RURAL INDUSTRIES RESEARCH
& DEVELOPMENT CORPORATION

Commercial Production of

Medicinal Herbs in Tasmania

A report for the Rural Industries Research and Development Corporation

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Foreword

The growing interest in alternative medicine has seen a surge in the medicinal herb farming industry in Australia, particularly in Tasmania.

Given the Tasmania's climatic and environmental conditions, it has long been seen to have substantial potential to support a healthy, growing industry.

While there has been considerable development, the medicinal herb industry in Tasmania has been limited by its fractured nature. The formation of the Tasmanian Herb Growers Association and its subsequent commercial off-shoot Tasmanian Fine Herbs, has been a tremendous marketing and networking boost to the industry.

This report addresses the other main limitations to the industry :

- a lack of plant material of known quality; and
- limited knowledge of production techniques and market quality requirements.

While the project concentrated on only a small number of species of medicinal herbs, it concludes that there is good potential for a wide range of herbs and essential oils to be grown in Tasmania. This was emphasised by a study tour of New Zealand with its similar climatic and environmental conditions.

Literature reviews and trials were conducted for echinacea, valerian and scullcap. The report provides a comprehensive discussion of their agromony, medicinal properties, production methods, plant establishment, cultivation, pests and diseases and harvesting.

The report also outlines fundamental aspects of the herbs' commercial development such as economic analysis, input variables, returns, cost factors and gross margins.

This report, a new addition to RIRDC's diverse range of over 400 research publications, forms part of our New Plant Products R&D Program, which aims to foster the development of new industries based on plants or plant products that have commercial potential for Australia.

Most of our publications are available for viewing, downloading or purchasing online through our website:

- downloads at www.rirdc.gov.au/reports/Index.htm
- purchases at www.rirdc.gov.au/pub/cat/contents.html

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Executive Summary

When this project was initially embarked upon the medicinal herb industry throughout Australia was growing rapidly and pharmaceutical companies were interested in sourcing high quality Australian grown herbs. At that time Tasmania had only a small number of herb growers and production levels were very low. However with the rise of interest in alternative medicine there was a growing awareness of the potential for this industry.

Tasmania was identified as a potential region for establishing a long-term sustainable medicinal herb industry, mainly because of its climatic and environmental conditions. In the beginning expansion of the industry was limited by: a scarcity of plant material of known quality; limited knowledge of production techniques and market quality requirements; and an uncoordinated approach to production and marketing.

It was anticipated that a project aimed at addressing these issues would be of significant benefit to growers and enable a co-ordinated approach to the development of a medicinal herb industry in Tasmania. One of the main problems was the fractured nature of the industry and a lack of a co-ordinated approach to the production of medicinal herbs on a commercial basis. The formation of the Tasmanian Herb Growers Association and its subsequent commercial off-shoot Tasmanian Fine Herbs, went a long way to alleviating this problem and the two groups continue to complement one another through their market and networking approaches.

The trial work provided successful demonstrations of field establishment and crop management techniques as well as providing benchmarks for harvesting and processing the crops and extracting the critical medicinal constituents. Although this study concentrated on only four species of medicinal herbs, there is good potential for a wide range of herbs and essential oils to be grown in this State. This was substantiated by a study tour to New Zealand where numerous government and grower trials have proved successful in progressing industry goals. With New Zealand's climatic and environmental similarities to Tasmania there is strong evidence for production potential which should encourage prospective herb growers in this State.

The major agronomic factors of note from this investigation included priming of Echinacea seed to encourage germination, direct seeding as a method of establishment, defining both the sowing rate required to achieve optimum density and harvest date to optimise yield. It was also found that pre-establishment site management

was as important as actual crop management. Echinacea and Scullcap are particularly susceptible to weed invasion in the early establishment phase, whereas the more vigorous Valerian quickly establishes good ground cover and is able to smother weed competition. Weeds present the biggest challenge to growers both in time and money, especially for those seeking to produce organically grown herbs where the use of chemical pesticides is generally prohibited.

The medicinal herb industry in Tasmania continues to grow with an increasing number of dedicated growers expanding their enterprises as well as investigating niche and value added markets. The industry has now moved beyond the need for pilot studies as grower expertise and knowledge has been gained.

The future of the industry now lies in the hands of the growers and their associations and the ongoing challenge will be to provide sufficient quantities of herb products for the local and mainland markets. A longer term objective should be for a guaranteed quality and quantity of production to meet export opportunities. With the knowledge gained from this study and the positive approach of growers this objective should be achievable in the foreseeable future.

Recommendations and Outcomes

The results obtained from the trial work is very preliminary and as yet does not give a clear indication of how the selected herbs will perform in a commercial environment. Of the four herbs, Valerian and *E. purpurea* proved to be the most resilient and therefore the most successful and would be recommended as excellent herbs for a grower first embarking on medicinal herb production. The quality of these herbs was acceptable to current market specifications and yields compared favourably with regions where commercial production occurs. However, it appears that more practical experience and agronomic information is required to achieve reliable production of both Scullcap and *E. angustifolia*.

Networking and Marketing

This area is considered to be the key component to the success or failure of the medicinal herb industry. Growers, whether they be in Tasmania or other areas throughout Australia, need to develop co-operative relationships, whether they be commercial companies such as Fine Herbs of Tasmania or less formal grower groups, in order to successfully access markets with a uniform product of known quality. Generally, organic herb production comprises a large number of small producers with similar goals and it is therefore important that resources be shared through a grower network.

Herb Production

Valerian and *Echinacea purpurea* would be recommended as suitable herbs for the grower first embarking on medicinal herb production. Scullcap also would be recommended as a medicinal herb of commercial value but limited agronomic information on this herb entails increased risk.

Plant Establishment

Direct seeding in spring (October) is a suitable method for the establishment of *E. purpurea* and Valerian. A sowing rate of 6 kg/ha for *E. purpurea* and 1.5 kg/ha for Valerian is recommended. No pre-treatment of *E. purpurea* seed would be advised as good plant density was achieved without this. A row spacing of 40 cm was successful for both herbs. Further work is required to confirm that Scullcap can be established in the field by direct seeding.

Site Selection and Preparation

For Valerian and Echinacea a soil type that is easily washed from the roots, one with a low clay content, is essential. The soil type for Scullcap is not as critical as only the tops are harvested. Good soil drainage is essential for Echinacea survival over winter and productivity. Irrigation was required for all herbs. Scullcap had a higher water requirement than either Valerian or Echinacea and it is recommended that it be grown at sites where water is not a limiting factor.

Weed Management

The greatest expense in time and therefore cost is weed management. Pre-plant practices should be aimed at reducing the weed population. Valerian would be the preferred herb if time available for weed management was limited. The row spacing for Echinacea could be set to allow mechanical weed control.

Harvest

In this investigation there was no advantage in maintaining Valerian beyond the first dormant season so that harvest could be made within 12 months of planting.

De-heading Valerian

The removal of flower heads from Valerian would be recommended to prevent its establishment as a weed in subsequent crops. The effect of this practice on root yield should be further investigated as a substantial increase in root yield occurred in the three months post-flower removal.

Echinacea angustifolia

Further work is required to determine the agronomic requirements of this herb. It is recommended that an earlier sowing or planting date be investigated as a means of ensuring persistence over winter.

1. Introduction

On an international scale the medicinal herb industry is considered to be well established, with raw material being grown in many countries on a commercial basis and a significant amount of herbs being collected from wild sources, especially in America and Canada. A resurgence in the popularity of herbs has been attributed to: a shrinking availability of synthetics; the increasing difficulty of establishing new drugs on the market due to health regulations; the expense of drug registration; an increased awareness of the unwanted side-effects of synthetic drugs; and growing consumer support for natural products (Cartwright 1991).

In 1991 the rapidly growing medicinal herb industry in Australia was valued at around A$5 million, based largely on imports (Hemphill 1991). Over the following six years this estimate grew to $40-50 million, indicating a ten-fold increase in the value of the industry (Purbrick pers. com. 1997).

Prompted by poor quality and inconsistent supplies of imported products, Tabco Pty Ltd, a large Australian pharmaceutical processor, started to search for locally supplied herbs in the early 1990s. Based on climatic and environmental factors, Tasmania was identified as a potential region for medicinal herb production.

The inability of Tasmania's producers to meet national market demands was the prompt for this study into the potential for a commercial medicinal herb industry being established in the State. The study determined the technical feasibility and economic potential for growing high quality medicinal herbs and made recommendations to herb growers. The herbs initially evaluated as being most suited to Tasmania's environmental conditions and identified by industry as having the greatest commercial potential included:

Echinacea purpurea	Purple coneflower
Echinacea angustifolia	Narrow leaved coneflower
Scutellaria lateriflora	Virginian Scullcap
Valeriana officinalis	Valerian
Hydrastis canadensis	Goldenseal

Problems arose in the securing of planting material for Goldenseal. Seed was not easily available and imported roots and rhizomes were killed by fumigation with methyl bromide, a procedure required by Australian quarantine control. Goldenseal therefore had to be omitted from the study. However, a comprehensive review of Goldenseal's potential is given in Appendix III which provides a report from Dr Jeanine Davis from North Carolina State University. Dr Davis conducted a three year study into the viability of replacing harvesting wild stocks of this herb with the commercial production of cultivated crops.

1.1 Project Outline

There were six main components to this project:

- Literature Reviews
- Field Trials
- Study Tour to New Zealand
- Establishment of a Grower Network
- Commercial Potential and Development
- Publication of Production Guides

The literature reviews provide background on the knowledge and production status of the medicinal herb industry in many countries. They also sought to provide agronomic information and recommendations which could be applied in Tasmania and to highlight areas where information was lacking which this study could possibly answer.

The field trials were developed to compare establishment and management techniques and to determine the most cost effective method of growing medicinal herbs on a commercial basis. They were also used as a focus to initiate a regional network of herb growers, harvesting contractors and processors. This was done through field discussions, economic evaluation after the first season's harvest and encouragement of industry information and resource sharing.

The study tour to New Zealand allowed comparisons between growing regimes and establishment difficulties to be made. It also increased the communication links between New Zealand and Tasmania, allowing industry representatives to take advantage of shared information.

The commercial development section in this report investigates the costs involved in establishing a herb crop and the returns and benefits over time. It provides a detailed break-down of infrastructure costs as well as ongoing production requirements.

The publication of production guides (Appendix I) following the field trials will provide useful extension tools for new producers. To date only production guides for Echinacea and Valerian have been produced because of the lack of comprehensive theoretical and agronomic information on Scullcap. Jeanine Davis (North Carolina) is currently undertaking trials on *Scutellaria lateriflora* and further work in Australia should provide a better understanding in the production of this herb.

The Department of Primary Industry, Water and Environment (DPIWE) has also collated an introductory package to assist potential new growers of medicinal herbs. Colloquially known as *The Herb Pack* it includes a range of general information as well as references, seed and plant material sources and industry contacts.

1.2 References

Cartright, L. 1991. *Medicinal Plants - Back to Nature*. Australian Horticulture August.

Hemphill, I. 1991. *Prospects for Herb and Spice Production in Australia*. RIRDC Report.

Purbrick, P. 1997. Mediherb, PO Box 713, Warwick, Queensland 4370. Personal communication.

2. Literature Reviews

Literature reviews were undertaken for the following medicinal herbs:

Common Name	Scientific Name	Reviewer
Echinacea	*Echinacea angustifolia* *Echinacea purpurea*	S. Lardiges
Valerian	*Valeriana officinalis*	S. Lardiges
Scullcap	*Scutellaria lateriflora* L.	K. Butler

2.1 Echinacea

2.1.1 Taxonomic characters


Echinacea purpurea

Echinacea purpurea belongs to the family Compositae and is commonly know as the 'purple coneflower'. The genus derives its name from the Greek word *ekhinos* meaning hedgehog, reflecting the spiny bracts which protrude from the umbonate seed heads of genus members.

There are nine species endemic to the prairie lands of North America and the two species which have been commercialised are *Echinacea purpurea* Muench. and *Echinacea angustifolia*. Unless specified, the following description applies to both commercial species.

Echinacea are perennial herbs which in the early stages produce a cluster of leaves to about 30 cm from a short rhizome. *Echinacea angustifolia* has a tap root and rhizomes, its entire lanceolate leaves possess stiff, bristly hairs and range from 5-30 cm in length. *Echinacea purpurea* Muench. has fibrous roots and rhizomes, its glabrous leaves are ovate and coarsely serrated and may reach over 30 cm in length. The upper leaves in both species are sessile. Commonly *E. Angustifolia* is known as narrow-leaf Echinacea and *E. Purpurea* is known as broad-leaf Echinacea.

Echinacea are perennial plants with the flower stems and most of the leaves dying off in winter. Over the cooler months several rhizomes are produced from which emerge new shoots the following season. During the first year of growth one or more flowering stems are produced each growing up to 1.5 m high and bearing a single large (10-15 cm) daisy-like flower with a single row of petals around the edge of the flower head and the centre made up of an aggregate of small individual flowers without petals. The fruits are four-sided seed-like achenes.

2.1.2 Medicinal properties

The primary medicinal parts are the roots but the shoots may also be used. It has been found that there is a degree of medicinal variability between individuals of *E. angustifolia* whereas *E. purpurea* is more consistent and thus preferred by most herbalists (Hall 1988).

The body's primary response to Echinacea is to enhance the immune system through: increasing the blood leucocyte count; providing essential fatty acids (oleic, linoleic and palmitic) to aid the liver, the blood and lymphatic circulatory systems; possessing inulin, a muscle sugar which promotes muscle tone and activity; and providing high levels of iron and the essential micronutrients copper and cobalt, essential in aiding iron absorption (Hall 1988).

The British Herbal Pharmacopoeia (British Herbal Medicine Association 1983), as well as other pharmacopoeia, provides detailed information on individual herb medicinal properties and the different essential active constituents.

2.1.3 Agronomy

2.1.3.1 Methods of production

Both the shoots and the roots of Echinacea contain the required medicinal properties. Where the shoots are to be harvested rotations of 3-4 years are recommended with the herb being harvested annually. Roots can be harvested at the end of the rotation period (Bomme 1986). If the root is the main focus then the rotations can be reduced to 1-2 years and root yields will generally be increased if the shoots are not harvested during this period.

2.1.3.2 Plant establishment

It is recommended that crop establishment take place in spring with transplants, rather than direct seeding. Seedling transplants have achieved the best and most reliable results in both species, with direct seeding giving erratic results. It has also been found that few plants flower in the first year when grown from direct seeding establishment.

A trial conducted at the Kansas State University Horticulture Farm at Manhattan compared *E. purpurea* direct seeded in April (equivalent to October in the southern hemisphere) with three month old seedling transplants planted in May (November southern hemisphere). The direct seeded plants were shorter and had very few flowers four months after sowing with an average of 0.04 flowers/plant compared to 10.5 for transplants. Direct seeded Echinacea had reduced root weight per plant compared to the transplants one year after establishment (Smith-Jochum and Albrecht 1988). However, the transplants had the advantage of three months growth in a greenhouse prior to transplanting into the field. This would have given a substantial growth advantage over the direct seeded plants.

In order to overcome seed dormancy and poor establishment in the field, researchers have been able to encourage germination by priming the seeds prior to sowing.

2.1.3.2.1 Priming

Samfield *et al* (1991) found the optimum priming treatment for *Echinacea purpurea* to be six to nine days in aerated distilled water at 20-25°C. This treatment gave both faster and more uniform germination compared to the untreated control. Primed seeds which were then germinated in a dark laboratory at 23°C achieved 93% germination in seven days, compared to only 48% germination for non-primed seeds.

Finnerty and Zajicek (1992) found that priming treatments may help to overcome adverse environmental conditions. For example, under highly saturated soil conditions, priming in potassium salts for nine days improved seedling emergence from 21% to 47% after 28 days.

2.1.3.3 Planting density

In Germany row spacings of 0.4 m and plant spacing of 0.3 m are used to give a density of 16 plants/m^2 (Bomme 1986). An experiment in New Zealand's South Island compared densities of 6.2, 12.5 and 25 plants/m^2. The highest yield achieved after two years was 6.9 t/ha dry root matter with 25 plants/m^2 compared to 3.9 and 4.4 t/ha dried root matter respectively for the lower densities (Douglas 1993).

2.1.3.4 Cultivation

Echinacea prefer sunny conditions and are drought and frost tolerant. They grow well in fertile free-draining soils and soil texture is important for harvesting and processing, with light or peaty soils being more easily washed from the roots.

Optimum pH range for Echinacea is between 6 and 8, with *E. angustifolia* typically found in lime-rich soils. However, *E. purpurea* has been grown successfully in New Zealand in soils with a pH range between 5.5 and 6 (Douglas 1993). Testing for pH is therefore important prior to establishment and an application of lime may be necessary to maintain a neutral or slightly alkaline soil pH.

2.1.3.5 Fertiliser

In Germany the procedure is to apply 70-100 kg/ha P and 220-250 kg/ha K before planting. Then 150-180 kg/ha N is applied in three split applications starting three weeks after transplanting or seed germination until the end

of the growing season. If a second harvest of the herb is expected, an application of 30 kg/ha N is added after the first cut (Bomme 1986).

The New Zealand recommendation is to apply N:P:K:S 15:10:10:8 at 500 kg/ha (equivalent to 75 kg/ha N, 50 kg/ha P, 50 kg/ha K and 40kg/ha S) at planting, with follow-up dressings of N (Douglas 1992).

2.1.3.6 Weed control

The slow growth rate of Echinacea seedlings necessitate early weed control. In New Zealand, Echinacea has shown tolerance to pendimethalin, oryzalin and a combination of oryzalin and chlorpropham at planting and tolerance to terbacil, diuron or chlorpropham once established (Douglas 1992).

Herbicides found to be useful in Yugoslavia include simazine @ 2 kg/ha; metrobromuron and metoachlor @ 5 L/ha; terbutryn @ 4 L/ha; dipropetryn @ 4 L/ha; and phenmedipham plu desmedipham @ 6 L/ha (Macek and Ilc 1991).

2.1.3.7 Pests and disease

Aphids have reputedly caused severe leaf deformation in New Zealand. No significant diseases have been observed although some plants have demonstrated a yellow mottle identified as cucumber mosaic virus (Douglas 1992). In Germany plants infected with a virus have been observed as well as some symptoms caused by bacteria infections. No plant protection measures apart from removal of the infected plants have been recommended (Bomme, 1986).

2.1.3.8 Harvest and drying

To ensure the maximum harvest of the critical ingredients Echinacea is harvested at 'bloom' (at least one flower opened on the main shoot) during the first year and at 'full bloom' (at least one flower opened on most side shoots) (Bomme, 1987).

After harvest the herb must be dried immediately at 40-45^{o}C (Bomme, 1986). The shoots are harvested in autumn before the roots are extracted using a digger which should work to a depth of 30 cm. Any shoot residue must be removed before roots are cut into 5-10 cm pieces and thoroughly washed. The fibrous roots of *E. purpurea* are more difficult to clean than the tap roots of *E. angustifolia*. The harvested roots comprise about 30-35% dry matter and are artificially dried at 40-45°C until brittle.

2.1.3.8.1 Yield

In Germany the herb is harvested by mowing the plants about 10 cm above ground level. Reported yield of dried leaf for *E. angustifolia* in years one and two is 3 t/ha, and in later years 7 t/ha. Yield for *E. purpurea* in years one and two is 7 t/ha and in later years may reach 14 t/ha.

Both *E. angustifolia* and *E. purpurea* yield 2-3 t/ha of dried root in the first year and up to 6 t/ha after two years (Bomme 1986). Root yield after four years of harvesting the shoots is similar to that in the first year (Bomme 1990).

2.1.4 Markets

The Australian pharmaceutical industry uses the whole plant in preparations. Around 10 tonnes of whole plant per annum is currently used by one major company (Tabco pers comm). The world trade in Echinacea root is not known. In June 1993, Whole Foods reported the results of the Dietary Supplements Sales Survey which found Echinacea to be the third most popular medicinal herb after garlic and goldenseal (Oliver 1994). In 1989, MAFTech identified Echinacea as one of two crops with the greatest export potential for New Zealand (Parmenter *et al.* 1992).

2.2 Valerian

2.2.1 Taxonomic characters

Valerian belongs to the family Valerianaceae, a cosmopolitan family, which includes other medicinal herbs like *Valeriana wallichii*, used in Indian medicine.

The genus *Valeriana* contains about 200 species, which are mostly found in the cold and temperate regions of the northern hemisphere.

There are three species of Valarian (*V. officinalis*, *V. mexicana* and V. *edulis*) in use as medicinals. The most commonly cultivated species *V. officinalis* originated in Europe and Northern Asia and is the species discussed here.

Valerian is perennial, producing in the first year a basal rosette of pinnate leaves which can vary markedly in shape and colour (Hall 1988). In following years the plant will produce flowering stems up to 1.5 m tall bearing pink or white cyme inflorescences. The calyx is modified to form a pappus which aids in the wind dispersal of the single-seeded 2.5 mm fruit. The plant has a very strong foetid odour with a lingering potency which requires it to be stored separately.

2.2.2 Medicinal Properties

The roots and rhizomes of Valerian possess the active medicinal properties in the plant, the leaves and flowers are of no medical benefit (Ah Ket 1983). Some herbalists extract the essential oils from the fresh roots and rhizomes for various preparations, whilst others use the dried product. In the drying process chemical changes take place resulting in the production of the critical iso-valerianic acid, which is thought to be responsible for the foetid smell (Hall 1988; Ah Ket 1983). The method of drying is critical as high temperatures can destroy the essential constituents through increased enzyme activity. The optimum temperature to maintain integrity of the essential oils has been found to be 40°C (Douglas 1993).

Over 70 other compounds have been identified in Valerian including high levels of the essential minerals magnesium and phosphorus. It is now believed that it is the combined action of the various compounds which gives Valerian its medicinal value as a herbal relaxant (Hendriks 1980; Hendricks *et al.* 1981).

Valerian is often used as a natural sedative in cases of hysteria or nervous shock (Ah Ket 1983) and it may also be used in the treatment of a variety of general disorders ranging from insomnia to coughs and colds.

2.2.3 Agronomy

2.2.3.1 Plant establishment

It has been found that better results are achieved through transplanting nursery grown seedlings, although direct seeding is also possible provided there is sufficient irrigation. For direct sowing, seed should be sown into fine, firm, weed-free seed-beds in either autumn or spring. Seed at a rate of 2-3 kg/ha is sown into rows 40-50 cm apart. It is generally recommended that the small seed is sown near the surface and that the bed is rolled after sowing (Douglas & Parmenter 1993). Sowing to germination is between 2-4 weeks (Bomme 1984).

In trials in Germany, Valerian was sown at the end of August (equivalent to February in the southern hemisphere) and harvested at the end of October (April in southern hemisphere) in the following year. No significant germination differences were detected between sowing rates between 1.5-3.0 kg/ha, however rates of 2.0-2.5 kg/ha were recommended to ensure a high percentage germination rate (Bomme 1983).

It is important to note, that the viability of Valerian seeds deteriorates relatively quickly. It is therefore necessary to ensure that seed is fresh and to undertake germination tests prior to sowing. In order to prevent possible difficulties in the supply of seeds, German growers have been advised to harvest their own seed. From the second growing year about 5 g of seed can be collected per plant. The seed must be dried at 35^{o}C and stored in airtight containers in a dry, cool place (Bomme 1984).

2.2.3.2 Planting density

In nurseries seed is sown into rows 15-20 cm apart and covered with 1 mm of compost. To produce enough seedlings for 1 ha 0.5-0.7 kg of seed needs to be sown over 500-700 m^2 (Hornok 1992). It is also possible to broadcast the seed and lightly cover or leave it at the surface. In this method the final density of the seedlings should be 500-600 plants per m^2 (Bomme 1984). To avoid fungal 'damping off' the seed should be treated with a fungicide containing metiram. The seedlings require regular irrigation and light shading is recommended until emergence. The establishment period, seed to fourth leaf stage, is 2-2.5 months.

Overseas sowing recommendations vary according to size of harvester and whether mechanical or manual weeding is to be done. However, most suggest that seedlings be planted 20-30 cm apart, with 30-35 cm between the rows for hand hoeing and 50-60 cm or more for mechanical hoeing (Hornok 1992; Bomme 1984; Douglas & Parmenter 1993).

2.2.3.3 Cultivation

Valerian grows well in medium loam to sandy loam soils, with lighter soils facilitating cleaning of the harvested root. The soil should be ploughed and harrowed before sowing or transplanting. In cases of spring planting deep ploughing in autumn has been recommended (Hornok 1992).

2.2.3.4 Fertiliser

In Germany 100-120 kg/ha N, 50-70 kg/ha P and 150-180 kg/ha K is applied prior to transplanting seedlings. In addition 100-150 kg/ha nitrogen is added in three split applications throughout the growing season. Where seeds are directly sown fertiliser is added through: 130-150 kg/ha N in three applications; 50-70 kg/ha P and 180-200 kg/ha K in two applications (Bomme 1984).
In New Zealand Douglas & Parmenter (1993) recommend applying N:P:K:S 15:10:10:8 at 500 kg/ha (equivalent to 75 kg/ha N, 50 kg/ha P, 50 kg/ha K and 40 kg/ha S) at planting with a follow-up dressing of nitrogen.

2.2.3.5 Weed control

Effective weed control is essential until the plants have established good ground cover, at which point they are able to suppress most weeds through competition.

In New Zealand, Valerian showed good tolerance to trifluralin (1 kg ai/ha) (only effective in the absence of black nightshade), pendimethaline (1.5 kg ai/ha) and oryzalin (3.0 kg ai/ha) at the transplanting stage. Once established, best results were achieved with terbacil (1.0 kg ai/ha) and diuron (2.0 kg ai/ha) (Hartley, 1993).

2.2.3.6 Pests and diseases

In New Zealand Valerian has been reported as relatively free from pests and diseases. However German research found that the fungi *Verticillium dahliae*. Klebahn and *Thielavopsis basicola* may infect Valerian. *T. basicola* was transmitted via seed (Gerlach & Franz, 1973). *Valeriana officinalis* has also been identified as a winter host for cucumber mosaic virus (MacFarlane 1968).

Phoma spp. and *Sclerotina* spp. fungal diseases have been identified from infected plants in New Zealand (Parmenter *et al*. 1992). Whilst in Germany *Phoma exigua* has caused damage to crops (Bomme 1984).

Grass grub, *Costelytra zealandica*, can cause root damage and should be controlled by cultivation or insecticide before sowing (Parmenter *et al.* 1992). A larva of *Scoparia ambigualis* (Lepidoptera) has been observed feeding on the roots of Valerian in the UK (Bland 1987)

2.2.3.7 Harvest and drying

Shoots are removed at ground level prior to root harvest. Roots are harvested using a digger to a depth of 30 cm. A potato combine can be successfully used which will result in lower contamination with soil but may result in a yield loss of up to 10% (Bomme 1984). After harvest the roots must be thoroughly washed which can be achieved mechanically in a long drum washing machine.

The junction of the roots and the rhizome is especially hard to clean and the harvested material may have to be broken up. The difficulty in cleaning makes it important to harvest when the weather and soil is dry (Bomme 1983). This cleaning of the root post-harvest presents a major labour input to growers and it may be feasible to reduce this by discarding the rhizome altogether. Only 5-10% of the harvested root material is in the rhizomes and if labour costs can be reduced with no compromise to product quality then this might be a viable option in certain cases (Douglas 1993).

Drying should be commenced immediately after washing to prevent a breakdown of the active constituents. Experiments in New Zealand have found that for the best preservation of both valepotriates and essential oils a temperature of 40ºC and airflow of 0.05 kg/m^2 is recommended (Douglas 1992). In Germany, a higher drying temperature of 45-50ºC is used without any recommendation of airflow. Roots should be dried until brittle, which takes between 20-40 hours (Bomme 1984). Since the roots have a strong smell they should be dried separately from other herbs. The dried product should be stored in a cool, dry place.

2.2.3.7.1 Yield

In Germany yield expectations for spring planted Valerian are 16-20 t/ha of fresh root and 4-5 t/ha of dry root. For autumn sown crops 22-26 t/ha fresh root and 5.5-6.5 t/ha of dry root are expected (Bomme 1984).

New Zealand trials achieved a maximum of 4.6 t/ha dry root yields from spring planted seedlings which were harvested six months later the following autumn (Parmenter *et al.* 1992; Douglas 1993).

2.2.4 Markets

MAFTech identified Valerian as one of two medicinal crops with the greatest export potential for New Zealand (Parmenter *et al.* 1992). The Australian pharmaceutical industry uses only the roots in preparations. Around 10 tonnes per annum is currently used by one major company (Tabco pers comm). Prices range from $5 to $25/kg of dried root.

2.3 Scullcap

2.3.1 Taxonomic Characters

Scutellaria lateriflora

Scutellaria lateriflora L. (Lamiaceae) commonly known as Virginian Scullcap, belongs to the mint family Laviatae. The genus *Scutellaria* contains upwards of 300 species mostly occurring in temperate or mountainous regions of the subtropics and is represented endemically in many countries around the world.

Scutellaria lateriflora L. is the species commonly used in western or folklore medicine for a wide range of ailments, as a tranquilliser and sedative. The native habitat of Scullcap is the moist thickets and woodlands of North America and it continues to be harvested from wild stocks.

Scullcap is a perennial plant growing to 1.5 m with stems erect and branching. The leaves are ovate, opposite and have serrated margins, they have dark green upper surfaces and paler green, hairy lower surfaces. The flowers are pale lilac or blue appearing in summer (Everett 1982). Flowers are lipped and the calyx, especially when mature, has a typical 'hooded' appendage at the top of the flower giving the genus its common designation of 'Scullcap'. *S. lateriflora* is generally easily distinguished

from other members of the genus by its flowers which occur on one side of a raceme arising from leaf axils. Stems are four-angled (square-shaped) and there are distinct channels or striations in the stem which help distinguish it from other species (Foster 1996).

2.3.2 Medicinal Properties

Scullcap consists of the dried aerial parts of *Scutellaria lateriflora* L. which are harvested in the late flowering period (Duke 1985). It is commonly used in western medicine as an anti-convulsive and sedative. It contains the volatile oil scutellarin and bitter glucoside yielding scutellarein (Foster 1996).

Few studies have been undertaken on the identification of the active ingredient in Scullcap, however the essential oils of *Scutellaria lateriflora* L. were investigated in some detail by Yaghmai (1988). These were found to be composed mainly of sesquiterpenes (78%) of which δ-cadinene (27%), calamienene (15%), β-elemene (9%), α-cubebene (4%) and α-humulene (4%) are the major components. At least 73 compounds were found to be present in the oil.

2.3.3 Agronomy

Scullcap is reputed to prefer rich damp soil and is found naturally in open areas within rich woods and moist thickets throughout northern America (Foster 1996). It is frost resistant but drought tender (Duke 1985). Propagation can be by seed, vegetative propagation or root division.

Virginian Scullcap (*S. lateriflora* L.) is sometimes not correctly identified and is confused with *S. icana* and *S. epilobifolium.* Pink Scullcap, *Teucrium candense*, is also on the market and care needs to be taken to ensure propagation material is properly identified as *S. lateriflora* L. because *T. candense* can have toxic and even fatal effects (Foster 1996). It is therefore important to use the scientific rather than the common name when ordering Scullcap propagation material.

2.3.3.1 Plant establishment

Of the entire family, only one species has been subject to any significant scientific studies. This is baikal Scullcap (*S. baicalensis*) an east Asian species whose root is a source of Chinese traditional medicine (Foster 1996). Lee and Ahn (1988) undertook yield and density experiments of this species sowing seed at 10 cm spacing with rows of 10, 20, 30, 40, 50 or 60 cm width. They found that as planting density increased the dry weight of roots and leaves decreased, as did the stems per plant and stem diameter, but plant height increased. The optimum planting regime was found to be 10 x 30 cm spacing.

2.3.3.2 Planting density

Plants need to be planted 30 cm apart or in continuous rows 90 cm apart. For ease of harvesting set rows out in blocks of three rows wide (Whitten 1997).

2.3.3.3 Cultivation

Planting of seed usually occurs in early spring. Crowns are divided in autumn to early spring and the rhizomes planted at the same time. It is necessary to irrigate weekly in summer but care needs to be taken not to over water. Avoid excess fertiliser as the stems of Scullcap are brittle and will not support excess leaf growth (Whitten 1997).

2.3.3.4 Weed control

Scullcap needs to be kept weed free with regular inter-row cultivation. Winter active weeds can be a problem as Scullcap becomes fully dormant and dies back to ground level in winter, giving weeds an opportunity to take over (Whitten 1997).

2.3.3.5 Pests and disease

The only pest documented is grasshoppers which can have population explosions in summer. Damage can be reduced with more consistent watering so plants are not stressed. Some growers have successfully used ducks to keep grasshopper numbers down (Whitten 1997).

2.3.3.6 Harvest and drying

Harvest occurs when Scullcap is in flower or earlier if the leaf is starting to deteriorate. The first cut should be ready around November to December with subsequent cuts ready at 6-8 week intervals. The best recovery is made if the plant is cut a little above the base with some green leaf remaining (Whitten 1997).

Scullcap should be dried at a temperature of up to 35°C and will dry quickly with no problems. A freeze treatment is necessary to control moth larvae before sale or storage (Whitten 1997).

2.3.3.6.1 Yield

Once established yields of approximately 0.4 kg/m^2 of aerial parts per annum can be expected. This may be slightly lower for tea-grade leaf - about 3kg/m^2 - as tea grade leaf is rubbed through a 2.5 or 3 dent screen to remove the stems (Whitten 1997).

2.3.4 Markets

Around 10 tonnes per annum of Scullcap is currently used by one major company in Australia (Tabco pers comm). Prices can range from $5-$29/kg dry product, depending on quality, grade and organic certification.

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3. Field Trials

3.1 Method

The objective of the field trials was to test the productivity and quality of the herbs *Echinacea* spp., Valerian and Scullcap under Tasmanian conditions. Two distinct sites were initially chosen to spread the risk in the establishment phase and to give a comparison of performance in different environments, particularly soil type.

The basic agronomy of factors such as plant density and establishment methods have been tested in other countries for both Echinacea and Valerian and these factors formed a major part of the assessment under Tasmanian conditions. The literature on Scullcap cultivation is extremely limited and it was hoped that the field trials would provide basic information on the performance of this herb.

A significant component of field testing new plants under local conditions is observations of pest and disease incidence and plant phenology which will assist in future crop management.

Various planting densities of seeds and seedlings were trialled, to enable useful comparisons in harvest and yield results within the same crop. Analysis of results covered both agronomic and economic aspects including: growth rates; harvesting; crop yield; competitiveness; input costs; finished product returns; and market opportunities.

3.1.1 Site selection

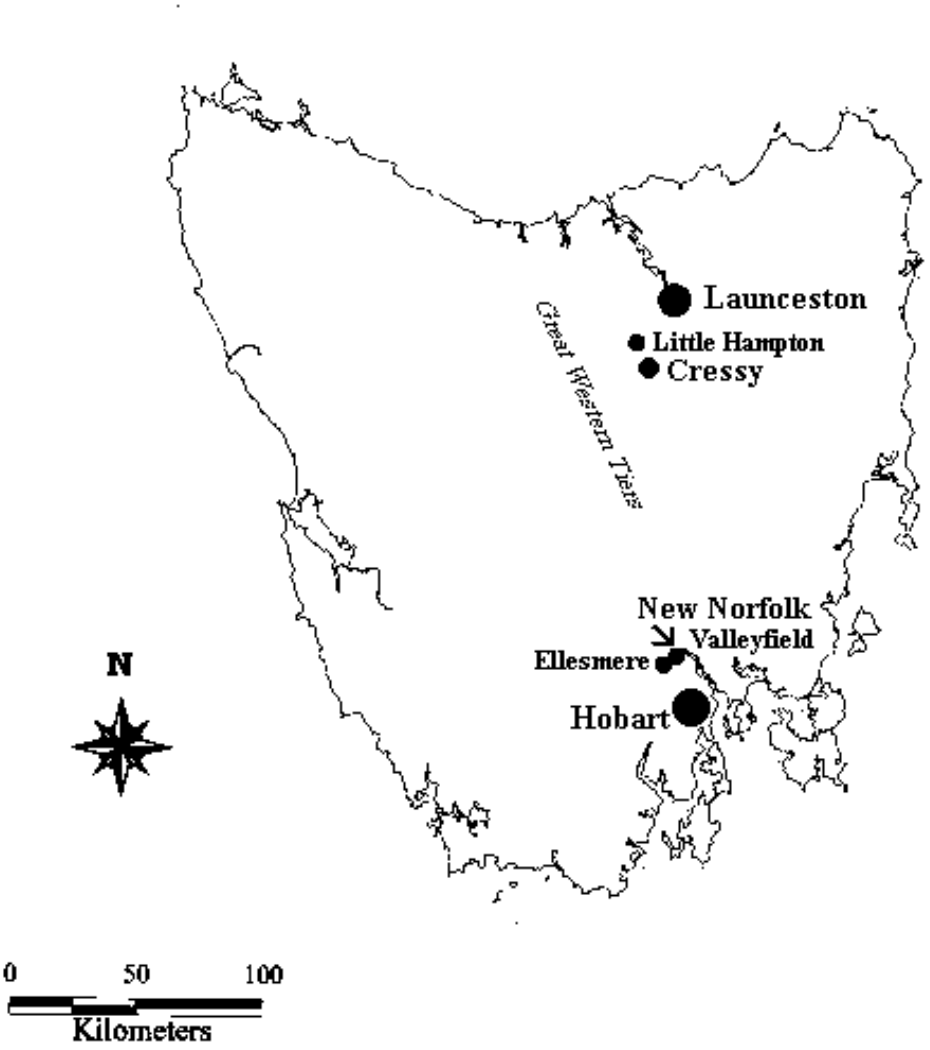
Field sites were established in two regions in Tasmania, one in the north and one in the south. These sites differed in climate, topography and soil type and were chosen to enable performance comparisons to be made of the different herbs. In selecting differing sites, variables such as: soil type; slope; aspect; rainfall and temperatures were considered.

The northern site was 10 km north-west of Cressy, a small rural town located approximately 30 km south of Launceston in the Northern Midlands region of Tasmania (refer Figure 1). The property, Little Hampton, is located in an area known locally as 'Toiberry', situated in a valley bordered to the west by the Great Western Tiers mountain range. The region is characterised by low rolling hills and flat plains. The average annual rainfall is 640 mm and temperatures range between averages of 0.9°C - 23.6°C (Bureau of Meteorology 1999). Temperatures during these trials ranged from a minimum of -4°C to a maximum of 34°C. This site was established in December 1994.

The first of the southern sites was also established in December 1994 on the property Valleyfield near New Norfolk, approximately 40 km north-west of Hobart in the Derwent Valley region (refer Figure 1). The Valley is one of the main hop producing regions in the world. The average annual rainfall for the New Norfolk region is 550 mm and temperatures range between averages of 1.9°C - 24°C (Bureau of Metereology 1999). The temperatures during these trials ranged from a minimum of -3°C to a maximum of 39°C.

Following certain establishment and maintenance problems experienced on Valleyfield a third site was selected in October 1995 about 10 km away but still within the Derwent Valley, on the property Ellesmere. There were no significant agronomic differences between Ellesmere and Valleyfield for the purposes of this study.

Figure 1 Field Trials - Site Locations



A brief description of each site follows.

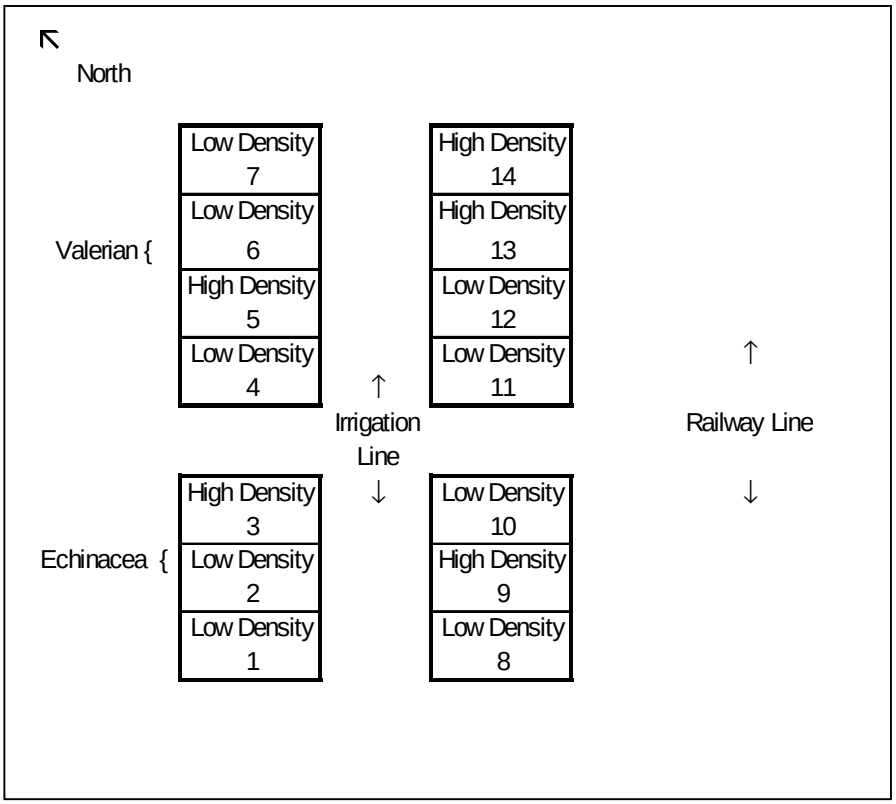
3.1.1.1 Little Hampton, owned by P. Reader, Toiberry

The site is located in the mixed cropping/grazing district of Cressy. Processing facilities in this district include commercial dryers, a pelletising plant, steam distillation, solvent extraction and chilling. The area around the site is used extensively for grazing and cropping. Toiberry is serviced by the Cressy-Longford irrigation scheme and produces cereals, vegetables and opium poppies. Livestock enterprises include wool, prime lamb and cattle.

The alluvial sandy-clay soils in the area were deposited during the formation of the lagoon (now dry) during the quaternary period. The trial site was in a swamp which had been drained two years previously, comprising black clay soils topped by an organic layer. The soil was well drained with good structural characteristics and the site had successfully produced root crops such as fresh market carrots as well as vegetable seed crops and pasture for grazing. The site was on level ground but exposed to westerly winds.

The site plan and details of the planting density are included in Figure 2.

Figure 2 Site Plan Little Hampton, Cressy



Plot Size:
1.2 x 3.6 = 4.4 m^2

Low Density:
40 x 20 spacing, to give 12.5 plants/m^2

High Density:
20 x 20 spacing to give 25 plants/m^2

Planting date:
December 1994

Echinacea: *Echinacea purpurea*

Valerian: *Valeriana officinalis*

Note: Number of plots reflects number of available seedlings.

3.1.1.2 Valleyfield, owned by R. Warner, New Norfolk

The first of the southern sites was located on a riverside farm approximately three km north of New Norfolk. The property grew a wide range of horticultural crops including flower bulbs and seed crops for vegetables and flowers. Valleyfield was originally a hop farm and has a restored kiln on site, which could be used for drying herb material. The local area also supports grazing, cropping and forestry.

The site was on level ground with a deep duplex soil consisting of loamy sand or a sandy clay loam typically found along the river flats in the Derwent Valley. The soils are deep and well drained but possess little organic matter.

Unfortunately a combination of problems including poor irrigation coverage, high weed numbers and the deleterious effects of an applied mulch meant that many plots at Valleyfield had to be abandoned in October 1995. The worst affected areas of the Valleyfield site were Block 1 where mulching killed most Echinacea plants and Plots 6,7,10,11 and 12 where irrigation coverage was poor. The remaining plots that were maintained included plot numbers 8, 9, 13 and 14.

The site plan and planting densities for Valleyfield are given in Figure 3.

Figure 3 Site Plan Valleyfield, New Norfolk

	Block 1	Block 2	Block 3 → North
	1 Echinacea Low Density		10 Echinacea High Density
River	2 Echinacea Low Density	6 Valerian Low Density	11 Echinacea High Density
	3 Echinacea Low Density	7 Valerian High Density	12 Echinacea High Density
	4 Echinacea High Density	8 Valerian Low Density	13 Echinacea Low Density
	5 Valerian High Density	9 Valerian Low Density	14 Echinacea Low Density

Plot Size:
1.2 x 3.6 = 4.4 m^2

Low Density:
40 x 20 spacing, to give
12.5 plants/m^2

High Density:
20 x 20 spacing to give
25 plants/m^2

Planting date:
December 1994

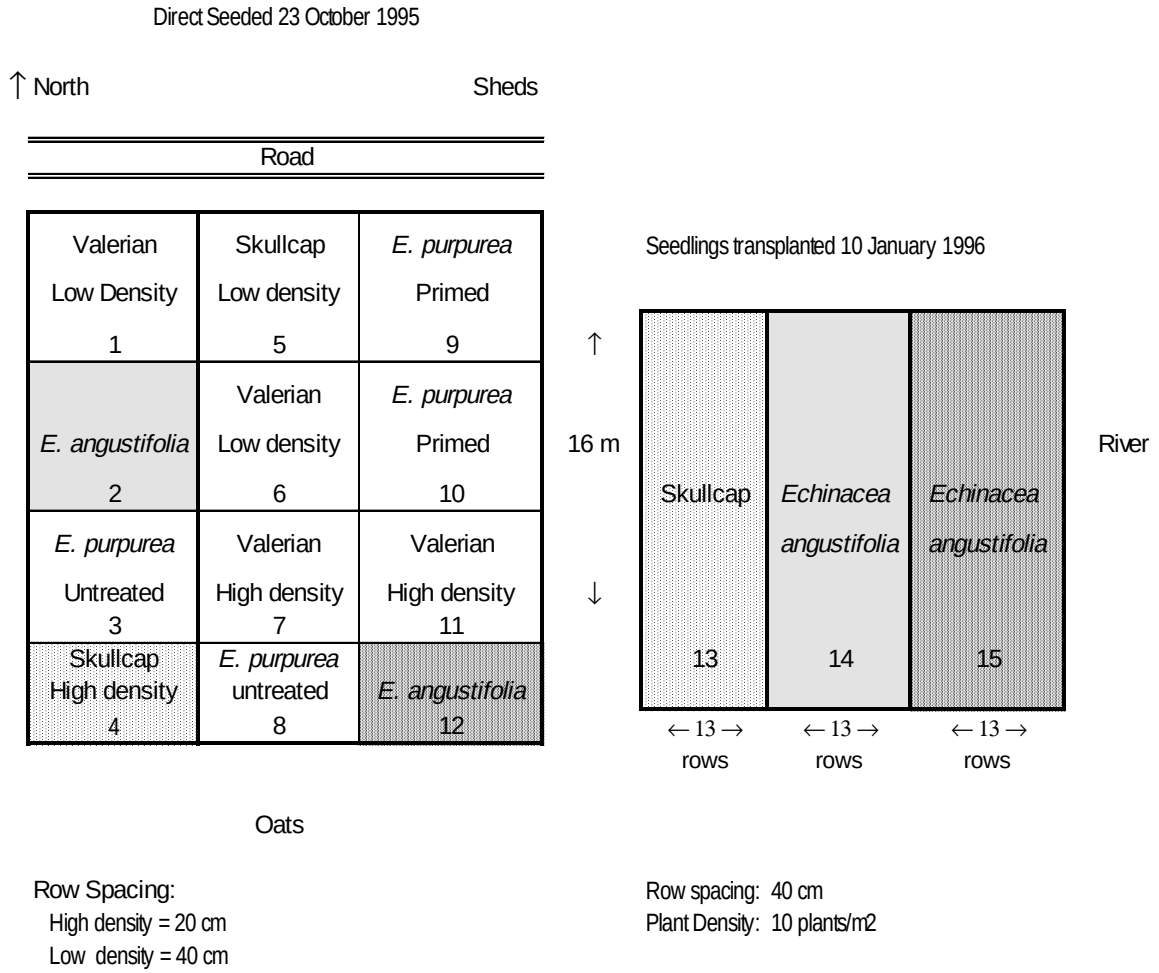
Echinacea: *Echinacea purpurea*
Valerian: *Valeriana officinalis*

3.1.1.3 Ellesmere, owned by The Uniting Church and Skill Share, Hayes

Ellesmere is located at Hayes, approximately 15 km north of New Norfolk on the Derwent River. The soils on this property were similar to those of Valleyfield, being a deep duplex consisting of sandy loam alluvial soil but with a higher organic matter content. As with the other two sites these plots were on level ground.

The site plan and planting densities for both direct seeded and seedling plots are given in Figure 4.

Figure 4 Site Plan for Direct Seeded and Seedling Trials on Ellesmere, Hayes



Note : Plots 2, 4 and 12 in the direct seeded block were originally sown with Scullcap. After the herbicide application these plots were re-established with Scullcap or *E. angustifolia* seedlings. Plot 5 was left as some Scullcap survived the herbicide application. (Refer 3.1.3.1 below.)

3.1.2 Herb selection

Herb seed companies in the United Kingdom, Germany, New Zealand, United States, Canada and Australia were investigated for their potential to supply medicinal herb seeds, roots or seedlings.

Seed of the herbs *Echinacea purpurea*, *Echinacea angustifolia*, *Valeriana officinalis* (Valerian) and *Scutellaria lateriflora* (Scullcap) were successfully obtained. *Echinacea purpurea* and *Valeriana officinalis* seed was obtained from Richter's Ltd in Canada; *Echinacea angustifolia* and *Scutellaria lateriflora* seeds were obtained from White Crane Trading (New York).

Glasshouse germination tests confirmed that the seed obtained was of good quality with in excess of 70% germination being achieved for all species and varieties.

3.1.2.1 Seedling establishment

Seedlings of *E. purpurea* and Valerian were propagated by the commercial nursery Hills Transplants at Don, in Northern Tasmania. The seedlings were planted out in early December 1994 in two densities, low and high, at Little Hampton and Valleyfield as shown in Figures 2 and 3.

In January 1996 seedlings of *E. angustifolia* and Scullcap were planted at Ellesmere. The seedlings had been raised by Hills Transplants.

Table 1 gives the different regimes for seedling plantings at the three sites.

Table 1 Planting Density for Valerian, Echinacea and Scullcap Seedlings

Site	Herb	Sowing Rate (plants/m^2)	
		Low Density	High Density
Little Hampton	Valarian	12.5	25
	Echinacea	12.5	25
Valleyfield	Valerian	12.5	25
	Echinacea	12.5	25
Ellesmere	*Echinacea angustifolia*	10	-
	Scullcap	10	-

Low Density row spacing = 40 cm x 20 cm
High Density row spacing = 20 cm x 20 cm

Little Hampton and Valleyfield were established in year one but with limited seed available so that only *Echinacea purpurea* and Valerian were trialled. Following problems with weeds and irrigation at Valleyfield it was decided to establish a new but similar site in the Derwent Valley in year two at Ellesmere.

Seedlings of *E. purpurea* and Valerian were not established at Ellesmere because this establishment method had already proved successful at the other two sites and resources available at this time were limited.

3.1.2.2 Direct seed establishment

Direct seeding trials were only undertaken on the southern property Ellesmere in year two. The plan had been to establish similar trial plots for comparison at Little Hampton but due to unseasonal heavy rain where the trial area at Little Hampton was under water for most of the spring, no new establishments could be made at this site.

The three herbs *Valeriana officinalis*, *Echinacea purpurea* and *Scutellaria lateriflora* were selected for the direct seeding trial. Limited availability of *E. angustifolia* seed restricted this herb to seedling propagation for transplanting. Direct seeding of the three herbs was undertaken on 23 October 1995 and the different sowing densities applied are given in Table 2. Half the *E. purpurea* seed was primed by submerging for three days in running water and half was left untreated (refer Figure 4). All other herb seed was untreated.

Table 2 Planting Density for Direct Seeded Valerian, Scullcap and Echinacea

Site	Herb	Sowing Rate(kg/ha)	
		Low Density	High Density
Ellesmere	Valarian	4	8
	Scullcap	2	4
	Echniacea (primed)	-	6
	Echinacea (untreated)	-	6

Low Density row spacing = 40 cm x 20 cm
High Density row spacing = 20 cm x 20 cm

In November 1995 on Ellesmere, an initial count of emerged Valerian seedlings from October's direct sowing was made. Three samples per plot were counted with each sample consisting of a randomly selected 0.5 m long portion of the innermost rows of the plots. Neither Echinacea nor Scullcap seedlings had emerged sufficiently for a count to be undertaken at this stage.

In May 1996, six months after direct seeding, a seedling count of Valerian and Echinacea was made on Ellesmere to determine germination rate. Three samples per plot were counted with each sample consisting of a randomly selected 0.5 m long portion of the innermost rows of the low and high density plots.

In July 1996, one of the high density plots (No 7) of Valerian on Ellesmere was thinned out by removing every alternate row to increase spacing to 40 cm x 20 cm.

In November 1996, a second count of Valerian and Echinacea was conducted as well as a count of Scullcap, to determine survival over winter. The technique this time using a 0.5 m x 0.5 m quadrat.

3.1.3 Monitoring and maintenance program for plots

At Valleyfield in November 1995 Valerian flower heads were removed using hedge trimmers in order to prevent the herb becoming a weed problem. The prolific seeding nature of Valerian makes it a potential weed in future crops if not managed in this manner.

There was no indication in any literature that either Echinacea or Scullcap may present potential weed problems. Echinacea is not highly competitive and its natural habitat is in impoverished soils so it is unlikely to become a weed in a cropping situation. Scullcap spreads by both rhizome and seed but does not appear to be invasive.

3.1.3.1 Weed and pest management

All plots on Little Hampton and Valleyfield were hand weeded with the borders maintained by mowing or spraying with a glyphosate herbicide.

At Ellesmere plots 1-12 (refer Figure 4) were intensively managed by regular hand weeding. Plots 13-15 relied on inter-row cultivation at a less regular interval.

In August 1995 mulched peppermint and fennel marc was spread over the plots at Valleyfield to a depth of 75 mm. A layer of each mulch was spread evenly over entire area so that all plots received both mulches. The aim was to reduce the time required in continuous hand-weeding at this site. The peppermint mulch was two years old and had a pH of 8.5. The fennel marc was a year old and had a pH of 7.5.

On 27 October 1995 a glufosinate-ammonium broad spectrum post-emergence herbicide (Basta®) was applied to all plots on Ellesmere. The target weed species included Fumitory, wild radish, fat hen, wire weed and *Amaranthus* spp. which were present as seedlings at time of sowing. It was believed that the herbicide treatment would knock-down the weeds and that no Scullcap seeds would have germinated within the four day period. Unfortunately, this was not the case and a large majority of Scullcap seedlings were also killed, necessitating re-establishment of these plots.

3.1.3.2 Fertiliser application

In January 1995, one month after transplanting, Valleyfield and Little Hampton plots were fertilised with 8:4:10 N:P:K (8% N as sulphate of ammonia; 4% P as single superphosphate; 10% K as potassium chloride) at a rate of 300 kg/ha.

By March 1995 on Valleyfield Echinacea plants were beginning to produce flower buds but the plants showed signs of yellowing. To remedy deficiency symptoms additional nitrogen was added using Nitram (ammonium nitrate, 33% N) applied at a rate of 150 kg/ha.

In November 1995, one month after sowing, Ellesmere plots were fertilised with 9:14:17 N:P:K (9% N as sulphate of ammonia; 14% P as single superphosphate; 17% K as potassium chloride) at a rate of 200 kg/ha.

In February 1996, one month after seedlings were transplanted, Ellesmere plots were fertilised with 8:4:10 (8% N as sulphate of ammonia; 4% P as single superphosphate; 10% K as potassium chloride) at a rate of 200 kg/ha.

3.1.3.3 Irrigation

All sites were irrigated by overhead sprinkler irrigation as required to supplement rainfall. Problems encountered at Valleyfield included uneven distribution and infrequent application.

3.1.4 Harvesting herbs

The harvests conducted at the three field sites included root harvests of Echinacea and Valerian and shoot harvests of Echinacea and Scullcap. The harvesting involved random samples of either 1 m of row or a 1 m^2 quadrat. Quadrat samples were more suitable in the second year due to the high density of shoots making identification of rows less clear.

Roots were harvested by digging with a spade. The roots were returned to the laboratory and washed carefully to remove dirt. Dry matter yield was established by removing a sub-sample from the main sample and drying at 70°C. Sub-samples for quality analysis were dried at the lower temperature of 40°C to prevent degradation of heat sensitive medicinal components. Shoot samples of Echinacea were harvested with secateurs and Scullcap was harvested with hedge trimmers.

3.1.4.1 21 June 1995, Little Hampton and Valleyfield

The first harvest of Valerian and Echinacea roots on Little Hampton and Valleyfield occurred six months after planting in June 1995 when plants were dormant. Due to slow establishment, only plants in the high density plots were suitable for harvest. A 1 m^2 quadrat was removed from plots 3, 5, 9, 13 and 14 at Little Hampton and 5, 7, 10, 11 and 12 at Valleyfield. Roots were removed by digging with a conventional hand spade. The roots were transported back to the laboratory where they were cleaned of all dirt then dried at 70°C to establish a dry matter yield. Plot 4 was not harvested at Valleyfield because of poor establishment due to uneven watering.

3.1.4.2 16 January 1996, Valleyfield

In January 1996 whole plants of *E. purpurea* were harvested from the low density plots 13 and 14 and sub-sampled, one to be tested for plant quality and the other to determine the dry matter content of both roots and shoots. Shoots and roots were separated in the laboratory. Samples for quality analysis were dried at the lower temperature of 40°C until a moisture content of around 12% was obtained. Yield samples were dried at 70°C to establish dry matter weights.

3.1.4.3 22 January 1996 Valleyfield

Also in January 1996 whole plants of *E. purpurea* were harvested from 1 m^2 quadrats in each of the low density plots. The plants were returned to the laboratory where they were divided into roots and shoots, cleaned of all dirt then dried at 70°C for dry weight determination.

3.1.4.4 16 April 1996, Valleyfield and Ellesmere

Whole plants of *E. purpurea* and Valerian were harvested from low density plots at Valleyfield and Ellesmere. A sample of 1 m^2 was taken randomly from each plot harvested. The plants were returned to the laboratory where they were divided into roots and shoots, cleaned of all dirt then dried at 70°C for dry weight determination.

There was insufficient top growth of either Scullcap or *E. angustifolia* to warrant a harvest at this stage.

3.1.4.5 25 June 1996, Little Hampton

The roots of dormant Valerian were harvested by digging with a conventional spade. A sample of 1 m^2 was harvested from the high density plots 5 and 14 and returned to the laboratory for cleaning and dry matter yield determination. The roots were dried at 70°C. A sample from this harvest was also used for quality analysis and dried at the lower temperature of 40°C.

3.1.4.6 30 September 1996, Valleyfield

The roots of Valerian were harvested by digging with a conventional spade. A sample of 1 m^2 was harvested from the low density plots 6, 8 and 9 and returned to the laboratory for cleaning and dry matter yield determination. The roots were dried at 70°C. A sample from this harvest was also used for quality analysis and dried at the lower temperature of 40°C.

3.1.4.7 10 October 1996, Little Hampton

The roots of Valerian were harvested by digging with a conventional spade. A sample of 1 m^2 was harvested from the low density plots 4 and 11, although plot identification was difficult due to much of the area being partially submerged. The samples were returned to the laboratory for cleaning and dry matter yield determination. The roots were dried at 70°C. A sample from this harvest was also used for quality analysis and dried at the lower temperature of 40°C.

3.1.4.8 9 December 1996, Ellesmere

Whole plants of *E. purpurea* were harvested from both primed and untreated direct seeded plots on Ellesmere. The sample size was 1 m^2 taken randomly from each plot. The plants were returned to the laboratory where they were divided into roots and shoots, cleaned of all dirt then dried at 70°C for dry weight yield determination. A small sample of *E. purpurea* was also harvested from these plots for quality analysis and dried at the lower temperature of 40°C.

3.1.4.9 8 January 1997, Ellesmere

Whole plants of *E. purpurea* were again harvested following the same regime as described for the 9 December 1996 harvest.

3.1.4.10 12 February 1997, Ellesmere

The leafy tops of Scullcap were harvested from plots 4, 5, and 13 using manual hedge trimmers. The sample size was 1 m^2 taken randomly from each plot. All the above-ground plant parts, including leaves and flowers, were harvested and returned to the laboratory where they were dried at 70°C for dry weight yield determination. A sample was also harvested for quality analysis which was dried at the lower temperature of 40°C.

3.1.5 Quality Analysis

The quality analysis test performed by Tabco was gel electrophoresis which indicates the presence or absence of the desired medicinal component when compared with a standard. In cases where uncharacteristic peaks are observed further testing is required by a more high powered technology of GC-MS (Gas Chromatography Mass Spectrometry) which enables more accurate characterisation of extracts.

Gas Chromatography is the process in which the components of a mixture, in this case an oil, are separated from one another by volatilising the sample into a carrier gas stream which is passing through a bed of inert packing at different rates and so appear one after the other at the effluent end where they are detected. In the case of GC-MS, the effluent is passed through a mass spectrometer. The mass spectrometer is a method of chemical analysis in which ions are passed in a vacuum first through an accelerating electric field. This separates the ions according to their mass, as they traverse the magnetic field at different velocities. The compounds are then identified on the basis of their mass (Hawley 1971).

3.2 Results

3.2.1 Herb selection

3.2.1.1 Seedling establishment

The success of planting seedlings in the summer months was site dependent. Seedlings of Echinacea and Valerian did not establish well at Valleyfield whereas seedlings of both herbs established successfully at Little Hampton.

Valerian re-emerged with good vigour at both Valleyfield and Little Hampton in year two. Few Echinacea plants re-emerged in the second year at Little Hampton in contrast to Valleyfield where Echinacea re-emerged successfully.

Seedlings of *Echinacea angustifolia* planted at Ellesmere in the summer established well but did not re-emerge in the second year.

Scullcap established well from seedlings planted on Ellesmere in January and their survival over winter was high with plant density increasing six-fold in the second year (refer Table 3). Complete ground cover was achieved early in year two.

Table 3 Scullcap Plant Counts from Seedling Plots 1 November 1996, Ellesmere

Plot	Density	Number of plants/0.5 m^2		Average density
	planted	Count 1	Count 2	plants/m^2
13	10/m^2	20	46	66

3.2.1.2 Direct seeding establishment

All direct sown herbs had emerged by October in the second growing season. *Echinacea purpurea* flowered in the first growing season. Valerian seed germinated at around 14 days after sowing but did not flower until year two. Of the three herbs being trialled Scullcap germinated the most rapidly, emerging within four days of sowing.

Time taken for germination and production of leaves and flowers for Valerian and Echinacea direct sown in October 1995 is presented in Table 4 below. The data given for Scullcap as a comparison is from the remaining plants in the direct seeded low density plot 5.

Table 4 Phenology of Direct Seeded Herbs

Herb	Direct sown in Spring - Year 1					Year 2	
	Germination time (days)	1st true leaf (weeks)	2 true leaves (weeks)	Flowering	Senesce	Emergence	Flowering
Echinacea purpurea	21	4		April	May	October	December
Valerian	14		4			October	November
Scullcap	4			March	May	October	February

Direct seeding establishment of Scullcap at Ellesmere was impaired by the early application of herbicide to plots. Field observations determined that some seeds had germinated within the four day period between direct seeding and herbicide application.

Results from the November 1995 seedling count indicated that Valerian was successfully established from direct seeding, as illustrated by the data in Table 5.

A further count was made of both Valerian and Echinacea in May 1996 (Table 6) to assess the success of establishment by direct seeding.

It was found that priming the seeds of *Echinacea purpurea* before sowing did increase seedling density, but is probably of little commercial relevance due to the high germination rate of the untreated seed.

Table 5 Valerian Seedlings Counted at Ellesmere, 9 November 1995

Plot	Planted density	Number/1.5 m of row			Average number per m of row	Average density seedlings/m^2
		1	2	3		
11	High - 8 kg/ha	171	43	62	61	307
7	High - 8 kg/ha	62	50	92	45	227
6	Low - 4 kg/ha	49	64	63	39	98
1	Low - 4 kg/ha	58	54	62	39	97

By comparing data in Tables 5 and 6, it can be seen that there was an increase of between 37% and over 100% in the number of Valerian growing points over the six months between counts.

Table 6 Echinacea and Valerian Shoots Counted 2 May 1996 after Direct Seeding on Ellesmere

Plot No.	Treatment	Planting Density	Row Number	Average number/m of row	Average density shoots/m^2

			1	3	5	7		
Echinacea								
8	Untreated	Low	36	37	46	60	30	75
10	Primed	Low	36	43	71	60	35	88
Valerian								
11	Untreated	High	89	141	124	150	84	420
7	Untreated	High	93	143	140	106	80	402
6	Untreated	Low	110	122	166	81	80	200

Table 7 gives data on counts taken in the second season for herbs in the direct seeded plots. Thinning of Valerian seedlings reduced the density in Plot 7 to an acceptable level of 29 plants/m^2 (Table 7).

There was a large reduction in the number of *Echinacea purpurea* shoots surviving over winter from an initial 75 shoots/m^2 to 15 plants/m^2 in plot 8, untreated seed (refer Tables 6 and 7, Plot 8).

Table 7 Counts of Direct Seeding Plots in Second Summer (November 1996) Ellesmere

Herb	Plot	Density planted	Number of plants/0.5 m^2		Average density plants/m^2
			Quadrat #1	Quadrat #2	
Echinacea pupurea	8	Low	8	7	15
Valerian	7	Thinned	13	16	29

3.2.2 Monitoring and maintenance program

De-heading of Valerian in November 1995 on Valleyfield, was successful in preventing weed seedling establishment. Subsequent reports indicated that only sporadic Valerian plants appeared at this site.

3.2.2.1 Weed and pest management

Hand weeding for small scale production achieved relatively weed free herb samples. The time required for weeding was significantly dependent on: site history; site preparation; and the individual herb. Valleyfield had a history of poor weed management and included weeds such as *Amaranthus* spp. (Prince of Wales Feather) *Chenopodium* sp. (fat hen) and *Polygonum* sp. (wireweed). Mulching with peppermint and fennel marc produced variable results. Whilst weed emergence was greatly reduced by mulching, Echinacea was particularly sensitive to the mulch and a large percentage of the plants were killed or stunted.

The site at Little Hampton had been cropped recently and had a much lower weed load than at Valleyfield. This substantially reduced the amount of time required for hand weeding.

At Ellesmere prior site treatments aided in weed management, for example: previous cereal crop grown on site; a pre-plant fallow; and application of herbicide.

Of all the herbs, Valerian was able to quickly achieve ground cover and smother weed competition. In general Echinacea and Scullcap were less vigorous than Valerian and therefore required more careful weed management.

All herbs except *Echinacea angustifolia* were particularly hardy and were not seriously affected by pest or disease. A suspected mosaic virus was observed on isolated plants of Echinacea at Valleyfield in March 1995. In November 1995, an isolated sclerotinia (*Sclerotinia sclerotiorum*) infection was observed in Valerian at Valleyfield which resulted in the death of the growing point followed by a single plant death.

Soldier beetles (*Chaulignathus lugubris*) were observed on flowering *Echinacea purpurea* at Ellesmere but no damage was evident. Red legged earth mite was observed on the remaining few *Echinacea angustifolia* plants at Ellesmere but appeared to be secondary to general plant decline.

3.2.2.2 Irrigation

All plants responded well to supplementary irrigation but were deleteriously affected by poor coverage as demonstrated at Valleyfield.

Of the three herbs studied, Echinacea was the most tolerant of dry conditions, whilst Scullcap was the most sensitive to infrequent irrigation, with plants often observed to be in a wilted state.

3.2.3 Harvesting

3.2.3.1 Roots

Valerian and Echinacea plants harvested for their roots from the Little Hampton site, were difficult to clean due to the high clay content of the soil which adhered to roots. Valerian in particular was more affected by soil type due to the fibrous nature of its root system. The sandier soil types at Valleyfield and Ellesmere made harvesting a quicker and easier operation with less loss of root material due to over cleaning. Digging was also easier at Valleyfield and Ellesmere.

3.2.3.1.1 Harvest yields - Echinacea

The first harvests (21 June 95) of *Echinacea purpurea* roots from both Little Hampton and Valleyfield were during the first dormant period, six months after planting (Table 8).

Only high density plots were harvested in June 1995 as insufficient plant material was available from the low density plots. From data in Table 8 it can be seen that the yield from Valleyfield is over four times that achieved at Little Hampton. This was the only harvest of *E. purpurea* at Little Hampton, as few plants re-emerged in the second season, due to water-logging of the site over the winter and spring months.

The first Echinacea root harvest at Ellesmere was taken six months after direct seeding (April 1996) and gave a yield of 1 t/ha. Over the following eight months this figure more than tripled with the final harvest yielding 3.5 t/ha 14 months after direct seeding.

From data in Table 8 it can be seen that the yield of roots from the low density plot at Valleyfield taken in the summer of the second year (January 1996) was lower than for the high density harvest taken in the previous winter (June 1995). However, the second season low density autumn harvest (April 1996) taken 16 months after planting gave the highest root yield results.

This early high yield achieved in the high density plots would be expected due to the higher plant numbers. However this yield was greatly surpassed by the low density plots in year two, where interplant competition in the high density plots may have inhibited plant development.

Table 8 Summary of *Echinacea purpurea* Root Yield from Three Sites

Harvest date	Planting Density	Dry wieght of roots kg/ha		
		Valleyfield	Little Hampton	Ellesmere
21/06/95	High	2600	596	
22/01/96	Low	1837		
16/04/96	Low	6672		1025 (DS)
09/12/96	Low			3485 (DS)

Where: High density seedling planting = (20 cm x 20 cm)
Low density seedling planting = (40 cm x 20 cm)
DS = Direct seeded at 6 kg/ha = (40 cm x 20 cm)

Note: The results on Ellesmere are a combination of both primed and untreated plots.

The combination of poor irrigation coverage and mulching destroyed the high and some low density Echinacea plots at Valleyfield so that year two data is taken from low density plots 13 and 14 only. The survival of plants in plots 13 and 14 may be explained by the better irrigation received, which would have enabled the plants to be more vigorous and thus better able to grow through the thick mulch layer.

The yield of root taken from the first harvest at Valleyfield of 2.6 t/ha (Table 8) is well in excess of that recorded at a similar stage in New Zealand trials of 0.3-0.8 t/ha (Parmenter 1992) and comparable with yields achieved in Germany of between 2-3 t/ha (Bomme 1986). The peak yield of roots recorded from the three sites was 6.7 t/ha at Valleyfield 16 months after planting. This compares favourably with the yield of 6.9 t/ha obtained in southern New Zealand (Parmenter 1992) and 6 t/ha achieved in Germany (Bomme 1986).

The results from Valleyfield indicate that a substantial increase in root production occurs from mid-summer to mid-autumn (Table 8) which would indicate that the crop at Ellesmere had further potential for yield increase in its second year.

An interesting yield comparison can be made between similar aged transplants and direct seeded Echinacea. Results from Valleyfield transplants harvested on 22 January 1996 compared with results of those direct seeded at Ellesmere on 19 December 1996, both being approximately 13 months old, show the direct seeded plants at Ellesmere giving a greater yield than the transplants at Valleyfield (Table 8).

3.2.3.1.2 Harvest yields - Valerian

The yield of Valerian root reached a peak at between 6 and 18 months after planting at both Little Hampton and Valleyfield (Table 9).

The yield achieved after 6 months at Valleyfield, 1.7 t/ha, was substantially lower than at Little Hampton, 5.5 t./ha. The yield from Little Hampton is comparable to German and New Zealand yield results for spring sown Valerian, being 4-5 t/ha and 4 t/ha respectively (Bomme 1986, Parmenter 1992). The better early establishment at Little Hampton compared to the drier site of Valleyfield is likely to have contributed to the differences observed in yield for the first harvest.

Table 9 Summary of Valerian Root Yield from Valleyfield, Little Hampton and Ellesmere

Harvest Date	Planting Density	Dry weight of roots kg/ha		
		Valleyfield	Little Hampton	Ellesmere
21/06/95	High	1770	5500	
16/04/96	Low	6340		7010
25/06/96	High		5310	
30/09/96	Low	4555		
10/10/96	Low		2060	

Where: High density seedling planting = (20 cm x 20 cm)
Low density seedling planting = (40 cm x 20 cm)
Ellesmere direct seeded @ 4 kg/ha = low density planting

The results in Table 9 suggest that there is little advantage in maintaining Valerian beyond the first year, unless late or poor establishment has occurred, as was the case at Valleyfield. In this situation, the yield after 16 months was more typical of an autumn sown crop, reaching 6.3 t/ha. Bomme (1986) reports the yield from autumn sown Valerian as being in the range of 5 to 6 t/ha. The yield of Valerian root at Little Hampton was no greater at 18 months after planting and actually declined by 22 months. A similar trend was noted at Valleyfield.

3.2.3.2 Yield - shoots

3.2.3.2.1 Echinacea

The shoots of Echinacea also have medicinal commercial value. Plants at Valleyfield produced large amounts of shoot biomass by year two, with a peak yield of 32 t/ha during mid-flowering. At Ellesmere, this was substantially less at 11 t/ha but is more comparable with results reported for production in Germany of 14 t/ha in year two (Bomme 1986).

The yields of *Echinacea purpurea* shoots from both Valleyfield and Ellesmere are summarised in Table 10. The yield appeared to peak in the second season during flowering at Valleyfield (22 January 96). The two harvests from Ellesmere represent the first and second seasons of production. The yield of shoots was substantially greater in the second season. *E. purpurea* on Little Hampton did not produce shoots of sufficient size to warrant a harvest in the first year and there was no re-emergence in year two.

Table 10 Summary of *Echinacea purpurea* Shoot Yield from Valleyfield and Ellesmere

Harvest date	Dry weight of shoots kg/ha	
	Valleyfield	Ellesmere
22/01/96	32,838 (LD)	
16/04/96	20,250 (LD)	2,275 (DS)
09/12/96		11,660 (DS)

Where: LD = Low density seedling planting (40 cm x 20 cm)
DS = Direct seeded at 6 kg/ha (40 cm x 20 cm)

Note: The results on Ellesmere are a combination of both primed and untreated plots.

3.2.3.2.2 Scullcap

The flowering tops of Scullcap harvested in the second year after planting yielded between 5.8 and 9 t/ha. Scullcap shoot yields from the semi-commercial scale plot 13 (Figure 4) were substantially less than the yield obtained from the more intensively managed plot 4 (Table 11). The harvest was taken 13 months after planting.

Table 11 Yield of Scullcap Shoots Harvested from Ellesmere, 12 February 1997

Plot	Dry weight of shoots (kg/ha)
4	9000
13	5765
Average	7383

3.2.4 Quality Analysis

All samples were accepted by Tabco Pty Ltd and except for one, they were declared to be of a commercial grade. The sample that Tabco identified as being uncharacteristic of Valerian was sampled from Valleyfield in May 1996. It was identified as producing an uncharacteristic peak on gel electrophoresis. A further sample was harvested and the oil extracted to determine if the oil was characteristic of *Valeriana officinalis*. The GC-MS of the oil indicated typical oil composition for *Valeriana officinalis*. The results of quality testing from Tabco can be found in Appendix III.

3.3 Discussion

3.3.1 Herb Selection

Seed of the four species studied, *Echinacea purpurea*, *Echinacea angustifolia*, *Valeriana officinalis* and *Scutellaria lateriflora*, was readily available in commercial quantities (1 kg or greater) once contact with seed merchants had been established. However, information on issues such as: purity; species certainty; and agronomic or medicinal performance; was unavailable from most suppliers. Richters Pty Ltd was the only company approached which could supply this kind of information.

During the initial search for seeds, it was found that the seed available from Australian or New Zealand merchants was imported from overseas. Seed of *E. purpurea* and *E. angustifolia* was available from an Australian grower but no guarantee of species purity could be given. Species purity is a particularly important issue in Echinacea production since the species cross pollinate readily. One of the largest world Echinacea producers, Trout Lake Farm in the US, was approached for supply of seed. This company undertakes a breeding program for supply of superior strains to its local growers but maintains their competitive advantage by retaining the rights to these varieties and does not sell seed to other producers.

Since this study began the problem with obtaining seed is now being alleviated with the emergence of a number of companies advertising locally grown seed of a range of medicinal herbs, including some organically grown. (Refer Australian Herb Industry Resource Guide by K Fletcher in Appendix V for list of local producers.)

The future for local medicinal herb growers will depend on the resources available and potential support from processors. Growers may themselves undertake selection based on agronomic performance from their own stock. The viability of selection for superior medicinal properties will depend on the commercial value of this trait to processors. If it does become a significant issue, support from both growers and processors may advance this area. The potential for selection was evident by the high degree of phenotypic variability observed in the Valerian population. This was less apparent for Echinacea and Scullcap. Once established the maintenance and propagation of a superior strain of Scullcap would be relatively simple, due to the ability to propagate from vegetative stolons.

3.3.1.1 Seedling transplanting

The mixed success of establishing herb seedlings in the field could largely be attributed to irrigation design, soil type and time of planting. This was critical since the seedlings were planted in early summer when evapotranspiration was commonly 25 mm/week. This problem could be alleviated by planting seedlings earlier in spring or by ensuring adequate irrigation coverage. Valleyfield herbs suffered severely from poor irrigation coverage so that a large percentage of herb seedlings in outlying plots did not survive.

The greater moisture holding capacity of the soil at Little Hampton gave an initial advantage with excellent establishment and growth of both Valerian and Echinacea in the first year compared to Valleyfield. This advantage was not, however, carried through to the second year due to an unseasonably wet winter and spring in

1995. The soil surface at Little Hampton became puddled and remained saturated for much of September and October. This is believed to be the main cause of Echinacea mortality at this site. Echinacea originates from the semi-arid regions of North America and appears to be better adapted to the drier free draining soils of the Derwent Valley.

Although a direct comparison is not possible from these trials, a general observation of the performance of Echinacea transplants and direct seeded plants indicates that direct seeding has the potential to yield as well, if not better than, transplants, contrary to the findings of Smith-Jochum and Albrecht, 1988. In their study the direct seeded Echinacea were shorter, had very few flowers and reduced root weight per plant compared to transplants.

Valerian appears to be tolerant of a wide range of soil conditions, thriving at both Cressy and the Derwent Valley and re-emerging strongly at all sites in year two.

Echinacea angustifolia was only planted at Ellesmere because of a very limited supply of seed. It established well in the first year but failed to re-emerge in year two. A possible explanation for this could be the need for *E. angustifolia* to achieve a minimum size prior to becoming dormant in autumn. If insufficient development occurs in the first year, over-wintering buds required for re-growth in year two may not be produced. The relatively late planting in January may have contributed to this. This could be confirmed by establishing sequential plantings of *E. angustifolia* from early spring and examining plants in autumn for basal bud development.

Scullcap established well from seedlings planted in January. These went on to re-emerge the following year with a greatly increased number of shoots. Complete ground cover was achieved early in year two.

3.3.1.2 Direct seeding

Establishment of the herbs *Echinacea purpurea*, Valerian and Scullcap by direct seeding in spring proved to be a reliable and cost effective method of herb establishment.

A sowing rate of 6 kg/ha for *E. purpurea* at a row spacing of 40 cm produced a good density of plants at 15/m^2 and a commercially acceptable yield of shoots and roots. This density is half-way between that recommended by German producers at 8 plants/m^2 (Bomme 1986) and that resulting in the highest yields under New Zealand conditions, 25 plants/m^2 (Douglas 1993).

The pre-treatment of *E. purpurea* seed by priming in running water did increase the shoot density. Samfield (1991) also found that priming improved the rate and uniformity of germination. The size of this advantage in a field situation is likely to be outweighed by the lower cost and easier handling of untreated seed in most instances. Sowing at a slightly higher rate would be a more viable option for most growers to achieve a higher density.

Finnerty and Zajick (1992) found that primed seeds performed better under the adverse condition of a highly saturated soil. However, it would be more beneficial for growers to select sites which do not suffer from poor drainage in order to establish and develop a successful crop, rather than rely on the more expensive and time consuming seed priming to achieve improved establishment. Priming not only requires extra preparation of seed prior to sowing but also requires specialised equipment for sowing the wet seed.

The plant density achieved by direct sowing of Valerian was extremely high at both the high (8 kg/ha) and low (4 kg/ha) sowing rates. Bomme (1983) recommended a sowing rate of between 1.5 and 3.0 kg/ha to achieve a plant density in the range 6.4 to 9.5 plants/m^2. New Zealand researchers recommended a similar scenario sowing at 2 to 3 kg/ha with a resultant plant density of between 6.6 and 10 plants/m^2 (Douglas and Parmenter 1992).

The low sowing rate of 4 kg/ha was initially chosen to achieve a plant density of around 10 plants/m^2, similar to the planting density of seedlings. Even though the low sowing rate at Ellesmere was only 1.3 times that recommended, the density achieved was 10 times greater at 97 and 98 plants/m^2. This suggests that the seed used was in excellent condition and the field conditions for germination were ideal.

The interplant competition in the high density plot (Ellesmere plot 7) prior to thinning resulted in yellowing, weak stemmed and stunted plants compared to the low density plot. Thinning by removal of every alternate row in the high density plot reduced the plant density to a more acceptable but still excessive 29 plants/m^2 in year

two. The target density was 20 plants/m^2, similar to the high density plantings at Little Hampton and Valleyfield.

It would be recommended that a lower sowing rate of around 1.5 to 2 kg/ha be used when seed of good quality is being used and appropriate field conditions exist.

Only the root of Valerian is used commercially in medicinal preparations. The roots are normally harvested after the first season of growth which can be 8 to 13 months after planting depending on whether the crop is planted in spring or autumn. In this investigation, all Valerian was summer planted and harvested 6, 16 and 22 months after planting.

Valerian root yield was greatest at between six and 18 months after planting. It would appear that direct seeding was more successful than transplanting seedlings. This may in part be due to site factors with the yield at Valleyfield being restricted by poor irrigation and at Little Hampton by waterlogging of the soil in year two. Direct seeding is a much cheaper option and this method would be recommended for the establishment of Valerian.

Unlike Echinacea, Valerian appears to be more tolerant of saturated soil conditions, performing well in the majority of soil types and climatic conditions. This was particularly evident at Little Hampton where Echinacea plants failed to survive the wet winter and spring conditions whereas Valerian survived to produce acceptable root yields of 5.3 tonnes/ha.

Since only the above ground portions of Scullcap are harvested, an increased plant density in year one is likely to achieve greater yields in the first year. Alternatively, an earlier planting time and greater use of supplementary irrigation and fertiliser may achieve the same or better results. Performance in the second season would need to be monitored to ensure that this was not deleteriously affected through overcrowding.

Scullcap appeared to be the least tolerant of dry conditions and irregular irrigation, with plants often observed in a wilted state. It would therefore be recommended that a soil with a high clay content and hence increased water-holding capacity, be optimum for Scullcap production.

3.3.2 Monitoring and maintenance

The practice of de-heading Valerian is only an issue for autumn plantings or if the crop is maintained beyond the first dormant season. In this investigation, it was found that if growing conditions were adequate there was no advantage in maintaining Valerian longer than one growing season.

3.3.2.1 Weed and pest management

The greatest expense in time and therefore cost in the production of medicinal herbs is weed management. In this investigation, the three sites provided a variety of weed management issues with a range of cropping and weed histories. The Valleyfield site proved the most difficult due to a poor weed management history.

The use of mulching on Valleyfield greatly reduced the need to hand weed with the added benefit of increased soil moisture retention. However, the death of Echinacea plants indicates that the mulch may not have been fully composted at the time of application or that Echinacea is particularly sensitive to having its growing point buried. Observations revealed that temperatures within the mulched layer were high. These issues should be important considerations when using a mulch on sensitive plants such as Echinacea.

The prior cropping and site preparation carried out at Little Hampton and Ellesmere greatly reduced the time required for hand weeding. Although the pre-plant application of herbicide on Ellesmere is not considered an option for those interested in organic production, this could be substituted by mechanical weeding or a period of fallow followed by cultivation. Other alternatives include the use of green manure crops in the year preceding herb production which also provide additional nutritional benefits.

The ability of the different herbs to smother weed competition was distinct. Echinacea, with its open rosette habit, was a poor weed competitor. Valerian quickly achieved ground cover with its large spreading leaves and smothered a large proportion of weeds. In the second season of production, Scullcap produced a ground covering mat which effectively reduced weed competition.

The production of rhizomes, important for increasing plant density, made mechanical weed removal a delicate operation in late summer. Therefore any strategy for weed management will depend on the site history as well as the herb to be grown.

Row spacing could be used to advantage in Echinacea plantings to allow the use of mechanical weeding tools between rows. Valerian would be the preferred herb to plant if time for fallow operations are limited. The initial plant density and planting time of Scullcap could be used to advantage in weed management. Planting in autumn or early spring at a high plant density is likely to assist in achieving ground cover quickly.

The herbs *E. purpurea*, Valerian and Scullcap proved particularly resilient to pest and disease infestation with no damaging outbreaks being observed. Isolated instances that did occur included a mosaic-type virus symptom on a solitary Echinacea plant at Valleyfield in year one. Virus infection of Echinacea has also been recorded in New Zealand (Parmenter 1992) and Germany (Bomme 1986). The New Zealand study identified the virus as cucumber mosaic virus. Bomme (1986) reports that no plant protection measures are used apart from removal of infected plants. The incidence of *Sclerotinia* spp. observed infecting Valerian at Valleyfield was again isolated to one or two plants which were removed for laboratory inspection. The occurrence of *Sclerotinia* spp. infection has also been reported in New Zealand (Parmenter 1992).

These results are encouraging but do not preclude the potential for pest and disease infestation occurring. Particular pests that have potential to damage and transmit disease are aphids which caused severe leaf deformation of Echinacea in New Zealand (Parmenter 1992). Reported diseases of Valerian include *Phoma* spp. (Parmenter *et al.* 1992; Bomme 1984), *Verticillium dahliae* and *Thielavopsis basicola (*Gerlach and Franz 1973). A larva of *Scoparia ambiguualis* (Lepidoptera) has been observed feeding on the roots of Valerian in the UK (Bland 1987). (Refer Literature Reviews section of this report for more information.)

3.3.2.2 Fertiliser application

The nutritional requirements appeared to be met by the fertiliser regime used except in the case of the over-crowded high density planting of Valerian at Ellesmere, where interplant competition was high. Otherwise, no deficiency symptoms were obvious indicating that the soils in this trial provided adequate nutritional levels with only moderate quantities of the major plant nutrients nitrogen, phosphorus and potassium being supplemented.

3.3.2.3 Irrigation

Overhead irrigation proved suitable for the herbs grown in this study. The need for irrigation under normal summer rainfall conditions in Tasmania was apparent from the poor establishment of Echinacea and Valerian at Valleyfield, where irrigation coverage was insufficient.

Even though the top growth of Valerian appeared unaffected by reduced irrigation, the root yields indicate that substantial benefit was gained by maintaining good soil moisture levels throughout the growing season, which occurred at Little Hampton.

3.3.3 Harvest yields

The low yield of Echinacea roots from Little Hampton in the first year was not reflected by the high vigour of the shoots at this site. This indicates that good soil conditions in autumn are necessary for maximum root growth, irrespective of plant top growth during summer. The excessive soil moisture on Little Hampton was a likely cause for the low yield observed at the first harvest. This low yield could be a function of both physical loss of root material in the cleaning process and reduced yield due to inhibited growth in the saturated soil conditions.

The root and shoot yields achieved in this study indicate that under suitable growing conditions *E. purpurea* production in Tasmania is comparable to, if not better than, other world regions of production.

Valerian performed well in all soil types and climatic conditions. Valerian thrived where other herbs struggled to survive the very wet conditions.

Senescence is important in making the process of harvesting Valerian easier. By ensuring that there is minimal vegetative matter on the surface, removal of roots is a quicker operation. It was noted that complete senescence had occurred by late autumn in each year. Treating Valerian as an annual crop appears to be advantageous, as

there was no significant increase in root yield in year two. This would also aid in preventing this herb from becoming a pest weed species in neighbouring areas.

In the results for Scullcap, the semi-commercial plot provides a more indicative figure on which to base potential economic returns, with the weeding techniques used here more applicable to a larger scale commercial situation. However, the season was particularly dry and irrigation was not sufficient for Scullcap and wilting plants were often observed. Observations of Scullcap crops by members of the Tasmanian Herb Growers Association suggest that there is a greater potential for biomass production than was achieved at the Ellesmere site.

3.3.4 Quality Analysis

The quality testing carried out by Tabco Pty Ltd indicated that all except one Valerian sample were of commercial grade. However, no indication of the level of active constituents was able to be supplied and only a qualitative report was available. This does not give any scope for bargaining on superior grade material that could be supplied or any scope to improve agronomic practices or genetic material. Therefore the recommendation is to identify the agronomic practices that increase the dry matter yield of roots for greatest commercial benefit until quality testing becomes quantitative.

The sample of Valerian identified as being uncharacteristic was due to an additional peak observed on gel electrophoresis. This could be attributed to the various ploidy levels that exist in populations of *V. officinalis* or alternatively there could have been contamination by anethole from the fennel mulch. Further testing of Valerian samples by the University of Tasmania using GC-MS indicated the oil was typical for *V. officinalis*. The departure from normal in the Tabco sample may be attributed to the small sample size, where inclusion of one plant of a different ploidy may produce the uncharacteristic result. Quality results and certification are presented in Appendix III.

3.4 Conclusions

Site selection is an extremely important aspect of medicinal herb production. For example with Valerian and Echinacea, where the roots hold the medicinal properties, choosing a soil type which is easily removed from roots would be an advantage. Site selection proved to be critical to the over winter survival of Echinacea. It was unable to survive extended periods of soil saturation. In the selection of a suitable soil type for mixed herb production, a well drained sandy loam or similar would be favoured for both winter survival of perennial herbs and easy harvesting of roots.

Pre-planting management of the site and the seeds/seedlings is as important as the ongoing management of the established crops. Echinacea is clearly a poor competitor against weed invasion, however where there had been a fallow period or herbicides had been used to remove weeds, Echinacea was better able to reach its potential.

The major agronomic factors of note from this investigation included priming of Echinacea seed, direct seeding as a method of establishment, the sowing rate required to achieve optimum density and harvest date to optimise yield.

Although priming Echinacea seeds did result in increased plant density by direct sowing, this practice would only be of commercial value if germination was extremely poor without treatment and/or if seed was in short supply. In this investigation, adequate plant density was achieved using unprimed seeds. Priming could be of advantage to small scale production where hand sowing is practiced. However, it would not be as applicable to large scale production using conventional drilling equipment because handling of wet seed requires the use of more specialised machinery.

Seedlings of Valerian and *Echinacea purpurea* were successfully established by the direct seeding method. It is also believed that their is good potential for Scullcap to be established by this method. Yields did not appear to be compromised although a direct side-by-side comparison with transplants is required to confirm this.

A sowing rate of 6 kg/ha for *E. purpurea* at a row spacing of 40 cm produced a good density of plants at 15/m^2 and a commercially acceptable yield of shoots and roots. In contrast, the sowing rates for Valerian at 4 and 8 kg/ha were excessive resulting in high plant density. A lower sowing rate of 1.5 to 2.0 kg/ha would be recommended for Valerian.

The optimum harvest date for Valerian could be brought forward to within the first year of production as yield did not appear to increase substantially beyond this time. The results for *E. purpurea* indicate that there is a potential benefit in maintaining the plants through to the autumn of the second year of production to maximise root yield.

Scullcap biomass increased substantially in its second year of production. There is scope to manipulate Scullcap planting time further than was possible in this study, with autumn planting offering potential to obtain production in the first season of growth.

The lack of persistence of *E. angustifolia* in this study requires further investigation, particularly with respect to time of establishment.

The results obtained from the trial work are very preliminary and as yet do not give a clear indication of how the selected herbs will perform in a commercial environment. Of the four herbs, Valerian and *E. purpurea* proved to be the most resilient and therefore the most successful and would be recommended as excellent herbs for a grower first embarking on medicinal herb production. The quality of these herbs was acceptable to current market specifications and yields compared favourably with regions where commercial production occurs.

It appears that some experience and more agronomic information is required to achieve reliable production of both Scullcap and *E. angustifolia*.

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4. Study Tour

News articles and correspondence with researchers in New Zealand indicated that the New Zealand medicinal herb industry was flourishing with research being conducted on a range of herbs with allied commercial production also growing. The similar climatic conditions of New Zealand and Tasmania made the study of the New Zealand industry and research particularly relevant. The closely allied essential oil industry was also looked at during the tour.

4.1 New Zealand Herb and Essential Oil Industry - Research and Industry Development - January 1995

Herb trials were being conducted in New Zealand at a variety of locations including: Invercargill; Redbank; Hamilton; sites on the East Coast of the North Island; and Blenheim. The research was aimed at comparing yields and oil purity from each of the different growing regions.

A study tour was undertaken to investigate the techniques employed in New Zealand and to determine whether these would be suitable for Tasmania.

The centres visited included:

- **Otago**
  Redbank Research Centre
  Ginseng, herb and essential oil research

- **Christchurch**
  Crop and Food Research Institute

- **Ashburton district**
  Dill production for essential oil

- **Riwaka**
  Crop and Food Research, Riwaka Research Centre
  Herbs, essential oils and green tea

- **Wellington district**
  Medicinal herb growers

4.2 Site Visits

4.2.1 Otago - Redbank Research Centre

4.2.1.1 Herb and essential oil research

Contacts: Mr Malcolm Douglas
Scientist - New Crops
Ms Jenny McGimpsey
Agronomist - New Crops

4.2.1.2 Soils

The soils at Redbank comprised a silty brown loam with low buffering capacity and low organic matter content, which allowed crusting and compaction to occur easily. Large quantities of peat were added to increase the soil's organic matter content. Surface pH was 6.0-6.5 whilst the presence of $CaSO_4$ and $CaCO_3$ in lower layers resulted in a higher pH at depth.

4.2.1.3 Medicinal herbs

Medicinal herb trials at Redbank closely followed those of the German medicinal herb industry. Malcolm Douglas had sourced seed from Germany but had not been successful in establishing formal links with pharmaceutical companies.

The work was at the initial stage of quality assay before progress with agronomic assessment could begin.

4.2.1.3.1 Valerian (Valeriana officinalis)

Agronomic trials of Valerian were aimed at maximising productivity. The main factors investigated included plant density and nutritional requirements of the major elements: nitrogen, phosphorus and potassium. The plants were established as seedlings in spring. Once seed heads appeared the tops were removed to prevent seed production. This has been reported to encourage better root yields and is also carried out to prevent seed dispersal weed problems. A huge variability in type has been observed at Redbank which indicates that the population is very heterogeneous. Yields ranged from 1.5 t/ha to 6 t/ha of dry root.

Weed control was not an issue due to the vigorous nature of the plant which smothers weeds by the second year. No oil extraction had yet been carried out with the first harvest occurring eight months after planting, in autumn.

4.2.1.3.2 Echinacea

Investigations of Echinacea were of a similar nature to the Valerian trials with productivity at different plant densities and fertiliser regimes being studied. Both *Echinacea purpurea* (purple coneflower) and *Echinacea angustifolia* (narrow leafed coneflower) were planted at Redbank. Yields ranged from 4 to 14 t/ha of dry root with *Echinacea purpurea* being the most productive. Malcolm Douglas also reported yields to be higher elsewhere. There had been evidence of cucumber mosaic virus but this was not extensive.

4.2.1.4 Other herbs and oils

A wide range of both medicinal and culinary herbs were established at Redbank, mainly with the intent of observation for performance under local conditions. They included:

- Bergamont
- Many varieties of Lavender
- Hyssop
- Lemon Balm with no lemon scent
- Clary Sage
- Thyme
- Ginseng
- Oregano
- Spanish Gourd
- Peppermint
- Arvensis Spearmint
- Poplar buds
- Bulgarian roses.

Herbs tested in the past included:

- Angelica
- Feverfew
- Ferula
- St Johns Wort.

4.2.1.4.1 Thyme

Introduced by early gold miners, this herb now grows prolifically as a weed around the hills of Otago. High yields of the herb have been obtained at Redbank, however further selection work needs to be undertaken to produce plants with a better aroma than the wild type.

4.2.1.4.2 Ginseng

Approximately 0.5 ha of Ginseng was established under artificial shade at Redbank. The American species (*Panax quinquefolium*) was the primary crop grown and a small area was planted with Korean Ginseng (*Panax ginseng*). High rates of N:P:K fertilisers were applied with good results.

Disease was a major factor determining the survival of Ginseng plants. A high incidence of botrytis collar rot was observed. The fungicide mancozeb was applied on a regular basis during the growing season as a protectant. The eradicant fungicide ridomil® was tested and found to be deleterious to Ginseng.

Researchers have found that the sunlight intensity in New Zealand is greater than that in the northern hemisphere, where Ginseng is grown with some success. This has caused interveinal chlorosis and some tip distortion in the plants grown in New Zealand and shade was increased from the standard 90% cover to 95%. A significant improvement in the vigour of the Ginseng plants was noticed with the increased shading. This situation could apply equally in Tasmania and mainland Australia.

Yields of dry root harvested at year four were 2-4.7 g/plant at an initial plant density of 28 plants/m^2 which equates to 56-130 kg/ha. From this initial density significant plant losses had occurred over the four years and it is not known what the final crop density was before harvest.

4.2.1.5 Essential oils

The main focus of the essential oil program included the Australian native brown boronia, *Boronia megastigma* and the New Zealand native Manuka, *Leptospermum scoparium*. The interest in boronia has developed from the reported success of the industry in Tasmania. Manuka, has similar medicinal properties to the commercial tea tree grown in Australia and has been used extensively by the Maori people of New Zealand.

A large collection of damask roses were planted at Redbank for essential oil investigation. Oil production has been successful but the cost of production was not internationally competitive. Most commercial rose oil is sourced from Bulgaria, Turkey and Hungary where labour costs are comparatively low.

Crop and Food Research relies on commercial trading companies, such as R.C. Treat, to provide organoleptic quality assessment of oils. It was suggested that an independent role could be provided by the experienced organoleptic assessment team located at the University of Tasmania for New Zealand products.

In addition to government research, the NZ Pharmaceutical Co, Westchem are also investigating essential oil production. Sclareol production from the plant Clary Sage, *Salvia sclarea*, was investigated by a collaboration between the commercial company Westchem and the Chemistry Department (Professor Robinson) of Auckland's University. Sclareol is a commercially valuable component of oil from the plant clary sage and is particularly used as a substitute for whale products in the cosmetic industry. Clary sage has been trialled for essential oil production in Tasmania with success but no sclareol extraction has been undertaken. The crop was grown in Tasmania for the purpose of investigating sclareol extraction techniques by the University of Tasmania and Essential Oils of Tasmania. The small quantity of oil produced was in high demand by an Australian essential oil trader, primarily dealing with the aroma-therapy market.

4.2.2 Christchurch - Crop and Food Research Institute

Contact : Dr Noel Porter

4.2.2.1 Institute

The Crop and Food Institute consists of three divisions:

4.2.2.1.1 Plant Improvement

Tissue culture and genetic manipulation of vegetables, arable crops, seafood, cereals, quality vegetables, eg. onion flavour, onion storage ability.

4.2.2.1.2 Plant Production

Soil, fertilisers, management and agronomy.

4.2.2.1.3 Food Science and Technology

Grain foods, seafood, food quality research, looking at identifying and characterising the behaviour of food components.

4.2.2.2 Essential oils and herbs

Selection work on Boronia (*Boronia megastigma*) was underway. This was based on a subjective 1-10 rating system for plants which were also rated on disease, frost resistance and oil analysis. Problems had been encountered with propagation, with only limited success with striking plants from cuttings.

No tissue culture had been developed and all propagation was by tip cuttings. Plant longevity had not been considered as an issue for selection although it was recognised as a serious problem. Crop and Food did not undertake any quality control work.

Alexander Fleischer of Florasynth, a fragrance and flavour manufacturer and trading company, has developed a very good solvent system for improved oil recovery through image analysis, which looks at ways of improving oil and water separation.

4.2.3 Ashburton district

Contacts: Dr Noel Porter
Mr Evan Walker
Mr Warren Bishop of Crop Mark.

4.2.3.1 Soils

The soils of this region were generally shallow silty composites sitting atop sedimentary rocks of either mudstone or shingle. As with the Redbank soils these tended to crust readily.

4.2.3.2 Dill

Several dill crops were visited in the Ashburton district. The crops ranged in size from 1-7 ha. Most had been sown around the end of October and early November which is late when compared to the usual practice of sowing dill in September in Tasmania. Consequently although the plants showed good vigour there was reduced vegetative development, crops were short and flowering was delayed. Disease was noted in one crop and a bacterial infection of the flowering heads was suspected.

Dill flowers in response to day length, therefore if it does not achieve sufficient vegetative growth prior to optimum day length for flowering, the herb will flower anyway. Flowering is over an extended period, with primary secondary and tertiary order umbels being produced. Oil accumulation occurs as seed ripens but if umbels are not fully formed less oil is produced, it is therefore important to establish this herb early in the growing season.

The company Crop Mark represents about two-thirds of growers in New Zealand and provides the link between local growers and Essential Oils of Tasmania. The Company was established primarily to provide agronomic support and to market NZ seeds, principally barley, wheat and now others including rye, forage, borage, oilseeds, felicia and evening primrose. Evening primrose is grown in co-operation with Roberts Ltd Tasmania for Effamol Ltd, a U.K. company producing health and body care products from Evening Primrose oil.

4.2.4 Riwaka Research Station

Contacts: Dr Mike Nelson
Dr Peter Smale

4.2.4.1 Herb research

Similar to Redbank, a large number of herbs were established at Riwaka Research Station to observe their commercial potential. Both Peter Smale and Mike Nelson have also worked on green tea and wasabi establishment. The main focus for medicinal herb research at Riwaka is now specifically for the Japanese market and in particular one importer.

A local group called MEDINSA produces medicinal herbs for the Japanese market. Testing is done by the local pharmaceutical Cawthron Institute.

4.2.5 Wellington district

Contacts: Mr Rob Bargh
Ms Michelle Bargh

Three growers in a small ex-dairying district west of Wellington were looking for alternative crops. One of the three, Rob Bargh, was interested in the opportunities for medicinal herb production. The group planted small plots of a range of different herbs. Echinacea proved to be the best on price and volume. HerbPharm (NZ Pharmaceutical Co) now takes all *Echinacea pallida, E. angustifolia* and *E. purpurea* produced.

Each grower raises about 1/4 acre of spring planted Echinacea. Rob Bargh grows seedlings for the group. Best growth has occurred on sandy soils with a low clay content. Some plants have been known to flower in their first year. Cawthron Institute will take both the shoots and roots for processing into health care products.

4.2.5.1 Organics

Organic certification was being investigated. It appeared to be possible to have only the shoot production side certified, which would be easier than having the whole plant production certified. At the time of the visit costs were considered prohibitive to seeking organic certification, with both annual fees and commission percentages being of concern to the growers.

4.3 Summary and Implications of Study Tour

4.3.1 Medicinal herbs

The screening work undertaken in New Zealand is useful information that should allow Tasmanian growers to focus on herbs identified as having the greatest commercial benefit, being Echinacea and Valerian. However, it is noted that the New Zealand group did discount pyrethrum as a potential crop which is now a $2 million industry in Tasmania. The main benefits to Tasmanian growers is the agronomic information that has been developed in New Zealand and is covered in the literature review section of this report. The results of the multi-location trial being conducted in New Zealand by Crop and Food Research headed by Malcolm Douglas, when complete, should be of interest to growers throughout southern Australia.

It was surprising to note that what was portrayed in the media as substantial commercial production of Echinacea in New Zealand, was found to be very limited with no structured approach to production and marketing. Isolated groups, such as a few growers in the Riwaka district had developed commercial linkages with Japanese buyers of a specific medicinal herb, Angelica, and this appeared to be very successful. However, the general impression of the industry in New Zealand was one of fragmentation with each group working in isolation.

An issue of interest to medicinal herb growers was that of organic certification. For this to be successful, the system for obtaining certification should not preclude smaller growers due to excessive costs as was the case in New Zealand. This has not been the case in Australia so far and should be seen as an advantage.

4.3.2 Essential oils

The potential to further develop the co-operative relationship between New Zealand producers and Essential Oils of Tasmania exists. The benefit would be a united front in the marketing of essential oils from the southern hemisphere rather than buyers trading one group off against the other, with a no win situation for producers. A further benefit would be the spread of risk over a wider production base, reducing the likelihood of production shortfalls due to unfavourable climatic conditions. The sharing of expertise on Boronia production could potentially be reciprocated by New Zealand producers on the production of Manuka.

5. Establishment of a Regional Network for Herb Growers

5.1 Introduction

Part of the project's aim was to facilitate and assist in the promotion and establishment of a regional network of herb growers in Tasmania.

Initial discussions were made with Mrs Kim Fletcher author of *The Australian Herb Industry Resource Guide* and *A Modern Australasian Herbal* on the most appropriate format for a regional network. In 1993 Kim Fletcher was instrumental in bringing herb industry representatives together in the inaugural Australian Herb Industry Workshop.

In 1994 a meeting was held with Heather Thorpe, a southern Tasmanian herb grower, to discuss the formation of the Tasmanian Herb Growers Association, medicinal herb production and the role of the then Department of Primary Industry and Fisheries (DPIF) now the Department *of* Primary Industries, Water *and* Environment.

5.2 Promotion of Herb Production in Tasmania

The establishment of a herb network for Tasmania was fostered initially through publicising the trial work to be conducted. A display was held at the Royal Hobart Show (five days in October 1995) featuring new crops for Tasmania including medicinal herbs. The display was staffed by DPIF 'New Crops' field officers and information leaflets were distributed to interested growers. The New Crop program also featured in the first edition of the magazine Tasmania Agriculture which is distributed to all primary producers. Follow-up promotion activities included radio interviews on the ABC Country Hour, a segment on a local television show promoting agriculture and the food industry and several articles published in the Tasmanian Herb Growers Association's journal *The Herbal*.

In addition, a 'Herb Pack' was developed containing comprehensive information on the industry and relevant literature. This was mailed to interested new growers of herbs who contacted the DPIF.

5.3 Formation of the Tasmanian Herb Growers Association

In June 1995 a meeting was called for people interested in the formation of a Tasmanian Herb Growers Association. At the inaugural meeting the DPIF gave a presentation on the work being undertaken on medicinal herbs in Tasmania and on areas where assistance could be given to new herb growers.

The Tasmanian Herb Growers Association Inc. was formally established in June 1995. The objectives of the Association are to:

- Exchange information on herb growing.
- Assist growers with marketing.
- Encourage the organic certification of herb growers.
- Co-ordinate crops to meet market needs.
- Identify, encourage and support value-adding opportunities using herbs grown in Tasmania.
- Assist growers with production advice and off-farm production facilities where feasible and appropriate.

In the first year the following new initiatives were proposed by the Association:

- Development of a quality assurance standard for herbs grown by members of the Association.
- Production of a Dandelion coffee as a value-added flagship product.
- Revamping of the Hobart Botanical Garden's herb display, including a section on indigenous Tasmanian bush foods, to help promote the Association.

A market report by the Association's Committee identified Valerian, Scullcap, Echinacea, Red Clover, Angelica roots, Calendula and Dandelion as having greatest commercial potential.

Regional development progressed with meetings in Deloraine, Bothwell, Scottsdale, Burnie and St Marys. The aim was to establish regional support groups for local production related issues, whilst linking in to the Association for support in areas such as: certification; training; access to planting material; co-ordination of product; and marketing.

By spring 1996 the Tasmanian Herb Growers Association had grown to over 100 members with more than eight hectares of cultivated crops, including Echinacea, Valerian, Peppermint, Chamomile and Calendula, under production.

The Association established formal networking procedures to enable co-operative harvesting and processing operations, information exchange and marketing of product. Regular meetings and field days are held and a quarterly journal is published. The Association also took on the responsibility for the collection of information, such as production surveys, to compile a state-wide database. The industry's intent was to be self-supporting and not be reliant on the DPIF to conduct field days and seminars.

In mid 1997 a split between the commercial and non-commercial growers of the Association occurred. The commercial growers are now represented by the company Fine Herbs of Tasmania Pty Ltd which has taken over the services of marketing, on-farm advice and production information for commercial growers.

The Tasmanian Herb Growers Association is maintaining the role of networking, information support and field days as an initial entry point for commercial and non-commercial growers to the industry.

5.4 DPIF Liaison with the Tasmanian Herb Growers Association

In the first year following the establishment of the Tasmanian Herb Growers Association there was close liaison between the DPIF and the Association's Committee, particularly with respect to areas such as literature; industry contacts; government services available to the group (particularly testing and diagnostic services); and in the development of a training package for new herb growers.

Further liaison after this time was at a reduced level and focused on field officers being available at meetings and helping with industry development activities.

5.5 Commercial Development

The rapid growth of the Tasmanian Herb Growers Association and its commercial development meant that any commercial activity or demonstration promoted by the DPIF should be closely allied with this group. The decision was made that the best test of commercial potential of the medicinal herbs selected would be by establishing trials on individual growers' properties.

Seedlings of Valerian, *Echinacea purpurea* and Scullcap were propagated by the commercial nursery Hills Transplants in spring 1995. The plants were made available to selected commercial herb growers through the Tasmanian Herb Growers Association for semi-commercial testing. Observations on the performance of the herbs at different sites was made throughout the following growing season.

The Tasmanian Herb Growers Association provided a database of information that concurred favourably with the findings of the DPIF trials. There were mixed reports of both success and failure.

5.5.1 Echinacea purpurea

Echinacea purpurea was generally successful with good growth in most soil types and climates. It survived transplant well and the high rainfall received in most areas during that year. Most concern and discussion centred on the correct time of harvesting for roots and tops.

5.5.2 Echinacea angustifolia

Echinacea angustifolia had little success in any area succumbing to transplant mortality and high rainfall.

5.5.3 *Valeriana officinalis*

Valerian (*Valeriana officinalis*) performed well in the majority of soil types and climatic conditions. It thrived in the increased wet conditions where the other herbs struggled to produce good yields or even survive. Those growing the herb on heavier soils found harvesting a little more difficult and reported decreases in yields due to losses during cleaning of the root material.

5.5.4 *Scutellaria lateriflora*

Scullcap (*Scutellaria lateriflora*) overall did not perform well in any area. Generally, it was slow to grow, gave poor performance and patchy low yields. Only one grower reported good success with a tall well flowering crop. This was in a light sandy soil receiving good irrigation.

5.6 Future for the Network

The successful establishment of a regional network for herb growers in Tasmania in the form of the Tasmanian Herb Growers Association, was the result of the drive and commitment of a few dedicated herb producers with a positive vision for the herb industry in Tasmania. It proved highly successful in the first two years with a large membership and excellent services being provided to the wide range of grower needs including: a quarterly newsletter; regular meetings and field days; marketing advice; crop co-ordination; the collection of data on production advice; and off-farm facilities such as centralised drying facilities.

The Association also provided the DPIF with a more efficient means of reaching as many herb growers as possible and assisting those who wished to become involved in the industry, whether as a hobby, interest group or commercial grower. However, there was a heavy reliance on a few experienced volunteers which led to the split of the Association in 1997. Links between the two groups The Tasmanian Herb Growers Association and Fine Herbs of Tasmania are still maintained and the services provided by each complement one another. This is encouraging for the future of an effective networking herb growers industry in Tasmania.

5.7 References

Fletcher K. Herb consultant, PO Box 203, Launceston Tasmania 7250. Personal communication.

6. Commercial Development

6.1 Economic Analysis

Gross margin analyses for Echinacea, Valerian and Scullcap are presented on the following pages. Also included are the crucial input assumptions to the analyses, the results in terms of the Net Present Value (NPV) and sensitivity analyses of the NPV to changes in the price and yield of the shoots and/or roots.

In summary the following gross margins are observed:

Table 1 Summary Gross Margins of Echinacea, Valerian and Scullcap

	Year 1	Year 2
Echinacea (shoot & root)	-$7,495	$56,018
Valerian	-$7,515	$51,405
Scullcap	-$9,015	$33,814

6.2 Medicinal Herb Gross Margin Model

A gross margin model assesses the potential annual returns and economic benefits that can be obtained from growing a particular crop. The model should be able to reflect a realistic situation. The gross margins assessed in this report are related to each of three medicinal herbs: Echinacea, Valerian or Scullcap. Decisions as to the size of the plot on which these herbs are grown, the yield and the price have an impact on the annual gross margin that results. These parameters are called the 'input variables'.

6.2.1 Input variables

The result of any analysis that is undertaken will be dependent on the assumptions that are made and the assumptions that underlie the analysis. It is important to decide on these assumptions, such as the size of the operation, the price that can be obtained etc., prior to analysing the results. The variables are discussed in the following sections.

6.2.1.1 Size of the plantation

An important variable is the size of the plot, which in this case is assumed to be one hectare for each of the herbs. The size of the plot has an impact on all cost aspects such as the amount of seed purchased to establish the plot (which will increase proportionally with the size of the area) and the cultivation labour cost which will also increase with larger areas.

6.2.1.2 Number of harvests

The returns of a plot will depend on the number of harvests that can be obtained per annum. For Echinacea, Valerian and Scullcap it is assumed that only one harvest will occur which is in year two. The crop in that context is like an annual such as potatoes, in that new seeding will need to take place after the year of harvest.

6.2.1.3 Yield

The yield figures used in the model have been obtained from trials carried out interstate and in Tasmania. Yield figures published in papers from other states have been used as a guide in this analysis. Yield and price figures are the most uncertain parameters in this analysis. The most useful interpretation of financial results is through a sensitivity analysis of yield and price figures.

The yield range used for Echinacea, Valerian, and Scullcap is from 1,500-6,000 kilogram per hectare. The average used is 4,000 kilogram per hectare.

6.2.1.4 Price

The price of each of the herbs has been obtained through available market information from interstate and overseas. A sensitivity analysis using different price levels for Echinacea, Valerian and Scullcap indicates how strongly changes in price affect the financial outcome of growing these crops. The price ranges used in this analysis are:

Echinacea root	$4.00 to	$12.00	Average	$8.00
Echinacea shoot	$1.25 to	$2.50	Average	$2.00
Valerian	$5.00 to	$15.00	Average	$10.00
Scullcap	$4.00 to	$8.00	Average	$6.00

6.2.1.5 Capital

Because the medicinal herbs discussed here are treated as an annual crop, the capital costs are not taken into consideration. It was assumed that farmers interested in growing this crop would be doing this initially as a sideline to other farming activities. These farmers are likely to be in possession of most of the ground-working equipment and possibly the harvesting equipment. The only equipment that may need to be purchased is a heated air dryer.

The running costs of the equipment have been included as variable running costs in this gross margin analysis.

6.2.2 Returns

The return from growing one hectare of Echinacea, Valerian or Scullcap is simply the amount of product multiplied by the price obtained.

6.2.3 Cost factors

A gross margin analysis takes into consideration all establishment costs and variable costs over time. The establishment costs are incurred in the first years of development, the variable costs are incurred in both the year of establishment and harvest. Each of these costs is broken down into its component parts. The individual cost sections are discussed below.

6.2.3.1 Establishment cost

The purchase of the plant seed and labour cost of planting the seed are the main establishment costs incurred in year one, referred to as 'establishment material' cost. Other costs are land preparation and irrigation costs and planting, manure spreading labour costs, referred to as 'establishment running costs' and 'establishment labour costs' respectively.

6.2.3.2 Variable cost

Annual variable cost is divided into variable material cost, variable labour cost and variable tractor running cost. The variable material cost for medicinal herb production is mainly for the purchase of fertilisers. Other materials in this case are straw and animal manure. Variable labour cost is mainly in terms of fertilising, harvesting and mowing. The running cost is for the operation of the machinery required and the washing and drying equipment.

6.2.4 Gross margin

The gross margin is simply the returns minus the establishment and variable cost incurred. In this analysis the gross margin is negative in year one and mostly positive in year two. This is because costs are incurred in year one but no returns are obtained.

6.2.5 NPV

The NPV of the plantation establishment is defined as today's value of a series of future payments (negative values) and income (positive values). The NPV is dependent on the interest rate as the periodic cash flows are discounted. The interest rate used in this analysis is 8%. The NPV is a 'real' indication of what the gross margin in year two is worth now.

6.3 Discussion of Results

A sensitivity analysis using different levels of price and yield for Echinacea, Valerian and Scullcap is shown in the tables below. The analysis is for one hectare of production.

6.3.1 Echinacea

Table 2 Sensitivity of the Gross Margin in Year Two to Changes in the PRICE of Echinacea Root and Shoot (assuming a yield of 4000 for both the root and the shoot)

Price of the shoot ($/kg)

Price of the root ($/kg)	$1.25	$1.50	$2.00	$2.25	$2.50
$4	$7,429	$8,429	$10,429	$11,429	$12,429
$6	$15,429	$16,429	$18,429	$19,429	$20,429
$8	$23,429	$24,429	$26,429	$27,429	$28,429
$10	$31,429	$32,429	$34,429	$35,429	$36,429
$12	$39,429	$40,429	$42,429	$43,429	$44,429

Table 3 Sensitivity of the Gross Margin in Year Two to Changes in the YIELD of Echinacea Root and Shoot (assuming a price of $8 for the root and $2 for the shoot)

	Yield of the shoot (kg/ha)				
Yield of the root (kg/ha)	1,500	2,500	4,000	5,500	7,000
1,500	$6,032	$7,506	$9,718	$11,930	$14,141
2,500	$12,716	$14,191	$16,403	$18,614	$20,826
4,000	$22,743	$24,218	$26,429	$28,641	$30,853
5,500	$32,770	$34,245	$36,456	$38,668	$40,880
7,000	$42,797	$44,271	$46,483	$48,695	$50,907

6.3.2 Valerian

Table 4 Sensitivity of the Gross Margin in Year Two to Changes in the PRICE and YIELD of Valerian

$34,035	1,500	2,500	4,000	5,500	7,000
$5.00	$4,824	$8,508	$14,035	$19,562	$25,089
$7.50	$8,574	$14,758	$24,035	$33,312	$42,589
$10.00	$12,324	$21,008	$34,035	$47,062	$60,089
$12.50	$16,074	$27,258	$44,035	$60,812	$77,589
$15.00	$19,824	$33,508	$54,035	$74,562	$95,089

6.3.3 Scullcap

Table 5 Sensitivity of the Gross Margin in Year Two to Changes in the PRICE and YIELD of Scullcap

20,788	1,500	2,500	4,000	5,500	7,000
$4.00	$4,763	$7,973	$12,788	$17,603	$22,419
$5.00	$6,263	$10,473	$16,788	$23,103	$29,419
$6.00	$7,763	$12,973	$20,788	$28,603	$36,419
$7.00	$9,263	$15,473	$24,788	$34,103	$43,419
$8.00	$10,763	$17,973	$28,788	$39,603	$50,419

At the low price low yield end of the spectrum the gross margins of each of the herbs remains at about $4,000 to $6,000 per annum per hectare. At the high range of the price and yield bracket the gross margin for Valerian is estimated significantly higher than the other two herbs.

It has to be pointed out that the analysis presented here only takes into consideration the variable cost of growing these medicinal herbs. If capital has to be invested the financial outcomes are likely to be significantly different and possibly not as high as the gross margins presented here.

It also needs to be pointed out that many of the figures used in this analysis are based on the production of one crop. The error in the estimates is possibly high and caution should be taken in using the above figures as a guide. Further research into the financial outcomes of these crops will deliver figures that are likely to be more robust than those presented here.

Appendix II provides detailed tables outlining the costs for Echinacea, Valerian and Scullcap.

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Echinacea Production Guide

Prepared by K Butler, Department of Primary Industry and Fisheries. September 1997

Introduction to the Plant

Echinacea is a perennial herb belonging to the family Compositae and is endemic to the prairie lands of North America. Three species are cultivated for commercial medicinal herb production: Most commonly, *Echinacea purpurea* (purple coneflower), *Echinacea angustifolia* (narrow leaved purple coneflower) and the least common *Echinacea pallida* (pale purple coneflower). The whole plant of *E. purpurea* is utilised, but only the roots of *E. angustifolia* are used.

Echinacea has a world-wide reputation as a natural non-specific stimulant of the immune system. It is also used for internal infections, to heal wounds and sores and for inflammatory skin conditions such as eczema, sunburn and minor burns. Historically, Echinacea was one of the most important plants used medicinally by the North American Indians.

Echinacea angustifolia grows to 60 cm, has long, narrow, entire leaves covered with coarse hairs and is tap rooted. *Echinacea purpurea* grows to 1.2 metres, has larger, more ovate, similarly hairy leaves with the lower ones coarsely toothed and a fibrous root system.

The flower heads are large and solitary and characteristic of the species giving them the common name of coneflower. They are usually rose or purple ray flowers with a cone-shaped receptacle in the centre. Flowering is from December to January.

Cultivation

Both the aerial parts and the roots of *Echinacea purpurea* contain the active ingredient. It therefore can be grown in a short one or two year rotation as a root crop or in a longer three to four year rotation with the 'tops' (leaves, stems and flowers) as the main consideration.

Echinacea are drought and frost resistant, prefer sunny conditions and grow well in soils with a pH range of 6-8. They are lime-loving plants and grow best on fertile, free draining loams. Soil texture is important for harvesting and processing and a soil that can be easily washed from roots is desirable.

Planting and Plant Arrangement

Echinacea can be propagated from seed, crown division or root section. Direct seeding of *E. purpurea* can be successful and should be carried out in early spring. When conditions are not optimum, seed germination can be enhanced by priming and cold stratification of the seed. This consists of putting seeds in damp sand at 4°C (a refrigerator) for a month. Seedlings should be planted in spring. Cell transplants are recommended for planting out of *E. angustifolia* seedlings as having a tap root makes survival more difficult.

Plant density

The current recommended plant density is 25 plants/m^2 on lighter less fertile soils and 10-15 plants/m^2 on more fertile soils. Sowing rate is 6 kg/ha into 40 cm spaced rows. This seems to be a good spacing for weed control and any mechanical operations.

Nutrition and Fertilisers

There is only limited information on the specific nutrient requirements of Echinacea. Fertiliser application information is based on the current knowledge from Tasmania, New Zealand and Germany.

Fertiliser application to any soil depends on the inherent fertility of the soil which will be different for each site. A soil test will give an indication of the phosphorus (P), nitrogen (N) and potassium (K) levels in the soil. Echinacea enjoys a fertile soil and so application of fertilisers will be necessary at most sites.

In Tasmanian trials, fertiliser was applied as N:P:K 8:4:10 at a rate of 300 kg/ha directly after planting. This is equivalent to 24 kg/ha N, 12 kg/ha P and 30 kg/ha K. A follow-up dressing of nitrogen in the form of ammonium nitrate at a rate of 150 kg/ha was applied three months after planting.

In Germany, 150-180 kg/ha of nitrogen is applied in three applications starting three weeks after planting or germination until the end of growing. Phosphorus and potassium are incorporated into the soil prior to planting at a

rate of 70-100 kg/ha P and 220-250 kg/ha K. New Zealand recommendations are to apply N:P:K:S 15:10:10:8 at 500 kg/ha at planting with a follow-up dressing of nitrogen.

Sources of nutrients for organic growing

Organic sources of nutrients may be necessary if the crop is to be grown for organic certification.

Nitrogen can be sourced from animal manures ploughed into the soil immediately after spreading and through using leguminous or green manure crops. The manure crop must be turned into the soil, including tops, at a green, succulent stage. Crops such as alfalfa will fix larger amounts of nitrogen than a crop of garden beans. The crop should be grown in the year prior to the planting of Echinacea.

The best source of phosphorus is from animal bone meal but this is expensive and so difficult to use over a large area. Unless restricted by regulation, it may be necessary to build-up the soil phosphorus reserves with the addition of superphosphates and then maintain levels with plant residues, farm manures and composts which are much lower sources of P.

Most plant residues and farm manures will serve as sources of potassium. These could include hay, straws, hulls and shells as well as dried or fresh manures.

Weed Control

Good weed control is essential to achieve acceptable yields of Echinacea. Pre-sow spraying or planting into a completely weed free bed is imperative. Weed control without the use of pesticides is time consuming but often essential if the crop is to be grown chemical-free. Mechanical weeding or mulching are useful techniques to help contain weed growth.

No herbicides are currently registered for use in the growing of Echinacea in Australia. Preliminary trials undertaken in New Zealand indicate that *E. purpurea* seedlings tolerate the chemicals pendimethalin, oryzalin, and a combination of oryzalin and chlorpropham at planting. Tolerance to terbacil, diuron and chlorpropham when plants are established is also indicated.

Pests and Diseases

There is little information on any major pests or diseases of Echinacea. Few signs of pests and diseases have been recorded in Tasmanian trials.

Pests

Aphids: Aphid infestations on young plants are reported from New Zealand, causing leaf distortion directly attributable to aphid leaf feeding.

Red Legged Earth Mite: There was a suspected isolated outbreak of Red Legged Earth Mite in Tasmanian trials. This caused little damage.

Diseases

There are no recorded root diseases of Echinacea.

Mosaic virus: Cucumber mosaic virus is reported to cause yellow mottling on leaves. Isolated plants should be removed to prevent further spread of the virus by insects.

Harvest and Drying

Aerial parts of the plant collectively known as the ‘tops’ are harvested during summer at ‘Bloom’ or ‘Full bloom’ to maximise the content of active ingredient. ‘Bloom’ refers to at least one flower opened on the main shoot while ‘Full Bloom’ refers to at least one flower opened at most side shoots. Tops must be dried immediately following harvest at 40-45°C.

Roots are harvested during autumn. The tops can be removed before the roots are lifted. Over large areas it is possible to use a digger that can work to approximately 30 cm. Shoot residue needs to be removed, roots are cut into 5-10 cm pieces and thoroughly washed. The fibrous roots of *E. purpurea* are more difficult to clean than the tap root of *E. angustifolia*. The roots are dried at 40-45°C to 12% moisture content at which stage they are brittle.

Drying

Adequate dehydration or drying of product is important to remove most of the moisture from the tops or roots to ensure moulds or decay cannot occur. Drying will remove over 80% of the water from fresh product. It is important to dry without too much heat so losses of volatile ingredient do not occur but at the same time not too slowly so spoilage is prevented.

Expected Yields

In Tasmanian trials, dry weight yields of *E. pupurea* roots after six months ranged from 1000-2600 kg/ha and after 12-18 months ranged from 3500-6600 kg/ha. This variation depended on the planting density, whether direct seeded or seedlings and different environmental conditions. The largest harvest of 6600 kg/ha came from planted seedlings whose roots were lifted at the end of autumn in the second year.

In the same trials, dry weight yields of 'tops' after six months averaged 17,500 kg/ha and after 12-18 months averaged 15,900 kg/ha. Direct seeded Echinacea gave slightly lower yields in both years.

Seed Suppliers

Several varieties have been selected for both pharmaceutical and ornamental purposes. Seed sources include:

Australia
Ellyett's Farm
Lot 102
Peach Orchard Rd
Ourimbah NSW 2258

Diggers Club
105 Latrobe Parade
Dromana Vic 3936

Kings Herb Seeds
3 Church Lane
Cranebrook NSW 2749

Canada
Richter's
Goodwood
Ontario Loc 1A0 Canada

Germany
Flecke-saaten Handle
Germany

United Kingdom
Philip C (ed Lord T) 1991:
The Plant Finder 1991/92 Ed
Headmain Ltd, UK

Seed costs of between $250-$1200 /kg can be expected depending on the species sought. The thousand seed weight is about 3.3 g but can vary from 2.5 to 5g.

Markets

The Australian pharmaceutical industry uses the whole plant in preparations. Around 10 tonnes is current used by one major company (Tabco Pty Ltd).

Prices paid for dried root typically range from $20 to $60/ kg. The price of leaf is in the $8-25 range. The largest markets for Echinacea are in Europe. It is important to identify major buyers and determine their requirements before larger scale production is undertaken.

Further Reading

Fletcher K. *Australian Herb Industry Resource Guide.* PO Box 203 Launceston TAS 7250

Ellyett C. Prof. *The Growing of Echinacea in Australia*. Avalilable from Prof. Ellyett, RMB 5640 Peach Orchard Rd, Ourimbah NSW 2258. Ph 043 621626 or fax 043 484345

Parmenter G *et al*. 1992. *Production of the medicinal crops Valerian and Echinacea in New Zealand.* Proceedings of the New Zealand Agronomy Society 22.

Whitten G. *Herbal Harvest - Commercial Production of Quality Dried Herbs in Australia.* Agmedia, Melbourne Ph 1800 800 755

Valerian Production Guide

Prepared by K Butler, Department of Primary Industry and Fisheries September 1997

Introduction to the Plant

Valerian (*Valeriana officinalis*) is a herbaceous perennial belonging to the family Valerianaceae. This family comprises 150-200 perennial herbs and shrubs and is naturally found in the temperate and cold regions of the northern hemisphere. *V. officinalis* or common Valerian is indigenous to Europe and temperate Asia. The genus also includes species used medicinally in India (*V. wallichii),* Asia *(V. officinalis var. latifolia* - Kesso root) and the Americas (*V. edulis*).

The dried root or rhizome is widely used in herbal and homeopathic medicine for its sedative properties especially in the treatment of nervous exhaustion.

Valeriana officinalis is found in moist woodland and other damp, fertile soils and in drier habitats at higher altitudes. After an autumn establishment and winter dormancy the plant grows from a short rhizome to 1.5-2 m high, flowers and then dies back again in the winter. It bears roundish clusters of pink or white flowers in a dense head. The fresh root has the appearance of a mop - a mass of long, white, relatively unbranched roots, up to 5 mm in diameter and 30 cm long - with a very distinctive and strong penetrating odour.

The species is highly variable and shows widespread differences in ploidy level with diploid, tetraploid and octaploid types occurring. *V. officinalis* is usually polyploidy, English Valerian is usually octaploidy and Central European Valerian usually tetraploidy.

Cultivation

Valerian is easily propagated, grown and harvested. It will grow successfully in a range of soil types and climatic conditions provided it has sufficient water and nutrients. It is said to thrive best in rich loams with adequate moisture but with free drainage. A soil that can be easily washed from the roots is desirable.

Planting and Plant Arrangement

Valerian can be propagated from seed or root stock and can be established in either autumn or spring. Seeds can be raised to a seedling stage and transplanted or direct seeded. Seed viability deteriorates relatively quickly so to ensure fresh supplies it may be necessary to harvest seed in the second growing season. It is dried at 35°C and stored in airtight containers in a cool, dry area.

Plant density

Seed should be sown into a weed-free bed in rows approximately 40 cm apart at a rate of 1.5-3 kg/ha. The seed is small, needs to be sown close to the surface (2-3 cm) and requires good moisture conditions to germinate which will occur in two to four weeks.

Seedlings should be planted in rows 40-50 cm apart with 20-30 cm between plants.

Nutrition and Fertilisers

There is only limited information on the specific nutrient requirements of Valerian. Fertiliser application information is based on the current knowledge from Tasmania, New Zealand and Germany.

Fertiliser application to any soil depends on the inherent fertility of the soil which will be different for each site. A soil test will give an indication of the phosphorus (P), nitrogen (N) and potassium (K) levels in the soil. Valerian prefers a more fertile soil and so application of fertilisers will be necessary at most sites.

In Tasmanian trials, fertiliser was applied as N:P:K 8:4:10 at a rate of 300 kg/ha directly after planting. This is equivalent to 24 kg/ha N, 12 kg/ha P and 30 kg/ha K. A follow-up dressing of nitrogen in the form of ammonium nitrate at a rate of 150 kg/ha was applied three months after planting.

In Germany, 100-120 kg/ha of nitrogen, 50-70 kg/ha of phosphorus and 150-180 kg/ha of potassium is the recommended application to seedlings. Nitrogen is given in three applications throughout the growing season while phosphorus and potassium are incorporated during autumn. For direct sown crops of Valerian, nitrogen is applied at 130-150 kg/ha in three applications, phosphorus at 50-70 kg/ha and potassium in two applications at 180-200 kg/ha.

New Zealand recommendations are to apply N:P:K:S 15:10:10:8 at 500 kg/ha at planting with a follow-up dressing of nitrogen. This is equivalent to 75 kg/ha N, 50 kg/ha P, 50 kg/ha K, 40 kg/ha S.

Sources of nutrients for organic growing

Organic sources of nutrients may be necessary if the crop is to be grown for organic certification.

Nitrogen can be sourced from animal manures ploughed into the soil immediately after spreading and through using leguminous or green manure crops. The manure crop must be turned into the soil, including tops, at a green, succulent stage. Crops such as alfalfa will fix larger amounts of nitrogen than a crop of garden beans. The crop should be grown in the year prior to the planting of Valerian.

The best source of phosphorus is from animal bone meal but this is expensive and so difficult to use over a large area. Unless restricted by regulation, it may be necessary to build-up the soil phosphorus reserves with the addition of superphosphates and then maintain levels with plant residues, farm manures and composts which are much lower sources of P.

Most plant residues and farm manures will serve as sources of potassium. These could include hay, straws, hulls and shells as well as dried or fresh manures.

Weed Control

Good weed control is essential to achieve acceptable yields of Valerian. Pre-sow spraying or planting into a completely weed-free bed is imperative. Weed control without the use of pesticides is time consuming but often essential if the crop is to be grown chemical-free. Mechanical weeding or mulching are useful techniques to help contain weed growth.
Weeding is necessary for plant establishment in the developmental stages but once established Valerian forms a fairly thick root mat which ensures weeds are suppressed. No herbicides are currently registered for use in the growing of Valerian in Australia.

Preliminary trials have been undertaken in New Zealand and indicate that, at the transplant stage, Valerian shows good tolerance to pendimethalin or oryzalin. Established plants showed a high tolerance to all herbicides tested with best growth and weed control following terbacil and diuron.

Pests and Diseases

Few signs of pest or diseases were recorded over the two years of trials in Tasmania. A suspected mosaic virus was observed on some plants at one site and an isolated outbreak of sclerotinia (*Sclerotinia sclerotiorum*) was identified. Neither caused significant damage.

New Zealand reports also indicate that Valerian is relatively free from pests and diseases. *Sclerotinia* spp and *Phoma* spp. were identified in some New Zealand plantings - *Phoma* occurring in moist conditions in spring and *Sclerotinia* in cooler areas in autumn. Grass grub was also identified as causing damage to roots. Control is recommended by cultivation or insecticide prior to sowing.

Harvesting and Drying

Roots are harvested during the winter dormant period. After harvest it is necessary to wash the crop thoroughly. Junctions of roots are especially difficult to clean and the material will often have to be broken up. Drying should commence immediately after washing to prevent the breakdown of the active constituents. A temperature of 40-45°C is recommended for the best preservation of valepotriates, the volatile ingredients. Roots should be dried until brittle which may take between 20-40 hours. They have a strong smell and should be dried separately from other herbs. Store in a dry place.

Drying

Adequate dehydration or drying of product is important to remove most of the moisture from the roots to ensure moulds or decay cannot occur. Drying will remove over 80% of the water from fresh product. It is important to dry without too much heat so losses of volatile ingredient do not occur but at the same time not too slowly so spoilage is prevented.

Expected Yields

In Tasmanian trials, yields of roots ranged from 1700-6300 kg/ha dry weight depending on the growing time, planting densities and different environmental conditions. After six months, the average dry weight of root was 3600 kg/ha. Harvests taken 12-18 months after planting gave an average root dry weight of 5300 kg/ha. This

compares favourably with New Zealand harvests which reported dried root yields of 4000-5000 kg/ha under good conditions.

Seed Sources

Canada
Richter's
Goodwood
Ontario Loc 1AO CANADA
Fax: 0015 1 905 640 6641
Phone: 0011 1 905 640 6677

USA
White Crane Trading Co
447 Tenth Ave
New York, New York 10001 USA
Fax: 0015 1 212 268 9269
Phone: 0011 1 212 736 1457

Markets and Quality

The valepotriate acids present in the root and the aerial parts of the plant are believed to be the active constituents, although their actual mode of activity has not yet been fully determined. The essential oil or valepotriate content is usually used as a measure of quality but most individual companies use their own in-house standards to assess quality based on experience and chemical tests.

The price paid for Valerian depends on quality and processing and is usually in the range of $2-$20/kg.

Further Reading

Fletcher K. *Australian Herb Industry Resource Guide*. PO Box 203 Launceston TAS 7250

Foster S. 1990, *Valerian*. American Botanical Council. Botanical Series No 312

Hobbs C. 1989, *Valerian*: a literature review. Herbalgram 21 (Fall): 19-34

Parmenter G *et al*. 1992. *Production of the medicinal crops Valerian and Echinacea in New Zealand.* Proceedings of the New Zealand Agronomy Society 22.

Whitten G. *Herbal Harvest - Commercial Production of Quality Dried Herbs in Australia.* Agmedia, Melbourne Ph 1800 800 755

Cost Analysis

Cost Analysis for Medicinal Herb Production

Cost Analysis for Echinacea per Hectare

ECHINACEA		
Input assumptions		
Area	1	hectare
Yield (root)	**Year 1**	**Year 2**
Echinacea root (max yield)	4,000	kg/ha
Echinacea root	0%	100%
Total root yield	0	4,000
Yield (herb)	**Year 1**	**Year 2**
Echinacea herb (max yield)	4,000	kg/ha
Echinacea herb	0%	100%
Total herb yield	0	4,000
Prices (root & herb)		
Echinacea root	$8	/kg
Echinacea herb	$2	/kg
Seed cost		
Sowing density	6	kg/ha
Cost of seed	$180	/kg

Results		
	Year 1	**Year 2**
Establishment cost	$1,581	
Variable cost (roots)	$0	$5,965

Variable cost	*(herb)*	$0	$2,271
Other variable cost		$5,915	$5,335
Total variable cost		$5,915	$13,571
Total Returns	(roots)	$0	$32,000
Total Returns	(herb)	$0	$8,000
Gross margin	(roots)	-$7,495	$20,701
Gross margin	(herb)	-$7,495	$394
Gross margin (roots & herb)		**-$7,495**	**$26,429**
Net Present Value		$15,719	

Sensitivity of the gross margin in year 2 to changes in the PRICE of Echinacea root and herb

$26,429	$1.25	$1.50	$2.00	$2.25	$2.50
$4	$7,429	$8,429	$10,429	$11,429	$12,429
$6	$15,429	$16,429	$18,429	$19,429	$20,429
$8	$23,429	$24,429	$26,429	$27,429	$28,429
$10	$31,429	$32,429	$34,429	$35,429	$36,429
$12	$39,429	$40,429	$42,429	$43,429	$44,429

Sensitivity of the gross margin in year 2 to changes in the YIELD of Echinacea root and herb

$26,429	1,500	2,500	4,000	5,500	7,000
1,500	$6,032	$7,506	$9,718	$11,930	$14,141
2,500	$12,716	$14,191	$16,403	$18,614	$20,826
4,000	$22,743	$24,218	$26,429	$28,641	$30,853
5,500	$32,770	$34,245	$36,456	$38,668	$40,880
7,000	$42,797	$44,271	$46,483	$48,695	$50,907

ECHINACEA

RETURNS						Year 1	Year 2
Yield Roots	4,000	kg/ha	@	$8	/kg	$0	$32,000
Yield Herb	4,000	kg/ha	@	$2	/kg	$0	$8,000
TOTAL RETURNS						**$0**	**$40,000**

ESTABLISHMENT MATERIAL COST	No	Rate		$	/unit	Year 1
Echinacea seed	6	kg/ha	@	$180	/kg	$1,080
Green manure			@	$100	/ha	$100
TOTAL ESTABLISHMENT MATERIAL COST						**$1,180**

ESTABLISHMENT LABOUR COST	No	Rate		$	/unit	Year 1
Sowing labour cost	3.5	hr/ha	@	$13.02	/hr	$46
Manure spreading labour cost	1	hr/ha	@	$13.02	/hr	$13
Mouldboard plough labour cost	3	hr/ha	@	$13.02	/hr	$39
Harrow labour cost	0.5	hr/ha	@	$13.02	/hr	$7
Cultivation labour cost	2	hr/ha	@	$13.02	/hr	$26
Irrigation labour cost (3 waterings)	1.5	hr/ha	@	$13.02	/hr	$20
TOTAL ESTABLISHMENT LABOUR COST						**$150**

ESTABLISHMENT RUNNING COST	No	Rate		$	/unit	Year 1
Mouldboard plough running cost	3	hr/ha	@	$6.14	/hr	$18
Harrow running cost	0.5	hr/ha	@	$6.14	/hr	$3
Cultivation running cost	2	hr/ha	@	$6.14	/hr	$12
Irrigator running cost	125	mm/ha	@	$1.74	/mm	$217
TOTAL ESTABLISHMENT RUNNING COST						**$251**

TOTAL ESTABLISHMENT COST	**$1,581**

VARIABLE MATERIAL COST	No	Rate		$	/unit	Year 1	Year 2
Fish fertilizer			@	$190	/ha	$190	$190
Dolomite	2	t/ha	@	$40	/t	$80	
Straw	500	bales/ha	@	$3.50	/20 kg bale	$1,750	$1,750
Animal manure			@	$500	/ha	$500	
TOTAL VARIABLE MATERIAL COST						**$2,520**	**$1,940**

VARIABLE LABOUR COST	No	Rate		$	/unit	Year 1	Year 2
Fertilizer labour cost	0.6	hr/ha	@	$13.02	/hr	$8	$8
Mulching labour cost			@	$50.00	/ha	$50	$50
Manual weed control	256	hr/ha	@	$13.02	/hr	$3,333	$3,333
Digging - **(roots)**	54	hr/ha	@	$13.02	/hr		$703
Washing labour cost - **(roots)**	50	kg/hr	@	$13.02	/hr		$1,042
Heat air drying - **(roots)**	20	kg/hr	@	$13.02	/hr		$2,604
Mowing - **(herb)**	4	hr/ha	@	$13.02	/hr		$52
Harvesting - **(herb)**	9	hr/ha	@	$13.02	/hr		$117
Heat air assisted drying - **(herb)**	40	kg/hr	@	$13.02	/hr		$1,302
TOTAL VARIABLE LABOUR COST						**$3,391**	**$9,211**

VARIABLE RUNNING COST	No	Rate		$	/unit	Year 1	Year 2
Fertilizer tractor running cost	0.6	hr/ha	@	$6.14	/hr	$4	$4
Washing running cost - **(roots)**	50	kg/hr	@	$0.20	/hr		$16
Heat air drying - **(roots)**	0.5	kg/hr	@	$0.20	/hr		$1,600
Heat air assisted drying - **(herb)**	0.5	kg/hr	@	$0.10	/hr		$800
TOTAL VARIABLE RUNNING COST						**$4**	**$2,420**
VARIABLE COST (ROOTS)						$0	$5,965
VARIABLE COST (HERB)						$0	$2,271
TOTAL VARIABLE COST						**$5,915**	**$13,571**

Cost Analysis for Valerian per Hectare

VALERIAN		
Input assumptions		
Area	1	hectare
Yield (root)	**Year 1**	**Year 2**
Valerian root (max yield)	4,000	kg/ha
Valerian root	0%	100%
Total root yield	0	4,000
Price		
Valerian root	$10	/kg
Seed cost		
Sowing density	2	kg/ha
Cost of seed	$550	/kg

Results			
		Year 1	**Year 2**
Establishment cost		$1,601	
Total variable cost		$5,915	$5,965
Total Returns (roots)		$0	$40,000
Gross margin	**(roots)**	**-$7,515**	**$34,035**
Net Present Value		$22,221	

Sensitivity of the gross margin in year 2 to changes in the PRICE and YIELD of Valerian

	$34,035	1,500	2,500	4,000	5,500	7,000
$5.00		$4,824	$8,508	$14,035	$19,562	$25,089
$7.50		$8,574	$14,758	$24,035	$33,312	$42,589
$10.00		$12,324	$21,008	$34,035	$47,062	$60,089
$12.50		$16,074	$27,258	$44,035	$60,812	$77,589
$15.00		$19,824	$33,508	$54,035	$74,562	$95,089

Valerian

RETURNS						Year 1	Year 2
Yield Roots	4,000	kg/ha	@	$10	/kg	$0	$40,000
TOTAL RETURNS						**$0**	**$40,000**

ESTABLISHMENT MATERIAL COST	No	Rate		$	/unit	Year 1
Valerian seed	2	kg/ha	@	$550	/kg	$1,100
Green manure			@	$100	/ha	$100
TOTAL ESTABLISHMENT MATERIAL COST						**$1,200**

ESTABLISHMENT LABOUR COST	No	Rate		$	/unit	Year 1
Sowing labour cost	3.5	hr/ha	@	$13.02	/hr	$46
Manure spreading labour cost	1	hr/ha	@	$13.02	/hr	$13
Mouldboard plough labour cost	3	hr/ha	@	$13.02	/hr	$39
Harrow labour cost	0.5	hr/ha	@	$13.02	/hr	$7
Cultivation labour cost	2	hr/ha	@	$13.02	/hr	$26
Irrigation labour cost (3 waterings)	1.5	hr/ha	@	$13.02	/hr	$20
TOTAL ESTABLISHMENT LABOUR COST						**$150**

ESTABLISHMENT RUNNING COST	No	Rate		$	/unit	Year 1
Mouldboard plough running cost	3	hr/ha	@	$6.14	/hr	$18
Harrow running cost	0.5	hr/ha	@	$6.14	/hr	$3
Cultivation running cost	2	hr/ha	@	$6.14	/hr	$12
Irrigator running cost	125	mm/ha	@	$1.74	/mm	$217
TOTAL ESTABLISHMENT RUNNING COST						**$251**

TOTAL ESTABLISHMENT COST	**$1,601**

VARIABLE MATERIAL COST	No	Rate		$	/unit	Year 1	Year 2
Fish fertilizer			@	$190	/ha	$190	
Dolomite	2	t/ha	@	$40	/t	$80	
Straw	500	bales/ha	@	$3.50	/20 kg bale	$1,750	
Animal manure			@	$500	/ha	$500	
TOTAL VARIABLE MATERIAL COST						**$2,520**	**$0**

VARIABLE LABOUR COST	No	Rate		$	/unit	Year 1	Year 2
Fertilizer labour cost	0.6	hr/ha	@	$13.02	/hr	$8	
Mulching labour cost			@	$50.00	/ha	$50	
Manual weed control	256	hr/ha	@	$13.02	/hr	$3,333	
Digging	54	hr/ha	@	$13.02	/hr		$703
Washing labour cost	50	kg/hr	@	$13.02	/hr		$1,042
Heat air drying	20	kg/hr	@	$13.02	/hr		$2,604
TOTAL VARIABLE LABOUR COST						**$3,391**	**$4,349**

VARIABLE RUNNING COST	No	Rate		$	/unit	Year 1	Year 2
Fertilizer tractor running cost	0.6	hr/ha	@	$6.14	/hr	$4	
Washing running cost	50	kg/hr	@	$0.20	/hr		$16
Heat air drying	0.5	kg/hr	@	$0.20	/hr		$1,600
TOTAL VARIABLE RUNNING COST						**$4**	**$1,616**

TOTAL VARIABLE COST	**$5,915**	**$5,965**

Cost Analysis for Scullcap per Hectare

SCULLCAP		
Input assumptions		
Area	1	hectare
Yield	**Year 1**	**Year 2**
Scullcap (max yield)	4,000	kg/ha
Scullcap	0%	100%
Total yield	0	4,000
Price		
Scullcap	$6	/kg
Seed cost		
Sowing density	2	kg/ha
Cost of seed	$1,300	/kg

Results		
	Year 1	**Year 2**
Establishment cost	$3,101	
Total variable cost	$5,915	$3,212
Total Returns	$0	$24,000
Gross margin	**-$9,015**	**$20,788**
Net Present Value	$9,475	

Sensitivity of the gross margin in year 2 to changes in the PRICE and YIELD of Scullcap

$20,788	1,500	2,500	4,000	5,500	7,000
$4.00	$4,763	$7,973	$12,788	$17,603	$22,419
$5.00	$6,263	$10,473	$16,788	$23,103	$29,419
$6.00	$7,763	$12,973	$20,788	$28,603	$36,419
$7.00	$9,263	$15,473	$24,788	$34,103	$43,419
$8.00	$10,763	$17,973	$28,788	$39,603	$50,419

Scullcap

RETURNS						Year 1	Year 2
Yield	4,000	kg/ha	@	$6	/kg	$0	$24,000
TOTAL RETURNS						**$0**	**$24,000**

ESTABLISHMENT MATERIAL COST	No	Rate		$	/unit	Year 1
Scullcap seed	2	kg/ha	@	$1,300	/kg	$2,600
Green manure			@	$100	/ha	$100
TOTAL ESTABLISHMENT MATERIAL COST						**$2,700**

ESTABLISHMENT LABOUR COST	No	Rate		$	/unit	Year 1
Sowing labour cost	3.5	hr/ha	@	$13.02	/hr	$46
Manure spreading labour cost	1	hr/ha	@	$13.02	/hr	$13
Mouldboard plough labour cost	3	hr/ha	@	$13.02	/hr	$39
Harrow labour cost	0.5	hr/ha	@	$13.02	/hr	$7
Cultivation labour cost	2	hr/ha	@	$13.02	/hr	$26
Irrigation labour cost (3 waterings)	1.5	hr/ha	@	$13.02	/hr	$20
TOTAL ESTABLISHMENT LABOUR COST						**$150**

ESTABLISHMENT RUNNING COST	No	Rate		$	/unit	Year 1
Mouldboard plough running cost	3	hr/ha	@	$6.14	/hr	$18
Harrow running cost	0.5	hr/ha	@	$6.14	/hr	$3
Cultivation running cost	2	hr/ha	@	$6.14	/hr	$12
Irrigator running cost	125	mm/ha	@	$1.74	/mm	$217
TOTAL ESTABLISHMENT RUNNING COST						**$251**

TOTAL ESTABLISHMENT COST	$3,101

VARIABLE MATERIAL COST	No	Rate		$	/unit	Year 1	Year 2
Fish fertilizer			@	$190	/ha	$190	
Dolomite	2	t/ha	@	$40	/t	$80	
Straw	500	bales/ha	@	$3.50	/20 kg bale	$1,750	
Animal manure			@	$500	/ha	$500	
TOTAL VARIABLE MATERIAL COST						**$2,520**	**$0**

VARIABLE LABOUR COST	No	Rate		$	/unit	Year 1	Year 2
Fertilizer labour cost	0.6	hr/ha	@	$13.02	/hr	$8	
Mulching labour cost			@	$50.00	/ha	$50	
Manual weed control	256	hr/ha	@	$13.02	/hr	$3,333	
Mowing	4	hr/ha	@	$13.02	/hr		$52
Washing labour cost	50	kg/hr	@	$13.02	/hr		$1,042
Heat air assisted drying	40	kg/hr	@	$13.02	/hr		$1,302
TOTAL VARIABLE LABOUR COST						**$3,391**	**$2,396**

VARIABLE RUNNING COST	No	Rate		$	/unit	Year 1	Year 2
Fertilizer tractor running cost	0.6	hr/ha	@	$6.14	/hr	$4	
Washing running cost	50	kg/hr	@	$0.20	/hr		$16
Heat air assisted drying	0.5	kg/hr	@	$0.10	/hr		$800
TOTAL VARIABLE RUNNING COST						**$4**	**$816**

TOTAL VARIABLE COST	$5,915	$3,212

Capital Cost Analysis for Echinacea, Valerian and Scullcap

CAPITAL COST	Year 1
Land (cropping quality)	$5,000
Plough, 3 furrow reversible	$14,758
Cultivator, "S" tyne 2.4n c/w crumbler	$1,535
Spray rig	$2,215
Roller	$2,500
Travelling irrigator* (200m run, 16-20 ha capacity)	$13,000
45kW pump & motor	$9,500
Pipes & fittings	$15,000
HEC installation	$5,000
Water supply	$30,000
Small tractor	$25,000
Heavy tractor	$60,000
TOTAL CAPITAL COST	**$183,508**

OVERHEAD COST	Year 1	Year 2 etc.
Rates	$600	$600
Insurance	$1,500	$1,500
Vehicle rego & licence	$1,500	$1,500
Stationary	$1,000	$1,000
Telephone	$1,100	$1,100
Accountant & legal	$1,500	$1,500
Travelling expenses	$1,200	$1,200
Owner/operator labour	$30,000	$30,000
Workers compensation	$2,000	$2,000
TOTAL OVERHEAD COST	**$40,400**	**$40,400**

Cash Flow Development Budget for Intensive Medicinal Herb Production

TRACTOR RUNNING COSTS

Lighter operations tractor running cost						
Fuel consumption	8	L/hr	@	$0.75	/L	
Federal rebate	$0.33	/L				
Total Fuel cost	$3.43	/hr				
Oil (2.5% of Fuel used)	2.5%	/of fuel used	@	$3.33	/L	
Total fuel & oil cost	$4.09	/hr				
Repairs and Maintenance	50%	/of fuel & oil cost				
Small tractor running cost	**$6.14**	**/hr**				
Heavier operations tractor running cost						
Fuel consumption	12	L/hr	@	$0.75	/L	
Federal rebate	$0.33	/L				
Total Fuel cost	$5.14	/hr				
Oil (2.5% of Fuel used)	2.5%	/of fuel used	@	$3.33	/L	
Total fuel & oil cost	$6.14	/hr				
Repairs and Maintenance	50%	/of fuel & oil cost				
Large tractor running cost	**$11.67**	**/hr**				

IRRIGATION COST

Shaft power	38	kW
Assumed efficiency	90%	
Time operated	6	hr/ha
Water applied in time	37	mm/6hr
Average HEC tariff	$0.09	/kWh
Electricity cost	$21.89	/ha
HEC supply charge	$0.01	/hr
Repairs and Maintenance	25%	/of electricity cost
Tractor running cost	$6.14	/hr
Irrigator running cost	**$1.74**	**/mm**

LABOUR COST

Permanent labour cost	$13.02	/hr	Cash crop enterprise budgets 1996

CONTRACT RATES

Potato harvesting contract rates	1	ha	@	$25	/ha	$65,000 potato harvester, Cash crop enterprise budgets 1996 (app 2)
Precision seeding contract rates	1	hr/ha	@	$160	/hr	$15,000 precision seeder, Cash crop enterprise budgets 1996 (app 2)
Manure spreading contract rates	1	hh/ha	@	$50	/hr	

HEC RATES

Network (60 c) & service charge (39 c)	$0.96	/day	=	$0.04	/hr
Light & power				$0.06	/kWh
Total cultivated area	1	Hectares			

Tabco Quality Analysis

T A B C O PTY. LTD.
26 Roseberry St.
Balgowlah N.S.W. 2093

Q.C. NUMBER : S0192

CERTIFICATE OF ANALYSIS

STARTING MATERIAL

ECHINACEA PURPUREA HERB

CODE NO. : 50443A
TRADE NAME : ECHINACEA PURPUREA
DISTRIBUTOR:
LOT NO. : ELLESMERELD
DATE REC'D : 20/05/96
QUANTITY :
CONT. SAMPL: 1
SAMPLED BY : JV
APPEARANCE:
PALE BROWN TO YELLOW/BROWN RHIZOMES, GREEN FOLIAGE AND FLOWERS

PREPARED BY:LB
CHECKED BY :WB
DATE :19/07/93
SUPERCEDES :

TEST	RESULT	Q.C. RELEASE LIMITS
APPEARANCE	CONFORMS	CONFORMS
IDENTIFICATION (TLC)	POSITIVE*	POSITIVE
IDENTIFICATION (A)	POSITIVE	POSITIVE
LOSS ON DRYING	11.22 %	0.00 to 12.00 %
pH RANGE	6.5	4.0 to 7.0
ASH	9.81* %	0.00 to 9.00 %
ACID INSOLUBLE ASH	2.78 %	0.00 to 6.00 %
MICRO TPC	N/T	NMT 10000 Org/g
MICRO YEAST	N/T	NMT 100 Org/g
MICRO MOULD	N/T	NMT 100 Org/g
MICRO COLIFORMS	N/T	NONE DETECTED
MICRO STAPH	N/T	NONE DETECTED
MICRO PSEUDOMONAS	N/T	NONE DETECTED

Comments: SAMPLE IS TOPS WITHOUT FLOWER ONLY
* TLC : MORE INTENSE THAN STD.

ANALYST (S) :JV MB
EXPIRY DATE : 20.05.98

RELEASED BY :
FAILED BY :

DATE OF RELEASE : 3/5/96
DATE OF FAILURE :

T A B C O PTY. LTD.
26 Roseberry St.
Balgowlah N.S.W. 2093

Q.C. NUMBER : S0194

CERTIFICATE OF ANALYSIS

STARTING MATERIAL

ECHINACEA PURPUREA HERB

CODE NO. : 50443A
TRADE NAME : ECHINACEA PURPUREA
DISTRIBUTOR:
LOT NO. : VALLEYFIELD 388 G
DATE REC'D : 20/05/96
QUANTITY :
CONT. SAMPL: 1
SAMPLED BY : JV
APPEARANCE:
PALE BROWN TO YELLOW/BROWN RHIZOMES, GREEN FOLIAGE AND FLOWERS

PREPARED BY:LB
CHECKED BY :WB
DATE :19/07/93
SUPERCEDES :

TEST	RESULT	Q.C. RELEASE LIMITS
APPEARANCE	CONFORMS	CONFORMS
IDENTIFICATION (TLC)	POSITIVE*	POSITIVE
IDENTIFICATION (A)	POSITIVE	POSITIVE
LOSS ON DRYING	8.32 %	0.00 to 12.00 %
pH RANGE	6.2	4.0 to 7.0
ASH	5.68 %	0.00 to 9.00 %
ACID INSOLUBLE ASH	0.80 %	0.00 to 6.00 %
MICRO TPC	N/T	NMT 10000 Org/g
MICRO YEAST	N/T	NMT 100 Org/g
MICRO MOULD	N/T	NMT 100 Org/g
MICRO COLIFORMS	N/T	NONE DETECTED
MICRO STAPH	N/T	NONE DETECTED
MICRO PSEUDOMONAS	N/T	NONE DETECTED

Comments: SAMPLE IS TOPS ONLY
* TLC : MORE INTENSE THAN STD.

ANALYST (S) :JV MB
EXPIRY DATE : 20.05.98

RELEASED BY : Smith
DATE OF RELEASE : 3/5/96

FAILED BY :
DATE OF FAILURE :

T A B C O PTY. LTD.
26 Roseberry St.
Balgowlah N.S.W. 2093

Q.C. NUMBER : S0191

CERTIFICATE OF ANALYSIS

STARTING MATERIAL

ECHINACEA PURPUREA HERB

CODE NO. : 50443A
TRADE NAME : ECHINACEA PURPUREA
DISTRIBUTOR:
LOT NO. : VALLEYFIELD
DATE REC'D : 20/05/96
QUANTITY :
CONT. SAMPL: 1
SAMPLED BY : JV
APPEARANCE:
PALE BROWN TO YELLOW/BROWN RHIZOMES, GREEN FOLIAGE AND FLOWERS

PREPARED BY:LB
CHECKED BY :WB
DATE :19/07/93
SUPERCEDES :

TEST	RESULT	Q.C. RELEASE LIMITS
APPEARANCE	CONFORMS	CONFORMS
IDENTIFICATION (TLC)	POSITIVE*	POSITIVE
IDENTIFICATION (A)	POSITIVE	POSITIVE
LOSS ON DRYING	8.83 %	0.00 to 12.00 %
pH RANGE	6.7	4.0 to 7.0
ASH	0.94 %	0.00 to 9.00 %
ACID INSOLUBLE ASH	0.21 %	0.00 to 6.00 %
MICRO TPC	N/T	NMT 10000 Org/g
MICRO YEAST	N/T	NMT 100 Org/g
MICRO MOULD	N/T	NMT 100 Org/g
MICRO COLIFORMS	N/T	NONE DETECTED
MICRO STAPH	N/T	NONE DETECTED
MICRO PSEUDOMONAS	N/T	NONE DETECTED

Comments: SAMPLE IS ROOT ONLY
* TLC : MORE INTENSE THAN STD.

ANALYST (S) :JV MB
EXPIRY DATE : 20.05.98

RELEASED BY : [signature]
FAILED BY :

DATE OF RELEASE : 3/5/96
DATE OF FAILURE :

T A B C O PTY. LTD.
26 Roseberry St.
Balgowlah N.S.W. 2093

Q.C. NUMBER : S0190

CERTIFICATE OF ANALYSIS

STARTING MATERIAL

ECHINACEA PURPUREA HERB

CODE NO. : 50443A
TRADE NAME : ECHINACEA PURPUREA
DISTRIBUTOR:
LOT NO. : ELLESMERE
DATE REC'D : 20/05/96
QUANTITY :
CONT. SAMPL: 1
SAMPLED BY : JV
APPEARANCE:
PALE BROWN TO YELLOW/BROWN RHIZOMES, GREEN FOLIAGE AND FLOWERS

PREPARED BY:LB
CHECKED BY :WB
DATE :19/07/93
SUPERCEDES :

TEST	RESULT	Q.C. RELEASE LIMITS
APPEARANCE	CONFORMS	CONFORMS
IDENTIFICATION (TLC)	POSITIVE*	POSITIVE
IDENTIFICATION (A)	POSITIVE	POSITIVE
LOSS ON DRYING	7.49 %	0.00 to 12.00 %
pH RANGE	7.0	4.0 to 7.0
ASH	6.29 %	0.00 to 9.00 %
ACID INSOLUBLE ASH	1.12 %	0.00 to 6.00 %
MICRO TPC	N/T	NMT 10000 Org/g
MICRO YEAST	N/T	NMT 100 Org/g
MICRO MOULD	N/T	NMT 100 Org/g
MICRO COLIFORMS	N/T	NONE DETECTED
MICRO STAPH	N/T	NONE DETECTED
MICRO PSEUDOMONAS	N/T	NONE DETECTED

Comments: SAMPLE IS ROOT ONLY
* TLC : MORE INTENSE THAN STD.

ANALYST (S) :JV MB
EXPIRY DATE : 20.05.98

RELEASED BY : [signature]
FAILED BY :

DATE OF RELEASE : 3/5/96
DATE OF FAILURE :

T A R C O PTY. LTD.
26 Roseberry St.
Balgowlah N.S.W. 2093

Q.C. NUMBER : S0189

CERTIFICATE OF ANALYSIS

STARTING MATERIAL

VALERIANA OFFICINALIS ROOT

CODE NO. : 51187A
TRADE NAME : VALERIAN
DISTRIBUTOR:
LOT NO. : VALLEYFIELD
DATE REC'D : 20/05/96
QUANTITY :
CONT. SAMPL: 1
SAMPLED BY : JV
APPEARANCE:
LIGHT BROWN TO YELLOW ROOTS

PREPARED BY:LB
CHECKED BY :WB
DATE :15/09/93
SUPERCEDES :

TEST	RESULT	Q.C. RELEASE LIMITS
APPEARANCE	CONFORMS	CONFORMS
IDENTIFICATION (TLC)	POSITIVE*	POSITIVE
LOSS ON DRYING	7.80 %	0.00 to 15.00 %
pH RANGE	6.0	4.0 to 7.0
ASH	4.29 %	0.00 to 15.00 %
MICRO TPC	N/T	NMT 10000 Org/g
MICRO YEAST	N/T	NMT 100 Org/g
MICRO MOULD	N/T	NMT 100 Org/g
MICRO COLIFORMS	N/T	NONE DETECTED
MICRO STAPH	N/T	NONE DETECTED
MICRO PSEUDOMONAS	N/T	NONE DETECTED

Comments: * TLC:SAMPLE COMPARES WITH LAST BATCHES AND WITH FLACHSMANN-STD.;SAMPLE HAS DARK SPOTS AT RF 0.6 + 0.3

ANALYST (S) :JV MB
EXPIRY DATE :

RELEASED BY :
FAILED BY :

DATE OF RELEASE :
DATE OF FAILURE :

T A B C O PTY. LTD.
26 Roseberry St.
Balgowlah N.S.W. 2093

Q.C. NUMBER : S0188

CERTIFICATE OF ANALYSIS

STARTING MATERIAL

VALERIANA OFFICINALIS ROOT

CODE NO. : 51187A
TRADE NAME : VALERIAN
DISTRIBUTOR:
LOT NO. : ELLESMERE
DATE REC'D : 20/05/96
QUANTITY :
CONT. SAMPL: 1
SAMPLED BY : JV
APPEARANCE:
LIGHT BROWN TO YELLOW ROOTS

PREPARED BY:LB
CHECKED BY :WB
DATE :15/09/93
SUPERCEDES :

TEST	RESULT	Q.C. RELEASE LIMITS
APPEARANCE	CONFORMS	CONFORMS
IDENTIFICATION (TLC)	POSITIVE*	POSITIVE
LOSS ON DRYING	7.59 %	0.00 to 15.00 %
pH RANGE	6.7	4.0 to 7.0
ASH	5.06 %	0.00 to 15.00 %
MICRO TPC	N/T	NMT 10000 Org/g
MICRO YEAST	N/T	NMT 100 Org/g
MICRO MOULD	N/T	NMT 100 Org/g
MICRO COLIFORMS	N/T	NONE DETECTED
MICRO STAPH	N/T	NONE DETECTED
MICRO PSEUDOMONAS	N/T	NONE DETECTED

Comments: * TLC:SAMPLE COMPARES WITH LAST BATCHES AND WITH FLACHSMANN-STD.;IT HAS TWO DARK SPOTS AT RF 0.6 + 0.3

ANALYST (S) :JV MB
EXPIRY DATE :

RELEASED BY :
FAILED BY :

DATE OF RELEASE :
DATE OF FAILURE :

Goldenseal

Problems arose in the securing of planting material for Goldenseal. Seed was not easily available and imported roots and rhizomes were killed by fumigation with methyl bromide, a procedure required by Australian quarantine control. Goldenseal therefore had to be omitted from the study. A comprehensive review of Goldenseal's potential is given below in the form of a report from Dr Jeanine Davis of North Carolina State University. Dr Davis conducted a three year study into the viability of replacing harvesting wild stocks of this herb with the commercial production of cultivated crops.

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Mountain Horticultural Crops Research and Extension Centre
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Fletcher, NC 28732

Originally printed in the 1994 Proceedings of the International Herb Growers and Marketers Associations Conference.

Introduction

Goldenseal (*Hydrastis canadensis* L.) a North American native perennial, is a highly valued medicinal herb which has been collected from the wild throughout the Appalachian region for generations. Unfortunately, native populations have been seriously reduced by over collection in many areas. This is not a new phenomenon. As early as 1884 dramatic declines in wild populations due to over harvesting and deforestation were documented. In North Carolina, goldenseal is now listed as an endangered species, making harvest from the wild illegal. However, this has not stopped people from collecting it and populations continue to decrease. Fortunately, cultivation of this herb is fairly easy.

I encourage cultivation of goldenseal to reduce pressure on native populations. Because of its endangered status in North Carolina, permits from the North Carolina Department of Agriculture are required to cultivate or propagate goldenseal in that state.

Goldenseal also shows some promise as a rotational crop for ginseng. It is difficult, in many cases impossible, to grow ginseng in the same location twice. Growers' experience and preliminary research indicates that goldenseal thrives where ginseng has been grown previously, even where ginseng diseases such as leaf blight and root rot were present.

History

Goldenseal has a long and colourful history. It is known by a large number of names, including yellow root, ground raspberry, eye-balm, yellow paint, wild turmeric and yelloweye. Goldenseal can be found growing wild in forests as far north as Vermont, south to Georgia and west to Arkansas. Goldenseal is usually found growing in patches in open woods in an area with good drainage and a rich soil.

The medicinal properties of goldenseal are attributed to the alkaloids hydrastine and berberine which are present in concentrations of 2-4%. Cherokee Indians used goldenseal as an antiseptic, a general health tonic and to treat snakebite. Iroquois Indians used it to treat whooping cough, pneumonia and digestive disorders. Early American pioneers used it primarily as an eyewash and to treat mouth sores. Commercial demand for the root began in about 1860. It is now a top selling herb in North America and can be found in many formulations in health food stores across the country. Current uses include treatment of nasal congestion, mouth sores, eye infections, ringworm, haemorrhoids, acne and as a topical antiseptic. There is also a common misconception that goldenseal will mask urine tests for illegal drugs. The odour of fresh goldenseal is quite disagreeable and the taste bitter. The odour is only slightly diminished by drying.

Plant Description

Goldenseal is a herbaceous perennial with a bright yellow rhizome marked by cup-like depressions, which look like old wax seals, where the annual stem falls away. The plant emerges in early spring (mid-late April in many areas) from buds that over-winter on the perennial rootstock. Mature plants (at least three years old) have two or more erect hairy stems, 10-14 inches tall and usually two leaves. The five lobed, toothed leaves can be up to twelve inches wide and eight inches long. A flower bud quickly develops and small, inconspicuous, greenish white flowers open in late April to early May. Plants started from seed usually flower when 3-4 years old whereas vegetatively propagated plants may flower the first year. A single, green raspberry-like fruit with 10-30 seeds develops. It turns red and ripens in July. At this stage it is obvious why it is sometimes called ground raspberry. The plants die down slowly after the fruits mature. The goldenseal 'root' is actually a horizontal rhizome, one-half to three quarters of an inch thick, with many fibrous rootlets. The rhizome and rootlets are bright yellow. Usually two buds form near the base of the stem on the rhizome for the next season's growth.

Cultivation

Although goldenseal is fairly easy to grow and has been cultivated since the early 1900s there is little detailed information available on production practices. Many of the current recommendations for goldenseal cultivation are from 1914 U.S.D.A. Farmers' Bulletins and from growers' experience. I can find no reports of replicated university or U.S.D.A. field studies on goldenseal production practices. I have begun some of this research, but it is too early to report results. Therefore, the information provided here is based on: references cited at the end of this article; demonstrations conducted on farms and the research station; and from conversations with goldenseal growers and collectors.

Shade

Goldenseal needs to be grown in the shade, which can be provided artificially or by a natural forest canopy. In general, 75-80% shade is required for optimum growth. Artificial shade can be provided by a wood lath structure, where vine plants grow over a support, or polypropylene shade cloth. When designing the shade structure or preparing beds in the forest, provide for adequate air circulation. For artificial shade, make the structure seven feet tall or higher with the northern and eastern ends open, if possible. For forest culture, select a site with good air and soil drainage in an area shaded by high hardwood trees. In both cases, a slight slope may be desirable to improve drainage.

Soil Preparation

Goldenseal should be planted in a rich, well-drained, moist, loamy soil. I am a firm believer in crop rotation and do not recommend replanting goldenseal in a site immediately after a crop of goldenseal. In a woodland site, remove small, undesirable trees, tree roots, weeds and other undergrowth. In all cases, till the soil and amend, if necessary, to prepare a good planting bed. To promote good water drainage and to warm the soil early in the spring, raised beds should be constructed. Beds can be two to six inches tall and three to five feet across. Leave sufficient alley way between beds to allow for easy walking, pushing a wheelbarrow and kneeling for weeding and picking fruit.

Information in the literature on fertilisation for goldenseal is conflicting. Therefore, take a soil test and follow recommendations for native ornamentals. Most references recommend an organic source of fertiliser, such as composted manure, composted leaves, bone meal, or cottonseed meal and I concur. Most references also state that excessive fertilisation should be avoided. There are no recommendations for soil pH, although goldenseal does grow well under the same soil conditions as cultivated ginseng, which is pH 5.5. Many growers, however, adjust the soil pH to 6-7. A balanced fertiliser can be applied at a low rate each spring as growth commences.

Propagation

Goldenseal can be propagated from rhizome pieces, rootlet cuttings, or seed. It takes 5 to 6 years to grow harvestable roots from seed and 3 to 4 years to grow harvestable roots from rhizome pieces or rootlet cuttings.

Goldenseal can be vegetatively propagated by dividing rhizomes into ½ inch or larger pieces, preferably with a bud on each piece. Most growers want each rhizome piece to have a bud and a few roots, however, I have had success even when no obvious bud was present. Most references state that planting should be done in the fall, however, I have had excellent results with spring planting.

Another method of vegetative propagation is to remove two inch sections of the strong fibrous rootlets exhibiting buds or even just a swelling. This should be done in early spring. Layer them under one inch of soil in a nursery bed. Many of the rootlets should form buds and can be planted in the production beds the following October. Plant rhizome or rootlet pieces 6 to 8 inches apart in rows 6-8 inches apart.

Stratified goldenseal seed is best planted in the fall. Plant 3-4 seeds per foot in rows six inches apart with seeds ½ inch deep. Because of the high price of goldenseal seed, use of a mechanical seeder is recommended. Cover with 2-3 inches of straw or other mulch. Goldenseal seed can also be planted in the spring, but it must be done very early and handled very gently because the seed will certainly have germinated by that time.

Mulch and Irrigation

Goldenseal should be mulched to hold in soil moisture, reduce weed growth, moderate soil temperature changes and provide winter protection. The mulch layer should be several inches deep at time of planting. Depending on the type of mulch, it may need to be replenished every year or two. Extra mulch can be added for winter protection, raking it back to a depth of an inch or so by April 1. Goldenseal can be mulched with shredded leaves, hardwood bark or bark and sawdust mixture, or straw.

Goldenseal is a hardy plant and rarely needs watering, however, under drought conditions if not irrigated the plants will drop their foliage and go dormant earlier than usual.

Pests

Goldenseal suffers few attacks from diseases or insects. My major problem has been slugs which eat the entire crown and fruit. They can be controlled by hand picking or with a slug and snail bait. Moles in the USA, may also damage the beds and should be controlled with traps or by bordering the beds with wire mesh set 8-12 inches deep in the soil. If beds are prepared and mulched properly, weeds are not usually a serious problem. The can usually be managed by hand weeding several times during the season.

Goldenseal has been grown successfully in old ginseng beds, even those known to be infested with disease that would seriously damage ginseng. Root knot nematodes, however, are harmful to goldenseal and the soil should always be tested for their presence before planting. *Phytophthora cactorum*, which causes ginseng root rot, does not seem to affect goldenseal. In artificial shade structures, there may be some problems with damping-off in areas where there is excessive drip from the structure, as under joints and seams.

Seed Collection and Stratification

To collect seed, harvest the fruit when fully ripe. Mash the fruit by kneading, being careful not to damage the seed and ferment in water in a bucket for several days. Decant and rinse until the water is clean or spray the seeds with water over a fine-mesh screen. The seed are small, round, black and hard. Like ginseng seed, they should never be allowed to dry out. Never! Mix the seed, or layer it, with fine, clean, damp sand in a screen pouch or a wooden box with a fine-mesh screen top and bottom. Bury in a shaded, well-drained area exposed to natural rain. The box should remain in the ground for at least 30 days. If the weather has been very wet or dry, after two weeks, uncover the box and ensure that the sand is damp and not waterlogged. The seed can be planted that fall.

Harvest

When goldenseal plants have fully occupied the land they were planted in, about 3-4 years, either harvest the roots or divide the plants. If you don’t, the plants will start to crowd themselves out and the oldest roots will die.

Dig roots in the fall after the tops have died down. If you also have a market for the leaves and stems, you will have to harvest earlier, probably early September while the foliage is still green. Dig carefully, keeping the many fibrous roots intact. Select pieces with buds for replanting and have a container available to keep them moist and cool or have beds prepared to replant immediately. Carefully wash the remaining roots by spraying with a hose over a large mesh screen. Remove all dirt, breaking larger roots if necessary, but do not use a brush. Spread the clean roots on screens and dry in a well-ventilated area in the shade or in a forced-air drier. The roots will lose about 70% during drying. Test for dryness by breaking a large root, it should snap cleanly. Commonly reported yields are 1000-2000 lbs. of dried root per acre. Dried roots should be packed loosely into boxes or cardboard cartons and stored in a cool, dry area secure from rodents.

Current Research

As mentioned previously, many of the specifics for goldenseal production are not available. Therefore, I am conducting experiments looking at soil pH and fertility for optimum goldenseal growth. The old literature says a soil pH of 6-7 is best, but goldenseal grows well in old ginseng beds with a pH of 5.5. To determine the best soil pH, I am growing goldenseal for 3-4 years in soils with pH from 4.5 to 7.5.

Optimum nitrogen and phosphorus levels will also be determined. In this study, growth is measured annually and at the end of the study roots will be analysed to determine if any of these practices influence alkaloid content.

The current supply of vegetative planting stock is limiting to large scale productions of goldenseal. Therefore I am also looking at what is feasible to use as planting stock. It is a common conception that a rhizome piece must have a bud and roots, but my experience has been otherwise. Therefore, use of various sizes and types of propagating material is being studied.
Propagation from seed can be difficult. Some years, 10-90% of the stratified seed is not viable. Growers report the seeds rot or are empty inside, indicating that either an embryo never developed or the embryo died and decayed. Viability loss may be due to poor pollination, disease, or improper stratification conditions. I also have a concern over genetic diversity with extensive vegetative propagation. So, improvements in seed propagation need to be made and will be studied.

Effect of Cultivation

Some people in industry have expressed concern over what effect large-scale cultivation of goldenseal will have on the market situation. In some areas, buyers consider goldenseal to be quite abundant and think there is no need for cultivated sources. In other areas, buyers have noticed a reduction in quantities brought for sale but are leery about cultivated goldenseal because they do not understand how quality and price may be affected. I am not qualified to address these issues and probably only time will tell.

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