DISEASE CONTROL IN FOREST NURSERIES

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Rather than trying to cover the entire gamut of nursery disease control I would like to restrict this discussion to control of soil-borne diseases, specifically to control by soil fumigation. I hope that during this discussion we will be able to clear up some of the current misconceptions about the effect of soil fumigants on beneficial soil microorganisms. To this end I would prefer that you interrupt with questions from the floor at any time. Most of the terms I will be using can be found in the two handouts: PSW Miscellaneous Paper No. 52 and Plant Disease Reporter 48:3.

Except for two of our nurseries in California - most of our disease problems, because of climate, are soil-borne. The two exceptions are in our north coast fog belt where we are plagued with both soil-borne and aerial diseases.

These soilborne diseases - caused primarily by fungi - are found in all stages of the seedling's growth and are usually grouped into three general categories:

1. Pre-emergence damping-off where the germinated seeds or seedlings rot before they emerge from the soil. This disease is not usually seen unless the young seedlings are dug at germination time; therefore, the extent of damage caused by pre-emergence damping off is difficult to determine and the loss is usually attributed to "bad seed." This "bad seed" frequently results in next year's seeding density being increased to compensate for last year's losses.

2. Post-emergence damping-off -- this is the one that all of you are familiar with -- where the seedling is attacked just after it has emerged from the soil. The attack usually takes place at or just below the soil line where the tissue collapses leaving the seedling without adequate support and it topples over. This is a disease only of very young seedlings and is confined to the first month or so after emergence.

3. Later stage root diseases - Again a complex disease caused by soil fungi which attack the roots of the plant causing death of part or all of the root system. This type of attach lowers the absorptive capacity of the root system and if severe enough or if on the upper portion of the tap root can cause death of the seedling. Direct losses are measured in mortality in the bed and in the large number of plants culled during lifting for having stunted or inadequate root systems. Further losses occur after lifting when diseased seedlings not showing obvious symptoms are outplanted or transplanted. (slides showing three types of disease)

Losses due to these soil-borne fungus diseases are both direct, the actual loss in growing stock, and indirect. Indirect losses are measured in such things as the use of more seed and the planting of larger areas to compensate for decrease in inventory. The big auestion at present is why should we have, or better yet, why should we tolerate these losses when we already have at hand much information from other types of agriculture; information pertaining to seed selection, seed certification, soil conditioning, soil fumigation, and plant certification? Most of these techniques are easily adaptable to forestry practice. Granted we are using many of these approaches at the present time; it is, however, on a somewhat limited scale. Soil fumigation, for example, is frequently rejected because of the cost factor or because of the mycorrhizal factor.

To answer the cost factor question we need only to analyze the costs involved in losses in the nursery, the subsequent losses in transport and storage, and the again subsequent losses after transplanting. These cumulative costs frequently far outweigh the cost of fumigation. The fear of killing-off all beneficial microorganisms from the soil, especially mycorrhizal fungi, has plagued nurserymen for some time. I would like to empha size here that we are not aiming at soil sterilization, but merely at selec tive fumigation, designed to not wipe: out soil microorganisms completely but to reduce populations to a beneficial level. We can now show that with proper manipulation of the fumigant we can actually stimulate mycorrhizal development. (slides of mycorrhizae stimulation)

In California we now have two Experiment Station Pathologists (Dr. Richard S. Smith and myself) conducting research on seed and seedling disease. This program was started in 1959 when we were asked to investigate seedling losses in the Placerville nursery. Mortality in sugar pine, Douglas fir, and giant Sequoia was running from 30 - 60 percent, and many of the remaining seedlings were small with heavily diseased. and inadequate root systems. Subsequent inspection of other Federal, State, and private forest nurseries showed a high incidence of losses in most species of conifers. In addition, continued reports from field men showed that survival after outplanting was low in many species - 40 - 50 percent survival in sugar pine and Douglas fir, for example, was common. Laboratory studies of damaged seedlings both from the nurseries and from plantations showed that root disease fungi were the primary cause of the losses.

In the spring of 1960 a series of soil fumigation tests were established using different dosages of several soil fungicides and fumigants. These tests clearly showed the advantage of direct chemical control of soil• borne diseases in the nursery. The most effective fumigant we found was a mixture of 57 percent Methyl Bromide + 43 percent Chloropicrin at 300-325

Nacre. This mixture is injected into the soil and immediately tarped with polyethylene. (slides showing method of application)

As an example of the effectiveness of soil fumigation, 10 acres of the Placerville nursery were fumigated in 1961 and resulted in excellent disease and weed control. Seedling losses were reduced to 0.3 percent in ponderosa, Jeffrey, and Coulter pines, 0.1 percent in Douglas fir, and 5-17 percent in sugar pine depending on source and age of seed used. In addition to reducing losses in the nursery, improved vigor of seedlings was reflected in subsequent field survival. Douglas fir outplanting tests showed 83 percent survival of stock grown in fumigated nursery soil as compared to 34 percent survival of stock grown in unfumigated nursery soil. Sugar pine outplanting tests showed 87 percent survival of stock from fumigated and I5 percent survival of stock from unfumigated soils. (slides showing comparison of plants and weed control)

On the basis of our tests, forest tree nurserymen in California agreed to start a program of maintenance control of soil borne diseases in 1961. In addition to reducing losses in the nursery, this soil fumigation program is paying off in several other ways:

1. A reduction in the amount of seed used and hence a reduction in seed costs.

2. A reduced cost of weed control. In some years the savings from weed control in the first 3 months almost pays the cost of fumigation.

3. The production of larger, more uniform, and more vigorous seedlings with a better developed root system.

4- The production of disease-free stock thereby minimizing the risk of moving destructive disease organisms from the nursery to the forest plantation.

In conclusion I would like to reemphasize one important point. What we are practicing in California is soil fumigation and not soil sterilization. We are not eliminating beneficial microorganisms from the soil - especially mycorrhizal fungi. Results from several of our nurseries in different climatic and soil zones show that when properly applied - the fumigant and dosages we are using actually stimulate mycorrhizal production in the first year.