THE EFFECTS OF SOIL STERILANT CHEMICALS ON THE GERMINATION AND DEVELOPMENT OF CONIFER SEEDLINGS AND WEED CONTROL

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Numerous chemicals that can be used as soil fumigants[1] have been placed on the market during the last few years. These chemicals when applied from a few days to a month before sowing kill most of the weed seeds, insects, fungi, and nematodes in the soil, yet lose their toxicity in a short time. Information was needed on their use and effectiveness as fumigants, as well as their effect on the germination and development of conifer seed. To obtain this information several small study plots were established, the first of these in the spring of 1957.

In the 1957 studies the chemicals were applied as recommended by the manufacturer. Vegadex and Bedrench were mixed with water, and the solution was sprinkled on the soil; irrigation followed. Mylone was spread on the soil and then immediately rotary tilled to a depth of 6 inches. Dowfume MC-2 was injected under polyethylene film tarps. Half of each Bedrench, Vegadex, and Mylone plot was covered with polyethylene film following treatment. The film was left on all plots for 2 days, then removed.

Soil in the nursery varies from a rubicon to montcalm sand. The beds were all sown for densities of 40 to 50 seedlings per square foot, but occasionally germination was affected by weather conditions, such as heavy rains or winds. In 1959 and 1960, the seed germinated at a higher rate than tests indicated, and along with good germination conditions the result was a much greater density in the plots.

While red pine was used in all the treatments, the plots treated in 1957 were sown half to red pine and half to white.

Most of the weeds common to the nursery were controlled by the chemicals mentioned. Some of the more common were large crabgrass (Digitaria sanquinalis), small crabgrass (D. ischaemum), lambsquarters (Chenopodium album), rough pigweed (Amaranthus retroflexus), carpetweed (Mollugo verticillata), and purslane (Portulaca oleracea).

The clovers as a group appeared to be resistant to these chemicals, and often they were the only weed found in the plots.

From observations and counts made at this nursery [2], any treatment that reduced the weeds to six per square foot for the season was considered effective. All chemicals reduced the weeds to six or less per square foot.

Discussion

No attempt was made to analyze these experiments statistically nor to draw any conclusions as to the superiority of one chemical over another. Neither was a comparison of cost of treating the soil with each chemical attempted, but on an acre basis the costs were very close. While the price of some chemicals is less than that of others, their application costs more. Each' chemical is discussed individually, based on data collected and observations made during the study.

[1] Ahrens, John F. Chemical control of weeds in nursery planting. Conn. Agr. Expt. Sta. Bul. 638. March 1961.
2 Henry, Berch. Letters and notes on file at nursery.

Allyl alcohol

Allyl alcohol was used several years to control damping-off and weeds. It has consistently given fair control of damping-off and good control of weeds (table 1). No retarding of seedling development was noted in the treated beds (table 2).

Allyl alcohol is difficult to use, because it is very volatile and may cause burns and injury to the eyes. The volatility is reduced by mixing the material with water, but it is still dangerous to handle. Handlers must wear a gas mask and protective clothing, including boots and gloves. The fumes from this material will injure plants for several feet around the treated area.

Allyl alcohol is usually applied by means of a sprinkling cart. It is pumped directly into the sprinkling tank that is partly filled with water, and then sprinkled on the area to be treated. The area is immediately irrigated for 1 to 2 hours. Two weeks or more must elapse before sowing or planting. The soil should not be disturbed to a depth of over an inch, because the weed seed below this surface inch or so are not destroyed.

Bedrench

Bedrench is allyl alcohol with chemicals added to reduce the volatility. This solution requires the same handling precautions required for allyl alcohol. Used at the recommended amounts, it gave very good weed control (table 1). Growth was not retarded in any of the plots. In the 1958 study, the seedlings from the Bedrench plots were the longest but not the heaviest (table 2). Bedrench is applied in the same manner as allyl alcohol, and it rated a little lower than allyl alcohol in the control of weeds.

Dowfume MC-2

Dowfume MC-2 (methyl bromide plus 2 percent chloropicrin) was first tried out as a soil fumigant for the control of a root rot that occurred on white pine and white and black spruce. It proved to be the best chemical available for control of the root rot and also gave good weed control.

This chemical has been used as the standard soil fumigant treatment at Chittenden Nursery for several years.[3] It has reduced the root rot losses to almost nothing and is rated high in weed control (table 1). The seedlings in beds treated with Dowfume MC-2 have consistently had better growth and color than stock in untreated beds or in beds treated with most of the other chemicals. In one earlier test 2-0 seedlings were measured and weighed (table 2). These seedlings were larger and better balanced than seedlings from other treatments.

Seedlings from treated areas were also examined for development of mycorrhiza. Very little mycorrhiza was found on these seedlings at the end of the first year, but the seedlings from the control plots and other treatments showed good development of mycorrhiza. Examination of seedlings from the same plots when the seedlings were 2 years old showed the roots of these from the Dowfume MC-2 plots had well-developed mycorrhiza growth. This seems to indicate that the soil becomes reinoculated with mycorrhiza within a year after fumigation with Dowfume MC-2.

The usual rate of application is 1 pound per 100 square feet, but, in beds that are used for white pine, white spruce, and black spruce the rate is increased to 1.5 to 2 pounds per 100 sq. ft. to insure good control of the root rot and nematodes.

3 Clifford, E. D. A rapid method of fumigating nursery stock with methyl bromide. Tree Planters' Notes 37, Forest Service, U.S. Dept. of Agr., August 1959.

TABLE 1.--Average stand of red pine seedlings and total number of weeds per square foot at end of first season in plots treated with various soil fumigants

Chemical and treatment	1957		1958		1959		1960		1961	
	Trees	Weeds	Trees	Weeds	Trees	Weeds	Trees	Weeds	Trees	Weeds
Allyl alcohol:										
50 gal./A sprinkle, irrigate	--	--	35.3	2.25	70.5	1.5	--	--	--	--
Atrazine:										
1 oz./100 sq. ft. sprinkle, irrigate.	--	--	--	--	0.0	0.0	--	--	--	--
2 oz./100 sq. ft. sprinkle, irrigate.	--	--	--	--	0.0	0.0	--	--	--	--
Bedrench:										
1-1/2 gal./900 sq. ft. sprinkle, covered.	43.0	3.5	--	--	--	--	--	--	--	--
1-1/2 gal./900 sq. ft. sprinkle, irrigate not covered.	57.3	4.8	40.8	.34	--	--	106.0	6.0	--	--
2-1/2 gal./900 sq. ft. sprinkle, irrigate not covered.	--	--	--	--	--	--	106.0	4.0	--	--
Brozone:										
35 gal./A injected, covered	--	--	--	--	102.0	2.4	99.0	6.0	--	--
50 gal./A do. do.	--	--	--	--	107.0	1.7	76.0	4.0	--	--
75 gal./A do. do.	--	--	--	--	54.0	.5	95.0	4.0	--	--
Dowfume MC-2:										
1/4 lb./100 sq. ft. covered hot gas	--	--	45.0	2.25	--	--	--	--	--	--
1/2 lb./100 sq. ft. do. do. do.	--	--	34.0	1.25	--	--	--	--	--	--
3/4 lb./100 sq. ft. do. do. do.	--	--	51.75	5.25	--	--	--	--	--	--
1 lb./100 sq. ft. do. do. do.	42.0	.3	38.25	2.0	77.0	2.0	76.6	2.5	36.7	5.0
1.2 lb./100 sq. ft. do. do. do.										
1.5 lb./100 sq. ft. do. do. do.	42.0	.3	--	--	87.0	1.0	86.0	.5	--	--
Mylone W-85:										
150 lb./A covered) All plots	38.5	3.25	--	--	--	--	--	--	--	--
150 lb./A not covered) sprinkled,	33.0	17.0	--	--	--	--	--	--	--	--
300 lb./A covered) irrigated,	23.0	2.75	--	--	--	--	--	--	--	--
300 lb./A not covered) and rotary tilled.	34.0	6.7	--	--	--	--	--	--	--	--

TABLE 1.--(continued)

Chemical and treatment	1957		1958		1959		1960		1961	
	Trees	Weeds	Trees	Weeds	Trees	Weeds	Trees	Weeds	Trees	Weeds
Mylone										
Preplant 50-D:										
580 lb./A broadcast, irrigated....	--	--	32.8	.8	--	--	--	--	--	--
1 lb./100 sq. ft. broadcast, irrigated.	--	--	--	--	--	--	57.9	1.0	38.7	2.0
Simazine:										
1 oz./100 sq. ft. sprinkle, irrigate	16.0	0.0	--	--	--	--	--	--	--	--
2 oz./100 sq. ft. " "	0	.0	--	--	--	--	--	--	--	--
3 oz./100 sq. ft. " "	0	.0	--	--	--	--	--	--	--	--
Trizone:										
140 lbs./A.....	--	--	--	--	187	0.3	--	--	--	--
160 lbs./A-0.....	--	--	--	--	130	1.0	102	1	94	0.6
200 lbs./A.....	--	--	--	--	--	--	67	3	--	--
220 lbs./A.....	--	--	--	--	--	--	88	2	--	--
260 lbs./A.....	--	--	--	--	99	.6	--	--	--	--
Vapam:										
1 qt./100 sq. ft. sprinkle, covered	--	--	--	--	--	--	104.0	5.0	--	--
1 qt./100 sq. ft. sprinkle, water seal.	--	--	--	--	--	--	75.0	7.0	39.0	2.25
Vegadex:										
6 qts./A before sowing, sprinkle, cover.	2.0	1.25	--	--	--	--	--	--	--	--
6 qts./A before sowing, sprinkle, not covered.	27.5	3.0	--	--	--	--	--	--	--	--
6 qts./A after sowing	27.0	1.25	--	--	--	--	--	--	--	--
6 qts./A before sowing, irrigate ..	36.5	.75	--	--	--	--	--	--	--	--
Control.....	36.5	17.0	37.0	17.0	63.0	130.0	75.0	58.0	29.0	14.1

TABLE 2.--Effect of certain soil fumigants on size of 2-0 red pine seedlings

Chemical	Stem length	Root length	Stem caliper	Weights		Total
				Top	Roots	
	Inches	*Inches*	*32d of inch*	*Grams*	*Grams*	*Grams*
Allyl alcohol.....	2.5	6.6	2.5	0.8	0.2	1.0
Bedrench.....	2.9	6.6	2.5	1.1	.24	1.34
MC-2, 1 lb./100 sq. ft....	3.0	6.1	2.8	1.3	.28	1.58
MC-2, 3/4 lb./100 sq. ft..	3.1	6.7	2.8	1.68	.3	1.98
MC-2, 1/2 lb./100 sq. ft..	2.5	6.6	2.5	.76	.2	.96
MC-2, 1/4 lb./100 sq. ft..	2.3	6.9	2.6	.96	.26	1.22
Mylone.....	1.9	7.0	2.8	.84	.2	1.04
Vegadex.....	2.5	6.4	2.5	1.00	.24	1.24
Control.....	2.4	6.8	2.0	.64	.18	.82

Dowfume MC-2 must be covered with tarps, usually polyethylene film for a period of 24 to 48 hours. However, with the improved methods of injecting the gas and laying the tarp, the cost of this treatment has been greatly reduced. Two-mil polyethylene film can be picked up, rerolled, and reused several times. Every year, Dowfume MC-2 has rated high in control of weeds.

Mylone

Mylone was first used as a powder called Mylone W-85, to be spread on soil, then mixed with the soil to a depth of 5 to 6 inches. When applied in this manner, Mylone acted as a soil fumigant, and in the 1957 plots it was so applied. The weed control obtained was not as effective as from other treatments. Covering after treatment decreased the number of weeds but also reduced the number of seedlings. Later the manufacturer recommended that where it was to be used as a soil fumigant, it should be applied at a much higher rate and mixed with the soil. Where it was to be used primarily for weed control, it should be spread on the surface and then the soil irrigated (1 inch of water) for about 7 hours. When used in this manner, the soil must not be stirred over 1 inch in depth, as only the weed seed in the top inch has been killed.

In 1958 Mylone was manufactured in a new form mixed with bran and called Preplant 50-D. This material was easier to handle than the previous product, and was used in the rest of the studies only for weed control (table 1). Preplant 50-D gave very good weed control. The seedlings were slightly shorter than those from all the other treatments and the control. The height growth of the seedlings was retarded in comparison with those in the control plots, but the stem caliper and plant weight were better than the control (table 2). The seedlings have been consistently smaller than those in other treatments. The color also seemed to be somewhat lighter than in other plots, especially those on which Dowfume MC-2 was used.

Brozone

Brozone is methyl bromide and 1.4 percent chloropicrin in oil which makes it less volatile and easier to handle. It is injected into the soil at a depth of 6 to 8 inches. The soil must be covered with polyethylene film or similar material for 24 to 48 hours. Good weed control was obtained at all levels at which it was used; 50 gallons and 75 gallons per acre gave the best control.[4] However, at the higher dosages the red pine germination was reduced in 1959.

4 Howe, R. G., and Clifford, E. D. The effects of soil fumigants on disease and weed control in conifer seed and transplant beds. Down to Earth. Spring 1962.

Trizone

Trizone is a combination of methyl bromide, chloropicrin, and propargyl bromide. These chemicals separately are good soil fumigants and combined they should provide a well-balanced soil fumigant that would be highly effective against fungi, insects, nematodes, weed seeds, and other live plant material in the soil. This solution is injected into the soil, and the soil is covered with polyethylene tarps for 24 to 48 hours. A period of 15 days or more should elapse before transplanting in the treated soil or 5 days before sowing seed.[4,5] The soil should be stirred as soon as the polyethylene film is removed and perhaps once or twice more before sowing or transplanting, as the chloropicrin volatilizes very slowly from the soil.

Trizone has given very good control of damping-off, especially preemergence damping-off, and also very good weed control. No retarding of growth or injury has been noted on seedlings. However, some injury has occurred in transplant beds. These losses occurred at spots where the injector was stopped for some reason, and the soil at that point received a heavy dose, which requires a longer aeration period. The equipment should be checked at the start of each run to see that all injector tubes are discharging and the equipment should not be stopped until the end of the run.

Vapam or V.P.M.

Vapam or V.P.M. has been used only in a few studies. This chemical has been rather erratic in its weed control, giving good control in some plots and not so good in others. Where it was covered immediately after applying, very good control of the weeds was secured. Where only a water seal was used or a few minutes delayoccurredin covering, the control has been much lower (table 1). Seedlings from Vapam plots did not appear to be as well developed, and were definitely off color.

A few beds were treated in the fall of 1961 by injecting the material to a depth of about 6 inches. This will be compared with surface application covered and not covered.

Vegadex

Vegadex is not a soil fumigant but is used in these studies for weed control. This chemical was rather erratic in its control.[1] When the plots were covered, the control was good in presowing treatments. Applied after sowing, it gave good weed control. Germination of white pine and red pine was reduced in all plots over that in other treatments, and in two places over that obtained in the controls. Ahrens[1] reports that Vegadex works, best when incorporated in a dry soil and is more effective on grassy weeds than on broadleaf weeds.

The liquid form was used in these studies and was mixed with water and sprinkled on the soil.

Atrazine

Atrazine is primarily a weed-control chemical, but if applied in high dosages or repeated applications, it sterilizes the soil so nothing will grow until the Atrazine disintegrates. This may be from a few weeks to a year or more depending, on the amount of material applied.

Atrazine was used in the 1960 studies as a test of its toxicity. The germination of red pine was not affected by Atrazine, but the seedlings all died within a few days after

5 Dow Chemical Co. Trizone triple action soil fumigant. Agricultural Chemical Dept. Tech. Bul. 120, May 1961.

emergence (table 1). This chemical gave 100-percent weed control throughout the season and also very good weed control during the second year. A test should be made to see if it can be safely used on older stock.

Simazine

Simazine like Atrazine is primarily a weed-control chemical but when used in high dosages or repeated applications, it becomes a soil sterilant. This chemical has a longer residual life than Atrazine.

Good germination occurred in all the Simazine plots but, except for the plots treated with 1 ounce per 100 square feet, the seedlings soon died (table 1). The 1-oz. treatment showed an average of 16 seedlings per square foot at the end of the season, but these seedlings were dead by the next spring. The weeds were controlled 100 percent the first season, and very few weeds were found during the second season.

Simazine has been used for weed control in older seedlings and transplants, but if applied at 2 pounds or more active per acre injury to the seedlings is apt to occur. Applied at 1-pound active per acre, good weed control can be obtained for several weeks. This application can be repeated after several weeks without injury to the seedlings.

Counts were made on the 1958 studies during the second year. Some carryover effect was noted, but it was not consistent. Most check plots had a few more weeds. The difference in seedling development and color was distinguishable between the different chemical treatments and was confirmed by tree measurements and weights taken at the end of the season (table 2).

Conclusion

All the chemicals used in these studies gave good weed control. While the seedlings did not develop as well under some treatments as under others, all except Atrazine and Simazine produced better seedlings than the control plots. Those from Dowfume MC-2 and Trizone were always of better color and better developed.