ZINC RODENT REPELLENTS ALSO IMPROVE ROOT GROWTH OF DOUGLAS-FIR SEEDLINGS, BUT HIGHER LEVELS CAUSE MORTALITY[1]

HARRY W. ANDERSON, *Soils Forester,*
Washington State Department of Natural Resources,
Olympia, Wash.

The impact of wildlife damage on forest plantations in the Pacific Northwest has stimulated great interest and research in control methods. At present, applying a repellent spray in the nursery before lifting trees is one method of controlling deer and hare damage on newly planted seedlings. This protects the seedlings in the field during the first dormant season. The usual treatment is to spray the seedlings with a 10-percent TMTD [2] repellent utilizing Rhoplex AC-33 [3] as an adhesive.

Other materials produced by several chemical firms are being evaluated for repellent characteristics in controlled pen studies conducted by the Olympia Field Station of the Bureau of Sports Fisheries and Wildlife, U.S. Department of Interior. One such material, Z.I.P.[4] animal repellent, has proved as effective as TMTD. Z.I.P. ranked higher in 13 of 14 completed enclosure tests as a deer repellent and ranked better than TMTD in five of seven completed tests on hares (3). There was, however, no significant difference between Z.I.P. and TMTD in these tests.

1 Forest Land Management Division Research Report 1.
2 Active ingredient, tetramethylthiuram.
3 An acrylic resin manufactured by Rohm and Haas Co.
4 Zinc dithiocarbamate-amine complex manufactured by Morton Chemical Co.

Although Z.I.P. may be a more efficient repellent, both for hare and deer, than the presently used TMTD, it has not been used in Northwest nurseries because it is suspected, that repeated applications could cause soil buildup of zinc to toxic levels. Brown et al. (1, 2) have shown that zinc applied as $ZnSO_4$, may be residual for several years, and that one application of zinc fertilizer at 25 lb. Zn/acre was adequate for 6 or 7 successive crops of sweet corn grown in zinc deficient soils.

This study describes a greenhouse pot trial to determine the effects of various soil concentrations of Z.I.P. and $ZnSO_4$, zinc on the development of one-year-old Douglas-fir seedlings.

In pot culture tests. Gall and Barnette (6) found that 0.688 to 1.376 m.e. of zinc per 100 gm. of soil (approximately 450 to 900 lb. Zn/acre) were toxic to corn on a Norfolk sand; 0.758 to 1.137 m.e. (approx. 500-750 lb. Zn/acre) on an Orangeburg fine sandy loam; and between 1.615 and 2.153 m.e. (1,065-1,420 lb. Zn/acre) on a Greenville clay loam. Cowpeas were affected on a Norfolk sand at 0.275 to 0.482 m.e. (180-320 lb. Zn /acre) per 100 gm. soil.

Under normal operational spraying conditions in forest nurseries, a 10-percent Z.I.P. (active ingredient) formulation would deposit approximately 6 fib. of elemental zinc per acre, assuming that a maximum of 70 percent of the spray reached the ground (8).

Duffield and Eide (4) have shown that root growth of Douglas-fir was benefited from concentrations of 0.0312 percent (approximately 20 lb. Zn/acre) zinc dithiocarbamate-amine complex in the soil. Several applications of Z.I.P. did not appear to be detrimental to the growth of Douglas-fir. But the specific effects of various levels of zinc on the growth of Douglas-fir were not known.

Methods and Procedures

Soil was collected from the surface 6-inches at the L. T. "Mike" Webster Forest Nursery, near Olympia, Wash., and it was air-dried, and screened through a 4-mm. sieve. From this soil, 1,000-gram samples were weighed, and zinc was added as either Z.I.P. or $ZnSO_4$, (table 1). Z.I.P. rates were replicated four times and $ZnSO_4$ rates three times.

The Z.I.P. or ZnSO, treatments were first added to 100 cc. of Arnon's nutrient solution (7), and the mixture was rolled into the soil to insure an even distribution. A glass plate was placed in the bottom of each 6-inch pot, and the soil added. After all treatments were made, four 1-0 Douglas-fir seedlings (approximately 6 weeks old) were planted per pot. The pots were then randomly arranged on the greenhouse bench.

TABLE 1.—*Rates of Z.I.P. and $ZnSO_4$ applied to Webster Forest Nursery soil in a greenhouse pot trial* [1]

Zinc	Z.I.P./Pot	$ZnSO_4$/Pot
lb./acre	*ml.*	*gm.*
0	0	0
2	0.16	—
4	0.32	[2]2.0
6	0.48	—
8	0.64	[2]4.0
10	0.80	—
20	1.6	[2]10.0
40	3.2	—
80	6.4	[3]0.2
100	8.0	—
200	16.0	[3]0.5
400	32.0	—
600	48.0	[3]1.5
800	64.0	—
1,000	80.0	[3]2.5

[1] Calculations based on the assumption that 70 percent of the spray reaches the ground (6).
[2] Zinc added as 1,000 p.p.m. Zn in talc-$ZnSO_4$ mixture.
[3] Zinc added as $ZnSO_4$.

Seedlings were planted on July 15 and harvested on Nov. 15, 1965. During this period the pots received frequent light watering from above. At harvest all live seedlings were removed from the pots, soil was washed from the roots, and top and root weights (ovendry weight) were recorded.

Results and Discussion

The results are summarized in table 2. Increasing the level of zinc in the soil caused an increase in seedling mortality. When zinc was applied as $ZnSO_4$ mortality occurred at concentrations above 200 lb. Zn/acre, and above 600 lb. Zn/acre, all seedlings were dead. When zinc was applied as Z.I.P., mortality occurred at 20 lb. Zn/acre, and at 800 and 1,000 lb. Zn/acre all trees were dead.

The mortality that occurred at lower concentrations when zinc was applied as Z.I.P. could be caused by the zinc being more readily available or to the adhesive (Rhoplex) utilized in the Z.I.P. formulation. The effects of the adhesive were obvious at the higher zinc levels where the soil particles were bound together to form a 1/4- to 1/2-inch crust on the soil surface.

Seedling growth showed a definite response to zinc (fig. 1). When zinc was applied as $ZnSO_4$

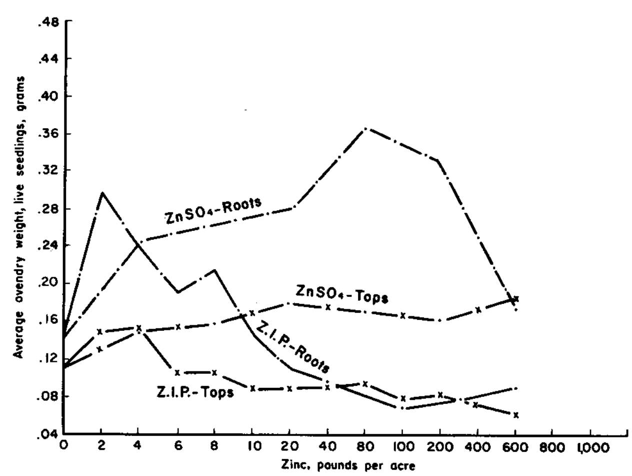

Figure 1.—Effects of zinc added to Webster Nursery soil as Z.I.P. and $ZnSO_4$, on the growth of 1-0 Douglas-fir, grown in a greenhouse pot trial.

Table 2.—*Effects of zinc as Z.I.P. or $ZnSO_4$ on the growth of 1–0 Douglas fir grown in a greenhouse pot trial with Webster Forest Nursery soil.*

	Z.I.P. (zinc dithiocarbamate-amine complex)						$ZnSO_4$ (Zinc sufate)					
Treatment	Trees alive	Top-root ratio	Ovendry Weight average live tree: Tops	Roots	Total	Increase or decrease compared to Controls (no zinc) (Whole tree)	Trees alive	Top-root ratio	Ovendry Weight average live tree: Tops	Roots	Total	Increase or decrease compared to Controls (no zinc) (Whole tree)
Lb.Zn./acre	*Number*					*Percent*	*Number*					*Percent*
0	16	0.68	0.071	0.104	0.175	0	[1]16	0.68	0.071	0.104	0.175	0
2	16	0.43	0.111	0.258	0.369	+110						
4	16	0.57	0.114	0.201	0.315	+80	12	0.54	0.112	0.208	0.320	+83
6	16	0.44	0.067	0.152	0.219	+25						
8	16	0.38	0.066	0.175	0.241	+38	12	0.53	0.120	0.226	0.346	+98
10	16	0.44	0.048	0.109	0.157	−10						
20	15	0.71	0.051	0.072	0.123	−30	12	0.58	0.139	0.240	0.379	+116
40	15	0.91	0.052	0.057	0.109	−38						
80	15	1.27	0.056	0.044	0.100	−43	12	0.40	0.133	0.330	0.463	+165
100	15	1.34	0.039	0.029	0.068	−61						
200	13	1.23	0.043	0.035	0.078	−55	12	0.42	0.123	0.293	0.416	+138
400	6	0.80	0.032	0.040	0.072	−59						
600	4	0.48	0.025	0.052	0.077	−56	7	1.09	0.148	0.136	0.284	+62
800	0	—	—	—	—	—						
1,000	0	—	—	—	—	—	0	—	—	—	—	—

[1] The controls for the $ZnSO_4$ treatments were the same as the Z.I.P. controls; so there were 4 replications (16 trees).

ovendry weight of seedling roots increased to a maximum at 80 lb. Zn/acre and then decreased. Top growth showed a general increase in dry weight with increasing zinc concentration, but the response was not as dramatic as the root response.

When zinc was applied to the soil as Z.I.P., 1-0 Douglas-fir roots responded to between 2 and 8 lb. Zn/acre; the maximum dry weight yield was obtained at 2 lb. Zn/acre. Top growth followed the same pattern as the roots for Z.I.P. applied zinc; however, the response was much less. At concentrations above 10 lb. Zn/acre applied as Z.I.P., the growth of 1-0 Douglas-fir was depressed.

The difference in the response of 1-0 Douglas-fir to Z.I.P. and $ZnSO_4$ applied zinc was probably caused by reduced soil aeration, available soil moisture, and nutrient uptake caused by the adhesive contained in the Z.I.P. formulation.

What would be the effects of repeated applications of Z.I.P. to Douglas-fir nursery stock? There is no question of the benefits of zinc since a definite response was obtained with $ZnSO_4$. The adhesive in the Z.I.P. formulation appears to be the cause of the poor growth when Z.I.P.-applied zinc is used.

Under normal spraying operations in the Webster Nursery, a particular area of 2-0 stock would be treated only with Z.I.P. rabbit repellent every 3 to 4 years depending on the rotation period. Between repellent applications, the Rhoplex in the Z.I.P. formulation should completely disappear from the soil leaving only the zinc dithiocarbamate-amine complex.

The two reasons for this conclusion are first, the adhesive (Rhoplex) in the standard repellent (TMTD) treatment has caused no problems after 8 years of nursery application; and second, the adhesive, by its very composition, is probably broken down rapidly by soil organisms.

But to determine more exactly the effects of the zinc complex alone on the growth of Douglas-fir, further greenhouse studies will be conducted. These trials will also investigate the effects of Rhoplex on soil binding and of incorporated treatments vs. surface applications.

Literature Cited

(1) Brown, A. L., Krantz, B. A., and Martin, P. E.
1962. Plant uptake and fate of soil applied zinc. Soil Sci. Soc. Am. Proc. 26: 167-170.

(2)
1964. The residual effect of zinc applied to soils. Soil Sci. Soc. Am. Proc. 28: 236-238.

(3) Dodge, W. E.
1963. Field testing and development of selected chemicals for preventing wildlife damage to forest crops in the Northwest. Unpub. Annu. Progr. Rpt. Wildlife Res. Work Unit, Denver Wildlife Res. Cent., 20 pp.

(4) Duffield, J. W. and Eide, R. P.
1962. Application of rabbit repellent to coniferous planting stock in the Pacific Northwest. J. Forest. 60: 109-111.

(5) Gall, 0. E.
1936. Zinc sulfate studies in the soil. Citrus Ind 17 (1) : 20-21.

(6) Gall, 0. E., and Barnette, R. M.
1940. Toxic limits of replaceable zinc to corn and cowpeas grown on three Florida soils. J. Amer. Soc. Agron. 32: 23-32.

(7) Hewitt, E. J.
1952. Sand and water culture methods used in the study of plant nutrition. Commonwealth Agr. Bur. Tech. Comm. 22, 241 pp.

(8) Radwan, M. A., and Dodge, W. E.
1965. Effective application rates of TMTD rabbit repellent to Douglas-fir seedlings in the nursery. Tree Planter's Notes No. 72: 7-9.