees 1975). Fusarium will induce concentrations of ethylene sufficient to result in flower abortion or malformation (De Hertogh and Le Nard 1993). Stem topple (the stem collapses slightly below the base of the flower) may be related to a calcium deficiency, excessively cold-treated bulbs, or forcing at a very high temperature (De Hertogh 1996).

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Many thanks to Brent Heath (first edition) and Roy Snow (second edition) for reviewing this section.

Tweedia caerulea

Asclepiadaceae

annual Argentina blue 12–20″/12″ (30–50 cm/30 cm)

In the first edition of the book, *Tweedia caerulea* (syn. *Oxypetalum caeruleum*) was described as "a plant with exciting potential as a cut flower or a pot plant" and, although its gains in popularity at Dutch auctions were noted, it was judged "relatively unknown in the American market." Boy, was that statement right on! Is anybody growing even a single plant of this stuff? Perhaps the negatives mentioned in the first edition, such as the milky sap, unappealing foliar fragrance, and twining habit, did not endear this species to growers, but that does not change the unique sky-blue color of the starlike flowers. Still, for the hard-core specialists, we decided to keep the plant with the wonderful name in this edition as well. Plants may be grown in the greenhouse or under protection outdoors.

The botanical name was recently changed from *Oxypetalum* to *Tweedia*, commemorating the Scotsman James Tweedie (1775–1862). He was the head gardener at the Royal Botanic Garden in Edinburgh and later emigrated to South America, where he kept a small shop in Buenos Aires. He botanized throughout the continent, sending material back to Scotland for study.

Propagation

Propagate by sowing seed in plugs or open seed trays at 68–72F (20–22C) under high humidity. Approximately 0.25 oz (7 g) of seed yields 1000 plants (Nau 1999). A significantly longer time is needed to germinate seed that is direct sown. Two to 3″ (5–8 cm) terminal shoot cuttings may be rooted if seed supply is inconsistent.

Growing-on

Fertilize newly emerged seedlings or rooted cuttings with 50–75 ppm N from potassium nitrate and transplant to field when the root system fills a 3½″ (9 cm) pot or plug. Grow at approximately 70F (21C).

Environmental Factors

Temperature: Temperature has the greatest effect on growth and flowering of tweedia. Temperatures above 60F (15C) are necessary for optimum growth, but temperatures above 86F (30C) result in long, lanky stems, aborted flowers, and poor flower color. If plants are consistently grown below 60F (15C), growth is significantly slowed and flowering delayed; the following table summarizes the influence of temperature on tweedia (Armitage et al. 1990).

Tweedia caerulea

The effect of temperature on flowering and growth of tweedia at first harvest.

Temperature	Days to flower^{z}	Stem length (in)^{y}	Aborted flowers (%)
57F (14C)	115	18.0	10
70F (21C)	38	20.0	4
86F (30C)	32	24.8	20

z = time between placing 8-week-old plants at specific temperature to harvesting of 3 flower stems
y = multiply (in) by 2.54 to obtain (cm)

Light: High light intensity is best for flowering; low light levels cause stretching and thinning of flower stems. Provide shade in high light areas to increase stem length.

Photoperiod: No photoperiodic effects on time to flower occur, but long days (>12 hours) result in extended internodes and therefore longer stems. Also, less flower abortion occurs on plants subjected to LD, and higher-quality flowering stems are formed.

Field Performance

Flowers are susceptible to weather damage, particularly rain and wind. Greenhouse production is recommended, but field production is possible if protection from the elements is provided. Support of plants is necessary in the South but not in the Northwest.

Yield in outdoor production is 5–10 stems/plant the first year and may be doubled if plants can be overwintered. Stem length is longest and stems are strongest if plants are well fertilized, temperatures of at least 65F (18C) are provided, and some shading is present.

Fertilize with side dressing of N or with liquid fertility of 300–500 ppm N once a week.

Greenhouse Performance

Tweedia is well suited for greenhouse production. Space plants 6–9" (15–23 cm) apart and fertilize consistently with liquid or slow-release fertilizer. Plants may be grown in containers or ground beds. If temperatures are above 70F (21C), support may be necessary.

Stage of Harvest

Flowers are indeterminate: flowers occur in the nodes of the stems, and the stems continue to produce additional leaves and flowers. Groups of 2–4 flowers (cymes) occur in each node. Long seed pods form from the flowers, which some designers find useful. To each his own!

Harvest when approximately 6 cymes are present. The first 1 or 2 should be open, the last showing color.

Postharvest

Flowers persist 6–10 days, depending on temperature and light. The stems exude a milky sap that, although messy, does not seem to reduce the vase life. Studies with various solvents, such as alcohol and hot water, showed that removal of the sap did not affect vase life. Use of silver thiosulfate did not significantly extend vase life.

Cultivars

'Heavenborn' bears deeper blue flowers. This selection has been successful in Dutch greenhouses.

Pests and Diseases

Root rots under conditions of poor drainage and hot weather are not uncommon. Aphids, in particular, relish the plants. Otherwise, few pests bother them.

Grower Comments

"I picked up a 4″ pot at a local nursery just by chance one spring. It got about 2′ tall and bloomed very well that summer—a pale iridescent clear blue with slightly fuzzy leaves. No problems at all. It made tons of milkweed-type seed pods with a lot of viable seeds and reseeded some in the bed. It's a tender perennial in Louisiana and probably well worth fooling with, though stems are a little short." Denyse Cummins, Lafayette, La.

Reading

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Verbena bonariensis

South American verbena, tall verbena Verbenaceae
perennial, Zones 6–9 South America rose-violet
3–4′/3′ (0.9–1.2 m/0.9 m)

Of all the verbenas, this is among the taller species and particularly effective as a filler. Named for the city of Buenos Aires, where it was first discovered, it has since become naturalized in the United States from South Carolina to Texas. The wiry stems are roughly hairy and conspicuously 4-angled. The individual flowers measure only about ¼″ (6 mm) across but the entire inflorescence is 2–4″ (5–13 cm) wide.

Propagation

Seed germination is inconsistent at best; conventional sowing can result in yields as low as 30% (Nau 1999). Stratifying seed has provided benefit occasionally; sow in moist media and place the tray at 40F (4C) for 3–4 weeks, after which time the tray may be moved to 70–75F (21–24C). Germination is erratic, and seedlings appear over 3–5 weeks.

Two to 3″ (5–8 cm) terminal cuttings of new spring growth may be rooted and transplanted 3–5 weeks later. Root cuttings, taken in the spring, may also be used.

Growing-on

Grow on at 55–62F (13–17C) in a minimum pot size of 4″ (10 cm). Plants should remain in the greenhouse for as short a time as possible. Cutting back the plant results in a many-branched specimen with a shrub-like habit.

Environmental Factors

Plants flower all season, from early spring until frost, indicating little or no photoperiodic response. Plants flower the first year from seed, suggesting that neither is a cold treatment necessary. Likely flower initiation is a function of node number (maturity).

Field Performance

Yield: Ten to 12 stems per plant is obtainable. Plants do not branch much on their own; however, a single pinch yields additional stems.

Spacing: Plants are taller than they are wide, and spacing can be dense. Plants can be spaced as closely as 12″ (30 cm) apart; however, powdery mildew is a problem, and more open spacing (18–20″, 45–50 cm) is recommended for air movement.

Longevity: Plants can be treated as annuals. If planted early in the spring, they will be no more productive in subsequent years, even if they overwinter. Plants will reseed, but it has been our experience that the volunteers are not as vigorous as when started anew.

Stage of Harvest

Harvest when most flowers are open. The stems can become tangled, and harvesting individual stems can be difficult; some growers cut an entire row at one time. If using this method, stems must be graded to cull those that have been harvested too early or too late.

Postharvest

Flowers tend to shatter, which can be a problem, particularly for customers who like the neat-and-tidy look. Susan O'Connell of Hartwick, Vt., states, "I find it sheds a lot of blooms immediately after cutting, no matter what postharvest treatment I try. It continues to shed some after that, but not copious amounts, and I make sure I have shaken out any dead florets before it gets to market. But flowers are alive, and life is not static, it is constantly changing. So I try to make sure my customers are aware that it will be messy, and show them all the buds that continue to open. Most appreciate it and enjoy that gorgeous purple!"

Flowers can be stored at 36–41F (2–5C).

Additional Species

Verbena rigida (rigid verbena) is similar to *V. bonariensis* in all respects except size: *V. rigida* is only 1–2′ (30–60 cm) tall. The flowers are similar, the square stems are also coarse, and the color is similar, perhaps a little darker. We recommend *V. rigida* as a short-stemmed annual; however, plants are winter hardy only to Zone 7.

Pests and Diseases

Powdery mildew is the biggest problem with verbenas in general, and the cut flower forms are no exception. Spray fungicides beginning in early summer.

Grower Comments

"I gave up trying to cut individual stems, and just started clear-cutting all the large stems without looking at the heads, putting them in 30-stem bunches. I actually sold to the wholesaler this way, and at home it's easy enough to throw out the unbloomed heads as we make bouquets." Ralph Thurston, Bindweed Farm, Blackfoot, Idaho.

"I grew *Verbena bonariensis* last year and it bloomed forever. Because it was such a pain to cut, I didn't grow it this year. All my customers kept asking for it, so I am going to try it again next year. I will make sure to wear gloves when I strip the foliage and also leave a little more space between plants, so I can see where the individual stems are. It is easy to grow from seed, and I got a few volunteers this year even though I tilled the area very well and applied 2″ of compost on top of the soil." Kate Sparks, Lilies and Lavender, Doylestown, Pa.

"When the verbena blooms start looking ratty, I take the brush hog on my tractor set high and mow it all down. It reblooms in a few weeks with fresh flowers." Mary Vanderslice, Laughing Flowers Farm, Maypearl, Tex.

"I wish I had some verbena planted this season. I gave up on this stuff due to my personal dislike of the flower's tendency to shatter. Not a week goes without a few customers asking when the verbena will be ready." Paul Shumaker, Never Should Have Started Farm, Bangor, Pa.

"It is an invaluable cut for me, and I can't make a bouquet without reaching for some verbena as a final touch. Mixed with sunflowers and amaranth, or crocosmia, or red yarrow, it is a winning combination. I let the flower heads get fairly large before cutting. After it has stretched out and has the side stems blooming as well, it is perfect for my bouquet needs." Susan O'Connell, Fertile Crescent Farm, Hardwick, Vt.

Reading

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Veronica speedwell Scrophulariaceae

perennial, Zones 4–8 Europe, Asia blue 2–3′/2′ (60–90 cm/60 cm)

This genus has enjoyed steady increases in cut flower production, particularly in Europe and in the United States, although it is still considered a minor crop by most growers. Much of the increase may be attributed to the improved vase life of newer cultivars. If treated properly, veronica can be shipped significant distances, but it is still recommended for local sales. Fresh local material will always be better than material shipped in from other parts of the country or other parts of the world. This can be said for many crops but is especially true for veronica.

Several *Veronica* species are available from perennial plant growers, but longleaf veronica (*Veronica longifolia*) is the most suitable for the cut flower trade. Plants are robust and relatively winter hardy and tolerate warm summers well. Many more choices for flower color are available with spiked speedwell (*V. spicata*), but stem length is shorter on cultivars, unless selected for cut flower use. 'Sunny Border Blue' and other hybrids are important landscape plants but are seldom used as cut flowers. The main problem with veronica as a cut flower is that flowers on the bottom of the inflorescence decline before the top flowers are open. The stage of harvest and postharvest procedures become particularly important with these plants.

Propagation

Most cultivars are propagated by division or terminal cuttings; however, the species and a few cultivars may be seed-propagated. The small seeds should be lightly covered and placed at 68–72F (20–22C). Germination occurs in 10–14 days. Approximately 1/128 oz (221 mg) of seed yields 1000 seedlings (Nau 1999).

Growing-on

If small propagules are received or seedlings are being grown prior to planting in the field, initially place at 58–65F (14–18C) and lower the temperature 2–4 degrees F (1–2 degrees C) after 2–3 weeks of growth. Fertilize sparingly (75–100 ppm N once a week) until plants are large enough to plant to the field.

Environmental Factors

Temperature: Little is known about the effects of cooling, but it is likely beneficial, if not necessary, for all species. Cooling is not necessary for those cultivars that flower the first year from seed. The hybrid 'Sunny Border Blue' requires 6 weeks of cooling at 41F (5C) for flowering; 10 weeks provides even more rapid flowering under greenhouse forcing conditions (Runkle et al. 2000). Yields of

Veronica longifolia 'Blauriesin'

field-grown plants are lower the first year (after a winter) than in 2-year-old plants, but this is probably more to do with the plants' maturing than to cooling. Plants tolerate hot summer temperatures, and they perform well in the Northeast and the West.

Photoperiod: Plants begin flowering naturally in late spring in the South, early summer in the North, and flower sporadically all summer. Photoperiod appears to be of little importance, but LD may play a role in forcing greenhouse plants. In forcing 'Sunny Border Blue', researchers found that if plants received a sufficient cold period, they flowered regardless of photoperiod (Runkle et al. 2000).

Field Performance

For cultivars of *Veronica longifolia*, no cooling or photoperiod appears to be needed; harvest times are 12–16 weeks after planting, and successive harvests are about 12 weeks later, depending on temperatures. Second-year yield will always be better than first-year yield.

Spacing: Space plants on 9–12″ (23–30 cm) or as wide as 15″ (38 cm) centers.

Pinching: Pinching is recommended for field growing, but may not be necessary for greenhouse forcing. Pinch plants about 3 weeks after receiving plugs or when 3–4 leaves can be left on the plant. Pinching out the center flower (disbudding) provides later harvests and a fuller flower head.

Yield: Longevity of plants in the field is at least 5 years, although plants may be renewed as often as every 3 years. Field studies at Georgia on *Veronica longifolia* 'Schneeriesin', an excellent white-flowered cultivar, are shown in the following table.

Longevity of *Veronica longifolia* 'Schneeriesin'. Spacing 15" (38 cm) centers.

Year	Stems/ plant	Stem length (in)^z	Stem width (mm)^y
1	50	16.8	3.0
2	84	21.4	3.3
2 (shade)	26	30.0	3.9
3	30	28.7	5.0

z = multiply (in) by 2.54 to obtain (cm)
y = divide (mm) by 25.4 to obtain (in)

Second-year yield for 'Blauriesin', a blue-flowered cultivar, was 31 stems/plant with an average stem length of 20″ (51 cm). Stems are longer in cooler climates. Ed Pincus in Vermont finds that through selection of taller plants and continual division, stem length of his plants has increased to 32–42″ (0.8–1.1 m).

Shade: Shade cannot be recommended. Although the previous table shows that stem length and diameter benefitted from the presence of 55% shade cloth, yield was much reduced. One reason for the large difference in yield between sun and shade was because of the longer harvest time for plants in full sun. Those in shade were harvested from 14 May to 3 July, whereas those in full sun were harvested well into October. If the additional late summer harvests were not counted, then full-sun plants yielded 40 stems/plant in the same time as shade plants produced 26 stems.

Greenhouse Performance

For *Veronica longifolia*, seed-propagated cultivars are popular and may be obtained as plugs. No cooling or photoperiod appears to be needed; initial harvest time is 12–16 weeks after planting, and successive harvest is about 12 weeks later. Provide as much light as possible if forcing plants during the winter.

Although cooling does not appear to be necessary for many cultivars of *Veronica longifolia*, it is needed for 'Sunny Border Blue', even in the field.

For all species and cultivars, natural days are sufficient, regardless of cold. Temperatures of 60/70F (15/21C) night/day are recommended, although lower temperatures (50–55F, 10–13C) may be used.

Guideline for Foliar Analyses

At field trials in Athens, Ga., foliage was sampled from vigorously growing healthy plants when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis.

'Schneeriesin'

(%)				
N	P	K	Ca	Mg
2.9	0.35	1.20	0.58	0.23
(ppm)				
Fe	Mn	B	Al	Zn
82	30	11	30	57

Stage of Harvest

Harvest when ⅓ to ½ of the flowers on the inflorescence are open (Nowak and Rudnicki 1990). Place immediately in preservative in the field. The inflorescences decline rapidly if too many flowers are already open. According to Ed Pincus, flower droop after harvest can be a problem; he finds that afternoon or morning shade lessens flower droop (harvesting before sunrise or after sunset achieves the same result). Sometimes drooped flowers recover in the cooler. Store at 36–41F (3–5C) and keep away from fresh fruit, etc., as flowers are ethylene sensitive.

Postharvest

Fresh: Flowers are sensitive to ethylene and should be treated with STS, if available. Bacteria can also significantly reduce water uptake, so treat with a preservative containing a bactericide. If plants are harvested at the proper stage of development, they persist about 7 days. Recut the stems prior to shipping and instruct buyers to do the same.

Storage: Storage is not recommended; if necessary, stems may be kept at 36–41F (3–5C) (Vaughan 1988), and storage for up to a week at 33F (1C) is sometimes practiced. Be sure the cooler doesn't fall a few degrees.

Dried: Flowers do not dry well.

Cultivars (*Veronica longifolia*)

'Anna' has rose-red flowers and an improved vase life compared to 'Blauriesin' and other older cultivars. From cuttings.

'Blauriesin' bears lavender-blue flowers on 2–2½′ (60–75 cm) stems. Common and excellent. From seed or cuttings.

'Caya' provides clean white flowers.

'Foerster's Blue' is about 2′ (60 cm) tall and bears deep blue flowers.

'Leonie' has pink flowers. From cuttings.

'Martje' consists of flowers in blue and purple ('Dark Martje'). They are the standard cultivars in Holland.

'Rosalinde' is a hybrid with handsome rose-pink flowers on upright stems.

'Schneeriesin' is an exceptional performer, flowering the first year from seed. Flowers are fairly clean; still, as with all white forms, its flowers appear to decline more rapidly than the flowers of blue-flowered forms.

var. *subsessilis*, sometimes sold as *Veronica subsessilis*, is an excellent form for cut flowers. Plants are 2–3′ (60–90 cm) tall and bear lilac-blue flowers.

Additional Species

Veronica spicata is generally too short and compact for use as a cut flower, but its selection 'Blue Charm', with lavender-blue flowers, is sufficiently tall, up to 3′ (90 cm). 'Sightseeing', a seed-propagated mix of white, pink, and blue flowers on 24″ (60 cm) stems, is also highly useful as a cut (see "Grower Comments").

Veronica virginica (culver's root) is properly known as *Veronicastrum virginicum*, which see.

Pests and Diseases

Aphids and thrips are the major pests. Leaf spots, caused by *Septoria veronicae* as well as other fungi (*Sclerotinia*), can result in ragged-looking leaves. Control with fungicidal sprays; start the spray program in early June and continue once every 3 weeks with a general fungicide. Powdery mildew can also be a problem.

Grower Comments

"I planted the 'Sightseeing' mix in the spring of 1999; it bloomed a little in the fall (short stems), but this spring it is fabulous! I'm Zone 7 and I'm expecting it to be a perennial. My only complaint is that my mix turned out to be only blue with a few whites, so I'm going to plant some more with hopes to get a few pinks too." Kathy York, Scarborough Farm, Mechanicsville, Md.

"My 'Sightseeing' is like the Eveready bunny. It keeps going and going and going. It is about 4 years old and gets better every year." Eileen Stephens, Green and Gold, Earlysville, Va.

Reading

Nau, J. 1999. *Ball Culture Guide*. 3rd ed. Ball Publishing, Batavia, Ill.

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Many thanks to Ed Pincus and Roxana Whitt for reviewing this section.

Veronicastrum virginicum culver's root Scrophulariaceae

perennial, Zones 3–8 eastern United States light blue
3–4′/2′ (0.9–1.2 m/0.6 m)

Often referred to as *Veronica virginica*, culver's root is closely related to *Veronica* (the suffix *astrum* means "resembling"). Flowers of the species are light blue, but the white-flowered var. *album* is the best form for cut flowers. And Betsy Hitt from North Carolina adds something that may be important to many growers: "Veronicastrum seems to be of no interest to white-tailed deer."

Propagation

Seed: Seeds germinate in 2–3 weeks if placed at 65–70F (18–21C) under mist. Approximately 0.02 oz (0.6 g) of seed yields 1000 seedlings (Kieft 1996). Most plants are divided or grown from cuttings.

Division: Divide plants after 2–3 years.

Cuttings: Terminal cuttings, about 2–3″ (5–8 cm) long, should be taken in early summer or fall. Roots form in 2–3 weeks.

Veronicastrum virginicum

Growing-on

Grow plants in cell packs or 4″ (10 cm) pots at 55–65F (13–18C). Fertilize with 75–100 ppm N using potassium nitrate or calcium nitrate. Plant in field in early fall or early spring.

Environmental Factors

No photoperiodic responses have been shown with *Veronicastrum*, but its close relationship with *Veronica* suggests the genera would respond similarly. Plants must attain a certain leaf area or maturity prior to flowering; they tolerate warm temperatures, but stem strength is better in areas where summer nights fall below 70F (21C).

Field Performance

Spacing: Space plants 12 × 18″ (30 × 45 cm) or 12 × 12″ (30 × 30 cm). Stems branch considerably, particularly near the top; therefore, avoid high-density spacing (<12″, 30 cm): flowers chafe against each other and can be damaged.

Center-flower pinch: Pinching out the center flower results in the lateral breaks flushing at the same time. The resulting inflorescence is more handsome and eye-catching than a stem where the center flower is not removed.

Longevity: Plants persist indefinitely; however, division may be accomplished as often as every 3 years, or plants may be allowed to form a solid mass.

Support: Not necessary in cool areas but useful in the Midwest and South after the first year.

Yield: The following table provides the results of 2-year trials in Georgia and California.

Yield and stem quality of *Veronicastrum virginicum* var. *album* in Athens, Ga., and Watsonville, Calif.

	Year	Stems/ plant	Stem length (in)^z	Stem width (mm)^y
Georgia	1	19	22.7	3.5
California	1	8	33.0	6.0
Georgia	2	43	27.2	5.0
California	2	11	29.0	9.0
Georgia only	3	48	40.2	5.5

z = multiply (stems/ft^2) by 10.8 to obtain (stems/m^2)
y = multiply (in) by 2.54 to obtain (cm)

Obvious differences include higher yield in Georgia than California, but stems were stronger, as measured by stem width, in California than in Georgia. Stem strength in Georgia, however, was certainly adequate.

Shade: Shading is not recommended. Second-year harvests of plants grown in full sun compared with those under 55% shade at the University of Georgia resulted in longer stems but reduced yield of plants grown under shade.

Stage of Harvest

For higher-quality stems, remove the terminal flowers as they form. This is labor intensive and may not be feasible; however, all the axillary flowers will open at the same time, resulting in a fuller flower head and more "flower power." Stems should be cut when the inflorescence is approximately ⅓ open. This occurs when fewer than 10 flowers on the inflorescence are open. If cut too early, the foliage will decline before all the flowers open.

Postharvest

Flowers persist 7–10 days in floral preservative. One of the problems with veronicastrum is the incidence of marginal leaf browning. In work conducted at the University of Georgia, flowers cut at early bud stage persisted for 10 days in a flower preservative but only 4–5 days in water. Leaf browning was also significantly reduced. The use of sugar solutions (2.5–5%) also reduced the incidence of leaf browning.

Cultivars

var. *album* ('Album') has creamy white (often with a tinge of pink) flowers and a much-branched inflorescence. This is the cultivar of choice.

Pests and Diseases

Downy mildew (*Peronospora grisea*) results in pale spots on the top of the foliage. The undersides are covered with a grayish mildew.

Leaf spots (*Septoria veronicae*) occur as small violet to brown circular spots of varying sizes on the top of the foliage. The spots may run together, resulting in a scorched appearance. Use a general-purpose fungicide.

Reading

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Zantedeschia calla lily Araceae

bulb, Zones 7–10 South Africa many colors
2–4′/2–3′ (0.6–1.2 m/0.6–0.9 m)

Approximately 6 species are found in the genus, but significant selection and hybridization have taken place, resulting in many hybrids and cultivars. For simplicity's sake, callas may be thought of as "summer" or "winter" callas, monikers based on their native habitats.

The summer callas consist of deciduous foliage, green fruit, and disk-shaped, flattened rhizomes. The inflorescence of callas consists of 2 parts: the cylindrical spadix, consisting of the flowers, and the large ornamental spathe (bract), often colored or white. When descriptions include flower color, they refer to spathe color. Species included as summer types are *Zantedeschia albomaculata* (white flowers, spotted leaves), *Z. elliottiana* (yellow, spotted), *Z. jucunda* (yellow, spotted), *Z. pentlandii* (lemon-yellow, usually unspotted), and *Z. rehmannii* (pink, usually unspotted). The colored hybrids have been developed from these species.

Winter callas have evergreen foliage, yellow to red fruits, and elongated rhizomes. They are represented by *Zantedeschia aethiopica* (white, unspotted leaves), *Z. aethiopica* 'Green Goddess' (white with green flowers), *Z.* 'Pink Mist' (white with pink throat), and occasionally the dwarf *Z. aethiopica* var. *childsiana* ('Childsiana'; Childsiana white calla). The winter callas are common, but it is the deciduous, colored hybrids of the summer callas that are the more popular items for cut flowers and potted calla lilies. Rhizomes are rapidly produced through tissue culture and division, and are available from U.S. producers as well as from abroad. Rhizomes may be left in the ground in Zones 7–10 but should be lifted further north.

Propagation

Seed: Seed propagation is generally limited to the true species and breeding programs. Flowers occur approximately 3 years from sowing (Tjia 1989). Seed propagation has yielded a limited number of cut flower cultivars, but by using seed-propagated rhizomes rather than those that have been divided, disease is reduced.

Division: Growers should not divide rhizomes before the rhizomes are 2 years old, and care must be taken not to introduce bacterial and viral diseases. Rhizomes should be lifted after foliage has died back. Lift carefully from the field and remove soil, leaving roots to shrivel during curing. Divide with a sharp, sterile knife. Cure rhizomes in curing chambers for 10–14 days or until a protective skin develops. Curing chambers should be at 70–80F (21–27C), 70–80% humidity, and have good air circulation. After curing, store rhizomes at 68–70F (20–21C) for 6–8 weeks prior to planting (Welsh and Baldwin 1989). This assumes that dormancy has not been broken. If dormancy is broken after curing, temperatures of 68–70F (20–21C) may reduce the ability of the rhizome to flower.

If rhizomes must be stored for a prolonged period, 45–48F (7–9C) will inhibit sprouting and maintain the health of the rhizome. Store in single-layer mesh trays using dry sawdust or peat moss and provide plenty of air circulation. Do not store below 40F (4C), or rapid loss of flowering potential will occur. Rhizomes will be destroyed if temperatures fall below freezing (Tjia 1989).

Tissue culture: This process should be carried out only by competent laboratories; growers need not be involved. Stock propagated by division, rather than by seed or tissue culture, will likely result in virus-ridden plants that lack vigor.

Zantedeschia aethiopica

Environmental Factors

Light: Calla lilies do well in high light areas, particularly if forced during the winter, but if forced outdoors during the summer, light intensity is seldom a problem. The use of shade during field production is most useful to extend the length of the flower scape (see “Field Performance”). Low light, sometimes a problem during greenhouse forcing in the winter months, results in etiolated leaves and flower stems.

Temperature: Temperature extremes, lack of water, or root disturbance result in dormancy of rhizomes. In nature, dormancy of the colored callas normally occurs after flowering and is characterized by yellowing of foliage and rapid dieback. White callas (*Zantedeschia aethiopica*) do not go dormant if temperatures are cool and moisture is available; they remain evergreen.

Photoperiod: Flowering is not affected by photoperiod; however, plants grown under short days are shorter than those grown under long days. Flower buds form and develop under any condition favorable for vegetative growth (Post 1936).

Gibberellic acid: Gibberellic acid increases the number of flowers on cultivars of colored calla lilies (Funnell et al. 1988). Although most GA research was done with potted callas, similar results occur with cut forms. Best results have been obtained when GA is applied as a preplant dip to the rhizome, where up to a 300% increase in flowering can be expected. A wide range of concentrations and application times have been recorded as preplant dips or rhizome sprays. A GA_3 quick dip of 25 ppm for 30 seconds, a GA_3 soak of 500 ppm for 10 minutes, or a Promalin™ (GA_{4+7} and benzyladenine) soak of 50–100 ppm (GA equivalents) for 30 minutes—all have been effective (Welsh and Baldwin 1989). Corr (1988) suggests that best results occur with GA dip after a 6-week storage at 50F (10C). A fungicide/bactericide (such as copper hydroxide or copper oxychloride) should be incorporated into the solution. Limited success with a rhizome spray has also been described (Funell 1993), and Promalin™ at 1.8% (1.3 tbsp/gallon, 5.5 ml/l) is recommended. In summary, many growers have selected 50–100 ppm GA or Promalin™ as a dip (5–15 minutes) or spray to run off over rhizomes as soon as they are received. Spraying rather than dipping minimizes spread of disease. For many growers, ordering pretreated tubers from a reputable distributor takes the guesswork out of timing and application methods.

Field Performance

Rhizome size: Rhizomes come in bizarre shapes, but commerce nevertheless demands they be classified in various sizes. Some classifications try to make standard grade: grade 1 (2–2.25″, 5–6 cm in diameter); grade 2 (1.5–1.8″, 4–4.5 cm); or grade 3 (0.88–1.4″, 2.5–3.5 cm) (Dole and Wilkins 1999). Others use different measurements and grade classifications; however, mostly they are simply sold as large, medium, and small. Rhizomes of white callas are often further divided into “horns” (elongated rhizomes with few side [daughter] rhizomes) or “clusters” (compressed rhizomes with attached daughter rhizomes). In general, horns are preferred for cuts, clusters for potted callas. (This is true—we could not make this up.)

For colored callas, nearly all rhizomes 1½–2″ (4–5 cm) wide will flower with a GA treatment, whereas smaller rhizomes may require an additional year to flowering. However, research showed that small rhizomes (1″, 2.5 cm wide) of *Zantedeschia elliottiana* and *Z. rehmannii* required the same time from planting to flower as rhizomes greater than 2½″ (6 cm) in diameter (Corr and Widmer 1991). Treatment with GA is recommended for all sizes of colored callas. Smaller rhizomes produce smaller flowers (Corr and Widmer 1991).

Planting: Plant rhizomes as soon as they arrive, but if you cannot, place tubers in dry storage of 46F (8C), 70–80% relative humidity for up to 6 weeks (De Hertogh 1996). Check for incidence of soft rot (*Erwinia*) and physiological problems such as chalking (see "Pests and Diseases").

Soil: Rhizomes are best forced in well-drained sandy or silty loam, particularly if rhizomes are lifted every year. Clay soils result in poor aeration, poor drainage, and a greater incidence of *Erwinia*. The importance of well-drained soils in reducing *Erwinia* cannot be overemphasized. Clay soils are also difficult to clean from the rhizomes after lifting. Adjust pH to 6.0–6.5.

Fertilization: Fertilize sparingly as excessive nitrogen fertilizer results in leafy growth at the expense of flower production. A moderate application of complete fertilizer (100–150 ppm N) from emergence to flower color is often used.

Spacing: Welsh and Baldwin (1989) provide 2 spacing systems, depending on whether rhizomes are lifted or not. The increase in flowering by lifting and retreating with GA every year may offset the savings in labor and storage of keeping the rhizomes in the ground.

System 1: standard for greenhouse forcing, rhizome multiplication
- Lift annually
- 4 rows per bed, rows and plants 8" (20 cm) apart
- 43,000 rhizomes/acre (106,000 rhizomes/hectare), 1½" (4 cm) rhizomes

System 2: standard for field production
- Lift after 2 years
- 2 rows per bed, 8" (20 cm) between plants. Beds 16" (40 cm) apart
- 27,000 rhizomes/acre (67,000 rhizomes/hectare), 1½" (4 cm) rhizomes

Shading: The use of shade cloth or natural shade (e.g., pine trees) results in significant stem elongation of calla lilies. Work at the University of Georgia, shown in the following table, demonstrates the effect of shade on stem (scape) length (Armitage 1991). Shade was artificially provided by commercial shade cloth. Results will differ under different climates and latitude.

The effect of shade on scape length of calla lilies.

Cultivar	Shade level (%)	Scape length (in)[z]
Black Magic	0	18.0
	55	22.8
Pacific Pink	0	14.4
	55	21.2
Pink Persuasion	0	15.2
	55	22.0
Majestic Red	0	14.0
	55	24.4

z = multiply (in) by 2.54 to obtain (cm)

Harvesting: Flowers can be pulled or cut at the base of the stem. Pulling flowers often results in extra stem length, but scapes must be turgid. Flowers of sparsely rooted plants or plants irrigated improperly should be cut, not pulled. Harvest flowers in the cool of the day (see "Postharvest").

Scheduling: Research in Georgia and Minnesota showed that 1½″ (4 cm) spring-planted rhizomes required approximately 11 weeks to produce the first flower in the field (Welsh and Baldwin 1989). If planted in the field after danger of frost, most callas will bloom in July and August; however, later plantings (late May, early June) will give good September production (first blooms 60–90 days post-planting).

Lifting and curing: After the foliage declines, the rhizomes should be lifted, cleaned, and cured. Rhizomes may be cured in the fall outdoors under shade or in a curing shed with good air circulation (see "Propagation," information on division). After curing is complete, roots should be removed and rhizomes inspected for *Erwinia* and stored at approximately 68F (20C). Provide 8–10 weeks of storage prior to replanting (although some growers store as little as 6 weeks), depending on how completely the foliage has died down at harvest.

Greenhouse Performance

Rhizomes should be planted in ground beds 6–8″ (15–20 cm) apart, or 3 in an 8½″ (22 cm) pot (De Hertogh 1996). Well-drained soils are an absolute must for reducing the incidence of *Erwinia*. Pots may remain pot to pot until the final 3–5 weeks. Rhizomes can remain in pots for harvesting and curing. After curing and when dormancy is broken, rhizomes may be reflowered.

Irrigation: White callas (*Zantedeschia aethiopica*) tolerate moist soils. Colored callas are less tolerant of wet soils than the white forms, but plants should not be allowed to wilt.

Temperature: Start plants at 60–65F (15–18C) until sprouting. After sprouts have appeared, reduce night temperature to 55F (13C) for white callas and 60F (15C) for colored forms (De Hertogh 1996). For colored callas, approximately

64/61F (18/16C) day/night is recommended; for white callas, 64/55F (18/13C) (De Hertogh 1996). Warm temperatures result in faster flowering but also increase the incidence of disease.

Spacing: Ostensen (2000) did work on spacing of white callas in raised beds.

The effect of spacing on *Zantedeschia aethiopica*. Spacing 36–42" beds, 2 rows per bed.

	Duration of stand		
	1 yr.	2 yr.	3 yr.
Rhizome size (in)[z]	Spacing (in)[z]		
1¼	6	8	10
1½	8	10	12
1¾	10	12	14
2	12	14	16
2¼	14	16	18

z = multiply (in) by 2.54 to obtain (cm)

Fertilization: A preplant incorporation of a 30-day slow-release fertilizer with N and K, but without P, into the media is recommended. Application of CLF at 100 ppm N and K should follow.

Scheduling: Callas normally flower 10–13 weeks from planting, but exact time depends on cultivar, planting date, duration of storage, and forcing temperature. Work by Corr (1988) with *Zantedeschia rehmannii* showed that the greater the time of rhizome storage time at 59F (15C), the less time was required in the greenhouse. Three weeks storage resulted in approximately 20 weeks in the greenhouse; 12 weeks storage only required 12 weeks in the greenhouse. Total time (storage plus greenhouse time) was essentially the same, regardless of storage duration.

Yield: The average yield per rhizome varies greatly between cultivars, but the average for rhizomes wider than 2″ (5 cm) bred for cut flower production is 5–12 stems. Yields from new cultivars are in general better than old, but not always.

Guideline for Foliar Analyses

At field trials in Watsonville, Calif., foliage was sampled from vigorously growing healthy plants of *Zantedeschia elliottiana* when flower buds were visible but prior to flower opening. These are guidelines only and should not be considered absolute standards. Based on dry weight analysis.

(%)				
N	P	K	Ca	Mg
3.9	0.34	3.9	0.96	0.23
(ppm)				
Fe	Mn	B	Al	Zn
300	193	13	90	94

Stage of Harvest

To ensure good color expression, flowers should be cut when the spathes unroll and are almost fully open.

Postharvest

Fresh: Cut stems should be placed in a conditioning solution for 8–12 hours (Tjia 1989). Flowers persist 7–20 days depending on cultivar and environment. Flowers of *Zantedeschia aethiopica* var. *childsiana* remain unblemished for 10 days (Plummer et al. 1990). Other flower problems include stem splitting and rolling. A 2–5% sugar pulse may be used. Do not allow the stems to remain in the sugar for more than 30 minutes, or various microorganisms will proliferate. Occasionally, flowers are sprayed with an antitranspirant if they are to be shipped a long distance, although no objective data have shown any benefit of this treatment.

Storage: Storage of cut stems is not recommended; however, if necessary, stems of *Zantedeschia aethiopica* may be stored wet at 38F (3C) for up to one week (Plummer et al. 1990). Colored callas should be stored at 33–35F (1–2C). Lower temperatures can result in chilling injury to the flowers. Ship stems dry and, if possible, cool.

Dried: Flowers may be microwaved, but otherwise do not dry well.

Cultivars

It is important to purchase cultivars bred for cut flower use; a good deal of breeding has been toward dwarf forms for pot plant use, and stem length of these may be disappointing. Pot forms often provide higher yield, however, and if stem length is of minor consideration, then the list of cultivars can be expanded. Breeding programs in the United States and New Zealand have resulted in numerous cultivars useful for cut flowers. Along with the evergreen white-flowered *Zantedeschia aethiopica* and its var. *childsiana*, deciduous hybrids of yellow, pink, green, red, and peach are available. Breeding continues for additional flower colors, and breeding for *Erwinia* resistance remains an important challenge to the calla breeder.

'Black Eye Beauty' has lemon-yellow flowers with a dark throat.

'Black Magic' bears flowers of clear yellow with a black throat. Yielded 10–15, 2–3′ (60–90 cm) stems/plant in University of Georgia trials; rhizomes persisted for 3 years without lifting.

'Cameo' produces peach-colored blooms with a dark pink throat on long stems.

'Chianti' was bred for cuts and pot plant use. The rich purple flowers are produced among speckled foliage.

'Crystal Glow' has medium-length stems with rose-pink flowers.

'Florex Gold', bred for the cut market, bears golden flowers.

'Golden State's Hybrid Yellow' is golden-yellow.

'Hazel Marie' bears apricot flowers with a blush of gold. Long stems.

'Hot Shot' has orange flowers with a red blush and long stems.

'Lilac Mist' is a handsome cut form with lilac-purple flowers.

'Majestic Red' produces deep red flowers.

'Mango' has mango-orange flowers.

'Neroli' has apricot-peach flowers on medium-length stems.

'Pastel Magic' bears lemon-yellow blossoms with a clear center.

'Pink Persuasion' produces rose-pink flowers with a dark throat.

'Pot of Gold' has golden flowers with medium-length stems.

'Sensation' bears salmon-apricot flowers on long stems.

'Sunrise' is a cut form whose flowers are yellow inside with a red rim around the edges.

'Superba', a selection of *Zantedeschia rehmannii*, has light pink blooms.

'Treasure' bears deep orange flowers with medium-length stems.

Pests and Diseases

All aspects of calla culture must be focused on providing environmental factors that favor the plant rather than the disease organisms that can limit production. Close attention must be paid to temperature and water management.

Bacterial soft rot (*Erwinia*) is the most common and insidious disease organism. There is always some level of erwinia in a calla crop, visible or not. Caused by injury during handling and digging of the rhizome, infection is characterized by milky-colored, foul-smelling areas on the rhizome. The rhizome becomes soft at the infected areas. Outbreaks are more common in heavy, poorly drained soils. "Gentle" handling and proper curing techniques reduce incidence of the disease. Keys to reducing infection are temperature management (soil temperature <73F, 23C), water management (moist but not saturated), and pathogen prevention (either by chemical fungicides or biologicals).

Some growers dip cut rhizomes in a dilute solution (2%) of hydrogen peroxide for quick curing. Kuehny et al. (1998) found that a 30-minute 200-ppm streptomycin dip provided the best control and a one-hour 10% formaldehyde dip provided the second best control. Blom and Brown (1999) tried various copper-based chemicals to reduce soft rot incidence with limited success. Once it is established, there is no known chemical cure for erwinia. Good drainage and aeration around the rhizome are vital for control of infection. Patrick Zweifel of Tillamook, Ore., makes a good point: "Research on biological control of diseases in Oregon is built around the theory of enhancing biological activity of beneficial organisms through the use of compost teas and commercial inoculants. Rather than using fungicides that wipe out good and bad organisms, biological treatments promote natural soil balances and minimize losses from organisms like *Erwinia*."

Black spot (*Alternaria*) occurs on the flower spathe when conditions are wet and humid. Iprodione is effective in suppressing the fungus (Tjia and Funnell 1986).

Chalking is a physiological disorder that is most prevalent in *Zantedeschia aethiopica* var. *childsiana*. During prolonged storage, the rhizomes develop a hard chalky exterior that results in poor sprouting and growth. If rhizomes are stored properly, chalking is much reduced.

Thrips and aphids can also be problems; besides being destructive, they are vectors for virus.

Grower Comments

"When spraying, use 100 ppm Promalin™ or 125 ppm ProGibb™. When dipping, reduce concentration to 75 ppm Promalin™ or 100 ppm ProGibb™. Gibberellic acid is much more effective if you have green shoots to absorb the hormone. In general, you can expect at least a 300% increase in flowering with GA_3 treatment." Patrick Zweifel, Oregon Coastal Flowers & Bulbs, Tillamook, Ore.

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Zinnia elegans Asteraceae

annual Mexico many colors 2–3′/2′ (60–90 cm/60 cm)

Linnaeus did not shy away from commemorating his fellow botanists. Johann Gottfried Zinn (1727–1759), a professor of botany at Gottingen, Germany, lived a short but productive life, and his legacy plant has been used as a cut flower for years. Although zinnias no longer have the appeal of lesser-known, more exotic species, they are useful as an inexpensive "cut and come again" filler crop. Their flowering season extends from April to October, and zinnias can even be produced in the greenhouse as a winter crop. It is worth noting that zinnias still have great appeal to those who don't see a lot of them in the landscape; off-season production makes sense in Florida, the Gulf Coast states, and other such locales.

Propagation

Always propagated from seed. Most cut flower types are open pollinated, but excellent F_1 cultivars have been developed. Approximately 1 oz (28 g) of seed yields 1000 plants (Nau 1999). Seed germinates in 3–5 days at 80–85F (27–29C), 5–7 days at 70–75F (21–24C). If seed is direct sown, 0.4 oz per 100′ (37 g per 100 m) may be used (Kieft 1996).

Growing-on

Grow at 60–65F (15–18C) nights and 70F (21C) days. Soil should have a pH of 6.3–6.8. Fertilize with 100 ppm N at each irrigation. Greater concentrations of nitrogen should be avoided. Plant out after 5–6 weeks in the final container.

Environmental Factors

Photoperiod: Zinnias are quantitative short day plants. That is, they flower more rapidly under short days but eventually flower regardless of photoperiod. Daylengths of 12 hours or less stimulate flowering (Armitage 1985). Continuous LD produces the longest stems but delays flowering by about 3 weeks (this is not a problem in the field but should be considered if forcing in the winter); a treatment of SD followed by LD produces flowers on the longest stem in the shortest time (Healy 1991). From the commercial point of view, however, control of photoperiod is seldom practiced.

Light intensity: Zinnias are high-light plants and flower poorly on stretched stems under low winter intensities.

Temperature: Temperatures below 60F (15C) result in chlorotic foliage and delayed flowering.

Field Performance

Plants produce higher-quality flowers if sequential plantings are used. Transplant or sow to the field every 2 weeks for 6 successive plantings. Transplants may be planted as soon as the last frost has occurred. Planting in raised beds is highly recommended if soils are heavy (e.g., clay). Some growers use transplants for a quicker crop time and the immediate benefit of shading out potential weeds.

Space as close as 6 × 6″ (15 × 15 cm) or on 9–12″ (23–30 cm) centers. The denser the spacing, the taller and less branched the plants will be. While this may be positive, the potential for disease is also greater at close spacings. No pinching or support is necessary.

Planting where zinnias are exposed to winds is a useful production technique to reduce the incidence of powdery mildew. Of course, high winds mean plants can be knocked over. If wind-aided control of disease makes sense, some support may be needed.

Greenhouse Performance

Zinnias are seldom grown as cut flowers in the greenhouse; however, if forced in the greenhouse, grow at 65/70F (18/21C) night/days. Fertilize at 150–200 ppm N using a balanced fertilizer source. Long days, from incandescent lamps, can be applied for 2–4 weeks, followed by short days (<12 hours) until plants are budded. They may then be placed under LD. Plant at least 3 successive crops, 2 weeks apart, for winter flowers of the best quality. Some growers pinch out all laterals to produce stems of the highest quality. Supplemental light during the day results in superior crops in more northern climes but may not be cost-effective.

Nutrient problems are not uncommon with zinnias, and although a well-balanced program of N, P, K, and minors is generally sufficient, disorders may occur. Calcium deficiency shows up as stunted plants with minimal root growth, magnesium deficiency as interveinal chlorosis, boron deficiency in thick leaves and bud abortion. Dharmalingam et al. (2000) did some nice work showing nutrient deficiencies in zinnia; it is worth the time to refer to the article.

Stage of Harvest

Plants may be harvested just before pollen is visible or as pollen begins to form, that is, when flowers are almost fully mature. Flowers are best for the local market.

Postharvest

Fresh: Flowers persist 7–10 days in preservative.

Storage: There is no scientific basis for the rumor that zinnias don't do well in coolers below 45F (7C). Healy (1991) showed that flowers may be stored wet for up to 5 days at 36–38F (2–3C); however, since we are talking about zinnias, the less time stored at any temperature, the better.

Cultivars

Dahlia- and cactus-flowered forms are often used for cut flowers. They are available as mixes only.

Benary's Giant series was the ASCFG'S 1999 Fresh Cut Flower of the Year. Plants grow 3–4′ (0.9–1.2 m) tall with flowers 4–5″ (10–13 cm) wide. Until January 1999, this series was known as Giant Dahlia Benary's Blue Point Strain. Color include bright pink, carmine-rose, coral, crimson, deep red, golden-yellow, lilac, orange, purple, salmon-rose, scarlet, and white. Excellent disease resistance guarantees their continued popularity.

Burpeeana Giant Mixed produces bushy, erect plants about 2′ (60 cm) tall. Also available in separate colors of red, white, pink, rose, and orange.

'California Giants' bears flat-petaled flowers on 34″ (85 cm) flower stems. Varieties include Giants of California Mix, Indian Summer Mix, 'Isabelina', 'Orange King', 'Pastel Giants', 'Purity', 'Salmon Queen', and 'Violet Queen'.

'Candy Cane' produces striped flowers on 28″ (70 cm) plants. People really notice them, although the streaking is somewhat unreliable.

'Cut and Come Again' is a mix with 24–28″ (60–70 cm) stems.

'Early Wonder' bears double flowers that bloom earlier than others.

'Envy' is a green-flowered zinnia that has received mixed responses from both growers and buyers. The unique chartreuse color of the 3″ (8 cm) wide flowers seems to be loved or hated in equal measure.

Florist Medium Strain Mixture grows to about 2′ (60 cm) with medium-sized flowers. The mix includes pink, orange, yellow, white, scarlet, rose, and salmon.

Giant Mammoth Flowered series carries large 4–5″ (10–13 cm) flowers on 30″ (75 cm) stems. 'Canary Bird' (golden-yellow), 'Dream' (orchid-lavender), 'Luminosa' (deep pink), and Gold Medal Mixture are part of this series.

Indian Summer Mix has yellow, orange, and red flowers on 3–4′ (0.9–1.2 m) stems.

Magnificent Mix contains semi-double 4–5″ (10–13 cm) dahlia-type flowers on 3½′ (1.1 m) stems.

Oklahoma series from Benary was so named because it performed so impressively at cut flower trials at Oklahoma State University in Stillwater. Mainly double flowers, 1½″ (4 cm) wide, are borne on 28–36″ (70–90 cm) stems. Colors include golden-yellow, pink, scarlet, salmon, white, and a formula mix.

Profusion series has been extraordinarily well received by the bedding plant trade. Plants are tolerant of inclement weather and are among the most disease resistant plants in the trade. For cut flowers, their only drawback is height: they are seldom more than 15″ (38 cm) tall. Colors include white, cherry, and orange.

'Ruffles' is a fine F_1 cultivar available in 4 single colors and mixed.

'Sombrero' is a mix of gold and red and single and double flowers on 2′ (60 cm) stems.

'State Fair', a popular, large-flowered, 2–3′ (60–90 cm) tall cultivar, is often asked for by name.

Sun series comes in gold, red, and a mix. Large double flowers are borne on 24–32″ (60–80 cm) stems.

Sunbow series grows to 24–30″ (60–75 cm) and comes in a veritable rainbow of colors—orange, purple, rose-pink, scarlet, golden-yellow, white, and a mix.

'Swirls' grows to 24″ (60 cm) with double, bicolor flowers of rose and white, or red and yellow.

Whirligig series has large semi-cactus flowers; petals end in contrasting colors.

Yoga is an early-flowering series with large double and semi-double blooms with overlapping petals. Grows 2–3′ (60–90 cm) tall.

National field trials

Zinnias have been evaluated since the inception of the ASCFG's national trials in 1994. The following table (Dole 1995–1998) is a summary of the average stem lengths and yields of zinnias submitted for trialing. These data are averages over a wide geographical range and must be viewed as guidelines only; individual experience may differ significantly.

Cultivar	Year of trial	Stem length (in)[z]	Stems/ plant
Benary's Giant Mix	1994	18	12
Giant Dahlia[y] Crimson Monarch	1995	17	29
Giant Dahlia Dream	1996	18	11
Giant Dahlia Eldorado	1995	15	21
Giant Dahlia Exquisite	1996	18	11
Giant Dahlia Golden State	1996	17	8
Giant Dahlia Hallo	1995	16	27
Giant Dahlia Polar Bear	1996	16	9
Giant Dahlia Rose	1995	18	33
Giant Dahlia Scarlet Flame	1995	17	29
Oklahoma Golden Yellow	1996	12	12
Oklahoma Mix	1997	9	17
Oklahoma Pink	1996	13	18
Oklahoma Salmon	1996	15	17
Oklahoma Scarlet	1996	14	14
Oklahoma White	1996	13	13

z = multiply (in) by 2.54 to obtain (cm)
y = in January 1999 the entire Giant Dahlia Benary's Blue Point Strain was renamed Benary's Giant series

Additional Species

Zinnia haageana 'Persian Carpet' produces double and semi-double flowers in orange, gold, maroon, and burgundy, some with creamy-tipped petals. Less prone to leaf diseases. Short but productive. 'Old Mexico' has overlapping pointed copper and gold petals on 18″ (45 cm) plants.

Zinnia peruviana (syn. *Z. pauciflora*) 'Bonita' produces smaller flowers than *Z. elegans*, in more muted earth tones. Plants are only 1½–2′ (45–60 cm) tall.

Pests and Diseases

Numerous leaf spot organisms occur, including *Alternaria*, *Cercospora*, and *Erysiphe*, the causal agent of powdery mildew. Alternaria can be a very serious problem under stressful environmental conditions, like drought or overwatering. Cull infected plants. Powdery mildew is a greater problem when warm days are interwoven with cool, damp nights. Application of general-purpose foliar fungicides at 10-day to 2-week intervals helps control the diseases.

Sclerotinia sclerotiorum, a soil fungus, is highly lethal to zinnias, particularly those under environmental stress. In the South, it is nearly always involved in root and foliar problems. This is reduced if more than one crop is planted. Crops planted late in the season are less susceptible.

"Zinnia meltdown" is a term coined by a number of growers to describe the rapid (within 24 hours) deterioration of perfectly good-looking flowers after being cut. Stems turn brown and mushy. The problem may be caused by a bacterial infection, although the application of a copper-based bactericide has had only limited success. A floral preservative to reduce pH also appears to help, but if the bacteria is present in sufficient numbers, problems may still occur. Some cultivars appear far more susceptible than others. Zinnias are sensitive to boron, and if high boron is present in the water, similar symptoms may appear.

Insects that feed on zinnias include grasshoppers, cucumber beetles, blister beetles, Japanese beetles, mites, and aphids. Every critter loves a zinnia. Nematodes cause angular spots on the foliage and can be quite destructive.

Grower Comments

"After trialing lots of big and small zinnias, I grow only 'Blue Point'." Bob Wollam, Wollam Gardens, Jeffersonton, Va.

"It is my experience that [zinnias] look better left out at 70F heat for 2 days than in the cooler at 40F." Ralph Thurston, Bindweed Farm, Blackfoot, Idaho.

"I think well-grown white flowers are always marketable. It seems we had problems with these holding up. . . . I really think people who live in drier climates have an easier time raising quality zinnias, than we in the rain-soaked Northwest. Especially white and light-colored zinnias seem prone to getting diseases that cause them to get mushy after cutting. The other thing about postharvest here is that sometimes they last and sometimes they don't, but I've never gotten them to last more than a week." Janet Foss, J. Foss Garden Flowers, Everett, Wash.

Reading

Armitage, A. M. 1985. *Zinnia elegans* and *Z. angustifolia*. In *The Handbook of Flowering*. Vol. 4. A. H. Halevy, ed. CRC Press, Boca Raton, Fla.
Dharmalingam, S., S. Pitchay, J. L. Gibson, P. V. Nelson, C. R. Campbell, and B. Whipker. 2000. Nutrient deficiencies of zinnia. *GMPRO* 20(7):64–66, 68–78.
Dole, J. 1995–1998. ASCFG National Cut Flower Trials. *The Cut Flower Quarterly*.
Healy, W. 1991. Cut flowers: cut zinnias. *Georgia Commercial Flower Growers Assoc. Newsletter* 1(5):8–9.
Kieft, C. 1996. *Kieft Grower's Manual*. 2nd ed. Kieft Bloemzaden, Venhuizen, The Netherlands.
Nau, J. 1999. *Ball Culture Guide*. 3rd ed. Ball Publishing, Batavia, Ill.

Many thanks to Vicki Stamback for reviewing this section.

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REFERENCES

References for specific crops are found in the appropriate crop entry; however, additional, more "global" references were used during the writing of both the first and the second editions of this book. Most are available in reference libraries, and some are still sold through various vendors. All are highly recommended.

Books

Armitage, Allan M. 1997. *Herbaceous Perennial Plants: A Treatise on Their Identification, Culture, and Garden Attributes*. 2nd ed. Stipes Publishing, Champaign, Ill.

A good, readable book on perennials. Morphological and taxonomic descriptions, uses, and propagation of the common and not-so-common species are covered here. References are occasionally made to cut flower uses, but it is mainly a book for general perennial plant reference.

Armitage, Allan M. 2000. *Armitage's Manual of Annuals, Biennials, and Half-Hardy Perennials*. Timber Press, Portland, Ore.

The best in-depth book on annuals and also covers biennials and some half-hardy perennials. The companion to *Herbaceous Perennial Plants* and formatted similarly. An excellent reference.

Bloom, Alan. 1956. *Hardy Perennials*. Faber and Faber, London.

The only reason for recommending this out-of-print book is the chapter on perennials for cutting (chapter 11). Bloom is best known for his nursery, Blooms of Bressingham, which specializes in garden perennials. He provides insightful comments on the use of perennials for cut flowers. His experiences in the early 1940s with selling market flowers provide much food for thought—we can see how far we have progressed, and yet how similar the problems that beset him are to those we still face. He speaks firsthand of "the hazards and disappointments of market growing" and has "every sympathy for growers and understands their problems—including the need for variety."

Bullivant, Elizabeth. 1989. *Dried Fresh Flowers from Your Garden*. Pelham Books/Stephen Greene Press, London.

A delightful book written by a grande dame of English gardening. She is certainly a fountain of knowledge about drying flowers. Nothing is safe from her zeal for drying, and she includes a wealth of information on annuals, perennials, berries, foliage, and even vegetables. Not written with the commercial, large-volume dryer in mind, this book nevertheless provides some excellent ideas and concepts. A great read.

Byczynski, Lynn. 1997. *The Flower Farmer: An Organic Grower's Guide to Growing and Selling Cut Flowers*. Chelsea Green Publishing Company, White River Junction, Vt.

Drawing on her own experience as a cut flower grower in northeast Kansas, Lynn offers valuable information on production and marketing for small-scale farmers. Also features profiles of successful growers across the country. Always excellent information within.

De Hertogh, A. A. 1996. *Holland Bulb Forcer's Guide*. 5th ed. International Flower Bulb Center, Hillegom, The Netherlands.

The bible of bulb manuals—each new edition is expanded to include relevant information on cut flower crops for greenhouse and field production. While greenhouse forcing of tulips, daffodils, and hyacinths still holds center stage, the sections on outdoor cut flowers, and diseases and pests of bulb species are updated and more useful than ever in this edition of the guide. A must for anyone even contemplating the growing of bulb crops.

Dirr, Michael A. 1998. *Manual of Woody Landscape Plants: Their Identification, Ornamental Characteristics, Culture, Propagation, and Uses*. 5th ed. Stipes Publishing, Champaign, Ill.

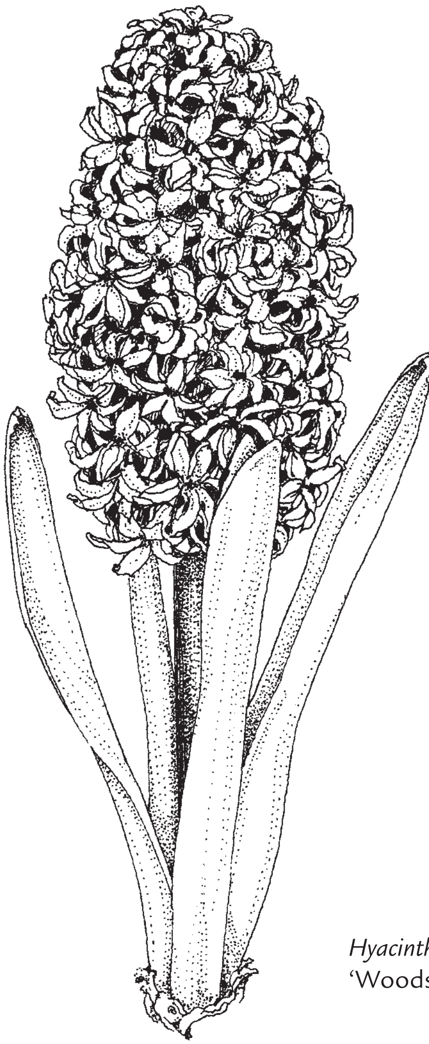
If Gus De Hertogh's manual is the bible for bulbs, this is the bible for woody plants. The manual's focus is the identification and use of woody species in the landscape; however, plant habit, propagation methods, and the most up-to-date descriptions of cultivars of any publication are contained within. A truly enlightening book and an enjoyable read as well.

Dole, John M., and Harold F. Wilkins. 1999. *Floriculture: Principles and Species*. Prentice Hall, Upper Saddle River, N.J.

A comprehensive text mainly designed for greenhouse production. Contains useful charts for the propagation of crops and pertinent information on many cut flower crops. Highly recommended as a text for references in floriculture.

Gill, Stanton, David L. Clement, and Ethel Dutky. 1999. *Pests and Diseases of Herbaceous Perennials: The Biological Approach*. Ball Publishing, Batavia, Ill.

A valuable reference for anyone producing perennial plants. The authors provide comprehensive coverage of common pest and diseases with emphasis on integrated pest management.



Hyacinthus orientalis
'Woodstock'

Kieft, Cornelius. 1996. *Kieft Grower's Manual*. 2nd ed. Kieft Bloemzaden, Venhuizen, The Netherlands.

Available through the Association of Specialty Cut Flower Growers (see "Newsletters and Periodicals"). Kieft was the first European representative of the ASCFG.

Nau, Jim. 1999. *Ball Culture Guide: The Encyclopedia of Seed Germination*. 3rd ed. Ball Publishing, Batavia, Ill.

An excellent guide to the seed germination of many annual and perennial species. Includes the number of seeds necessary to raise 1000 plants or the number of seeds needed for 1000 square feet of field production, along with other tidbits about many cut flower species. Handy and informative.

Nell, Terril A., and Michael S. Reid. 2000. *Flower and Plant Care: the 21st-Century Approach*. Society of American Florists, Alexandria, Va.

A must—the best manual for postharvest information on cut flowers. It covers dozens of crops and offers easy-to-read postharvest solutions. Highly recommended.

Nowak, Joanna, and Ryszard M. Rudnicki. 1990. *Postharvest Handling and Storage of Cut Flowers, Florist Greens, and Potted Plants*. Timber Press, Portland, Ore.

An in-depth reference on postharvest information on a wealth of cut flower crops, now unfortunately out of print. Written mainly for the scientist, the book brings together much of the literature on postharvest research from the early 1900s through the mid 1980s. A excellent resource for answering questions concerning stage of harvest, postharvest storage techniques, and floral preservatives.

Perry, Leonard. 1998. *Herbaceous Perennials Production: A Guide from Propagation to Marketing*. Northeast Regional Agricultural Engineering Service, Ithaca, N.Y.

Sections on starting a perennials business, building production facilities, and planning production systems and schedules are complemented by easy-to-use appendices on propagation, germination, pests and diseases, and conversions and calculations. Probably the best book on perennial production.

Pirone, P. P. 1989. *Diseases and Pests of Ornamental Plants*. 5th ed. Ronald Press, New York.

All the diseases and pests you ever wanted to know about. General sections on common diseases caused by bacteria, fungi, and viruses as well as common insect pests are covered. Genera are presented alphabetically, and information concerning problems and their control for each genus and species are provided. A reference book of the highest caliber.

Sacalis, J. N. 1989. *Fresh (Cut) Flowers for Designs: Postproduction Guide*. D. C. Kiplinger Chair, Ohio State Univ., Columbus.

Sacalis assembled much of the known literature in the postharvest and handling of cut flowers; he treats each species individually and completely. A useful guide for the major crops, it was republished in 1993 by Ball Publishing Co., Geneva, Ill., as *Cut Flowers: Prolonging Freshness*.

Stevens, Alan. 1997. *Field Grown Cut Flowers: A Practical Guide and Sourcebook*. Avatar's World, Edgerton, Wis.

New growers especially will welcome the information provided on the production of fresh and dried cut flowers. Details on production systems and labor management are particularly valuable.

Vaughan, Mary Jane. 1988. *The Complete Book of Cut Flower Care*. Timber Press, Portland, Ore.

A marvelous little book, specifically aimed at cut flower care for retailers and full of tips concerning vase life, storage when necessary, optimum stage of maturity, and when flowers are usually available to the florist. A good section on flowers useful for drying is also included. Growers and wholesalers would do well to track down a copy of this book, now unfortunately out of print.

Book Set

The Handbook of Flowering (CRC Press, Boca Raton, Fla.), edited by Abraham H. Halevy, was published from 1985 through 1989 in 6 volumes and 2 supplements. It is by far the most comprehensive series of book dealing with the environmental and physiological aspects of flowering. Halevy brought together dozens of scientists to provide scientific data dealing with all aspects of flowering. Heavy reading but excellent information for those who want to know more about the crops being produced. Available through university libraries.

Newsletters and Periodicals

The Cut Flower Quarterly, the newsletter of the Association of Specialty Cut Flower Growers, is an invaluable (and often the only) reference that provides a continuous flow of new information on the culture and marketing of specialty flowers. Published quarterly, it provides literature updates, regional synopses, and articles of national interest by leading growers and researchers. Available through membership to ASCFG, MPO Box 268, Oberlin, OH 44074-0268.

FloraCulture International is an international journal published for American growers by *GrowerTalks*. It concentrates on European floriculture; information on cut flowers is frequently provided.

Greenhouse Grower is a monthly publication for the greenhouse and allied trades. Coverage of cut flower features and articles is excellent and includes new cultivars as well as analysis of events occurring in the cut flower business. Part of the Meister Publication Company.

GMPRO (Greenhouse Management & Production) is part of the Branch-Smith Publishing group, which also includes NMPRO (Nursery Management & Production). GMPRO covers field production as well as greenhouse and is generous in its coverage of cut flower growers.

Miscellaneous

So much information can be found on the web, but it is almost impossible for us to list anything that won't change in the next few weeks. However, searching for specific crops can yield a great deal of information, some more valuable than others. Karen Gast of Kansas State University has placed some of her research work on cut flowers at www.oznet.ksu.edu/library, under "Report of Progress." We used this information and found it most useful.

Excellent catalogs are put out by many seed firms, among them Ball Seed Company/PanAmerican Seed, Ernst Benary of America, Germania Seed Company, Gloeckner Seed Co., Harris Seeds, Jelitto Perennial Seed, Johnny's Selected Seeds, and Modena Seed Company.

Many companies produce up-to-date CDs that have excellent photos and useful information about their products. These are inexpensive (often free) and highly recommended. Check with the appropriate representative in your area:

Armitage, Allan M. 2002. *Armitage's Photo-Library of Herbaceous Plants*. Horticopia, Chicago, Ill.

A large reference containing well over 7000 downloadable photos. The photos include cut flower species and cultivars, but it is not designed for cut flower growers only.

Dirr, Michael A. 1996. *Dirr's Photo-Library of Woody Plants*. PlantAmerica, New York.

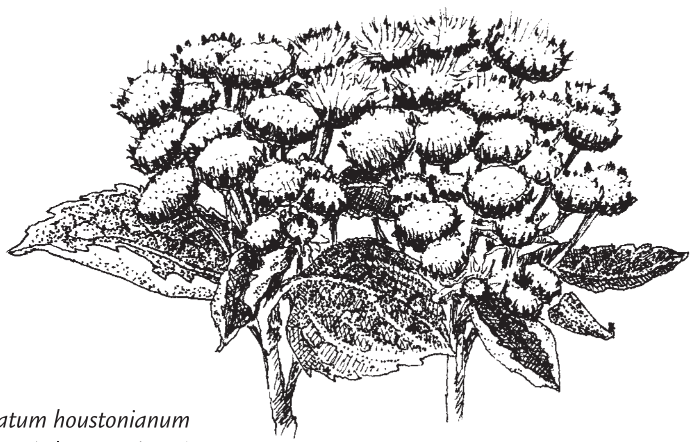
Another large photo reference—7600 images of approximately 3000 different woody plants.

APPENDIX I.

STAGE OF HARVEST

The following list is a summary of recommendations for the optimal stage of harvest for fresh flower use. In general, cut stems when flowers are as tight as possible and place in a hydrating solution immediately. Information is derived from references (see “Reading” at entries throughout the book) and from field observations.

Achillea	Flowers should not be harvested until pollen is visible on the inflorescence.
Aconitum	Inflorescences should be harvested when 1–3 basal flowers are open.
Agastache	Harvest when the inflorescence is about ⅔ open.
Ageratum	Harvest when flowers are just opening.
Agrostemma	Stems should be harvested when 1 or 2 flowers are open on the inflorescence.
Allium	Harvest most species when ½ the flowers are open. Flowers of *Allium sphaerocephalon* may be harvested as early as when ¼ of the flowers are open.
Alstroemeria	Pull stems when the first flowers are fully colored and the majority are showing color.
Amaranthus	Cut when at least ¾ of the flowers on the inflorescence are open. If producing dried flowers, allow the flowers of all species to grow until seed has begun to set and the flowers feel firm to the touch.
Ammi	Harvest when flower heads are approximately 80% open.
Anemone	Harvest when the sepals have started to separate from the center but are not fully open.
Antirrhinum	Cut when ⅓ to ½ of the flowers are open. For long-distance shipping, harvest when ⅓ of the flowers are open.
Artemisia	Stems are cut when they are fresh. Flowers are unimportant.
Asclepias	Harvest when ½ to ⅔ of the flowers are open, flowers do not open well once stems are cut.
Aster	Cut the stems when 2–4 flowers in the inflorescence have opened.

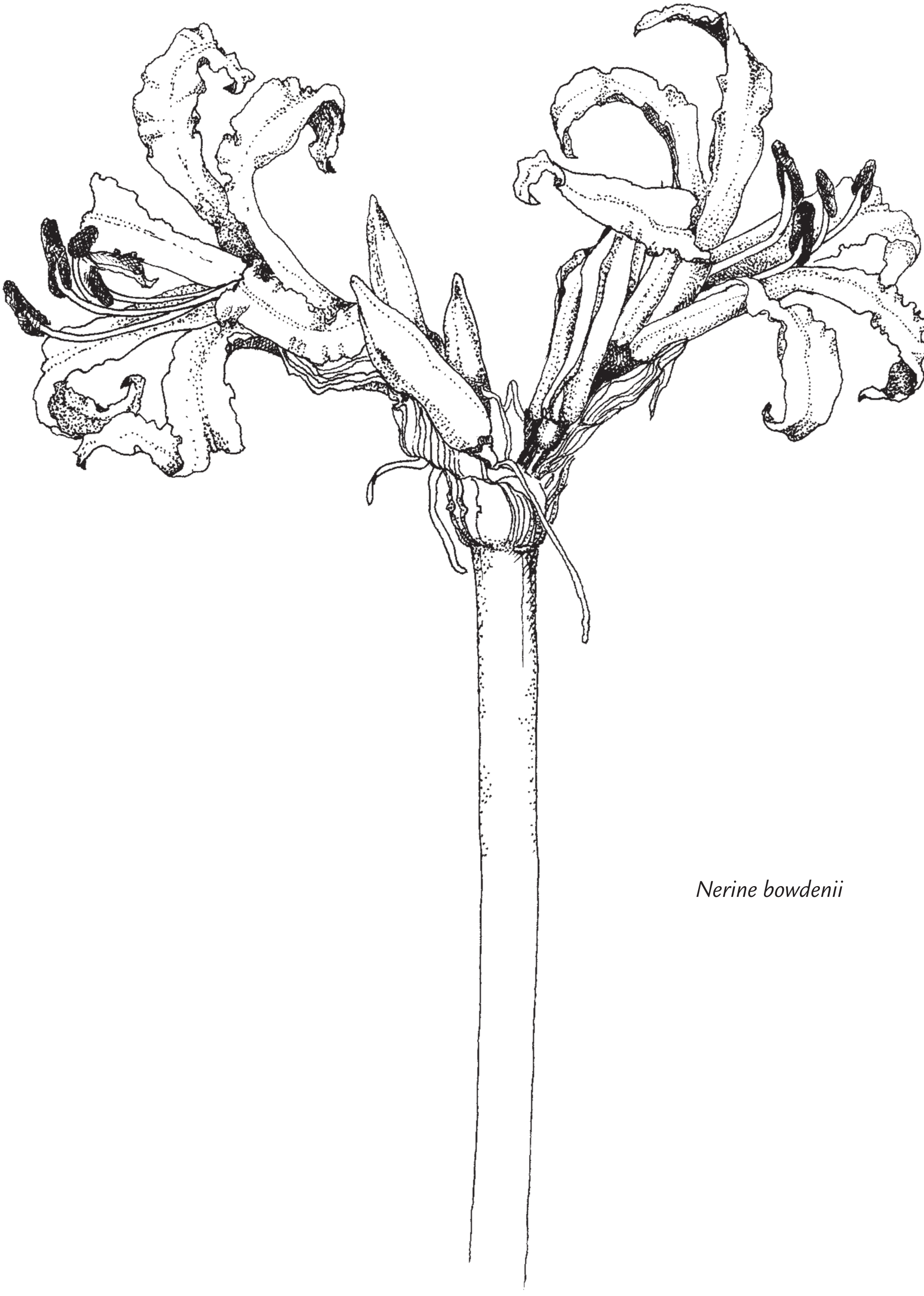


Ageratum houstonianum 'Blue Horizon'

Astilbe	Inflorescences should be harvested when ½ to ¾ of the flowers are open. The uppermost buds should be swollen and showing color.
Astrantia	Harvest when the uppermost flowers are open.
Baptisia	Flowers are harvested when approximately ⅓ of the flowers on the inflorescence are open.
Belamcanda	Harvest fruit when the covering of the fruit begins to shed. Fruit should be black before harvesting.
Buddleia	Harvest when ½ the flowers on the inflorescence are open but before the open flowers have started to fade.
Bupleurum	Cut when flowers are almost all open.
Callicarpa	Cut stems when the basal fruit clusters are fully colored and the terminal fruits are still green.
Callistephus	Harvest when outside ray florets begin to open.
Campanula	Harvest when 1 or 2 flowers of the inflorescence are open.
Carthamus	Cut stems when the majority of buds have begun to open and petals are clearly visible.
Caryopteris	Stems should be harvested when buds show color or when the first whorl of flowers is open.
Celosia	Flowers should be fully developed on crested forms and 90–100% developed in the plumose form.
Centaurea	For annuals, harvest when flowers are ¼ to ½ open. In the case of multiple flowered stems (i.e., sprays), the uppermost flower may be ¾ open. For *Centaurea macrocephala*, harvest when flowers are ½ to ¾ open.
Centranthus	Harvest when the first flowers in the inflorescence are fully open.
Cirsium	Harvest when the flowers are open.

Clarkia	Harvest when the first flowers on the stem are open.
Consolida	Allow 2–5 basal flowers to open or up to ⅓ of the flowers on the stem.
Coreopsis	Harvest when the flowers are fully open.
Cornus	To harvest stems, cut after leaves have dropped and before new foliage appears. Harvest flowers when the bracts are beginning to open but prior to pollen formation in the flower.
Cosmos	Harvest when petals on first flower are just opening, but have not yet flattened out.
Crocosmia	The first few flower buds should be showing color but need not be open.
Dahlia	Harvest when the flowers are ¾ to fully open but before the outer petals begin to decline.
Delphinium	Harvest when ⅓ to ¼ of the flowers on the stem are open.
Dianthus	Harvest when 10–20% of the flowers in the inflorescence are open.
Digitalis	Harvest when 2 or 3 lower flowers are beginning to open or as late as when ½ the flowers are open.
Echinacea	Harvest when petals are expanding. If used as a disk flower only, allow additional time on the plant to color disk, then remove petals.
Echinops	Harvest flowers when ½ to ¾ of the globe has turned blue.
Emilia	Harvest stems when the first flower is fully open.
Eremurus	Stems are harvested when about half the flowers are open.
Eryngium	Flowers should be harvested when the entire flower head, including bracts, turns blue.
Eupatorium	Cut when the flowers are almost fully open.
Euphorbia	Cut stems when bracts are fully colored but before the flowers are open.
Eustoma	Harvest when one flower in the inflorescence is fully colored.
Forsythia	For forcing, harvest when buds are tight.
Freesia	Harvest when the first flower is beginning to open and at least 2 additional flowers are showing color.
Gentiana	Harvest when flowers are in colored bud stage or when 1 or 2 are open.
Gladiolus	Cut when 1–5 flowers on the spike are showing color.
Gomphrena	Harvest when flowers are in color but before fully open.
Gypsophila	For the fresh flower market, stems should be cut with 60–70% of the flowers open. For drying, 80–90% of the flowers should be open.
Helianthus	Cut stems when the flowers are almost completely open.
Helichrysum	Cut flowers when bracts are unfolding and centers are visible. Always harvest before flowers are fully open.
Helleborus	For fresh flowers, cut when stamens become visible. For drying, flowers can be cut any time but are also useful later

	when the follicles (seed capsules) become visible in the inside of the flower.
Hydrangea	Stems should be harvested when ½ the flowers on the panicle are open.
Hypericum	Harvest stems when fruit is fully colored.
Ilex	Branches should be harvested before the fruit reaches maturity.
Iris	Cut all Dutch iris except 'Blue Ribbon' ('Prof Blaauw') when the flower has fully emerged from the sheath ("pencil" stage). 'Blue Ribbon' should be cut when the falls begin to open. All other iris species are cut in tight bud stage.
Lathyrus	Harvest sweet peas when 2 or 3 flowers start to show color and stems are about 12″ (30 cm) long. Cut the stems or snap the stem with the fingers near the base.
Lavatera	Cut when the flowers are uncurling or when they have just begun to open.
Liatris	Harvest when 3 or 4 flowers have opened.
Lilium	Cut when the first flower is fully colored, but not yet open.
Limonium	Harvest when 80% of the flower head has opened.
Lobelia	Cut the stems when the bottom ⅓ of the flower is open.
Lunaria	Harvest when the pods are fully developed.
Lysimachia	Cut when flowers in the inflorescence are ⅓ to ½ open.
Matthiola	Stems should be harvested when ½ the flowers in the inflorescences are open.
Moluccella	Cut when flowers are ½ open and green.
Monarda	Harvest when the flowers are almost entirely open.
Narcissus	Single, large flowers should be harvested when closed but with color showing (goose-neck stage) and at a 90–120° angle from the stem. Harvest double-flowered cultivars when the flowers are just beginning to open.
Nerine	Harvest when the first flower is just about to open.
Nigella	Harvest when the pods are turning purple-bronze.
Oreganum	Harvest when flowers are purple and ⅓ are open.
Ornithogalum	Harvest when the first flower is open if flowers are to be shipped long distances; approximately ¼ of the flowers may be open for local sales.
Oxypetalum	Harvest when approximately 6 cymes are present. The first 1 or 2 should be open, the last showing color.
Paeonia	As a general rule, flowers should be harvested when the first true color appears on top of the tight bud. Double-flowered types should be further developed than single forms and red cultivars should be more developed than whites.
Papaver	Harvest flowers at colored bud stage (fuzzy sheaths are splitting open and color is showing). Some flowers fail to open if cut too early.
Phlox	Harvest when ½ the flowers are open on the inflorescence.



Nerine bowdenii

Physalis	Harvest when the fruit is fully colored.
Physostegia	Flowers may be cut when the spikes are fully elongated but before individual flowers are open.
Platycodon	Harvest when 2 or 3 flowers are open on the flower stem.
Polianthes	Harvest when 2–4 flowers are open and others are showing color.
Ranunculus	Cut flowers when buds show color and are about to open.
Rudbeckia	Harvest when the flowers are fully open.
Salix	Harvest leafless stems at peak of color.
Salvia	Harvest when 3 or 4 basal flowers are open. For *Salvia leucantha*, the white petals (corolla) should have emerged from the blue sepals (calyx) on 3 or 4 basal flowers.
Scabiosa	For the perennial *Scabiosa caucasica*, flowers may be harvested as soon as flower color is visible. The annual *S. atropurpurea* may be harvested when the flower is almost fully open.
Solidago	Harvest inflorescence when approximately ½ the flowers are open.
×*Solidaster*	Harvest when ⅓ of the flowers are open.
Stachys	For flowers, cut when the inflorescence is ½ open.
Tagetes	Harvest when flowers are fully open.
Thalictrum	Flowers should be harvested when most of the flowers are open.
Trachelium	Harvest the stem when ¼ to ⅓ of the flowers are open.
Triteleia	Harvest when 4–6 flowers are open.
Tulipa	Harvest flowers when ½ to ¾ of the flower is colored.
Verbena	Harvest when most of the flowers are open.
Veronica	Cut when approximately ½ the flowers on the inflorescence are open.
Veronicastrum	Remove terminal flower and cut when the lateral flowers are approximately ⅓ open.
Zantedeschia	Flowers should be cut when the spathes unroll and are almost fully open.
Zinnia	Harvest when flowers are fully mature.

APPENDIX II.

ADDITIONAL PLANTS SUITABLE FOR CUT FLOWER PRODUCTION

Over the years working with cut flowers and the people who grow them, it has become increasingly obvious that almost any plant can and will be grown for cut flower use. Forget the old notion that flower stems must be a certain length or that flowers must have a certain shape, color, or fragrance. Also, we have seen growers growing "niche" assortments; for example, local native plant material (*Penstemon*, *Solidago*, *Liatris*) are planted and promoted. Anything goes, as long as there is demand.

In addition to the plants discussed in detail in the book, many other species and cultivars are used as cut flowers, either fresh or dried. From the commercial viewpoint, sufficient production must be possible under local conditions, and vase life of fresh flowers should be at least 7 days if shipped any distance. However, sometimes only a day or two of beauty is needed if flowers are being used for special events.

We have seen all these plants either in the field, in the greenhouse, in the market, or in an arrangement. Key to the list that follows: Su = full sun, Ps = partial shade, F = fresh flowers, D = dried flowers, Fo = foliage, Fr = fruit, St = stem. Exposure refers to plants grown in the field.

Annuals

Species	Common name	Exposure	Use
Alcea spp.	hollyhock	Su	F
Ammobium alatum	winged everlasting	Su,Ps	D
Anethum graveolens	flowering dill	Su	F
Arctotis spp.	Cape daisy	Su	F
Argyranthemum frutescens	marguerite daisy	Su	F
Atriplex hortensis	orache	Su	F
Brassica oleracea	ornamental kale	Su	F
Bupleurum griffithii	bupleurum	Su,Ps	F,D
Calendula officinalis	calendula	Su,Ps	F
Capsicum annuum	ornamental pepper	Su	D,Fr

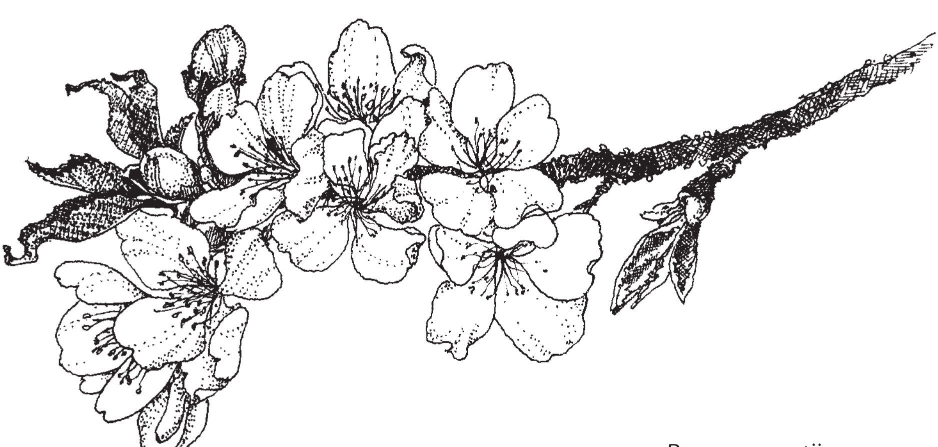
Species	Common name	Exposure	Use
[Annuals]			
Chenopodium quinoa	goosefoot	Su	D
Chrysanthemum segetum	corn marigold	Su	F
Craspedia globosa	golden drumstick	Su	F,D
Cynara cardunculus	cardoon	Su,Ps	F,D
Dianthus chinensis	China pink	Su	F
Fibigia clypeata	paper pumpkin seed	Su	D,Fr
fruit (ornamental)	cotton, okra, pepper, tomato, etc.	Su	F,D
Gerbera jamesonii	gerbera daisy	Su	F
Helipterum manglesii	Swan River everlasting	Su	D
Helipterum roseum	sunray everlasting	Su	D
herbs	sage, rosemary, thyme, etc.	Su	F,D
Iberis amara	rocket candytuft	Su,Ps	F,D
Jasione perennis	shepherd's scabious	Su,Ps	F,Fo
Mentha spp.	mint	Su	F,D
Moluccella laevis	bells-of-Ireland	Su,Ps	F,D
Nicandra physaloides	shoo-fly	Su	D
Reseda odorata	mignonette	Su,Ps	F
Rhodanthe manglesii	rhodanthe	Su	D
Tagetes erecta	marigold	Su	F
Tithonia rotundifolia	Mexican sunflower	Su	F
Trachymene (*Didiscus*)	blue lace flower	Su,Ps	F
Vaccaria pyramidata	rose cockle	Su,Ps	F
Xeranthemum annuum	immortelle	Su	D
Zea mays	ornamental corn	Su	D
Perennials			
Agapanthus spp.	blue African lily	Su	F
Anaphalis margaritacea	pearly everlasting	Su,Ps	F,D
Anigozanthos spp.	kangaroo paw	Su	F
Aquilegia ×hybrida	columbine	Ps	F
Armeria pseudoarmeria	giant sea pink	Su	F,D
Belamcanda spp.	blackberry lily	Su	F,Fr
Carlina acaulis	silver thistle	Su	F,D
Catananche caerulea	cupid's dart	Su,Ps	F,D
Cephalaria gigantea	giant scabious	Su	F
Chasmanthium latifolium	sea oats	Su	F,D
Chelone obliqua	turtlehead	Su	F
Chrysanthemum parthenium	feverfew	Su,Ps	F,D
Chrysanthemum ×superbum	shasta daisy	Su	F

Species	Common name	Exposure	Use
Dicentra spectabilis	bleeding heart	Ps	F
Dodecatheon meadia	shooting star	Ps	F
Doronicum plantagineum	leopard's bane	Su	F
Eupatorium purpureum	joe-pye weed	Su	F
Filipendula rubra	queen of the prairie	Su	F
Gaillardia ×grandiflora	blanket flower	Su	F
Gaura lindheimeri	gaura	Su	F
Gentiana asclepiadea	gentian	Su,Ps	F
Helenium autumnale	autumn sunspray	Su	F,D
Helianthus angustifolius	swamp sunflower	Su	F,D
Heliopsis helianthoides	heliopsis	Su	F,D
Heuchera sanguinea	coral bells	Ps	F
Kniphofia spp.	red hot poker	Su	F
Lavandula spp.	lavender	Su	F,D
Lupinus spp.	lupine	Ps,Su	F
Monarda didyma	bee balm	Su,Ps	F
Penstemon spp.	beardtongue	Su	F
Perovskia atriplicifolia	Russian sage	Su	F,D
Polygonatum odoratum 'Variegatum'	solomon's seal	Ps	F
Pontederia cordata	pickerel weed	Su	F
Primula vialii	cone primrose	Ps	F
Rubus spp.	blackberry	Su	F,D
Salvia patens	gentian sage	Su	F
Sedum 'Autumn Joy'	stonecrop	Su	F
Sidalcea malviflora	checkerbloom	Su,Ps	F
Stachys spp.	stachys	Ps	Fo,F,D
Typha spp.	cattail	Su	F
Verbascum chaixii	mullein	Su,Ps	F
Viola odorata	sweet violet	Ps	F

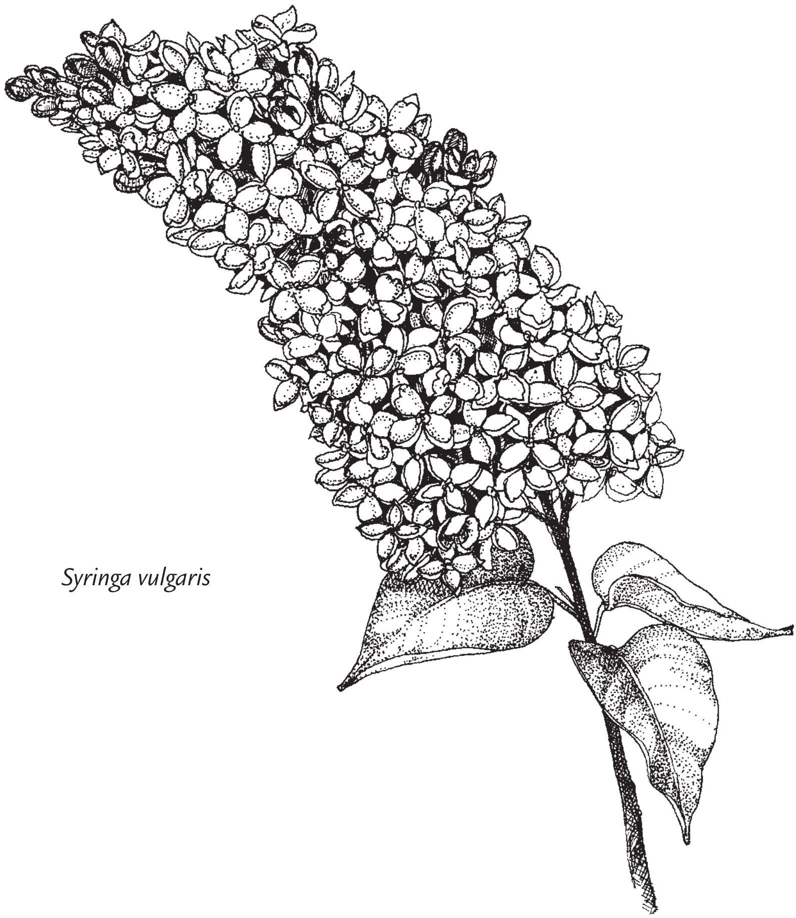
Bulbs

Arum italicum 'Pictum'	arum lily	Ps	F,Fo,Fr
Caladium bicolor	caladium	Ps	F,Fo
Convallaria spp.	lily-of-the-valley	Ps	F,D
Curcuma spp.	hidden lily	Su	F
Hippeastrum spp.	amaryllis	Su	F
Ixia spp.	ixia	Su	F
Lycoris spp.	resurrection lily	Su	F
Muscari armeniacum	grape hyacinth	Su	F
Oxalis spp.	oxalis	Su,Ps	F
Vallota spp.	Scarborough lily	Su	F

Species	Common name	Exposure	Use
Woodies			
Amorpha canescens	amorpha	Su	F
Aronia arbutifolia	red chokeberry	Su	Fr
Aucuba japonica	aucuba	S,Ps	Fo
Buxus spp.	boxwood	Su	Fo
Calluna vulgaris	heather	Su	F,D
Calycanthus floridus	sweetshrub	Su	F
Camellia sasanqua	camellia	S	F,Fo
Celastrus spp.	bittersweet	Su	Fr
Chamelaucium uncinatum	Geraldton waxflower	Su	F
Chimonanthus praecox	fragrant wintersweet	Su	F,D
Chionanthus retusus	grancy gray-beard	Su	Fo,F
Clethra alnifolia	summersweet	Ps	F
Corylopsis spp.	winterhazel	Su,Ps	F
Corylus avellana 'Contorta'	Harry Lauder's walking stick	Su	St
Cotinus coggygria	smokebush	Su	F,Fo
Cytisus spp.	broom	Su	F
Danae racemosa	Alexandrian-laurel	Ps	Fo
Daphne spp.	daphne	Ps,Su	F,Fo
Deutzia spp.	deutzia	Ps,Su	F
Erica spp.	heath	Su	F,D
Eucalyptus spp.	silver dollar tree	Su	F,D
Euonymus alatus	winged euonymus	Su	St,Fo
×*Fatshedera lizei*	fatshedera	Ps	Fo



Prunus sargentii



Syringa vulgaris

Species	Common name	Exposure	Use
Forsythia spp.	forsythia	Su	F
Gaultheria shallon	lemonleaf, salal	Ps	F
Hamamelis ×intermedia	witch hazel	Su	F
Itea virginica	Virginia sweetspire	Ps,Su	F,Fo
Jasminum mesnyi	primrose jasmine	Su	F
Kalmia latifolia	mountain laurel	Ps	F
Kerria japonica	kerria	Su	F
Koelreuteria bipinnata	goldenraintree	Su	Fr
Lonicera fragrantissima	winter honeysuckle	Su	F
Magnolia grandiflora	southern magnolia	Su	F,Fo
Malus spp.	crabapple	Su	F,Fr
Michelia figo	banana shrub	Su	F

Species	Common name	Exposure	Use
[Woodies]			
Morus australis 'Unryu'	contorted mulberry	Su	St
Myrica spp.	bayberry, myrtle	Su,Ps	Fo,Fr
Nandina domestica	heavenly bamboo	Su	F,Fo
Pieris japonica	pieris	Ps	F
Poncirus trifoliata	hardy-orange	Su	St
Prunus spp.	apricot, cherry, peach, plum	Su	F
Rosa spp.	rose	Su	F,Fr
Ruscus spp.	butcher's broom	Su,Ps	F
Sarcococca hookeriana	sweetbox	Su	F,Fo
Skimmia spp.	skimmia	Su	F,Fr
Spiraea spp.	spirea	Su	F
Symphoricarpos albus	snowberry	Su	F,Fr
Syringa spp.	lilac	Su	F,D
Ulmus alata	winged elm	Su	St
Viburnum spp.	viburnum	Su,Ps	F,D
Vitex agnus-castus	chaste tree	Su	F

Viburnum carlesii

APPENDIX III.

USEFUL CONVERSIONS

To convert inches to cm: multiply inches by 2.54.
Example: stems that are 40″ long are roughly 100 cm, or 40×2.54.

To convert ft² to m²: multiply ft^2 by 0.09.
Example: an area of 500 ft^2 is equivalent to 45 m^2.

To convert spacing in inches to spacing in plants/ft²: multiply spacing in inches, then divide product into 144.
Example (spacing of $9 \times 9''$): $144/9 \times 9 = 1.77$ plants/ft^2, or 177 plants/100 ft^2.
Example (spacing of $1 \times 2'$): $144/12 \times 24 = 0.5$ plants ft^2, or 50 plants/100 ft^2

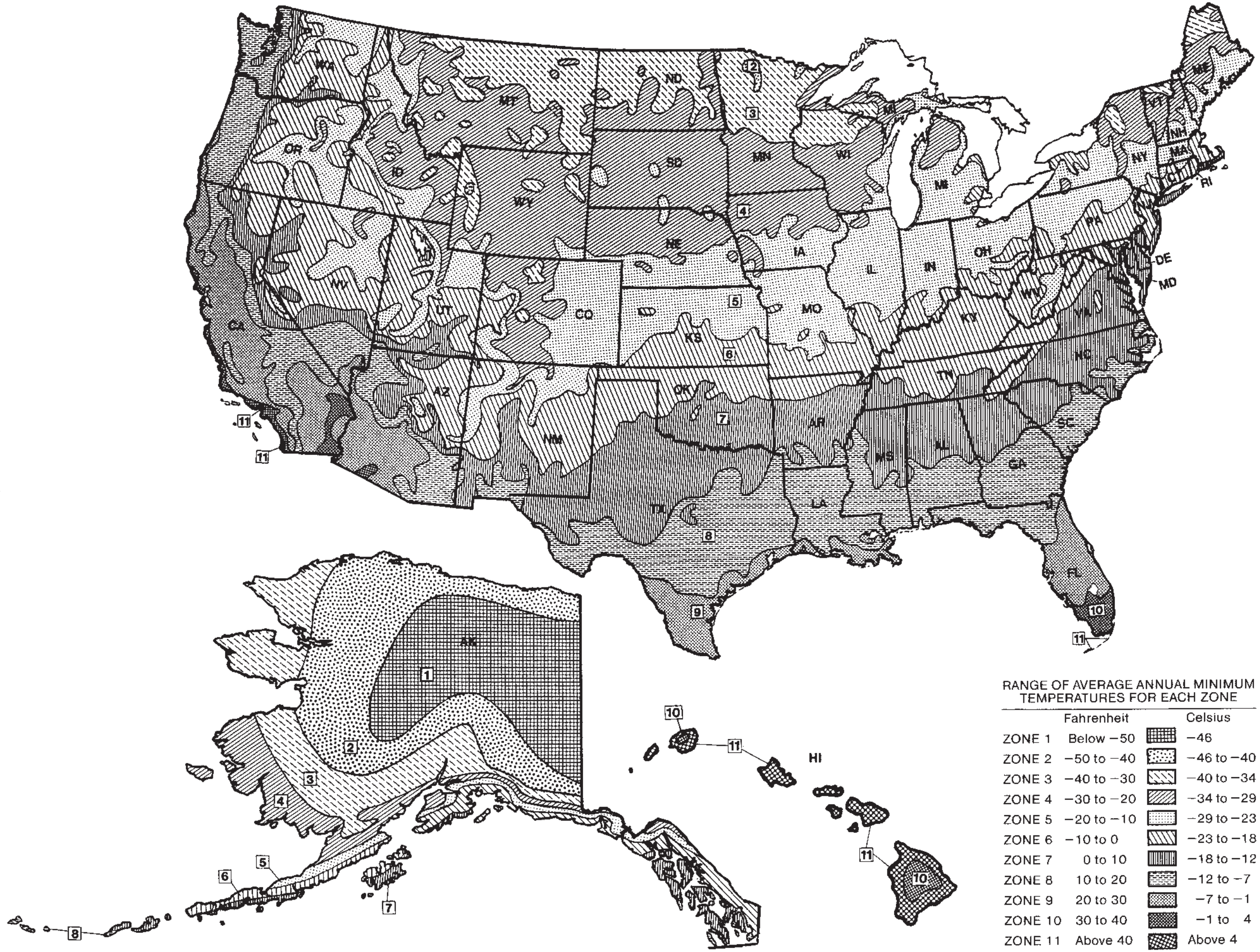
To convert plants/ft² to plants/m²: multiply plants/ft^2 by 10.76.
Example (spacing of 1.77 plants/ft^2): $1.77 \times 10.76 = 19.04$ plants/m^2, or 1904 plants/100 m^2.
Example (spacing of 0.5 plants/ft^2): $0.5 \times 10.76 = 5.38$ plants/m^2, or 538 plants/100 m^2.

To convert acres to hectares: divide acres by 2.47.
Example: 10 acres = 4.08 hectares.

To convert plants/acre to plants/hectare: multiply plants by 2.47.
Example: 30,000 plants/acre = 74,100 plants/hectare.

To convert ounces of seed/100 ft² to grams of seed/100 m: multiply ounces of seed by 93.5.
Example: 0.6 oz/100 ft^2 = 56 g/100m^2.

U.S.D.A. HARDINESS MAP



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