Preventing fir coneworm damage to newly grafted ponderosa pine

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Lindane applied in minute amount (18 mg/free or about 9 gm/acre) to the graft union of newly grafted ponderosa pines provided a high degree of protection from attacks by the fir coneworm (Dioryctria *abiet*elia). The application takes only a few minutes for each tree, and simple, inexpensive equipment can be used.

The larvae of the fir coneworm *(Dioryctria abietella (D & S))* have repeatedly been found attacking newly grafted ponderosa pines *(Pinus ponderosa* Laws.) in California seed orchards. They feed initially in the graft union and later invade the scion and rootstock. In 1972 we found that 74.1 percent of the newly grafted trees at the Mount Shasta seed orchard, Shasta Trinity National Forest, were infested. During this study, 36.8 percent of the unprotected new grafts at the Foresthill seed orchard, Tahoe National Forest, were infested by the fir coneworm.

Starting with ponderosa pine seedlings, it takes 4 to 5 years for the trees to grow to graftable size. Meanwhile, an extensive search is conducted to find ponderosa pines with superior growth and form characteristics to serve as sources of scions to be grafted on the rootstocks. When the rootstocks are large enough to be grafted, scions are collected from the widely scattered superior trees by climbers and brought to the seed orchard for grafting.

At the Foresthill seed orchard, the prorated cost of site preparation, rootstock establishment, scion collection, and grafting is about ? > I per tree. Therefore, by the time the trees have been grafted and are subect to attack by the fir coneworm, an investment of $31 a tree and 6 to 7 years' time has already been made.

This paper describes a technique of protecting newly grafted ponderosa pines by applying minute quantities of lindane.

Insect Habits and Damage

The fir coneworm is usually found feeding in the cones of Douglas-fir, true firs and pines Ill. This insect also bores into the shoots of pines and feeds in wounds and cankers of pine and Douglas-fir tree boles. We believe the similarity of a fresh graft union to a wound makes it attractive to this insect. The fir coneworm does not establish self-sustaining populations in graft unions. We have observed that attacks in graft unions are much more frequent in years following an abundant cone crop, suggesting that the moths depositing eggs in the graft unions originate from larvae infesting the previous year's cone crop.

The fir coneworm has multiple overlapping generations per year and may develop at different rates in the various types of host material. Consequently, adult females may be laying eggs at almost any time from May to October. The female moth deposits eggs in or near the graft union. The eggs are reddish orange, flecked with red and oval about 0.7 x 0.4 mm. They hatch in about a week and the new larvae begin feeding in the graft union. The larvae spin silk webs over their feeding sites. Fecal pellets, bark flakes, and other debris are incorporated into the webbing and serve to conceal the insect. Usually the mass of fecal pellets and webbing is the first visible sign of damage noticed.

As the larvae grow larger, feeding activity is extended under the bark. both upward into the scion and downward into the rootstock. Usually the larvae also bore into the graft union and feed in the pith of both the scion and rootstock. In attacks made in late summer the terminal bud is often mined out. As mining proceeds extensive webbing, mixed with fecal pellets and trash, is produced on the outside of the infested shoots. This material covers numerous entrance holes and feeding sites (figure 1).

The larva is a reddish brown caterpillar with a pale stripe down the middle of the back, sparse long hair, and a brown head. Brown sclerotized shields are found on the first segment behind the head and on the last segment. Mature larvae are 15 to 20 nun long.

The mature larva spins an oval cocoon of white silk, sometimes inside the damaged shoot or under the

webbing and trash accumulated on the outside, but more often in the litter on the ground under the tree. The outside of the cocoon is always completely covered with soil granules, dry fecal pellets, or other foreign matter. Within the cocoon the larva transforms to the pupal stage. The pupa is a typical moth pupa, dark reddish brown from 9 to 12 mm long.

Transformation to the moth stage is completed in 10 to 12 days. The adult moth is grey in general appearance and has a wing span of 25 to 30 mm. The forewings are grey with darker grey cross bands and narrow zig-zag white and black lines.

Methods

In spring 1972, 2,018 ponderosa pines were grafted at the Foresthill seed orchard. The cleft graft system with succulent scions was used (31. The scion and top of the rootstock were enclosed in a plastic bag to prevent drying. A Kraft paper bag was inverted over the graft and stapled to a stake driven beside the tree to shade it from direct sun. On July 17 the plastic bags were opened exposing the grafts to attack of the fir coneworm. Two treatments for preventing infestation of the graft unions by the fir coneworm were tested. One treatment consisted of spraying the scion and top of the rootstock with a 1 percent emulsion of lindane. Lindane was chosen because it had previously been found effective against several species of *Dioryctria* (2). The other treatment consisted of covering the graft union with a mechanical harrier of Stickem Special (hydrogenated castor oil) . The Stickem coating was chosen because we felt a nontoxic protective material would be preferable to an insecticide. The lindane emulsion was sprayed on the scion and upper part of the rootstock to runoff using a 3-gallon Hudson sprayer. The Stickem was applied with a spatula to thoroughly coat the graft union. The trees in the orchard are planted in 27 rows. Treatments were assigned arbitrarily to alternate rows so that nine rows of trees were sprayed with lindane. The graft unions of nine rows were coated with Stickem and nine rows served as controls. Both treatments were applied on July 17 immediately after opening plastic bags.

On August 17 the condition of each graft was recorded. On August 18 half of the trees in each treatment including previously untreated checks were sprayed with lindane to test its effectiveness for preventing late summer attacks and for killing established coneworm larvae. On October 18. 1972, and on June 4, 1973, the condition of each graft was again recorded. Dead grafts were closely examined to determine the cause of death. Grafts which failed to "take" or in which the scion died of causes other than fir coneworm damage were eliminated from the data analysis.

Results

In mid-August 1972, 1.7 percent (9 of 522) of the grafts treated with lindane were infested by the fir coneworm. In contrast, 28.2 percent 1135 of 479) of the grafts treated with Stickem were infested, and 36.8 percent (184 of 500) untreated grafts were infested. Chi square analysis of these results shows that the probability of obtaining the difference between the lindane treatment and the untreated check by chance is less than .001 and the probability of obtaining the difference between the Stickem treatment and the check by chance is less than .01.

Only 23 additional grafts were infested between the application of the second lindane treatment and the end of the study. The distribution of the attacks was such that we were unable to determine the effectiveness of the second treatment in preventing additional attacks. However, 21.8 percent (36 of 165) of the infested grafts sprayed with lindane survived

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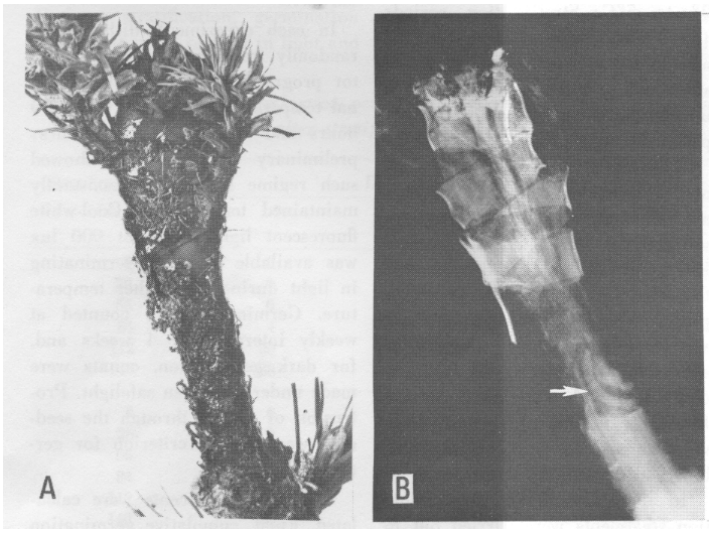

Figure 1-(A) Ponderosa pine graft infested by fir coneworm. (B) X-ray view of A, showing fir coneworm larva inside infested graft.

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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.

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.

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

Treatment	Height	Fresh weights	
		Tops	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.

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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