STAND, GROWTH, AND NITROGEN CONTENT OF RED PINE SEEDLINGS FOLLOWING CHEMICAL TREATMENT OF THE SOIL TO CONTROL DISEASE [1]

Jack R. Sutherland and R. E. Adams [2]

Summary

D-D mixture, methyl bromide, Nemagon, and Vapam were used to control nematodes and fungi--the possible causes of pre- and post-emergence losses of red pine in a West Virginia nursery. Their effects on growth and nitrogen content of the seedlings also were determined. Methyl bromide was the most effective material for improving seedling stands . the first year, Vapam was partially effective, and the other materials were ineffective. After the first year, none of the treatments resulted in a significantly greater seedling top growth than what occurred in the control. Only seedlings from the methyl bromide treatment showed a significantly greater root length.

At the beginning of the third growing season, seedlings in the methyl bromide and control plots had the best top growth. There were no significant differences in the nitrogen content of the seedling tops from any of the treatments the first year. Only the roots from the methyl bromide treatment had a significant increase in nitrogen content. At the beginning of the third growing season, the tops of seedlings from the methyl bromide plots contained less nitrogen than did seedlings from the other plots.

Introduction

Much land in West Virginia needs to be reforested. At present the planting of high-quality, disease-free, nursery-grown seedlings is the best method for accomplishing this. Thus, the production of coniferous nursery stock free of plant parasitic nematodes and diseases is important to the forestry-based economy of the State. Studies have been undertaken to find both the cause of losses and methods of improving quantity and quality of seedlings produced at the State nursery at Parsons. Nematodes and fungi are blamed frequently for serious losses of forest nursery stock. The quantitative response of the different seedling species to soil treatment is largely unknown.

Nematicidal, and nematicidal and fungicidal chemicals were applied to seedbed soil that was later planted to red pine. The experiment, reported in another paper (4), was designed primarily to determine the response of nematodes to these chemicals. The response of the seedlings--emergence, growth, and production on treated areas, and nitrogen content-are reported here.

Materials and Methods

Two permanent counting sites were established on each plot after the seeds were distributed on the seedbed and before they were covered. Counts were taken of all the seeds within a rectangular, steel counting frame 4 ft. long and 3 in. wide. The counting sites were located about 7 ft. from the ends of each plot to eliminate border effects.

[1] Published with approval of the Director of the West Virginia Agricultural Experiment Station as Scientific Paper 817.

[2] Formerly Graduate Research Assistant, and Associate Professor, respectively, Department of Plant Pathology. Bacteriology and Entomology, West Virginia University, Morgantown. Mr. Sutherland is presently with the Forest Research Laboratory, P.O. Box 35, Quebec, Quebec.

Seeding and counting were done early in the morning to avoid sun damage to the seeds. The seeds were then covered and the plots cared for as previously described (4). Seedling emergence and post-emergence losses were determined by placing the counting frame on the counting sites and recording the number of living seedlings.

At the end of the first growing season, November 2, 1962, 20 seedlings were removed at random from each plot and the shoot and root growth measured. K jeldahl-nitrogen (organic plus ammonium-nitrogen) determinations were made on the shoot and root tissues of these seedlings. The samples were dried overnight at 55° C. and ground in a Wiley mill equipped with a 40-mesh screen. The samples were kept in sealed jars until analyzed. A conventional micro-K jeldahl method employing a copper sulfate-seleniumsodium sulfate catalyst was used. The analytical results were calculated as mg. of nitrogen/ 150 mg. dry pine tissue.

Seedling top growth was determined also at the beginning of the third growing season, April 25, 1964, but root growth was not determined because the extensive root systems prevented satisfactory sampling.

The data on the nitrogen content and seedling growth taken at the end of the first growing season were subjected to analyses of covariance. However, the data obtained at the beginning of the third growing season and that on the pre- and post-emergence seedling losses were not analyzed. Duncan's new multiple-range test (3) was used to compare adjusted means for the data analyzed by covariance.

Results

One year after seeding there were nearly twice as many seedlings in the methyl bromide plots as in the controls (table 1). Vapam was the next best material for controlling pre- and post-emergence losses, whereas the

TABLE 1.--Seeding and seedling densities at various days

Treatments	Seeds	Seedlings	Seedlings	Seedlings	Seedlings	Seedlings
	No. per sq. ft.	No. per sq. ft.	No. per sq. ft.	No. per sq. ft.	No. per sq. ft.	No. per sq. ft.
Methyl bromide:						
Mean[1]	147.7	104.2	111.8	106.6	107.4	50.6
Percentage[1]	100.0	70.6	75.7	72.2	72.7	34.3
Vapam:						
Mean	149.7	92.2	94.4	77.3	80.5	40.1
Percentage	100.0	61.6	63.1	51.6	53.8	26.8
Nemagon:						
Mean	136.5	68.8	63.5	54.0	53.9	28.1
Percentage	100.0	50.4	46.5	39.6	39.5	20.6
D-D mixture:						
Mean	146.7	81.3	75.6	66.0	62.9	32.9
Percentage	100.0	55.4	51.5	45.0	42.9	22.4
Control:						
Mean	136.8	71.8	71.7	62.4	63.0	26.6
Percentage	100.0	52.5	52.4	45.6	46.1	19.4
Date	5/29/62	6/18/62	6/26/62	8/15/62	11/2/62	5/27/63

[1] Based on 10 counting sites (each 4 ft. x 3 in. = 1 ft.^{2}) for each treatment, numbers approximated to one place.

other materials were only slightly effective. Although some of the treatments were only partially effective for reducing losses in the seedbed, the overwintering ability of the seedlings in the treated plots appeared to be slightly better than, in the control plots (table 1).

After one growing season, no significant differences in top growth resulted from any of the treatments (table 2). Only methyl bromide gave a significantly greater root length. At the beginning of the third growing season, the top growth in the control and methyl bromide plots was better than that in the other three.

The nitrogen content studies were undertaken because the needle tips of the seedlings in the methyl bromide plots showed a yellowing after the first growing season following two or three autumn frosts. The discoloration disappeared the next summer, and was not evident when the nitrogen content of the seedlings was determined again at the beginning of the third growing season. The nitrogen content of the seedling tops at the end of the first year was greatest in seedlings from the methyl bromide plots. The nitrogen content was lower progressively in the seedlings from the Nemagon, Vapam, control, and D-D mixture treatments (table 2). These differences were not statistically significant.

Analyses of the seedling roots revealed a nitrogen content lower than that in the tops. Seedlings from the methyl bromide plots had the highest root nitrogen content, followed by those from the Nemagon, Vapam, D-D mixture, and control plots. An analysis of these results showed that roots from the methyl bromide treatment had a nitrogen content significantly higher than did those of the other treatments (table 2).

The nitrogen determinations made on the seedling tops at the beginning of the third growing season showed no significant differences between the control and any of the other materials except methyl bromide. At

TABLE 2.--Growth and Kjeldahl-nitrogen content of red pine seedlings[1]

Treatment	Growth		Nitrogen content	
	Shoot	Root	Shoot	Root
	November 2, 1962			
	Cm.	*Cm.*	*Mg.*	*Mg.*
Methyl bromide..	5.217	[4] 16.012	3.885	[4] 2.680
Vapam.....	4.691	14.420	3.719	2.342
Nemagon.....	4.587	15.085	3.922	2.407
D-D mixture.....	4.839	15.453	3.430	2.284
Control.....	5.004	14.511	3.711	2.242
	April 25, 1964[5]			
Methyl bromide..	7.348	--	2.380	--
Vapam.....	5.860	--	2.951	--
Nemagon.....	6.431	--	2.881	--
D-D mixture.....	6.387	--	2.954	--
Control.....	7.092	--	2.960	--

[1] Mean values.
[2] Per 150 mg. pine tissue.
[3] End of first growing season.
[4] Significantly different at 0.05 level.
[5] Beginning of third growing season. These data were not tested statistically.

this final sampling, seedlings from the methyl bromide plots contained less nitrogen than seedlings from any of the other plots. These data were not tested statistically, but the difference appears to be real.

Discussion

This study has shown that the most beneficial effect resulting from the control of nematodes and pathogenic fungi (4) in a red pine nursery seedbed is the reduction of seedling losses (table 1). Methyl bromide, a fumigant that exhibits no specificity against pathogenic or beneficial organisms, was found to be the most efficient material in this respect. The lack of a significant increase in the top growth of the seedlings in the methyl bromide plots the first year may have been because of the high number of seedlings in these plots (table 1). This would have created greater competition for nutrients and space among the seedlings.

The yellowing of the foilage of the seedlings in the methyl bromide plots may have been related to the higher nitrogen content of the roots (table 2). These results could be misleading because nutrients in the foliage of coniferous trees may be translocated in the autumn (2). An increase in the ammonium ion content of the soil, or greater susceptibility to frost damage, may have caused the yellowing of the foliage in the methyl bromide plots. Methyl bromide has been shown to kill nitrifying bacteria (6). The low nitrogen content of the seedlings taken from the methyl bromide plots at the beginning of the third growing season points to competition for nutrients among seedlings. Switzer and Nelson (5) have shown that the total nutrient content of loblolly pine decreases as seedling stand increases. Our results also agree with those of Hansbrough and Hollis (1), who found a lower nitrogen content in loblolly pines grown in fumigated soils.

Literature Cited

1. Hansbrough, T., and Hollis, J. P.
   1959. The influence of soil fumigation, fertilization and other cultural factors on nutrient content of pine nursery seedlings and soil. (Abs.) Phytopathology49: 450.
2. Kramer, P. J., and Kozlowski, T. T.
   1960. Physiology of trees. 462 pp. New York: McGraw-Hill Book Co. Inc.
3. Steel, R. C. D., and Torrie, J. H.
   1960. Principles and procedures of statistics. 481 pp. New York: McGrawHill Book Co. Inc.
4. Sutherland, J. R., and Adams, R. E.
   1965. The population dynamics of nematodes, associated with red pine following chemical treatment of the soil. Nematologica. [Submitted for publication.]
5. Switzer, G. L., and Nelson, L. E.
   1963. Effects of nursery fertility and density on seedling characteristics, yield and field performance of loblolly pine (Pinus taeda L.). Soil Sci. Soc. Amer. Proc. 27: 461-464.
6. Wensley, R. N.
   1953. Microbiological studies of the action of some selected soil fumigants. Canad. Jour. Bot. 31: 277-308.