Alternative Crops Suitable for the Tararua District: Stage 2 Report

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DISCLAIMER

This report has been prepared by The Horticulture and Food Research Institute of New Zealand Ltd (HortResearch), which has its Head Office at 120 Mt Albert Rd, Mt Albert, AUCKLAND. This report has been approved by:

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INTRODUCTION

In this project, Crop & Food Research and HortResearch provide information for a series of publications (booklets, handouts etc.) and maps to explore alternative land use options for the Tararua district and to encourage investment in new crops. Here we address only those crops that have already been short-listed by Tararua District Council during Stage 1 (30 September 2005) of this project. Table 1 outlines crops that are discussed in this report.

Table 1: Crops described in this document

Crops to be described by Crop & Food Research	Crops to be described by HortResearch
Ginseng (Garry Burge)	Feijoa (Tessa Mills)
White Truffles (Garry Burge)	Rootstock grapes (Tessa Mills)
Daikon (Garry Burge)	Passionfruit (Tessa Mills)
Hazelnuts (Garry Burge)	
Gevuina (Garry Burge)	
Goldenseal (Garry Burge)	
Valerian (Garry Burge)	
Saffron (Bruce Searle)	

NIWA has compiled maps of the suitability of the Tararua area for growing those crops listed in Table 1. Simple quantitative rules for each crop were supplied to NIWA from Crop and Food and HortResearch. The soil and climate rules used to evaluate land resources suitable for the crops listed in Table 1 are outlined in Tables 2 and 3. Only critical values are used as the interpretation of the maps produced from the rules provided becomes more difficult as more variables are added (Appendices 1 and 2). Here we aim to minimise the number of variables used for each crop to those critical for crop success.

Table 2: Climate variables for mapping rules

Variable	Description	Class Breakdown
Thermal time	Using Tbase of 5ºC, calculated from September 1 through to April 30	Not suitable = <1000 Marginal = 1000-1500 Optimal = >1500
Frost free period	Number of consecutive days with minimum air temperature above 0ºC starting from the last frost of the year	Not suitable = <100 Marginal = 100-120 Optimal = >120
Autumn rainfall	Average total rainfall March to May	Not suitable = <100, >300 Marginal = 100-130, 270-300 Optimal = 130-270

Table 3: Soil variables for mapping rules

Variable	Description	Class Breakdown
NZLRI Slope Class	7-class unequal-interval classification with breaks at agriculturally sensitive thresholds	A= flat to gently undulating (0-3°) B= undulating (4-7°) C= rolling (8-15°) D= strongly rolling (16-20°) E= moderately steep (21-25°) F= steep (26-35°) G= very steep (>35°)
Subsoil acidity	7-class classification, at specified pH unit intervals	1= high (7.6 - 8.3) 2= moderately high (6.5 - 7.5) 3= near neutral (5.8 - 6.4) 4= moderately low (5.5 - 5.7) 5= low (4.9 - 5.4) 6= very low (4.5 - 4.8) 7= extremely low (2.5 - 4.4)
Potential rooting depth	Depth to a layer that may impede root extension. 6-class classification, at specified meter intervals	1= very deep (1.2 - 1.5 m) 2= deep (0.9 - 1.2 m) 3= moderately deep (0.6 - 0.9 m) 4= slightly deep (0.45 - 0.6 m) 5= shallow (0.25 - 0.45 m) 6= very shallow (0.15 - 0.25 m)
Drainage class	Assessed either using criteria of depth and chroma or diagnostic horizons. 5-classification, qualitative (e.g. poor, imperfect) classification	1= very poorly drained 2= poorly drained 3= imperfectly drained 4= moderately well drained 5= well drained
Profile total available water	Weighted averages (-10 to -1500 Kpa) to 0.9 m depth or potential rooting depth, whichever is the lesser. 6-class classification, at specified mm intervals	1= very high (>249 mm) 2= high (150 - 249 mm) 3= moderately high (90 - 149 mm) 4= moderate (60 - 89 mm) 5= low (30 - 59 mm) 6= very low (<30 mm)
Land cover	Values from the Land Cover Database	Options are 'Broadleaved Indigenous Hardwoods', 'Deciduous Hardwoods', 'Indigenous Forest', 'Manuka and or Kanuka', 'Other Exotic Forest', 'Pine Forest - Closed Canopy', 'Pine Forest - Open Canopy'

CROP INFORMATION

1 GINSENG

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1.1 Why Ginseng?

Ginseng is a high value crop that can be grown under shade structures or under a forest canopy and is suitable for the environment in much of New Zealand. Under a radiata pine or Douglas fir canopy, with careful management, old (7-10 year old) and valuable root can be grown, adding substantially to returns from forest alone (Figures 1 and 2). Production under shade structures produces lower value root but in processed form is a component in many added value products in a hugely diverse market (Figure 3).

1.2 Brief description of the crop

Korean ginseng (*Panax ginseng*) is a native of Eastern China, and American ginseng (*Panax quinquefolius*) is a native of North America. The root of both species is highly prized for its medicinal properties. Traditionally, the crop was harvested from the wild. Its high value has led to excessive exploitation resulting in the virtual extinction of the plant in its native habitat both in Asia and North America. As a result, ginseng is now grown mainly as a horticultural crop. The major use of ginseng is in Asia. While ginseng has not been recognised by Western pharmacology, it is being used widely in herbal, health food and cosmetic applications.

Figure 1: 5-year old ginseng under *Pinus radiata* forest in New Zealand. Photo by Robert Lamberts.

Commercial ginseng is mainly produced in intensive production systems under shade structures. Intensive management results in a crop that can be harvested in three years. Because of the risk of disease, which is considered to be one of the main limiting factors to production, most growers in North America harvest their crop after three years. Rusty root, a physiological disorder, can cause downgrading of roots and significant losses in returns.

Some other production systems that take much longer to mature include:

- wild-simulated production, where ginseng is cultivated in the woods using a low input system (seed scattered or sown into uncultivated soil) to produce roots resembling wild ginseng
- intensive forest production, in which beds or strips of soil are prepared for drilling seed into, and netting used to keep out damaging birds.

Figure 2: Seedling ginseng under *Pinus radiata* forest in New Zealand. Photo by Robert Lamberts.

Figure 3: 6-year old ginseng under traditional shade structures in Korea. Photo by Graeme Parmenter.

1.3 Growing requirements

Ginseng is an herbaceous perennial plant. The native habitat of the two ginseng species is the open, broad-leaved woodlands in hilly areas between latitudes 36° and 48° N. Most commercial production occurs in areas that experience a continental-type climate with cold winters and dry summers. The preferred soil type is free draining with no hard pan. In its native environment ginseng grows under high levels of shade provided by the forest canopy. The plant quickly loses vigour and dies if the shade is removed. Shade can be provided by wooden lath, shade cloth or by growing the crop commercially under a forest canopy. Most shading systems provide between 75 to 90% shade. Intensive production of American ginseng using artificial shade results in average crop yields of approximately 2.5 t/ha after three to four years. Intensive production under a forest canopy results in an average yield of 1.1 t/ha after five to six years while wild simulated plantings result in average yields of 0.3 t/ha after six to twelve years.

1.4 Infrastructure requirements

Requirements differ for ginseng grown under shade structures and under forest. Under structures one of several possible shade structure designs must be chosen and this is the major setup cost. The nature of the forest will dictate whether it is possible to grow a crop of ginseng (e.g. tree density and age). Under forest, pruning debris and weeds must be cleared.

Soil cultivation is a requirement under artificial shade. Under forest some form of cultivation is required in more intensive systems but a very low input extensive system of growing “wild simulated” ginseng, may require little mechanised cultivation.

Mechanised seeding is generally practised for crops grown under artificial shade. Under forest mechanised seeding is usually replaced by hand sowing, although the regularity of tree rows in New Zealand production forests makes mechanised seeding a viable option that gives New Zealand a potential competitive advantage compared with traditional forest producers.

Mulch spreading is usually a requirement for ginseng production under shade structures.

During the 3-10 year life of the crop, regular spraying to control diseases is a usual requirement except in “wild simulated” systems. Weeds are controlled with mulches or spraying during ginseng’s senescent period (April-September).

Potato or carrot harvesters can be used to dig roots which are the size, shape and appearance of small branched parsnips (minus tops). Forest grown wild simulated roots are often sold in much smaller quantities and may be dug by hand.

Root washing is required (carrot washer) and a chiller is often needed to store roots for a period before drying (forced air 30-35°C). A chiller is also required for stratification of seed.

Root is normally shipped internationally in plastic lined waxed cardboard barrels in lots of 40-50 kg.

1.5 Current industry/market status

The annual world trade is about 4000 t. The main exporting countries, in decreasing order of production, are China, Korea, US, Canada and Japan. Hong Kong is currently the major world centre for ginseng trade. The international market for ginseng places substantial premium on old (>6 years) woods-grown and wild simulated root, paying NZ$500-1000/kg compared with

NZ$100-200 for 3-4 year old material grown under shade structures. Because of the consistent price premium for woods-grown ginseng, production under forest appears the most realistic option for New Zealand. Woods-grown ginseng has been difficult to grow because of the many plant losses over the life of the crop. However, recent research has identified the main causes of plant losses during the first three seasons. The largest planting of ginseng in New Zealand is owned by Ginseng NZ Ltd (100 ha) (see www.ginseng.co.nz).

1.6 Further sources of information

Persons, Scott W. and Jeanine Davis. 2005. Growing and marketing ginseng, goldenseal and other woodland medicinals. Bright Mountain Books Inc., Fairview, North Carolina.

Smallfield B.M. and Follett J.A. 2004. Ginseng a growers guide for commercial production. New Zealand Institute for Crop & Food Research, Christchurch New Zealand.

2 TRUFFLES – BIANCHETTO AND PÉRIGORD BLACK TRUFFLE

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2.1 Why Truffles?

Truffles are a gourmet food and very high prices are paid internationally for them. However, truffles are a relatively new crop in New Zealand and other Southern Hemisphere countries, and there are associated risks because of our limited experience. Southern Hemisphere truffles will be out of season to Northern Hemisphere product.

2.2 Brief description of the crop

Most plant roots form close symbiotic associations with some specialised fungi. This combined structure formed by the fungus and the host plant's root is called a **mycorrhiza**. About half of the world's species of edible mushrooms belong to the mycorrhizal group. All of the mycorrhizal mushrooms are seasonal, best eaten fresh and do not preserve well. Therefore, there is an opportunity to produce these high value foods in New Zealand for out-of-season Northern Hemisphere markets.

One of the best known mycorrhizal mushrooms is the **Périgord black truffle** (*Tuber melanosporum*) (Figure 4). This mushroom is found in the forests of southern France, northern Italy and north-eastern Spain on the roots of, for example, oaks and hazels.

Like all truffles, the Périgord black truffle produces its fruiting bodies under the surface of the soil, and so they are generally located with the aid of a good truffle dog. The truffles mature in May to early September. The fruiting bodies are black, roughly spherical and covered with small diamond-shaped projections, making them look a little like deformed, dark coloured avocados. These are considered one of the best edible mushrooms.

Bianchetto or white truffle (Figure 5) is well known in parts of Italy, but is not well known internationally. However, interest in this truffle is growing as techniques are developed to separate it from other truffle species with poorer flavours. Bianchetto truffles vary from pea to egg sized, are pale yellow to reddish brown in colour and either smooth or like fine suede especially in cracks in the truffle surface. Bianchetto is found throughout Europe and is particularly common in northern Europe. In Italy it is common in coastal, calcareous, sandy soils such as the land around Marina di Ravenna and in the Apennine Mountains where the Italian white truffle and Périgord black truffle are found.

Bianchetto forms mycorrhizas with a wide range of trees including Italian alder (*Ainus cordata*), European lime (*Tilia platyphyllos*), oaks (*Quercus* spp.), hazelnut (*Corylus* spp.), poplar (*Populus*), linden (*Tilia europea*), chestnut (*Castanea sativa*) and cedars (*Cedrus*).

Bianchetto is harvested during winter and early spring, while the Périgord black truffle is harvested in autumn to early winter. Hence bianchetto truffles would follow Périgord black truffles on the market.

Figure 4: Périgord black truffle.

Figure 5: Bianchetto truffles.

2.3 Growing requirements

Trees infected with the mycorrhizal fungi are produced in specialised nurseries. These trees are planted in the field at about 400 trees per hectare. It is critical that infected plants are planted in areas where the ecological conditions suit both the host plant and the mycorrhizal fungi. Because New Zealand has an oceanic climate and Europe a continental one, summer temperatures are cooler in New Zealand at the equivalent latitude. Thus Périgord black truffle cultivation should only be attempted in the North Island and the more northern, warmer parts of the South Island of New Zealand.

The optimum requirements for establishing a Périgord black truffle truffière (truffle plantation) are:

- warm summers and cool winters
- a free draining, high pH (above 7.5 with an optimum of 7.9), well aerated soil with a well defined structure, about 400 mm deep overlying a limestone base, e.g. rendzina and related soils. However, of the eight productive Périgord black truffle truffières in New Zealand, six are on naturally acidic soils (pH 5.9 to 7.0) that have had their pH increased by the application of large quantities of lime
- irrigation water
- the absence of other trees that may have competing fungi on their roots.

Bianchetto truffles appear to be less demanding in terms of growing requirements. However, there is very little information regarding the cultivation of the bianchetto truffle with only two experimental truffières established in Italy. These truffières fruited three to four years after planting. Many of the growing requirements of bianchetto truffle are probably similar to Périgord black truffle, but there are indications that the black truffles will need warmer temperatures for consistent fruiting.

Bianchetto is widespread in Northern Europe but extremes of climate applicable to New Zealand are encompassed by the climates at Durham, northern England, and central Italy. The soil pH is typically 7 to 8 in Italy where the truffle is found. However, bianchetto can also be found growing in soil where the pH is 6.0 to 7.0.

Figure 6: Truffière (truffle plantation) in Gisborne.

Figure 7: Trained dog searching for truffles.

2.4 Infrastructure requirements

The main costs of establishing a truffière are:

- the preparation of the area before planting including the addition of large quantities of lime to increase the soil pH
- the cost of the infected trees ($30 to $60 each).

There is also the maintenance of the block until it starts to produce truffles. Once a truffière starts to produce, cool storage and packing facilities will be required.

2.5 Current industry/market status

At the turn of the 19th century about 1000-2000 tonnes of the Périgord black truffle were harvested in Europe. Since then the harvest has steadily declined because of disturbance of their natural habitat so that now only 50 to 150 tonnes are harvested. Prices vary greatly. In a typical in-season, prices in Europe are NZ$1000-1500/kg. In New Zealand Grade 1 truffles are currently selling for NZ$3000/kg.

New Zealand's first commercial truffière was established in 1987. Since then more than 80 have been established between the Bay of Islands (35°S) and Alexandra in the South Island (45°S) (Figures 6 and 7). The first truffles were harvested in 1993 from a truffière on the east coast of the North Island five years after planting. Seven other truffières are now producing Périgord black truffles. Truffières exist in the Horowhenua and Hawke's Bay but they are not yet producing truffles.

Currently there are only small trial plantings of bianchetto truffle infected trees in New Zealand.

The typical price for bianchetto truffles in Italy is about NZ$600 kg although higher prices are paid in the main European and North American centres. Bianchetto truffles produced out-of-season to the Northern Hemisphere should command more than NZ$600 kg.

2.6 Further sources of information

Tuber melanosporum – Perigord black truffle. http://www.crop.cri.nz/home/products-services/publications/broadsheets/t-melanosporum.pdf

Zambonelli, A., Lotti, M., Giomaro, G., Hall, I. R., Stocchi, V. 2002. *T. borchii* cultivation: an interesting perspective. Edible mycorrhizal mushrooms and their cultivation. Proceedings of the Second International Conference on Edible Mycorrhizal Mushrooms (CD-ROM), Christchurch, New Zealand, 3-6 July 2001 : 7 p.

3 HAZELNUTS

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3.1 Why Hazelnuts?

New Zealand grows only small areas of nut crops and most of the nuts consumed in New Zealand are imported. Hazelnuts are a non-perishable product and hence New Zealand production needs to be competitive with imports from overseas. A commercially successful hazelnut orchard will need to be productive, not located on very valuable land, and use machinery to reduce production costs.

3.2 Brief description of the crop

The terms 'filbert' and 'hazelnut' are often used interchangeably to include all plants in the genus *Corylus*. The hazelnut (*Corylus avellana*) forms the basis for the more important commercial cultivars. In its natural form the hazelnut is a deciduous, monoecious (separate male and female flowers on the same tree), multi-stemmed bush, but commercially should be grown as a single trunk tree. Tree sizes are up to 6 m tall in commercial orchards.

3.3 Growing requirements

A suitable climate and reliable rainfall or irrigation are important for good tree growth and the production of high quality nuts. The preferred climate is characterised by a mild summer and cool winter. Chilling is required to ensure fruitfulness and reliable hazelnut yields. Chilling requirements vary for male catkins, female flowers and leaf buds but about 1200 hours between 5°C and 7°C is suitable (similar to the requirements of many apple varieties). For female flowers severe frost areas should be avoided and temperatures below –5°C should be avoided when the female flowers are opening. Hazelnuts do not tolerate windy conditions combined with high summer temperatures and low humidity. Hazelnuts require a well-drained soil. Heavy clays and very sandy soils should be avoided and a deep loam is preferred.

Hazelnuts are self-sterile, and peak periods of male and female flowering vary between varieties. It is important for growers to have compatible pollinators and pollinators that shed pollen at the time female flowers are receptive. It is recommended that a range of varieties be planted to ensure the dissemination of cross-compatible pollen. Variety trials have been undertaken at Lincoln University to determine productivity and quality.

Tree spacing of 200 to 500 trees per hectare are used, with the closer spacing giving higher yields in the first 10 years of the orchard. Hazelnuts require a minimal amount of pruning but sucker control can be time-consuming.

Hazelnuts begin to bear at approximately three years old and at six years yields should approach 2–2.5 kg/tree (1000 kg/ha, assuming 500 trees/ha). The nuts fall in late summer - autumn and are harvested by hand or mechanically. Hazelnuts should be collected promptly after falling as rain can cause discolouration of the shell. Following collection, the nuts should be cleaned and dried.

3.4 Infrastructure requirements

Establishment costs are high due to the cost of the trees and waiting time to full production. Permanent irrigation is sometimes installed to improve tree growth during the early years of establishment. Once the trees come into production, machinery is required to gather the nuts from under the trees, and to dry, sort and grade the nuts.

3.5 Current industry/market status

Total world production of hazelnuts in 2000 was about 800,000 tonnes from about 500,000 ha. Turkey produces about 75% and Italy about 15%, respectively, of total hazelnut production. However, commercial production in New Zealand was estimated to be only 10 tonnes in 1996. Imports were about 250 tonnes per year at that time. The New Zealand Tree Crops Association supports the development of a number of nut crops in New Zealand, including hazelnuts. Over the last 3-4 years several hazelnut orchards (each about 4 ha) have been planted in Otago.

3.6 Further sources of information

Anonymous. 2005. High hopes for hazels. Growing Today 19 (2): 22-24.

Murdock, D., McIntosh, K., McNeil D.L. 1995. Vegetative and reproductive productivity and quality of hazelnuts after year nine in a replicated variety trial in Canterbury, New Zealand. Lincoln University. 9p.

New Zealand Tree Crops Association at www.treecrops.org.nz

Redpath, M. 1990. Hazels. Which variety should I grow? Growing Today 4: (3) 44-45.

Smith, P., McNeil, D.L. 1994. Propagation of New Zealand hazelnut (*Corylus avellana* L.) lines from cuttings. Lincoln University. 7p.

4 GEVUINA

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4.1 Why Gevuina?

Gevuina nuts are not well known on international markets. However, they have an attractive flavour and can be grown in temperate climatic areas such as New Zealand. We have limited experience in New Zealand with this nut crop, but with further development and identification of superior selections, it is likely to become a popular nut.

4.2 Brief description of the crop

Gevuina (*Gevuina avellana*) is a nut crop related to the macadamia, and sometimes referred to as a cool climate macadamia (Figures 8 and 9). The tree is native to southern Chile and Argentina from latitude 35 to 44ºS. The nuts vary in size between varieties from 1.3 to 2.5 cm diameter, and they are enclosed in a softer thinner shell than macadamia. The roasted nuts are well accepted by the public in Chile. Gevuina is barely known outside its native area of Chile.

Gevuinas are high in essential amino acids and high quality unsaturated fatty acids, and are lower in fats than macadamia. The nuts have attractive flavour, although the flavour varies between selections. The nuts can be eaten fresh or roasted, and used in confectionary (chocolates, cakes, muesli bars). They can also be processed into gevuina butter or the oils can be extracted.

Gevuina trees have been grown in New Zealand for 50 years. Selections have been identified with superior characteristics. However, the crop is still in the early stages of domestication and significant improvements are possible through breeding and selection. In Chile, selections with larger nuts have been identified. Little research has been undertaken on this crop and production systems could be improved by research on the causes of tree losses, pollination, fruit set and development, pollinator varieties, tree management and harvesting. Estimated nut yields in the shell are 3 to 9 t/ha (Halloy et al. 1996).

Figure 8: Gevuina fruit.

Figure 9: A fruiting gevuina tree.

4.3 Growing requirements

Gevuina is the southernmost species in the *Macadamieae* tribe of the Proteaceae. It grows well under temperate climatic conditions and mature trees tolerate winter frosts of -8ºC. However, young trees only tolerate -5°C. Gevuina trees do not tolerate windy situations so shelter needs to be considered in many locations. As a new crop there is much to be learnt about gevuina.

Gevuina are mainly propagated by cuttings or tissue culture as seed derived plants have variable nut qualities (size, flavour, etc.). There are several selections available in New Zealand. Cutting-grown trees usually set fruit within four years from planting in the field, and produce reasonable yields after seven years. Gevuina trees are relatively vigorous trees in their early years and eventually grow to about 10 m. Trees are susceptible to root diseases and plant losses can be high. Healthy nursery stock with vigorous well-formed roots, and good management practices are important for tree survival. Cross pollination is essential for good fruit set and hence orchards must have several varieties.

4.4 Infrastructure requirements

Establishment costs are high because of the cost of the trees and waiting time to full production. Trees are planted at about 500 per hectare. Permanent irrigation is often installed to improve tree growth during the early years of establishment.

Once the trees come into production, machinery is required to gather the nuts from under the trees, and to sort and grade the nuts.

4.5 Current industry/market status

In Chile gevuina is mainly gathered from the wild, but experimental orchards have recently been established in Chile. Gevuina has been grown in New Zealand for 50 years. Over the last decade there has been significant interest in the crop and many small areas have been planted, especially in southern parts of the South Island. The Gevuina Action Group, an offshoot of the New Zealand Tree Crops Association, has co-ordinated growers and supported the development of the crop. Experimental sites have been set up throughout the country to assess different climates, soils, selections and management practices. Only small volumes of nuts are currently produced, as most of the trees are less than four years old.

The roasted nut is well accepted by the public in Chile, retailing for at least NZ$7/kg. It is difficult to determine the future wholesale price of gevuina, but comparison with macadamia may give some guidance.

4.6 Further sources of information

Halloy, S.R.P., Grau, A., McKenzie, B. 1996. Gevuina nut (*Gevuina avellana*, Proteaceae), a cool climate alternative to macadamia. Economic Botany 50 (2): 224-235.

5 GOLDENSEAL

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5.1 Why Goldenseal?

Goldenseal is very much a niche market crop, but can be grown in conditions similar to those suitable for ginseng. This helps maximise the use that can be made of shade structures or forest canopies used for ginseng (Figure 10). Having already grown a ginseng crop, land must be spelled for a considerable time before a second crop can be grown.

Figure 10: Goldenseal leaf. Photo by Robert Lamberts.

5.2 Brief description of the crop

Goldenseal (*Hydrastis canadenis* L.) is a highly valued North American medicinal plant. It is used as a muscle stimulant, stomach strengthener, antihaemorrhagic and as a laxative. Goldenseal also has some antibacterial activity. Collection of goldenseal from the wild has resulted in its near extinction. However, as a result of intensive cultivation it has become more commonly used. Goldenseal is a small perennial herb, native to the open woodland areas of the north eastern United States. The plant over-winters as a rhizome with leaves emerging relatively early in spring (Figure 11).

Figure 11: Goldenseal root. Photo by Robert Lamberts.

All parts of the plants are used for medicinal purposes. However, it is the rhizome that is the most valued component because it contains the highest concentration of active ingredients including 2-4% hydrastine and 2-3% berberine. Other active ingredients include hydrastinine and canadine. The pharmacological action of goldenseal is thought to result mainly from hydrastine and to a lesser extent berberine.

5.3 Growing requirements

Goldenseal prefers a rich, friable, well-drained soil. In New Zealand, excellent growth has been achieved on the free draining sandy loam ash soils found in the Waikato and Rotorua areas. In North America, goldenseal is planted out 20 cm apart in rows spaced 25-30 cm apart in either late autumn after crop harvest or in spring. Goldenseal requires shade to grow well with 75% shade commonly recommended. Shade can be provided by wooden lath, shade cloth or by growing the crop under a forest canopy. If propagated by division, plants can be harvested after three or four years while seed-propagated plants may require an extra year. After five years goldenseal will yield up to 2.5 t/ha dried root. After harvesting in late autumn, when the top growth has died down, roots are washed and either air dried or oven dried at approximately 25°C until brittle. If dried properly, it has a long shelf life.

5.4 Infrastructure requirements

Because of the relatively small market volumes, the area used for this crop is likely to mean infrastructure requirements will be modest. Shade structures of the sort used for ginseng can be utilized for goldenseal, and areas of forest that grow ginseng can also be used for goldenseal. Diseases of goldenseal are few so spraying for fungal problems is not usually required during the life of the crop (3-5 years). Being a shallow rooted crop, it is very sensitive to moisture deficits in the top 5-10 cm of soil, so mulching is required. Harvesting by hand digging may be an option where kilograms rather than tonnes are required. For larger quantities, mechanised harvesting using potato or carrot harvesters is an option. Washing and drying facilities are also required.

5.5 Current industry/market status

Historically, goldenseal buyers and prices have tended to vary from year to year so it is essential to obtain up-to-date marketing information. Goldenseal has a variety of uses and is among the top-selling herbs in the American health food industry. In 1996 the price for dried goldenseal root and rhizome was US$77/kg, while dried leaves and petioles sold for US$16/kg. This increased to US$220/kg for dried root and rhizome in 2000. However, in 2004 the price fell to around US$44/kg because of concerns over chemical residues in the root and rhizome.

Research on goldenseal in the Waikato indicates that it is relatively easy to grow intensively under shade cloth with no major pest or disease problems. In the Rotorua area, goldenseal grows well under pine (*Pinus radiata*) plantations although growth is slower. Provided the demand and price remain high, early indications are that goldenseal has potential as an export crop for New Zealand. Currently there is very little production in New Zealand. Limited access to plant material is currently the main limiting factor to industry development in New Zealand.

5.6 Further sources of information

Persons, Scott W. and Jeanine Davis. 2005. Growing and marketing ginseng, goldenseal and other woodland medicinals. Bright Mountain Books Inc., Fairview, North Carolina.

6 VALERIAN

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6.1 Why Valerian?

Valerian is a crop that grows well in the temperate climate of New Zealand. It makes a useful root crop in a rotation with other crops, particularly where all of the infrastructure required is available (harvesting/washing/drying). Returns are not large, and opportunities for export may be limited, but there opportunities to supply high quality material to specific companies.

6.2 Brief description of the crop

Valerian is a perennial herb, although when grown commercially is effectively an annual. The dried rhizome and roots of *Valeriana officinalis* comprise the herbal drug valerian, which has been used for at least 1000 years. Valerian is widely used in Europe as a mild sedative and sleep aid for insomnia, excitability, and exhaustion.

Valerian has depressant activities on the central nervous system, is antispasmodic, and has been described as having equalising effects. The long-standing clinical use of valerian is as a sedative mainly because of the valepotriates present and the volatile oil constituents, notably valerenic acid.

Valerian oil is obtained from the steam distillation of the dried, ground roots and yield is reported to be between 0.2 and 0.7%. The oil is used in the flavour and pharmaceutical industries, with limited quantities used in the fragrance industry. Valerian is approved as a GRAS (generally recognised as safe) food ingredient in the USA. Extracts and the essential oil are used in flavouring components in most major food product groups including alcoholic and nonalcoholic beverages, meat and meat products, frozen dairy desserts, sweets and baked goods.

6.3 Growing requirements

Valerian is not particular about soil type, and will grow in many climates hot or cold, wet or dry - providing that it gets sufficient water and nitrogen. Valerian thrives best in rich, heavy loams with adequate moisture but with free drainage. For ease of postharvest root washing, a relatively loose soil with a low clay content is desirable. In the absence of irrigation, soil will also need to have good water-holding capacity.

The crop is usually established in New Zealand in spring or autumn using transplants. Plant spacing of 40-50 cm between rows and 20-30 cm spacing between plants in-row is recommended. With spring establishment, and growing under favourable conditions, the plants will usually be large enough for harvesting in the following autumn. Valerian may also be propagated from seed, but weed control is more difficult.

Valerian will produce 16-20 t/ha of fresh root, which has a dry matter close to 25%. Dried root yields of 4-5 t/ha are achievable under good conditions. The crop is usually harvested in autumn with the tops cut to ground level before the roots are lifted. Dry soil conditions and mechanical shaking to remove excess soil are desirable before washing. Subsequent washing using a rotary root washer is necessary to remove all soil. The roots are usually dried with warm temperatures and forced air movement. The roots need to be dried rapidly without overheating to prevent enzymatic breakdown of the constituents.

6.4 Infrastructure requirements

Soil cultivators and bed formers are a basic requirement. Material is usually transplanted in the autumn to gain maximum yield. Sowing seed is a much less reliable option. Potato/carrot harvesters should be adequate for harvesting, particularly if plants are in raised beds. Cleaning roots is an issue. Soils need to be easily removed from roots, and chopping root before cleaning may be required in order to clean roots properly. Root drying facilities (30-40ºC) are also required.

6.5 Current industry/market status

The major commercial producers are Belgium, France, Holland, Germany, Russia, China, and Eastern European countries. The largest market for herbal medicines using valerian is Europe, where total phytomedicine counter sales in 1990 were $US 2.4 billion, and 65% of this total was in Germany. The volume of valerian root traded is unknown, but traded values suggest that it is hundreds rather than thousands of tonnes annually. The prices depend on quality and degree of processing and are in the range $2 to $20/kg, with a typical price around $5/kg.

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7 SAFFRON

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7.1 Why Saffron?

The climate of the Tararua region is well suited to the growing of saffron. There are readily accessible domestic and export markets and even though saffron has a high labour requirement, it offers good returns to growers.

Figure 12: Saffron flower showing orange stigmas

7.2 Brief description of the crop

Saffron is the world's most expensive spice. It obtained from the stigmas of the flowers of *Crocus sativus* L. a member of the iris family, which has been cultivated for some 35 centuries in Asia Minor, Greece and the eastern Mediterranean. Traditional uses for saffron included its use as a medicinal plant as well as a spice. While saffron extracts have been shown to have pharmacological properties in laboratory tests, including stimulating respiration, lowering blood pressure, and anti-tumour properties, its main use is as a spice in cooking. The saffron plant is sterile, and so must be propagated vegetatively. The plants are dormant over summer, with flowering occurring in autumn.

Saffron provides a characteristic flavour and colour to dishes it is used in. The bright yellow colour comes from carotenoids, which also have antioxidant properties, the taste from picocricin and the aroma from safranal, which has anti-bacterial properties. The unique bio-chemistry of the plant means that these chemicals are accumulated in the stigmas of flowers, which need to be harvested by hand (Figure 13). This is a laborious process and takes approximately 400-450 hours to produce 1 kg of saffron. The high labour input is part of what makes the spice so expensive. Stringent international standards have been established to ensure and maintain saffron quality.

Figure 13: Harvested saffron.

7.3 Basic growing requirements

Saffron grows best in areas with cool winters and dry, warm summers. It requires a sandy or loamy, well drained soil, with reasonably high levels of organic matter. Corms should be planted into raised beds in late spring-early summer at a depth of 10 cm, with 10 cm between plants and 20 cm between rows. Each season, 4-10 new daughter corms are formed, and the old ones eventually rot away. Thus, the density rapidly increases, and reaches a stage where production declines after approximately four years. The crop must therefore be dug up and replanted periodically. Autumn temperatures should average 17°C or less for flowering to occur. Flowering lasts for 4-5 weeks, and fully open flowers must be picked by hand, and the stigmas separated from flowers by hand for drying in an airflow of 30°C for 24 hours. Yields increase up to the second season, reaching up to 4.3 kg/ha, and declining from then on.

7.4 Infrastructure requirements

Saffron production needs labour and stigma drying facilities.

Saffron is a labour intensive crop that requires hand harvesting. The flowers are harvested in the morning after the dew has dried, but before the flowers wither. Stigmas are then removed by hand from the flowers. Following removal from the flower, the stigmas need to be dried. This can be done using an airflow oven set at 30ºC for 24 hours. A domestic dehydrator set at a low temperature could also be suitable for drying. Saffron production needs labour and stigma drying facilities.

7.5 Current industry/market status

Production is dominated by Iran, who supply Spain, who then re-export a large amount of saffron. Prices vary depending on the quality and season, but top quality saffron can reach US$10/g. In New Zealand prices range from $8-$15/g ($8000 – 15000/kg), but recently it has been sold for $24/g on world markets.

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8 FEIJOA

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Figure 14: Ripe Feijoa

8.1 Why Feijoa?

Feijoa is a versatile, hardy tree species which requires minimum care once established. With little chemical intervention required, the opportunity to grow feijoa organically has appeal. Winter and spring frosts are common within the Tararua district so any crop selected must be frost hardy. Feijoa tolerate frost to -5°C and are therefore considered moderately frost hardy. There are many areas of suitable soil for good feijoa production within the Tararua district. An evenly distributed year round rainfall typical in the Tararua area also suits feijoa production.

Many New Zealanders now live in small urban dwellings with little room for the traditional feijoa and lemon tree characteristic of many home gardens in the past. Feijoa are a popular fresh fruit in New Zealand and consequently there is a strong domestic market for the fruit. The international market for high quality fruit is also becoming significant as are processing opportunities.

8.2 Brief description of the crop

Feijoa (*Feijoa sellowiana* O. Myrtaceae) is an evergreen species that can grow up to 5 m tall but will generally reach between 2-3 m. They can be grown as individual trees or as a hedge. The species is native to South America but is particularly well suited to New Zealand with few pest or disease problems associated with feijoa production. When fruit is mature it drops from the tree; however, if fruit is to be sold it must be picked before natural drop and must be picked by hand (Figure 14). Yields of up to 30 kg per tree are average once the trees are mature (7-10 years). Depending on the variety, fruit is produced from March through to June (Amoamo 2003). Currently most feijoas are produced in the Bay of Plenty, Northland and the Auckland region but there are many other areas of the country that suit production of this subtropical species including the Tararua district (www.hortnet.co.nz).

8.3 Growing requirements

Feijoa are tolerant of a wide range of soil types but do best on heavy but reasonably well-drained soils with a pH between 6–6.5. Feijoa also perform well in partial shade and are tolerant of salt spray. Feijoa will tolerate frost (-5°C) but only for short periods. Water requirements for feijoa are relatively low, but readily available water throughout the fruiting period will ensure good quality well sized fruit. Feijoa, as with many other plant species, do better under sheltered conditions and fruit quality can be enhanced if the growing site is well sheltered from prevailing winds. Wind may cause fruit damage which reduces export pack out

and therefore returns. Feijoa requires 100-200 hours of winter chilling (base temperature 5ºC) for good flowering. Most areas within the Tararua district will receive adequate chilling. Pollination is generally carried out by large birds including blackbirds and mynas (Feijoas 2006). Although smaller nectar feeding birds regularly visit feijoa flowers they are not effective pollinators.

For optimum air circulation and light interception feijoa trees should be spaced at approximately 3-3.5 x 4.4-5 m which will give approximately 800-900 trees per ha. At this spacing the canopy closure of the planting will take approximately five years. Regular pruning from the third year is required to maintain an open central canopy which will also aid light penetration and air circulation. Flowers are produced on current season's wood so a bushy growth habit is desirable and encourages precocious flowering. A bushy growth habit must be balanced with canopy characteristics that encourage light and air penetration (Incredible Edible Feijoa 2006).

Fertiliser application at the time of planting should include a base dressing of Nitrogen-Phosphorous-Potassium (NPK). During establishment NPK should also be applied yearly at rates comparable to those outlined in Table 4.

Table 4: Fertiliser programme for Feijoa (Thorp 1996)

Plant Age	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)
1	25	40	20
2	30	40	20
3	45	40	20
4	60	60	80
5	75	80	100
6	90	100	100
7	100	100	100
8	120	100	100

Feijoa do host some pests but most are unlikely to cause significant damage to the tree or the fruit. Of those pests which may cause damage the Australian Guava moth is causing the most concern to commercial growers in New Zealand. Guava moth is easily controlled using pheromone traps (www.gardenscience.co.nz). Scale insects may also be a problem. This pest results in sooty mould growth on leaves and wood reducing leaf performance and may superficially mark fruit. Scale insects can be adequately controlled using commercially approved pesticides. Monitoring for pest and disease incidence is the best technique for early detection and will help minimise crop damage and the need for chemical intervention.

There are a number of feijoa varieties available and some will be better suited than others to particular locations. It may be advisable to plant a selection of varieties so that maturity dates and supply to the market is spread. Many feijoa varieties now available commercially are self-fertile but not all. This must be considered when selecting varieties for planting. Plants do not produce fruit until their third year with maximum yields reached by year seven.

Feijoas grown for export must comply with the spray residue restrictions as outlined in the New Zealand Feijoa Growers Association web site (www.feijoa.org.nz).

8.4 Infrastructure requirements

Feijoa is a labour intensive crop to harvest as it requires hand picking at the optimum maturity. Touch picking, once fruit have developed an abscission zone between the fruit stalk and the fruit but before natural abscission occurs, is recommended to ensure maximum storage life from fruit that are ready to eat. If fruit are not refrigerated they must be consumed within 2-4 days of picking. Figure 15 below illustrates the optimum eating stages (C and D) for feijoa. Fruit picked at maturity stage A will never develop good flavour or texture for eating.

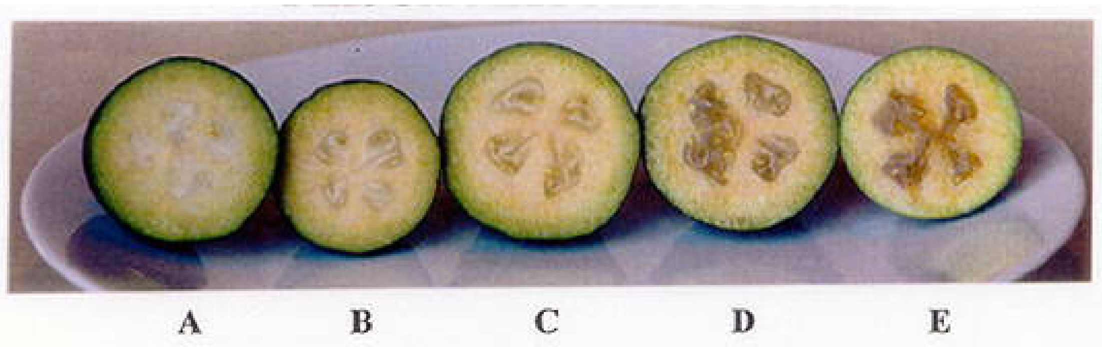

Figure 15: Maturity stages for feijoa (Local market quality and handling standards 2000).

Once harvested at stage B (touch picked) fruit will store for a maximum of three weeks at 4°C. During picking care must be taken to avoid bruising the fruit. Internal fruit damage can occur without any obvious external signs and eating quality and storage potential is then compromised. The transport of fruit in shallow trays (maximum height 120 mm) to avoid the top fruit damaging those at the bottom of the tray is recommended. Fruit should be transported using refrigerated vehicles and must be dispatched the day of picking if no cool storage facilities are located on the property.

8.5 Current industry/market status

The feijoa industry is small but now well established. Approximately 500 tonnes of fruit was exported in the 2005 season with most of the fruit going to the US. The New Zealand Feijoa Growers Association (NZFGA) was formed in 1985. The establishment of this incorporated society gives members access to information on marketing and production of feijoas. The feijoa growers association also provides professional advice for people wishing to grow feijoas commercially. The NZFGA is funded through a 2% levy on all fruit sold. Not all feijoa growers belong to the growers association but membership is advised to ensure the sound development of business opportunities for feijoa production. The NZFGA also actively promotes exported fruit in international markets.

An ideal fruit production ratio of 60% for export at approximately $2 kg, 30% local at $1 kg and 10% processing at $0.25 kg will give approximate returns of about $25,000 ha on a mature block (Amoamo 2003). The local market tends to become saturated during the season so prices can be low. By growing a mix of early and late maturing varieties there will be better marketing opportunities both early and late in the season and better fruit prices received by growers at either end of the season.

A small market also exists for feijoa foliage because of its attractive silver underside of the leaves. Auckland Flower Exporters (NZ) Ltd list feijoa foliage in their product list (www.flowernz.co.nz).

8.6 Further sources of information

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9 ROOTSTOCK GRAPES

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9.1 Why Rootstock Grapes?

The production of rootstock grapes and the delivery of grafted grape vines requires a high capital investment and skilled nursery staff. However, the ready market and good returns may make this venture attractive. Tararua district is well suited to the production of grape root stocks. The prevailing climatic conditions are appropriate for rootstock production and the area does not currently host grape production and therefore the region is grape pest and disease free. The regions close proximity to both Wairarapa and Hawke's Bay, two premium wine producing regions, gives Tararua good market access and minimum freight costs for good quality grafted plants.

9.2 Brief description of the crop

Wine production has become New Zealand's second most valuable horticultural industry after kiwifruit (Fresh Facts 2005). In 2005 the 500th vineyard was established (New Zealand wines on line 2006). Grapevines belong to the family *Vitaceae* which is made up of up to 14 genera and about 700 species, with *Vitis* being the most important genera to commercial viticulture (Dry and Coombe 2004). The predominant species for wine production is *Vitis vinifera* although other species have been used to develop root stocks (Dry and Coombe 2004).

Most commercially grown wine grapevines in New Zealand consist of a varietal scion, the fruiting portion of the grape vine, grafted onto a rootstock with desirable traits of root performance and which impart sought-after scion characteristics. One primary reason for rootstock use in grape vines is the protection against soil borne insects and pathogens such as phylloxera, a root feeding aphid, and phytophthora, a root rot disease. Other characteristics including early maturity and controlled vigour may also be transferred from root stock to scion (Clarke 2004). There are many varieties of root stock available for grapes in New Zealand and it is a matter of matching particular stock varieties with the conditions that the vines will be grown in once grafted. The Tararua district offers areas suitable for grape rootstock production.

9.3 Infrastructure requirements

Extensive horticultural knowledge along with some specialised horticultural equipment is required for the successful production of rootstock grapevines. The harvesting and shipping of grafted grapevines does not require a cold chain as fruit products may, but access to blocks for the harvest of plants for shipment must be good throughout the dormant winter months.

9.4 Growing requirements

Grape plants may be sensitive to early spring or late autumn frosts but frost susceptibility depends on variety. A long growing season is desirable as this encourages vegetative growth from the mother vines, scion plants and the grafted vines. For all root stock production it is desirable to have the production units discretely located from the major crop growing areas. This ensures root stock material remains virus free. Vegetative plant material must be kept free of pest and diseases in order to maximise growth and therefore regular spraying for both insect and fungal pests must be carried out.

The key to successful root stock and high quality grafted plant production is the development of strong, fibrous roots that will ensure good performance from the stock once grafted and planted in the vineyard. If trench layering techniques are used then roots are produced on the layered mother vine material under sawdust (McKenzie 1994). Alternative production methods include the removal of root stock material from the mother vine and placement into rooting media such as vermiculite or sand under misting. Some supplementary lighting and heat can increase cutting strike and reduce production time but this needs to be conducted under glass, which significantly increases setup costs. Once the root stock material has developed a strong root mass, grafting of the scion follows with a cleft graft traditionally being used (Walker and Golino 1999). A detailed account of recent grating trials and strike rate of important scion varieties is discussed in Creasy et al., (2003).

Figure 16: Grafted grapevine plants ready for planting out.

Once the graft has taken, the newly grafted plant is grown out in a relatively light soil where strong root growth is encouraged (Figure 16). To promote optimum plant growth of the grafted plants, nutrients need to be readily available within soil and therefore moderate but regular applications of a multi-nutrient mix is recommended.

Figure 17: Grafted grapevine plants growing in a New Zealand field nursery.

Most traditional forms of rootstock production take at least 3-4 years before the mother vines produce adequate bud numbers for good rootstock production (www.ormondnurseries.co.nz) (Figures 17 and 18).

Figure 18: Mother grapevines from which bud wood for rootstock production is harvested. Here mother vines are grown on a trellis structure.

9.5 Current industry/market status

Grape rootstock production is unable to keep up with current demand and waiting times of up to two years are being reported in the market place. Although many new plantings of grape have been established in recent years, replanting of vines is also common practice and so there is the requirement for a continuous supply even after the current boom in grape planting has passed. Good industry linkages between rootstock producers and fruit producers are vital to ensure appropriate material is supplied in good time to industry growers. The shortage of plant material for vineyards is not limited to New Zealand. Areas such as the US struggle to source plant material to satisfy demand (Walker and Golino 1999). Care to produce the rootstock varieties that are currently in demand and those that will be in demand in the future is vital to the business success of grape rootstock production. There are many different varieties to choose from and the current top 15 rootstocks are constantly changing. With the diverse range of soil types and climatic conditions experienced within the vineyards of New Zealand, a wide variety of rootstocks being available is essential. Access into the market place requires a high quality product which can compete with existing suppliers.

9.6 Further sources of information

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10 PASSIONFRUIT

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Figure 19: Ripe Passionfruit

10.1 Why Passionfruit?

Although passionfruit have a well deserved reputation for being a difficult crop to grow successfully, the returns can be high. The Tararua district has a contrast of land and climate characteristics, so it is likely that there are niche locations that will suit passionfruit. Growing passionfruit is not considered a part-time profession as the picking and packing requirements during the season and the regular and vigilant spray regime required make this crop quite labour intensive. Nonetheless returns can be good and passionfruit production offers a viable lifestyle choice.

10.2 Brief crop description

There are approximately 500 species of *Passiflora* but only one, *P. edulis* Sims that is used for fruit production in New Zealand (Figure 19). Native to South America they have been grown in New Zealand since the 1930s. In New Zealand the purple cultivar is grown as the yellow cultivar, classified as a tropical species, is not frost tolerant. Passionfruit are produced on a woody perennial vine which climbs with the aid of tendrils. Vines are quick to begin fruit production with significant harvests after just two years from planting (Sale 2003). Production in New Zealand is centred around the Bay of Plenty, but suitable pockets of land and climate can be found throughout the North Island so there is some opportunity for passionfruit in the Tararua district.

10.3 Growing requirements

For optimum fruit production passionfruit need a warm moist environment and free draining soil (Considerations for intending passionfruit growers 2002). The humid conditions which are favoured by passionfruit also favour fungal diseases which are the primary concern of passionfruit growers. Diseases including Brown Spot, Septoria Blotch, Bitter Rot and Root Rot can all cause a serious decline in the health and production of a passionfruit vine (Passionfruit diseases 2002). In an orchard situation passionfruit are more susceptible to disease and therefore a rigorous spray schedule is necessary. The high rates of copper use in passionfruit production may cause long-term site contamination problems. Therefore caution

is required to ensure timely and accurate spray application. Pests that may have an impact on passionfruit production include thrips, Fuller's rose weevil (Sale 2003) and passion vine hopper (Hallinan 2001). Fruit must be free of pests and disease if fruit is to be exported.

Sufficient soil moisture is vital to passionfruit production and therefore irrigation is critical during fruit growth if soil conditions are likely to be dry. Lack of water during fruiting reduces yield and fruit quality. However, passionfruit do require a well drained slightly acid (pH 6) soil to thrive.

There are a number of structural systems which passionfruit may be trained on to including a 1.8 m pergola, a 1.8 m two-wire fence, or a wooden A-frame (Figure 20). The type of structure used will influence initial setup cost and will significantly influence spray penetration and effectiveness, fruit quality and overall vine performance.

Figure 20: Two-wire fence structure and unplanted A-frame structure.

In most systems vines are spaced at 5 m within rows and 2.5 - 3 m between rows running at a north to south orientation. Wind damage to vines will significantly reduce yield and fruit quality so a well sheltered site is also important.

Passionfruit vines reach maximum yields of about 12 t per ha by year 4-5, however, these values drop as vines become older. Vine replanting therefore needs to be factored in to the business plan for passionfruit production. Planting needs to occur between October and December to ensure that the young foliage is not exposed to frost. An initial fertiliser application of 75-100 kg/ha N, 30 kg/ha P, and 100 kg/ha K is recommended at planting. Passionfruit have a high nitrogen demand (150-200 kg/ha per annum) and therefore on-going fertiliser application is critical and should be applied periodically throughout the growing season (Developments in growing 1995). Passionfruit are also susceptible to boron deficiency thus extra applications of boron may be necessary to maximise vine health.

10.4 Infrastructure requirements

The initial set up costs for implementing the structural requirements and planting of a passionfruit block may be up to $25,000 per ha (Sale 2003). Interestingly, New Zealand has many small growers with the average block covering just 0.4 ha with the corresponding *pro rata* setup costs.

Generally smaller growers will grade and pack fruit by hand without any specialised equipment, e.g. on the kitchen bench. Single layer plastic lined trays are used to protect fruit against bruising. Fruit must be uniform in both colour and size and be individually labelled

with a PLU sticker when packed (Packing and Packaging Standards 2002). There should be no visible spray residue on packed fruit and should appear free of dust, dirt and insect stains. With the high application rates of copper there may be a need to dip fruit in a 1% hydrochloric acid solution for 1-2 minutes to remove any residue present on fruit.

Cool storage at 5°C is recommended for packed fruit. However, passionfruit are more tolerant of room temperature storage than many other fruit crops. There are a number of international exporters and local suppliers of New Zealand passionfruit. A full list can be downloaded from: www.passionfruit.org./New Zealand_Market.htm
www.passionfruit.org.nz/World_Market.htm

10.5 Current industry/market status

The market for purple passionfruit is strong with excellent repeat purchase shown by customers. There is some competition between the yellow and purple varieties within the market place. Passionfruit store extremely well if handled correctly so supply can be regulated and fruit may be available for eight months of the year. Currently in New Zealand there are about 100 passionfruit growers producing an annual crop of about 240 t per annum (Hallinan 2001). The annual passionfruit crop in 2002 was worth NZ$400,000 (Amoamo 2003). Approximately 30–40% of the crop produced per annum is of export quality (Amoamo 2003). Current prices during the season range from a premium of $9 kg in January but drops to $2.50 kg in the middle of the season. A minimum average price of at least $4 kg is required to be profitable as picking and packing requirements are time consuming. A typical fruit grade analysis for a passionfruit production block is 40% export, 40% domestic and 20% processed (Amoamo 2003). A levy of 1.25% of the price of all fruit sold is paid to the New Zealand Passionfruit Growers Association (NZPGA). These levy funds are used for promotion of fruit in the market place and research (Passionfruit: Commodity levies act 2002).

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APPENDIX 1: RULES FOR MAPPING

Ginseng (Graeme Parmenter)

Canopy (for ginseng that could be grown under forest immediately)

0=no trees, Manuka or Kanuka

1=Broadleaved Indigenous Hardwoods, Indigenous Forest, Other Exotic Forest

2=Deciduous Hardwoods, Pine Forest - Closed Canopy, Pine Forest - Open Canopy (suitable in future)

Slope

0=Classes D, E, F, G

1=Classes A, C

2=Class B

Aspect

0=

1=West, North

2=South, East

pH

0=pH 2.5-4.5, 6.6-8.0

1=pH 4.6-4.9, 6.1-6.5

2=pH 5-6

Profile total available water (used here in part as a surrogate for soil organic matter and terrains)

0=5, 6

1=4

2=1, 2, 3

Drainage class

0=1, 2

1 = 3

2 = 4, 5

Winter 10cm soil temperatures (mean monthly temperature May-July)

0=>10°C

1=8-9°C

2=2-7°C

Mean maximum daily air temperatures (Dec-Feb)

0=25-30

1=21-24

2=16-20

Truffles (Garry Burge)

	Périgord black truffle	Truffles - Bianchetto truffle
Slope	0=Classes E, F, G 1=Classes D 2=Class A, B, C	0=Classes E, F, G 1=Classes D 2=Class A, B, C
Subsoil acidity	0=Class 5, 6, 7 1=Class 4 2=Class 1, 2, 3	0=Class 5, 6, 7 1=Class 4 2=Class 1, 2, 3
Drainage	0=Class 1, 2, 3 1=Class 4 2=Class 5	0=Class 1, 2, 3 1=Class 4 2=Class 5
Average temperature January – March	0=<15°C 1=15-16°C 2=>16°C	0=<14°C 1=14-15°C 2=>15°C

Hazelnuts (Garry Burge)

<u>Slope</u>

0=Classes D, E, F, G

1=Classes C

2=Class A, B

<u>Drainage class</u>

0=Class 1-3

1=Class 4

2=Class 5

<u>Frosts during flowering (July-August) at screen height</u>

0=< -8°C

1=-5 to -8°C

2=> -5°C

Gevuina (Garry Burge)

<u>Slope</u>

0=Classes D, E, F, G

1=Classes C

2=Class A, B

<u>pH</u>

0=Class 1, 2, 5, 6 7

1=Class 4

2=Class 3

<u>Drainage</u>

0=Class 1, 2, 3

1=Class 4

2=Class 5

Profile total available water

0=5, 6

1=4

2=1, 2, 3

Rainfall (December – March without irrigation)

0=<50 mm; >200 mm

1=50-100 mm

2=100-200 mm

Tmin spring (to avoid frost damage to new growth)

0=< -8°C

1=-6 to -7°C

2=>-5°

There probably is an accumulated degree days required for the nut to mature. But difficult to say what this is. The crop grows in Dunedin to Auckland, so Dunedin may be the minimum degree days required. Not sure what base temperature is appropriate, as the nuts take nearly a year to mature.

Goldenseal (Graeme Parmenter)

Slope

0=Classes D, E, F, G

1=Classes C

2=Class A, B

pH

0=pH <5.0, >7.0

1=pH 5.1-5.4, 6.6-7.0

2=pH 5.5-6.5

Profile total available water (used here in part as a surrogate for soil texture and organic matter)

0=5, 6

1=4

2=1, 2, 3

Drainage class

0=1, 2

1=3

2=4, 5

Winter 10 cm soil temperatures (mean monthly temperature May-July)

0=>10^{o}C

1=8-10^{o}C

2=<8^{o}C

Rainfall (mean monthly December-February)

0=<50 mm

1=50-100 mm

2=>100 mm

Mean maximum daily air temperatures (December-February)

0=25-30

1=21-24

2=16-20

Valerian (Graeme Parmenter)

Slope

0=C-F

1=B

2=A

Potential rooting depth

0=1, 2, 6

1=3, 5

2=4

Drainage class

0=

1=1, 5

2=2, 3, 4

Profile AWC

0=5, 6

1=1, 4

2=2, 3

Thermal time (December-February av. monthly GDD base 10)

0=<100

1=100-200

2=200-300

Rainfall (November-January av. monthly)

0=<50

1=50-100

2=100-200

Saffron (Bruce Searle)

Slope

0=Classes D, E, F, G

1=Classes C

2=Class A, B

pH

0=pH <5.0, >7.0

1=pH 5.1-5.4, 6.6-7.0

2=pH 5.5-6.5

Subsoil Acidity

0=Class 5-7

1=Class 1, 2

2=Class 3, 4

Drainage

0=Class 1-3

1=Class 4

2=Class 5

Profile total available water (used here in part as a surrogate for soil texture and organic matter)

0=5, 6

1=4

2=1, 2, 3

Average autumn temperature

0=>20^{o}C

1=17-20^{o}C

2=<17^{o}C

Rainfall (mean monthly March and April)

0=>100 mm

1=50-100 mm

2 <50 mm

Feijoa (Tessa Mills)

Variables

Slope Class	A, B and C
Subsoil acidity	3 and 4
Potential Rooting Depth	1, 2 and 3
Drainage Class	4 and 5
Profile total available water	1, 2, 3 and 4

Frost Free period >120 days (0ºC), minimum daily temperature throughout the year not to exceed -5ºC

Rootstock grapes (Tessa Mills)

Variables

Slope Class	A and B
Subsoil acidity	2, 3 and 4
Potential Rooting Depth	3 and 4
Drainage Class	3 and 4
Profile total available water	2, 3 and 4

Frost Free period >120 days (OºC)

Passionfruit (Tessa Mills)

Variables

Slope Class	A, B and C
Subsoil acidity	2, 3 and 4
Potential Rooting Depth	2 and 3
Drainage Class	5
Profile total available water	3 and 4

Frost Free period >120 days (0ºC), minimum daily temperature throughout the year not to exceed -1ºC

APPENDIX 2: ADDITIONAL CLIMATE VARIABLES TO CONSIDER FOR MAPPING RULES

Variable	Description	Class Breakdown
Tmax	Air temp at screen height, daily maximum	Spring Summer Autumn Winter
Tmin	Air temp at screen height, daily minimum	Spring Summer Autumn Winter
Tbase 1	Base temperature for degree day calculations, specify use (e.g. vegetative growth through to flowering)	Specify use
Tbase 2	Base temperature for degree day calculations, specify use (e.g. flowering to maturity)	Specify use
Tbase 3	Base temperature for degree day calculations, specify use	Specify use
Thermal time 1	Accumulated degree days for successful crop. Specify if there is a particular period during which this must be achieved (e.g. between 1 September and 31 March)	Specify period or conditions
Soil temperature Tbase	Base temperature (10 cm depth) for degree day calculations, specify use (e.g. germination, 50% emergence)	Specify use
Thermal time 2	Accumulated degree days (soil temperature) for successful crop germination and emergence. Specify if there is a particular period during which this must be achieved (e.g. between 1 September and 30 December)	Specify period or conditions
Rainfall	Monthly rainfall that you would normally consider suitable for crop production without irrigation	January February March April May June July August September October

Variable	Description	Class Breakdown
		November December
Sunshine	Monthly total sunshine hours OR solar radiation that you would normally consider necessary for successful crop production	January
	Specify unit here (e.g. sunshine hours, MJ/m^2)	February
	Notes: Blenheim gets about 2400 sunshine hours per year, Invercargill gets about 1800	March April
	Auckland gets about 660 MJ/m^2 in December	May
	Invercargill gets about 606 MJ/m^2 in December	June
	1 Langley = 1 cal/cm^2 = 42 kJ/m^2 = 0.042 MJ/m^2	July
		August September October November December
Wind	Windspeed that can be tolerated in unsheltered conditions	May need to specify month and height if necessary
Humidity	Relative humidity or vapour pressure deficit	Specify units and time of year if necessary
Frost risk	Tolerable risk of frost by month of the year	January February March April May June July August September October November December