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Effects of Vesicular-Arbuscular Mycorrhizae on The Growth of American Ginseng

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Abstract□Newly sprouted American ginseng (*Panax quinquefolium* L.) seedlings were transplanted to forest pots with mycorrhizae-infested soil and grown in screenhouse for 2 years. Growth patterns, mortality rate and fresh root weight were investigated. Plants in VAM soil had lower mortality rates than control. In soils infested with two species of mycorrhizal fungi (*Glomus deserticola*, Trappe, Bloss and Menge and *G. intraradices*, Schenck and Smith), 28~35% of plants produced 3-prongs in the second season and significantly increased fresh root weight by 41 to 43%.

Key words□*Panax quinquefolium* L., VA mycorrhizae.

Introduction

Mycorrhizae refer to the symbiotic association of fungal mycelium and plant roots. The most common type is vesicular-arbuscular mycorrhizae (VAM), which can improve nutrient uptake,[1,2] particularly immobile ions such as phosphate.[3] Mycorrhizal plants generally grow more vigorously and appear more healthy than non-mycorrhizal plants. VAM may also play a role on control of soil-borne diseases of plants.[4,5]

There is no information available in the literature regarding the effects of mycorrhizae on ginseng except three reports of natural infection of VAM on American[6] (*Panax quinquefolium* L.) and Asian ginseng[7,8] (*P. ginseng* C. A. Meyer). A survey of 145 species in a deciduous forest near Urbana of Illinois, U.S.A., McDougall and Liebtag[6] claimed that endotrophic mycorrhizae were found in the roots of American ginseng. In China, after an ecological distribution study of VAM in Asian ginseng, Ren *et al.*[7] reported that the rate of natural infection of VAM on roots varied with the age of ginseng plants; 43, 54 and 62% for 4-, 5- and 6-yr-old ginseng. They also found that *Acaulospora* spp. was the predominant type which forming VAM in *P. ginseng* followed by *Glomus* and *Sclerocystis* spp. The purpose of this study is to examine the effects of various mycorrhizal infested soil on the growth pattern, seedling mortality rate and fresh root weight of American ginseng.

Materials and Methods

Three species of VAM, *Glomus deserticola* Trappe, Bloss and Menge (M6), *G. intraradices* Schenck & Smith (M7), *G. mosseae* (Nicolson & Gerdemann) Gerdemann & Trappe (M8) and a local isolate from an apple orchard *G.* spp. (M9b) were selected in this experiment. Infested soils containing each VAM species were supplied by Dr. R. S. Utkhede (Agriculture Canada, Research Center, Summerland, British Columbia, Canada V0H 1Z0). The population of each VAM was increased by mixing infested soil with pasteurized (80℃, 20 min in a microwave oven) potting soil (1 : 2, v/v) in plastic pots (15 cm diam.), seeding with sudan grass (*Sorghum vulgare* Pers.), and placed these pots in a greenhouse (22℃, 16 hr days). Sudan grass in non-infested soil was used as control. After 20 weeks of cultivation, roots were examined for the existence of VAM, leaves and stems of the sudan grass were discarded. Sudan grass roots and soil were chopped into fine pieces and mixed with pasteurized potting

soil (1 : 2, v/v), which was used as culture media for ginseng. Chemical analysis of the potting soil (Griffin Laboratory, Kelowna, British Columbia, Canada) revealed: organic matter 3.6%; pH 7.2; N, 37 ppm; P, 21 ppm; K, 139 ppm; Mg, 242 ppm; Ca, 1162 ppm; Na, 76 ppm; S, 44 ppm; B, 3.3 ppm; Cu, 1.0 ppm; Fe, 13.3 ppm; Mn, 4.0 ppm and Z, 20 ppm.

Stratified American ginseng (*Panax quinquefolium* L.) seeds were germinted in perlite. Newly emerged seedlings were transplanted to black plastic forestry pots (6 cm diam., 22 cm deep) filled with VAM-infested soil. There was one plant per pot, twenty pots per treatment including control. Experiments were conducted in a shadehouse ("Sundown Shade Cloth", 73% density, Vomelia Textiles Inc., Georgia, U.S.A.). Pots were arranged in a randomized block design. Ginseng plants were moved to cold storage (0~2℃) for winter dormancy after one growing season, and back to the shadehouse four months later for second season. Growth patterns, mortality rate and percentage of plants with 3 prongs in the second year of growth, and fresh root weight were recorded. Analysis of variance was conducted using the SAS GLM procedures and Duncan's New Multiple Range Test was applied to compare differences among treatments.

Results

There were no visible differences among ginseng seedlings, with or without VAM, at the beginning of the first growing season. A few of the ginseng seedlings grown in M6, M7 and M9b-infested soil began to sprout a second prong 10~12 weeks later (Fig. 1). Plants without mycorrhizae (control) went into dormancy 4~6 weeks earlier than mycorrhizal plants and remained one prong throughout the first growing season. In the beginning of second growing season, a few plants failed to sprouts and their roots were rotted. The mortality rates in the control were highest (15%) among all treatments, with 10% for M8, M7, M9b and 5% for M6 (Table 1). There were 16.7% (M8), 27.8% (M7), 35% (M6) and 27.8% (M9b) of the 2-yr-old plants showing 3 prongs (Fig. 2) and none in the control (Table 1).

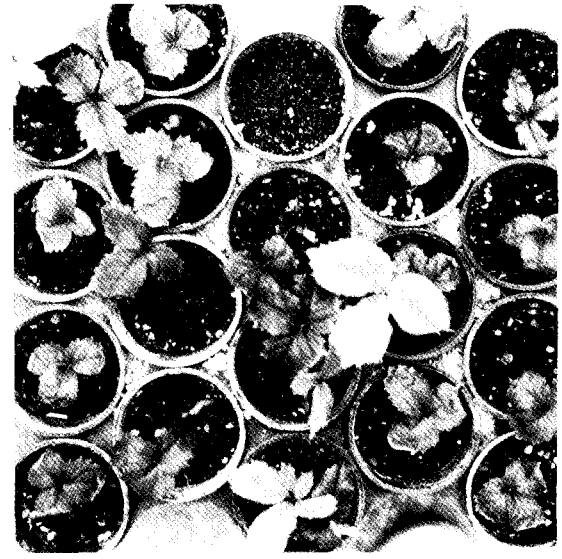

Fig. 1. Mycorrhizal effects on 1-yr-old American Ginseng.

There were significant differences in fresh weight of roots among treatments. Roots with M6 (2.77 g) and M7 (2.74 g) were significantly heavier than M8 (2.19 g), M9b (2.34 g) and the control (1.94 g), which is more than 40% increase relative to the

Table 1. Effects of vesicular-arbuscular mycorrhizae on the growth of American ginseng

Treatment	Second year mortality rate (%)	Plants with 3 prongs in second year (%)	Average fresh root wt.(g)	Root fresh wt. relative to the control (%)
No mycor. (control)	15	0	1.94 c*	100
Glomus mosseae (M8)	10	16.7	2.19 bc	113
G. intraradices (M7)	10	27.8	2.77 a	143
G. deserticcola (M6)	5	35.0	2.74 ab	141
G. spp. (M9b)	10	27.8	2.34 abc	121

*Values in each column with a common letter are not significantly different (p=0.01) according to Duncan's New Multiple Range Test.

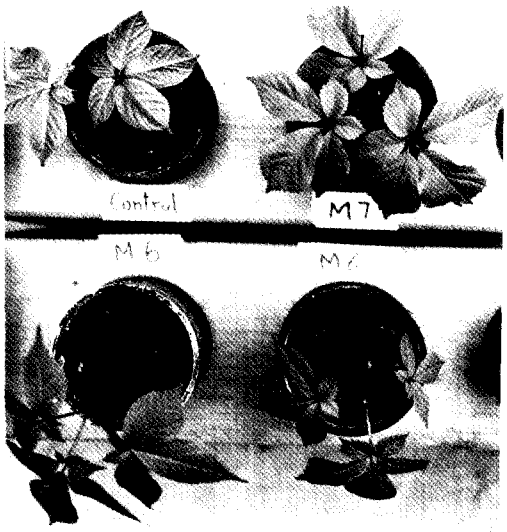

Fig. 2 Mycorrhizal effects on 2-yr-old American Ginseng.

control (Table 1). Comparisons between 3- and 2-prong plants within each VAM treatment showed that plants with greater number of prongs tended to have heavier fresh root weights (Table 2).

Discussion

The aerial stem of *Panax quinquefolium* has whorled leaves, known as prongs, each having a petiole with three to five palmately compound leaflets. Number of prongs is an important indicator of plant age.[9] In the cultivated North American ginseng, newly emerged seedlings produce a single prong with three leaflets in the first year.[10] In the second growing season, there are two prongs with 3 and 5 leaflets in each plant.[11] If the number of the prongs served as an indication of the age of ginseng plants as described by Anderson *et al.*[11] and Lewis and Zenger,[9] mycorrhizae treated ginseng plants in this experiment showed the equivalent of one extra growing season compared with non-mycorrhizal plants. This resulted in root fresh weight increases of over 30% (Table 2). Roots infested with *G. intraradices* (M7) and *G. deserticola* (M6) had significantly heavier (40%) fresh weights compared to control plants. On the other hand, roots infested with *G. mosseae* and *G.* spp. showed no significant differences compared to non-mycorrhizal roots (Table 1). It was reported that mycorrhizae show little host specificity.[12] The results from this experiment suggest that ginseng roots responded to VAM species differently and certain selective species of VAM have better effects on fresh root weight than others.

Over the years, the importance of VAM to crop production is well established. It has been experimentally managed in crop production systems by purposely adding mycorrhizae fungal propagules to soils.[13] Numerous reports indicate that VAM fungi frequently improve yields of crops such as citrus,[14] apple,[15] pepper,[16] wheat,[17] corn,[18] and potato.[19] Based on the results of the present study, VAM can also have beneficial effects on ginseng. Mycorrhizal population in ginseng fields can be improved by proper cultural practices such as cropping sequence, cover crop, pesticides and fertilizers. Yield of ginseng crop can also be improved by introducing beneficial or favorable species of VAM artificially to ginseng field.

Table 2. Effects of vesicular-arbuscular mycorrhizae on 2-yr-old root fresh weight (g)

Treatment	Plant with 2 prongs	Plant with 3 prongs	Root fresh wt. of 3-prong relative to 2-prong (%)
No-mycor. (control)	1.94		
Glomus mosseae (M8)	2.08 a*	2.78 b	134
G. intraradices (M7)	2.51 a	3.46 b	138
G. deserticola (M6)	2.44 a	3.21 b	132
G. spp. (M9b)	2.07 a	2.88 b	139

*Values in each row with a different letter are significantly different according to t-test ($p=0.05$).

Conclusions

This pot experiment in a screenhouse over two years clearly demonstrated that VAM in the soil plays an important role for the growth of American ginseng. This is a relatively new approach in ginseng, which needs further long term research expecially in the field. More development of practical cultural management to assure VAM existence in the ginseng field is needed.

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