Growth stimulation of sweetgum seedlings induced by the endomycorrhizal fungus Glomus mosseae

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In a greenhouse study, potted sweetgum seedlings in soil inoculated with the endo-mycorrhi:ol fungus Glomus mosseae grew significantly foster than those in noninoculated soil. Height growth and fresh top and root weights differed considerably after 6 months.

Sweetgum *(Liquidambar styraciflua L.)* is an economically important forest tree species native to the eastern United States and to limited areas of Central America (2). Its favorable wood characteristics make it useful for a large number of products, causing it to be the choice species for reforesting suitable hardwood sites. According to Rowan (6), sweetgum is one of the five leading hardwood tree species grown in nurseries in the southern United States. The recent increased demand for this important species has stimulated interest in determining whether mycorrhizal associations affect survival and growth of sweetgum in nurseries and in subsequent outplantings.

In 1964, Gray [1] reported that roots of sweetgum formed vesiculararbuscular mycorrhizae after infection *by Glomus mosseae* (Nicol. and Gerd.) Gerdemann and Trappe. Later, Gray and Gerdemann (1) found that 41/-month-old *endomycorrhizal seedlings of sweetgum absorbed approximately 15 times as much ^{32}P as nonmycorrhizal seedlings. Mosse et al. (4) and Mosse (3) obtained increased height growth and leaf size on sweetgum seedlings inoculated with *G. mosseae.* Our results supplement those from previous studies, with some additional measurements obtained from comparison of mycorrhizal and nonrnycorrhizal sweetgum seedlings.

Methods

A soil mixture prepared with sandy loam of low fertility and builder's sand 11:2 v, v l was placed in 25-cm clay pots and steamed twice on alternate days for 2 hour; at ca. 80°C each day. Inoculum was prepared by growing *Sorghum vulgare* infected with G. *mosseae* for 9 weeks in a greenhouse and then chopping and mixing the infected roots with soil from the pot cultures. A similar mixture of chopped roots and soil from pots of nonmycorrhizal *S. vulgare* was used for controls. The soil of each of eight pots was thoroughly mixed with 50 g of the inoculum of G. *mosseae,* and that of another eight pots was similarly mixed with the control inoculum.

A mixed lot of sweetgum seed collected from Greene County, Georgia, was stratified, surface-sterilized with 35 percent H_2O_2, and germinated in a flat of steamed soil in the greenhouse. After 6 weeks, the resulting seedlings were graded to approximately the same size and planted in pairs in each pot immediately after the addition of inoculum. Sieved and filtered rinse water (50 ml) from inoculated and control sorghum roots was added reciprocally to each pot

replicate of the two treatments. This procedure was followed to standardize the microorganisms in the two treatments, except for the endomycorrhizal fungus inoculum.

The pots were placed on a bench in a shaded greenhouse (68 Klux) with sufficient spacing to prevent cross-contamination between treatments. Ambient temperatures during daylight (ca. 14 hours) averaged 27`C. At monthly intervals, 250 ml of a solution of a commercially available fertilizer (ca. 4 to 5 p/m each of N, P, and K) were added to the soil of each pot. A low level of fertility, particularly P, was desired to avoid inhibition of mycorrhizal development.

After 6 months the study was terminated. All seedlings were carefully removed from the pots, the stems were clipped at the soil line. and the tops were measured for height and weighed. The roots were rinsed free of soil with tap water, blotted dry, and weighed.

Twenty-five segments leach 1 cm long) were removed at random from the root systems of each seedling. These segments were cleared and stained according to the procedure

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of Phillips and Hayman (5). Subsequent microscopic examination confirmed mycorrhizal infection. The approximate percentage of infection for each seedling inoculated with G. *mosseae* was determined by comparing numbers of infected segments with numbers of noninfected segments. No attempt was made to determine the intensity of infection within each segment.

Table 1.—Effect of mycorrhizal development by Glomus mosseae on top and root growth of sweetgum seedlings [a]

Treatment	Height	Fresh weights Tops	Fresh weights Roots
	Cm	*G*	
G. mosseae ..	29.9 [b]	11.7 [b]	12.0 [b]
Control	16.4	4.7	5.0

[a] Mean values for 16 seedlings in each treatment after 6 months.

[b] Indicates significant differences at the 1-percent level between means within a column by Student's T test.

Results and Discussion

Mycorrhizal seedlings were 82 percent taller and the tops and roots were 149 and 140 percent heavier, respectively, than the nonmycorrhizal seedlings (table 1). Microscopic examination showed that *G. mosseac* formed endomycorrhizae on 99.7 percent of the root segments. None of the roots in noninfested soil formed endomycorrhizae.

The marked beneficial effect of mycorrhizal infection on growth and development of sweetgum seedlings suggests that this species is highly dependent on the mycorrhizal association for optimum growth. Such dependence may be the cause of past failures with seedling crops of sweetgum grown in recently fumigated soils in nurseries. Fumigation would undoubtedly eradicate a significant quantity of indigenous inoculum of endomycorrhizal fungi. The resulting sweetgum seedlings would, therefore, be nonmycorrhizal or only mildly infected and could not grow at acceptable rates.

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while 14.5 percent (26 of 180) of the infested grafts which were not treated survived. The difference in survival rate was shown by chi square analysis to have a probability of less than 0.10 of occurring by chance.

Conclusions

These results clearly show that lindane is effective . in protecting newly grafted ponderosa pine from attack by the fir coneworm. A coating of Stickem Special affords some protection, but is not nearly as effective as the lindane treatment. Application of a second lindane treatment in late summer may afford some additional protection if the fir coneworm is abundant in the late summer and fall; a condition which has been observed but did not occur in 1972. In any event the second treatment may help to salvage grafts which become infested in spite of the first treatment. Only a minute amount of insecticide was required. In our study about 18 mg per tree or 9 gm ($^1/_9$ oz) per acre was used. The amount required would vary depending on the size of the scions and number of trees per acre but would never be large enough conceivably to have any adverse environmental impact. The equipment used was simple and inexpensive. Only a few minutes were required to treat each tree. Thus the treatment is not only effective but safe and inexpensive.

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