Production of the medicinal crops Valerian and Echinacea in New Zealand

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Abstract

Seedlings of valerian (*Valeriana officinalis* L.) and echinacea (*Echinacea purpurea* Moench) were planted (4.44 plants/m^2) at five sites around New Zealand, in December of 1991. All sites were well fertilized and watered. Valerian root production, measured in May of 1992, ranged from 70 to 100 g/plant, with no significant difference ($P<0.05$) between sites. Echinacea production ranged from 5 to 20 g/plant, with significantly lower production from three South Island sites than from two North Island sites. *Phoma* and *Sclerotinia* spp. were identified as two fungal pathogens affecting valerian. Valerian root damage, probably caused by grass grub was also recorded at one site. South Island echinacea was affected by an, as yet, unidentified agent causing leaf deformation. Medically-active compounds of both species are briefly discussed.

Introduction

In 1989, MAFTech (now part of Crop & Food Research) commissioned the Trade Development Board to report on medicinal crops with export potential for New Zealand. They identified several important species in the medicinals market. Two of them, valerian and echinacea are traded internationally in moderate quantities, with major markets in Europe. Both have well proven uses and a secure place in the alternative medicines market, and in Germany at least, are widely used in mainstream medicine. In 1991 MAFTech South initiated a trial to assess the production potential of these two medicinal crops under New Zealand conditions.

Valerian

Description. *Valeriana officinalis* (L.) belongs to the Valerianaceae and is indigenous to Europe and Northern Asia, although other species of the genus have an important place in the traditional medicines of Japan, India and Mexico. It is a perennial, grows to a height of 1.5 m and has small white to pinkish flowers borne in an inflorescence.

Uses. Valerian root has been used as a medicine in Europe for more than 2000 years, but its reputation in the last 200 years has been built upon its sedative effect. It is often prescribed by doctors in Germany as a mild sedative, but is little used in the USA by the medical profession. Herbalists there use valerian to treat emotional stress, muscle pain, cramps, tension headaches and insomnia. (Hobbs, 1989). An alcohol extraction of fresh or dried root is the traditional method of preparation, but in Germany a product is available that standardises the content of three of the important active ingredients (valepotriates).

Activity. The essential oil, particularly the valerenic acid component, was first thought to be the active compound in root extracts. The amount and chemical composition of the oil is very variable and no consistent correlation between oil content and sedative activity has been found. Gstirmer and Kind (1951) estimated that only one third of the sedative effect of the extract could be accounted for by the effect of the volatile oil. Another class of compounds the valepotriates, was identified (Thies, 1966), and demonstration of their sedative activity (von Eickstedt, 1969) appeared to account for the difference, particularly as numerous clinical tests have confirmed their sedative activity (Houghton, 1988). However, Japanese *V. officinalis* var. *latifolia*, with a high essential oil content, showed greater sedative activity than varieties with a higher valepotriate content (Hikino *et al.*, 1980). To complicate matters further, a water soluble fraction, containing no valepotriate and little oil has also been shown to have a sedative effect (Leathwood et al., 1982). Cytotoxic effects of some of the valepotriates has encouraged attempts to find species that lack these compounds (Koch and Hölzl, 1985).

Market. A Trade Development Board study (George, 1990), showed prices for whole valerian root ranging

from $2-10/kg, depending on country of purchase and quality. The Rote List of the German pharmaceutical industry lists more than 100 products containing valerian and valepotriates. Accurate traded volumes are not available, but these are probably in the hundreds of tonnes/annum (George, 1990).

Echinacea

Description. Echinacea (*Echinacea purpurea* Moench), also known as purple coneflower, is one of nine species in a genus, which is indigenous to North America. It is a member of the Compositae and grows to a height of 0.5-1.5 m, with large (10-15 cm) flower heads and purple ray flowers. It is the best known of the cultivated species with numerous cultivars available commercially.

Uses. *Echinacea* spp. have a long history of use amongst North American Indians, from whom early settlers and eventually the medical profession learned of its role in treating a number of ailments. Although dismissed as valueless by the American Medical Association in 1909, by the 1920s eclectic physicians in the US were reporting numerous cases of echinacea having beneficial effects in the treatment of cancerous growths, inflammation, and skin disorders, and had already recognised it as an immune system enhancer (Foster, 1991). Since the 1940s most studies of the effects of echinacea have been published in Germany (Hobbs, 1989). They have established that echinacea improves non-specific immunity and stimulates new tissue growth by increasing fibroblast production. It is regarded as effective in treating certain viral and bacterial infections, healing wounds and controlling inflammations (Foster, 1991).

Activity. Polysaccharides from *Echinacea purpurea* have been shown to possess immuno-stimulating properties (Wagner *et al.*, 1985), and have been shown to inhibit bacterial growth *in vitro* and *in vivo* (Roesler *et al.*, 1991). Moring (1984) suggested that polysaccharides act by binding to carbohydrate receptors on cell surfaces of T-lymphocytes, inducing the production of interferon and triggering the activation of phagocytic macrophages. Anti-viral activity appears to be related to the release of interferon. Immunostimulatory activity has also been shown in low molecular weight, fat soluble compounds (alkamides) (Bauer *et al.*, 1989).

Market. Stringent regulations and the high cost of developing new products limits the use of herbal products in main stream medicine in the USA (Tyler, 1986). Germany appears to be the principal market for echinacea. A Trade Development Board study lists dried root market prices at $25-$45/kg of dried whole root, although traded volumes were uncertain (George, 1990). One organic grower from Trout Lake Farm, Oregon, supplies 9 t of dried root annually to Germany. More than 280 products containing echinacea are available in Germany (Foster, 1991).

Methods

Sites

Location of sites and soil types (DSIR, 1954 and 1968) were: Hamilton, Horatiu silt loam; Hastings, Hastings clay loam; Alexandra, Annan silt loam; Mosgiel, Wingatui silt loam; Woodlands, Waikiwi silt loam.

Ground preparation

Soil tests were conducted at all sites (Table 1). On the basis of these results, fertilizers were applied to achieve comparable levels of available major nutrients at all sites. Without published information on nutrient requirements for these crops, recommended levels for root vegetables were used as a guide to target soil nutrient levels (Wood *et al.*, 1986). Target levels (in Olsen units) of major nutrients were: P, 40-65 according to P retention; K, 10-12; Ca, 8-10; Mg, 10-12; and S, 12.

All sites received the equivalent of 0.85t/ha of diammonium phosphate (DAP, 18%N, 20%P), 0.5t/ha during ground preparation and 0.35t/ha in February. Additional nutrients were applied at each during ground preparation (Table 2).

Sites were rotary hoed and soil was formed into beds 1.5 m across. Each bed was covered with weed-matting (CIL Weedmat).

Crops were watered to maintain soil water potential (at 150 mm depth) higher than -0.1 MPa.

Plant propagation

Seed of valerian (Samen Mauser, Switzerland) and echinacea (Flecke-saaten Handle, Germany), was sown in seed trays. Echinacea was grown to the 3-4 leaf stage and valerian to the 5-10 leaf stage before being transplanted into the field.

Planting design

Plants were transplanted into beds in two rows, 0.6 m apart, with 0.3 m between plants (effective density 4.44 plants/m^2). All sites were planted in mid-December 1991. At each site there were six beds, each containing 48 plants. Plants in the central four beds were subsequently harvested.

Table 1. Soil test results for soil (0-10cm) collected in October from each of the five sites where valerian and echinacea were grown. (PR - Phosphate retention; fCE - Effective cation exchange capacity (me/100g)).

	Olsen Quick Test							
Site	pH	Ca	P	K	S	Mg	PR	fCE	C:N
Hamilton	5.3	3	45	4	78	6	90	6.2	10.4
Hastings	6.0	19	28	20	8	51	17	16.2	8.2
Alexandra	5.6	8	28	7	17	24	15	7.3	7.9
Mosgiel	5.8	21	16	6	14	48	38	17.7	10.3
Woodlands	5.8	6	10	6	22	10	57	8.6	10.8

Table 2. Fertilizers applied at each of 5 sites prior to planting valerian and echinacea.

	Applied fertilizer				
Site	Gypsum (20% S)	Lime	30% potash serpentine super (5.5% P, 14% K, 8% S, 4% Mg)	K_2SO_4 (40% K, 17% S)	15% potash super (6% P, 7% K, 9% S)
Hamilton		5 t/ha	1 t/ha		
Hastings	30 kg/ha				
Alexandra		2 t/ha		360 kg/ha	
Mosgiel					3 t/ha
Woodlands		1 t/ha			3 t/ha

Harvests

During the first growing season, plants were harvested at planting and in January, March and May. At planting, eight plants from those used to plant each replicate were dried and weighed. At each of the remaining harvests, two adjacent plants were removed from each replicate, taken from locations surrounded by unharvested plants (a total of eight plants at each site). Each plant was removed by digging a 30 cm square block centered on the plant, dug to a depth sufficient to include most of the root (0.3-0.4 m). Soil was removed by washing.

Measurements

For each of the plants harvested at each site, shoot and root dry weights were recorded after drying at 80-90°C for 16 h. Root material harvested in May was dried at 40°C to less than 15% water content and stored (2-3°C, 30% RH) for later analysis of chemical composition. A subsample of that root was dried completely at 80-90°C to get an estimate of dry weight.

Results and Discussion

Valerian

Root weight. Root dry weight harvested in May was up to 90 g/plant (Table 3), equivalent to 4 t/ha. This compares favourably with German figures for production of 4-5 t/ha for valerian planted in Spring at densities of 6-9 plants/m^2 (Anon, 1984). There were no differences ($P<0.05$) between sites, although there was high within site variability in root weight. Plants remained vegetative at all sites throughout the season. The proportion of rhizome present in the root was measured at Invermay for the harvests in March and May. It was about 8-10% of the total root weight. It is necessary to separate root from rhizome before washing. Dirt trapped at the junction of root and rhizome accounted for as much as 5-15% of the dried root weight of some hand-washed test samples.

Weeds. The weed matting used in this trial provided excellent weed control. Some weeds were removed by hand from the exposed soil immediately adjacent to each plant, but this would be unwarranted in a commercial operation. Trials of valerian tolerance to a range of

Table 3. Dry root weight (g/plant; mean of 5 sites) of valerian harvested from December 1991, until May 1992.

Harvest date	Dec	Jan	Mar	May
Dry root weight	0.18	0.44	27.4	83.3

herbicides were conducted at Invermay and Hastings and some preliminary information on compatible herbicides is available (Hartley, 1992; Mitchell, 1992). The demand for "organically-grown" product is probably greater for medicinal herbs than for many crops, which may make the use of many herbicides unacceptable. The weed matting used in this trial helped to standardise production methods between sites, but more traditional mulches mulches may also be successful. Because the crop grows rapidly to form a relatively tall canopy, many weeds may be effectively controlled by the crop itself.

Pests and diseases. A fungal disease affected the crop soon after planting at Hamilton, checking plant growth and causing some deaths. The likely pathogen was identified as a *Phoma* sp., and after spraying with most infected plants recovered.

In very damp conditions in Autumn, sclerotinia rot was identified in plants from Woodlands, and a few plants at Mosgiel showed the same symptoms. Badly infected plants were removed and the crop was sprayed with Benlate.

At the May harvest, grass grub was identified in valerian plots at Woodlands and Mosgiel. Substantial damage to one of the eight plants harvested at Invermay was recorded.

Summary. Valerian grew well at all sites. In spite of relatively late planting and low densities, production was about 80% of quoted German production. Weed matting was highly successful for weed control, but valerian is tolerant to a number of commonly used herbicides. The crop appears prone to fungal diseases in wet conditions in Spring or Autumn. Grass grub may be a problem and avoidance of infested areas, or control of the pest prior to planting may be necessary.

Echinacea

Root weight. At the Autumn harvest in May, the two North Island sites yielded an average of 18.7 g/plant (0.8 t/ha) of dried root, substantially more than the average of 6.9 g/plant (0.3 t/ha) at the three South Island sites (Table 4). These yields are well below the 2-3 t/ha of dried root quoted for typical production in Germany (Anon., 1986), although this was for material planted in Spring and at nearly twice the density (8 plants/m^2) of that used in the present study. Echinacea was also planted in a density trial at Alexandra in December of 1990 (6-25 plants/m^2). Root harvested in April 1992 (Table 5), yielded 26-58 g/plant, producing the equivalent of 3.9-6.9 t/ha of dried root (Burton, 1992), close to the 5-6 t/ha quoted for German production after 2 years.

German growers typcially plant seedlings in rows 0.4 m apart with plants spaced 0.3 m apart within rows (8 plants/m^2) (Anon., 1986). American trials have used even lower densitites, with rows 0.9 m apart and plants 0.45 m apart within rows (2.5 plants/m^2) (George, 1990).

The Alexandra trial indicates that densities as high as 25 plants/m^2 may provide increases in root yield.

Weeds. Echinacea shoot grew less rapidly than valerian, so weed control is likely to be more of a problem where mulches are not used. Initial screening has revealed some common herbicides that do not appear to affect echinacea growth (Hartley, 1992; Mitchell, 1992).

Disease. Low yield of root at the three South Island sites may be related to an as yet unidentified pathogen, which caused severe leaf deformation on some plants and visibly affected most plants at Invermay, and was apparent at the other two sites in the South Island. Leaf samples from Invermay were analyzed but no likely agent was identified. Leaf samples from all sites will be

Table 4. Dry root weight (g/plant) of echinacea from 5 sites harvested from December 1991 to May 1992. (15 df).

Site	Harvest			
	Dec	Jan	Mar	May
Hamilton	0.04	0.23	5.4	20.6
Hastings	0.02	0.23	9.1	16.8
Alexandra	0.04	0.08	1.2	7.8
Mosgiel	0.06	0.10	2.4	7.9
Woodlands	0.06	0.13	1.8	5.1
SED	0.008	0.058	0.82	3.6

Table 5. Dry root weight of echinacea planted at 3 densities at Alexandra in December 1990 and harvested in April 1992. (6 df).

Plant density (plants/m^2)	Root weight (g/plant)	Root weight (t/ha)
6.2	58.0	3.9
12.5	40.1	4.4
25	26.2	6.9
SED	4.5	0.5

analyzed in the second season in an attempt to establish the cause of this serious problem.

Summary. Low root production at South Island sites is of major concern. Unless the cause of the problem can be identified, it obviously represents a severe limitation to attempts to grow the crop in this region.

Active compounds

The activity of many medicinal plants is poorly understood. Even with a medicinal plant that has been used as long as valerian there is uncertainty about the relative importance of different components. This makes the task of defining the 'quality' of root difficult and helps perpetuate claims such as one appearing recently in a herb growers newsletter - that "stunted and gnarled" herbs have the "optimum medicinal properties". As part of the process of testing the production of medicinal herbs in this country it is necessary to establish some measure of quality. The Plant Extracts Research Unit at Otago University is testing a range of analytical methods (Perry & van Klink, 1992) to measure the most widely recognised active components of valerian and echinacea root. This analysis will enable the effect of site, drying method and storage on these compounds to be tested in future work.

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