# Basamid and Solar Heating Effective for Control of Plant Parasitic Nematodes at Bessey Nursery, Nebraska[1]

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Abstract.--Methyl bromide/chloropicrin, Basamid®, and solar heating were compared for control of Fusarium spp., plant-parasitic nematodes and weeds at Bessey Nursery, Halsey Nebraska. All treatments controlled nematodes. Solar heating and polyethylene-sealed Basamid were less effective than methyl bromide for control of Fusarium spp. Water-sealed Basamid did not control Fusarium spp. Only methyl bromide and solar heating controlled weeds. A windstorm after treatment may have confounded results.

## INTRODUCTION

In order to control damping-off fungi and other soil-borne fungal pathogens, plant-parasitic nematodes, and weeds, pre-plant fumigation with methyl bromide/chloropicrin is used on a regular basis at most Federal tree nurseries (Ruehle, 1986). Due to health hazards, alternative chemicals and cultural practices are continually being tested. In summer, 1985, the Manager at Bessey Nursery (Halsey, Nebraska) requested an evaluation of Basamid® as an alternative chemical fumigant, especially for control of plant-parasitic nematodes.

Basamid® (dazomet) reacts with moist soil to form methyl isothiocyanate, a degradable biocide. The fumigant vapors are kept in the soil by surface compaction and sealing with water. Polyethylene sheeting may be required for the sandy soil at Bessey. Basamid has been reported as effective in controlling weeds, nematodes, and soil-borne fungal pathogens (Neumann et al., 1984; Hopkins Co.).

An alternative to chemical fumigation is soil solar heating. Solar heating of soil is accomplished by covering moist soil with clear polyethylene sheeting for several weeks during midsummer. Solar heating has reduced populations of weeds and soil-borne fungal pathogens in forest tree nurseries (Cooley 1985; Hildebrand 1987). A previous study of solar heating effects on nematode populations at Bessey resulted in no observable treatment effect because of very low and highly variable population levels of plant parasitic nematodes (Hildebrand 1985). Positive effects on tree seedling survival have not yet been demonstrated in forest nurseries, but a fallsown crop would be the most likely to show benefit.

The objective of this evaluation was to compare soil treatments with methyl bromide/chloropicrin (Dowfume® MC-33), Basamid® Granular, and solar heating for effectiveness in reducing populations of species of Pythium, Fusarium, plant parasitic nematodes, and weeds. Comparisons were planned also for effects on growth and survival of fall-sown eastern redcedar (Juniperus virginiana L.).

## MATERIALS AND METHODS

Soil treatments for fall-sown eastern redcedar were begun in summer 1986 at Bessey Nursery. The portion of the nursery unit chosen for this evaluation showed nematode damage in the eastern redcedar crop lifted in spring 1986. The limited area with high nematode concentrations and the need to prevent cross-contamination between treatments necessitated limited replication.

Five treatments were replicated in two plots of 10 x 40 ft arranged as in figure 1. At the time of sowing, the tractor formed and sowed beds first in the methyl bromide/chloropicrin plots, then the polyethylene-covered Basamid plots, then the water-sealed Basamid plots, then the solar-heated plots, and finally the check plots. This sequence helped minimize contamination of the treated beds during sowing because the intensity of the biocidal effects of the treatments were expected to follow the same order. This plot layout helped ensure the presence of sufficient nematodes in all treatments. The nursery bed area adjacent to the treatment area was

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|<---------------------160-ft------------------->|

|<--------- Eastern redcedar windbreak -------->|

| | | | | | |
|---|---|---|---|---|---|
| | S | S | C | C | M |
| North Edge | WB | WB | PB | PB | M |
| | M* | M* | M | M | M |

Figure l.--Treatment plot layout: S = Solar-heated, C = Check, WB = Water-sealed Basamid, PB = Polyethylene-sealed Basamid, M = Methyl bromide/chloropicrin, M* = M plots for this study.

fumigated with methyl bromide/chloropicrin and the entire unit was sown to easter redcedar following normal nursery practices.

### Treatments

1. (M) Fumigation with Dowfume® MC-33 (67% methyl bromide and 33% chloropicrin) at 350 lb per acre in late July, 1986. The chemical was injected into the soil and the soil surface sealed with polyethylene sheeting for 5 days and then the polyethylene was removed.

2. and 3. Basamid® Granular (Hopkins Co.) was spread evenly over the soil surface at 350 lb per acre and tilled into the top 8" in late July, 1986. The water-sealed (WB) plots were packed flat with a bed packer, and sealed by light irrigation. The water seal was repeated once to prevent surface cracking. The polyethylene-sealed (PB) plots were irrigated lightly and covered with 1.5 mil clear polyethylene sheeting for 10 days. After 10 days the four Basamid plots were cultivated to facilitate dispersal of fumigant vapors. Several oat seeds were sown in one check, one PB, and one WB plot 2 weeks after cultivation to test for residual toxicity.

4. (S) Solar-heated plots were watered to field capacity and covered with 1.5 mil clear polyethylene for 6 weeks beginning in early July, 1986. The polyethylene was removed immediately before sowing.

5. (C) No chemicals were applied to check plots. Check plots remained under the sudan grass cover crop until mid-July, 1986.

In order to maximize benefit from soil treatments, the sudan grass cover crop was plowed under about 2.5 weeks prior to each treatment. Beds were formed and eastern redcedar sown and mulched (covered with clear polyethylene and lathe board) three weeks after cultivation of the Basamid plots.

### Sampling

Soil samples were taken a few days before treatment and a few days before sowing. One 6" core was taken with a soil bucket auger (3" diameter) for each sample, with 5 samples per treatment plot. The bucket was wiped clean of soil between samples.

A small portion of each sample was assayed for population levels of species of *Pythium* and *Fusarium* at the Rocky Mountain Region Forest Pest Management Lab. Standard assay procedures developed by Forest Service Plant Pathologists for the Reforestation Improvement Program (Landis 1986) were used except for the selective media. The selective medium for *Pythium* spp. was from Hendrix and Kuhlmann (1965) and for *Fusarium* spp. from Nash and Snyder (1962). The rest of the soil from each sample was shipped to Peninsu-Lab (Kingston, Washington) for assay for plant-parasitic nematodes.

Fungal populations were again assayed in mid-June, 1987. Plant-parasitic nematodes were again assayed by Peninsu-Lab in soil samples taken in late July, 1987. The number of weeds per 3 sq ft and the percentage of weed cover were determined in mid-May, 1987, in 6 sample areas per treatment plot. Weeds were then removed by hand in the treatment plots. The number of living, dying, and dead eastern redcedar seedlings were counted every 3 to 4 weeks in 6 sample areas per treatment plot beginning in midMay, 1987. Dying seedlings were examined for causal agents and number of seedlings per square foot were determined. Final seedling counts were made in late July, 1987.

### Temperatures

Soil temperature data for solar heated and check plots were taken during previous studies at Bessey Nursery (Hildebrand 1987), and were not gathered for this evaluation.

## RESULTS

Two weeks after cultivation of the Basamid treatment plots, germination of oats indicated no residual toxicity, and sowing was completed on schedule. Because sample variances were quite heterogeneous, the test for equality of means with unequal variances was used for all comparisons (Sokal and Rohlf, 1981).

## Fungi

Population levels of *Pythium* spp. were too low to show any treatment effects. Population levels of *Fusarium* spp. were significantly decreased only by the methyl bromide (M) and solar (S) treatments (figure 2). Methyl bromide treatment was more effective than solar heating in reducing population levels of Fusarium. In both Basamid (PB and WB) treatments, *Fusarium* populations were concentrated in pockets, while those in solar plots were more evenly distributed at low levels. Between pretreatment and post treatment samples, *Fusarium* levels in check plots increased significantly while those in each Basamid treatment remained statistically similar. By the following June, 1987, *Fusarium* levels increased (not significantly except in M plots) in all treatments, but levels in M, S, and PB treatments were significantly lower than in check and WB treatments. Population levels of Fusarium spp. greater than 1000 propagules per gram o ovendried soil are expected to cause noticeable damping-off in susceptible species.

## Nematodes

Population levels of plant-parasitic nematodes in the check and PB plots were significantly higher than in other plots before treatment. Population levels remained high in the check plots, while being significantly reduced by all other treatments (figure 3). The chemical treatments, M, PB, and WB, were equally effective, and somewhat more so than solar heating. The nematode levels remaining in the solar plots were below the threshhold for seedling damage (200 nemas per pint of field moist soil), based on previous sampling in healthy and diseased eastern redcedar at Bessey Nursery. By the following July, 1987, nematode levels were still at potentially damaging levels in check plots, while remaining low in all other treatments.

## Weeds

In mid-May, 1987, the predominate dicotyledonous weed was mare's tail or hotseweed, *Conyza canadensis* (L.) Cronq., while the predominate grassy weed was downy brome, *Bromus tectorum* L. The average number of weeds and percentage weed cover in the treatment plots are summarized in figure 4. Numbers of weeds were significantly reduced compared to checks only in methyl bromide and solar plots. Weed cover was significantly reduced only in solar plots. Weeds and weed cover in the Basamid plots were not significantly reduced compared to that in check plots.

## Temperatures

Temperature data from a previous study at Bessey (Hildebrand 1987) is presented in figure 5. Highest temperatures averaged 8°C higher in solar than in check plots. Average high temperatures recorded at 30 cm depth were much lower than near

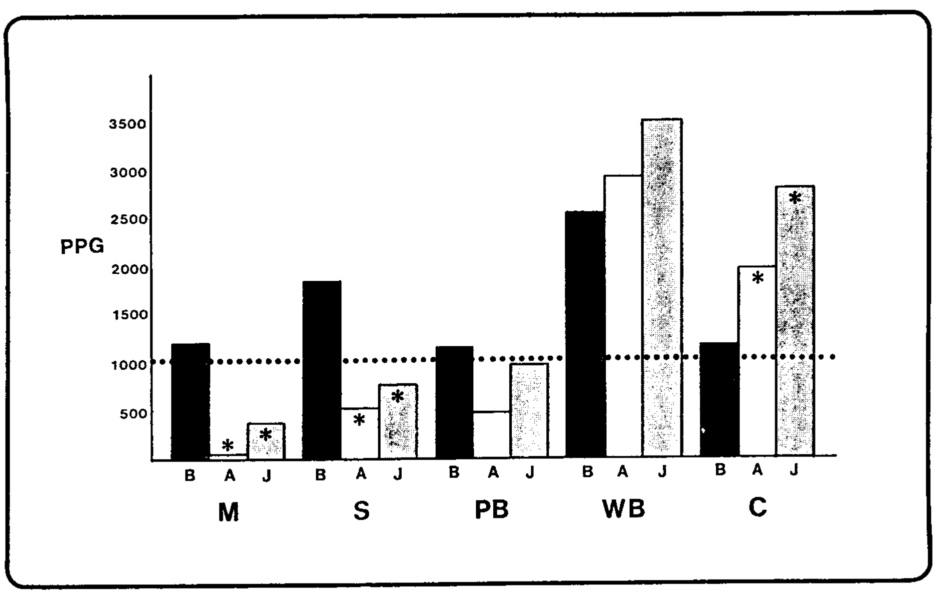


Figure 2.--Means and their significance for population levels of *Fusarium* spp. in propagules per gram of oven-dried soil (PPG) in methyl bromide/chloropicrin (M), polyethylene-sealed Basamid (PB), water-sealed Basamid (WB), solar-heated (S), and check (C) plots before (B) and after (A) treatment in summer 1986, and the following June (J) 1987 at Bessey Nursery. Asterisks indicate significant difference (P<0.05) from the before treatment mean.

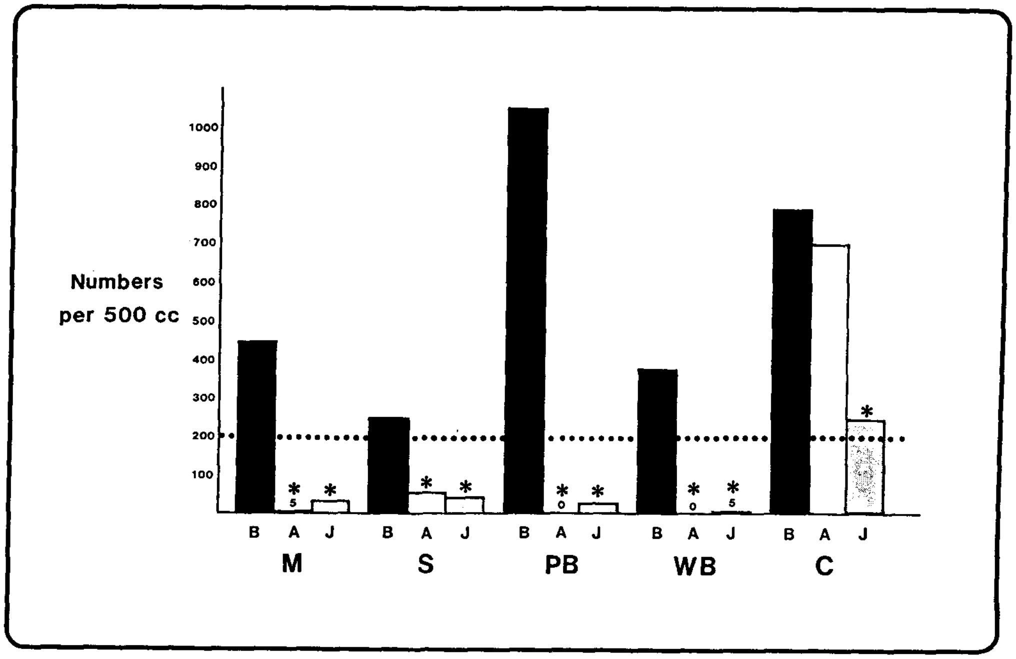


Figure 3.--Means and their significance for population levels of plant-parasitic nematodes (numbers per pint of soil) in methyl bromide/chloropicrin (M), polyethylene-sealed Basamid (PB), water-sealed Basamid (WB), solar-heated (S), and check (C) plots before (B) and after (A) treatment (summer 1986), and the following July (J) 1987 at Bessey Nursery. Asterisks indicate significantly different (P<0.05) from the before treatment levels.

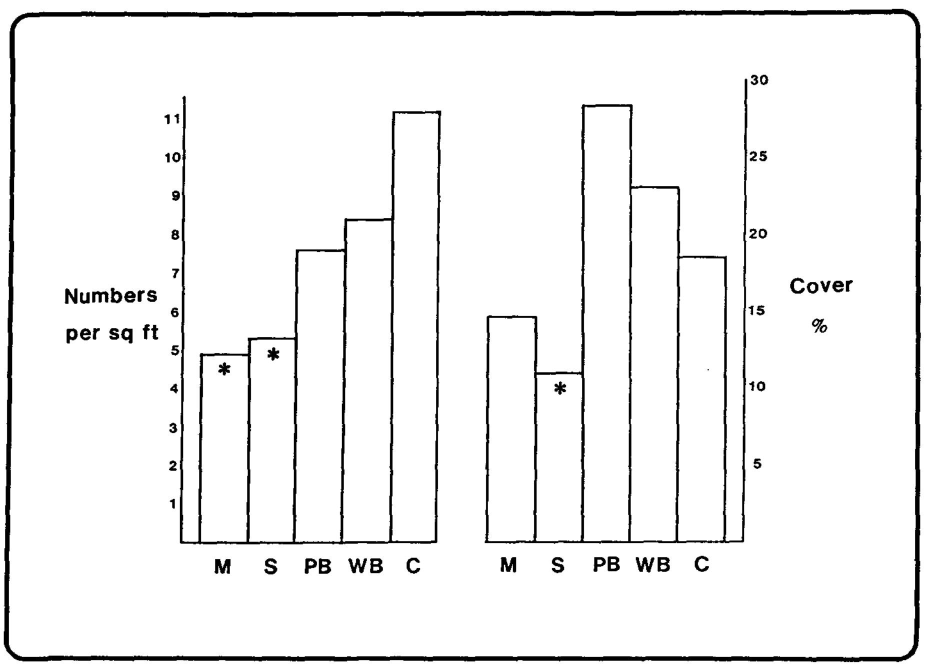


Figure 4.--Means and their significance for weed numbers (per sq ft) and weed cover in methyl bromide/chloropicrin (M), polyethylene-sealed Basamid (PB), water-sealed Basamid (WB), solar-heated (S), and check (C) plots in May 1987. Asterisks indicate significantly different from check.

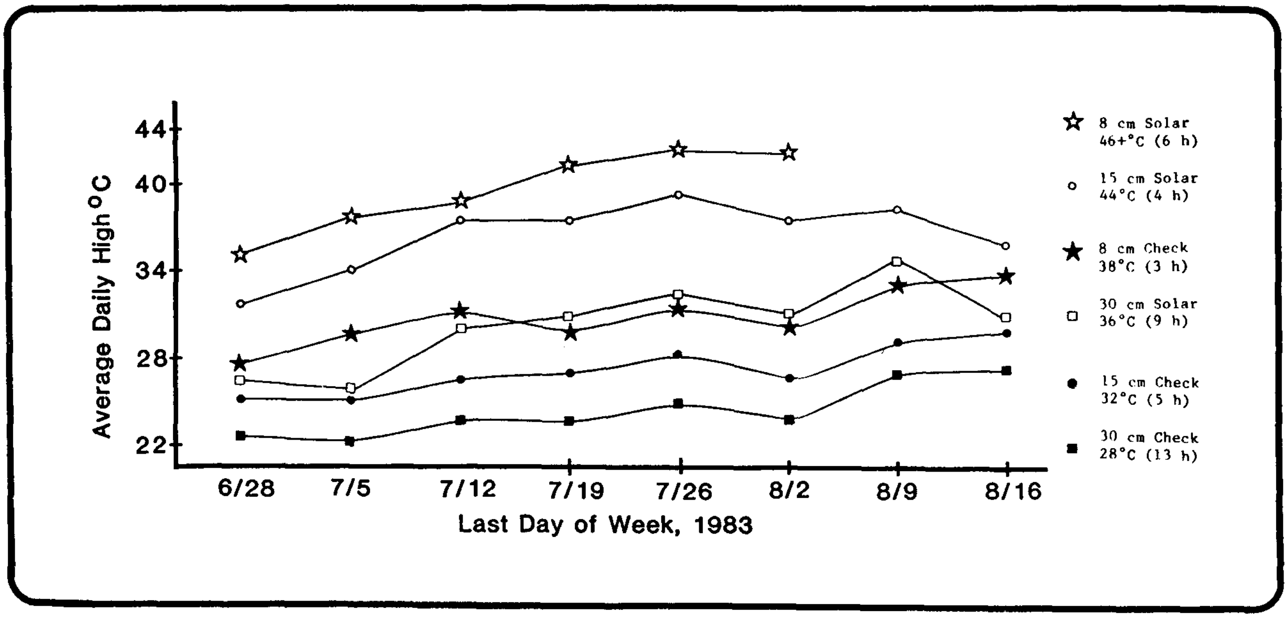


Figure 5.--Weekly averages of daily high temperatures recorded by thermographs buried at 8, 15, and 30 cm in one solar and one check plot at Bessey Nursery, 1983. Highest temperature achieved and the duration in hours (h) that the temperature remained within 1°C of the the high is given for each thermograph.

the surface (8 cm), but temperatures remained within 1°C of the daily highs much longer at greater depth. At 8 cm in the solar plot, 46°C (the limit of the recording capability of the thermograph used) was exceeded several times. At these times, the temperature remained above 45°C for 2 to 6 hours, averaging 4.1 hours. While the temperature was off-scale (46+°C) on August 2 at 8 cm in the solar plot, the recording chart tore and the subsequent record was lost.

## Seedling Survival

Eastern redcedar seedlings succumb to damping-off caused by *Fusarium* spp., but only rarely (0.6% in this study). Seedling survival in May and July 1987 is presented in Table 1. Stocking in all treatments was far less than the standard 25 seedlings per square foot. So few seedlings survived frost damage early in the spring that those remaining were more susceptible to sun scorch and burial by blowing sand.

Table 1.--Average number of seedlings per square foot in treatment plots: methyl bromide/chloropicrin (M), polyethylene-sealed Basamid (PB), water-sealed Basamid (WB), solar-heated (S), and check (C), in May and July 1987 at Bessey Nursery.

| | M | PB | WB | S | C |
|---|---|---|---|---|---|
| May | 11.4 | 0.1 | 6.8 | 0.1 | 0.1 |
| July | 9.9 | 0.1 | 5.2 | 0.1 | 0.1 |

## DISCUSSION

According to soil assays, Basamid was as effective as fumigation with methyl bromide/chloropicrin for controlling plant-parasitic nematodes. Solar heating was effective in reducing populations of plant-parasitic nematodes, but not quite as effective as chemical fumigation.

For reducing populations of *Fusarium* spp., methyl bromide fumigation was best, followed by solar heating and polyethylene-sealed Basamid. The heavy windstorm prior to sowing may have contributed many of the fungal propagules that increased the variability in population levels of *Fusarium* in post treatment samples. Vaartaja (1967) showed that fungal reinfestation of fumigated soil occurs by blowing dust. If the concentrated pockets of *Fusarium* in the Basamid plots were a result of Basamid treatment, use of Basamid would probably result in pockets of losses for most conifers. Movement of soil by wind or equipment would spread the inoculum. Since many conifers are susceptible to *Fusarium* root rot later in the season, cumulative losses could be high. Use of solar heating might have similar results, but to a lesser extent.

In this evaluation, solar-heating was the most effective treatment for weed control. The windstorm also blew many weed seeds into the study area after treatments. Even in the area treated with methyl bromide, more weeds than usual were observed under the clear polyethylene sheeting used as winter mulch over the eastern redcedar beds. Consequently, the weed control results may not adequately compare the efficacy of the treatments.

An early warming period in late winter, 1987, resulted in seedling emergence early in March. The polyethylene sheeting was removed March 12-13, 1987. Snow and cold weather followed, resulting in heavy losses to frost injury. Because of the sheltering effect of the windbreak, seedlings near the windbreak (S and C plots) were slower to emerge and were very susceptible when the frost occurred. So few seedlings survived that the treatment area was plowed under following soil sampling in July, 1987. The Nursery will try black polyethylene sheeting as mulch for subsequent eastern redcedar crops, to prevent much of the "greenhouse" warming that occurs under the clear sheeting.

Overall, fumigation with methyl bromide/ chloropicrin was the most effective treatment. Based on the results of this evaluation, solarheating and possibly polyethylene-sealed Basamid could be fairly effective substitutes for methyl bromide fumigation. Water-sealed Basamid could be used only for nematode control. Further evaluations for weed and disease control should be done with larger treatment areas and other conifer crops. The cost of treatment with polyethylene-sealed Basamid is higher than methyl bromide fumigation, but handling may be less hazardous. Solar heating is much less expensive than chemical fumigation.

Disclaimer

The use of trade and company names is for the benefit of the reader; such use does not constitute an official endorsement or approval of any service or product by the U. S. Department of Agriculture to the exclusion of others that may be suitable.

## LITERATURE CITED

Cooley, Sally J. 1985. Evaluation of solarization and fumigation at the J. Herbert Stone Nursery. 16 p. USDA Forest Service, Pacific Northwest Region, Portland, Oregon. [unnumbered publication].

Hendrix, F. F., Jr., and E. G. Kuhlman. 1965. Factors affecting direct recovery of Phytophthora cinnamomi from soil. Phytopathlogy 55: 1183-1187.

Hildebrand, Diane M. 1985. Soil solar heating for reductions in populations of P ty hium, Fusarium, nematodes, and weeds at the U.S. Forest Service Bessey Tree Nursery, Halsey, Nebraska. USDA Forest Service Technical Report R2-34, 16 p. plus appendix. Rocky Mountain Region, Lakewood, Colo.

Hildebrand, Diane M. 1987. Soil solar heating for pest control at Colorado and Nebraska forest tree nurseries. p. 177-185. In Current topics in forest research: Emphasis on contributions by women scientists: Proceedings of the symposium. [Gainesville, Flor, Nov. 4-6, 1986] USDA Forest Service General Technical Report SE-46, 197 p. Southeastern Forest Experiment Station, Asheville, N. Carol.

Hopkins Company. [not dated]. Basamid® Granular specimen label. Hopkins Agricultural Chemical Company, Box 7532, Madison, Wisc. 53707.

Landis, Thomas D. 1986. Letter to all Forest Service nursery pathologists describing the standard soil bioassay for the joint National Forest System--Research Reforestation Im provement Program. [March 17, 1986] USDA Forest Service File Designation 3220-1 Cooperative Forestry, Nurseries, 5 p. Rocky Mountain Region, Lakewood, Colo.

Nash, S. M., and W. C. Snyder. 1962. Quantitative estimations by plate counts of propagules of the bean root rot, Fusarium sp., in field soils. Phytopathology 52: 567-572.

Neumann, U., H. Will, and H. Groener. 1984. Soil fumigation with Basamid Granular, including new experimental results. Acts, Horticulture 152: 171-179.

Ruehle, John L. 1986. Letter to Julius Feldmesser regarding the forest nurseries aspect for the USDA Soil Fumigant Assessment Panel-Forestry [January 2, 1986]. USDA Forest Service File Designation 4050, Research Programs, 10 p. Southeastern Area, Athens, Georgia.

Sokal, R. R., and F. J. Rohlf. 1981. Biometry; the principles and practice of statistics in biological research. Second edition. 859 p. W. H. Freeman and Co., San Francisco, Calif.

Vaartaja, 0. 1967. Reinfestation of sterilized nursery seedbeds by fungi. Canadian Journal of Microbiology 13: 771-776.