SOIL FUMIGATION IN FOREST TREE NURSERIES

by

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Sometime back, Rodger Hagwood asked me if I would present a paper at this meeting on "Alternatives To Methyl Bromide". After considerable literature review, I found that I would be hard pressed to talk for 20 minutes on soil fumigation without including Methyl Bromide. This being the case, I decided to talk on principals and products for soil fumigation since procedures for fumigation do not vary widely among the available products.

As an introduction of sorts I think it would be worthwhile to review the reasons for which we fumigate nursery soil. After all, soil fumigation can cost well over $1000/acre which **makes** it one of our most expensive nursery cultural practices. (13) The cold hard fact is that some pathogenic soil fungi, nematodes, insects and even weeds cannot be controlled after sowing a crop of forest seedlings. When these pests are likely to cause economic losses practically dictates that the soil must be fumigated in order to grow a salable, healthy crop of seedlings.

This series of slides shows a variety of fungal problems the majority of which cannot be completely controlled by postemergence pesticides. An interesting fact is that all of these slides depict seedling damage on non-fumigated ground. The first is a slide of the effects of charcoal root rot and nematodes on loblolly pine. This disease forms a very durable spore stage which can exist in soil for years waiting for a host and stress to trigger germination. Charcoal root rot has been responsible for direct mortality or increased cull on millions of pine seedlings in the past. (11) Cylindro-cladium can cause mortality on both hardwoods and some conifer species. There is no control for it after sowing a crop. (11) Rhiztonia is a problem mostly on sandy sites. Even good soil fumigation has not always cleared this up. Other fungi such as Fusarium, Pythium and Phytophthora are potent pathogens which are not easily controlled by post plant fungicides. Although we have made considerable advances in chemicals for post plant weed control some such as the sedges remain difficult to control in pine seedbeds.

Fumigation is necessary if mycorrhizal inoculation is to be done. Neither spores nor mycellial inoculum will be very effective if applied to nonfumigated soil. Other benefits of fumigation are reported to be seen in better quality seedlings produced on fumigated soil. (3,6,7,8)

Regarding fumigation in general, I have often made the statement that a soil fumigation program is like buying life insurance. You may not think that you need it, but if you don't have it you are inviting disaster. I will continue to press for annual fumigation of S.C. Forestry Commission nurseries until we have effective postemergence chemicals for all of our most damaging seedling pests.

The soil fumigants which are available to nurserymen today are basically the same chemicals we have used for 30 years. (3,6,7,8) However, we do have better formulations and application techniques than were available at that time. The basic group of fumigants include Dazomet (basamid), Metam-sodium (vapam), Methyl Bromide/Chloropicrin mixtures, and Vorlex (which I accidentally left off of this slide).

Basamid is formulated as granules of almost pure Dazomet. It is applied as a broadcast treatment at a rate of 300 lbs/ac. and incorporated into the soil with a disk or rotary tiller. It reacts in soil to form Methyl Isothiocyanate which is a poisonous gas. Basamid must be irrigated after application to seal the soil, or covered with a polyethylene tarp. (1)

Metam-sodium is a liquid which is best used when injected into irrigation water. It also breaks down to Methyl Isothiocyanate to act as a fumigant. The application rate for Metam-sodium is 100 lbs/ac. (10)

Methyl Bromide/Chloropicrin is formulated as a liquefied gas which is pressure injected into the soil with a chisel type applicator. It must be immediately covered with a gas tight polyethylene tarp to trap it in the soil. (5)

Vorlex is also a liquid which consists of Methyl Isothiocyanate mixed with solvents. The application rate for it is about 35 gallons/acre followed by 1" of irrigation. It is applied by injection into the soil. (10)

The mode of action of Dazomet, Metam-sodium and Vorlex is similar since they all decompose to the same gas (Methyl Isothiocyanate) which does the actual fumigation. All require at least several days of exposure to the soil under a water seal to complete their fumigant activity.

Both Metam-sodium and Basamid are mildly toxic and carry a warning label. Vorlex and Methyl Bromide carry danger labels due to the toxic nature of their formulations. If I had to rank them as to ease of application I would say that Basamid is the easiest to apply followed by Methyl Bromide and Vorlex. Metam-sodium is difficult to apply since it must be metered into the irrigation system.

Any of the Methyl Isothiocyanate forming compounds when applied properly will control most soil organisms. Studies report fungi such as Pythium and Fusarium being completely suppressed by all of these fumigants. (4,9,10,12,14) Unfortunately, none of them will completely control some tough fungi such as Cylindrocladium and the black root rot fungus. These fungi form very tough spore stages called sclerotia which are hard to kill. (11) Methyl Bromide/ Chloropicrin remains the only available product which will control sclerotia forming fungi. The most effective combination of these two chemicals is 67% Methyl Bromide with 33% Chloropicrin. (13)

Weed control by all of these fumigants is reported to be acceptable. (3) However, the only data I have on nutsedge control by Dazomet is from a technical manual on Basamid by the BASF Company which reports complete yellow nutsedge control at the 300 lb/ac rate. (1)

Most of you are familiar with Methyl Bromide/Chloropicrin and techniques for its application. As I said before it is formulated as a liquefied gas and injected into the soil at a rate of 350 lbs/ac. This operation requires the soil to be tarped immediately after soil injection to prevent the gas from escaping. The fumigation can be done in strips, or with a solid tarp. Those of you with an above ground irrigation system should definitely consider solid tarping since it gives a more uniform job with less chance of soil contamination from adjacent unfumigated soil. Strip tarping can be very effective also, but you must keep in mind that each strip should slightly overlap the adjacent strip to minimize soil contamination. If you are stripping 10' wide strips of plastic and have 40' between riser lines, there is no way to avoid some contamination of fumigated soil with nonfumigated soil. We are currently using 10.5' plastic and I'm not sure that we don't get some contamination. If you have to fumigate around an underground irrigation system you will always have a small area of untreated soil which will serve as a reservoir for fungal inoculum and weed seeds. As you can see in this slide these beds closest to unfumigated riser lines will suffer the first and most losses.

Regardless of the fumigant used you need to be as careful as possible not to contaminate the fumigated area. (1) As I just mentioned unfumigated soil can spread disease and weeds to fumigated areas. Contamination can also be spread by dirty equipment, planting of infected seed, or by mulch. (5) Several years ago I checked some sawdust mulch for pathogens and it contained almost 100% Fusarium. Unfumigated pine straw can also harbor pathogens and weed seed. If you put unfumigated mulch on fumigated soil, you may have lost much of the benefit of fumigation.

With any of the fumigants there are several common critical factors which if ignored can' lead to an ineffective fumigation job. Soil temperature is one of the most critical factors. With any of the fumigants the soil temperature at 6" should be at least 50°. (5) If you fumigate in ground colder than this the gasses do not dissipate evenly resulting in unsatisfactory I&D control. Also at lower temperatures insects, fungi and weeds are less susceptible to being killed by fumigants since biological activity is low. (1)

All of the fumigants also require some soil moisture to work properly. Generally this is in the range of 50-75% of field capacity. For instance, in one study by McElroy, 1" of rain fell immediately after Dazomet application and irrigation driving it deeply into the soil. As a result, slow release of toxic gas caused mortality in the pine crop subsequently sown. (10)

Preparation of the soil for fumigation is very important. A good way to be sure the soil is prepared is to disk it until it looks perfect and then disk it again. All fumigants work by contacting the organisms they control. If a seed or spore is inside a clump of dirt, it will not be killed. When preparing soil you should avoid adding organic matter immediately prior to fumigation. Excess organic matter will tie up fumigants and reduce your degree of pest control. It may also release the fumigant slowly and do damage to your seedling crop. Soil tests for fertility should also be done after fumigation since fumigation affects nutrient availability. (1,5)

Of course the application rate is critical for all of the fumigants. Using less than the label rate may suppress the easy to kill fungi and weeds

and not affect organisms like charcoal root rot. This leaves a disaster situation as the charcoal root rot fungus could easily be fruitful and multiply. Using more than the label rate of fumigants can also cause problems not only due to cost but also due to possible direct seedling mortality from the slowly released gas. One check we use with Methyl Bromide is to use a flow meter to be sure no shanks are plugged during fumigation.

Exposure period to the fumigants is the last critical factor. At least 48 hours is the recommended exposure period for Methyl Bromide and 5-7 days for Dazomet. (1,5) At lower temperatures or higher moisture this should be increased.

With all fumigants the soil should be aerated following exposure to avoid crop damage. However, you should never aerate the soil to a depth greater than it was incorporated since this can cause soil contamination. (1)

There are alternatives to some pest problems which may occur if you have planted a pine crop on non-fumigated soil. The first step in what I call targeted control is to identify the exact pest which is causing losses. Once you have done this you can apply post plant pesticides to control some target organisms without damaging your seedling crop. We are fortunate to have pest specific chemicals, many of which were developed in the last 20 years, the use of which can reduce some pest losses. For example, prior to the development of Dieldrin (which is no longer available), white grubs caused heavy losses in many nurseries. I have heard nurserymen say that in the old days they could see seedlings shake as grubs ate their roots. Now we can use Dursban at 1 gallon/acre to reduce white grub population on non-fumigated soil. Mole crickets are another insect which can cause losses but are easily controlled with Orthene or Dursban. Although we still do not have a great postemergence herbicide for the sedges, weekly applications of Goal can at least stress the sedges and slow their spread. Some root rots such as those caused by Pythium can be minimized by applications of Tilt or Ridomil. Of course Captan is the old standby for reducing loss to Fusarium damping off.

Naturally none of these chemicals will help you if you sow a crop on non-fumigated land and find yourself with an outbreak of a tough pest like charcoal root rot or Cylindrocladium. It is naive to think that just because these pests were not a problem last year that they will not arise to haunt you. Alfred Foster in a 1961 paper says, "There are nurseries in which charcoal root rot appeared as a novelty one year and caused crop failure the next". (6)

An even worse tragedy would be to have a low level infection of something like charcoal root rot in your nursery which only caused minor losses in the seedbeds. Even though a seedling is green when lifted does not necessarily mean that it is uninfected and is healthy enough to survive outplanting. (2) We must recognize that nursery seedlings are on artificial life support systems. They get abundant light, water and nutrients which may keep them alive even if diseased. When seedlings are outplanted their value increases tremendously due to the costs of site preparation, planting and so forth. If diseased or unhealthy seedlings are shipped and planted there is great likelihood of planting failure due to stresses not found in the nursery. If such a failure was tracked back to the nursery it would be uncomfortable to

say the least.

Several years ago my recommendations for annual soil fumigation were challenged by a high-placed Forestry Commission official. He said that he bet I couldn't guarantee him that if we didn't fumigate that we would have soil pest problems. I said that he was right, I couldn't guarantee we would have problems, but I added that I could guarantee that if we fumigated correctly we would not have a disastrous loss to soil pests.

I have enjoyed talking with you today and will get down off my soap box. If anyone has questions I will attempt to answer them.

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