

THE EFFECTS OF CHLOROPHENOXY HERBICIDES
ON SALT CEDAR CUTTINGS GROWN IN
THE GREENHOUSE

by

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A Thesis Submitted to the Faculty of the
DEPARTMENT OF AGRONOMY
In Partial Fulfillment of the Requirements
For the Degree of
MASTER OF SCIENCE
In the Graduate College
UNIVERSITY OF ARIZONA

1960

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ACKNOWLEDGMENTS

The author wishes to express his sincere appreciation to Dr. K. C. Hamilton for constructive suggestions and criticisms during the course of this study and in the preparation of this manuscript.

He wishes to thank Dr. H. Tucker for his suggestions concerning the statistical design and analysis of the study, Dr. D. F. McAlister and Dr. C. T. Mason Jr. for their reading and criticisms of the manuscript. Also the author wishes to extend thanks to the Agricultural Engineering Department, University of Arizona for its facilities and help in the construction of the spray chamber used in this study.

This study was made possible, in part, by a grant to the University of Arizona from the Bureau of Reclamation and United States Army Corps of Engineers.

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INTRODUCTION

The encroachment of salt cedar (Tamarix pentandra Pall.) into the Southwestern riverbottoms and floodplains has aroused the concern of both state and federal governments. Two reasons for this concern are: (1) salt cedar has become a flood hazard due to its dense jungle-like growth which restricts the flow of flood-water and (2) salt cedar, a phreatophyte having no economic value, wastes large amounts of water through its growth.

In some areas salt cedar control programs have been initiated. Earlier control programs consisted mainly of mechanical methods but, with the development of chlorophenoxy compounds, herbicide treatments also have been employed. Most herbicide treatments have been made on salt cedar regrowth after mechanical control methods have been employed.

Field testing programs for new or untested herbicides on salt cedar often require considerable time and funds. This study was conducted to determine the possibility of screening herbicides to evaluate their phytotoxicity on salt cedar before expensive field tests are made.

PREVIOUS WORK

Until 1948 only mechanical methods of salt cedar control had been employed by investigators (3). The development of chlorophenoxy herbicides after World War II and the advancement in the testing of these chemicals on numerous weedy and brushy species was rapid. In 1948 several of these herbicides were tested on salt cedar in New Mexico and Arizona.

Bowser (3) discussed aircraft applications of 2,4-D on salt cedar during the late fall of 1948 near the McMillian Reservoir, New Mexico. These areas were retreated the following spring. An amine formulation of 2,4-D was used at low rates and was emulsified in one part diesel oil and four parts water. After two years the overall plant kill was estimated at 85 per cent. However, after four years salt cedar reinvasion of the area was very noticeable.

Subsequent foliage applications in the McMillian area resulted in poorer control of salt cedar than was obtained in 1948. In these later tests low rates of the low volatile esters (LVE) of 2,4-D and mixtures of 2,4-D and 2,4,5-T resulted in better kills than amine salts. Applications of 2,4-D amine at two pounds per acre in 3.5 gallons of water and one gallon of diesel oil were made to 2,000 acres above Cabbalo Reservoir and near Socorro, New Mexico several year later. The McMillian, Caballo and Socorro applications resulted in poor salt cedar control but killed many amentiferous plants.

The first chemical control work on salt cedar in Arizona was done, using the isopropyl ester of 2,4-D, applied in diesel oil, at a rate of five pounds per acre, as an aerial spray in the spring of 1948. The test area was a five acre plot of mature salt cedar south of Avondale, Arizona (4). This area was retreated in the fall with a sodium salt of 2,4-D. In conjunction with this work, the Bureau of Reclamation cooperating with the United States Department of Agriculture treated 30 acres of mature salt cedar at various rates up to five pounds per acre of sodium salt and an ester of 2,4-D. These tests (4) showed the ester formulation of 2,4-D to be more effective than the sodium salt, however, the following year the growth of salt cedar appeared normal.

The varying results of the different formulations of 2,4-D tested on mature plants, prompted the Bureau of Reclamation and the U.S.D.A. to set up a demonstrational area in the Gila River stream-bed near Phoenix, Arizona (8). This area consisted of 40 acres of salt cedar which had been bulldozed and the debris burned. Salt cedar regrowth of various ages was treated with ground equipment. An amine of 2,4-D and a mixture of the esters of 2,4-D/2,4,5-T were applied at the rate of 1.3 and 2.6 pounds per acre. The esters of 2,4-D/2,4,5-T proved the most successful giving 100 per cent kill with five applications at 2.6 pounds per acre on young regrowth.

In a separate test (4) to determine the resistance of salt cedar seedlings to 2,4-D applied at two pounds per acre, little difference was noted between ester formulations but an amine salt gave poor control. If seedlings were 15 months old and 3 to 6 feet in height both esters and the amine gave poor results.

In 1954-55 new herbicides were tested on the Gila River demonstrational area. By 1956 the results showed that silvex (LVE of 2-(2,4,5-trichlorophenoxy)propionic acid) was more effective than either amine or ester formulations of 2,4-D or 2,4,5-T. Therefore, a new test site was selected one mile upstream from Gillespie Dam on the Gila River (8). This 40 acres was bulldozed and the debris burned. Salt cedar regrowth was treated with a 50-50 mixture of 2,4-D/2,4,5-T esters, 2,4-D amine and silvex at rates up to five pounds per acre. Plots were sprayed in the spring and fall of each year with the use of ground equipment. Arle (2) reported that none of the herbicides in this test caused a high percentage of eradication following the initial treatment. Four applications of four pounds per acre of silvex on four-foot salt cedar regrowth gave 100 per cent kill while the amine of 2,4-D gave only 79 per cent kill. Silvex also proved more effective on older regrowth (one year plus) where five pounds per acre of silvex gave 82 per cent control after the initial treatment while the same rate of 2,4-D/2,4,5-T gave only 65 per cent control.

Arle (2) pointed out that repeated treatments are required for effective control of salt cedar. After the second and third applications there was no advantage for the higher rates of treatments. The lowest rate of silvex (three pounds per acre) gave excellent control when repeated three times.

The most practical method of preventing damage to nearby crops from chlorophenoxy compounds appeared to spray salt cedar during its dormant season (3). Bowser (3) reported dormant season aircraft spraying at Dome, Arizona and Avalon Reservoir, Carlsbad, New Mexico. At Dome,

six pounds per acre of a 2,4-D ester was used and the results were very poor. At the Avalon Reservoir a low volatile ester of 2,4-D and 2,4-D/2,4,5-T and an amine of 2,4-D were applied in water, or diesel oil, or oil (triton X-100) or kerosene. Ground rig applications were made of the same herbicides that were used at Dome. The applications showed fair results with the mixture of 2,4-D/2,4,5-T being superior and the amine of 2,4-D very inferior. Appraisal of the plots did not indicate high herbicide rates to be superior to low herbicide rates.

Spraying tests in 1952 (8) and more recent work (2) have shown all herbicides tested to be relatively ineffective in controlling salt cedar if applied when the plants were dormant. These were applied in a diesel oil carrier. Silvex was the most effective herbicide; however, it gave only 34 per cent control when applied to dormant plants. It appears that herbicidal applications during dormant growth gives little control even though this type of application might reduce the danger of crop damage.

METHODS AND MATERIALS

To evaluate the effects of herbicides on salt cedar, cuttings were treated in a calibrated spray chamber with chlorophenoxy herbicides that had already been used in field tests. The results were analyzed statistically and compared with results from the earlier field tests.

During the fall of 1958 salt cedar cuttings were obtained from the Gila riverbottom near Wellton, Arizona for use in preliminary studies. Techniques for growing salt cedar cuttings in the greenhouse were developed using this plant material. In addition, the rates of several chlorophenoxy herbicides which would result in differential killing were determined.

Propagation and Growth of Salt Cedar Cuttings

Cuttings, ten inches in length, were taken from normal mature trees (Figure 1). These cuttings were from spring growth taken in late summer or from fall growth taken in early summer. Ten cuttings from a tree were grown in the greenhouse for three weeks. At this time the cuttings were transplanted to individual one gallon metal cans filled with a 5:5:1, soil, sand and peat moss mixture. The cuttings were allowed to grow until about 50 days old before they were treated with herbicides (Figure 6). In tests where evaluation for more than three weeks after spraying was desired, the plants were carefully transplanted and placed in groups of five or ten in "graveyard cans" (Figure 11) to economize greenhouse space.



Figure 1. A mature salt cedar (Tamarix pentandra Pall.) in full bloom. Cuttings were propagated from plants such as this.

Temperature and relative humidity in the greenhouse were recorded with a hygrothermograph. The mean weekly high and low values are shown in Table 1. The mean high and mean low temperatures were 100 and 52 degrees Fahrenheit, respectively. The mean high and mean low relative humidity were 99 and 32 per cent, respectively. The light intensity in the greenhouse varied approximately from 1000 foot-candles to 2000 foot-candles during this period.

Application of Spray

Preliminary work demonstrated that an efficient and accurate method for applying herbicides must be developed and used. Shaw and Swanson (7) used a screening table with an endless conveyor belt which transported flats under a stationary nozzle at a given speed and nozzle pressure. Different rates of chemical could be delivered by changing the speed of the conveyor belt. Anliker and Morgan (1) in studying the relationship of herbicide spray characteristics to phytotoxicity used a moving platform similar to Shaw's.

In this study, due to the close proximity of plants susceptible to 2,4-D, the use of an enclosed spray chamber was desired to eliminate the hazard of spray drift. Such a chamber was constructed (Figure 2). The enclosed chamber is of the fixed platform, movable spray nozzle type. It was equipped with an exhaust fan, exhausting spray drift through an activated charcoal filter (Figure 3). Flushing the inside of the chamber with water, between spray applications, was facilitated by four spray nozzles in the ceiling.

Table 1. Mean weekly greenhouse temperature and relative humidity data where salt cedar cuttings were grown.

Date	Temperature		Relative humidity		Date	Temperature		Relative humidity	
	High	Low	High	Low		High	Low	High	Low
	°F.	°F.	%	%		°F.	°F.	%	%
June					October				
1-7	83	70	78	34	5-11	96	70	79	42
8-14	89	71	86	36	12-18	92	63	95	48
15-21	96	71	95	45	19-25	93	60	90	46
22-28	96	70	90	49	26-11/1	87	60	95	51
29-7/5	100	72	98	47					
July					November				
6-12	92	71	95	55	2-8	96	67	80	42
13-19	87	70	98	60	9-15	--	--	--	--
20-26	90	70	98	55	16-22	--	--	--	--
27-8/2	90	70	96	50	23-29	96	61	72	32
August					30-12/6	90	59	79	46
3-9	90	69	99	56	December				
10-16	86	69	99	63	7-13	81	61	75	37
17-23	86	68	99	58	14-20	88	54	80	39
24-30	88	70	98	54	21-27	80	55	82	48
31-9/6	91	66	99	55	28-1/3	78	54	82	48
September					January				
7-13	83	69	98	49	4-10	85	52	81	43
14-20	84	62	87	34	11-17	88	55	80	41
21-27	88	59	85	34	18-24	95	57	72	34
28-10/4	96	65	90	43	25-31	88	64	74	35
					February				
					1-7	86	58	82	42
					8-14	82	62	81	43
					15-21	86	59	79	36
					22-28	85	59	77	35



Figure 2. Spray chamber used to apply foliage applications of chlorophenoxy herbicides to salt cedar cuttings grown in the greenhouse. Spray containers and nozzles are displayed on top of the chamber.

Key to Figure 3. 1. Removable grate (steel). 2. Flexible air hose, 1/4 inch (rubber). 3. Frame construction (steel), 1 1/8 inches x 1 1/8 inches x 1/4 inch angle iron. Inside dimensions of the frame are: length - 6 feet, width - 3.5 feet, height - 4 feet. 4. Spray container (copper and bronze) and nozzle (Teejet 8003). 5. Electric exhaust fan, 8 inches. 6. Filter assembly, diameter 8 inches galvanized iron). 7. Activated charcoal containers (galvanized iron and screen). 8. Drive line, 1/4 inch (nylon). 9. Electric drive motor (.06 H.P.), gear driven (100:1 reduction ratio), reversible, 1 1/2 inch drive pulley. 10. Control panel - fan, light and motor switch; air valve and pressure regulator. 11. Air pressure valve (regulated). 12. Carrier pulleys, 5 1/2 inches, mounted on 1/2-inch shafts. 13. Glass window. 14. Doors (2), 2 feet 10 inches x 2 feet 4 inches. 15. Covering of frame, masonite 1/4 inch (tempered). 16. Stand (steel), same construction as frame, height 1 foot 4 inches. 17. Floor (galvanized iron), 24 gauge, 1/2-inch drain plug.

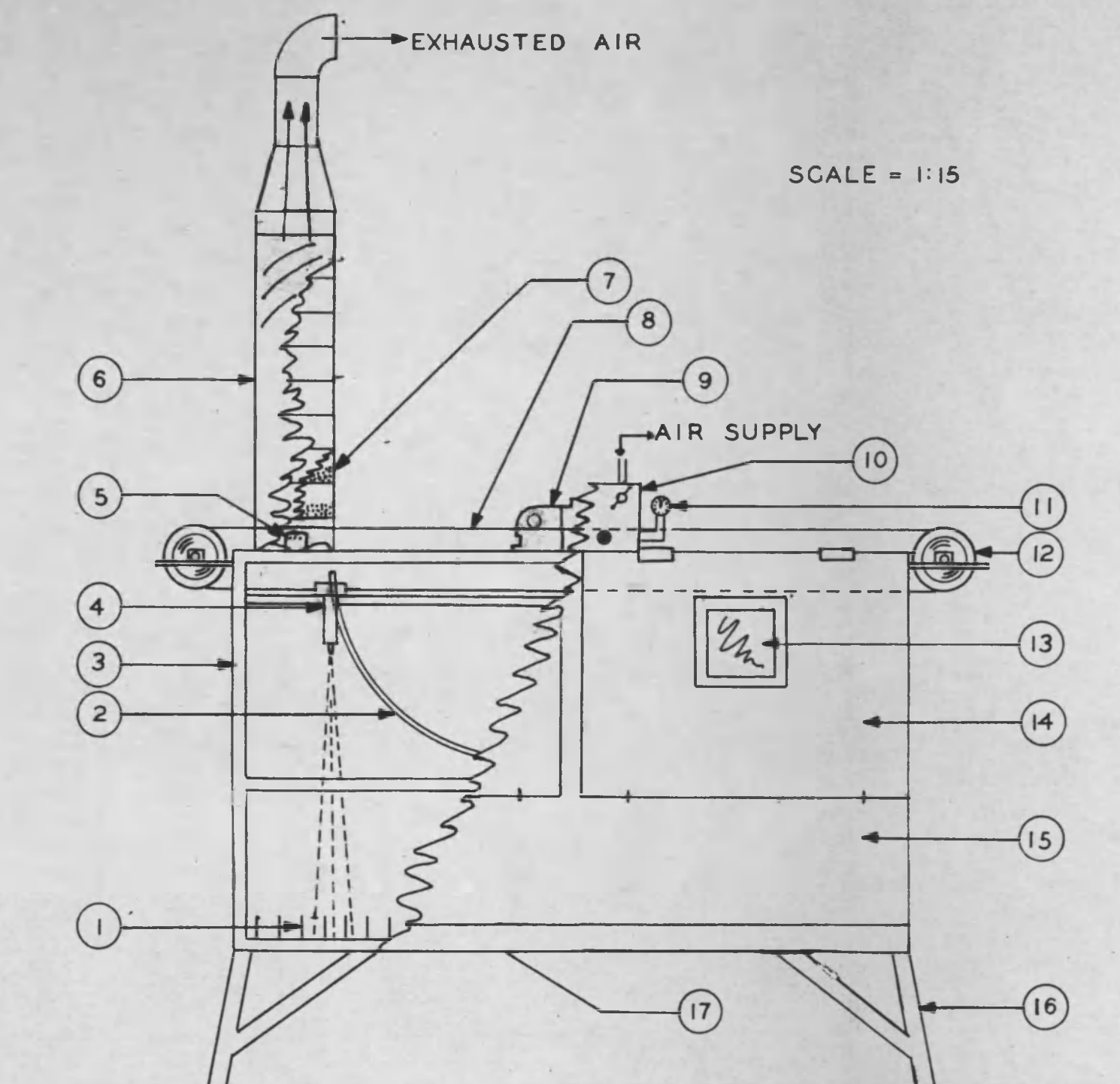


Figure 3. Diagrammatic illustration of spray chamber. ,

The calibration of the spray chamber was accomplished as follows:

Information Given A "Teejet" 8003 nozzle tip delivered 43 cc. of spray solution in three seconds, in three feet of travel at 30 pounds per square inch air pressure. This nozzle covered a 12-inch swath when the recipient surface was 7.16 inches below the nozzle tip and a 24-inch swath when the recipient surface was 14.32 inches below the nozzle tip. All herbicides used contained four pounds acid equivalent per gallon and, therefore, one pound of acid equals 946 cc. of spray material.

Calculations A 24-inch swath was used in all tests, therefore, six square feet received 43 cc., or 7.16 cc. per square foot. It was desirable to fill the spray container for a linear run of five feet or a coverage of ten square feet, requiring 71.6 cc. of spray material for each test run. A rate of one pound per acre was obtained when .2171 cc. of the formulation was added to 71.4 cc. of water. On this basis the appropriate amounts of herbicide were calculated for the treatment rates.

Spray Operation Five plants were treated at one time. The plants were placed in the chamber and the door closed (Figure 4). Then the spray container and nozzle made one spray run over the plants (Figure 5). Individual plants often varied in height, therefore, the height of each plant was adjusted so its crown spread was approximately 14 inches from the nozzle. When the nozzle had finished its spray run, the air supply was shut off and the drive motor stopped. The exhaust fan was then started and two minutes later the plants were removed from the chamber. All sprayed plants remained outside the greenhouse for at least four hours before being returned to the greenhouse.

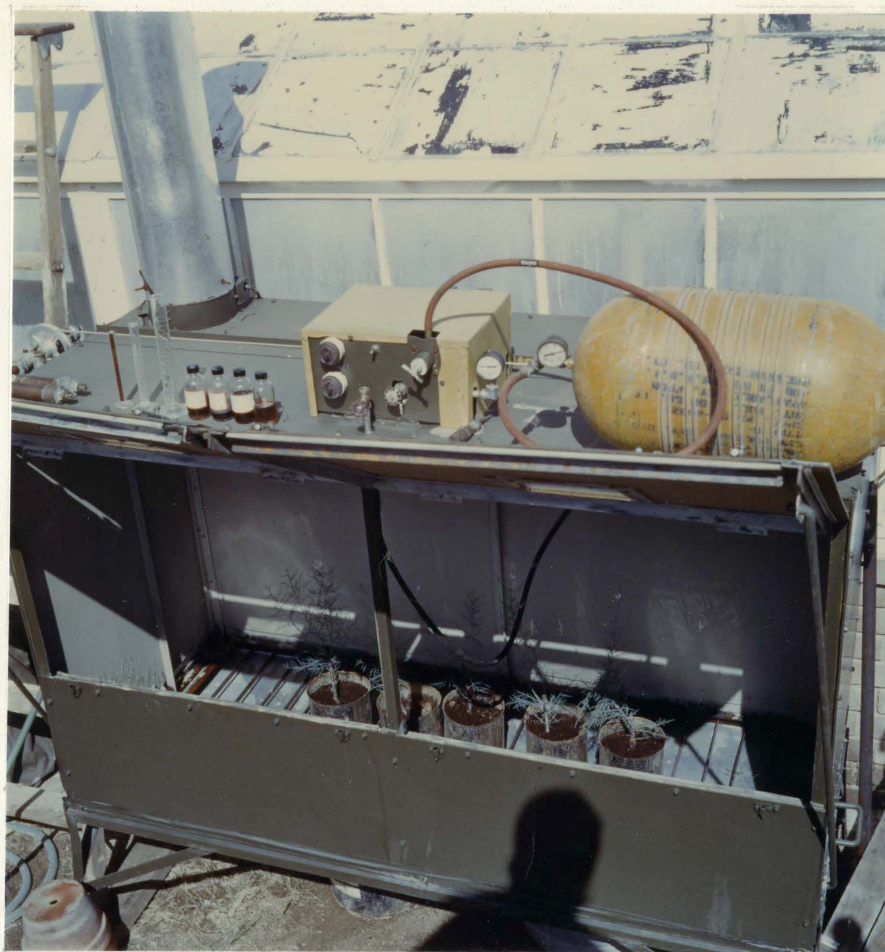


Figure 4. Inside view of spray chamber showing position of salt cedar plants when ready to apply herbicides.

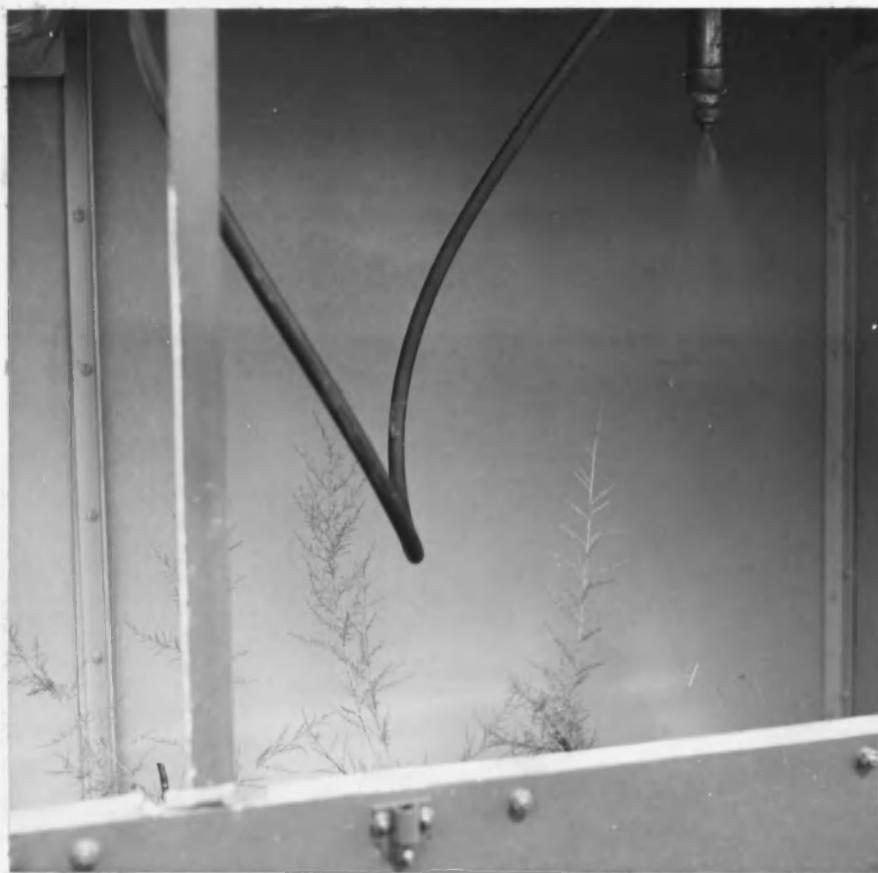


Figure 5. Spray application of herbicide to plants.



Figure 6. Fifty day-old salt cedar cuttings ready for herbicide treatment.

In testing chlorophenoxy herbicides on salt cedar cuttings four separate experiments were carried out.

Experiment 1 A test of the effects of herbicides already used in the field. An amine of 2,4-D and low volatile esters of 2,4-D, 2,4,5-T, 2,4-D/2,4,5-T and silvex were applied at .25, .50 and 1.0 pounds per acre to 20 replications of salt cedar. Ten replications, each replication consisting of cuttings from a single tree, were treated at two dates. Evaluations were made on the basis of complete top kill, green stems only, green stems and leaves. These were scored as 1, 2 and 3, respectively. These evaluations were made 21 days (before transplanting to "graveyard cans") and 90 days after treatment.

Experiment 2 A test was made of the effects of the herbicides used in Experiment 1 on cuttings obtained from trees growing in two different regions. These localities were Dome, Arizona (200 feet above sea level) and Pima, Arizona (3000 feet above sea level). These sites are on the lower and upper Gila River, respectively, and are approximately 260 miles apart. The herbicides used were an amine of 2,4-D and low volatile esters of 2,4-D, 2,4,5-T, 2,4-D/2,4,5-T and silvex applied at .125, .25, .50 and 1.0 pounds per acre. The two locations had five replications each. Evaluations were made as in Experiment 1.

Experiment 3 A test was made of the use of a wetting agent in conjunction with silvex. Rates of silvex used were .03, .0625, .125 and .25 pounds per acre. These treatments were used with three rates of "X-77" (a commercial wetting agent). The concentrations of "X-77" used were 0, .1 and .5 per cent (by volume). The treatments were replicated ten times. Evaluations were made as in Experiment 1.

Experiment 4 A test was made of the effect of increasing concentrations of silvex on plant growth (stem elongation). Concentrations used were .04, .13, .43, 1.29, 4.31, 12.92, 43.05, 129.16 and 387.48 parts per million (by weight). Ten replications were treated at each of two dates. Applications were made to plants after all except one main branch had been removed. Each branch was measured before treatment and then at 3, 7, 14 and 21 days after treatment.

In Experiments 1, 2 and 3 the analysis of variance and Duncan's multiple range test (5), for determining significance between treatment means was conducted to evaluate the data. All tests of significance were at the five per cent level. Usually this type of analysis is not used to evaluate plant kill scores, however, it was found applicable here.

In all experiments each replication contained one control plant.

RESULTS

All experiments were completed between June, 1959 and February, 1960. In the following results all control plants were omitted from the statistical analysis. Control plants in all experiments appeared healthy after 90 days. However, where some were kept for 120 days (170 days old) after treatment they began to look necrotic. These ailing plants appeared to be suffering from what is called "root bound."

Experiment 1 In this experiment five herbicides, that had already been used in the field, were each tested at three rates on salt cedar cuttings grown in the greenhouse. Ten replications (150 plants) were treated July 19, 1959 and ten replications were treated on August 19, 1959. The data for the results of the two applications at 21 and 90 days after treatment were subjected to statistical analysis (Tables 2 and 3).

At both the 21- and 90-day observations there appeared to be a significant difference between dates of applications and replications within dates. More plant kill was obtained among the first ten replications. After 21 days there was significant difference between herbicide treatments. The silvex treatment was significantly better than the other four formulations. The .5 pound per acre rate was significantly better than the .25 and the 1.0 pound per acre rate was significantly better than the .5 pound per acre rate (Figures 7 and 8).

Table 2. Analysis of variance of scores for plant kill for testing the effects of five chlorophenoxy herbicides on salt cedar cuttings.

Source of variance	Degrees of freedom	Mean square		F values	
		21 days	90 days	21 days	90 days
Dates	1	42.56	10.47	202.66*	29.08*
Replication in date	18	1.23	1.33	5.86*	3.69*
Herbicide	4	1.07	0.48	5.09*	1.33
Rate	2	10.27	4.58	48.90*	12.72*
Herb. x rate	8	0.27	0.44	1.28	1.22
Herb. x date	4	0.68	0.38	3.24*	1.06
Rate x date	2	4.42	1.69	21.05*	4.69*
Herb. x rate x date	8	0.31	0.63	1.48	1.75
Error	252	.21	.36		

* $P < .05$

Table 3. Mean scores for plant kill using five chlorophenoxy herbicides on salt cedar cuttings.

Herbicide	Mean score*		Rate	Mean score	
	21 days	90 days		21 days	90 days
			lbs./A.		
2,4-D, LVE	1.58a**	1.23a	0.25	1.82a	1.48a
2,4,5-T	1.58a	1.37a	0.50	1.47 b	1.34 b
2,4-D, amine	1.55a	1.37a	1.00	1.18 c	1.06 c
2,4-D/2,4,5-T	1.47a	1.17a			
silvex	1.27 b	1.33a			
Standard error of mean	.0592	.0775		.045	.003
Control plants	3.0	3.0			

* (3 = stems and leaves green, 2 = stems green, 1 = dead)

** Values with the same subscript are not significantly different.



Figure 7. Salt cedar cuttings one week after treatment with .25 pounds per acre of silvex (Experiment 1).



Figure 8. Salt cedar cuttings one week after treatment with 1.0 pounds per acre of silvex (Experiment 1).

However, 90 days after treatment no difference among herbicides could be detected, but the difference between rate means was the same as at 21 days.

Experiment 2 In this experiment the herbicides used in Experiment 1 were tested at four rates on salt cedar cuttings obtained from trees growing in two different regions. All plants were treated on September 15, 1959. The statistical analysis of the data obtained from both the 21- and 90-day observations is found in Tables 4 and 5.

At 21 days there was a significant difference between Pima and Dome cuttings and significance between replications at locations. At this time the Dome cuttings were more tolerant to the herbicide treatments. However, after 90 days there was no significance between locations, but still a significant difference between replications at locations.

At both 21 and 90 days after treatment there was a significance among herbicides and rates. Silvex and 2,4-D/2,4,5-T gave significantly better kills than the other three formulations after 21 days. The one pound per acre rate was significantly better than the .5 pound per acre rate and this .5 pound rate was significantly better than the .125 pound per acre rate but not the .25 pound rate. At 90 days the difference between the rate means remained, but the means for silvex and the mixture were not significantly different from one another. The mixture was significantly better than 2,4,5-T and the amine of 2,4-D (Figures 9 and 10). Silvex was significantly better than 2,4-D and 2,4,5-T.

Experiment 3 In this experiment a wetting agent (X-77) was used at three rates with each of four rates of silvex on salt cedar cuttings.

Table 4. Analysis of variance of scores for plant kill for testing the effects of five chlorophenoxy herbicides on salt cedar cuttings obtained from trees in two different regions.

Source of variance	Degrees of freedom	Mean square		F values	
		21 days	90 days	21 days	90 days
Locations	1	4.79	.84	9.58*	1.40
Replication in location	8	1.84	3.46	3.68*	5.77*
Herbicide	4	7.16	4.69	14.32*	7.82*
Rate	3	10.89	5.59	21.78*	9.32*
Herb. x rate	12	0.67	0.42	1.34	0.70
Herb. x loc.	4	0.93	0.73	1.86	1.22
Rate x loc.	3	0.14	0.17	.28	0.28
Herb. x rate x location	12	0.68	0.74	1.36	1.23
Error	152	0.50	0.60		

* $P < .05$

Table 5. Mean scores for plant kill using five chlorophenoxy herbicides on salt cedar cuttings obtained from trees in two different regions.

Herbicide	Mean score*		Rate	Mean score	
	21 days	90 days		21 days	90 days
			lbs./A.		
2,4-D amine	2.80a**	2.43a	0.125	2.72a	2.22a
2,4-D LVE	2.50a	2.05ab	0.25	2.56ab	2.30ab
2,4,5-T	2.50a	2.23a	0.50	2.28 b	1.94 b
2,4-D/2,4,5-T	1.90 b	1.73 bc	1.00	1.66 c	1.56 c
silvex	1.83 b	1.60 c			
Standard error of mean	.112	.123		.100	.110
Control plants	3.0	3.0			

* (3 = stems and leaves green, 2 = stems green, 1 = dead)

** Values with the same subscript are not significantly different.



Figure 9. Salt cedar cuttings 90 days after treatment with .125 pounds per acre of low volatile esters of 2,4-D/2,4,5-T. Cuttings propagated from trees in Pima, Arizona are on the left, while those on the right are from Dome, Arizona.



Figure 10. Salt cedar cuttings 90 days after treatment with 1.0 pounds per acre of low volatile esters of 2,4-D/2,4,5-T. Pima and Dome cuttings are arranged in the same manner as Figure 9.

All plants were treated November 27, 1959. The statistical analysis of the data obtained from both the 21- and 90-day observations is found in Tables 6 and 7.

A significant difference between replications was noticed at 21 days and there was a significance among herbicides and wetting agents at both 21 and 90 days after treatment. The .25 pound per acre rate of silvex was significantly better than the other three rates. The lowest rate at three weeks gave significantly poorer control than the other rates. Both the .1 and .5 per cent levels of the wetting agent gave significantly better results than no wetting agent at both the 21- and 90-day evaluations (Figures 11 and 12).

Experiment 4. In this experiment different concentrations of silvex were used to test the effect of silvex on growth of salt cedar cuttings. Ten replications were treated July 13, 1959 and the remaining ten replications were treated October 17, 1959 (Figure 13). The first half of this experiment consisted of nine treatments (the .04 parts per million rate was omitted) while the second half contained ten treatments. The data for the first half of the experiment indicated no relationship between dosage and growth. There was a marked effect of dosage on growth in the second half of the experiment. An examination of the data from the second half of this test indicated a non-linear relationship between dosage and growth. The regression of growth (y) on log. dosage (x) was computed. (Table 8 and Figure 14).

Seven, 14-, and 21-day data appeared to be logarithmic linear with increasing correlation values of $-.832$, $-.878$, and $-.932$. These were all significant at the 1 per cent level. The correlation coefficient

Table 6. Analysis of variance of scores for plant kill for testing the effects of using a wetting agent in conjunction with silvex on salt cedar cuttings.

Source of variance	Degrees of freedom	Mean square		F values	
		21 days	90 days	21 days	90 days
Replications	9	0.63	0.86	3.32*	1.26
Herbicide	3	3.14	5.01	16.53*	7.37*
Wetting agent	2	1.23	9.86	6.47*	14.50*
Herb. x W. A.	6	0.26	0.79	1.37	1.16
Error	99	0.19	0.68		

* $P < .05$

Table 7. Mean scores for plant kill using a wetting agent in conjunction with silvex on salt cedar cuttings.

Herbicide rate	Mean score*		Wetting agent rate	Mean score	
	21 days	90 days		21 days	90 days
lbs./A.			%		
.03	2.90a**	2.43a	0.0	2.73a	2.55a
.0625	2.63 b	2.17a	0.1	2.45 b	1.90 b
.125	2.43 b	1.97a	0.5	2.40 b	1.58 b
.25	2.13 c	1.47 b			
Standard error of mean	.079	.163		.069	.130
Control plants	3.0	3.0			

* (3 = stems and leaves green, 2 = stems green, 1 = dead)

** Values with the same subscript are not significantly different.



Figure 11. Salt cedar cuttings 90 days after treatment with .25 pounds per acre of silvex and no wetting agent (Experiment 3). Cans shown here are referred to as "graveyard cans."



Figure 12. Salt cedar cuttings 90 days after treatment with .25 pounds per acre of silvex and .5 per cent wetting agent (Experiment 3).



Figure 13. Salt cedar cuttings 7 days after treatment to test the effect of silvex on plant growth. Higher rates are at the left with the lower rates at the right. Growth measurements were made on one remaining branch of each plant (Experiment 4).

Table 8. Measured increase in length of stem growth, average rate of stem growth (b), and correlation coefficient (r) values for salt cedar cuttings.

Concentration of silvex		Days after treatment			
		3	7	14	21
ppm	logarithm	Mean increase in stem length (cm.)			
.04	-1.39794	1.72	4.52	6.28	7.63
.13	-0.88606	1.94	5.22	7.33	8.96
.43	-0.36653	1.81	4.55	5.46	6.45
1.29	+0.11059	1.43	3.02	3.38	3.92
4.31	+0.63448	2.63	4.83	4.83	4.83
12.92	+1.11126	2.55	3.25	3.25	3.25
43.05	+1.63397	2.58	2.94	2.94	2.94
129.16	+2.11113	2.77	2.82	2.82	2.82
387.48	+2.58825	1.33	1.33	1.33	1.33
Average rate of growth (b values)					
		+0.1227	-0.7625	-1.2837	-1.7128
Logarithmic linear correlation coefficients (r values)					
		+0.303	-0.832**	-0.878**	-0.932**

** Values are significant at the 1 per cent level.

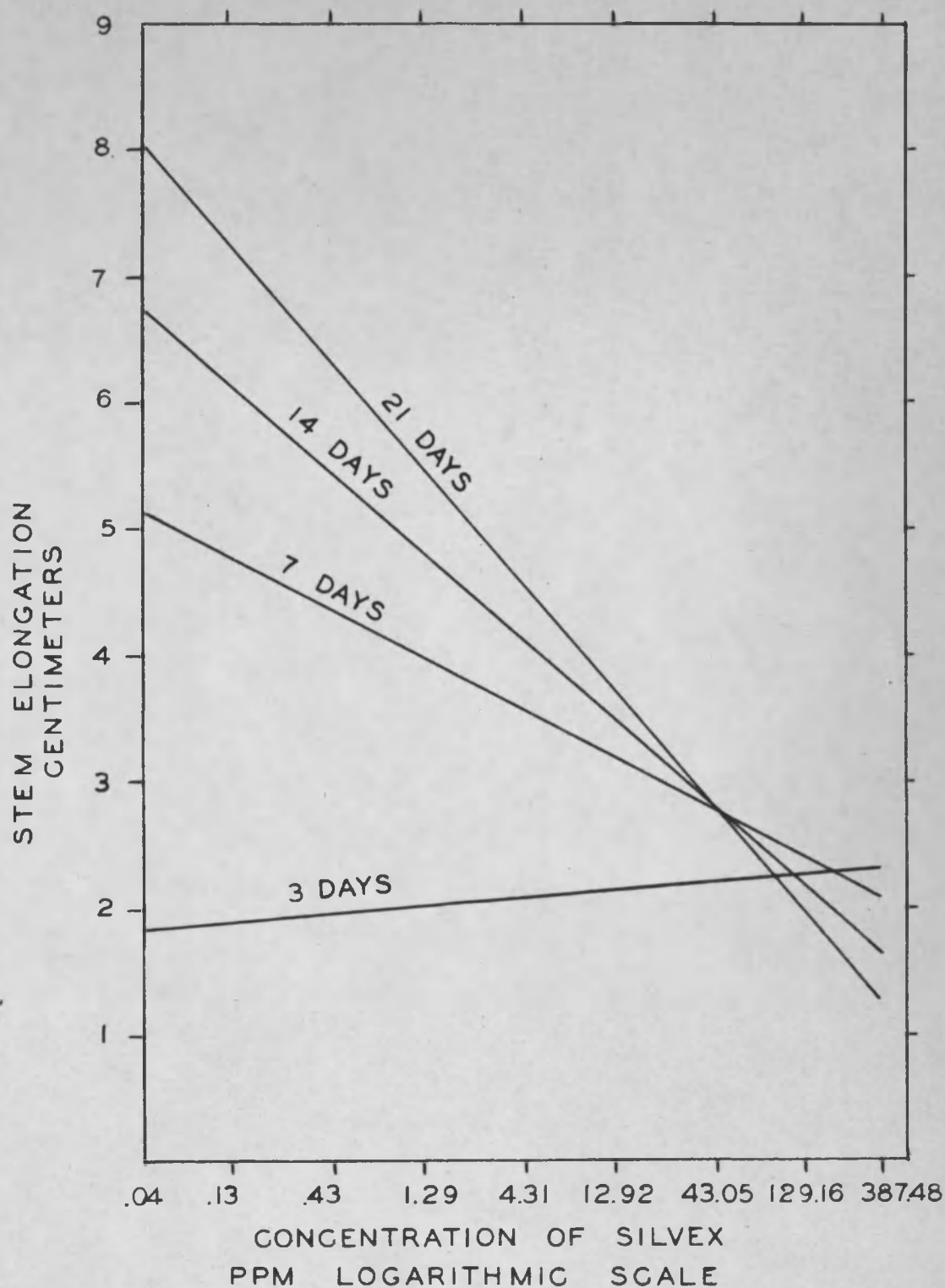


Figure 14. The regressions of stem elongation on concentrations of silvex for four observation periods after treatment (Experiment 4).

for three-day data was +.303. After seven days there was little growth of plants having been treated with 44 or more parts per million of silvex.

Visual observations made during these tests showed stem bending in 75 per cent of the plants treated with the five highest rates three days after treatment. At seven days there was still no stem curvature on plants treated with the smallest dosage while in the four highest dosages some plants were showing necrotic symptoms. After 21 days plants receiving the five highest dosages showed advanced necrosis.

DISCUSSION

Preliminary experiments had shown two to four pounds per acre of chlorophenoxy herbicides to be extremely toxic to salt cedar cuttings. One pound rates had been variable in kill in these experiments. Therefore, it was decided that no rates higher than one pound would be used if comparisons between rates and between herbicides were to be made.

However, in Experiment 1 a much higher rate of kill was obtained when the first ten replications were treated on July 19 than the plants treated at a later date. The experimental procedure was the same for these two dates. The large difference between these treatment dates was that of daytime temperature. The temperature in the treatment area was 105° Fahrenheit on July 19 while it was 95° Fahrenheit on August 19. Even though low volatile esters were used, contamination between treatments may have increased due to greater volatilization of the chemicals because of the higher temperature on July 19. Also, warmer weather usually is more favorable to plant growth and chlorophenoxy herbicides are more effective when plants are growing more actively.

In Experiment 4, somewhat the same situation, as mentioned above, may have existed. The first treatment date (July 13) data showed no response. The temperature for this date was recorded as 100° Fahrenheit in the treatment area. However, the temperature recorded on October 17, the second treatment date, was only 80° Fahrenheit and this response was found to be a log-linear. On treatment dates for Experiments 2 and 3,

where more variable kills were found day temperatures were relatively low. Thus, it appears temperature may have an effect on herbicidal response to salt cedar cuttings.

In all experiments salt cedar cuttings were killed by rates much lower than rates used in field experiments on salt cedar regrowth. Hull (6) found little cuticle development on mesquite seedlings grown in the greenhouse as compared to the thick cuticles on field grown mesquite. These greenhouse plants were very susceptible to the highly polar amines and sodium salts of 2,4,5-T where as field plants were not. Cuticle development of salt cedar cuttings grown in a greenhouse environment might, like mesquite grown under similar conditions, be characterized by a thin cuticle.

In Experiments 1 and 2 there was difference between replications after 21 and 90 days while in Experiment 3 there was only a difference between replications after 21 days. This points to the varietal response that different trees of the same species in the same area will give to herbicidal treatment. Evaluations of plant kill 90 days or more after treatment appear to be the most desirable.

The results obtained in the foregoing experiments were similar to those obtained in the field by other workers. As in the field, silvex and the mixture of low volatile esters of 2,4-D/2,4,5-T appeared to be more toxic than other chlorophenoxy herbicides. Silvex was perhaps a more effective herbicide than the mixture. As in the field tests, the amine of 2,4-D gave poor results on salt cedar cuttings grown in the greenhouse. Higher rates were shown here to be of a definite advantage as has been also found in the field.

At the present no results are available from field work on the influence of wetting agents in herbicide solutions used in salt cedar control. The evidence presented here indicates wetting agents should be tested with applications of herbicides on salt cedar in the field.

Considerable variability in susceptibility to herbicides was found between cuttings taken from trees growing in the same area. In field tests one might find more variability between plants within treatments than between two groups of plants given different treatments.

As the results of herbicide applications in the spray chamber to greenhouse grown salt cedar are comparable with field tests of chlorophenoxy herbicides, this method of herbicide evaluation may be useful in future studies. Since the treatments in the spray chamber were all made in very close proximity to plants susceptible to 2,4-D and no damage was observed, the confinement of the spray application to the chamber must have been adequate. No troubles of an important nature were noticed with the operation of the chamber.

SUMMARY

Four experiments were performed to determine the effect of chlorophenoxy herbicides on salt cedar cuttings grown in the greenhouse. Foliar applications were made using a calibrated spray chamber of the stationary platform, movable spray nozzle type. The experiments were completed between July, 1959 and February, 1960. They had been preceded by preliminary experiments for one year. Herbicide applications were made on 50-day old cuttings.

Herbicides used in these experiments were an amine of 2,4-D and low volatile esters of 2,4-D, 2,4,5-T, 2,4-D/2,4,5-T, and silvex. In two experiments silvex and 2,4-D/2,4,5-T were found to be the most effective. Higher rates were found to be more effective than lower rates with one pound per acre rates giving 100 per cent kills. No difference between groups of cuttings taken from two areas (varying greatly in elevation) was noticed three months after treatment. In a third experiment a wetting agent used as low as .1 per cent with silvex increased the effectiveness of the herbicide. In a fourth experiment a log-linear relationship was found in which plant growth decreased with an increase in silvex concentration with a correlation of $-.932$ when observations were made 21 days after treatment. All control plants appeared normal during the 90 days of observation.

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