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Experimental Herbicidal Control of Dwarfmistletoe on some California Conifers

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ABSTRACT: Dwarfmistletoes (Arceuthobium spp.) parasitize and damage most native conifers of California. The study of chemical control for dwarfmistletoe on pines and true firs was resumed in 1959. Over the past 5 years, 246 tests on 2,516 trees of five species have been started. Many phenoxy herbicides and some other materials were applied as sprays in fuel oil and water carriers. An isooctyl ester of 2,4,5-trichlorophenoxy butyric acid is the most promising herbicide so far tested for direct spray treatment of dwarfmistletoe on pines.

This paper reports on the progress of exploratory experiments being conducted by the Pacific Southwest Station to develop safe, effective herbicides for controlling dwarfmistletoe (Arceuthobium spp.). Although certain results show some promise, no control program based on the results of these exploratory studies can be recommended at the present.

The only methods of controlling dwarfmistletoe currently available are silvicultural: sanitation and selection cuts, weedings, and prunings. Forest managers have long sought a safe, effective chemical method of controlling this parasite. Such a technique would provide flexibility in its silvicultural control and would offer alternatives to destructive levels of pruning in high-use areas.

Several studies made in the past to develop chemical control of dwarfmistletoes have achieved some control. But no chemical method has ever been successful enough to go into widespread use. In 1959 this Station began a study aimed at defining a safe, effective method for controlling dwarfmistletoe on sugar pine, ponderosa pine, Jeffrey pine, red fir, and white fir.

TESTS AND METHODS

Test areas. --Almost all tests in the present series have been established in one of three areas: (a) Chowchilla Mountain, east of Mariposa, on the Sierra National Forest; (b) vicinity of the Stanislaus Experimental Forest, near Pinecrest, on the Stanislaus National Forest; and (c) along Road 21, Blacks Mountain Experimental Forest on the Lassen National Forest. Since 1959, we have

conducted 246 tests on some 2,516 trees of the five conifer species listed above in these three areas. A test means a number of trees treated at one time and place with one concentration of one herbicide formulation.

Application method. --With few exceptions all materials were applied as coarse sprays from small pump-up garden sprayers equipped with a simple disc nozzle with a medium-sized aperture. Treated parts of trees were sprayed to the point of run and drip. When infected areas only were treated, a "safety zone" of apparently uninfected tissue 2 to 8 inches wide surrounding the diseased area was also sprayed. Treated trees varied greatly in size and vigor, and in amount of dwarfmistletoe infection. Most infected saplings and poles on test areas were treated unless seriously suppressed or excessively infected. Some severely infected trees were treated in 1959 through 1961, but none survived the disease and treatment.

Many herbicides were applied in 1959 and again in 1960 as basal-stem treatments to determine effects on unsprayed dwarfmistletoe beyond limits of direct treatment. In the basal-stem treatment, all sides of the bole of a tree were sprayed to the point of run and drip from ground level to a specified height.

RECORDS AND CODES

Insofar as type of treatment and location of infection permit, each treated tree is annually inspected for effectiveness of herbicide on sprayed bole infection, unsprayed bole infection, sprayed limb infection, and unsprayed limb infection.

The following more or less subjective scale of effectiveness was used to record results of treatments:

Result:	Treatment Effectiveness Rating	Code
Infection apparently dead	Excellent	5
Infection looks dead, but may be only dormant	Good	4
Infection seriously affected, but obviously alive	Fair	3
Infection affected, but not seriously so	Poor	2
No apparent effect of treatment on infection	None	1

Average effectiveness rating is simply the arithmetic mean of effectiveness readings on one type of treatment and infection from the several trees of one or more tests. Another method of rating a test--a sort of all-or-nothing rating--is the percent of trees rated 5(excellent) for effectiveness of treatment.

A similar five-step scale was used to rate tree damage:

Damage	Scale
Tree is dead	5
Tree is heavily damaged	4
Tree is moderately damaged	3
Tree is lightly damaged	2
Tree shows no damage	1

The tree damage series is averaged similarly to the treatment effectiveness series. Percent of trees recorded 5 (dead) and 4 (heavily damaged) was often computed with the inference that trees rated 4 will die or be permanently damaged.

MATERIALS

About 50 different formulations have been applied. All data reported here result from applications of phenoxy herbicides, but a few other types of materials also have been tested. The names of acid moieties of the phenoxy herbicides considered below were abbreviated as follows:

Name	Abbreviation
4-chlorophenoxy acetic acid	4-CPA
2-methyl-4-chlorophenoxy acetic acid	MCPA
2-methyl-4-chlorophenoxy propionic acid	2-(MCPP)
2, 4-dichlorophenoxy acetic acid	2, 4-D
2, 4-dichlorophenoxy butyric acid	4-(2, 4-DB)
2, 4, 5-trichlorophenoxy acetic acid	2, 4, 5-T
2, 4, 5-trichlorophenoxy propionic acid	Silvex
2, 4, 5-trichlorophenoxy butyric acid	4-(2, 4, 5-TB)

Ester formulations of the various phenoxy acids are commonly used in oil carriers, but many such formulations also are miscible with water. Names of terminal moieties of phenoxy formulations were abbreviated as follows:

Name	Abbreviation
Butoxyethanol ester	BOEE
Isooctyl ester	IOE
Oil-soluble amine	OSA
Propylene glycol butyl ether ester	PGBEE

Spray carriers have been of three general types: (a) petroleum fuel oil, i. e., commonly kerosene, stove oil, or diesel oil (b) water with 10 to 25 percent of emulsifiable oil (agricultural spray oil) added; and (c) water with 5 to 20 percent of a polyglycol, such as polyethylene glycol (Carbowax 1500), added.

Table 1. --Effectiveness of three phenoxy herbicides in stove oil carrier on dwarf-mistletoe on Jeffrey pine and ponderosa pine, Blacks Mountain Experimental Forest, Lassen National Forest, California[1]

	Concentration a. e.	Trees treated	Mean tree height	Trees dead and heavily damaged	Average damage[3]	Effect of treatment on unsprayed bole infection[4]
	Percent	Number	Feet	Percent	Mean	Mean
4-(2, 4, 5-TB)[2]						
	0.200	12	12	0	1.1	1.0
	.324	9	16	11	1.6	1.0
	.540	10	18	0	1.0	1.0
	.900	12	15	8	1.5	1.5
	1.500	7	18	0	1.0	1.0
Total and means	0.693	50	16	4	1.2	1.1
2, 4, 5-T[2]						
	0.200	12	9	0	1.0	1.0
	.324	9	17	0	1.1	1.0
	.540	8	18	0	1.1	1.0
	.900	10	11	30	2.6	1.0
	1.500	14	7	79	4.2	--
Total and means	0.693	53	12	22	2.0	1.0
4-CPA[2]						
	0.500	8	14	13	1.6	1.0
	1.000	13	14	31	2.4	2.6
	1.500	14	8	36	2.4	1.0
	2.000	11	9	64	3.7	3.3
	3.000	11	13	27	2.7	2.2
Total and means	1.600	57	12	34	2.6	2.0

[1]Applied on September 1, 1961, checked July 11-12, 1963.

[2]Formulations: Chipman 245-TB, Weedar OSA 245-T, Amchem ACP-M-251.

[3]Rating of tree damage: 5(dead), 4 (heavy), 3(moderate), 2(light damage) and 1(no apparent damage).

[4]Effectiveness of treatment on unsprayed bole infection, in contrast to effect on sprayed bole infection which was consistently 5, excellent.

The MCPA formulation (Amchem's ACP-L-661)[1] contains "emulsifiable" phenoxy acid--presumably micronized acid--as the active ingredient. The refined kerosene spray carriers for all four of the 1959 tests contained potent bark-penetrating petroleum fractions as carrier additives. After 1960 a petroleum oil "heavier" than kerosene, e.g., stove oil or diesel oil, was commonly used as carrier without special adjuvants. This change simplified the preparation of field solutions and may have accomplished the desired improvement in bark penetration of applied materials.

RESULTS AND DISCUSSION

It is often difficult to tell by field inspection whether a treated dwarfmistletoe plant is or is not dead. We decided on effect of treatment by ocular inspections. Sometimes we shaved off scaly bark and used a hand lens to examine treated areas. But we have no positive way of telling just when an endophytic system of treated dwarfmistletoe is dead and incapable of sprouting.

Most promising herbicide. --To date the most promising herbicide has been 4-(2, 4, 5-TB)-IOE at concentrations between 0.2 and 1.5 percent acid equivalent (a.e.). The low and erratic damage to pine trees in these tests most likely shows a valuable difference between this formulation and many other phenoxy materials. Tree damage commonly increased rapidly with greater concentrations of these other phenoxy materials. That is, 4-(2, 4, 5-TB)-IOE appears to have a much broader range of concentration between the lowest concentration effective on dwarfmistletoe and the highest concentration tolerated by host pine trees.

First tests of this formulation were started early in September 1961 along Road 21, Blacks Mountain Experimental Forest. The test area is well out into the east side pine type and is at the latitude where Jeffrey pine from the south intermingles with ponderosa pine from the north. The two pine species and many intermediates mix on this area. No serious attempt was made to determine phenotype of each treated tree.

Table 1 summarizes data from five tests each with three phenoxy formulations: 4-(2, 4, 5-TB)-IOE; 2, 4, 5-T-OSA; and 4-CPA-BOEE. Parachlorophenoxy acetic acid is commonly considered less potent at comparable concentrations than many other phenoxy materials, and therefore was applied at about twice the concentration of the other two formulations. This 4-CPA material showed some systemic effect, but any concentration systemically effective on the parasite was accompanied by serious tree damage. Average tree damage as affected by phenoxy concentration in the three sets of tests is illustrated in (fig. 1). Several

[1] Trade names are used in this report for convenience and precision. Use of proprietary names is not to be considered endorsement by the U. S. Forest Service of particular products or brands. Comparable unnamed products are not assumed to be inferior.

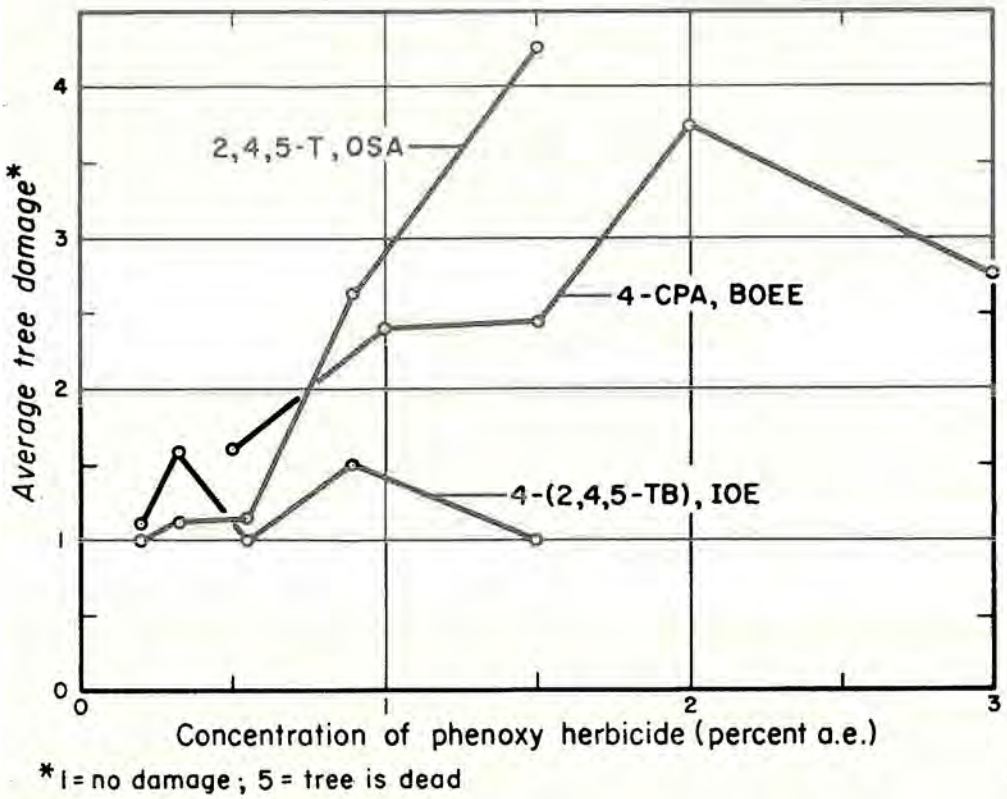

Figure 1. --Tree damage from treatment of dwarfmistletoe with phenoxy herbicides at five concentrations in stoveoil carrier.

chemicals have shown some systemic effectiveness, but all tested chemicals were most effective when sprayed directly on the parasitic plants and surrounding host tissue.

A regression equation for data from the five 2, 4, 5-T-OSA tests was: $E = 2.611 X + 0.199$, in which X is concentration a. e. in percent and E (estimated Y) is mean damage on the five-point tree damage scale. The coefficient of correlation, r, in these data is +0.978; the 1 percent level of significance of r is 0.959. If Y (damage) was 1 (no tree damage), X (concentration) is 0.307 percent; if Y was 5 (all trees were killed), then X (percent concentration) is 1.839.

First tests. --The first tests of the present series were started in August and September 1959 on Jeffrey pine second-growth at about 6,300 feet altitude along Cow Creek, Summit Ranger District, Stanislaus National Forest. Table 2 summarizes 1963 data from the most promising of these tests. After 4 years, these tests show good to excellent results where dwarfmistletoe was sprayed directly.

Table 2. --Effectiveness of three phenoxy herbicides in kerosene carrier on dwarfmistletoe on Jeffrey pine, Cow Creek, Stanislaus National Forest, California[1]

Herbicide	Carrier additive[2]		Trees treated	Mean tree height	Trees dead in 1963	Effectiveness of treatment on sprayed infection[3]											
						Bole infection						Limb infection					
						5	4	3	2	1	Mean	5	4	3	2	1	Mean
	Material	Percent	Number	Feet	Percent	Number of trees					Mean	Number of trees					Mean
2,4-D[4]	CAO#2	25.0	9	21	11	4	-	-	-	-	5.0	4	-	1	-	-	4.6
2,4-D[4]	CAO#2	20.0	4	27	0	2	-	-	1	-	4.0	3	-	-	1	-	4.3
2-(MCPP)[5]	CAO#2	25.0	6	23	17	4	-	-	-	-	5.0	4	-	-	-	-	5.0
MCPA[6]	OS#7R	12.5	9	18	0	5	-	1	-	-	4.7	3	-	-	-	-	5.0
Total and means		20.6	28	22	7	15	-	1	1	-	4.7	14	-	1	1	-	4.7

[1]Applied August and September 1959, checked June 28, 1963.

[2]CAO#2 is Chevron Absorption Oil #2, a "penetrating" machine oil. OS#7R is Ortho Solvent 7R, a petroleum fraction with considerable content of aromatics.

[3]Ratings of effectiveness: 5--excellent; 4--good; 3--fair; 2--poor; 1--none.

[4]As Amchem Weedone LV-4 at 0.2 percent a.e. conc.

[5]As Amchem ACP-L-702 at 0.2 percent a.e. conc.

[6]As Amchem ACP-L-661 at 0.4 percent a.e. conc.

Table 3. --Effectiveness of trichlorophenoxy herbicides on dwarfmistletoe on sugar pine, Chowchilla Mountain, Sierra National Forest, California[1]

Herbicide[2, 3]	Carrier additive[4]		Trees treated	Mean tree height	Trees dead and heavily damaged	Average damage[5]	Trees with effectiveness of treatment rated 5, (excellent)			
							Sprayed infection		Unsprayed infection	
							Bole	Limb	Bole	Limb
	Material	Percent	Number	Feet	Percent	Mean	Percent			
Silvex	SOE	20	10	15	0	1.1	100	100	50	57
Silvex	SOE	20	11	11	9	1.4	50	100	50	40
2, 4, 5-T	SOE	20	11	11	9	1.9	100	100	0	25
2, 4, 5-T	SOE	20	11	21	18	1.6	100	100	0	0
2, 4, 5-T	VSOS	15	13	11	31	2.5	100	100	0	0
4-(2, 4, 5-TB)	VSOS	15	13	11	0	1.0	100	89	0	0
2, 4, 5-T	VSOS	15	14	11	43	3.1	--	100	--	0

[1]Applied July 26-28, 1961, checked July 1-3, 1963.

[2]Formulations: Weedone 245-TP, Dow Kuron, Esteron 245-T, Pittsburgh LoVol 4 Brush Killer, Amchem ACP-L-329, Chipman 245-TB, and Weedar OSA 245-T.

[3]All materials applied at 2.5 percent a. e. in water-oil carrier.

[4]SOE is Summer Oil Emulsion, and VSOS is Volck Supreme Oil Spray.

[5]Rating of tree damage: 5--dead; 4--heavy; 3--moderate; 2--slight damage; 1--no apparent damage.

The 1960 tests. --Many tests were started in 1960 in each of the three general areas previously listed. Some were made on pine and fir trees during the great spring surge of growth, and severe tree damage resulted. For example, some 15 tests started in mid-July on white fir reproduction in thickets near Cow Creek Guard Station practically destroyed the treated fir.

Other tests, in August and September 1960, were applied to Jeffrey and ponderosa pine at excessive concentrations and likewise caused severe damage. Numerous tests in 1960 with 4-(2, 4-DB) indicated that this material was as damaging to conifers as 2, 4-D and offered no advantage over 2, 4-D in control of dwarfmistletoe.

The 1961 tests. --Table 3 reports 1963 data from several tests started in late July 1961 on sugar pine second-growth on Chowchilla Mountain. All materials were in water-oil carriers and applied at 2. 5 percent a. e. concentration. Such concentrations of trichlorophenoxy herbicides in stove oil on sugar pine in July would have resulted in severe damage. Excellent control of sprayed bole and limb infection resulted from treatment with all tested materials. Tree damage is considered excessive for 2, 4, 5-T-BOEE and 2, 4, 5-T-OSA. Two formulations of silvex show fair systemic control of dwarfmistletoe under conditions of this test. The four 2, 4, 5-T formulations and the 4-(2, 4, 5-TB)-IOE material show little or no systemic effectiveness. We plan additional inspections of these tests.

Later tests. --Some 38 tests (on 570 trees) were started in 1962, and 31 tests (on 285 trees) in 1963. In these tests we emphasized pine species and most promising formulations; for example, in 18 tests (on 206 trees) in 1963, we applied 4-(2, 4, 5-TB) formulations.

When all established tests have matured, it is believed that a safe, reasonably effective direct chemical control of dwarfmistletoe on pines can be defined.

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