Initial research on the production of American ginseng in the Waikato

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Abstract

American ginseng (*Panax quinquefolium* L.) is a perennial medicinal herb commonly grown in North America for the Asian market. It requires deep shade and free draining soils to grow well, and has a normal production cycle of three to six years. In North America most ginseng is grown intensively under artificial shade, with smaller volumes of more highly valued ginseng produced under a forest canopy. An intensive research programme on American ginseng has been carried out by Crop & Food Research since 1989. In this trial, American ginseng seedlings were planted in the Waikato in September 1991 under 75% shade cloth at densities of 15, 30 and 60 plants/m^2, and grown for four years. At harvest, plant densities had reduced to 7, 13 and 29 plants/m^2 with the highest death rate occurring in the first season after planting. After four years dry weight yields were 0.45, 0.74 and 1.81 t/ha for 7, 13 and 29 plants/m^2 respectively, about half the yield commonly quoted for North American growers using a three year rotation and higher plant densities. Seed yields were also assessed and in 1995 ranged from 38 to 181 kg/ha. American ginseng can be successfully grown in the Waikato, but the trial has highlighted the importance of adequate shade, phosphate nutrition and root knot nematode control.

Additional key words: Panax quinquefolium *L., plant population, dry matter yield.*

Introduction

American ginseng (*Panax quinquefolium* L.), an herbaceous perennial belonging to the Aralia family, is cultivated for its highly valued root. It had been used for centuries by North American Indians prior to its widespread production in North America for export to Asia where it is used as a medicinal herb alongside its close relative, Korean ginseng (*P. ginseng* C.A. Meyer). All parts of the plant are used but the root is the most valuable. It is sold as whole dried root, pieces of root, or powdered and used in teas, soups, capsules, wines and in a wide variety of herbal and cosmetic preparations.

American ginseng is a native of North American temperate hardwood forests from Georgia to Canada. The geographical range extends between 34° - 45° N latitude in eastern North America, a region which experiences a continental climate with hot dry summers and cold winters. Producing American ginseng is a significant minor industry in North America; main production areas are in Wisconsin, Ontario and British Columbia (Carlson, 1986; Fisher, 1995; Oliver, 1995). Commercial crops are grown intensively under high levels of artificial shade on free draining soils with a wide pH range (Proctor and Bailey, 1987). Many growers fumigate the soil prior to sowing (Fisher, 1995). Pre-ripened seed is precision sown into fertilised raised beds in autumn at a rate of between 78 - 156 kg/ha (Hartman, 1979). After sowing a mulch (usually oat straw) is applied. Most seed germinates in the following spring.

Roots are usually harvested after a minimum of three years, but may be grown for four or more years before harvest (Hartman, 1979) which is carried out with a modified potato harvester in autumn. Average yields for intensively grown ginseng are 2.5 t/ha dry weight (Thompson, 1987) but can be as high as 4.4 t/ha (Oliver *et al.*, 1992).

Almost all ginseng grown in North America is dried by the grower, packed into barrels, and sold at the farm gate with little or no grading prior to sale. Over 90% of the North American crop is exported to Hong Kong where it is sold by auction (Fisher, 1995).

Initial ginseng trials in Canterbury in 1973 demonstrated that ginseng could be grown in New Zealand (Palmer and Hurndell, 1986) but no commercial development followed. In the late 1980s a further programme to evaluate ginseng production in New Zealand was established (Follett *et al.*, 1995; Smallfield *et al.*, 1995). The programme follows the research

approach described by Douglas (1991). Well grown ginseng fetches high prices, and if established in New Zealand, it could form the basis of a viable industry. This paper outlines an initial evaluation of ginseng production in the Waikato.

Methods and Materials

A trial was established on the Horotiu sandy loam at the Blands Research Orchard at Rukuhia near Hamilton. Meteorological data are presented in Table 1. Stratified American ginseng seed, sown in January 1991, was grown on in paper pots in a heated glasshouse under lights until 13 August, then hardened off in a shade house prior to planting on 23 September 1991. Mean root wet weight at planting was 0.17 g (SD = 0.11), and dry weight was 0.028 g (SD = 0.016).

Plants were established at spacings of 13 x 13, 18 x 18 and 26 x 26 cm to give plant densities of 15, 30 and 60 plants/m^2 in 6 m long plots in beds 1 m wide with 0.5 m between beds. Treatments were arranged in randomised blocks with four replications to give 12 plots. Three plots, two from treatment one and one from treatment three, were lost as a result of rabbit diggings in the first year. In subsequent years beds were covered with bird netting.

Initially shade was provided by 75% shade cloth on the shadehouse, but this was found to provide insufficient shade, and leaves suffered from chlorosis and leaf tip necrosis. The problem was overcome by adding extra layers of shade cloth placed on cloches over the beds. The light was reduced from 23.1 MJ/m^2/day to 2.31 MJ/m^2/day (Follett *et al.*, 1995). The trial was mulched with fresh untreated *Pinus radiata* sawdust after planting, and again in August 1993.

A soil test carried out on 9 February 1990 gave Ca, P, K, S, Mg and Na test-values of 5, 8, 7, 67, 10 and 4 mg/kg soil respectively. The soil pH was 5.3. Lime was applied at 5 t/ha and soil incorporated in September 1991 prior to planting to raise the pH. Nitrophoska at 0.5 t/ha and triple superphosphate at 0.5 t/ha were broadcast on 24 November 1992. A soil test was repeated on 27 June 1994 with results for Ca, P, K, S, Mg and Na of 8, 30, 4, 89, 18 and 8 mg/kg soil respectively. The soil pH was 5.2. The addition of phosphate fertilisers raised soil phosphate concentrations which changed the leaf colour from red to green.

Weeds were controlled with a winter clean up spray of Roundup® (glyphosate) or Preeglone® (paraquat plus diquat) once a year and hand weeding as required during the growing season. Fusilade® (fluazifop-P-butyl) was applied as required to control grass weeds.

The fungicides Dithane® (mancozeb) and Ridomil® (metalaxyl plus mancozeb), were applied once every 10 - 14 days during the growing season. Mesurol® (methiocarb) was also applied for slug control and Lannate® (methomyl) and Attack® (permethrin plus pirimiphos-methyl) for insect control.

Plant numbers were recorded on 3 February 1993, 1 March 1994 and at harvest on 5 May 1995.

Ginseng seed was harvested and weighed in both the 1994 and 1995 seasons. Roots were harvested by hand from 5 to 9 June 1995. After harvesting, roots were washed and the wet weight recorded. Root weights were again measured after the roots had been oven dried and the presence of disease and root knot nematode nodules were also recorded.

After harvesting roots were cool stored at 4°C prior to drying. Roots were oven dried at 38°C with drying times based on the length of time roots were in cool storage (Van Hooren, 1991).

Results and Discussion

Plant survival

Plant densities fell from 15, 30 and 60 to 7, 13 and 29 plants/m^2 (Table 2) during the four year growing period. In 1993, two years after planting, the plant density for each treatment had been reduced by approximately 50%, with little further reduction in plant

Table 1. Meteorolgical data from Hamilton Airport automatic weather station.

	Temperature (°C)					Number of chilling days (from 1 June to 30 August)		
	January		July					
Year	max	min	max	min	Rainfall (mm)	<6	<9	<10
1992	22.7	12.1	13.6	5.3	1301	3	47	62
1993	22.8	10.5	12.6	3.5	985	4	41	55
1994	24.6	12.8	13.1	4.3	1272	4	46	60
1995	-	-	-	-	-	9	40	61

survival between 1993 and harvest in 1995 (Table 2). In Ontario, ginseng is often sown at rates of approximately 300 seeds/m^2 (Proctor, 1995). After one year, populations of between 130 to 200 seedlings/m^2 can be expected, with this population often reduced further to less than 100 plants/m^2 at harvesting after the third or fourth growing season. Survival rates from this trial and those observed in Ontario cannot be directly compared because of the differences in establishment (seed vs. seedling transplants), but significant plant losses, especially during the establishment phase, appear to be an industry wide problem (Proctor, 1995).

In 1994 the number of growing plants was slightly lower than that recorded in 1993 and 1995 (Table 2) with the plants not recorded having been summer dormant rather than dead. It is possible that after senescence in autumn some plants do not emerge in the following spring because of insufficient winter chilling. Stratification can be satisfied by exposure to 0° - 10°C for about 100 days (Lee *et al.*, 1985) while Konsler (1986) reported 100% emergence for roots stratified for 75 days at 6°C or 90 days at 9°C. The number of chilling days ([max daily temp-min daily temp]/2) below 10, 9 and 6°C (Table 1) recorded at the Hamilton Airport automatic weather station (less than 1 km from the trial site) indicates that for all criteria, except the number of degree days below 10°C, stratification temperatures were marginal for good bud emergence in spring. The low number of chilling days in the 1993 winter probably explains the low plant count in the following year. The studies by Konsler (1986) and Lee *et al.* (1985) were carried out under continuous cold stratification conditions which are more effective than situations (as in the Waikato) where periods of cold stratification alternate with periods of warm weather (Konsler, 1986; Seeley, 1996). As a result, the periods required for effective cold stratification in this trial are likely to be longer than those quoted by Konsler (1986) and Lee *et al.* (1985). In contrast, one year old American ginseng roots were overwintered outdoors for three months in the Waikato in 1995, and all emerged when grown on in a heated glasshouse in the following spring (B.M. Smallfield, unpubl.) despite the number of chilling days during 1995 being similar to the number recorded during this trial (Table 1). More work is required to clarify the winter chilling requirements of ginseng in a maritime environment.

Root yield

As plant density increased from 7 plants/m^2 to 29 plants/m^2, root dry weight yields increased from 0.45 t/ha to 1.81 t/ha after four years, but individual root dry weights were not affected by palnat density (Table 3). This is equivalent to a wet weight root yield of 5.94 t/ha at 29 plants/m^2. In North Carolina, density trials from four year old plants spaced at approximately 29 plants/m^2 produced a wet weight yield of 7.05 t/ha (Konsler, 1982; Konsler and Shelton, 1984). At this low density, yields were well below the 2.5 t/ha dry weight (Duke, 1989; Fisher, 1995) achieved by North American commercial crops which are grown at densities of approximately 300 plants/m^2.

Yield increases were closely related to increases in plant population, and the lack of any significant decrease in per plant weight (Table 3) indicated that at the populations evaluated there was little competition between plants.

Root weights varied from 0.1 to 51.3 g (Fig. 1). Overall, 49% of all roots had a dry weight of less than 2.5 g. Palmer and Hurndell (1986) also noted a large range in root weight in their Canterbury trial. Small roots caused by prolonged dormancy as a result of aerial shoots not appearing in spring have been reported in

Table 2. Plant counts for American ginseng grown at three plant densities.

	Plant Density (plants/m^2)			
	Planting			Harvest
Treatment	21.8.91	3.2.93	1.3.94	5.5.95
1	15	7	5	7
2	30	15	9	13
3	60	24	21	29
Total		46	35	49
Significance				p<0.001
SED; df=8				2.273

Table 3. Root yields (wet) and mean root dry weight of ginseng grown at three plant densities.

Plant density (plants/m^2)	Root yield (t/ha) Wet	Dry	Mean root weight (g)
7	1.39	0.45	5.8
13	2.47	0.74	5.8
29	5.94	1.81	6.3
Significance	p<0.001	p<0..001	NS
SED; df = 8	0.112	0.053	0.931

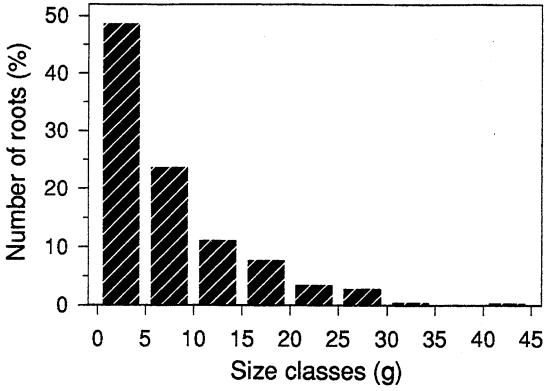

Figure 1. Distribution of dry weight in ginseng grown in the Waikato.

North America (Court *et al.*, 1996). This finding is consistent with the results from this trial, which suggest insufficient cold stratification may have contributed to poor spring emergence. Another possible explanation for the variation in root size is the premature shoot dieback during the growing season due to predation, i.e., slugs or caterpillars, or damage from Fungal pathogens such as *Alternaria* or *Phytophthora*. In spite of the dominance of small roots, some plants had large roots, which may indicate genetic variation that could be exploited to develop a Waikato ginseng variety.

Seed yield

Seed was first harvested on 2 February 1994 with seed collected weekly until 3 March 1994. In that year seed yield ranged from 5.7 to 26.6 kg/ha, with the high density treatment yielding significantly more seed than the other two treatments (Table 4). For seed harvested in 1995 from 17 January to 2 March, yields ranged from 38.1 to 180.8 kg/ha. Again the high density treatment yielded significantly more seed than the other two treatments (Table 4). In Ontario, commercial growers produce average seed yields of 336 kg/ha, although these yields are achieved with much higher plant populations (Fisher, 1995).

Pests and disease

Harvested roots had several disorders. Orange/brown superficial scuffing and scabbing caused by a *Rhizoctonia* spp. and patches of brown/grey/black corky tissue caused by *Pyrenochaeta* spp. were present on 45% of harvested roots. Adult females and larvae of the nematode *Meloidogyne hapla* were present on 53% of harvested roots. *Meloidogyne* spp. are common on North American ginseng (Proctor, 1984) and are controlled by fumigation (Conley, 1984). Nematodes, which are present in most horticultural areas in New Zealand, and cause establishment problems for many crops (Stirling *et al.*, 1992), may have contributed to the low initial survival of ginseng in this trial. Some roots had channels and holes probably caused by slugs.

Regular applications of fungicide ensured that most leaves remained disease free although *Phytophthora*, *Alternaria* and *Botrytis* did cause problems in some seasons.

Table 4. American ginseng seed yields and numbers grown at three plant densities.

Plant density (plants/m^2)	Seed yield (kg/ha) 1994	(kg/ha) 1995	(seeds/ha x1000) 1994	(seeds/ha x1000) 1995
7	5.7	38.1	29	262
13	2.9	59.2	31	437
29	26.6	180.8	249	1393
Significance		p<0.001		p<0.001
SED; df = 8		10.63		82.9

Conclusions

American ginseng can be grown successfully in the Waikato, Yields were only slightly less than those from experimental ginseng crops grown at similar densities in North America, but lower than yields from commercial gardens with much higher plant densities.

The high mortality of seedling transplants in the first year is unexplained. Overseas, high seedling mortality after seed sowing is also a recognised problem. In this trial, root knot nematode may have been a significant factor limiting plant growth.

Plant density had a major effect on per hectare root yields but no effect on individual mean root weights. Seed production in the third and fourth year suggests ginseng could be grown for seed production in the Waikato, although seed yields were low because of the low plant density.

Plant populations declined each year and there was a wide range of root sizes at harvest. The Waikato winters may not be consistently cold enough to provide reliable bud stratification, but results from this trial are

inconclusive. Premature leaf senescence due to pests or diseases may have also affected plant growth. Variations in plant response to the environment offer potential for breeding a ginseng variety suited to a maritime climate.

The low yields achieved in this trial can be partly explained by cultural practices. The relatively high light levels at establishment had a deleterious effect on plant growth in the first season. Soil sterilisation would have reduced the nematode and disease problems found on the roots at harvest while subsequent research on the nutritional requirements of ginseng (B.M. Smallfield, unpubl.) has shown that ginseng growth is very responsive to phosphate fertiliser. Intensive ginseng production in the Waikato is likely to require the same techniques used for commercial production in North America, i.e., high seeding rates, well targeted disease and pest control, adequate shading and careful soil fertility management.

A sample of the trial crop, which was test marketed in Taiwan, was considered easily marketable and of typical size range with the appropriate earthy smell.

Further research is required to determine the environmental constraints and agronomic requirements before the Waikato could be recommended as a suitable area for commercial ginseng production.

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