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Factors Affecting Endrin Content of Endrin-Coated[1] Douglas-Fir Seed

During the past 15 years, endrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-endo-5,8-dimethanonaphthalene) has been extensively used to protect direct-sown forest tree seeds from seed-eating rodents (Mann, 1968; Radwan, 1970). In the Pacific Northwest, although early field tests showed that adequate stocking with Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) was possible when endrin-coated seed was used (Dimock, 1957; Dick *et al.*, 1958; Roy, 1961), many operational seedings have failed. Preliminary bioassays and chemical analyses of treated seed in our laboratory indicated that some seeding failures could be due to insufficient endrin on the seed. We subsequently investigated effects of treatment, sowing by helicopter, and weathering in the field after seeding on the endrin content of treated Douglas-fir seed.

Materials and Methods

Endrin treatments. Six lots of endrin-treated seed were obtained from the 1968-69 inventories of four forest-management organizations in Oregon and Washington. All seeds were treated with Endrin 50-WP[2] (50 percent wettable powder) from Stauffer Chemical Company, using the adhesive Dow Latex 512-R (diluted 1 adhesive:9 water) from the Dow Chemical Company. Other pertinent information for each lot is shown in Table 1.

Sowing by helicopter. In February 1969, seeds from lots 5 and 6 were sown in the field by helicopter at approximately ¾ pound per acre. After sowing, seed samples of each lot were picked up from the ground and sent to the laboratory for analysis. Additional seed for analysis was obtained by simulated sowing of seed from lots 3 and 4. In each case, 1-pound samples were run through mechanical seeders of two different grounded helicopters with equipment set to deliver the same amounts of seed as those used to sow seed of lots 5 and 6. Samples of "sown" seed were collected on plastic sheets laid under the helicopters.

Weathering. In May 1969, seeds were collected for analysis from areas which were sown in February 1969 with seeds of lots 5 and 6. Only 500 seeds of each lot were collected since seed was difficult to find after exposure of about three months in the

[1] This article reports research involving pesticides. It does not contain recommendations for their use nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate state and/or federal agencies before they can be recommended.
[2] Mention of chemical products and chemical companies does not represent endorsement by the U.S. Department of Agriculture.

field. Attempts to collect "weathered" seeds from the area seeded with lot 3 were unsuccessful.

TABLE 1. Seed identification and endrin-treatment data as supplied by study participants.

Seed lot[a]	Organization	Active endrin	Chemical used for identification	Party treating the seed
		Percent by weight		
1	A	0.5	Aluminum powder	Organization A
2	B	.6	Monastral green	Commercial contractor No. 1
3	B	.6	Monastral green	Commercial contractor No. 1
4	C	1.0	Aluminum powder	Organization C
5	D	1.0	Aluminum powder	Commercial contractor No. 2
6	D	.5	Aluminum powder	Commercial contractor No. 2

[a] Seeds of lots 1 and 4 were wet with a slurry of endrin in the adhesive and then topped with the aluminum powder. Seeds of lots 2 and 3 were wet with a slurry of endrin and Monastral green (from the DuPont Co.) in the adhesive. Seeds of lots 5 and 6 were wet with a slurry of endrin and a small amount of aluminum powder in the adhesive and then topped with more aluminum powder; weight of endrin added was approximated by volume in a previously calibrated container.

Determination of endrin content. Samples of 200 seeds each were used for each analysis and determinations were made at least in duplicate. Endrin was extracted from the seed in Skellysolve B (n-hexane), and extracts were cleaned up of extracted fats, concentrated, and dried, essentially as outlined by Bann *et al.* (1958). Amounts of endrin in the extracts were determined by gas chromatography with an Aerograph Model 1840-1 instrument equipped with an electron capture detector and a 5 ft by ⅛ in I.D. glass column packed with 6 percent SE-30 on 80- to 100-mesh Varaport-30. Injector, column, and detector temperatures were 200°, 190°, and 200° C, respectively. Nitrogen was used as carrier gas at a flow rate of 40 ml per minute. Endrin was quantified by peak height, and data were appropriately corrected according to previously determined recovery efficiencies. Recovery percents were obtained from analyses of known quantities of endrin added to samples of untreated Douglas-fir seed, using Dow Latex 512-R as adhesive. To closely simulate actual treatments of the seed lots studied, aluminum powder and Monastral green were each added to one-half of the recovery samples in amounts comparable with those used by the different organizations.

Results

Efficiency of endrin recovery. Recovery of endrin added to the untreated seed samples did not vary with amount of endrin added or the coloring material used for identification. Thus, the average recovery of 85.0 percent, computed from data of 12 analyses, was used to correct all data shown in Figure 1.

Effect of treatment. Success of treatment, measured by endrin found on the seed as percent of endrin used as indicated by the participating organizations, differed

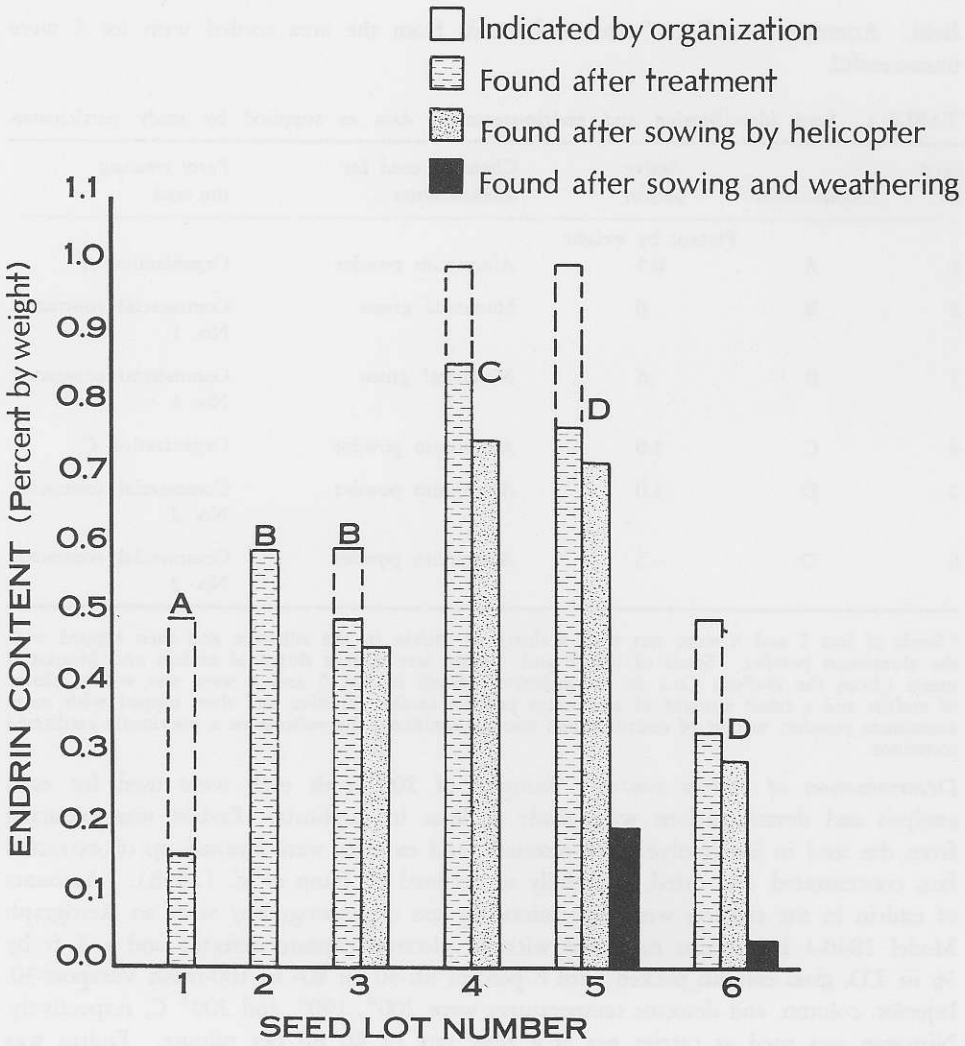

Figure 1. Endrin used in seed treatment as indicated by organization, and endrin found on treated seeds after treatment, sowing by helicopter, and after sowing and weathering. (Letters above bars identify participating organizations. Sowing was simulated in lots 3 and 4.)

among the treatments and was not consistent within seed lots of the same organization (Fig. 1). Thus, following treatment, endrin found on seeds of lots 1, 3, 4, 5, and 6 was less than the amounts indicated for the treatments. The difference varied among these lots; it was largest with lot 1, intermediate with lots 3, 5, and 6; and smallest with lot 4. Only seeds of lot 2 showed an endrin content equal to the theoretical value indicated.

Effect of sowing by helicopter. Aerial dissemination reduced the endrin content of the seed (Fig. 1). Reductions, however, were small, ranging from 4 to 17 percent of the original endrin, with little difference between actual and simulated seedings.

Effect of weathering. Losses of endrin caused by weathering were very large (Fig. 1).

After about three months of exposure in the field, seed of lots 5 and 6 lost 72 and 86 percent, respectively, of the endrin which was on the seeds after sowing. Thus, by May and still before full germination, only a very small fraction of the original endrin remained on this seed.

Discussion and Conclusions

Results show that endrin content of commercially treated Douglas-fir seed was affected by treatment, sowing by helicopter, and weathering. Following treatment, in all but one seed lot where probably more endrin than required was initially added, treated seed contained less endrin than the indicated amounts used. The endrin-coating method as originally proposed in 1956 (Anonymous, 1956) obviously does not allow application of all endrin to the seed. However, losses of endrin due to treatment in lots 1 and 6 appear excessive, and it is doubtful that seeds of these lots contained sufficient endrin for adequate protection from rodents (Radwan *et al.,* 1970).

Reductions of endrin content caused by aerial dissemination were small. These reductions, however, may be important when endrin content of the seed before sowing is already low. This was probably true in lots 3 and 6 where the combined effects of treatment and sowing reduced the endrin content of the seed to 0.46 and 0.29 percent, respectively.

Weathering caused the greatest endrin losses. It reduced the endrin on seeds of lots 5 and 6 tremendously and probably increased the vulnerability of the seeds to predation by rodents. Clearly, endrin was not adequately bound to the seeds by the adhesive used. Improvement of the endrin treatment by use of a higher concentration of the adhesive or another adhesive with better binding properties under the weathering conditions of the Pacific Northwest is, therefore, indicated. Alternatively, impregnation of seed with endrin would also minimize weathering losses.

The effects of treatment, sowing, and weathering on endrin content of Douglas-fir seed demonstrated here may partially explain observed reforestation failures with endrin-treated seed. Study results also show the importance of chemical analysis in evaluating endrin and indicate means for improving the treatment.

Concern over use of the "hard" pesticides dictates that endrin, a persistent chlorinated hydrocarbon, be eliminated as a seed protectant as soon as a more acceptable chemical becomes available. Fortunately, however, the chemical analysis approach used in this study can and should be employed together with the more common bioassay tests in evaluating candidate chemicals to replace endrin.

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