EFFECTIVE SOIL FUMIGATION

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INTRODUCTION

Pest control by fumigation is by no means a new practice. Attempts to control soil nematodes chemically date back to 1881. Carbon disulphide was extensively used for control of phylloxera of grape in Europe during the close of the last century. The practice of soil fumigation, however, has become widespread only since World War II. Since then, a number of fumigants such as methyl bromide, chloropicrin, dichloropropenes, and ethylene dibromide have been widely developed and today fumigation with these materials is an accepted practice in many agricultural areas. In fact, methyl bromide is the most widely used general-purpose fumigant in the world.

As with any business in the inflationary 1970's, the forest nursery industry is plagued by accelerating production costs. Yet, the nurseryman is as concerned today as he was 25 years ago about weed, soil-borne insect, disease, and nematode problems. The available chemicals for solving these problems are essentially the same as were available 25 years ago. The basic activity of these materials has not changed and their price has not increased appreciably since their market introduction. The real difference between now and then is summarized as follows:

1. Labor costs have quadrupled during the past 25 years.

2. Fumigant application methods have been refined considerably permitting more efficient use of chemicals and manpower.

3. Availability of highly specialized, professional applicators using the latest equipment and procedures to accomplish optimum results.

Soil fumigation is extensively used in United States forest tree nurseries today. A number of fumigants including methyl bromide - chloropicrin formulations, vorlex, vapam, and mylone are employed to control a variety of pest problems. The methyl bromide - chloropicrin formulations, however, are most frequently used as "broad spectrum" soil fumigants.

METHYL BROMIDE SOIL FUMIGATION

Registered Uses and Safety

Methyl bromide and methyl bromide - chloropicrin formulations are specifically registered through the U.S. Environmental Protection Agency as preplanting soil fumigants for the control of a variety of soil fungus organisms, nematodes, soil insects, weeds, and grasses in forest tree nurseries.

Methyl bromide can be as safely employed as any other chemical pesticide when maintaining due consideration and precaution for its potential toxicity and accompanying safety hazards.

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The specific fumigant formulation label should be read and understood prior to use. All handling and application directions and safety precautions should be closely followed. The fumigant is applied only by nursery personnel that are certified by the respective state pesticide regulatory agency. Recommended protective equipment should always be utilized as directed.

Procedures and Techniques - Application

The fumigant is most commonly applied by a chisel injection method beneath the soil. This method involves a tractor - drawn soil injection rig equipped with chisels not over 12 inches apart and set to inject the fumigant at an optimum 8-10 inch depth. More recently, soil injection rigs have been developed that permit fumigant injections at soil depths of 12 inches or more where particularly damaging disease problems threaten the production of deeper-rooted hardwood seedlings such as black walnut, and yellow poplar.

The fumigated soil is covered immediately with a minimum 2-mil. thickness polyethylene plactic covering. The fumigation and tarping can be effectively applied in either alternate strips or as solid fumigated and tarped fields using custom application equipment.

Dosage Rates

Fumigant dosage rates vary between 250-600 pounds active ingredient per acre. A rate of 350 pounds per acre is standard as a "broad spectrum" treatment.

Formulations and Target Organisms

The following three specific methyl bromide or methyl bromide - chloropicrin formulations are presently commercially available and registered for forest nursery seedbed preplant soil fumigation:

MC-33 = methyl bromide - 67%; chloropicrin - 33%

MC- 2 = methyl bromide - 98%; chloropicrin - 2%

Brozone type = methyl bromide - 68.6%; chloropicrin - 1.4%;
Inert petroleum hydrocarbons - 30%.

Other custom formulations (i.e., methyl bromide - chloropicrin mixtures) are also available from certain basic producers and distributors.

One prerequisite to effective soil fumigation is an adequate knowledge of the target soil organisms involved. Different methyl bromide - chloropicrin formulations are used against different target pests. The MC-33 formulations is particularly effective against pathogenic soil fungi with tough resistant spore stages (i.e., Cylindrocladium and Sclerotium bataticola). The MC-2 formulation is somewhat more effective than MC-33 for weed and grass control and is more of a broad spectrum fumigant. The brozone type formulation, with its reduced proportion of active ingredients, is less effective than either MC-33 or MC-2 at the same dosage rates.

Equipment Calibration and Monitoring

For effective and efficient fumigation, the application equipment must be calibrated to deliver the desired dosage rate as indicated in the following formula:

Fumigant Dosage = Concentration X Time

Therefore, the fumigant dosage rate is controlled by three interrelated but separate flexible factors - fumigant pressure, nozzle orifice size, and the tractor speed. Data concerning all three of these factors must be known and utilized in calibrating the dosage rate.

The fumigation equipment should be continuously monitored to maintain a constant even chemical flow through all hose outlets. A constant tractor speed must also be maintained to provide a uniform fumigant coverage.

Soil Preparation and Organic Matter

Proper soil preparation is highly important in achieving successful fumigation. Work the soil into a fine, loose, friable condition and as free of clods as possible to a minimum depth of 8-10 inches.

In general, excess nondecayed organic matter retards effective fumigation. The fumigant is absorbed by the organic matter preventing its vaporization and movement throughout the soil particles. In addition, organic matter serves as a reservoir for soil pathogenic fungi and nematodes. Consequently, green organic matter such as cover crops, residual tree seedlings, etc., should be thoroughly cut or chopped and worked into the soil a minimum of 3-4 weeks prior to fumigation.

Soil Environmental Factors-Moisture and Temperature

Two of the most important soil environmental factors to be considered in soil fumigation are moisture and temperature. Precautions must be taken to insure that the soil moisture is neither too high nor too low - especially in the light sandy soils. The optimum moisture content in sandy soils is between 50-75% field capacity while the heavier clay soils should be between 25-50% field capacity.

Soil temperatures should be above 50° F at the 6-inch depth. Precautions must also be taken not to correlate air temperatures with soil temperatures since air temperatures can be 10-20° F higher than soil temperatures in late fall or early spring. More effective fumigation has also been obtained when employed on sunny days rather than cloudy days which is correlated with the prevailing higher temperatures occurring under the tarped soil on sunny days.

Fumigation Exposure and Soil Aeration Periods

The particular fumigant label used should be consulted for the latest exposure and soil aeration periods recommendation. Normally, the minimum exposure period is 48 hours at soil temperatures above 60° F at the 6-inch depth and under optimum moisture conditions. For lower soil temperatures or where the fumigation is followed by wet or cold weather, the exposure period should be doubled.

The minimum recommended soil aeration period preceding the sowing of conifer or hardwood seeds in nursery seedbeds is 48-72 hours at soil temperatures above 60° F at the 6-inch depth and under optimum moisture conditions. The aeration period should also be doubled at lower soil temperatures or during periods of wet or cold weather. In addition, a minimum soil aeration period of 3 weeks is required when using the MC-33 fumigant followed by artificial seedbed inoculations with mycorrhizal fungi. Chopping or discing the fumigated soil several times during the aeration period will also aid the aeration and possibly shorten the time requirements.

Fumigated Soil Contamination

Avoid contamination of fumigated sites by transporation of contaminated soil, plants, mulches, etc. into these areas. Thoroughly clean, by use of steam or equivalent, all equipment such as plows, bed shapers, tractor tires, etc. prior to use in fumigated areas. Also, avoid any transplanting from non-fumigated to fumigated plant beds along with the use of nonfumigated mulch materials. Mulching materials such as pine needles, straw, and sawdust should be prefumigated with a fumigant such as MC-33 or MC-2 at a dosage rate of 1.0 lb. per yd^3. Polyethylene tarping, temperature and moisture requirements, and fumigant exposure and aeration periods are the same as for soil fumigation. Finally, the irrigation water supply, such as semi-stagnated ponds, may be a source of pathogenic soil fungi, nematodes, and weed seed contamination and should be tested for the presence of these organisms.

Soil Nutrient and Water Alterations

Following soil fumigation, the level of soluble salts and ammonia nitrogen may be increased due to decreased populations of soil bacteria. This condition occurs most frequently on heavily fumigated and fertilized acid, wet, cold or high organic matter soils. Therefore, nitrate rather than ammonia fertilizers should be used on plants that either require the nitrate form or are sensitive to ammonia until after they are well established and the soil temperature is above 65° F. All fertilization should be based on soil tests made after fumigation.

Water requirements per unit of seedling production are generally less on fumigated soil. Due to the larger seedlings and increased production, however, the amount of water needed per acre may be increased.

DISCUSSION AND SUMMARY

Effective soil fumigation has been repeatedly obtained with the methyl bromide - chloropicrin formulations previously described. As previously pointed out, the MC-33 formulation has been most effective for controlling soil-borne fungus-caused disease problems such as the root rots, while MC-2 and the Brozone-type formulations have been most effective as "broad spectrum" fumigants for controlling nematodes, soil insects, weeds and grasses, and some soil-borne fungi. The MC-33 formulation has consistently provided the most satisfactory control of root rot disease fungi such as Cylindrocladium and Macrophomina with their tough resistant spore stages. These root rot diseases are presently widespread in forest tree nurseries and present a potential severe threat to the successful production of both hardwood and conifer seedlings.

Fortunately for the nurseryman however, effective pest control measures as previously described are available and approved by the United States Environmental Protection Agency for routine nursery applications. The present cost of methyl bromide fumigation ranges between $600 - $750 per acre. The cost varies with the methyl bromide-chloropicrin formulation, dosage rate, tarp cover thickness, acreage fumigated, and commercial or private application. Based on an average conifer seedling production of 750,000 seedlings per acre, the cost ranges between $.80 - $1.00 per thousand seedlings. A consideration of the potential pest threats without fumigation, along with the benefits derived from its use, clearly demonstrates that this practice represents a profitable economic investment to help insure the sustained production of higher quality tree seedlings with improved survival capabilities for field plantings.

Consequently, the statement that "soil fumigation doesn't cost - it pays" is more appropriate today than ever before.

In summary, effective soil fumigation can be efficiently and consistently obtained in forest tree nurseries. Due consideration and utilization of the basic biological, chemical, and environmental factors involved, however, are required to obtain consistent successful results.