SOIL FUMIGATION EVALUATIONS IN WHITE PINE SEEDBEDS AND OTHER NURSERY INVESTIGATIONS

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General

In 1956 extensive evaluations of various fumigants and fungicides was completed at the east nursery at New Kent [1] and at the Charlottesville nursery. A complete report of the results of these trials is available in mimeographed form, entitled "Forest Tree Nursery Investigation--1956-57", March 26, 1958. These evaluations were part of an overall investigation into the causes of annual midsummer mortality of 1-year white pine seedlings at New Kent. A particularly favorable growing season in 1956 which resulted in only minor differences between treatments, and the failure of any of the materials tested to reduce midsummer mortality, resulted in a tentative conclusion that none of the fumigants or fungicidal drenches evaluated at New Kent was "financially" feasible. Nonetheless, all seedbeds planted to white pine in 1957 were drenched with Vapam (60 gal. per acre). Again we experienced the usual loss of from 20 to 30 percent of the germinated seedlings in late June and early July.

By this time it became increasingly apparent that either the fumigants used were ineffective or a physiological condition was responsible. Small scale shading plots and various mulching materials (including pine needles, chopped straw, and sawdust) were compared in 1958; there was no apparent reduction in the midsummer mortality by use of any of these cultural methods. Shading, unless it is extended over large areas, could well be ineffective in reducing heat damage because of free movement of hot air beneath the shades.

Fumigant Evaluations

In 1959, all nursery production was moved to a newly created "west" nursery at New Kent which had been carved out of a mixed pine-hardwood area in 1956. Limited planting of loblolly, shortleaf, Virginia, and white pine seed had been made in this new area in 1957 and all stock--white pine in particular--was stunted and generally inferior.

In order to investigate the desirability of fumigation of white pine seedbeds in this new nursery area, an evaluation of methyl bromide (as a gas) and Vapam (as a soildrench) was planned for spring 1959. Last minute arrangements with Bob Harrison and Dow Chemical's demonstration unit allowed us to include a series of test beds with three Dow products in several concentrations. A series of comparative evaluations of methyl bromide, formaldehyde, and Vapam were made concurrently at the Charlottesville Nursery.

Brozone (containing 68 percent liquid methyl bromide, 2 percent chloropicrin, 30 percent oil as a carrier), Dowfume MC-2 (as a gas through a tractor-mounted vaporizer) and Trizone (one of the newer Dow liquid fumigants) were all applied mechanically by the Dow crew on April 8 and the beds covered with polyethylene sheeting in one operation by an ingenuous tractor rig. The Vapam was applied April 17 at New Kent (along with two beds treated by hand with methyl bromide gas) as a drench in water; a total of 25 gallons of liquid was applied to 400 square feet of seedbed surface. The same drenching method and rate of application were followed at the Charlottesville nursery in the comparative series established on April 10.

Plastic covers (2 or 2.5 mil) were utilized with all fumigants except the Vapam and formaldehyde drenches. These covers remained on the seedbeds at New Kent for 48 hours;

[1] 20 miles southeast of Richmond. Va.

at Charlottesville--where the methyl bromide was vaporized--they remained on the beds only 12 hours. Seed stratified for 3 weeks was planted 10 days following all treatments at both nurseries.

Soil temperature at the time of machine application of the Dow products on April 8 at New Kent was approximately 65° F. Soil temperature at Charlottesville on April 10, when all fumigants were applied, was 63 F.

Soil moisture at New Kent was ideal; i.e., beds workable but still quite moist. At Charlottesville, the beds were somewhat drier in the surface two inches than was considered ideal for fumigation. The results indicate, however, this fact probably did not reduce effectiveness of the methyl bromide fumigation.

The strong differences in soil types involved in the fumigant trials are worth mentioning:

The west or Holly Landing section of the nursery where trials were carried out at New Kent is a very sandy soil. The older section, where fumigation was evaluated in 1956-57, is a "medium loam" (State Chemist's evaluation). The soil at the Charlottesville nursery is classified as a Cecil loam (VPI, 1953).

TABLE 1.--Surviving 1-year white pine seedlings in fumigated and unfumigated beds, west section, New Kent nursery, 1959

Treatment and rate of application	Location		Living seedlings per square foot[1]		
	Bed	Section	6/4/59	7/23/59	9/16/59
			Number	*Number*	*Number*
Dow Brozone (by injection):					
1/2 lb./100 sq. ft.	1	V	23.1	15.0	15.1
1 lb./100 sq. ft.	2	V	[2] 8.1	[2] 3.8	--
Dowfume (methyl bromide as gas by machine):					
1 lb./100 sq. ft.	3	V	14.5	13.1	10.4
1/2 lb./100 sq. ft.	4	V	30.8	16.4	16.0
Dow Trizone (liquid by injection):					
65 gal. active/acre	5	V	35.6	22.6	21.3
50 gal. active/acre	6	V	32.4	25.0	21.8
Dow Trizone (liquid by machine), 35 gal. active/acre	7	V	40.0	30.0	22.1
Dowfume (methyl bromide as gas by hand vaporizor), 1/2 lb./100 sq. ft.	7	U	15.3	11.3	[3] 8.1
Vapam 4-S (as drench):					
60 gal. active/acre	8	V	35.6	25.1	17.2
60 gal. active/acre	5	U	27.6	13.8	12.4
Check (untreated)	9	V	12.9	6.2	--
Check (untreated)	9	U	--	7.8	6.7

[1] An average of (12) 4 ft.[2] samples each treatment.

[2] The poor showing of Brozone in this treatment probably due to failure of material to dissipate completely prior to planting plus an unusually heavy mulch of sawdust following seeding.

[3] Replication of this treatment in Bed 8, Sec. U averaged 9.8 seedlings/sq. ft. this date.

The evaluation of the effectiveness of the various fumigants was made through periodic counts of surviving seedlings in treated and untreated beds throughout the summer of 1959. These counts for New Kent are shown in table 1. Similar counts in white pine seedbeds at the Charlottesville nursery are given in table 2.

One factor complicated the task of evaluation at Charlottesville. All pine seed was treated prior to planting with Dow Latex 512-R Sticker (1-9 diluation) and Arasan-75 for bird repellency. This treatment with a seed protectant strikingly reduced losses due to pre- and post-emergence damping-off fungi which had always been an annual problem with white pine at Charlottesville. Since all seed was treated, we can only assume that the unexpectedly good germination and survival of white pine in the "check" beds in table 2 were due to the seed treatment.

The white pine seedbeds involved in the evaluations at New Kent were confined to two "sections" (a section comprises nine 400 x 4 ft. beds) located on level land, while those at Charlottesville included four on comparatively level ground with the remainder running parallel to the contours on a 4-5 percent slope. Table 2 gives the average of all the sampling counts taken in four 100-ft. beds of each treatment on all positions of the slope. Differences between the fumigated and the check beds became more apparent on the lower slope beds where the soil is more eroded and compact.

The survival of white pine on the upper beds at Charlottesville is comparable regardless of treatment. As mentioned earlier, this fact is probably due to the preplanting treatment of seeds with thiram for bird repellency. The striking difference was apparent in the size and color of the seedlings in the treated beds. Seedlings in the Dowfume (methyl bromide as gas) and formaldehyde treated beds were comparable in appearance throughout the summer, were almost twice as tall as those from Vapam treated or check beds, were much more vigorous appearing, and maintained a dark green color. The differences in color were much less apparent by October of the first growing season. The size differential was still quite evident, however.

Differences in survival in treated and untreated beds at the New Kent nursery were much more striking. Here we lost 40-50 percent of the germinated seedlings regardless

TABLE 2.--Surviving 1-year white pine seedlings in fumigated and untreated beds, Charlottesville nursery, 1959

Treatment and rate of application	Location[1] (bed #)	Surviving seedlings per sq. ft.[2]	
		6/25/59	10/25/59
Methyl bromide[3], 3/4 lb./100 sq. ft.[2]	1, 5, 9, 13	33, 29, 28, 41 (33)	31, 21, 27, 44 (31)
Vapam 4-S, 60 gal./acre (in 25 gal. water per bed).....	2, 6, 10, 14	31, 28, 30, 38 (32)	25, 27, 25, 34 (28)
Formaldehyde, 37 percent, 340 gal./acre (in 25 gal. water per bed).....	3, 7, 11, 15	28, 24, 28, 36 (29)	23, 25, 29, 32 (27)
Check (untreated).....	4, 8, 12, 16	30, 16, 30, 24 (25)	30, 15, 29, 22 (24)

[1] 100' long beds numbered consecutively from top of slope to bottom.
[2] Average of the (24) 4-ft.[2] samples in the 4 treated beds in parenthesis.
[3] Applied by hand and vaporized by dropping cans into hot water after puncturing.

of treatment. This same condition was experienced in the 1956 and 1957 trials. Dow Trizone, even at the lowest rate (35 gal. active/acre), was consistently superior to all other treatments. Vapam, as was the case at Charlottesville, produced a good starting crop but these seedlings were chlorotic and stunted in comparison with those in the Trizone treated beds.

Other Concurrent Investigations

High soil surface temperature was suspected since 1957 as being the major cause of 1-year white pine seedling mortality at New Kent. Tempril temperature pellets which melted at 125° F., 138°, and 150° were placed in the seedbeds on July 15, 1958. Periodic readings indicated that although 125° was probably reached in several cases during the summer, the pellets were placed too late in the season to catch the critical period in late June.

In 1959, pellets were placed in six areas under various mulching conditions on June 15. An examination on July 2 showed the above ground portion of 138° pellets had disintegrated in one area in the east nursery and one area in the west nursery. In both cases these pellets were in the sawdust mulch which covered portions of the beds. Surface temperatures of exposed soil in adjacent beds reached 1250 F. but did not get as high as 138°. A second series placed at New Kent on August 1, showed late season temperature failed to reach 1250.

Extensive heat damage to loblolly pine seedlings was experienced during 1959 in a number of the southern nurseries. Dr. Charles Hodges, of the Southeastern Forest Experiment Station, visited the New Kent nursery on September 4 and concurred that heat damage was probably the main cause of mortality. Such fungi as Sclerotium bataticola and Fusarium sp., which have been isolated several times from dying roots of 1-year white pine at New Kent in the past several years, no doubt contribute to the decline following weakening by heat.

Delayed Germination and Survival on Treated Beds

Because of the short period of stratification this year, seedlings continued to germinate throughout the summer season following periods of wet weather. On July 28, approximately 100 newly germinated white pine seedlings were staked in fumigated and unfumigated beds to check subsequent survival. It was interesting to note that only a very occasional seedling germinated in the Trizone treated beds, the material having apparently stimulated almost complete initial germination. The following counts were made on August 14. Percent of seedlings still living is also given.

Treatment	Location		Living		Dead
	Bed	*Sec.*	*No.*	*Percent*	*No.*
Check.....	9	U	11	44	14
Check.....	9	V	18	47	20
Dowfume (½ lb., by hand)	7	U	10	43	13
Vapam.....	8	U	3	13	19

There was little apparent difference between the survival of late -germinating seedlings in seedbeds treated with the several fumigants checked.

Relationship Between Soil Fungi and Vigor

In February 1959 a series of soil samples were taken at New Kent (east nursery) in an attempt to correlate soil fungi with seedling vigor. The only relationship apparent from soil dilution plates was the predominant population of Tricoderma spp. in soil

supporting vigorous seedlings in beds drenched with allyl alcohol in spring 1958 and the great variety and large number of fungi isolated from untreated soil supporting seedlings of poor color and vigor. Conversely, other soil samples from spots in untreated beds supporting excellent seedlings yielded only a small number of fungus colonies.

Nematodes

A nematode survey in white pine seedbeds in the east nursery at New Kent was made in 1956. No parasitic nematodes were found at that time. Soil samples from two unfumigated areas in the west nursery were taken in August 1959 and analyzed by W. H. Matheny, Assistant State Entomologist, and he reports that from a 5-tablespoon soil sample from 1-year white pine beds (planted for first time this year) he found 50 saprophytes and one Aphelenchoides. "The latter is not considered of any consequence as far as tree seedlings are concerned." In a similar sample of soil from 1-year loblolly pine beds (planted for the first time this year) he found six saprophytic nematodes and two Neotylenchus. This latter nematode is suspected of feeding on fungi and algae in the soil. Matheny states further that: "The lack of saprophytic nematodes usually found in abundance as a natural part of the fauna indicates that some unhealthy condition must prevail."

Soil Analyses and pH

Annual soil tests are made at our nurseries by the State chemist. When a pH of 4.5 was noted in the west nursery in 1958, ground limestone was applied in spring of 1959 prior to planting. A series of twenty pH tests with a small colorometric kit on August 14, 1959, indicated the average pH at that time was 6.2. Additional potassium was also added in 1958 and 1959, when this element was found deficient.

Weed Control

Limited test with Neburon during the past several years has indicated its possible use in post-emergence weed control in the forest tree nursery. On July 2, a water suspension of Karmex-N (50 percent Neburon) was applied to two sections of 1-year loblolly pine at the rate of 4 pounds active per acre. A Hardie boom-type pressure sprayer was used to apply 100 gallons per acre at 80 p.s.i. Subsequent observations indicated this rate caused the death of only an occasional smaller-than-normal seedling in the treated beds. Since normal weed emergence suffered a sharp decline by July, no attempt to evaluate the degree of weed control was made.

Summary

Dow Trizone proved to be the outstanding soil fumigant evaluated at the west section of the New Kent nursery in 1959. The importance of fumigation in "new" soil was pointed up by the survival figures.

Heat injury is presumed to be the main cause of annual white pine seedling loss in late June-early July at the New Kent nursery. Soil surface temperatures were found to have reached 138^0 F. at least once between June 15 and July 2.

Methyl bromide released under plastic seedbed covers at the rate of 3/4 lb./ 100 sq. ft. by immersing the pressurized cans in a hot water bath produced excellent seedling stands of white pine at the Charlottesville nursery. Formaldehyde as a soil drench was about equally effective, but the high cost of this latter material must be taken into consideration. Vapam in the test this year at Charlottesville was relatively ineffective. These fumigant evaluations point out the Importance of finding the most suitable material for the particular soil in question.