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Note

Effect of Soil Phosphorus Levels on Seed Emergence, Seedling Mortality and Plant and Root Development of American Ginseng

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Abstract□The effects of soil phosphorus level on seed emergence, seedling mortality, plant and root development of American ginseng (*Panax quinquefolium* L.) were evaluated in a newly planted commercial ginseng garden. Phosphorus levels were increased from 58 ppm to 100, 150 and 200 ppm with triplephosphate (0-45-0). Higher phosphate levels increased, seed emergence and reduced seedling mortality. Root length, diameter, fresh root weight and total leaflet length were not affected by phosphate levels.

Key words□*Panax quinquefolium* L., phosphorus.

Introduction

American ginseng (*Panax quinquefolium* L.) is a relatively new crop in British Columbia, Canada. The industry has expanded rapidly since it was first planted in 1982. Total acreage exceeds over 600 hectares as of 1994. With the advantage of a dry climate in British Columbia, ginseng has a very low disease incidence compared with other major ginseng growing areas such as Ontario, Canada and Wisconsin, U.S.A. However, the loss due to low seed emergence and high seedling mortality rate are significant. Seed decay after planting and seedling damping-off are caused by Rhizoctonia, Fusarium, Phytophthora and Pythium.[1 3)]

Certain cultural management techniques can improve disease control in new ginseng gardens, and fertilization may play an important role.[1)] The population density of microorganisms at the root surface is several times higher than in bulk soil.[4)] Excess nitrogen can cause thin cell walls thus allowing fungi to penetrate more readily. Balanced nutrition can increase vigor and reduce damping-off. Some root diseases increase in severity with some forms of nitrogen; others are decreased. Diseases caused by Fusarium, Rhizoctonia increase in severity with use of ammonium nitrogen but decrease with nitrate nitrogen.[5)] Phosphorus and potassium promote root growth and reduce seedling disease and root rots.[6)] Sufficient soil phosphate reduces woot rot in apple trees,[7)] brown spot disease of rice[8)] and Botrytis infection on tulips.[9)] Phosphate solution sprayed on cucumber leaves have induced systemic resistance to anthracnose.[10)]

There is little information available in the literature regarding the effect of soil phosphorus levels in the severity of ginseng root diseases caused by soil pathogens Fusarium, Rhizoctonia, Phytophthora and Pythium. The present experiment studies the effect of phosphate levels in the soil on ginseng seed emergence, seedling mortality and plant and root development.

Materials and Methods

Stratified American ginseng seeds were seeded in a new commercial ginseng planting at the rate of 100 kg/ha with a spacing of 10 cm between rows, 4 cm within row, and a total of 12 rows in each raised bed (1.1 m width). The field was fertilized a few weeks before seedling with 10-25-20 (N-P-K) at 538 kg/ha plus 2% zinc sulfate. The soil nutrient levels of this field after fertilization were: pH 6.8, N (53 ppm), P (58 ppm), K (265 ppm), Mg (196 ppm), Ca (909 ppm), Na (23 ppm), S (17 ppm), B (0.38 ppm), Cu (1.1 ppm), Fe (24.6 ppm), Mn (6.4 ppm) and Zn (2.6 ppm), analyzed by Griffin Laboratory of Kelowna, British Columbia. Nitrate-nitrogen is extracted by the Kelowna extractant (0.25 N HOAc + 0.015 N NH_4F) and its concentration is determined as nitrite using an automated copper-cadmium reduction procedure and colour development by sulfanilamide and N-(1 napthyl) ethylenediamine dihydrochloride. Phosphorus is determined by extraction with 0.25 N HOAc and 0.015 N NH_4F) (Kelowna extractant) at a 1 : 10 v/v soil: solution ratio and its concentration measured on an inductively coupled argon plasma spectrophotometer-ARL 34000. Extractable, calcium, magnesium and sodium are determined by extraction with a 0.25 N acetic acid and 0.015 N ammonium fluoride solution (Kelowna extractant) at a 1 : 10 v/v soil-extractant ratio and their concentrations are measured on an inductively coupled argon plasma spectrophotometer.

All the experimental plots were mixed with Borax and increased the level of B in the soil up to 1.0 ppm. Triphosphate (0-45-0) was applied just before seedling in the fall. There were a total of four treatments: 1) control (58 ppm P) no extra P fertilizer added; 2) 100 ppm P (104.4 g of 0-45-0 added per plot); 3) 150 ppm P (228.7 g of 0-45-0 added per plot); 4) 200 ppm P (353 g of 0-45-0 added per plot). There were 6 replicates per treatment, in a plot size of 1.2×1.8 m.

Seedlings in each plot were counted at four and eight weeks after seed emergence to provide percentages of emergence and mortality. The total number of plants emerged in each plot was counted again at the beginning of the second year. At the end of second growing season, a random sample of 12 plants per plot were harvested and assessed for total leaflet length, root length, diameter and fresh weight. Data were subjected to ANOVA and means were evaluated by Duncan's new multiple range test.

Results and Discussion

There were significant differences among treatments for the percentage of seed emergence and seedling mortality rate (Table 1). Phosphorous levels of 150 and 200 ppm significantly increased seed emergence rate relative to the untreated control (58.3 and 59.9% vs. 52.2%). These results are in agreement with those of Whetzel and Rosenbaum,[1] who reported beneficial effects of P on control of soil-borne diseases such as seed decay and seedling damping-off, caused by Rhizoctonia, Phytophthora and Pythium. The increased vigour of P-adequate seedlings helps to outgrow the disease[11] and results in less disease incidence. This was demonstrated in this ginseng experiment, as all three P treatments have significantly lower mortality rates than the control (1.62~1.95% vs. 2.98%). Plant emergence in the second year did not show any significant difference with P treatments.

The differences among treatments for root length, diameter and fresh weight did not reach sig-

Table 1. Phosphorus effects on seedling emergence and mortality of American ginseng

Trt.	P level (ppm)	% emergence[a]	% mortality[b]	% emergence in second year[c]
1	58	52.2c*	3.0a*	86.2a*
2	100	54.3bc	2.0b	88.7a
3	150	58.3ab	1.6b	89.6a
4	200	59.9a	1.8b	88.5a

*Values in each column with a common letter are not significantly different according to Duncan's New Multiple Range Test (p=0.05).

[a] No. of seedlings/total no. of seeds planted at four weeks after seed emergence.

[b] No. of seedlings growing eight weeks after emergence/no. of seedlings emerged four weeks earlier.

[c] No. of plants emerged in the second year/no. of plants growing in the first year.

Table 2. Phosphorus effects on 2-yr-old root length, diameter, root fresh weight and total leaflet length of American ginseng

Treatment	P level (ppm)	Root length (cm)	Root diamater (mm)	Fresh root wt. (g)	Total leaflet length (cm)
1	58	17.4a*	12.8a*	7.4a*	58.9a*
2	100	17.2a	14.1a	8.2a	62.5a
3	150	17.0a	14.5a	8.6a	61.1a
4	200	16.9a	13.8a	7.7a	59.8a

*Values in each column with a common letter are not significantly different according to Duncan's New Multiple Range Test (p=0.05).

nificant level in this experiment (Table 2), although it was not statistically significant, the P level of 150 ppm tends to have wider root diameter (14.5 vs. 12.8 mm) and heavier fresh root weight (8.6 vs. 7.4 g) than control. Stoltz[12)] reported that addition of increasing P to the nutrient solution resulted in increased fresh root weight. Konsler and Shelton [13)] reported that in field experiments, addition of P tended to increase root weight at the two higher pH levels (4.6, 5.5 and 6.4). The differences of the total leaflet length of 2-yr-old plants did not reach significant level among four treatments.

Conclusions

This field experiment clearly demonstrated that P level in the soil plays an important role for the ginseng seed emergence and seedling mortality rate. Under the given soil nutritional component, increasing P level up to 150~200 ppm has significantly increased seed emergence rate and decreased mortality rate.

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