EFFECT OF THIRAM-ENDRIN FORMULATIONS ON THE GERMINATION OF JACK PINE AND WHITE SPRUCE SEED IN THE LABORATORY

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Pelleting of forest tree seed with thiram and endrin powders has been standard procedure since 1956 when the U.S. Fish and Wildlife Service recommended this treatment as a bird and rodent repellent (7). However, literature has been contradictory conderning the phytotoxicity of these substances. For example, Roy (5) reported that germination of Douglas-fit seed was not inhibited by a thiram-endrin coating, and Hodges and Scheer (4) found that repellents have no effect on germination of longleaf, slash, or sand pines. However, Harrington (3) noted a significant reduction of white pine germination following the application of thiram and endrin.

In 1963, Derr (2) recommended a treatment employing an aqueous suspension of thiram (Arasan-42S) and powdered endrin. This liquidpowder treatment is reputed to be safer to prepare ,and to afford a more durable coating than the previous powder-powder formulation. As part of the present study, a liquid-liquid treatment was developed as a possible further improvement on Derr's treatment. This treatment employed Arasan-42S and a commercially-available endrin product consisting of a 20 percent concentration of endrin dissolved in a solvent of heavy aromatic naptha (Endrin-20EC). This paper reports on the effect. of these formulations and their separate ingredients on the germination of jack pine *(Pinus banksiana* Lamb.) and white spruce *(Picea glauca* (Moench) Voss) seed in the laboratory.

Methods

Total apparent germination and average germination time (AGT) was assessed. AGT. a parameter suggested by Siinancik (6), is the mean time (in days) required for germination by those seeds which germinate. Seeds were counted as germinants when their radicles had protruded approximately one centimeter. Germination tests were conducted in a controlled environment germinator under a 16-hr. photoperiod. Day temperature was maintained at 30° C., night temperature at 20° C. and relative humidity exceeded 95 percent.

Twelve treatments (table 1) were applied to the seed. A latex sticker was employed in all treatments except the twelfth. In all treatments, except the fifth and twelfth, concentrations of either 2.0 percent thiram or 0.75 percent endrin, or both were applied to the seed. Each treatment was replicated four times, resulting in 48 plots for each species. Plots, consisting of 50 seeds each, were randomly located on germinator trays. The germination test was carried out over a 28day period; counts were made daily except on weekends. Results were statistically analyzed by Duncan's multiple range test; total germination data were first transformed to arc sin-/ percent.

Results and Discussion

Total termination of jack pine was significantly reduced ($p = .05$) and AGT was significantly increased by all treatments containing either endrin liquid or its solvent (table 1). No other treatment had a statistically significant effect on jack pine germination. Treatments containing endrin liquid affected germination more severely than those containing solvent alone. In all cases, AGT was more than doubled by the application of endrin liquid.

All treatments containing endrin liquid or its solvent prevented germination of white spruce seed, except for negligible germination in the solvent treatment. Germination was significantly reduced by all treatments containing thiram powder and by the treatment containing thiram liquid by itself. The AGT of untreated white spruce seed (approximately 12 days) was more than twice the AGT of untreated jack pine seed (less than 6 days).

In jack pine, the effect of a treatment in delay-

TABLE 1.—*Germination data for jack pine and white spruce seed treated with various thiram-endrin formulations and their separate ingredients*

Treatment	Jack Pine		White Spruce	
	Total germination	Average germination time	Total germination	Average germination time
	Percent	*Days*	*Percent*	*Days*
(1) thiram powder	88.0 a*	5.6 a	55.5 a	12.6 a
(2) thiram liquid	85.0 ab	5.4 a	55.5 a	11.5 a
(3) endrin powder	86.0 a	5.6 a	65.5 bc	11.4 a
(4) endrin liquid	42.0 e	12.4 d	0.0	—
(5) solvent	73.5 c	7.9 b	2.0	(14.3)
(6) thiram powder-endrin powder	85.0 a	5.8 a	59.0 ab	13.2 a
(7) thiram poweder-endrin liquid	54.0 d	12.7 d	0.0	—
(8) thiram powder-solvent	71.0 c	9.4 c	0.0	—
(9) thiram liquid-endrin powder	89.0 a	5.7 a	70.0	11.8 a
(10) thiram liquid-endrin liquid	69.5 c	12.0 d	0.0	—
(11) thiram liquid-solvent	76.0 bc	9.4 c	0.0	—
(12) control-no treatment	88.5 a	5.7 a	70.5 c	11.5 a

*Treatments sharing a letter-designation are not significantly (5 percent level) different from each other.

ing germination roughly corresponded to its effect in reducing total germination. In white spruce, however, there was more of a threshold phenomenon, i.e., unless a treatment had a devastating effect on total germination, it caused little delay in average germination time. Under field conditions, the consequences of delayed germination may be as serious as a reduction in total germination.

The application of liquid endrin to seeds led to marked delays and reductions of total germination in jack pine and to complete inhibition of white spruce germination. Comparison of these results with those from seeds treated with solvent in liquid endrin and with endrin powder suggests that phytotoxicity is due partly to the solvent per se and partly to its assistance in introducing the endrin molecule into the seed. Endrin powder did not significantly affect germination of either species.

Thiram, applied by itself as a powder or liquid, significantly reduced white spruce germination, although it had no apparent effect on jack pine germination. This agrees with Belcher and Carlson's (1) observation that the application of thiram seed coatings significantly reduced ($p = .05$) the germination of white spruce while having no significant effect on jack pine germination. Moreover, the standard repellent treatment, thiram powder and endrin powder, significantly reduced germination of white spruce and had no significant effect on jack pine seed.

Generally, the detrimental effect of liquid endrin or its solvent on jack pine germination was ameliorated by the addition of thiram, particularly liquid thiram. Penetration of the solvent may have been inhibited by the thiram.

In summary, the Derr formulation, using Arasan-42S and endrin powder, did not retard germination in the laboratory of either white spruce or jack pine seed. The standard powderpowder formulation had no adverse effect on jack pine, but it did reduce white spruce germination. In the applications used in this experiment, thiram proved phytotoxic to white spruce seed but not to jack pine seed. Endrin liquid retarded germination of jack pine seed and totally inhibited germination of white spruce seed.

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"Genetics of Black Walnut" by David T. Funk.
One of a series of publications on the genetics of important forest trees of North America. Available from the Timber Management Research Division, USDA Forest Service, Room 811-F, Rosslyn Plaza E, Arlington, Va. 22209.

"Selecting Seed Sources of Forest Trees for the Lake States-an Interim Guide" by James P. King and David H. Dawson.
Summarizes the best available seed source recommendations for the major species used in planting programs in the Lake States. Available from North Central Forest Experiment Station, USDA Forest Service, Folwell Avenue, St. Paul, Minn. 55101.

"Nursery Bed Density Affects Slash Pine Seedling Grade and Grade Indicates Field Performance" by Russell M. Bums and R. H. Brendemuehl-Forest Service Research Paper, SE 77, January 1971. Describes the effects of nursery bed densities on morphological seedling grade and the subsequent 5-year survival and growth. Available from Southeastern Forest Experiment Station, USDA Forest Service, Asheville, N.C. 28802.

"Fertilization of Young Longleaf Pine in a Cultivated Plantation" by Ralph H. Hughes, James E. Jack son, and Richard H. Hart. USDA Forest Service Research Paper SE-75, January 1971.
Describes a fertilization study conducted in a cultivated longleaf pine plantation in a flatwood site in south Georgia. Available from Southeastern Forest Experiment Station, USDA Forest Service, Asheville, N.C. 28802.

Erratum-In the article, "Natural Recovery of Surface Soils Disturbed in Logging," Vol. 22, No. 2, Page 5, the last sentence of the fourth paragraph "and earthworms tend to break down soil aggregation" should have read "and earthworms tend to speed up soil aggregation."