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# Comparison of Three Soil Fumigants in a Bareroot Conifer Nursery

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*Nursery soil was treated with dazomet (Basamid®), metam sodium (Soil Prep®), or methyl bromide-chloropicrin (Dowfume MC-33®) or left untreated (control). All three chemical treatments resulted in reduced levels of pathogenic fungi in the soil and improved survival of ponderosa pine (*Pinus ponderosa *Dougl. ex Laws.) seedlings and stand density. Seedling growth was the same regardless of treatment in the first growing season. Some growth differences were seen after the second growing season. Height and caliper variations were least with the dazomet treatment. Utilization of these chemicals in conifer nurseries is discussed.* Tree Planters' Notes 39(4):16-22 ; 1988.

Preplanting fumigation of soil with methyl bromide-chloropicrin (MB-C) fumigant has been used routinely in many forest nurseries. The purpose of fumigation is to rid soil of pests such as pathogenic fungi, nematodes, insects, and weeds. MB-C, however, can be hazardous to apply, and treatment costs are high (over $1,000 per acre); availability of MB-C fumigant in the future may be limited as well.

Alternative chemicals or cultural practices for control of soilborne pests need to be developed so that nursery managers will have several effective options for soil treatment. A test comparing two different chemicals, metam-sodium and dazomet, to MB-C, for control of pathogenic fungi is described. Growth of seedlings in the variously treated soils is also reported.

Metam-sodium (Soil Prep®, Vapam®, Metam®, Nemasoll®, and others) is a water-soluble liquid. It decomposes into the toxic gas methyl isothiocyanate after it is applied to the soil. It must be watered or injected into the soil and the soil surface sealed for 48 hours by rolling, tarping, or watering. Rates of 100 gallons per acre in conifer nurseries have resulted in significant reductions of the pathogenic soil fungi *Fusarium* spp, *Pythium* spp and *Phytophthora* spp (3).

Dazomet (Basamid Granular®,) is a dry, granular material. Like metam-sodium, it decomposes into methyl isothiocyanate gas following contact with moisture in the soil. Dazomet is applied to the soil surface and incorporated by tilling or discing; the soil surface is then sealed by rolling, watering, or tarping. Rates of 250 to 350 pounds per acre are recommended for control of most pathogenic fungi and germinating weed seeds.

## Methods

Plots treated with metamsodium, dazomet, or MB-C, and control plots were established at the USDA Forest Service Bend Nursery in August 1985. Chemical products, application rates and times of application are listed in table 1. Treatment plots, each 300 square feet (12 by 25 feet), were replicated four times in a randomized block design.

In the treated areas, soil was watered and kept at or near field capacity for 2 weeks before

**Table 1**—*Application rates and times of application for soil fumigants tested at Bend Nursery, August 1985*

| Trade name | Active ingredient | Rate | Application date |
|---|---|---|---|
| Dowfume MC-33 | Methyl bromide–chloropicrin | 350 lb/ac | September 15 |
| Soil Prep | Metam-sodium | 109 gal/ac | August 30–31 |
| Basamid Granular | Dazomet | 350 lb/ac | August 30 |

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treatment to allow pest propagules (fungal spores, insect eggs, and weed seeds) to imbibe water and become more sensitive to chemicals. Methyl bromide-chloropicrin (2.4 pounds Dowfume MC-33 per plot) was applied to each of four plots by a contractor, along with operational fumigation at the nursery. It was injected, and the treated soil was covered with tarps for 48 hours. Metam-sodium (.75 gallons of Soil Prep in 185 gallons of water per plot, the equivalent of 1 inch of water) was sprinkled on each of four plots over a 4-hour period. Dazomet (2.4 pounds Basamid Granular per plot) was spread on the soil surface of each of four plots, incorporated by roto-cultivator to the depth of 6 inches and then sealed by 1/4 inch of water, applied by hand. No chemical was applied to the remaining four control plots.

**Pathogen populations.** Populations of two genera of common pathogenic soil fungi, *Fusarium* and *Pythium,* were measured at three times: (a) before treatment, (b) after treatment, and (c) prior to sowing. Soil was collected from three locations in each plot; samples from each location were composites of five cores, 0 to 6 inches in depth. Soil was taken from approximately the same three locations in each plot at each of the three sample times. Dilutions of each soil sample were plated on Komada medium, which is selective for *Fusarium* species, and cornmeal agar amended with pimaricin, which is selective for *Pythium* species.

After incubation, the numbers of fungal colonies were counted on each soil dilution plate and a determination of propagules per gram of ovendry (OD) soil was made. Treatment effectiveness was determined by comparing populations (measured as propagules per gram of OD soil) of each fungus before and after treatments.

**Seedling survival.** The number of live and dead ponderosa pine seedlings was counted in eight subplots (1 square foot) in each treatment plot in October of the first growing season. Counts from the subplots were pooled, and the percentage survival was calculated for each treatment plot. Seedling density (number of live seedlings per square foot) was also determined.

**Seedling morphology.** Thirty surviving seedlings from each treatment plot were randomly selected and dug after the first growing season, following budset in October. Stem caliper and shoot height were measured on each seedling, and average caliper and shoot height were calculated for each plot. Roots were clipped from the shoots at the cotyledonary scar, and all roots were combined to get a combined root weight (fresh) and a combined root volume (volume determined by water displacement). Combined weights and volumes of the shoots were also measured. Stem volumes and root-to-shoot ratios (R:S) were calculated for each plot. Two R:S values were calculated, one based on fresh weights and the other on volume.

After the second growing season, 10 surviving seedlings from each treatment plot (40 per treatment) were randomly selected and their calipers and shoot heights measured. Average cal-

**Table 2**—Fusarium *populations (propagules per gram of ovendry soil); comparisons between four different treatments at three different sampling times*

| | Pretreatment | Posttreatment | Presow |
|---|---|---|---|
| Control | 843 a | 1160 a | 311 a |
| MB-C | 1126 a | 22 a | 0 a |
| Metam-sodium | 554 a | 483 a | 616 a |
| Dazomet | 543 a | 615 a | 332 a |

Means in each column followed by the same letter do not differ significantly at the .05 probability level according to Duncan's new multiple range test.

iper and shoot height were calculated for each plot. These measurements were used to calculate a stem volume for each plot. Density counts were not taken in the second year. Second-year densities were assumed to be similar to first-year densities since little or no mortality was observed after the first growing season.

**Statistical procedures.** Treatments were compared for all measures using analyses of variance and Duncan's new multiple range test. Differences at the .05 level are considered significant.

## Results and Discussion

**Pathogen populations.**

*Fusarium.* When treatments are compared with each other at each sample time (pretreatment, posttreatment, presow), it is seen that populations of *Fusarium* were lower (although not significantly) in MB-C soils compared to the other treatments at both posttreatment and presow times (table 2).

Within each treatment, significant reductions in *Fusarium* populations between pre- and posttreatment samples were seen only in the MB-C treatment; populations were reduced drastically following treatment and were still extremely low at sowing time (presow measurement) (fig. 1). With metamsodium and dazomet, population

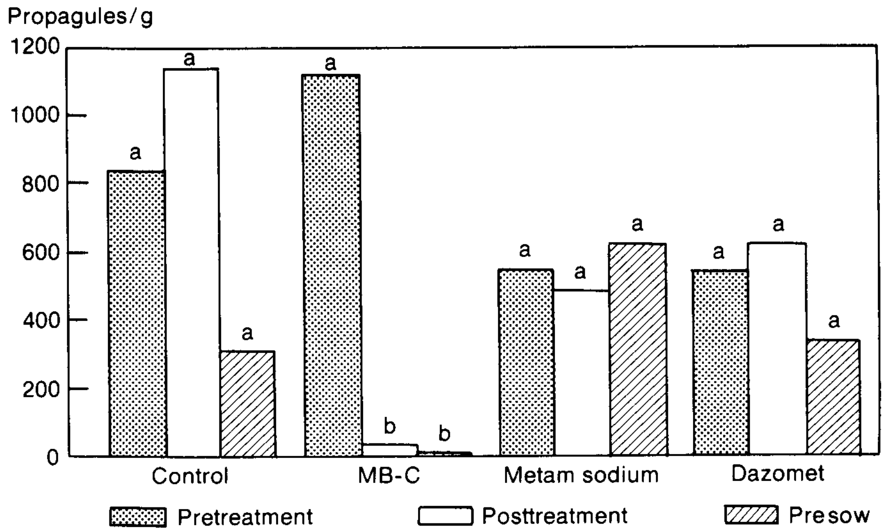


**Figure 1**—Fusarium *populations before and after treatment with the fumigants methyl bromide–chloropicrin (MB-C), metam-sodium, and dazomet. In each cluster of bars, bars with the same letter do not differ significantly according to Duncan's new multiple range test (P < .05).*

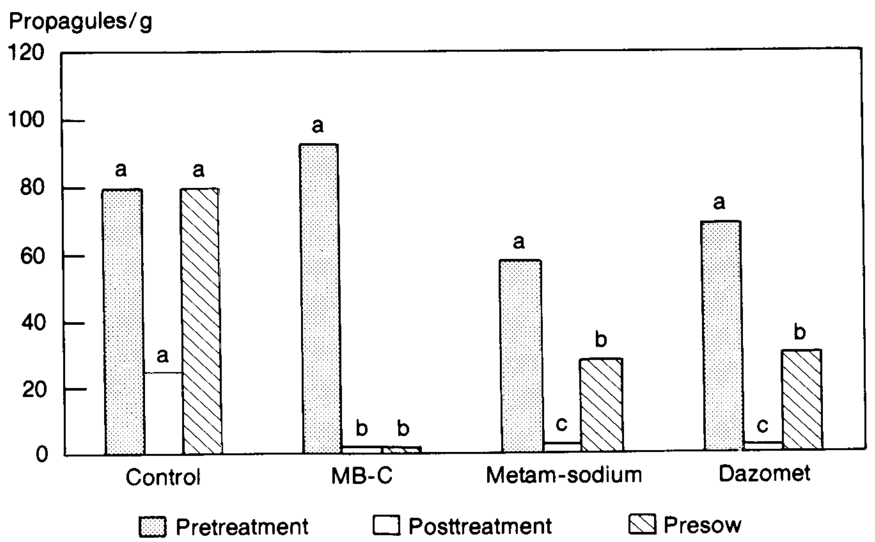


**Figure 2**—Pythium *populations before and after treatment with the fumigants methyl bromide–chloropicrin (MB-C), metam-sodium and dazomet. In each cluster of bars, those with the same letter do not differ significantly according to Duncan's new multiple range test (P < .05).*

changes were not statistically significant.

*Pythium.* When treatments are compared with each other at each sample time, treated soil had significantly lower populations of *Pythium* at posttreatment and presow times than did

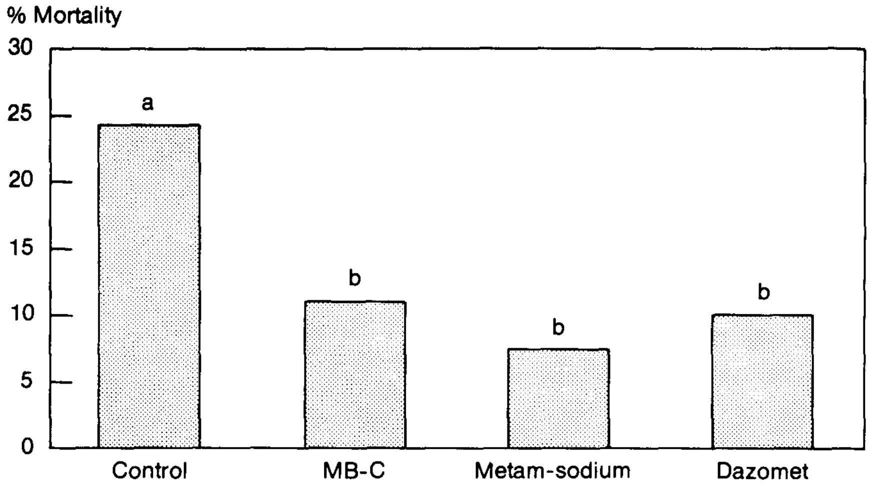


**Figure 3**—*Ponderosa pine seedling mortality in the first growing season. Bars with the same letter above them do not differ significantly according to Duncan's new multiple range test ($P < .05$).*

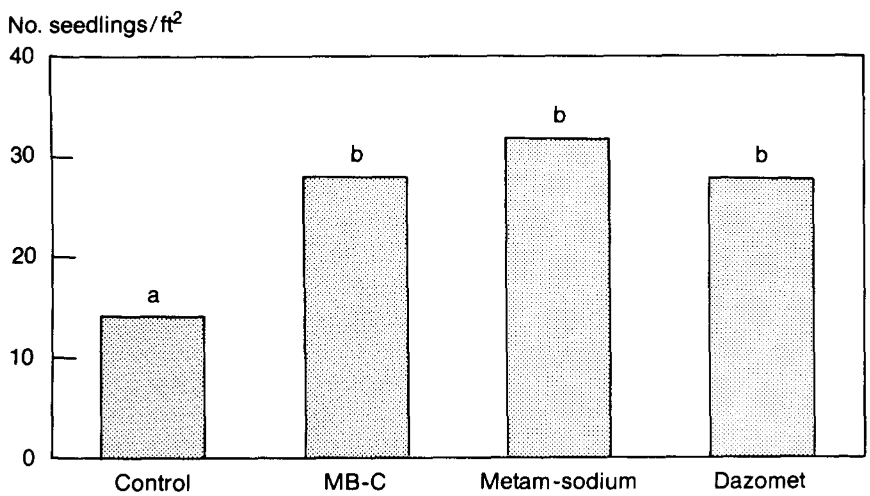


**Figure 4**—*Ponderosa pine seedling density after the first growing season. Bars with the same letter above them do not differ significantly according to Duncan's new multiple range test ($P < .05$).*

untreated soil (table 2). And, although not statistically significant, populations in MB-C plots were much lower than populations in either dazomet or metam-sodium plots.

Within each treatment, significant reductions in *Pythium* populations between pre- and posttreatment samples were seen for all treatments except the check (fig. 2). With MB-C, populations of *Pythium* were reduced to zero and were still near zero at sowing time.

With metam-sodium and dazomet, populations were reduced to near zero immediately following treatment; they then increased, although the levels at sowing were still significantly lower than the levels seen before treatment (table 3). It is interesting to note that a gradual increase in populations of *Pythium* in both metam-sodium and dazomet treatments occurred between treatment in the fall and sowing the next spring. This may be due to incomplete eradication of *Pythium so* that population increases resulted from inoculum remaining in the soil after treatment. Recolonization of pathogen-free portions of the soil (such as the top few inches where chemical concentration was probably greatest) by inoculum in portions of soil that were untreated or received less chemical may have also occurred.

*Pythium* appears to be more sensitive than *Fusarium* to dazomet and metam-sodium. This may be due to differences in cell-wall thickness of resting spores or differences in other mechanisms that allow fungi to withstand toxins. It may also be the result of a higher proportion

**Table 3**—*Pythium populations (propagules per gram of ovendry soil); comparisons between four different treatments at three different sampling times*

| | Pretreatment | Posttreatment | Presow |
|---|---|---|---|
| Control | 85 a | 29 a | 85 a |
| MB-C | 98 a | 0 b | 2 b |
| Metam-sodium | 63 b | 3 b | 31 b |
| Dazomet | 73 b | 2 b | 34 b |

Means in each column followed by the same letter do not differ significantly at the .05 probability level according to Duncan's new multiple range test.

**Table 4**—*First-year seedling morphology*

| | Shoot ht (cm) | Caliper (mm) | R:S wt | R:S vol | Stem vol ($mm^3$) |
|---|---|---|---|---|---|
| Control | 8.9 a | 2.8 a | .50 a | .42 a | 181 a |
| MB-C | 9.6 a | 2.5 a | .63 a | .54 a | 154 a |
| Metam-sodium | 8.5 a | 2.5 a | .50 a | .47 a | 146 a |
| Dazomet | 9.1 a | 2.7 a | .50 a | .39 a | 176 a |

Means in each column followed by the same letter do not differ significantly at the .05 probability level according to Duncan's new multiple range test.

**Table 5**—*Second-year seedling morphology*

| | Shoot ht | | Caliper | | Stem vol |
|---|---|---|---|---|---|
| | cm | cv | mm | cv | ($mm^3$) |
| Control | 19.8 ab | 3.7 | 6.6 a | 11.9 | 2257 a |
| MB-C | 18.4 b | 6.0 | 5.3 b | 4.9 | 1352 c |
| Metam-sodium | 20.7 ab | 9.5 | 5.7 b | 9.0 | 1760 abc |
| Dazomet | 21.7 a | 1.6 | 6.0 ab | 3.3 | 2042 ab |

Means in each column followed by the same letter do not differ significantly at the .05 probability level according to Duncan's new multiple range test. cv = coefficient of variation.

of Pythium propagules being in a sensitive stage (for example, zoospores or germinating resting spores) than Fusarium propagules at the time of treatment.

**Mortality.** At the end of the first growing season, seedling mortality was significantly lower in treated areas compared to untreated (control) areas. Average mortality in treated plots was about one-third of mortality in check plots (9.6% versus 24.5%). There were no real differences in mortality among the three chemical treatments (fig. 3).

**Seedling stand.** The number of surviving seedlings per square foot was significantly higher in treated areas than in untreated (control) areas. Treated areas averaged about 50% more seedlings than control areas. The highest number of seedlings per square foot was found in the metam-sodium treatment. Seedling numbers were identical in MB-C and dazomet areas (fig. 4).

**Seedling morphology.** At the end of the first growing season, various morphological measurements were made. The average shoot height and root-to-shoot ratios were slightly higher for seedlings from MB-C plots than other treatments. Caliper and stem volume were highest in control and dazomet seedlings. However, for all measurements-height, caliper, R:S (weight), R:S (volume), and stem volume-differences were not significant (table 4).

At the end of the second growing season, some significant differences in morphology were seen between treatments. Total height was greatest in dazomet-treated plots and lowest in MBC-treated plots. Similar to the first growing season, caliper and stem volume was highest in control and dazomet treatments; differences between these treatments and MB-C were significant, however (table 5).

The amount of variation in second-year seedling height and caliper was least in dazomet plots (see coefficient of variation, table 5). This lower variation has been observed in Douglas-fir seedlings as well, at another nursery in the Pacific Northwest, following dazomet treatment (5). Seedling height varied the most in metam-sodium plots and caliper varied the most in check plots.

Larger caliper and stem volumes seen in check seedlings in both the first and second year are most likely due to greater water and nutrient availability for individual control seedlings as a result of lower bed density. Similar conclusions were drawn by Boyd (2), who found that density effects concealed true fumigation effects. It is uncertain why second-year height and stem volume of the dazomet seedlings are greater than those in the MB-C treatment in this trial, even though first year densities were identical. This differs from the results found by Tanaka et al. (4), who observed that fumigation with similar rates of MB-C resulted in larger 1 +0 seedlings compared to dazomet or check seedlings grown under similar bed densities.

**Conclusions**

Based on results from this trial, it appears that the two "new" products, dazomet and metam-sodium, perform as well as the more commonly used methyl bromide-chloropicrin fumigant in terms of seedling survival and growth. Although pathogen populations were not reduced as much with either product as they were with MB-C, seedling survival and size surpassed or equaled those seen with MB-C. Similar results have been reported for these products in other conifer nurseries in the Pacific Northwest (1, 3, 5). Seedlings grown in dazomet-treated soil showed greater uniformity of height and caliper than seedlings in other treatments.

Operational use of dazomet and metam-sodium at the Bend Nursery would be warranted from an economical as well as a disease control standpoint. The per-unit chemical cost of applying dazomet is similar to that of MB-C. The per-unit cost of applying metam-sodium, at 100 gal/acre (the rate used in this test), is less than that of MB-C. The acute toxicities and handling hazards of dazomet and metam-sodium are considerably lower than that of MB-C. Dazomet has been used operationally in several conifer nurseries in 1986 and 1987; application technology is developed and fairly well-refined so that the material can be applied easily and effectively. Efficient, cost-effective methods for applying metam-sodium in conifer nurseries have not yet been worked out; since the material is best applied through the irrigation system, some modifications of existing systems must be made before this chemical can be used operationally.

Weather conditions, soil characteristics, and the kinds and amounts of soilborne pathogens at each individual nursery will undoubtedly influence the ease of application, duration of treatment and effectiveness of these materials. Ideal rates and application techniques will need to be developed at individual nurseries to ensure maximum pest control.

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