J. Ginseng Res.
Vol. 22, No. 2, 122~125(1998)

Effects of Soil Moisture on the Growth of American Ginseng (*Panax quinquefolium* L.)

Thomas S. C. Li[1] and R. G. Berard[2]

[1]*Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre, Summerland, BC. V0H1Z0, Canada*

[2]*Ag-Quest (Sask.) Inc., Group Site 204, Box 8, RR 2, Saskatoon, SK. S7K 3J5, Canada*

(Received April 14, 1998)

Abstract : Adequate available soil moisture level is considered to be one the most important components in growing high yields of good quality ginseng. Excessive soil moisture may promote soil-borne fungal pathogens and cause serious diseases in ginseng fields. This study showed that soil moisture levels for optimum growth and health of ginseng varied with soil texture. Fifty percent available moisture for sandy loam and 75% for silty loam are the best moisture levels for good growth and higher yield.

Key words : Soil texture, soil moisture.

Introduction

Cultivation of American ginseng (*Panax quinquefolium* L.) has expanded rapidly around the world in recent years.[2] Canada has become one of the leading countries for ginseng development in both agronomic and value-added research. The total acreage of cultivation in Canada has reached 3000 hectares in 1997. With increasing production in a very competitive world market, ginseng growers are searching for more efficient crop management practices to minimize their production costs. One of the major operation cost is the application of fungicides to control diseases, especially those caused by soil-borne fungal pathogens[4] which infect roots, flowers, and berries and result in reduced seed set and yield.[2] An excess or lack of soil moisture may predispose ginseng roots to pathogenic fungi.[4] Therefore, adequate soil moisture levels in ginseng gardens should be considered as an important disease preventative measure.

Water management is an essential part of ginseng production. Optimum yields can be obtained only where a suitable amount of moisture in the soil has been maintained.[7] It is difficult to determine an adequate soil moisture level for ginseng; the requirement varies with developmental stages of the plant and environmental factors such as soil and air temperature, air movement, and humidity. In China, it has been reported that ginseng needs a soil moisture content of 40% for germination, 35% for leaf growth, and 45% for flowering and seed set.[5] In Korea, pot experiments showed that soil moisture at 60% resulted in the best aerial and root growth in 2-yr-old *P. ginseng*, compared with 30, 45 and 80% of moisture levels.[7] On the other hand, Meng *et al.* (1992) pointed out, without indication of soil texture, that soil moisture at 80% during the whole growing period promoted the growth of *P. quinquefolium*, resulting in enlarged leaves, increased fresh weight of aerial parts, high photosynthetic rate and rapid weight gain of roots. In Japan, it has been reported that 50 to 60% soil moisture gave the best growth.[9,10] In our experimental

plots, tensiometers have been installed to pinpoint the soil moisture level at root zones, with good results (Li, unpublished data).

The objective of this study was to investigate the effects of soil moisture in sandy loam and silty loam soil on the growth of American ginseng, as determined by leaf size, and root weight and size.

Materials and Methods

Soil samples (Table 1) were collected in early spring from three commercial ginseng gardens located in different regions of British Columbia. Soil textures were classified,[1] based on soil particle size analysis (Table 1), as sandy loam (samples 1 and 3) and silty loam (sample 2). Soils were sieved and mixed separately. Plastic pots (12.5 cm diam.) were filled with soil up to 1.2 cm from the top and gently tapped to obtain uniform bulk density. For each of the three soil samples, pressure plate apparatus (Soil Moisture Equipment Co., Santa Barbara, Calif.) was used to determine field capacity and permanent wilting percentage, as well as the corresponding gravimetric soil moisture contents. From the moisture retention curve, gravimetric moisture contents were established for each soil corresponding to 25%, 50%, 75% and 100% available moisture.

Table 1. Soil chemical and particle size analysis of three soil samples collected from three major ginseng growing regions in British Columbia

Soil analysis	Soil sample*		
	1	2	3
Organic matter (%)	3.1	6.6	2.8
pH	7.8	6.7	6.9
Bulk Density (g/ml)	0.88	0.90	1.30
Salts (E.C.)(ds/m)	0.40	0.80	1.28
Nitrate (μg/ml)	12	64	67
Phosphorus (μg/ml)	148	22	39
Potassium (μg/ml)	247	154	146
Magnesium (μg/ml)	143	173	263
Calcium (μg/ml)	1435	2039	1203
Sodium (μg/ml)	25	26	42
Sulphate (μg/ml)	0.9	33	45
Boron (μg/ml)	0.46	0.30	0.88
Copper (μg/ml)	1.3	1.8	1.4
Iron (g/ml)	36.8	43.5	30.6
Manganese (μg/ml)	6.8	14.9	16.0
Zinc (μg/ml)	2.5	2.4	73.9
%Sand	66	45	61
%Silt	30	51	26
%Clay	5	4	14

* Soil sample 1, sandy loam; 2, silty loam; 3, sandy loam.

Experiment 1. A total of three available moisture level treatments were tested, 50, 75, and 100%, with 6 replications (pots) per treatment. Each pot was weighed every 4 days, then rewatered to give the required moisture level. The watering was controlled to avoid run-off by pouring the required amount of water into plastic containers fitted with small drain tubes, which allowed the water to trickle slowly into the pots.

Experiment 2. An addition treatment (25% available moisture level) was added for soil sample #2. A total of four moisture levels (25, 50, 75 and 100%) were evaluated for their effects on the growth of ginseng roots in silty loam.

In both experiments, four newly germinated ginseng seedlings were transplanted to each pot and grown in a shaded (Sundown Shade Cloth, 73% density, Vomelia Textiles Inc., Georgia, U.S.A.) greenhouse (20~22℃) for approximately five months. Pots were moved to cold storage (1~2℃) when the plants started to show signs of dormancy, and moved back to the shaded greenhouse for a second growing season after four months of dormancy. Leaves were harvested at the end of each experiment, and fresh and dried weight (60℃, 48 hrs. in an oven) were recorded. Roots were hand washed and blotted dry with paper towels before length (from rhizome to the tip of the main root), width (diameter of the widest area) and fresh weight were measured. Root dry weights were also recored after roots were dried in an oven (38℃) for 5 days. All data generated were subjected to analysis of variance using the SAS GLM[11] procedure. Duncan's New Multiple Range test was applied to compare differences among treatments.

Results

There were significant effects of soil moisture

Table 2. Effects of soil moisture levels on fresh and dry weight of leaves and roots and the length and width of roots in 2-yr-old American ginseng (experiment 1)

Soil sample*	moisture level (%)	Leaf wt. (g)		Root wt. (g)		Root size (cm)	
		Fresh	Dry	Fresh	Dry	Length	Width
1	100	0.77 a**	0.24 a	2.18 a	0.77 a	6.55 a	1.02 a
	75	0.69a	0.23 a	2.53 a	0.84 a	7.80 a	1.18 a
	50	0.67a	0.22 a	1.90 a	0.67 a	7.05 a	1.10 a
2	100	1.15 a	0.32 a	4.28 a	1.41 a	10.90 a	1.08 a
	75	0.96 ab	0.35 a	3.92 a	1.32 a	11.40 a	1.10 ab
	50	0.82 b	0.24 b	2.65 b	0.92 b	10.32 a	0.98 b
3	100	1.00 a	0.29 a	3.82 a	1.33 a	9.00 a	1.26 a
	75	0.80 a	0.24 a	2.68 ab	0.95 b	10.34 a	1.04 b
	50	0.80 a	0.23 a	2.45 b	0.83 b	8.93 a	1.01 b

* Soil sample 1, sandy loam; 2, silty loam; 3, sandy loam.
** Means in each column followed by the same letter are not significantly different (p=0.05) according to Duncan's New Multiple Range Test.

on the growth of ginseng plants in silty loam soil (sample #2)(Table 2). At 50% soil moisture level, both fresh and by weight of roots were lower than the two higher moisture levels tested. Soil moisture had no effect on root length; however, at 100% moisture, the roots were significantly wider than the roots grown in 50% soil moisture. Leaf fresh weight was greater in the 100% than in the 50% treatment, whereas both the 75% and 100% soil moisture treatments yielded greater root dry weights.

There was no significant effect of soil moisture on leaf and root weights for soil sample #1, and only fresh and dry root weight and root width were affected by soil moisture for soil sample #3 (Table 2).

In general, the effects of soil moisture on root weight and size were similar in experiments 1 and 2 for the 50, 75 and 100% soil moisture levels. At 25% soil moisture, root size and weight were significantly lower than those in the other 3 moisture treatments (Table 3).

Table 3. Effects of soil moisture levels in silty loam on fresh and dry weight of leaves and roots and the length and width of roots in American ginseng

Moisture levels (%)	Root wt. (g)		Root size (cm)	
	Fresh	Dry	Length	Width
100	4.07 a*	1.38 a	10.72 a	1.24 a
75	3.14 a	1.10 a	10.78 a	1.16 a
50	1.87 b	0.60 b	9.69 a	0.95 b
25	0.41 c	0.15 c	7.45 b	0.50 c

* Means in each column of followed by the same letter are not significantly different (p=0.05) according to Duncan's New Multiple Range test.

Discussion

Soil physical properties and moisture conditions are the most important factors in ginseng cultivation.[2,7] Sandy loam soil, with a low clay content, is the most suitable for ginseng.[2,8] The texture of soil will affect the shape and size of roots[3,5,12] and the incidence of soil-borne diseases.[4,10] Soil moisture content is one of the main factors influencing root quality and yield.[10] The best soil moisture levels for ginseng reported in china and Japan have ranged from 35 to 80%,[5,6,9,10] indicating that it varied with different soil textures. In our study, higher soil moisture levels increased fresh and dry leaf weight in the silt loam soil (Table 2); similar results were reported in China. it was also reported there that different soil moisture levels had little effect on root length[6]; this was confirmed by our experiments. The results presented in Tables 2 and 3 suggest that 100% soil moisture produced the heaviest roots in all three soil samples tested. This conflicts with the results reported by Meng *et al.*,[6] who reported, without indication of

soil type, that in 100% soil moisture, root weight was reduced by 5~15% when compared with roots grown at 40~60% soil moisture. At 25% soil moisture (Table 3) root weight and size were significantly reduced, indicating that this level is not suitable for silty loam soil.

This study demonstrated that soil moisture is an important factor to be considered in order to achieve a higher ginseng yield. The adequate moisture level varied with different soil textures.

References

1. Gulik van der, T. W. (ed.) B. C. Sprinkler irrigation manual. B. C. lirrigation Industry Association. Vernon, B. C. (1989).
2. Li, T. S. C. : *HortTechnology* **5**, 27 (1995).
3. Li, T. S. C. : *Korean J. Ginseng Sci.* **21**, 115 (1997)
4. Li, T. S. C. and R. Utkhede. : Current Topics in Bot. Res **1**, 101 (1993).
5. Liu, C. N (ed.) Cultural methods of ginseng. Wu-Chou Publication. Taipei, Taiwan. 428 p. (1988).
6. Meng, F., T. Wang, H. Wang. Y. Zhao, and C. Guo. : *Korean J. Ginseng Sci.* **18**, 256 (1992).
7. Mork, S. K., S. Y. Son, and H. Park. : *J. Koran Soc. Crop Sci.* **26**, 115-120 (1981).
8. Oliver, A. (ed.) Ginseng production guide for commerical growers. British Columbia Ministry of Agriculture, Fisheries and Food. 194 p. (1996).
9. Park, H. And C. H. Lee. Proc. 3rd. Internat. Ginseng Symp. Seoul, Korea. 60-62 (1980).
10. Sruamsiri, P., K. Ogaki and M. Sugino. : *Mem. Fac. Agri. Kinki Univ.* **24**, 71 (1991).
11. SAS Institute Inc : SAS/STAT Users guide. Version 6, 4th ed. SAS Institute Inc., Cary, NC. (1990).
12. Xiao, P. G., Z. Y. Zhu, F. Q. Zhang, W. H. Zhu, J. T. Chen, G. D. Zhang and G. T. Liu. (eds.) Ginseng research and cultivation. Agri. Publ. House. Beijing, China. 252 p. (1987).