RURAL INDUSTRIES RESEARCH & DEVELOPMENT CORPORATION

Native and Scotch Spearmint Oil Production

in Tasmania and Victoria

A report for the Rural Industries Research and Development Corporation

by Fred Bienvenu, Lee Peterson and Jacqueline Edwards

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Foreword

Peppermint oil has been in commercial production in Tasmania and Victoria for over ten years with production aimed at the export markets. Due to the short harvest distillation window (typically 4-6 weeks), extraction equipment is used for peppermint for only a short period and the equipment is then idle until the next season. Establishment of spearmint production in Victoria and Tasmania, would use identical extraction techniques used for peppermint. Export sales could be worth $1-3 m/yr (production from 250-750 ha) in direct oil sales and would significantly offset the cost of large capital investment in steam distilleries, harvest and planting equipment used for peppermint.

This study includes research in three states, Victoria, Tasmania and South Australia. Victoria and Tasmania are the main sites for investigation. A number of aspects of developing a spearmint producing industry have been addressed:

- agronomic parameters including geographic suitability to Victoria, Tasmania & the south eastern corner of South Australia
- pest and diseases management issues incorporating collaboration with Melbourne University study of mint rust control
- oil quality acceptance
- costs of production
- market opportunities
- restraints to adoption.

This report, a new addition to RIRDC's diverse range of over 400 research publications, forms part of our Essential Oils and Plant Extracts program which aims to support the growth of a profitable and sustainable essential oils and natural plant extracts industry in Australia. Agriculture Victoria, through the Specialised Rural Industries program, has similar aims to foster new and further develop emerging rural industries.

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Executive Summary

Spearmint oil crops are mainly grown in the USA with some recent development in China, India, Canada and South America. The world market for spearmint oils is approximately 1500 tonne/yr and increasing at approximately 5% per year. The spearmint oil market, while smaller than peppermint oil (approx. 3500 tonne/yr), is substantial and is one of the larger essential oil commodities. Many oral care products are now using a combination of spearmint and peppermint oils to “soften” the flavour and appeal to a wider market. In some cases blends may be up to 1:1 ratio of the two oils.

The potential of new spearmint oil producers in Canada and Argentina needs to be monitored to ensure that Australia can maintain a competitive advantage in producing the quality of spearmint oil the market requires. Buyers continue to be wary of the quality of spearmint oils produced by Asian suppliers.

The biosynthesis of chemical constituents in the spearmint plant does not have the strict geographic or climatic constraints that peppermint oil production involves. There are no major undesirable oil components and the quality of the spearmint oil produced is influenced mainly by variety and management rather than geographical location. This broadens the potential area suitable for spearmint oil production. The major limiting factors will be soil type, irrigation capacity and access to processing infrastructure.

The fungicide bitertanol (Baycor) gave the most effective control of mint rust and resulted in the highest oil yields of the six fungicides evaluated on Scotch spearmint at the Ovens Research Station. This was consistent over two seasons with different levels of disease in each. Tebuconazole (Folicur) was also effective, its use resulting in high levels of disease control and good oil yields, particularly under the high inoculum potential of the first year.

Similar results were observed in Tasmania. Oil yields were highest from bitertanol (Baycor) treated plots followed next by tebuconazole (Folicur). When compared with propiconazole (Tilt), the relative order of effectiveness is similar in both states. The magnitude of the difference is less in Tasmania than in Victoria.

Victorian peppermint growers rely on a single registered fungicide, propiconazole (Tilt) for rust control. This practice carries the risk of developing a fungicide-resistant pathogen population. The results from these trials show that several readily-available fungicides (but not registered for use on mint crops) are more effective at controlling mint rust on Scotch spearmint than propiconazole, with a corresponding increase in oil yield. Tasmanian peppermint growers use tebuconazole (Folicur) in addition to propiconazole (Tilt).

It is recommended that growers and governments pursue minor-use registration of bitertanol (Baycor) and tebuconazole (Folicur) which allow these fungicides to be alternated. Edwards (1998) suggests the use of multiple fungicides may reduce the likelihood of fungicide resistance arising in the local pathogen population.

Large scale harvesting and distillation were used in Victoria to permit more accurate estimation of commercial yield figures likely to be obtained in a full-scale spearmint oil production enterprise. The spearmint oil yield from semi-commercial plots in 1998 was higher than obtained when harvesting peppermint (113kg/ha compared with 105kg/ha for peppermint) using the same harvest and distillation equipment. These bulk blocks were treated with propiconazole fungicide only. As has been shown in the mint rust control section of this report, propiconazole (Tilt) was out-performed by bitertanol (Baycor) by approximately 40% in the same year as the bulk harvests (and 25% in the previous year). If a similar yield increase was realised by the use of bitertanol, bulk yields of Scotch spearmint using bitertanol fungicide may have produced Scotch spearmint oil yields of close to 160 kg/ha. This yield of spearmint oil is reached in only some areas of the USA.

Native spearmint oil production from a semi-commercial plot was some 20-30 % less than Scotch spearmint oil. With lower prices paid for Native than for Scotch spearmint oils there is little reason to produce the Native spearmint variety when Scotch spearmint can be successfully produced.

The two main producers of peppermint in Victoria have indicated that they are keen to put in trial blocks of Scotch spearmint adjacent to their peppermint oil production areas. These producers see the capital advantages in having multiple uses for their expensive harvest distillation equipment and diversification of their production base. They also consider that the economic opportunities for spearmint oil production are improving as the spearmint marketing order in the far-west of the USA breaks down. It is recommended the peppermint/spearmint planting ratio for Australia approximate the same ratio as demand worldwide ie: approximately 3:1 unless a very clear difference in profitability can be shown.

The oil produced in south eastern South Australian was of acceptable quality although the necessarily limited sample size made it more difficult to assume more. The results obtained so far are encouraging. Plantings should be scaled up to obtain more commercially realistic results which would enable potential investors to base their plans on reliable data.

Two samples of Scotch spearmint oil were sent overseas to be evaluated for their commercial acceptance by the flavour and fragrance industry. These samples were taken from the maximum yielding period of the trial crops. The samples were sent to be evaluated by European traders in essential oils. The oil samples were assessed on a purely visual and organoleptic basis. The results were very encouraging and indicated that the environmental conditions and the variety of Scotch spearmint trialed in this study are commercially acceptable.

Gross margin analysis has shown production of Scotch spearmint oil to be equally profitable to peppermint in the areas studied. Sensitivity to prices and production of spearmint oil are shown to assist in the decision making process.

Agronomic practices used for the production of peppermint were successful in producing satisfactory quality and yields of Scotch spearmint oil. The largest difference encountered in producing Scotch spearmint oil when compared to peppermint is the requirement for far more attention to produce a crop free from the ravages of mint rust.

As pointed out in this report industry development for spearmint oil is not geographically confined to the extent that peppermint oil production is. The lack of a negative oil component in spearmint allows for potential production sites from a wider area. The most limiting resource will be the availability of water in some regions.

This study has not produced a separate manual for likely producers due to a problem in recommending unregistered chemicals for rust control. The current Victorian Peppermint Growers Manual is adequate for general management and agronomic issues. The potential success of spearmint oil production in regions outside the current peppermint oil production areas is likely to depend more on an availability of registered pest/disease control chemicals than an agronomic practice.

Sufficient information has been established as an outcome of this study to steer potential producers towards the establishment of a second mint oil industry. Initially it is expected that the existing peppermint industry should act on these findings to augment their peppermint enterprises and make more use of the extensive capital infrastructure already in place. Further work may be required to study spearmint oil production in the wider geographic context.

1. Introduction

Oils from three main species/varieties of Mentha are commercially produced in the temperate areas of the world - peppermint oil (*Mentha x piperita*), Native spearmint oil (*Mentha spicata*) and Scotch spearmint oil, (*Mentha x gracilis* (syn: *M. cardiaca*)). A fourth mint oil, cornmint (*Mentha arvensis*) is produced mainly in India and China for the production of menthol flakes and dementholated peppermint oil.

Spearmint crops are mainly grown in the USA with some recent development in China, India, Canada and South America. The world market for spearmint oils is approximately 1500 tonne/yr and increasing at approximately 5% per year. The spearmint oil market, while smaller than peppermint oil (approx. 3500 tonne/yr), it is substantial and is one of the larger essential oil commodities. Many oral care products are now using a combination of spearmint and peppermint oils to “soften” the flavour and appeal to a wider market. In some cases blends may be up to 1:1 ratio of the two oils.

Peppermint oil is in commercial production in Tasmania and Victoria. Due to the short harvest distillation window (typically 4-6 weeks), extraction equipment is used for only a short period and the equipment is then idle until the next season. Diversification of any other crop that uses existing capital infrastructure has a considerable advantage over commencing with a new crop with the need for new processing facilities. Spearmint is a close botanical relative to peppermint and has similar but not identical production requirements to peppermint.

The price of spearmint oil fluctuates from year to year with Native spearmint typically at 20-40% less than peppermint oil and Scotch spearmint 0-10% more than peppermint oil. Maximum prices are only reached if the major oil components carvone and limonene are in the correct balance with the other flavour components. Currently spearmint prices are rising and are expected to continue rising for several years. Establishment of spearmint production in Vic. and Tas. could be worth $1-3m /yr (production from 250-750 ha) in direct oil sales and would significantly offset the cost of large capital investment in steam distilleries, harvest and planting equipment used for peppermint oil production. It is a rare new crop which can have its infrastructure costs already paid for by an existing crop.

The synthesis of the chemical constituents in spearmint oil does not have strict geographic or climatic constraints that peppermint oil production involves. There are no major undesirable oil components and the quality of the spearmint oil produced is influenced mainly a variety and management rather than geographical location. This broadens the potential area for suitable for spearmint oil production. The limiting factors will be soil type, irrigation capacity and access to processing infrastructure.

During the last 10 years there has been some small commercial production of spearmint oil in Tasmania. This has been solely from the Native variety. Some small areas of Scotch spearmint have been grown in Tasmania but not for many years. The major factor which limited and finally lead to production ceasing was the severe yield losses which resulted from defoliation due to rust infection. Therefore the re-establishment of a true to type Scotch spearmint planting was necessary in Tasmania as no true to type planting material could be identified in the State.

In Victoria no commercial scale spearmint oil crops have been produced to date. Both Scotch and Native spearmints were introduced with the original peppermint varieties from Oregon, USA in 1976. Spearmint of both varieties was included in the early trials established to investigate the potential to produce mint oils in Victoria. Early indications were that it had the potential to yield well but only if the mint rust fungus could be controlled.

More than leaf loss can result from unchecked mint rust infection. Total loss of plant material is possible as mint rust is particularly severe on Scotch spearmint. Unless an effective fungicide program is available to control mint rust, it is unlikely that spearmint oil could be produced economically in south east Australia

1.1 Objectives

1. To investigate the potential of Native and Scotch spearmint for production of high quality oil in Victoria and Tasmania by determining the effects of major production variables on yield and composition of oil produced.

2. To assess the effect of oil composition on the marketability of spearmint oils in the essential oil markets of the world.

3. To estimate cost of production and potential returns from commercial production of oil of spearmint.

4. To produce a manual for the cultivation of spearmint which includes: planting, establishment, pest and disease management, nutrition and harvest strategies to maximise yield and quality.

2. Methodology and Results

2.1 Agronomic Studies

Establishment of Trials Sites

The Department of Natural Resources and Environment in Victoria provided planting material in the form of washed stolons from plant stock held at the Ovens Research Station in Myrtleford. Genetically identical planting material was utilised for the trials in both states.

Some 25 kgs of stolons were transported to Tasmania and planted at Nichols Rivulet in southern Tasmania along a small alluvial river flat consisting of a brown clay loam on river wash.

In Victoria, the site was adjacent to sites used for considerable peppermint research over the past decade. The soil is a sandy clay loam possessing good drainage.

2.1.1 Preparation and Planting – Year 1

In Victoria, the site was treated with Roundup CT at 2l/ha and cultivated later in preparation for hand planting of stolons from a nearby nursery block. An equivalent rate of 250 kg/ha of 9:14:17 (NPK) was applied along with the equivalent of 1 tonne of lime/ha.

An area of 15m by 30m of scotch spearmint was established. An existing area of Native spearmint was rejuvenated by ploughing and fertilising. This provided the trial site necessary for the study.

In Tasmania, Roundup CT and MCPA 500 at 2 and 1.5 l/ha respectively were applied to the site in the last week of August. The weed spectrum at this point consisted of plantain, docks, brown top and clovers. Two weeks later the sprayed area was disced and rotary hoed to form a fine seedbed. A basal fertiliser plus lime was applied before the last working. An equivalent rate of 250 kg/ha of 9:14:17 (NPK) was applied along with the equivalent of 1 tonne of lime/ha.

Scotch spearmint stolons from Victoria were broken into approximately 50 to 60 mm lengths and planted by hand in rows. The distance between stolon fragments was approximately 200 mm and row spacing was 250 mm. The limited amount of material resulted in a final area of 10 m by 20 m.

A planting regime of 0.3m x 1m allowed for an area of 450 m2 to be established in Victoria (at the Ovens Research Station). This plot was slower to have overlap plants however it provided a planted area to conduct the fungicide trial year 1 (see details in this report). In Tasmania, this first year establishment of Scotch spearmint provided only 200 m2 of trial site. Only yield determination trials were performed on this material. Insufficient area was available to conduct fungicide trials until expansion of the trial site the following year.

At both sites, immediately following planting a pre-emergent herbicide was applied. The registered herbicide terbacil (Sinbar) was used at an equivalent rate of 1.5 kg/ha in 350 l/ha of water. Terbacil (Sinbar) requires irrigation to incorporate the material within three days of application. In Tasmania this was down within one hour while in Victoria this herbicide was watered the next day after application.

Irrigation for the duration of the two-year project utilised overhead sprinklers at both sites. These were a Rainspray no.15 that applied approximately 15 mm /hr in Tasmania and Naan applying 8-10mm /hr in Victoria.

In Tasmania two applications of ammonium nitrate each at a rate of 75 kg (act N)/ha were applied on the 5th of October and again on the 15th of December. Both applications were watered in with irrigation. In Victoria, a total of 200 kg (act N)/ha was applied for the season in three equal applications, again as ammonium nitrate. As in Tasmania, these nitrogen applications were irrigated in.

2.1.2 Preparation and Planting - Year 2

Considerable expansion of the planted area in Victoria was performed by hand as the commercial peppermint lifters and planters were considered too large for the limited material available. A planting density equal to the initial planting was used. The new area adjacent to the old site of approximately 1800 m^2 was established for use in year 2. A similar fertiliser regime to year 1 was employed.

In Tasmania in year 2 a similar program to the first was applied to the area adjacent to the first year trial site but this time in early May. The weed spectrum at this point consisted of plantain, docks, brown top and clovers.

Large plants from the first planting were lifted and stolons were washed and broken into pieces approximately 100 mm in length. These stolon segments were then planted by hand in rows. The distance between stolon fragments was approximately 200 mm and row spacing was 250 mm. Planting was completed on the 25th of July. The first planting was then cultivated to a depth of 50-70 mm using a rotary hoe and harrowed to disperse stolon segments evenly throughout the trial area. The new site plus the existing planting measured a total of 600 m^2 available for experimental use in year 2. For the second growing season both areas were treated as one in respect to irrigation and fertiliser applications.

The herbicide terbacil (Sinbar) was then applied at an equivalent rate of 2 kg/ha (in Tas) and 1.5 kg/ha (in Vic) in 350 l/ha of water.

2.2 Mint Rust Control

2.2.1 Victoria

Material, methods and treatments

In Victoria, during May 1996 *Mentha x gracilis* cv. Scotch spearmint rhizomes were transplanted to the trial area in a randomised complete block. Seven treatments and four replicates per treatment were applied to the trial site.

The seven treatments were as follows:

- control (no fungicide),
- bitertanol (1.7 ml/L as **Baycor** 300EC, Bayer)
- triadimenol (0.7 ml/L as **Bayfidan** 250EC, Bayer)
- fluquinconazole (30 g a.i./100L as **Castellan** 250WP, Agrevo, *now discontinued*)
- tebuconazole (300 ml/ha as **Folicur** 250, Bayer)
- myclobutanil (1.2 g/L as **Systhane** 400WP, Hoescht)
- propiconazole (500 ml/ha as **Tilt** 250EC, Novartis).

Each plot was 1m x 5m in area with rows separated from each other by guard rows of untreated Scotch spearmint. This reduced the drift of fungicide across the rows and kept inoculum pressure high. No inoculation with urediniospores was necessary prior to treatment as there was plenty of field inoculum.

In May 1997, rhizomes from the first year's trial site were transplanted to an adjacent larger area of paddock. A randomised complete block design was used with the same plot sizes as described above.

The fungicide treatments were applied using a 15 L knapsack sprayer with the addition of 1ml/L wetting agent (as Agral 600, manufactured by Crop Care Australasia) and the dates of application were:

- Trial 1 (1996/97): 25th November, 12th and 27th December 1996
- Trial 2 (1997/98): 1st, 14th and 28th December 1997

Disease assessment

- Disease incidence was calculated as the percentage of leaves on a shoot with one or more uredinia.
- Disease severity is a measure of the leaf area lost due to disease. In this study, it was calculated as the mean percentage leaf area loss per shoot, using a visual assessment key adapted for rust on peppermint by Beresford and Mulholland (1987). The mean of three measurements, one from each third of the shoot was taken as the disease severity value of the shoot. Missing leaves were ignored.
- Shoot defoliation was calculated as the percentage of bare leaf nodes per shoot.

Sampling

Samples were taken immediately prior to treatment application and again immediately prior to harvest for the purpose of disease assessment. Ten upper side-shoots were taken at regular intervals along a longitudinal transect of the plots. The samples were assessed as described above, and the mean values for disease incidence, disease severity and shoot defoliation were calculated for each sample. Pre-treatment assessments of each plot in both seasons confirmed that there were no significant plot differences in disease levels before the fungicides were applied.

Harvest and oil distillation

Trial 1 was harvested on 30 January 1997 and trial 2 on 28 January 1998. One m^2 was harvested from the centre of each plot, in order to minimise interplot interference, by cutting all the above-ground plant parts at ground level with a hedge trimmer. The cut herbage was weighed and then passed directly through a garden mulcher, in order to simulate the physical and chemical composition of field harvest. The herbage was then distilled and the volume of the distilled oil measured. Fresh weight / m^2 and oil yield, converted to kg/ha rate, were recorded for each plot.

Statistical analysis

Disease incidence, severity, shoot defoliation, fresh weight and oil yield per treatment were compared using one-way analysis of variance, and differences were compared using Fisher's least significance difference ($P < 0.05$). Disease severity data from trial 1 and both disease severity and defoliation data from trial 2 were transformed using a $\log_{10}$ transformation prior to analysis in order to satisfy the requirement for normality.

Detailed results

Bitertanol and tebuconazole were consistently the most effective fungicides and fluquinconazole was consistently the least effective in each trial, even though the level of disease was much higher in the first trial (Figure 1).

Environmental conditions in the first year (trial 1) were extremely favourable for disease development. Under the consequent high inoculum level, bitertanol significantly reduced the disease incidence, but in trial 2 with less inoculum potential, disease incidence was the same across all treatments (Table 1). Disease severity was significantly reduced by all of the fungicides, except fluquinconazole, in both trials, with the most effective, bitertanol, reducing severity to approximately 5% (Figure 1).

Under conditions conducive to severe disease, in trial 1, all fungicides reduced the level of shoot defoliation compared to the control, but under less disease pressure, in trial 2, fluquinconazole was not effective. Bitertanol was significantly better than all the rest over both years.

Fresh weights did not differ ($P < 0.05$) across treatments in trial 1, but there were significant differences between oil yields, with twice as much oil produced under the bitertanol and tebuconazole treatments than under the fluquinconazole treatment or the control. In trial 2, treatments with bitertanol and tebuconazole resulted in significantly higher yields both in terms of biomass and oil production. The other fungicides were not significantly better than the control in that year.

There was a clear negative correlation between the final level of disease severity on the upper side-shoots and the oil yield (Figure 1). The performance of the fungicides was fairly consistent for both years, although triadimenol was more effective and myclobutanil less effective when the conditions were conducive to severe disease (trial

1).

Discussion of results

The fungicide bitertanol (Baycor) gave the most effective control of mint rust and resulted in the highest oil yields of the six fungicides evaluated on Scotch spearmint at the Ovens Research Station. This was consistent over two seasons with different levels of disease in each. Bitertanol had shown potential in 1989/90 on peppermint and in 1990/91 on Scotch spearmint (in DAV 24A) and was nominated as a fungicide that should be investigated further.

Tebuconazole (Folicur) was also effective, its use resulting in high levels of disease control and good oil yields, particularly under the high inoculum potentials of the first year. It has also been reported to effectively control mint rust on peppermint in the USA (Grey and Welty 1995).

Two fungicides nominated (in DAV 24A), propiconazole (Tilt) and myclobutanil (Systhane), were not as effective at controlling mint rust as expected. Propiconazole is the most commonly used fungicide on several *Mentha* species and is currently registered for use as a fungicide in both Victorian and Tasmanian peppermint crops. In this experiment, while it was much more effective than the control, it was not as effective as the fungicides discussed above. Myclobutanil was not very effective, which was surprising considering it was the best fungicide in the 1990/91 screening trial (in DAV 24A) and has been reported as being particularly effective against mint rust on peppermint in the USA (Grey and Welty 1995, 1998). In the present study, its effectiveness broke down in trial 1 when the environment was especially favourable for disease development.

Victorian peppermint growers rely on a single fungicide, propiconazole (Tilt) for rust control. This practice carries the risk of developing a fungicide-resistant pathogen population. The results of this trial show that several readily-available fungicides are more effective at controlling mint rust on Scotch spearmint than propiconazole, with a corresponding increase in oil yield. For example, bitertanol reduced rust severity from 67% to 5% in the first year and from 27% to 6% in the second year, compared to propiconazole which reduced it from 67% to 56% in year 1 and 27% to 18% in year 2. In addition, bitertanol increased oil yield by 112% and 111% respectively compared to untreated controls, whereas propiconazole increased it by only 57% and 28% respectively.

In view of this, it could be recommended that growers use a combination of fungicides, alternating their use to reduce the likelihood of fungicide resistance arising in the local pathogen population. The fungicides identified in this study that could be used in such a manner were bitertanol and tebuconazole, with triadimenol in seasons particularly favourable to the development of the disease. Unfortunately, they are all demethylation-inhibiting (DMI) fungicides that inhibit C-14 sterol demethylation *ie.* they all have a similar mode of action, and changes in pathogen sensitivity to one may affect sensitivity to the others.

It has been recommended by Scheinpflug (1988) that to minimise the development of DMI fungicide resistance the following management strategies should be followed:

- “DMI fungicides should not be used continuously throughout the growing season.

The number of foliar applications should be limited to a maximum of four to eight sprays per season";

- "a minimum of two to three consecutive (block) treatments are necessary to achieve the maximum performance benefit from DMI fungicides. If more than this is required, two or more blocks of two to four treatments is the preferred method."

There is a need to investigate fungicides with different modes of action. Incorporation of two or more fungicides from different chemical groups into the growers' mint rust control program should be promoted to ensure that their effectiveness is not broken down.

Table 1 Effect of several fungicides on fresh weight, oil yield, disease incidence, severity and shoot defoliation of *M. x gracilis* cv. Scotch spearmint infected with mint rust.

	Fresh weight (mg/m^2)		Oil (kg/ha)		Disease incidence (%)		Disease severity (%)		Defoliation (%)	
	96/7	97/8	96/7	97/8	96/7	97/8	96/7	97/8	96/7	97/8
Control	2526a	1868bc	49c	64b	99.0a	59.5a	66.9e	26.6d	57.6d	31.0d
Bitertanol	3609a	3294a	104a	135a	54.9b	56.7a	5.3a	5.6a	24.2a	1.1a
Triadimenol	3459a	2016bc	86b	64b	96.7a	68.9a	51.2bc	18.3bc	38.6b	15.5bc
Fluquinconazole	2485a	1744c	54c	59b	97.9a	62.7a	65.9e	24.7d	49.4c	24.6d
Tebuconazole	3516a	3248a	100a	113a	96.8a	60.3a	27.1b	13.7b	35.6b	6.4b
Myclobutanil	3057a	2560ab	63bc	85b	96.8a	63.9a	67.9d	20.2c	42.1bc	19.7c
Propiconazole	3414a	2512b	78ab	82b	98.1a	61.1a	56.1cd	17.6c	38.8b	11.8c

NB: Values in the same column sharing a common letter are not significantly different at P=0.05.

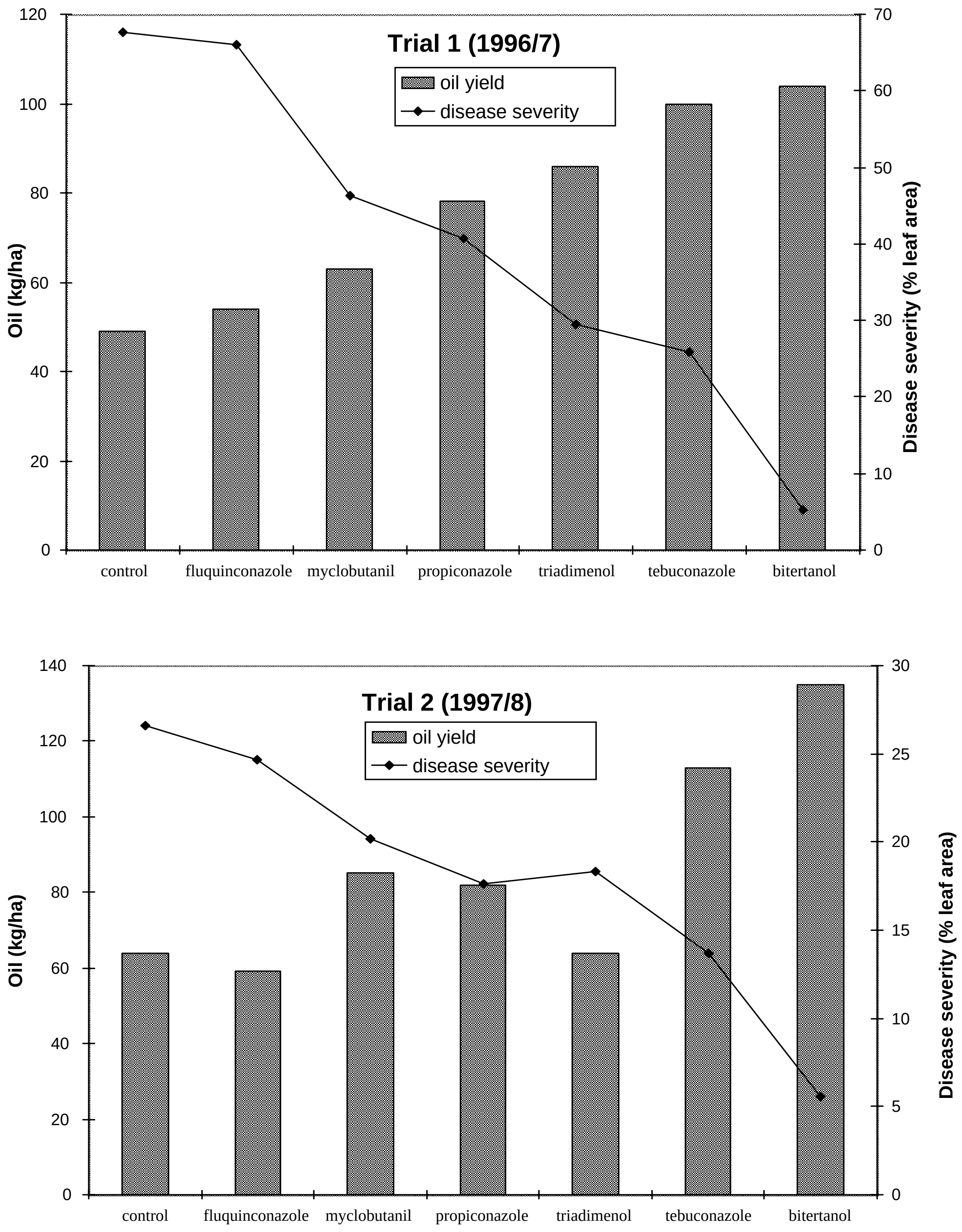

Figure 1 Oil yields and final disease severity levels of *M. x gracilis* cv. Scotch spearmint infected with mint rust after different fungicide treatments. The data presented is the mean of the replicates in the Victorian studies.

2.2.2 Tasmania

Material, methods and treatments

Seven fungicides treatments were examined for their efficacy on *Puccinia menthae*, rust. These are the same fungicides used in the Victorian experiments.

- control (no fungicide),
- bitertanol (1.7 ml/L as **Baycor** 300EC, Bayer)
- triadimenol (0.7 ml/L as **Bayfidan** 250EC, Bayer)
- fluquinconazole (30 g a.i./100L as **Castellan** 250WP, Agrevo, *now discontinued*),
- tebuconazole (300 ml/ha as **Folicur** 250, Bayer)
- myclobutanil (1.2 g/L as **Systhane** 400WP, Hoescht)
- propiconazole (500 ml/ha as **Tilt** 250EC, Novartis).

Stock solutions were made up using 10 ml of product into 100 ml volumetric flasks. A 20 ml sample was removed by pipette, made up to a 1 litre, resulting in a 2 ml/l dilution.

Plots were established 5 m long and 1.5 m wide with 1m buffer. Spray application was made using a knapsack sprayer so that final product application rate was 2.5 l/ha for all products. Fungicide applications commenced on the 11th of December and were repeated fortnightly through to 22nd of January.

Two main harvests were taken from the trial plots, the first was on the 7th of January and a second harvest on the 28th of January. All above-ground portion of the plant was harvested from three 1/2m^2 quadrats, weighed and distilled using laboratory scale steam distillation facilities. All samples were distilled for 2 hours and resultant oil samples weighed. Final yield determinations were then expressed as an equivalent yield in kg/ha.

Tasmanian Pathology Results

The results shown in figure 2 & 3 show the superior performance of bitertanol (Baycor) compared to the other treatment including propiconazole (Tilt). Whilst differences were not statistically significant (P=0.05) (due to the small number of plots and plot size involved from the small plot site available), results obtained support the trial results obtained in Victoria and can an additional level of confidence in the Victoria data.

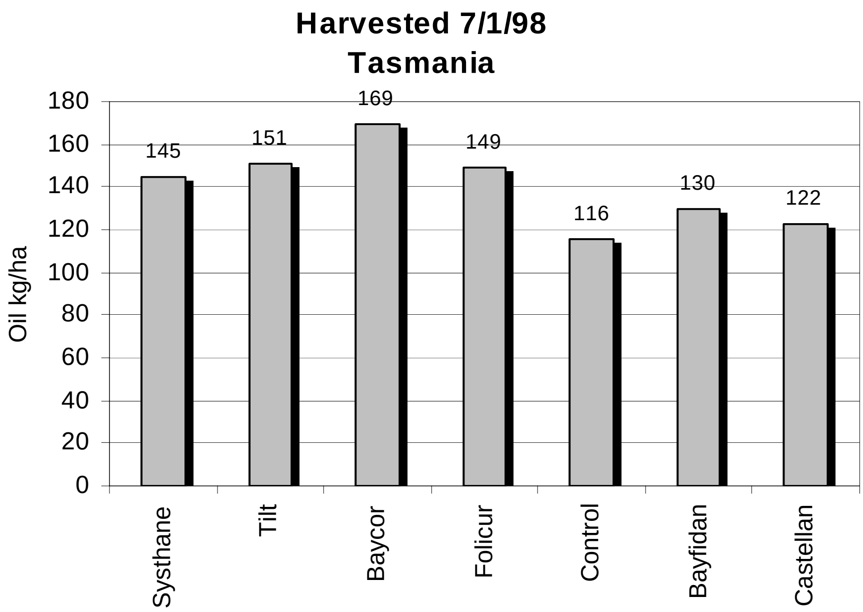

Figure 2 Means of oil yield from early samples are shown
In the second of the two sampling periods the relative differences in the two sampling dates are shown.

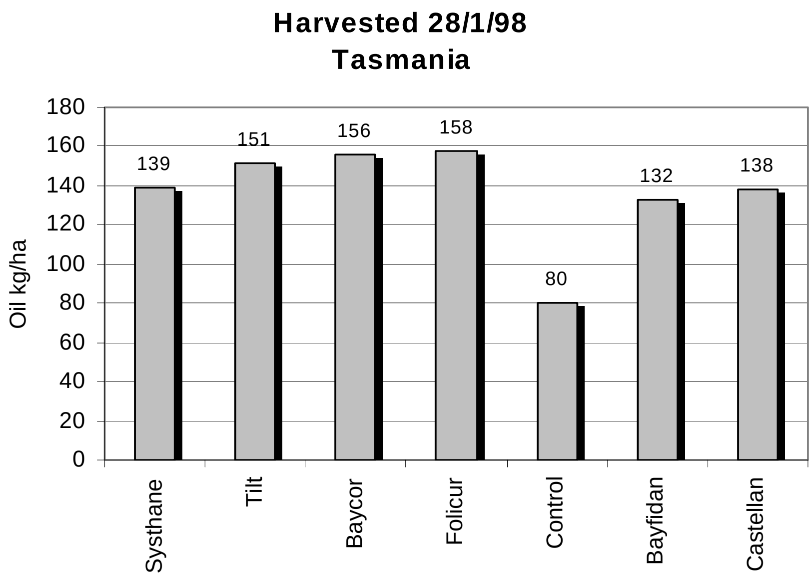

Figure 3 Means of oil yield from later samples are shown

The results have been expressed in figure 4 below as the performance in equivalent kg/ha compared to the yield from the trial plot samples that received the industry standard fungicide, propiconazole (Tilt). As in the Victorian results, the oil yields Baycor and Folicur tend to be superior to Tilt. The relative order of effectiveness is similar in both experiments. The magnitude of at the difference is less in Tasmania.

As observed in Victoria in the previous season, the yield potential was directly related to the degree of leaf retention and was therefore not statistically monitored.

The performance of the fungicides varied somewhat between Tasmania and Victoria. Given the clonal heritage of the spearmint growing in both areas this may be related to differing strains of rust present and/or climatic differences between Victoria and Tasmania. Further work would be needed to more fully understand the strains of mint rust across the two states (Edwards 1998).

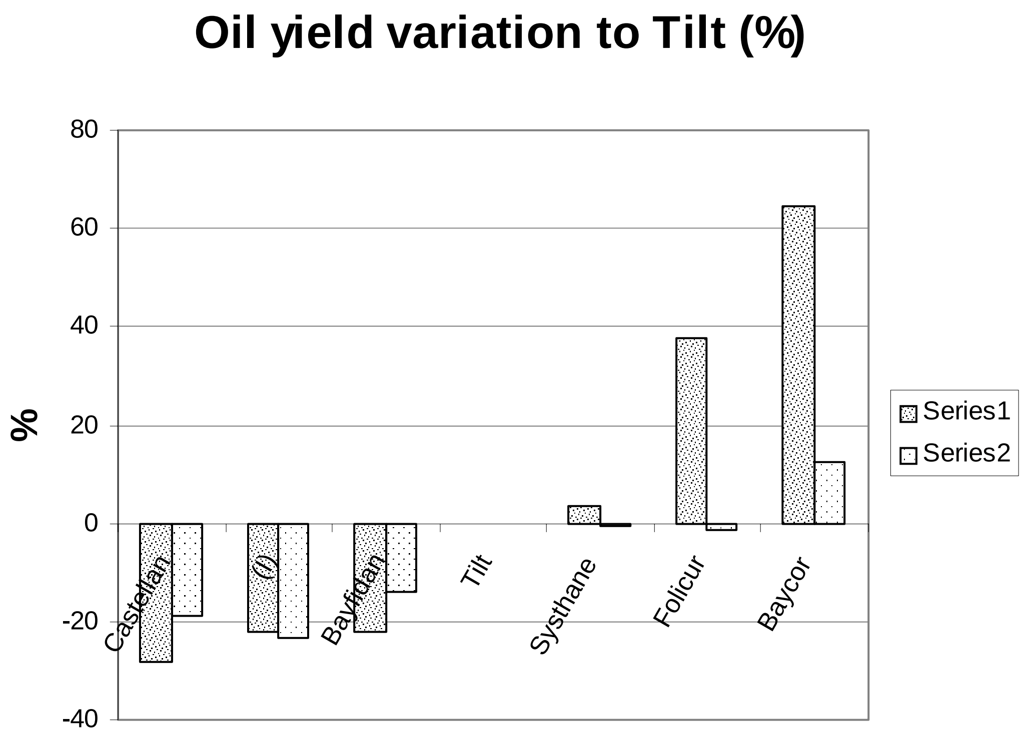

Figure 4 Oil Yield Variation to Tilt (%)

2.3 Harvest Studies

2.3.1 Yield/Time Determination

During the first year of establishment of the Scotch spearmint trial site in Tasmania, a study of the change in oil yield during the major growth phase of the crop was conducted.

As this crop was planted in rows fresh herb samples were taken from a 0.5 m length of row. Six harvest dates were examined and samples taken in duplicate. Further samples could not be taken due to the limited trial area. Considerable care was also taken to leave buffer areas around each sample to avoid any variation in sampling.

All above-ground portion of the plant was harvested from three ½ m^2 quadrats, weighed and distilled using laboratory scale steam distillation facilities. All samples were distilled for 2 hours and resultant oil samples weighed. Final yield determinations were then expressed as an equivalent yield in kg/ha. Sampling commenced on the 9th of January and was repeated approximately every 10 days through to the 6th of March.

Results

The yield profile in this first year exhibited an initial rapid rise in the second week of January the steadily climbed to a maximum yield of 84 kg oil/ha on the 20th February. The initial sharp rise coincided with the expansion of lateral shoots from the main stems. The following phase coincided with the development of new leaves on these lateral shoots.

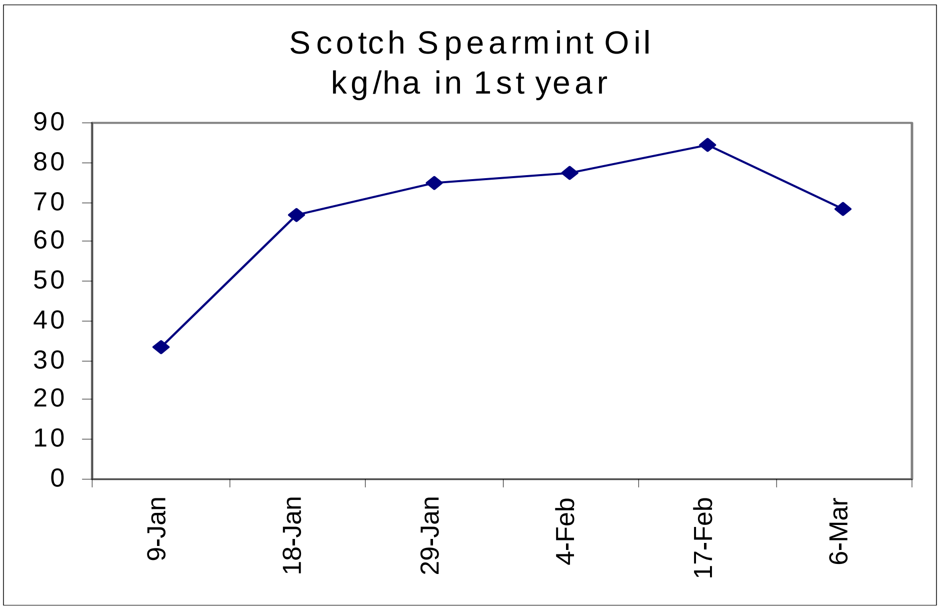

Figure 5 Oil yield from plots (mean) in time of harvest study in first year

This first year growth was especially pleasing as there was no incidence of rust observed until the 13th of February, leaf defoliation was observed on the 27th February accounting for the decrease in oil yield during the period following the maximum determined yield. See figure 5.

A similar profile in oil production over time is seen in Victoria with the only difference in the date of the peak. No detailed investigation of time or harvest was conducted in Victoria during this study as time of harvest has been investigated in DAV 24A. Sample harvests were distilled in the weeks leading up to harvest time to ensure that the harvest was appropriately timed.

In Victoria, generally spearmint crops have a maturity peak some two to three weeks before peppermint oil crops in most years. This will be in the last week or so of January in most years. With the lack of a negative component in the oil composition (ie: menthofuran in peppermint) maturity will have a major effect only on oil yield and a lesser effect on the oil quality. This gives the producer more latitude in harvest timing and allows for the dovetailing between the other crops.

2.3.2 Semi-commercial Harvesting of Spearmint in Victoria

Semi-commercial distillation testing was conducted in Victoria with plot sizes of 100 m^2 on bulk blocks of spearmint of both varieties. Harvest was by means of a forage-harvester and utilised semi-commercial distillation equipment installed at the Ovens Research Station. The tub size used is 1.2 m^3 and the system is powered by a 40 hp fire tube boiler. This scale of operation is large enough to permit more accurate estimation of potential commercial yield figure likely to be obtained in a full-scale spearmint oil production enterprise. The oil yields obtained were higher than those obtained when harvesting peppermint (113 kg/ha compared with 105 kg/ha for peppermint) using the same harvest and distillation equipment.

It should be noted that the bulk blocks were treated with propiconazole fungicide only. As has been shown in the mint rust control section of this report, propiconazole (Tilt) was out performed by bitertanol (Baycor) by approximately 40% in the same year as the bulk harvests (and 25% in the previous year). Unfortunately no data is available to do more than suggest that, if a similar yield increase was realised by the use of bitertanol, bulk yields of Scotch spearmint using bitertanol fungicide may have produced Scotch spearmint oil yields of close to 160 kg/ha.

Since the commencement of mint research at the Ovens Research Station, Native spearmint oil plots have consistently produced lower yields than Scotch spearmint.
In the latest comparison Native spearmint oil production was some 20-30 % less than Scotch spearmint oil. With lower prices paid for Native spearmint oils there is little reason to produce the Native spearmint variety when Scotch can be successfully produced.

Table 2 ORS bulk spearmint Trial

Source	Date	Plot no.	Variety	Limonene	Carvone	Yield kg/ha
ORS	30-12-97	2	Native	10.6	63.5	64
ORS	30-01-98	2	Native	12.1	63.3	82
ORS	30-12-97	1	Scotch	17.1	68.3	90
ORS	30-01-98	1	Scotch	17.7	68.6	113

3. South Australian Spearmint Oil

Production

Recent Developments

Three mint species were supplied to the Primary Industry & Resources, South Australia in 1997 to begin to investigate the potential for mint oil production in the south east region of the South Australia. These introductions included the two spearmint species. A group of potential producers in the Lucindale and Mingbool region of the south eastern corner of South Australia with the assistance of Mark Bartezko from Primary Industry & Resources, SA, has established initial plantings.

During the first year the South Australian spearmint oils were harvested, packed and sent to the Ovens Research Station for distillation. There were considerable losses in plant condition during transport. The samples were small (to reduce transport costs) and this has probably reduced the reliability of results. This was the first year of growth for the region. Results may only be a guide to the likely potential oil quality for the area. Recently a laboratory scaled distillation unit has been installed in Mt. Gambier to enable improved quality distillations to be performed.

Results and Discussion

The oil produced in South Australian was of acceptable. The results obtained so far are encouraging. Data is presented in table 3. Plantings should be scaled up to obtain more commercially realistic results to enable investors to base plans on reliable data.

Table 3 South Australian spearmint

Source	Date	Plot no.	Variety	Limonene	Carvone
Lucindale	21-01-98	7	Native	6.0	72.0
Lucindale	05-02-98	14	Native	10.3	69.9
Lucindale	21-01-98	6	Scotch	13.9	72.2
Lucindale	05-02-98	13	Scotch	15.0	71.9
Mingbool	08-01-98	2	Native	7.7	69.4
Mingbool	21-01-98	4	Native	11.0	69.1
Mingbool	05-02-98	11	Native	9.7	68.7
Mingbool	08-01-98	1	Scotch	13.0	73.2
Mingbool	21-01-98	3	Scotch	13.2	73.8
Mingbool	05-02-98	10	Scotch	13.8	73.4
BP Std					>55%

4. World Spearmint Oil Production Issues

and Implications for Commercial Prospects for Australia

The far west states of Washington, Oregon and Idaho make up the "marketing order" production areas in the USA. The group has moved from a position of almost total dominance a decade ago to a position of uncertainty. Production in these regions is tightly controlled in an attempt to control prices. The combined production of this group, now only amounts to about half of the world production for both Scotch and Native. Their share of the estimated market for this year is half of the Scotch and less than 1/3 of the Native spearmint see table 4.

Table 4. Estimated World Spearmint Production for 1998 (tonnes)

Origin	**Scotch**	**Native**
US - Marketing Order	434	512
US - Non-Marketing Order	190	10
Canada	94	-
China	172	-
India	12	449
Total	902	971
Carry-over stocks	314	894
Total Available	1216	1865
98 World Demand	916	1776

The US - Non-Marketing Order group (which includes Montana and other "newer" producing states) and Canada are increasing production of Scotch spearmint oil.

India is rapidly expanding native spearmint oil production but so far they have not expanded their Scotch spearmint industry. India will continue to capture market share from the North American growers as they are able to sell their native spearmint oil for lower prices - and their quality keeps improving.

India's biggest problem at this point is that the multi-national users do not trust the Indian growers and in particular the broker network that handles the Indian oil. So, for the immediate future the market still belongs to the Far West Marketing Order, the Canadians and maybe new comers such as Australia and Argentina.

A major US mint house is looking at joint venturing in India, endeavouring to contract directly with the Indian growers, thus eliminating the middle men. This may bring about a more consistent supply of quality Native spearmint oil at a very competitive price. Scotch spearmint oil production may be next to be pursued by such an arrangement.

China's spearmint production levels is uncertain. All indications are that their production continues to decrease by about 10% to 15% every year. The old Chinese Natural Products trading houses (actually arms of the government) are no longer subsidising the crop. The government is limiting their subsidies to staples cotton and tobacco so mint is becoming less and less attractive. China will not be likely to be a long term threat and India looks likely to capture their spearmint industry markets as they did the *Mentha arvensis* oil.

The potential of new Spearmint oil producers in Canada and Argentina needs to be monitored to ensure that Australia can maintain a competitive advantage in producing the quality of spearmint oil the market requires. Buyers continue to be wary of the quality of spearmint oils produced by Asian suppliers. Complacency in this area is risky as major mint buying companies are actively involved in trying to improve agronomy and therefore mint oil quality produced in Asia.

The two main producers of peppermint in Victoria have indicated that they are keen to put in trial blocks of Scotch spearmint adjacent to their peppermint oil production areas. These producers see the capital advantages in have multiple uses for their expensive distillation and diversification of their production base. They also consider that the economic opportunities for spearmint oil production improving as the spearmint marketing order in the far-west of the USA breaks down.

The peppermint/spearmint planting ratio for Australia may best approximate the same ratio as demand worldwide ie: approximately 3:1.

5. Commercial Evaluation of Locally Produced Spearmint Oil

Two samples of Scotch spearmint oil were sent overseas to be evaluated for their commercial acceptance by the flavour and fragrance industry. These samples were taken from the maximum yielding period of the trial crops.

The samples were sent to be evaluated by European traders in essential oils. The oil samples were assessed on a purely visual and organoleptic basis.

It was indicated to the assessors that the samples are only "type", that is to say indicative of the typical Scotch spearmint oil that could be produced in Australia. Consequently the assessment which was obtained was suitably non-committal as such evaluations are usually performed on samples from actual commercial batches.

The assessors indicated the following points in their report:

- colour and clarity was typical for Scotch spearmint oil
- good initial impact
- strong fresh odour
- bitter-sweet after-tones
- sample would be generally acceptable subject to individual customer requirements

These results are very encouraging and indicated that the environmental conditions and the variety of Scotch spearmint trialed in this study are commercially acceptable.

6. Economic Details of Spearmint Gross Margin Analysis

6.1 Gross Margins – Year 1

Establishment Year					
Enterprise Output					$/ha
Yield:	75 kg/ha spearmint oil				
Price:	$40.00 /kg				3000
Total Enterprise Output					**3,000**
Variable Costs					
Materials:					
Planting material – stolons			@	$100 /ha	100
Fertiliser:					
0:7:12		400 kg/ha	@	$350 /tonne	140
Ammonium Nitrate		400 kg/ha	@	$450 /tonne	180
Cartage		800 kg/ha	@	$13.50 /tonne	11
Weed Control:					
Terbacil		1.5 kg/ha	@	$90.00 /kilogram	135
Spot spraying		0.2 l/ha	@	$72.10 /litre	14
Disease Control:					
Propiconazole		2 l/ha	@	$94 /litre	187
Tractor and Plant:					
* Land Preparation**		4 hr/ha	@	$5.27 /hr	21
* Stolon Collection - 2 operations		2 hr/ha	@	$8.11 /hr	16
* Stolon Spreading - 2 operations		2 hr/ha	@	$8.11 /hr	16
* Stolon Discing-in		1.5 hr/ha	@	$5.27 /hr	8
* Harrowing		0.8 hr/ha	@	$5.27 /hr	4
* Rolling		0.5 hr/ha	@	$5.27 /hr	3
* Fertiliser Topdressing - 4 operations		2.4 hr/ha	@	$2.84 /hr	7
* Weed Control - 1 spray		1.2 hr/ha	@	$2.84 /hr	3
* Disease Control - 2 sprays		1.2 hr/ha	@	$2.84 /hr	3
* Mowing for Harvester		1 hr/ha	@	$2.84 /hr	3
Repairs, maintenance & lubrication on operations					100
Contract Operations:					
Soil Analysis		1 analysis	@	$55.00 /field	55
Hire of Potato Lifter			@	$55.00 /ha	55
Hire of Muck Spreader			@	$45.00 /ha	45
Harvesting & Distillation***			@	$750 /ha	750
Irrigation:					
Running costs		300 mm/ha	@	$19.39 / 25mm	233
Total Variable Costs					**2,089**
GROSS MARGIN – Establishment Year					**911**

* Fuel cost only.

** Land preparation is assumed to consist of 1 disc ploughing, 2 tyne cultivations and 1 harrowing.

*** Harvesting costs will vary with district and farm.

Establishment Year					
Allocated Overhead Costs					O/head per ha $
Interest on pre-harvest Variable Costs		10 months	**@**	10% p.a.	112
Pasture re-establishment contribution		12 months	**@**	158.80 /ha	16
Tractor and Plant					
Land preparation:					
	- Tractor	6.3 hr/ha	@	13.95 /hr	88
	- Disc plough	1.5 hr/ha	@	7.84 /hr	12
	- Tyne cultivator	2.0 hr/ha	@	2.09 /hr	4
	- Harrows	0.5 hr/ha	@	3.14 /hr	2
	- Disc Cultivator	1.5 hr/ha	@	6.28 /hr	9
	- Roller	0.8 hr/ha	@	4.71 /hr	4
Stolon Collection & Spreading:					
	- Tractor	4.0 hr/ha	@	8.84 /hr	35
	- Trailer	4.0 hr/ha	@	14.94 /hr	60
Weed Control:					
	- Tractor	1.2 hr/ha	@	8.84 /hr	11
	- Boom spray	1.2 hr/ha	@	2.63 /hr	3
Disease Control:					
	- Tractor	1.2 hr/ha	@	8.84 /hr	11
	- Boom Spray	0.0 hr/ha	@	2.63 /hr	0
Mowing pre-Harvest:					
	- Tractor	1.0 hr/ha	@	8.84 /hr	9
	- Mower	1.0 hr/ha	@	11.50 /hr	12
Irrigation:					
	- Tractor	3.3 hr/ha	@	8.84 /hr	29
	- Annual capital costs	0.160 hr/mm	@	19.65 /25mm	38
Permanent Labour*					
Tractor operations		20.75 hr/ha	@	12.21 /hr	253
	- includes allowances for superannuation contribution and leave loading.				
Total Allocated Overhead Costs					**706**
ENTERPRISE CONTRIBUTION (Gross Margin minus Total Allocated Costs)					
Establishment Year					**205**

**Permanent labour cost should be deducted where no labour is employed.*

6.2 Sensitivity Analysis

Establishment Year

Oil Yield (kg/ha)	Oil Price (A$/kg): 30	35	40	45	50
65	-139	186	511	836	1161
70	11	361	711	1061	1411
75	161	536	911	1286	1661
80	311	711	1111	1511	1911
85	461	886	1311	1736	2161

6.3 Gross Margins Years 2+

Year 2 to end of productive life.

								$/ha
Enterprise Output								
Yield:		75 kg/ha spearmint oil						
Price:		$40.00 /kg						3000
Total Enterprise Output								**3,000**
Variable Costs								
Materials:								
	Fertiliser:							
		0:7:12		400 kg/ha	@	$350 /tonne		140
		Ammonium Nitrate		400 kg/ha	@	$450 /tonne		180
		Muriate of Potash		125 kg/ha	@	$438 /tonne		55
		Cartage		925 kg/ha	@	$13.50 /tonne		12
	Weed Control:							
		terbacil****	1 spray	1 l/ha	@	$90.00 /litre		90
		spot spraying		0.175 l/ha	@	$72.10 /litre		13
		paraquat****	1 spray	1.5 l/ha	@	$15.60 /litre		23
	Disease Control:							
		mancozeb	2 sprays	2 l/ha	@	$7.75 /litre		31
		propiconazole		2 l/ha	@	$94 /litre		187
Tractor and Plant:								
	** Fertiliser Topdressing - 4 operations			2.4 hr/ha	@	$2.84 /hr		7
	** Weed Control		1 spray	0.6 hr/ha	@	$2.84 /hr		2
	** Disease Control		2 sprays	0.6 hr/ha	@	$2.84 /hr		3
	** Mowing for Harvester			1 hr/ha	@	$2.84 /hr		3
	Repairs, Maintenance & Lubrication on operations							16
Contract Operations:								
	***Harvesting & Distillation				@	$750 /ha		750
Irrigation:								
	Running costs			300 mm/ha	@	$19.39 / 25mm		233
	Total Variable Costs							**1,745**
GROSS MARGIN – Successive years								**1,255**

* Fuel cost only.
*** Harvesting costs will vary with district and farm.
****Combined in single application.

Year 2 to end of productive life.				
Allocated Overhead Costs				
				O/head Cost per ha $
Interest on pre-Harvest Variable Costs	10 months	**@**	10% p.a.	81
Pasture re-establishment contribution	12 months	**@**	158.80 /ha	16
Tractor and Plant				
Topdressing:				
- Tractor	2.4 hr/ha	@	8.84 /hr	21
- Fertiliser spreader	2.4 hr/ha	@	32.43 /hr	78
Weed & Pest Control:				
- Tractor	1.8 hr/ha	@	8.84 /hr	16
- Boom spray	1.8 hr/ha	@	2.63 /hr	5
Irrigation:				
- Tractor	3.3 hr/ha	@	8.84 /hr	29
- Annual capital costs	0.160 hr/mm	@	19.65 /25mm	38
Permanent Labour*				
Tractor operations	11.25 hr/ha	@	12.21 /hr	137
- includes allowances for superannuation contribution and leave loading.				
Total Allocated Overhead Costs				**421**
ENTERPRISE Edwards, J., (1998) **CONTRIBUTION (Gross Margin minus Total Allocated Costs)**				
Year 2 to end of productive life				**834**

**Permanent labour cost should be deducted where no labour is employed.*

6.4 Sensitivity Analysis

Year 2 to end of productive life

Oil Yield (kg/ha) \ Oil Price (A$/kg)	30	35	40	45	50
65	205	530	855	1180	1505
70	355	705	1055	1405	1755
75	505	880	1255	1630	2005
80	655	1055	1455	1855	2255
85	805	1230	1655	2080	2505

7. Implications and Recommendations

7.1 Implications

Introduction of production of Scotch spearmint oil will provide benefits to existing peppermint oil producers by:

- spreading the considerable cost of capital infrastructure over more than a single crop
- allowing for the better use of trained staff by prolonging overall harvesting periods
- permitting the movement of two similar commodities through the same marketing pathways/chain to similar buyers
- allowing for diversification into a crop which will spread the farm enterprise base while drawing on existing farm operational skills.

In addition spearmint oil production may present an economically sound opportunity for farmers in other areas to diversify.

7.2 Recommendations

Scotch spearmint production has been shown to be viable in south eastern Australia. Current peppermint producers and others contemplating essential oil industry development should look into Scotch spearmint oil production in combination with peppermint oil production or as a stand-alone crop.

It is recommended that growers and governments pursue minor-use registration of bitertanol (Baycor) and tebuconazole (Folicur) which allow these fungicides to be alternated with propiconazole (Tilt). There is also a need to investigate fungicides with different modes of action. Incorporation of two or more fungicides from different chemical groups into the growers' mint rust control program should be promoted to ensure that their effectiveness is not broken down.

Farmers, researchers, investors and funding bodies should consider establishment of demonstration blocks of Scotch spearmint in geographic regions not currently producing essential oils.

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