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FINAL REPORT

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Vegetation Control on Roadside and Similar Areas

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16. Abstract

This research was initiated to discover more effective, more efficient, and safer methods of controlling roadside vegetation. Specifically, the research was designed to find the safest way to control weeds near susceptible crops and to find the best herbicide(s) to selectively control "hard-to-kill" undesirable vegetation. All promising herbicides and thickening agents on the market at the time the research was initiated were evaluated.

The equivalent rates of several soil sterilant herbicides were established.

The effectiveness of growth retardants were studied.

The research can be readily applied to areas having plant populations and growing conditions similar to Missouri.

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VEGETATION CONTROL ON ROADSIDES AND SIMILAR AREAS

STUDY 69-2

Prepared for

MISSOURI STATE HIGHWAY COMMISSION

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ABSTRACT

Studies were conducted to discover more effective, more efficient, and safer methods of managing vegetation on roadsides.

Picloram gave excellent control of common milkweed (Asclepias syriaca L.) the fall and spring following summer application, but it may injure desirable broadleaved plants. Where picloram cannot be used, dicamba or dicamba plus 2,4-D, which are less hazardous to desirable broadleaved plants, could be used. Fenac and 2,4-DP also showed promise for common milkweed control.

Thickening agents affected viscosity of spray mixtures, but had less effect on surface tension and spray mixture density. Physical properties of the thickening agents varied widely. In these studies, tendency for spray mixtures to drift could not be predicted by physical properties of the thickening agents.

Thickening agents did not reduce the loss of spray mixture between the nozzle and the target. Weed control was not reduced by the addition of thickening agents to the spray mixture.

Bromacil, simazine, diuron, secbumeton, prometone, and karbutilate used as soil sterilants gave good weed control for one year. Bromacil and diuron persisted longer. Bromacil tended to move outside the target area with surface water more than the other sterilants.

Maelic hydrazide (MH) applied to tall fescue (*Festuca arundinacea* Schreb.) in the spring reduced height and number of seed stalks. Mowing before application made the MH treatment ineffective.

CHAPTER I

INTRODUCTION

The control of vegetation along rights-of-way in Missouri is a monumental task. Any new procedure resulting in greater control or less expense or risk would be useful. This research program was initiated to discover more effective, more efficient, and/or safer methods of controlling roadside vegetation.

The phenoxy herbicides are relatively inexpensive and give good control of most annual broadleaved weeds. However, other herbicides give better control of perennial broadleaved weeds. Common milkweed (*Asclepias syriaca*) is a perennial broadleaved weed that can be found throughout the state. It is one of the most difficult to control and was chosen to represent the "hard-to-kill" weeds for purposes of this research. Measures found to be effective for control of common milkweed could be expected to be effective for many other species.

Two greenhouse experiments were conducted to determine the most promising herbicides or combinations of herbicides for control of common milkweed. The herbicides were applied at different rates to permit estimation of rates for field use.

Three experiments were conducted on roadsides to evaluate several promising herbicide treatments for control of common milkweed under natural field conditions.

The discovery of highly active herbicides has permitted more efficient weed control, but it has increased the hazard of spray drift. The amount of spray drift depends on many factors. It is reasonable that viscosity, surface tension, and density of the spray mixture may be some of these factors. Experiments to measure the drift of herbicide sprays are expensive. If correlations between certain physical characteristics of spray mixtures and drift of the sprays could be determined, one could estimate the hazard of drift by measuring the physical characteristics of the spray mixtures. This information would also contribute to a better understanding of the nature of spray drift. The size of spray droplets is considered an important factor affecting spray drift. Thickening agents are sometimes used in spray mixtures to increase droplet size and thus decrease drift. An extensive laboratory study was conducted with four thickening agents to study their effect on viscosity, surface tension, and density. Another study was conducted in the field to evaluate drift control using thickened sprays. Since an increase in droplet size results in less uniform coverage of vegetation with a spray, one might expect the possibility of a decrease in weed control. However, this tendency might be countered by an increase in the proportion of the spray mixture reaching the target area due to a decrease in drift. Six experiments were conducted on roadsides to determine the effects of thickening agents on the performance of herbicide treatments.

Weeds around signposts and under guardrails cannot be controlled by mowing. Sterilization of the soil controls the weeds at low cost. Several herbicides were evaluated for their effectiveness and duration of control in three studies. One of the most important problems in the use of soil sterilants is the killing of vegetation outside the target area because of movement of the herbicides by the surface water. The area affected by eroded herbicide varies directly with the rate used. The estimates of equivalent rates of different soil sterilants presented here will be useful in making valid comparisons between herbicides with regard to their tendency to move from the target area.

Rights-of-way are more attractive and safer if the vegetation is maintained at a reasonably short, uniform height. This has required several cuttings throughout the summer. Elimination of one or more mowing operations through the use of a growth regulator might be possible. Three experiments were conducted to measure grass suppression under various growing conditions.

CHAPTER II

A COMPARISON OF SELECTED HERBICIDE TREATMENTS FOR THE CONTROL OF COMMON MILKWEED IN THE GREENHOUSE

Thirty-nine herbicide treatments were evaluated in two experiments in the greenhouse to determine their relative performance in killing common milkweed.

Materials and Methods:

LOCATION: University of Missouri Research Greenhouses in Columbia, Missouri.

EXPERIMENTAL DESIGN: These studies were conducted in a randomized complete block design with ten replications.

PLANT SPECIES STUDIED: Common milkweed (*Asclepias syriaca*). Rhizomes were dug up and planted in pots in the greenhouse.

POTTING MIXTURE: 3 parts Mexico silt loam, 2 parts sand, 1 part peat.

PLOT SIZE: 1 plant per pot.

DATE PLANTED: February 7, 1970 and July 29, 1970.

DATE TREATED: June 6, 1970 and October 10, 1970.

METHOD OF APPLICATION: Treatments were made with a small garden tractor plot sprayer at 40 gallons per acre.

DATA TAKEN: Percent injury weekly for 10 weeks after treatment; height of plant at treatment; height of treated plants excluding regrowth 10 weeks after treatment; fresh weights;

height of new shoots from rhizomes 10 weeks after treatment; normality of shoots from rhizomes 10 weeks after treatment; normality of regrowth 2, 4, and 5 weeks after harvest; vitality of rhizomes 5 weeks after harvest.

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Results and Discussion:

Although results from greenhouse experiments are not directly applicable to field conditions, they can provide useful information on some of the phytotoxic characteristics of herbicides.

Table 2 gives percent injury to milkweeds each week for 10 weeks after application. At 10 weeks, picloram, fenac, amitrole, and dicamba showed 90% or greater injury at the intermediate rates. Two,4-DP was slightly less active, giving

86% injury. Two,4-D; 2,4,5-T; and 2,3,6-TBA showed approximately 65% injury at the 2.0 lb/A rate. In all cases except for 2,4-D, the highest rate gave the greatest injury.

Rapid top kill soon after application is not always good. If the plant top is killed too rapidly, little translocation of the herbicide to the rhizome occurs and regrowth normally appears late in the season or the following spring. Regrowth data appear in Tables 3 and 4. The high rate of the phenoxy herbicides (2,4-D; 2,4,5-T; and 2,4-DP) and of 2,3,6-TBA generally resulted in greater regrowth than the intermediate rate. The high rate of the other herbicides generally resulted in equal or less regrowth.

There seems to be no advantage in mixing 2,4-D with the higher rates of dicamba; 2,3,6-TBA; or fenac. At low rates, however, there seems to be an enhancement of control.

The fresh weights of the milkweeds ten weeks after treatment appear in Figure 1. Recall, some of these plants were dead at harvest. The plants that were killed soon after treatment had a lower fresh weight than plants that were killed slowly. The herbicides ranked as follows according to fresh weight at the manufacturers recommended rates: picloram < amitrole < fenac < dicamba < 2,4-DP < 2,3,6-TBA < 2,4-D < 2,4,5-T.

The combinations of 2,4-D with dicamba seem to be better than the combinations of 2,4-D with 2,3,6-TBA and fenac.

In summary, the greenhouse ranking in order of decreasing performance was as follows:

1. picloram
2. fenac = amitrole
3. dicamba
4. 2,4-DP
5. 2,4-D = 2,4,5-T = 2,3,6-TBA

Table 1. Composition of materials

Common name	Trade name	Chemical name[1]	Concentration	Source
2,4-D	Esteron 99	2,4-dichlorophenoxy= acetic acid	4 lb/gal	Dow
2,4,5-T	Weedar 2,4,5-T	2,4,5-trichloro= phenoxyacetic acid	4 lb/gal	Amchem
2,3,6-TBA	Benzac 1281	2,3,6-trichloro= benzoic acid	2 lb/gal	Amchem
dichlorprop	Weedone 2,4-DP	2-(2,4-dichloro= phenoxy)propionic acid	4 lb/gal	Amchem
fenac	Fenac	2,3,6-trichloro= phenylacetic acid	1.5 lb/gal	Amchem
picloram	Tordon	4-amino-3,5,6-tri chloropicolinic acid	2 lb/gal	Dow
amitrole	Amitrol-T	3-amino-1,2,4-triazole	2 lb/gal	Amchem
dicamba	Banvel-D	3,6-dichloro-*o*-anisic acid	4 lb/gal	Velsicol

[1] As tabulated in this report a chemical name occupying two lines separated by an equal (=) sign is joined together without any separation if written on one line.

Table 2. Estimated percent injury to milkweed (average of two experiments)

Herbicide	Rate lb/A	Weeks after treatment									
		1	2	3	4	5	6	7	8	9	10
Amitrole	2.0	16	31	40	48	57	58	60	64	68	62
Amitrole	4.0	18	34	50	65	72	76	82	88	92	94
Amitrole	6.0	36	51	70	80	86	84	92	96	98	98
2,4-D	1.0	49	62	70	77	80	79	86	86	91	91
2,4-D	2.0	70	81	87	89	76	72	68	66	68	64
2,4-D	4.0	82	92	96	97	82	80	78	75	74	72
2,4,5-T	1.0	26	35	41	45	46	46	46	54	58	62
2,4,5-T	2.0	26	38	46	60	63	58	60	66	68	65
2,4,5-T	4.0	26	40	63	70	74	68	72	78	78	78
Fenac	1.0	32	48	58	74	77	75	77	84	84	83
Fenac	2.0	35	52	73	80	86	88	90	93	93	94
Fenac	4.0	33	68	88	97	99	98	97	97	98	98
2,4-DP	1.0	29	40	60	70	76	68	72	80	82	87
2,4-DP	2.0	21	33	49	63	68	64	73	79	82	86
2,4-DP	4.0	23	40	56	70	73	72	79	86	88	90
2,3,6-TBA	1.0	46	60	69	74	67	66	67	68	72	76
2,3,6-TBA	2.0	18	31	40	48	46	47	48	62	68	67
2,3,6-TBA	4.0	20	35	49	50	58	55	63	71	80	80
Picloram	0.5	32	61	83	92	94	92	93	96	97	98
Picloram	1.0	34	74	93	98	98	100	100	100	100	100
Picloram	2.0	38	79	99	100	100	100	100	100	100	100
Dicamba	0.5	33	50	68	76	78	79	80	82	90	88
Dicamba	1.0	30	47	70	84	88	84	87	88	90	90
Dicamba	2.0	33	57	82	87	90	90	89	92	92	92

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Table 2. Continued

Herbicide	Rate lb/A	Weeks after treatment 1	2	3	4	5	6	7	8	9	10
2,4-D + dicamba	0.5 + 0.25	38	56	83	92	94	96	97	98	98	98
2,4-D + dicamba	1.0 + 0.5	40	56	76	83	84	86	86	88	90	89
2,4-D + dicamba	2.0 + 1.0	56	75	91	95	90	90	89	88	89	88
2,4-D + dicamba	1.0 + 0.25	56	66	84	90	90	83	82	82	86	83
2,4-D + dicamba	2.0 + 0.25	60	74	80	85	80	78	78	80	81	78
2,4-D + 2,3,6-TBA	0.5 + 0.25	42	50	67	70	69	69	67	72	76	76
2,4-D + 2,3,6-TBA	1.0 + 0.5	48	68	80	84	82	79	79	79	80	76
2,4-D + 2,3,6-TBA	2.0 + 1.0	52	62	80	88	85	82	75	78	79	80
2,4-D + 2,3,6-TBA	1.0 + 0.25	46	56	71	82	78	78	78	79	80	82
2,4-D + 2,3,6-TBA	2.0 + 0.25	63	78	90	96	86	82	74	75	76	76
2,4-D + fenac	0.5 + 0.25	50	65	73	78	76	75	73	80	78	80
2,4-D + fenac	1.0 + 0.5	46	64	76	82	84	80	78	75	82	83
2,4-D + fenac	2.0 + 1.0	68	75	91	92	90	84	78	80	82	81
2,4-D + fenac	1.0 + 0.25	68	78	84	88	79	77	75	82	78	80
2,4-D + fenac	2.0 + 0.25	62	70	85	90	91	86	85	86	88	89

Table 3. Regrowth from axillary buds and rhizomes before and after harvest (Experiment 1)

Treatment	Rate lb/A	Rating of regrowth two weeks after treatment[1/]	Height of regrowth at harvest (in)		Rating of regrowth at harvest[1/]	
			From axillary buds	From rhizomes	From axillary buds	From rhizomes
Check		2.8	0.0	0.0	1.0	1.0
Amitrole	2.0	2.3	0.0	0.0	1.0	1.0
Amitrole	4.0	1.5	0.0	0.0	1.0	1.0
Amitrole	6.0	1.2	0.0	0.3	1.0	1.1
2,4-D	1.0	1.0	0.0	0.0	1.0	1.0
2,4-D	2.0	2.8	4.8	9.3	1.4	1.6
2,4-D	4.0	3.0	4.6	10.0	1.4	2.2
2,4,5-T	1.0	1.8	0.0	0.0	1.0	1.0
2,4,5-T	2.0	2.2	3.9	3.8	1.4	1.6
2,4,5-T	4.0	1.8	0.0	0.1	1.0	1.2
Fenac	1.0	2.2	0.0	3.3	1.0	1.6
Fenac	2.0	2.0	0.0	1.9	1.0	1.6
Fenac	4.0	1.8	0.0	2.1	1.0	1.4
2,4-DP	1.0	1.9	0.0	0.0	1.0	1.0
2,4-DP	2.0	1.8	0.0	0.7	1.0	1.2
2,4-DP	4.0	1.6	2.1	0.0	1.2	1.0
2,3,6-TBA	1.0	2.2	6.1	4.4	1.6	1.6
2,3,6-TBA	2.0	2.4	0.0	5.6	1.0	1.8
2,3,6-TBA	4.0	2.1	0.0	0.3	1.0	1.2
Picloram	0.5	1.5	0.0	1.3	1.0	1.1
Picloram	1.0	1.1	0.0	0.0	1.0	1.0
Picloram	2.0	1.0	0.0	0.0	1.0	1.0
Dicamba	0.5	2.3	0.0	3.1	1.0	1.8
Dicamba	1.0	1.8	0.0	4.0	1.0	1.4
Dicamba	2.0	1.6	1.1	2.2	1.2	1.4

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Table 3. Continued

Treatment	Rate lb/A	Rating of regrowth two weeks after treatment[1/]	Height of regrowth at harvest (in)		Rating of regrowth at harvest[1/]	
			From axillary buds	From rhizomes	From axillary buds	From rhizomes
2,4-D + dicamba	0.5 + 0.25	1.2	0.0	0.4	1.0	1.3
2,4-D + dicamba	1.0 + 0.5	2.1	3.0	2.1	1.4	1.5
2,4-D + dicamba	2.0 + 1.0	2.4	0.0	9.4	1.0	2.2
2,4-D + dicamba	1.0 + 0.25	2.4	7.7	3.1	1.8	1.4
2,4-D + dicamba	2.0 + 0.25	2.2	6.3	0.2	1.6	1.2
2,4-D + 2,3,6-TBA	0.5 + 0.25	2.3	1.9	1.7	1.2	1.4
2,4-D + 2,3,6-TBA	1.0 + 0.5	2.4	2.2	2.6	1.2	1.4
2,4-D + 2,3,6-TBA	2.0 + 1.0	2.4	2.3	9.8	1.2	2.2
2,4-D + 2,3,6-TBA	2.0 + 0.25	2.6	1.8	3.0	1.2	1.8
2,4-D + 2,3,6-TBA	2.0 + 0.25	3.0	3.9	9.7	1.4	2.2
2,4-D + fenac	0.5 + 0.25	2.4	1.6	4.4	1.2	1.6
2,4-D + fenac	1.0 + 0.5	2.0	2.0	4.0	1.4	1.6
2,4-D + fenac	2.0 + 1.0	2.6	4.3	9.2	1.4	2.2
2,4-D + fenac	1.0 + 0.25	2.6	0.0	10.2	1.0	2.2
2,4-D + fenac	2.0 + 0.25	2.6	5.0	0.0	1.6	1.0
LSD		0.73	4.581	5.008	0.4693	0.6639

[1/] 1 = no regrowth; 2 = abnormal regrowth; 3 = normal regrowth

Table 4. Regrowth from rhizomes before and after harvest (Experiment 2)

Treatment	Rate lb/A	Height of regrowth from rhizomes at harvest (in)	Rating of regrowth from rhizomes[1/] At harvest	2 weeks after harvest	4 weeks after harvest	5 weeks after harvest
Check		0.0	1.0	1.4	1.4	1.4
Amitrole	2.0	0.0	1.0	1.0	1.0	1.0
Amitrole	4.0	0.0	1.0	1.0	1.0	1.0
Amitrole	6.0	0.0	1.0	1.0	1.0	1.0
2,4-D	1.0	0.1	1.2	1.0	1.0	1.0
2,4-D	2.0	0.9	1.4	1.0	1.4	1.4
2,4-D	4.0	2.0	2.2	1.4	1.8	2.2
2,4,5-T	1.0	0.5	1.2	1.0	1.0	1.0
2,4,5-T	2.0	0.0	1.0	1.0	1.0	1.0
2,4,5-T	4.0	0.0	1.0	1.0	1.0	1.0
Fenac	1.0	0.0	1.0	1.0	1.0	1.0
Fenac	2.0	0.0	1.0	1.0	1.0	1.0
Fenac	4.0	0.0	1.0	1.0	1.0	1.0
2,4-DP	1.0	0.0	1.0	1.0	1.0	1.0
2,4-DP	2.0	0.0	1.0	1.0	1.0	1.0
2,4-DP	4.0	0.0	1.0	1.0	1.0	1.0
2,3,6-TBA	1.0	0.0	1.0	1.0	1.0	1.0
2,3,6-TBA	2.0	0.0	1.0	1.0	1.0	1.0
2,3,6-TBA	4.0	0.0	1.0	1.0	1.0	1.0
Picloram	0.5	0.1	1.1	1.0	1.0	1.0
Picloram	1.0	0.0	1.0	1.0	1.0	1.0
Picloram	2.0	0.0	0.9	1.0	1.0	1.0
Dicamba	0.5	0.1	1.1	1.0	1.0	1.0
Dicamba	1.0	0.0	1.0	1.2	1.2	1.4
Dicamba	2.0	0.0	1.0	1.0	1.0	1.0

-continued

Table 4. Continued

Treatment	Rate lb/A	Height of regrowth from rhizomes at harvest (in)	Rating of regrowth from rhizomes[1/] At harvest	2 weeks after harvest	4 weeks after harvest	5 weeks after harvest
2,4-D + dicamba	0.5 + 0.25	0.0	1.0	1.2	1.2	1.2
2,4-D + dicamba	1.0 + 0.5	0.1	1.1	1.2	1.4	1.4
2,4-D + dicamba	2.0 + 1.0	0.0	1.0	1.0	1.2	1.2
2,4-D + dicamba	1.0 + 0.25	0.6	1.3	1.2	1.2	1.3
2,4-D + dicamba	2.0 + 0.25	1.1	1.1	1.6	1.6	1.8
2,4-D + 2,3,6-TBA	0.5 + 0.25	0.0	1.0	1.4	1.4	1.4
2,4-D + 2,3,6-TBA	1.0 + 0.5	0.2	1.2	1.0	1.0	1.0
2,4-D + 2,3,6-TBA	2.0 + 1.0	0.1	1.2	1.0	1.0	1.0
2,4-D + 2,3,6-TBA	1.0 + 0.25	0.7	1.6	1.2	1.3	1.4
2,4-D + 2,3,6-TBA	2.0 + 0.25	0.6	1.2	1.2	1.2	1.2
2,4-D + fenac	0.5 + 0.25	0.0	1.0	1.0	1.2	1.2
2,4-D + fenac	1.0 + 0.5	0.0	1.0	1.2	1.2	1.4
2,4-D + fenac	2.0 + 1.0	0.2	1.2	1.2	1.4	1.6
2,4-D + fenac	1.0 + 0.25	0.6	1.2	1.2	1.2	1.2
2,4-D + fenac	2.0 + 0.25	0.3	1.2	1.0	1.0	1.0
LSD		0.7796	0.3656	0.3486	0.4184	0.4458

[1/] 1 = no regrowth; 2 = abnormal regrowth; 3 = normal regrowth

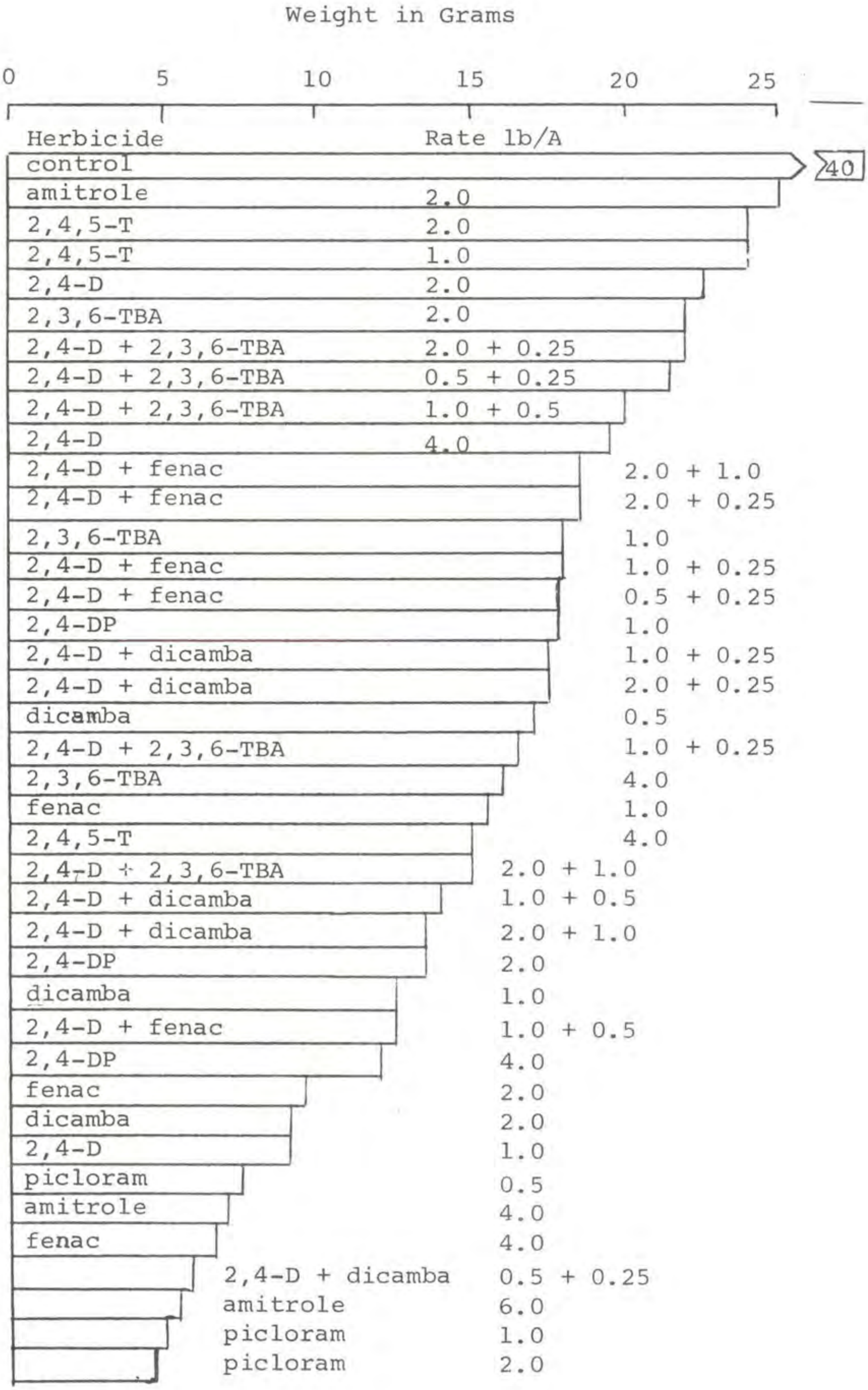


Figure 1. Fresh weights of milkweeds ten weeks after treatment in the greenhouse (average of two experiments)

CHAPTER III

HERBICIDE TREATMENTS FOR THE CONTROL OF COMMON MILKWEED ON ROADSIDES

Three experiments were conducted over a period of four years to evaluate selected herbicide treatments for control of common milkweed.

Materials and Methods:

LOCATION: Studies were located along the following roadsides in Boone County: Route AB, Route Z, and Rangeline Road.

EXPERIMENTAL DESIGN: All studies were conducted in a randomized complete block design with four replications.

PLANTS SPECIES STUDIED: Common milkweed (*Asclepias syriaca*)

DATES OF STUDIES: The study located along Route AB was conducted from June, 1970 to July, 1971. The study located along Route Z was conducted from June, 1972 to June, 1973. The study located along Rangeline Road was conducted from June, 1973 to June, 1974.

METHODS OF APPLICATIONS: Treatments along Route AB were made with a roller pump using a Teejet OC 150 nozzle applying 80 gpa at 35 psi and at a travel speed of 2.5 mph. Treatments along Route Z and Rangeline Road were made with a sprayer unit mounted on a platform behind a 1010 John Deere Tractor.

A 35 hp Wisconsin engine was used to drive a large capacity centrifugal pump. A Teejet OC 150 nozzle was used and treatments were applied in 50 gpa at 30 psi at a speed of 5 mph.

DATA TAKEN: The percent kill of common milkweed was determined in the fall following treatment in the experiment on Route Z and one year after treatment on all of the experiments. This was computed from plant counts made before treatment, in the fall following treatment, and in the spring one year after treatment.

LIST OF TABLES:

LIST OF FIGURES:

Results and Discussion:

The average control of common milkweed in three experiments is shown in Figures 1 through 6. Figure 7 gives this information for two experiments. Picloram gave the best control. Adding 2,4-D to picloram was of little benefit. There is an indication that it was detrimental. Dicamba and fenac were intermediate in performance. A combination of 2,4-D and dicamba at one-half normal rate of each gave better control than a full rate of either material. Control with 2,4-DP and 2,4-D averaged poorer than with the other herbicides.

The control of common milkweed in the experiment on Route Z is shown in Figures 8 through 14. In general, control in this experiment was better than the average. This was especially true for picloram and 2,4-DP. It is evident from these data that the true performance of herbicides for control of perennial weeds cannot be evaluated accurately in the fall of the year in which the treatments are made. Without exception, the apparent kill was higher than it was the following spring and, except for treatments that were highly effective, it was much higher. This is an indication that sufficient herbicide was absorbed to kill the tops of the plants, but not enough was translocated to kill most of the rhizomes.

Table 1. Composition of materials

Common name	Trade name	Chemical name[1/]	Concentration	Source
2,4-D	Weedone LV4	2,4-dichlorophenoxy= acetic acid, butoxy= ethanol ester	4 lb/gal	Amchem
dichlorprop (2,4-DP)	Weedone 2,4-DP	2-(2,4-dichlorophen= oxy)propionic acid, butylethyl ester	4 lb/gal	Amchem
fenac	Fenac	2,3,6-trichlorophen= ylacetic acid	1.5 lb/gal	Amchem
picloram	Tordon	4-amino-3,5,6-tri= chloropicolinic acid	2 lb/gal	Dow
dicamba	Banvel-D	3,6-dichloro-*o*-anisic acid	4 lb/gal	Velsicol

[1/] As tabulated in this report, a chemical name occupying two lines separated by an equal (=) sign is joined together without any separation if written on one line.

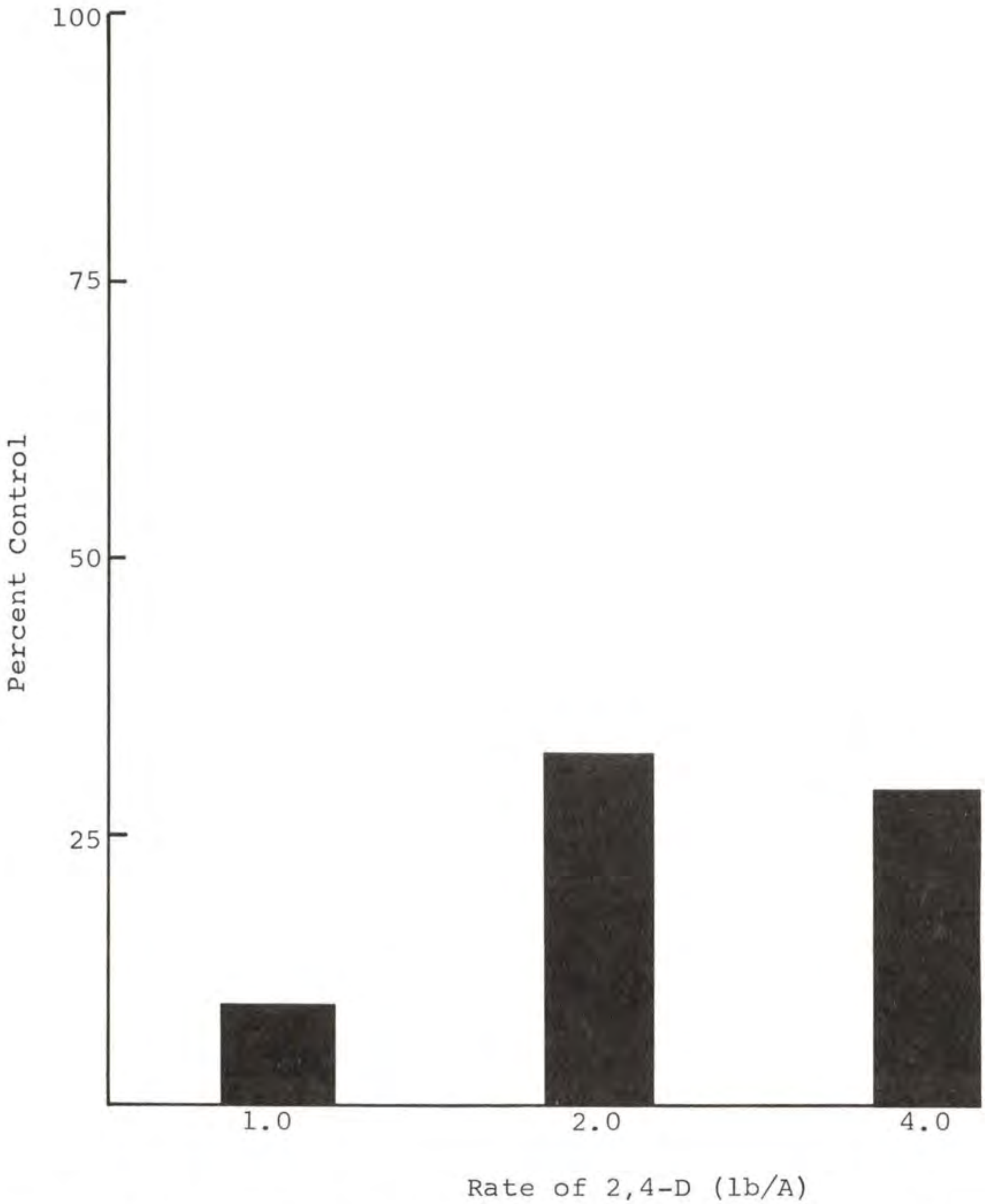


Figure 1. The control of common milkweed with 2,4-D in the spring one year after treatment (average of three experiments)

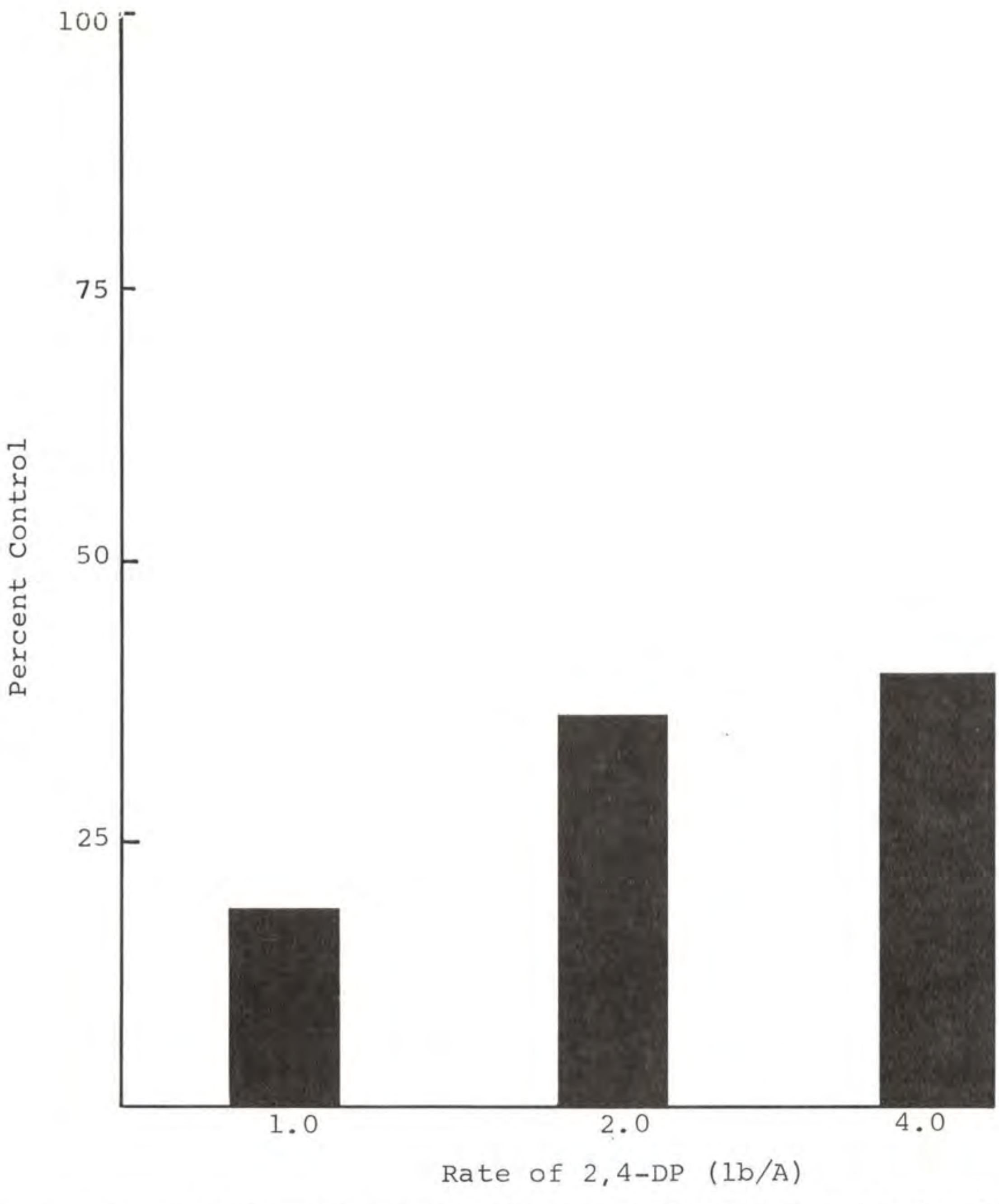


Figure 2. The control of common milkweed with 2,4-DP in the spring one year after treatment (average of three experiments)

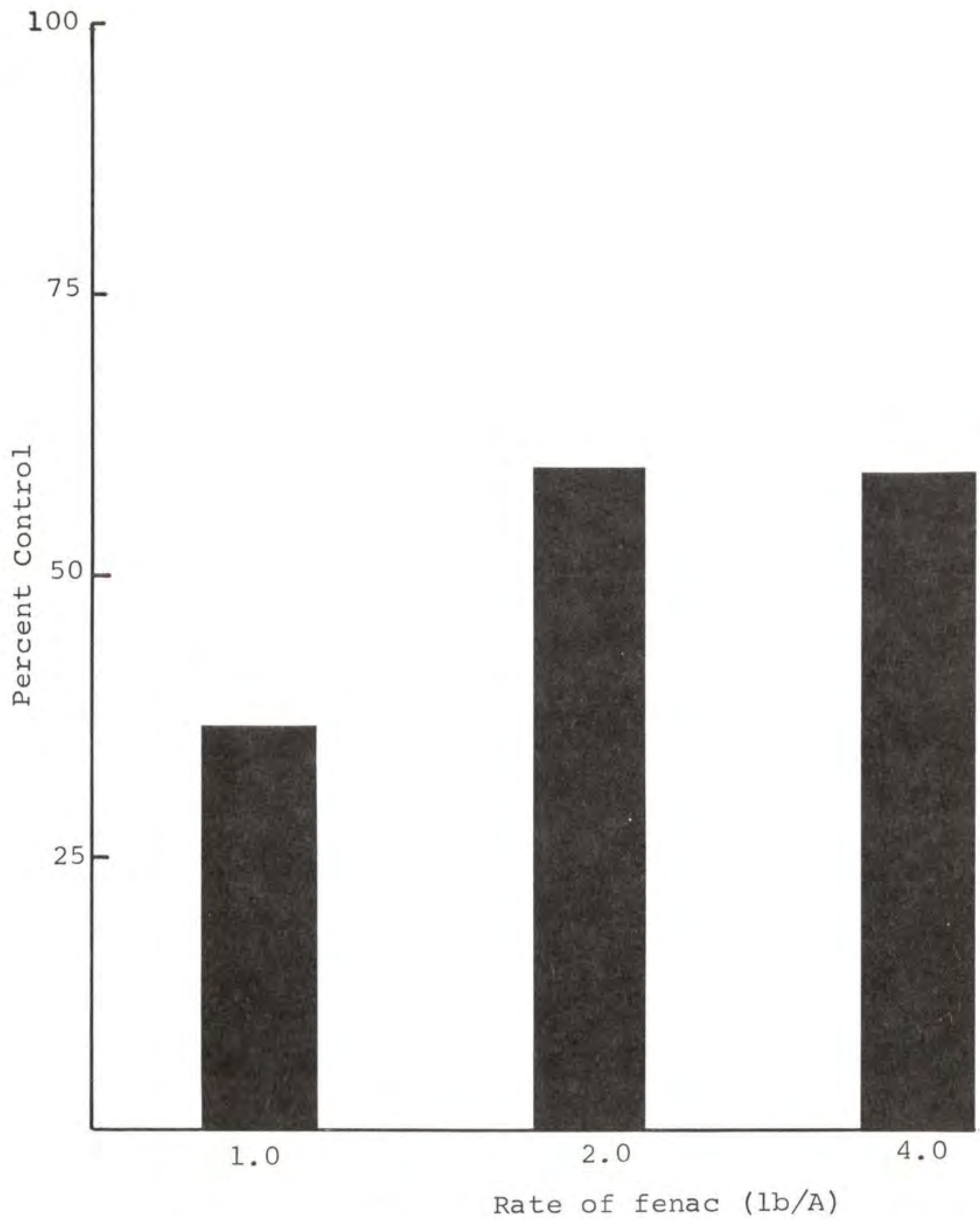


Figure 3. The control of common milkweed with fenac in the spring one year after treatment (average of three experiments)

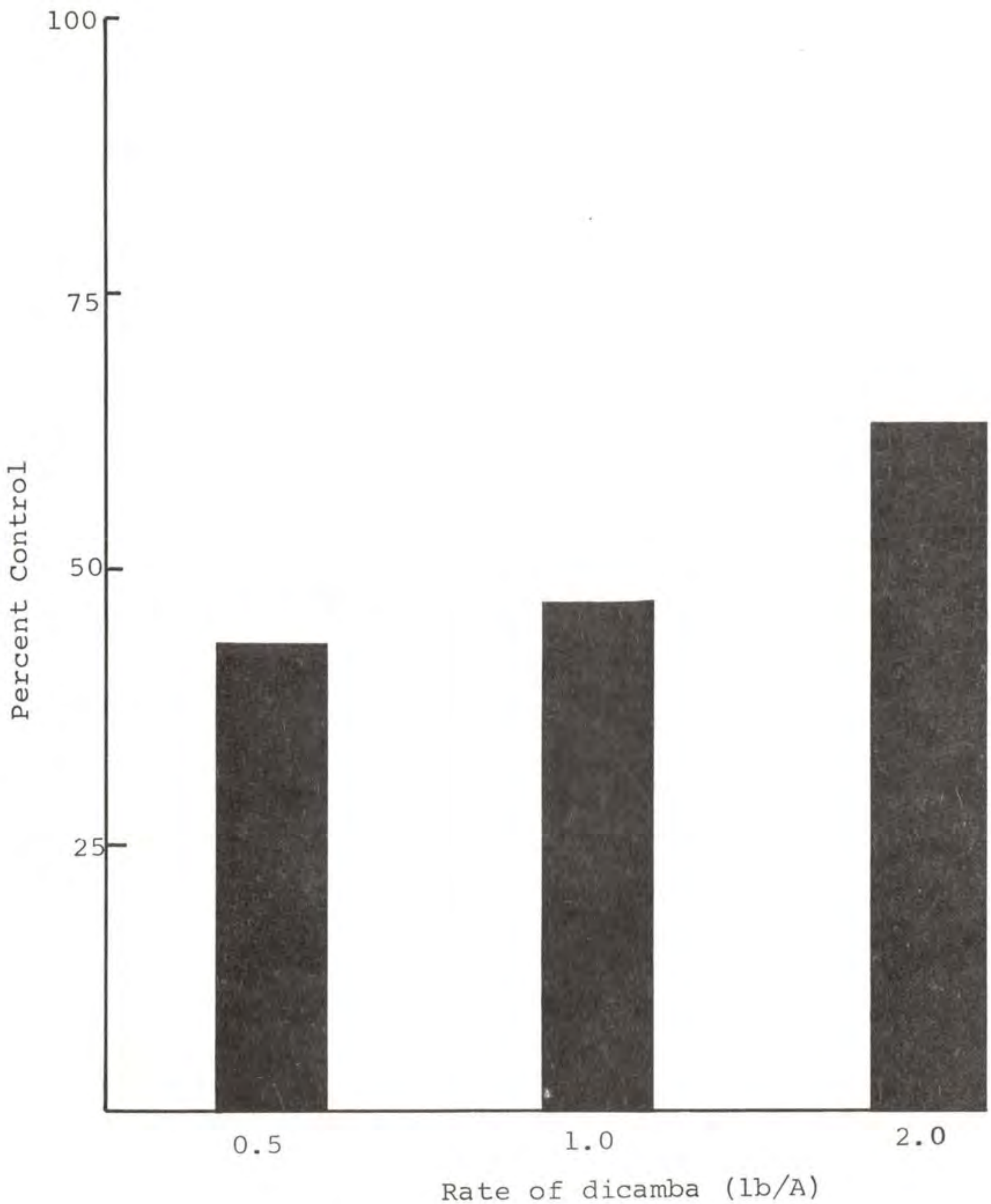


Figure 4. The control of common milkweed with dicamba in the spring one year after treatment (average of three experiments)

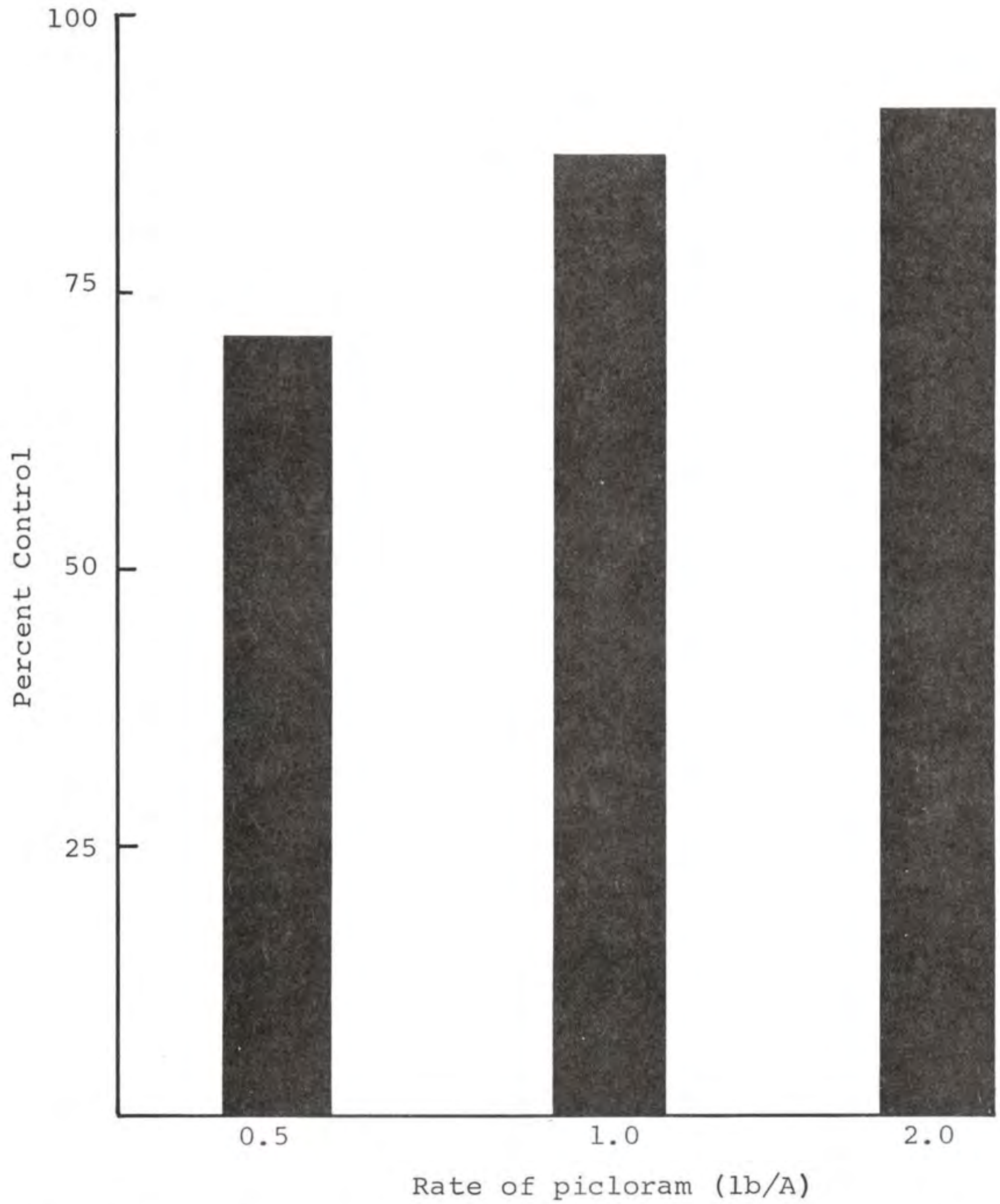


Figure 5. The control of common milkweed with picloram in the spring one year after treatment (average of three experiments)

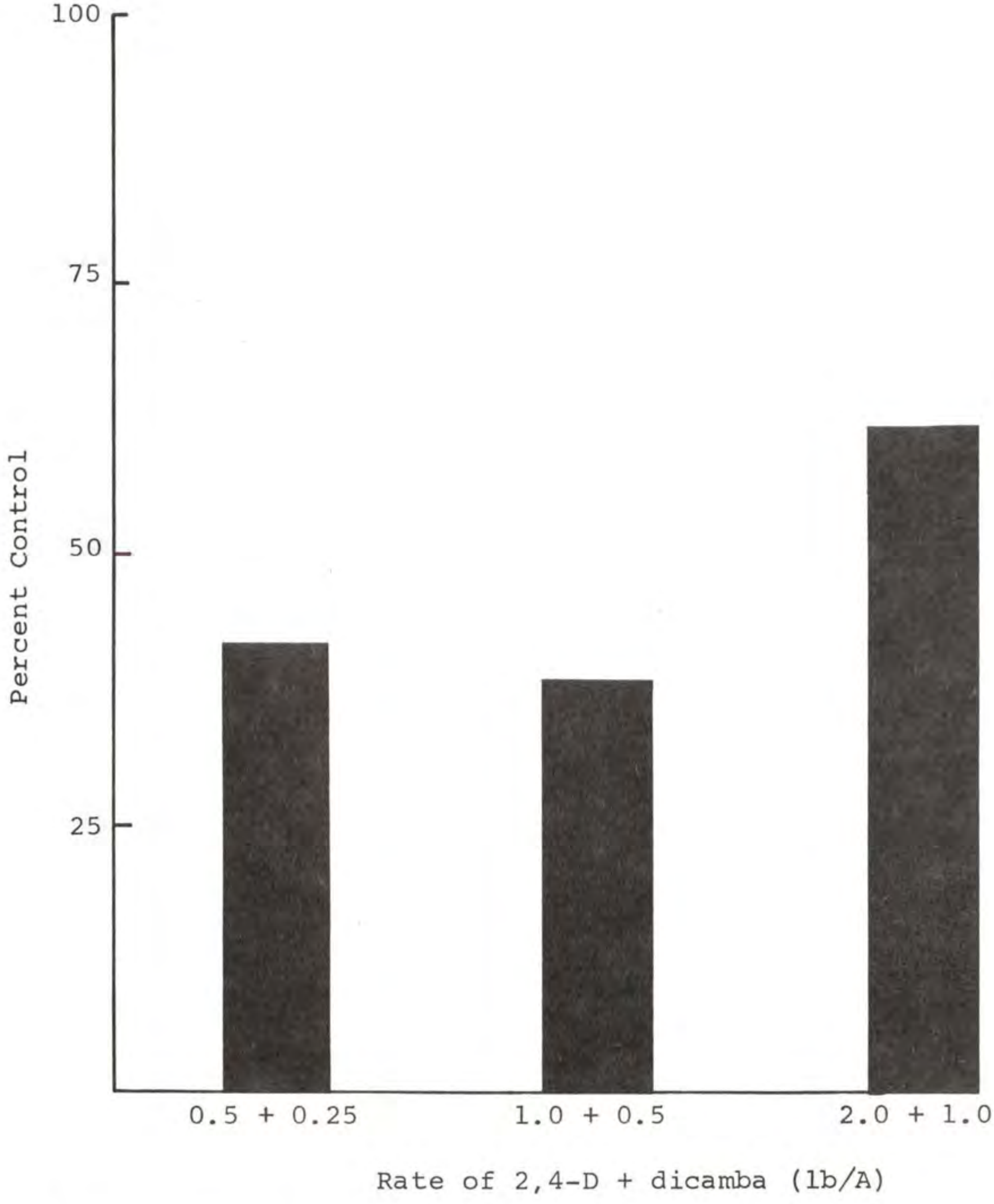


Figure 6. The control of common milkweed with 2,4-D + dicamba in the spring one year after treatment (average of three experiments)

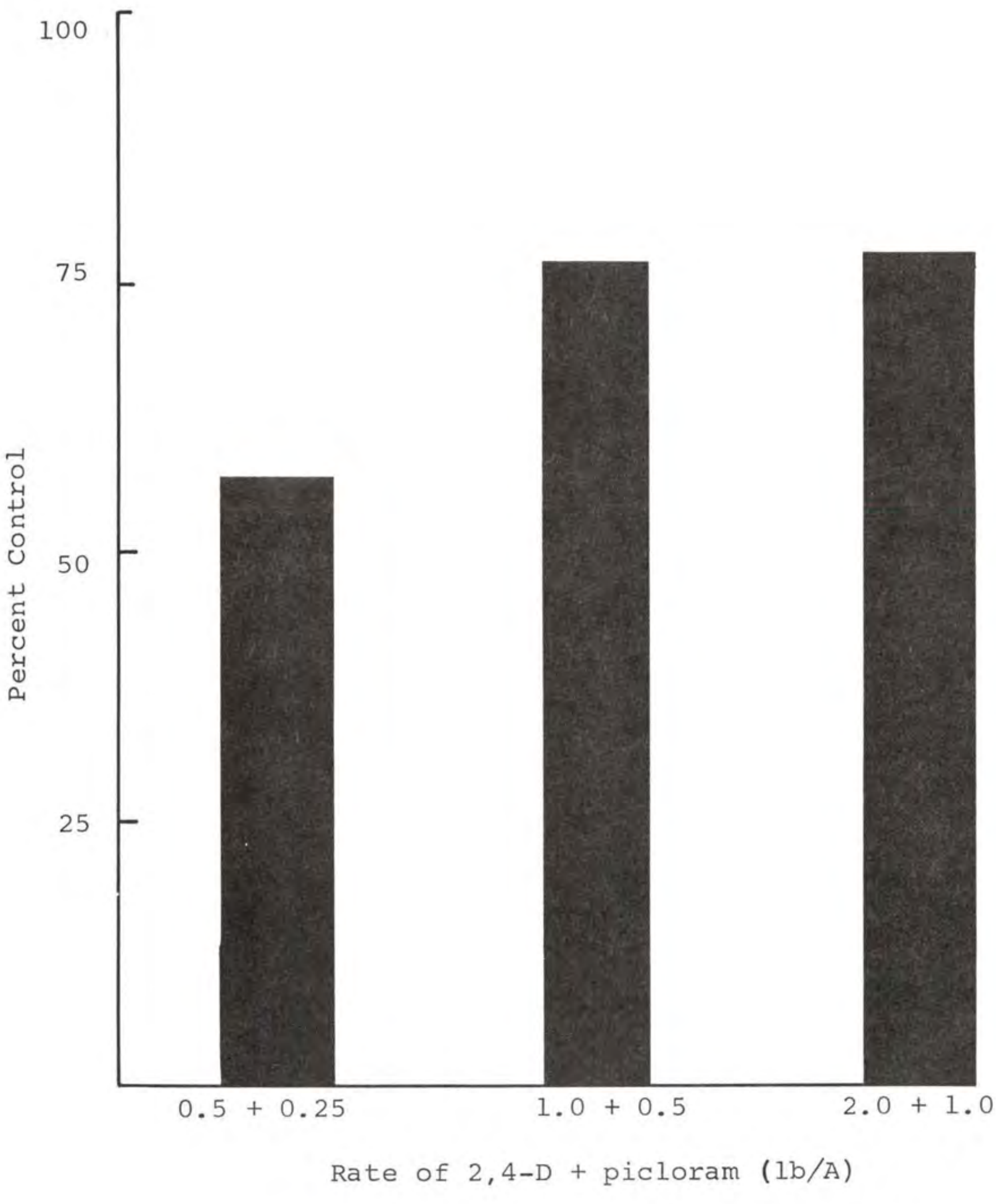


Figure 7. The control of common milkweed with 2,4-D + picloram in the spring one year after treatment (average of two experiments on Route Z and Rangeline Road)

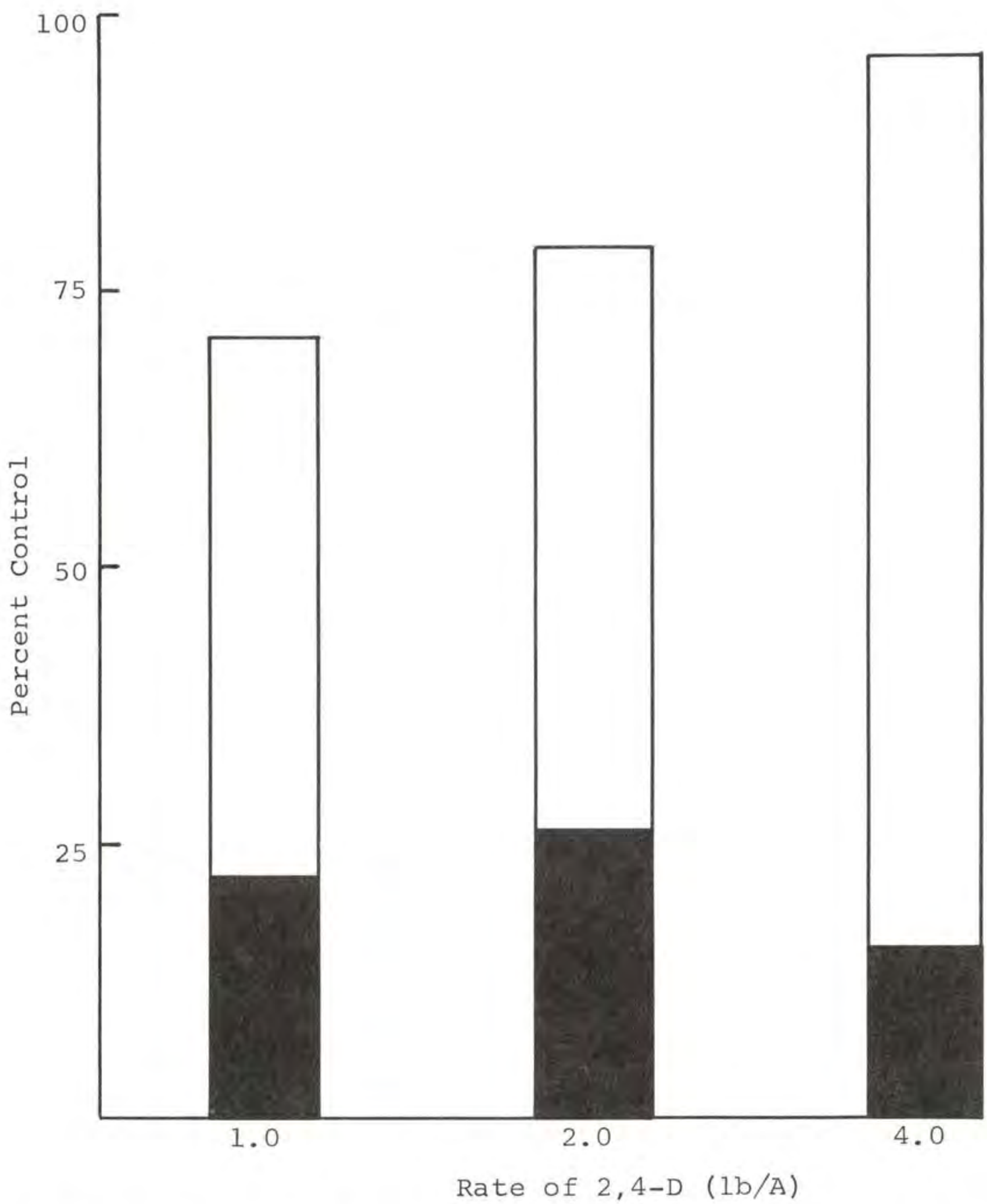


Figure 8. The control of common milkweed with 2,4-D in the fall (entire bar) and spring (shaded bar) after treatment (one experiment on Route Z)

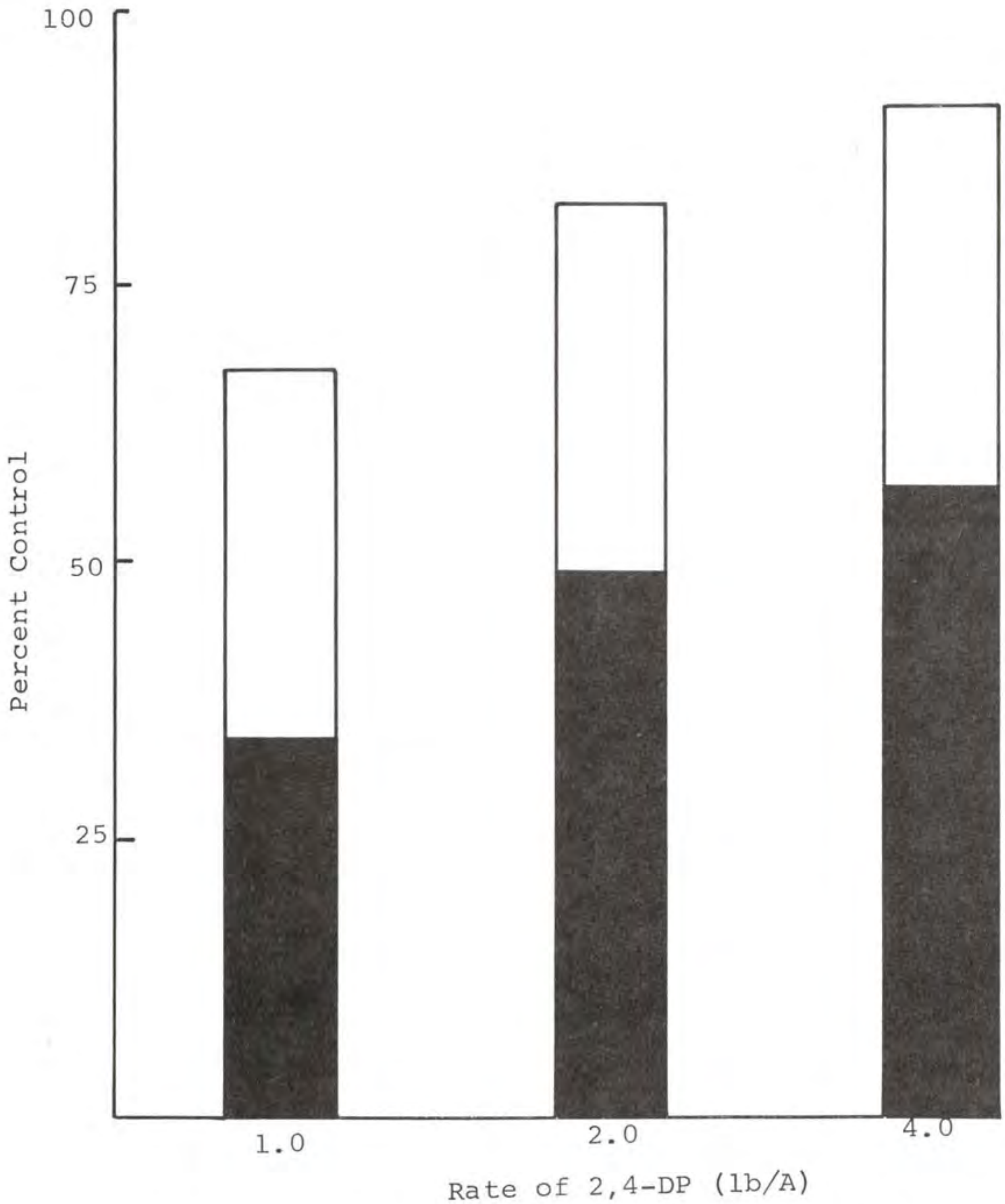


Figure 9. The control of common milkweed with 2,4-DP in the fall (entire bar) and spring (shaded bar) after treatment (one experiment on Route Z)

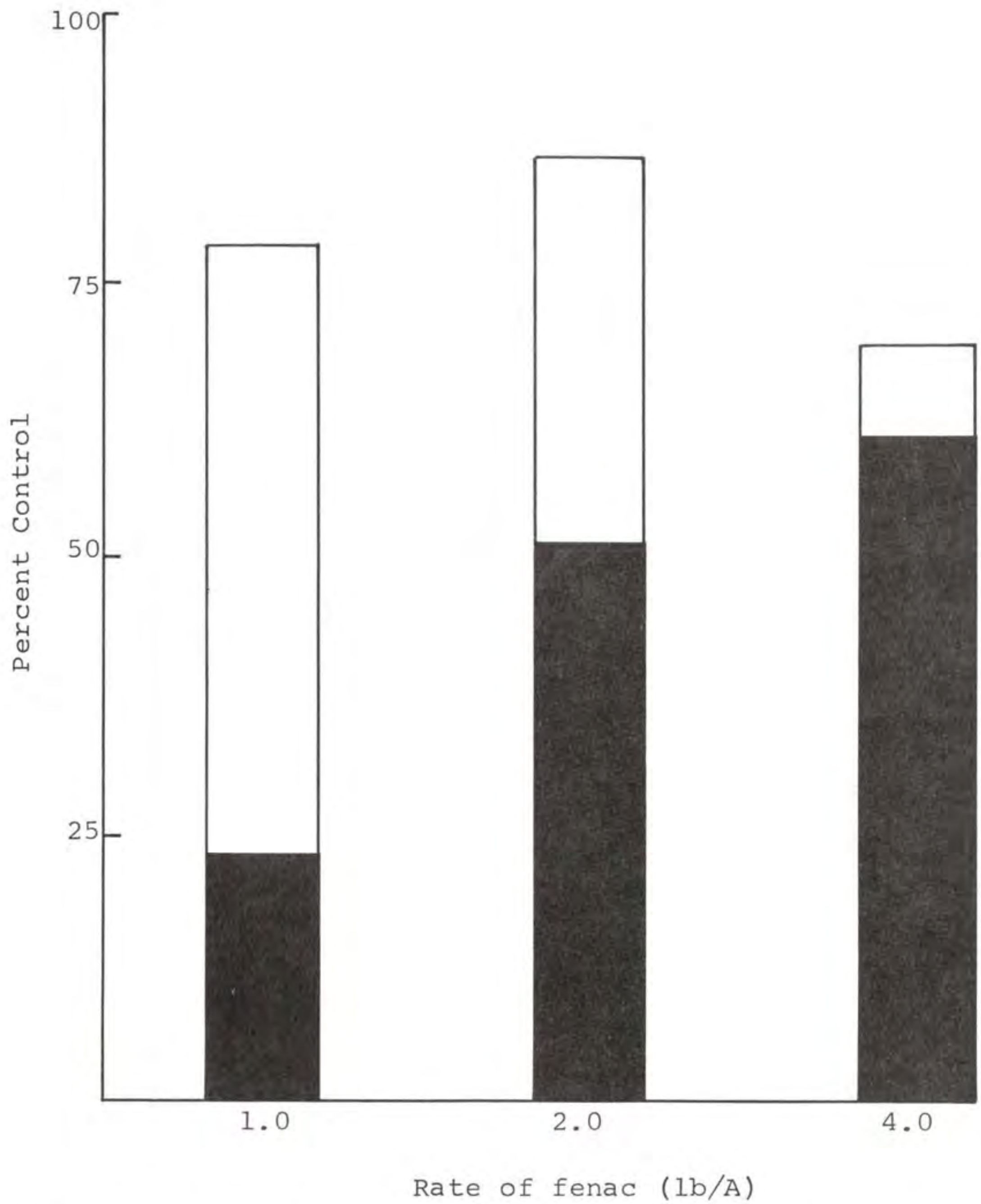


Figure 10. The control of common milkweed with fenac in the fall (entire bar) and spring (shaded bar) after treatment (one experiment on Route Z)

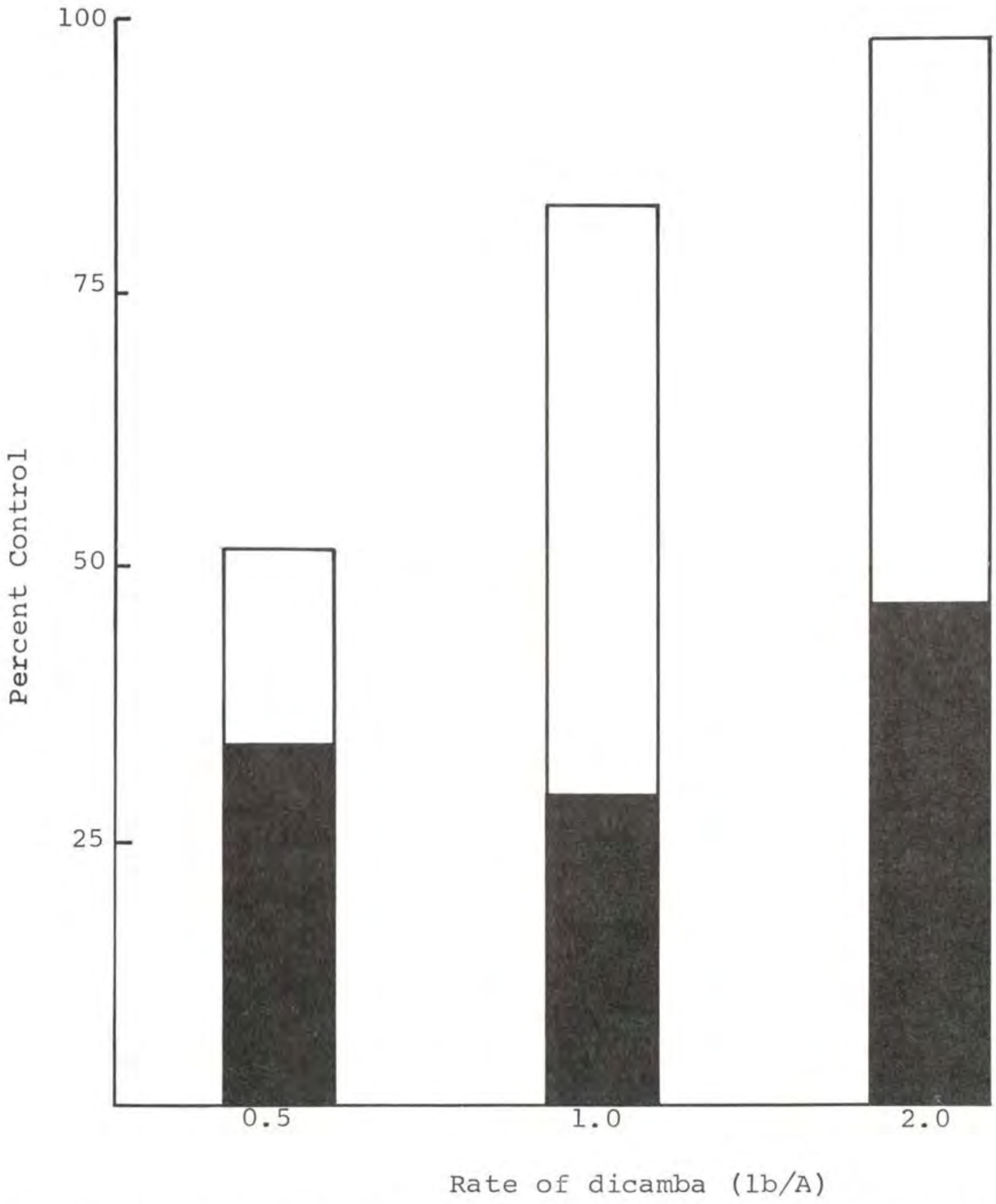


Figure 11. The control of common milkweed with dicamba in the fall (entire bar) and spring (shaded bar) after treatment (one experiment on Route Z)

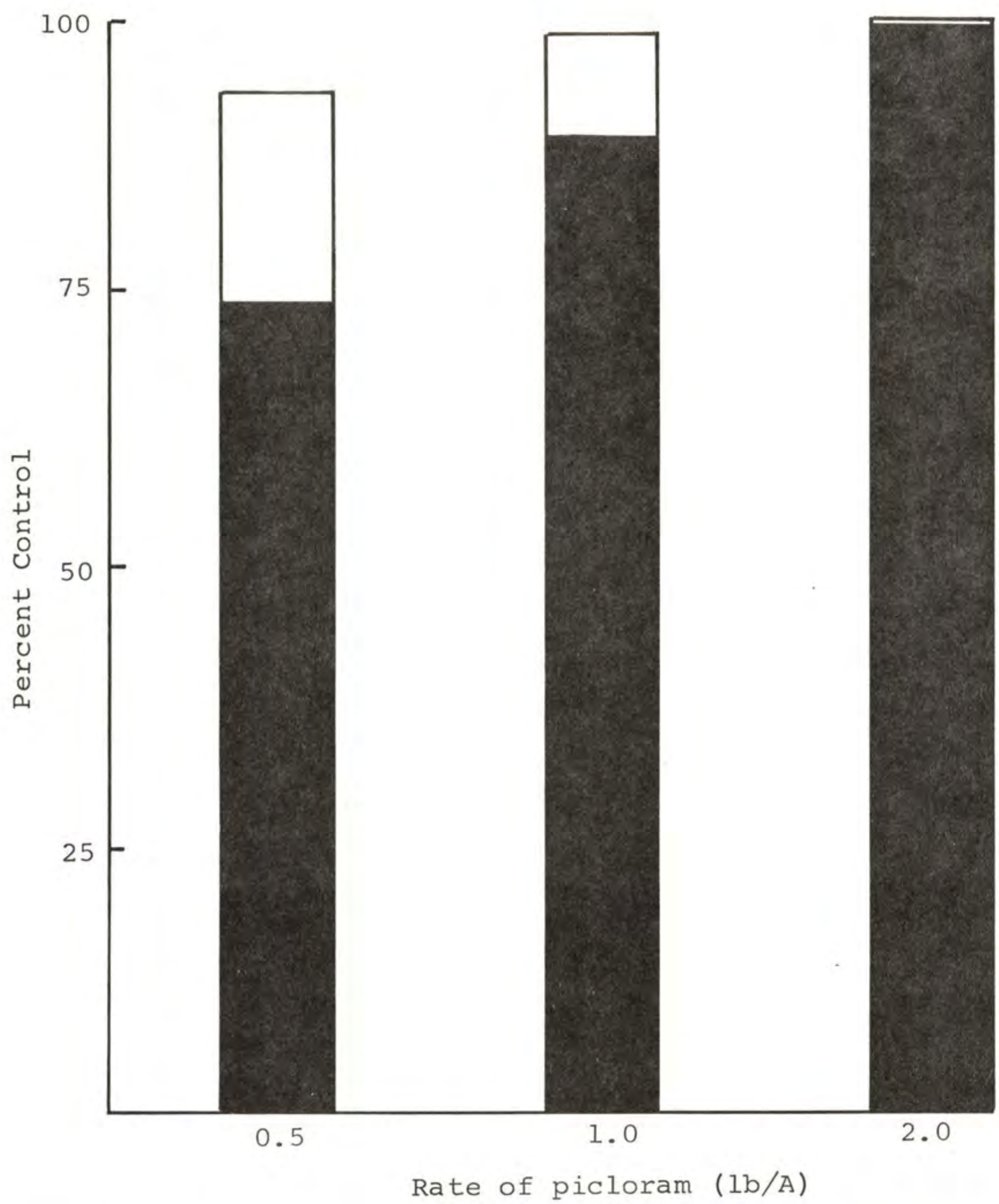


Figure 12. The control of common milkweed with picloram in the fall (entire bar) and spring (shaded bar) after treatment (one experiment on Route Z)

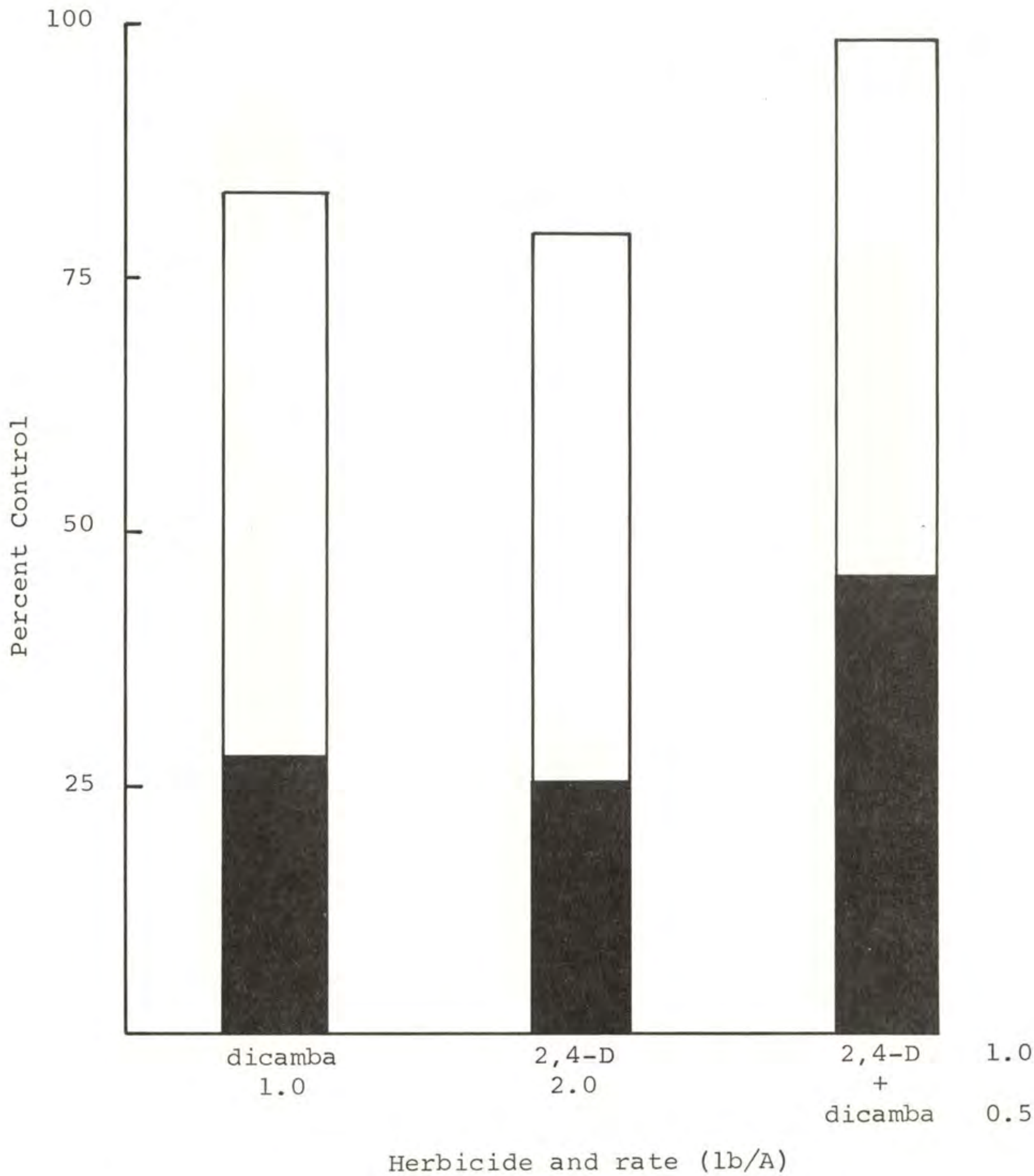


Figure 13. The control of common milkweed in the fall (entire bar) and spring (shaded bar) after treatment (one experiment on Route Z)

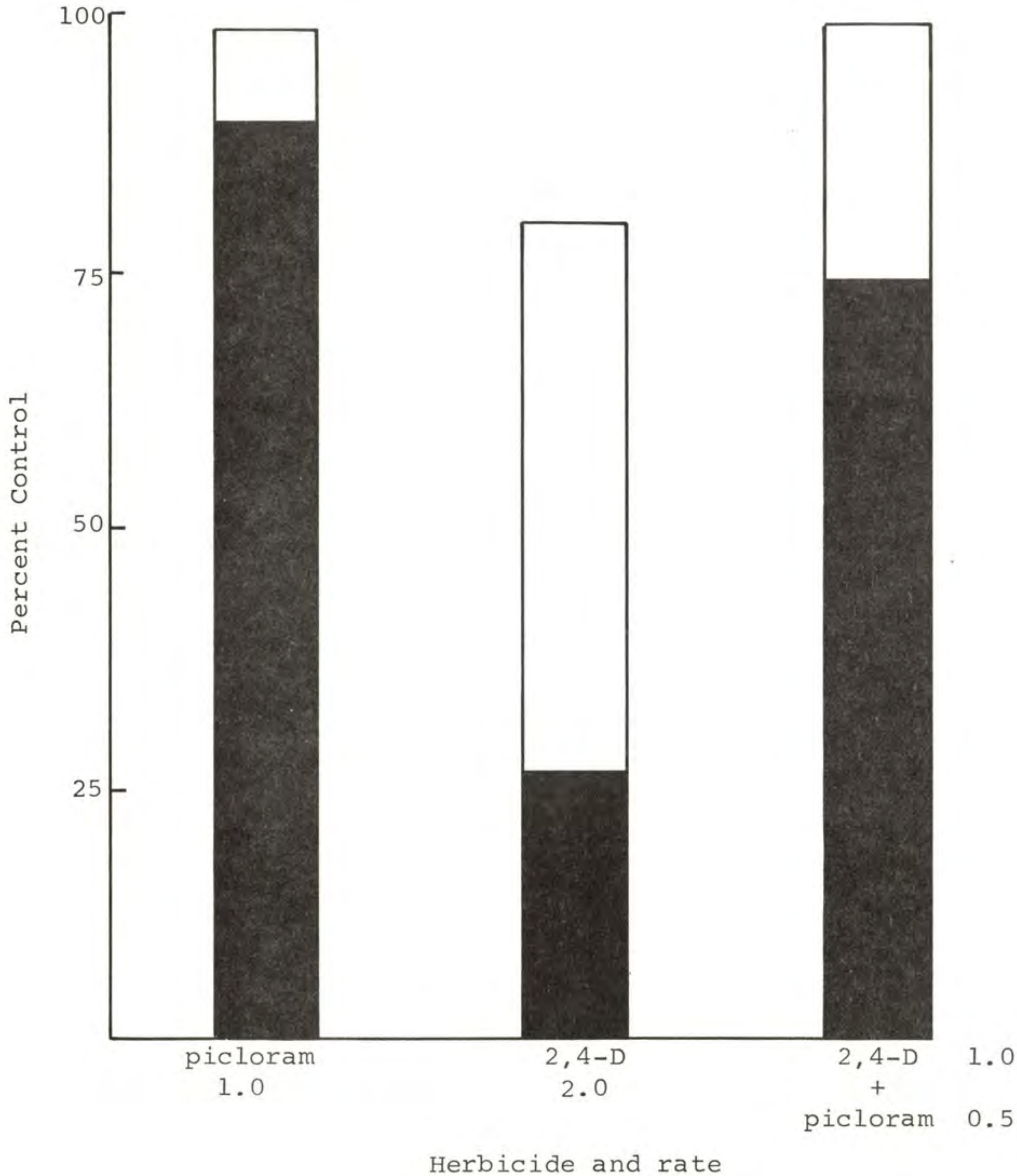


Figure 14. The control of common milkweed in the fall (entire bar) and spring (shaded bar) after treatment (one experiment on Route Z)

CHAPTER IV

PHYSICAL PROPERTIES OF THICKENED SPRAYS

The effects of thickening agent, herbicide, setting time, temperature, and type of agitation on the viscosity surface tension, and density of spray mixtures were determined. The concentrations of herbicides and thickening agents were varied.

Materials and Methods:

LOCATION: Agricultural Engineering Research Laboratory, Building T-12, University of Missouri, Columbia, Missouri.

TEMPERATURE: Room temperature was maintained at $70^{\circ}F$. A water bath was used for the 50° and $90^{\circ}F$ solutions. All ingredients were kept in the water bath until mixing. After mixing, they were returned until measurements were made.

TYPE OF MIXING: A Sovall Omni-mixer running at approximately 975 RPM was used to mix all samples except those in the type-of-mixing study. In this study, the Omni-mixer was compared to a small centrifugal pump that was run by an electric motor. Quart jars were used as the spray containers with the mixer. A five-gallon bucket was used with the centrifugal pump.

THICKENING AGENTS: The following thickening agents were used at the manufacturers' recommended rates (X rate):

1. Norbak, a water-swellable polymer manufactured by Dow Chemical Company
2. Dacagin, a gelling agent manufactured by Diamond Shamrock Chemical Company
3. Kelzan, a high molecular weight linear polysaccharide manufactured by Kelco Company
4. Vistik, a special extra-high viscosity grade of hydroxyethyl cellulose manufactured by Hercules Powder Company

HERBICIDES: Two,4-D; 2,4,5-T; 2,3,6-TBA; picloram; and dicamba were used at the recommended rates for controlling perennial broadleaved weeds on noncrop land at a simulated application volume of 50 gpa.

MEASUREMENTS TAKEN: The following measurements were taken;

1. viscosity with a Brookfield LV viscometer
2. surface tension with a DuNouy torsion balance manufactured by Fisher Apparatus Company
3. density by weighing a known volume of spray mixture

SETTING TIME: Measurements were taken at 30 minutes for all studies except the "time of mixing" study in which 15 and 50 minute setting times were compared.

EXPERIMENTAL DESIGN: A randomized complete block with four replications was used.

LIST OF TABLES:

Table 9. The physical properties of thickened sprays after two types of agitation (average of 4 replications)

Results and Discussion:

Special care was exercised in mixing all thickening agents with water. Norbak and Dacagin were easily thickened by gentle agitation necessary only for dispersion. Vistik also thickened easily but required the addition and dispersion of soda ash before the addition of herbicide. Dispersion was a problem with Kelzan. A few small lumps sometimes remained after mixing in the laboratory with the Omni-mixer. In the field it was necessary to disperse the powder with a low molecular weight alcohol before addition to water.

The viscosity of Norbak decreased as setting time (time elapse between mixing and measuring) increased, but became fairly constant after 30 minutes. There were no significant differences in viscosity between setting times of 15, 30, and 60 minutes for mixtures of Dacagin, Kelzan, and Vistik. Setting time had no appreciable effect on surface tension or density. Since the viscosity of Norbak became fairly constant after 30 minutes, all mixtures were allowed to set this amount of time before the physical properties were measured.

Significant differences in viscosity were attained among all three rates of mixtures of the four thickening agents except between the ½X and X rates of Vistik (See Table 3).

As the concentration of each agent increased, the viscosity increased. For most agents, the surface tension increased significantly as the rate of agent increased from ½X to X and also from X to 2 X. Dacagin mixtures had the greatest surface tension allowed by Norbak. Kelzan and Vistik had the lowest surface tension over this wide range of viscosity. (See Table 3)

The lowest density recorded for any thickened spray mixture was 0.9157 compared to 1.0 for water and 0.99 for 2,4-D and water. Density has little effect on droplet formation, particularly in the small range commercially encountered in spraying (0.78 to 1.2 g/cc). Therefore, our greatest change in density had little effect on droplet formation.

The viscosity of Vistik decreased markedly as the temperature increased from 50 to 90 F. The viscosity of Norbak was affected in a similar manner, but to a lesser degree. The viscosity of the gelling agent (Dacagin) was greatest at 70°. Kelzan was stable at higher temperatures. (See Table 4)

Changes in temperature had no effect on surface tension or density. The surface tensions of spray mixtures of Norbak, Kelzan, and Dacagin were significantly greater than the surface tensions of Vistik and water mixtures. (All mixtures contained 2,4-D.) The lowest density measured was 0.9157, not low enough to cause a significant change in droplet spectra.

The rates of Norbak and Dacagin recommended for 1% V/V mixture of 2,4-D ester were not sufficient to give adequate thickening of the amine salts (2,3,6-TBA; picloram; and dicamba). Therefore, the rates of Norbak and Dacagin were increased to give viscosities similar to mixtures containing 2,4-D ester. The rates evaluated are shown in Table 5.

After changing the rate of Norbak, there were no significant differences in viscosity between the mixtures containing different herbicides. However, the viscosity of Norbak and water without any herbicide was significantly greater than mixtures with herbicides. The viscosity of Dacagin mixtures without herbicide was less than that with herbicide. These data and personal experience show the viscosity of Dacagin mixtures is quite unpredictable, especially at high rates of amine salt herbicides.

The rates of Kelzan and Vistik were not adjusted for the amine salt herbicides as was necessary with Norbak and Dacagin. There were no significant differences between viscosities of all herbicide mixtures at 4.5 lb of Vistik/100 gallons of water. The viscosity without herbicide was much greater than the viscosity with herbicide. The viscosity of Kelzan mixtures was significantly greater when mixed with esters and no herbicide than with the amine salts. However, the rates of Kelzan were not adjusted because the difference was small (approximately 15%).

As the rate of herbicide increased, the viscosity of mixtures with all thickening agents except Vistik decreased. There was no significant difference between the three rates of herbicides with Vistik; however, viscosity tended to increase as rate of herbicide increased.

The surface tension of spray mixtures with Dacagin was significantly greater than water plus herbicide. However, mixtures of water with Kelzan or Vistik had significantly lower surface tensions than water plus herbicide.

The surface tensions of the five herbicides and water with no thickening agent were unpredictable, even after studying their molecular structures. The surface tension of the dimethylamine salt of dicamba in water was significantly greater than solutions with the dimethylamine salt of 2,3,6-TBA, which was significantly greater than the potassium salt of picloram and water. The surface tensions of mixtures of the butoxyethanol esters were similar to 2,3,6-TBA and picloram. As the rate of herbicide increased, the surface tension decreased only slightly.

The densities of mixtures of all four thickening agents were less than water. However, the greatest change in density was not great enough to cause significant changes in droplet formation.

Because the temperature of the shop in which the centrifugal pump was located was greater than 70 F, corrections were made using temperature data from the laboratory. The viscosity of Norbak, Kelzan, and Vistik mixtures with 2,4-D and water was greater when mixed in the laboratory with the blender than when mixed in the shop with the centrifugal pump. There was no significant difference in viscosity with Dacagin. There was no significant difference in surface tension between the two types of agitation. Agents mixed with the pump were more dense than those mixed with the blender (See Table 9). Again, the densities are significantly less than water, but not enough to affect droplet formation.

Table 1. Composition of materials

Common name	Trade name	Chemical name[1/]	Concentration[2/]	Source
2,4-D	Weedone LV4	Butoxyethanol ester of 2,4-dichlorophenoxy= acetic acid	4 lb/gal	Amchem
2,4,5-T	Weedone 2,4,5-T	Butoxyethanol ester of 2,4,5-trichlorophenoxy= acetic acid	4 lb/gal	Amchem
2,3,6-TBA	Benzac 1281	Dimethylamine salt of 2,3,6-trichlorobenzoic acid	2 lb/gal	Amchem
picloram	Tordon 22K	Potassium salt of 4-amino-3,5,6-trichloro= picolinic acid	2 lb/gal	Dow
dicamba	Banvel	Dimethylamine salt of 3,6-dichloro-o-anisic acid	4 lb/gal	Velsicol
	Norbak	Water-swellable polymer		Dow
	Dacagin	Polysaccharide gum		Diamond
	Kelzan	Xanthan gum		Kelco
	Vistik	Hydroxyethyl cellulose		Hercules

[1/] As tabulated in this report, a chemical name occupying two lines separated by an equal (=) sign is joined together without any separation if written on one line.

[2/] Expressed as acid equivalent or active ingredient.

Table 2. The physical properties of thickened sprays after setting 15, 30, and 60 minutes (average of 4 replications)

Thickening agent	15 min	30 min	60 min	Mean
		Viscosity (cps)		
Norbak	6670 A[1/]	6060 AB	6030 B	
Dacagin	1380 C	1520 C	1500 C	
Kelzan	217 D	216 D	212 D	
Vistik	872 E	906 E	916 E	
		Surface tension (dynes/cm)		
Water + herbicide	33.5	33.6	33.4	33.5 D
Norbak	39.6	40.0	39.8	39.8 B
Dacagin	40.8	43.7	41.0	41.8 A
Kelzan	34.2	34.2	34.3	34.2 D
Vistik	35.1	35.1	35.1	35.1 C
Mean	36.6 B	37.3 A	36.7 AB	
		Density (g mixture/g water)		
Water + herbicide	.9944	.9906	.9957	.9936 A
Norbak	.9190	.9488	.9591	.9423 B
Dacagin	.9507	.9437	.9338	.9427 B
Kelzan	.9228	.9415	.9346	.9330 B
Vistik	.9038	.9146	.8995	.9060 C
Mean	.9381	.9478 A	.9445 A	

[1/] Means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

Table 3. The physical properties of thickened sprays at ½X, X, and 2X rates of thickening agent (average of 4 replications)

Thickening agent	½X	X	2X	Mean
		Viscosity (cps)		
Norbak	1640 A[1]	6250 B	17890 C	
Dacagin	323 D	1359 E	1857 F	
Kelzan	58 G	221 H	595 I	
Vistik	743 J	930 J	7655 K	
		Surface tension (dynes/cm)		
Norbak	36.2	39.5	40.0	38.6 B
Dacagin	37.0	41.8	46.5	41.8 A
Kelzan	33.8	34.4	37.7	35.3 C
Vistik	34.3	35.3	37.8	35.8 C
Mean	35.3 C	37.7 B	40.5 A	
		Density (g mixture/g water)		
Norbak	.9168	.9157	.9502	.9276 B
Dacagin	.9550	.9442	.9770	.9587 A
Kelzan	.9691	.9275	.9200	.9389 AB
Vistik	.9931	.9256	.9207	.9465 AB
Mean	.9585 A	.9283 B	.9420 AB	

1/ Means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

Table 4. The physical properties of thickened sprays at 50, 70, and 90 F (average of 4 replications)

Thickening agent	50 F	70 F	90 F	Mean
		Viscosity (cps)		
Norbak	7193 A[1/]	6883 AB	6200 B	
Dacagin	1117 D	1454 C	1012 D	
Kelzan	254 E	216 F	221 F	
Vistik	1694 G	1060 H	653 I	
		Surface tension (dynes/cm)		
Water + herbicide	33.7	33.6	32.9	33.4 C
Norbak	40.1	40.0	39.4	39.8 A
Dacagin	34.6	43.7	33.8	37.4 B
Kelzan	39.8	34.2	40.5	38.2 AB
Vistik	34.3	35.1	33.4	34.3 C
Mean	36.5 A	37.3 A	36.0 A	
		Density (g mixture/g water)		
Water + herbicide	.9971	.9906	.9842	.9906 A
Norbak	.9755	.9489	.9880	.9708 B
Dacagin	.9515	.9437	.9434	.9462 C
Kelzan	.9232	.9415	.9241	.9296 D
Vistik	.9085	.9146	.9003	.9078 E
Mean	.9512 A	.9479 A	.9480 A	

[1/] Means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

Table 5. Rates of thickening agents used with 5 herbicides to give viscosity similar to mixtures containing 2,4-D ester

Thickening agent	Rate of agent for each herbicide (lb/100 gal)				
	2,4-D	2,4,5-T	2,3,6-TBA	Picloram	Dicamba
Norbak	2.4	2.4	5.3	4.0	5.3
Dacagin	4.0	4.0	9.0	9.0	9.0
Kelzan	2.0	2.0	2.0	2.0	2.0
Vistik +	4.5	4.5	4.5	4.5	4.5
soda ash	0.25	0.25	0.25	0.25	0.25

Table 6. The viscosity of thickened sprays with ½X, X, and 2X rates of 2,4-D; 2,4,5-T; 2,3,6-TBA; picloram; and dicamba in centipoise

Thickening agent	½X	X	2X
		2,4-D	
Norbak	6990	6883	3630
Dacagin	1413	1454	743
Kelzan	229	216	202
Vistik	1010	1060	1140
		2,4,5-T	
Norbak	6933	5453	4298
Dacagin	1423	1488	1205
Kelzan	234	229	210
Vistik	1043	1020	1104
		2,3,6-TBA	
Norbak	8260	5240	1972
Dacagin	1376	1126	992
Kelzan	202	193	179
Vistik	1018	1039	976
		Picloram	
Norbak	8040	5250	2210
Dacagin	1616	1314	1047
Kelzan	192	182	177
Vistik	968	981	976
		Dicamba	
Norbak	9222	5712	2105
Dacagin	1319	1157	923
Kelzan	186	174	178
Vistik	988	993	1050

Table 7. The surface tension of thickened sprays with ½X, X and 2X rates of 2,4-D; 2,4,5-T; 2,3,6-TBA; picloram; and dicamba in dynes/cm

Thickening agent	½X	X	2X
		2,4-D	
Water + herbicide	34.3	33.6	34.4
Norbak	39.5	40.0	37.4
Dacagin	45.6	43.7	38.8
Kelzan	34.5	34.2	33.8
Vistik	34.6	35.1	35.6
		2,4,5-T	
Water + herbicide	33.4	33.4	33.4
Norbak	41.3	40.4	39.1
Dacagin	44.1	42.6	40.8
Kelzan	35.5	34.6	34.7
Vistik	36.9	36.5	36.4
		2,3,6-TBA	
Water + herbicide	36.2	38.0	38.8
Norbak	43.5	40.9	38.2
Dacagin	49.4	46.2	44.5
Kelzan	35.1	29.2	32.6
Vistik	41.0	39.8	38.9
		Picloram	
Water + herbicide	31.7	31.4	31.7
Norbak	39.2	39.1	38.5
Dacagin	42.6	40.7	42.8
Kelzan	31.6	31.3	31.4
Vistik	31.9	32.2	32.2
		Dicamba	
Water + herbicide	53.5	53.9	51.5
Norbak	56.3	48.2	46.3
Dacagin	71.0	69.8	66.0
Kelzan	53.1	49.0	46.6
Vistik	44.3	44.5	43.6

Table 8. The density of thickened sprays with ½X, X, and 2X rates of 2,4-D; 2,4,5-T; 2,3,6-TBA; picloram; and dicamba in grams mixture/grams water

Thickening agent	½X	X	2X
		2,4-D	
Water + herbicide	.9936	.9906	.9971
Norbak	.9603	.9489	.9151
Dacagin	.9403	.9437	.9316
Kelzan	.9348	.9414	.9274
Vistik	.9164	.9146	.9135
		2,4,5-T	
Water + herbicide	1.0000	1.0040	.9982
Norbak	.9844	.9902	.9815
Dacagin	.9521	.9455	.9232
Kelzan	.9320	.9264	.9186
Vistik	.9040	.8976	.8890
		2,3,6-TBA	
Water + herbicide	.9996	1.0064	.9997
Norbak	.9325	.8935	.8470
Dacagin	.9847	.9798	.9710
Kelzan	.9181	.9349	.9520
Vistik	.9456	.9461	.9656
		Picloram	
Water + herbicide	.9942	.9934	.9941
Norbak	.9914	.9943	.9656
Dacagin	.9774	.9751	.9462
Kelzan	.9318	.9467	.9538
Vistik	.9219	.9312	.9267
		Dicamba	
Water + herbicide	.9982	1.0027	1.0038
Norbak	.9950	.9871	.9157
Dacagin	.9895	.9861	.9735
Kelzan	.9939	.9888	.9689
Vistik	.9079	.9212	.9270

Table 9. The physical properties of thickened sprays after two types of agitation (average of 4 replications)

Thickening agent	Pump	Blender	Mean
		Viscosity (cps)	
Norbak	4860 A[1/]	6883 B	
Dacagin	1485 C	1454 C	
Kelzan	172 D	216 E	
Vistik	628 F	1060 G	
	Surface tension (dynes/cm)		
Water + herbicide	33.4	33.6	33.5 B
Norbak	37.8	40.0	38.9 AB
Dacagin	46.1	43.7	44.9 A
Kelzan	32.0	34.2	33.1 B
Vistik	33.4	35.1	34.3 B
Mean	36.5 A	37.3 A	
	Density (g mixture/g water)		
Water + herbicide	1.0000	.9999	1.0000 A
Norbak	.9800	.9489	.9645 B
Dacagin	1.0017	.9437	.9727 B
Kelzan	.9868	.9415	.9642 B
Vistik	.9976	.9146	.9561 B
Mean	.9932 A	.9497 B	

[1/] Means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

CHAPTER V

THE EFFECTS OF THICKENING AGENTS ON DRIFT OF HERBICIDAL SPRAYS

The spray pattern and spray loss from the Spraying Systems OC 150 nozzle were determined in the field by use of a fluorescent dye and a fluoro-microphotometer.

Materials and Methods:

LOCATION: Agronomy Research Center (Bradford Farm) 8 miles east of Columbia, Missouri; and Agricultural Engineering Research Laboratory, Building T-12, University of Missouri, Columbia, Missouri.

SPRAYING EQUIPMENT: A Spraying Systems OC 150 nozzle was used to apply 50 gallons/acre on a 30 ft swath at approximately 5 miles/hr. The nozzle was connected to a large centrifugal pump driven by a gasoline engine. This unit was mounted on the back of a tractor which carried it along the edge of the target area at the desired speed. The nozzle was mounted 30 inches above the ground at 27^{o} from the horizontal.

TYPE OF MIXING: Hydraulic agitation was used by directing the spray mixture back into the 8 gallon tank under pressure.

HERBICIDE: Butoxyethanol ester of 2,4-D at 2 lb/A in 50 gpa spray mixture.

METHOD OF MEASUREMENT: The spray containing a fluorescent dye was collected on two- by three-inch stainless steel plates at one foot intervals across the spray pattern. Fifty plates were arranged on five boards, each ten feet long.

As the spray impacted on the plates, the following information was recorded:

1. Spray pressure
2. Wind velocity (Speed and direction)
3. Direction of plates
4. Wet-bulb temperature
5. Dry-bulb temperature

Immediately after spraying, the stainless steel plates were placed in separate plastic cottage cheese cups containing 90 to 95 ml distilled water, then sealed with a lid. These cups were then moved to the laboratory to measure the amount of fluorescent dye on each plate.

In the laboratory, the plate was removed from the cup and water was added to bring the weight of the water plus spray mixture up to 100 grams. A sample was poured into a cuvette for analysis in a fluoro-microphotometer. From the amount of dye in each sample, the application volume was measured and calculated for each plate across the spray pattern.

LIST OF TABLES:

LIST OF FIGURES:

Results and Discussion:

The spray pattern on the OC 150 nozzle was very sensitive to small changes in wind velocity. The spray width was increased by a wind vector blowing the same direction the spray droplets were traveling and decreased by a wind vector blowing against the direction of spray travel (Figures 1 and 2).

The spray pattern in no wind was also poor (Figure 3). The dashed line represents the ideal spray pattern. The distribution of spray would also vary significantly if the roadbank were not level with the road.

The spray losses with the OC 150 nozzle were quite high (Table 2). There was great variability in the field and considerable experimental error. The wind speeds averaged from 4.5 to 5.1 miles per hour. Since there was great variability, only two treatments were significantly different at the 0.5 percent level.

For any one thickening agent, the change in viscosity, brought about by a two-fold change in concentration of thickening agent, did not cause a significant change in percent loss. The 2X rate of Vistik was too thick for commercial application.

There were no significant differences between mixtures with 2,4-D and mixtures without 2,4-D. However, the approximate two-fold increase in surface tension in the absence of 2,4-D decreased the loss for Norbak, Dacagin, and water with no thickening agent. Notice the percent loss with water versus the percent loss with water plus 2,4-D. Again this is not significant but worthy of note. The mean loss of treatments without 2,4-D was 23.85%. The mean for the same treatments with 2,4-D was 26.70%.

The magnitude of these figures points out two things. First, there is tremendous ineffeciency in the amount of the herbicide applied to the target area. Second, a dangerous amount of spray is being released into non-target areas with a potential for damaging desirable vegetation.

The active herbicides necessary for effective control of problem weeds often encountered on rights-of-way must be handled with caution.

These data indicate the thickened sprays are not effective in reducing spray losses from the OC nozzle.

Table 1. Composition of materials

Common name	Trade name	Chemical name[1]	Concentration[2]	Source
2,4-D	Weedone LV4	Butoxyethanol ester of 2,4-dichlorophenoxy= acetic acid	4 lb/gal	Amchem
	Norbak	Water-swellable polymer		Dow
	Dacagin	Polysaccharide gum		Diamond
	Kelzan	Xanthan gum		Kelco
	Vistik	Hydroxyethyl cellulose		Hercules

1/ As tabulated in this report, a chemical name occupying two lines separated by an equal (=) sign is joined together without any separation if written on one line.

2/ Expressed as acid equivalent or active ingredient.

Table 2. Percent loss for each run made in the field

Thickening Agent	Rate	2,4-D[1/]	Replication I	II	III	IV	V	VI	VII	VIII	Mean [2/]
Norbak	X	0	26.66	26.54	59.61	28.18	6.64	28.97	-3.47	23.99	24.64 AB
Norbak	½X	+	23.31	40.50	34.79	36.41	30.86	23.14	10.39	14.04	26.68 AB
Norbak	X	+	40.69	28.46	67.16	35.06	24.02	2.26	17.59	25.56	30.10 A
Dacagin	X	0	48.65	-17.63	29.86	18.19	28.53	43.11	9.97	6.83	20.94 AB
Dacagin	X	+	35.74	25.77	31.36	23.64	20.98	34.11	31.59	21.89	28.14 AB
Dacagin	2X	+	40.86	-14.66	59.13	46.90	40.48	10.87	11.63	7.42	25.33 AB
Kelzan	X	0	24.00	24.29	22.07	25.42	16.33	79.16	-13.00	24.60	25.36 AB
Kelzan	X	+	9.98	15.84	14.24	16.88	34.82	29.36	8.83	14.60	18.07 AB
Kelzan	2X	+	-4.69	7.26	51.26	25.72	30.91	25.58	12.01	20.21	21.03 AB
Vistik	X	0	9.73	0.16	48.66	29.99	23.87	26.57	19.92	41.95	25.11 AB
Vistik	X	+	25.33	34.20	27.82	20.94	24.04	19.70	15.95	19.64	23.45 AB
Vistik	2X	+	-13.77	2.33	67.53	-1.96	-4.41	14.69	12.23	10.10	10.84 B
Water	-	0	4.06	10.74	35.69	28.13	34.40	16.26	26.33	29.50	23.14 AB
Water	-	+	26.24	31.78	63.72	24.45	34.45	34.76	29.18	25.51	33.76 A
Mean			21.20 BC	15.40 BC	43.78 A	25.57 BC	24.71 BC	27.75 B	13.51 C	20.42 BC	

1/ Treatments with 2,4-D are represented by "+" and treatments without 2,4-D by "0".

2/ Means followed by the same letter are not significantly different at the 5% level according to Duncan's multiple range test.

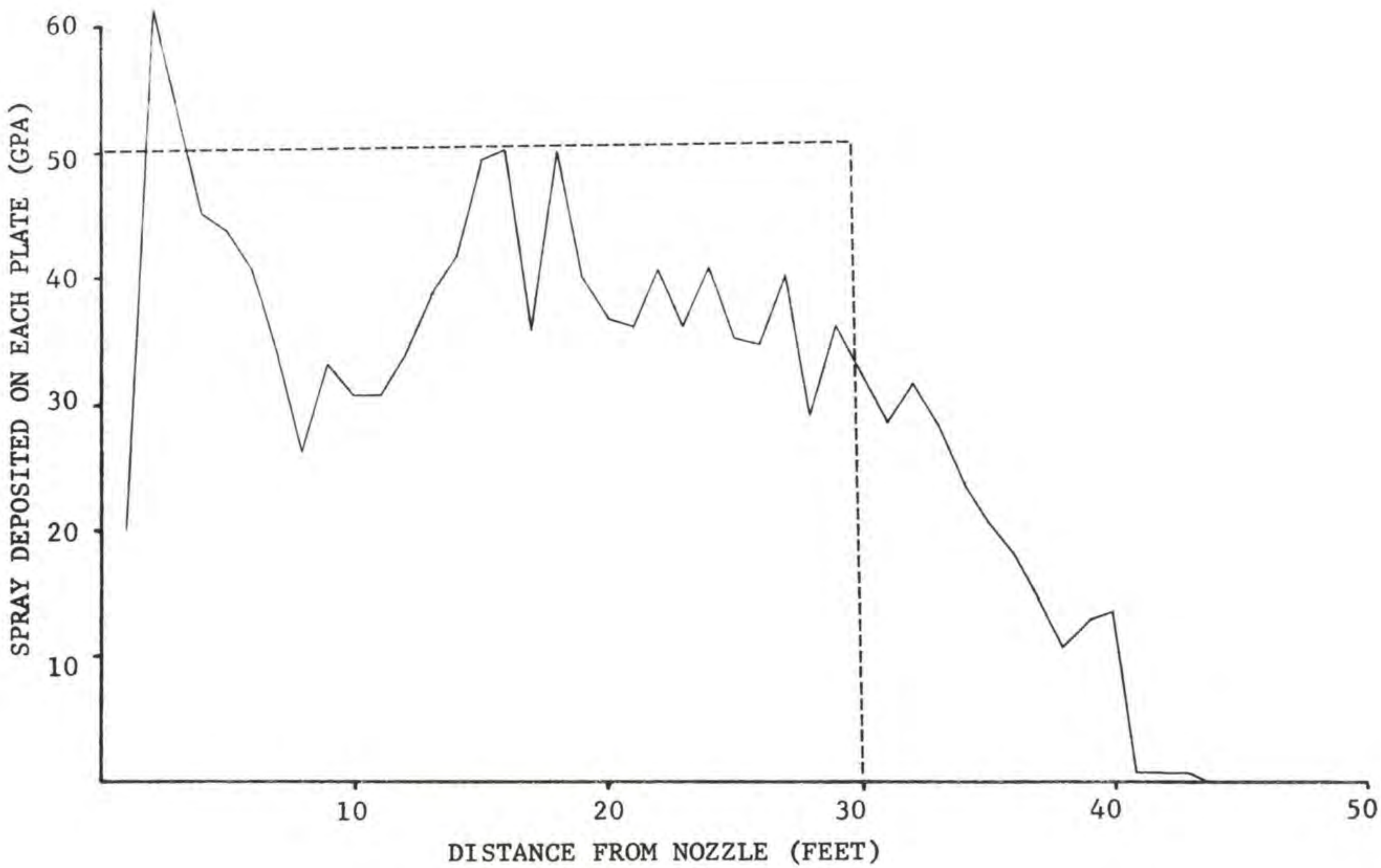


Figure 1. The spray pattern of the X rate of Kelzan with 2,4-D in a 6.3 mph wind blowing in the same direction the spray is traveling

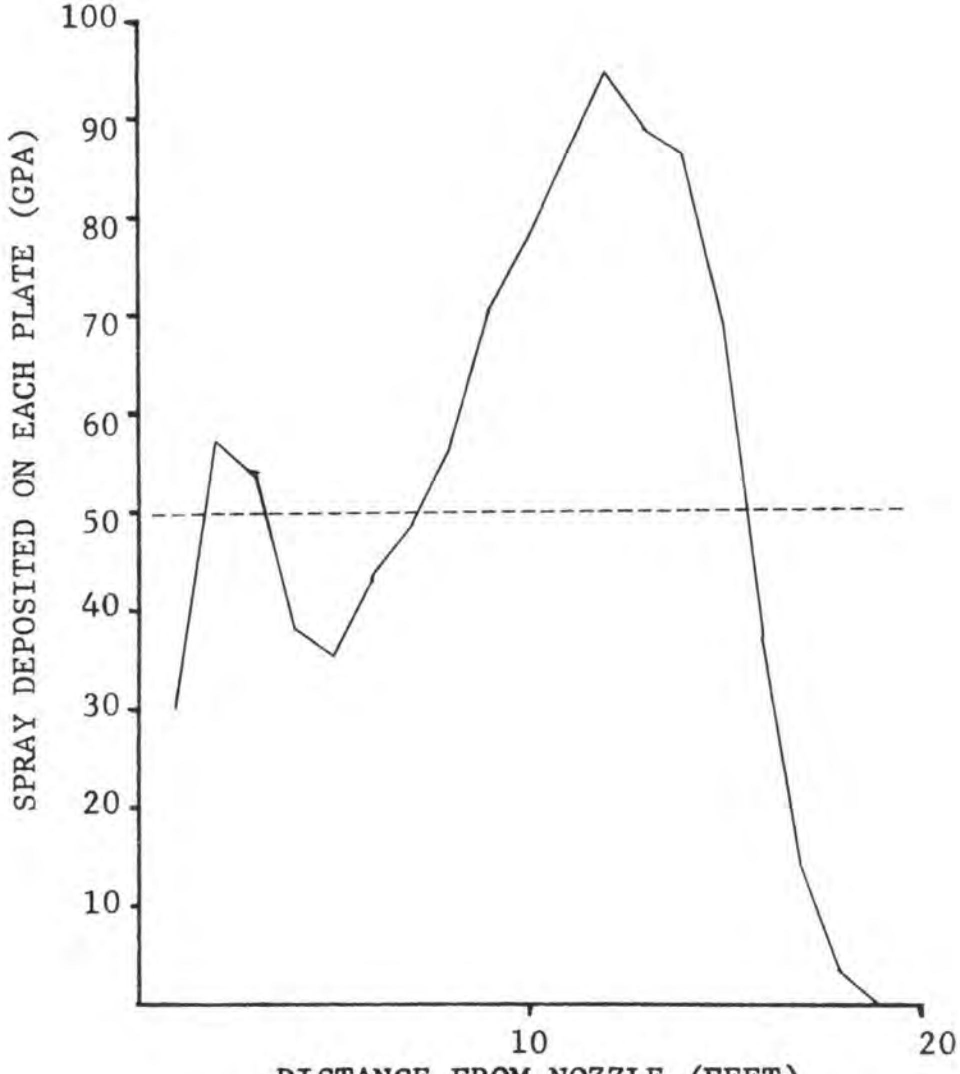


Figure 2. The spray pattern of the X rate of Kelzan with 2,4-D in a 1.2 mph wind blowing against the direction of spray travel

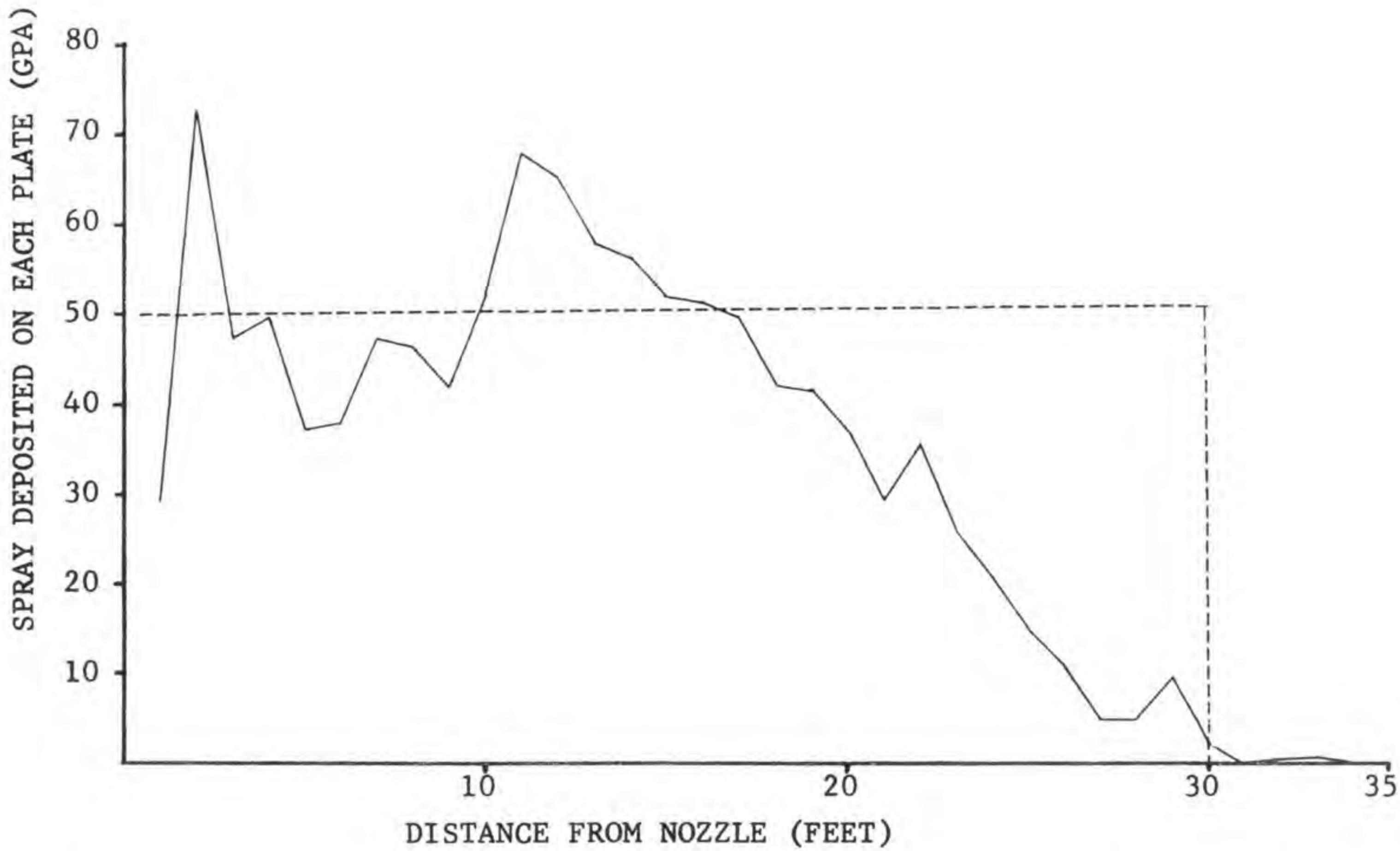


Figure 3. The spray pattern of the X rate of Vistik with 2,4-D in no wind

CHAPTER VI

THE EFFECT OF THICKENED SPRAYS ON THE CONTROL OF COMMON MILKWEED

Six experiments were conducted to determine the effects of thickening spray mixtures on the control of common milkweed with 2,4-D; 2,4,5-T; 2,3,6-TBA; picloram; and dicamba.

Materials and Methods:

LOCATION: Studies were located along the following roadsides in the vicinity of Columbia, Missouri: Experiment 1 - Route Z, 10 miles northeast of Columbia; Experiment 2 - Route H, 14 miles southeast of Columbia; Experiment 3 - Route P, 17 miles northeast of Columbia; Experiment 4 - Route U, 15 miles northwest of Columbia; Experiment 5 - retreatment of experiment one located on Route Z; Experiment 6 - retreatment of experiment two located on Route H.

EXPERIMENTAL DESIGN: All studies were conducted in randomized complete block design with four replications.

PLANT SPECIES STUDIED: Common milkweed (*Asclepias syriaca*).

METHOD OF APPLICATION: All treatments were made with a sprayer unit mounted on a platform attached to a tractor. This unit consisted of a 35-horsepower air-cooled Wisconsin engine turning a large capacity centrifugal pump. A Spraying System off-center nozzle (OC 150) was used to cover a 30-foot swath. Spray mixtures were applied in 50 gallons per acre at 30 pounds per square inch.

DATA TAKEN: Injury ratings were made at weekly intervals throughout the first twelve weeks following treatment. The number of milkweed plants per plot were counted before herbicide treatment to determine the exact number of plants per plot. In the fall following treatment, the number of living plants on each plot were counted to determine the percent apparent control. The following spring the number of living plants were counted again and the percent control was computed.

LIST OF TABLES:

LIST OF FIGURES:

Results and Discussion:

In an effort to determine whether thickened sprays reduce the phytotoxicity of herbicides, this study was conducted over a three-year period at four locations. In general, thickening agents did not significantly hinder or enhance the performance of herbicides in controlling common milkweed.

There were greater differences between effects of herbicides than effects of thickening agents in controlling common milkweed. Picloram was most effective resulting in over 95 percent control. Dicamba was slightly less effective resulting in approximately 80 percent control. Two,4-D and 2,4,5-T were significantly poorer than dicamba. Two,4,5-T was slightly more effective than 2,4-D, resulting in about 50 percent control. Two,3,6-TBA was least effective (Figures 1 through 10).

Norbak slightly reduced the control of milkweeds when used with 2,4-D; 2,4,5-T; and 2,3,6-TBA. Control from picloram and dicamba were not affected by Norbak spray solutions. Dacagin reduced milkweed control of 2,4-D by approximately 16 percentage points.

Vistik slightly reduced the control by 2,4,5-T. It enhanced control with picloram and dicamba slightly.

Kelzan slightly reduced the control of milkweeds in treatments with 2,4-D and 2,4,5-T; but had no effect on 2,3,6-TBA, picloram, or dicamba.

The invert emulsions of 2,4-D and 2,4,5-T gave rapid injury symptoms. This was probably due to the contact action of the diesel oil in the mix. However, control the following year was not affected significantly.

None of the thickeners hindered the good control of picloram and dicamba. The marginal control of 2,4-D and 2,4,5-T was sometimes affected by the various agents.

There was no significant difference between the effects of thickening agents one year after initial treatments or one year after retreatment. There were significant differences between herbicides. Retreatment with the phenoxy herbicides is essential for adequate control.

Table 1. Composition of materials

Common name	Trade name	Chemical name[1/]	Concentration[2/]	Source
2,4-D	Weedone LV4	Butoxyethanol ester of 2,4-dichlorophenoxy= acetic acid	4 lb/gal	Amchem
2,4,5-T	Weedone 2,4,5-T	Butoxyethanol ester of 2,4,5-trichlorophenoxy= acetic acid	4 lb/gal	Amchem
2,3,6-TBA	Benzac 1281	Dimethylamine salt of 2,3,6-trichlorobenzoic acid	2 lb/gal	Amchem
picloram	Tordon 22K	Potassium salt of 4-amino-3,5,6-trichloro= picolinic acid	2 lb/gal	Dow
dicamba	Banvel	Dimethylamine salt of 3,6-dichloro-o-anisic acid	4 lb/gal	Velsicol
	Norbak	Water-swellable polymer		Dow
	Dacagin	Polysaccharide gum		Diamond
	Kelzan	Xanthan gum		Kelco
	Vistik	Hydroxyethyl cellulose		Hercules

[1/] As tabulated in this report, a chemical name occupying two lines separated by an equal (=) sign is joined together without any separation if written on one line.

[2/] Expressed as acid equivalent or active ingredient.

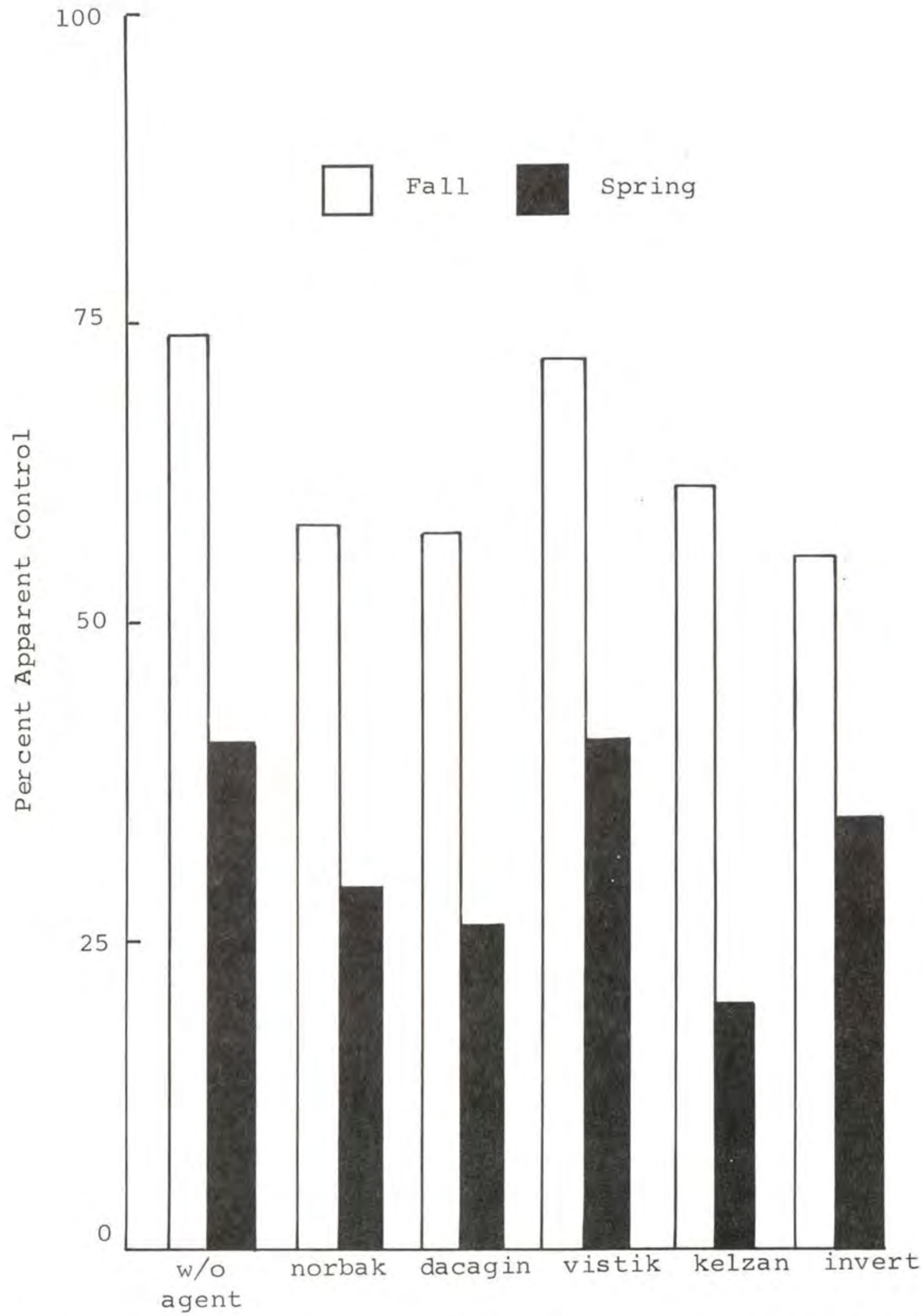


Figure 1. Percent apparent control of milkweeds treated with 2,4-D (Experiments one, two, three, and four)

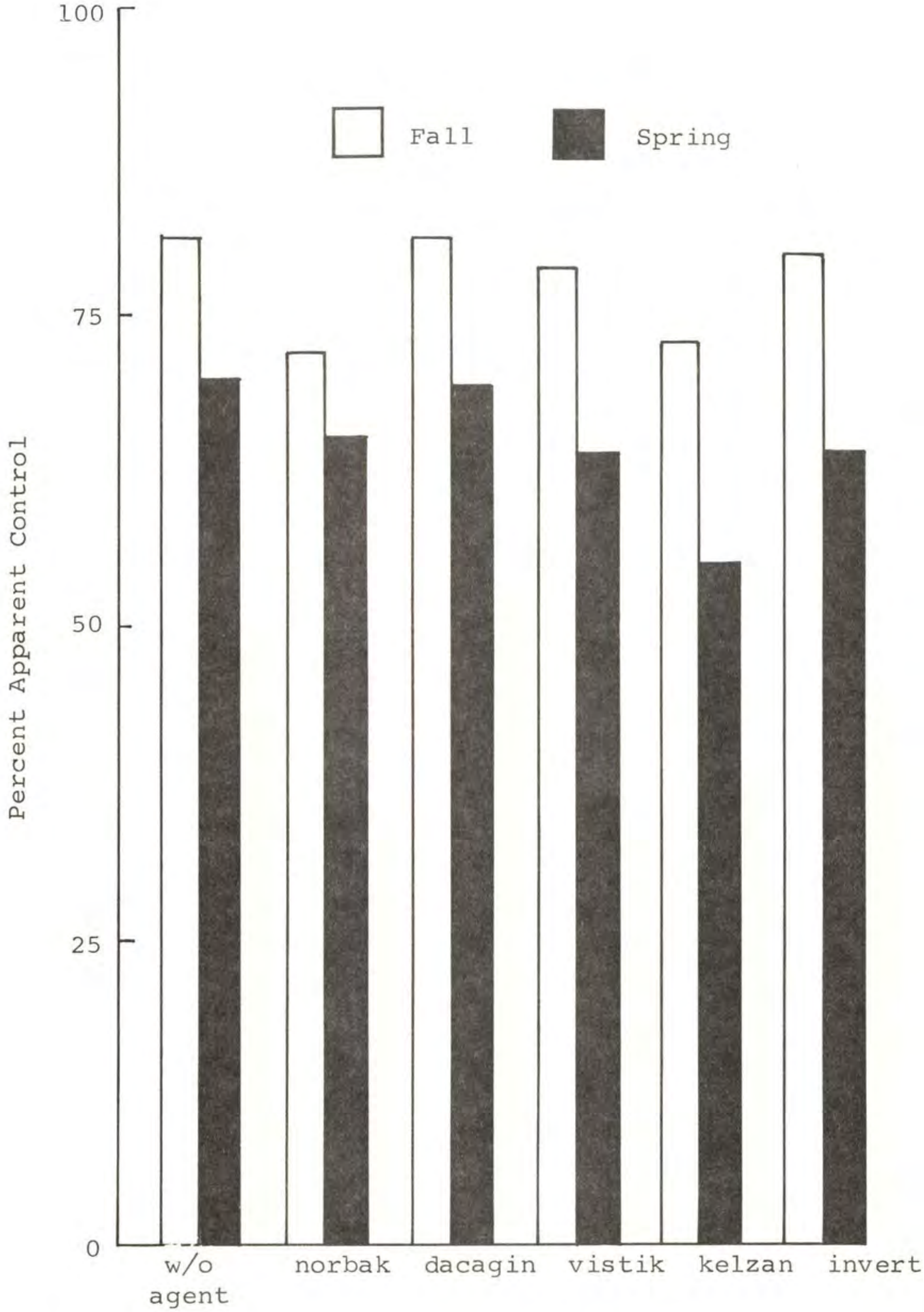


Figure 2. Percent apparent control of milkweeds treated with 2,4-D (Experiments five and six)

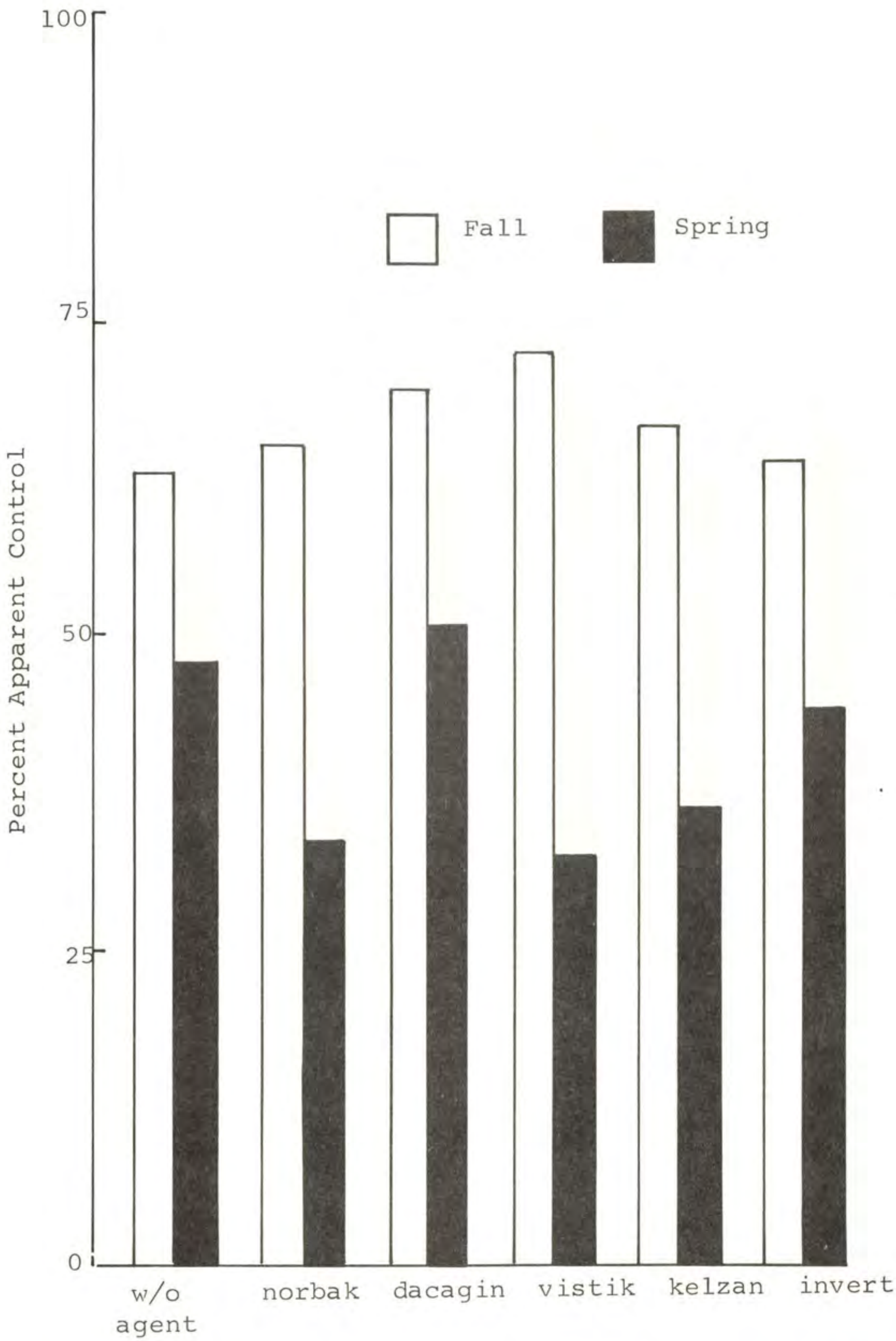


Figure 3. Percent apparent control of milkweeds treated with 2,4,5-T (Experiments one, two, three, and four)

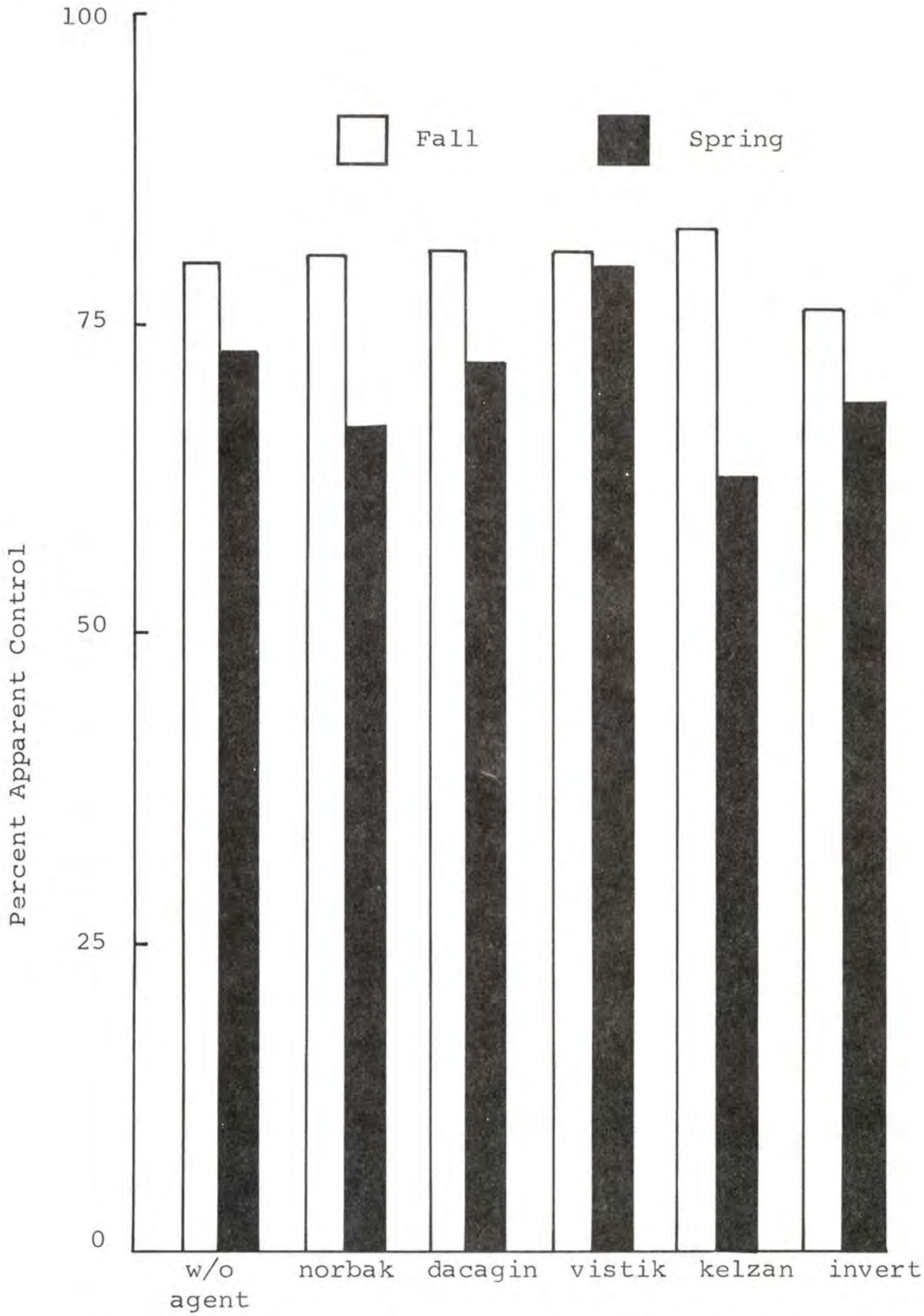


Figure 4. Percent apparent control of milkweed treated with 2,4,5-T (Experiment five and six)

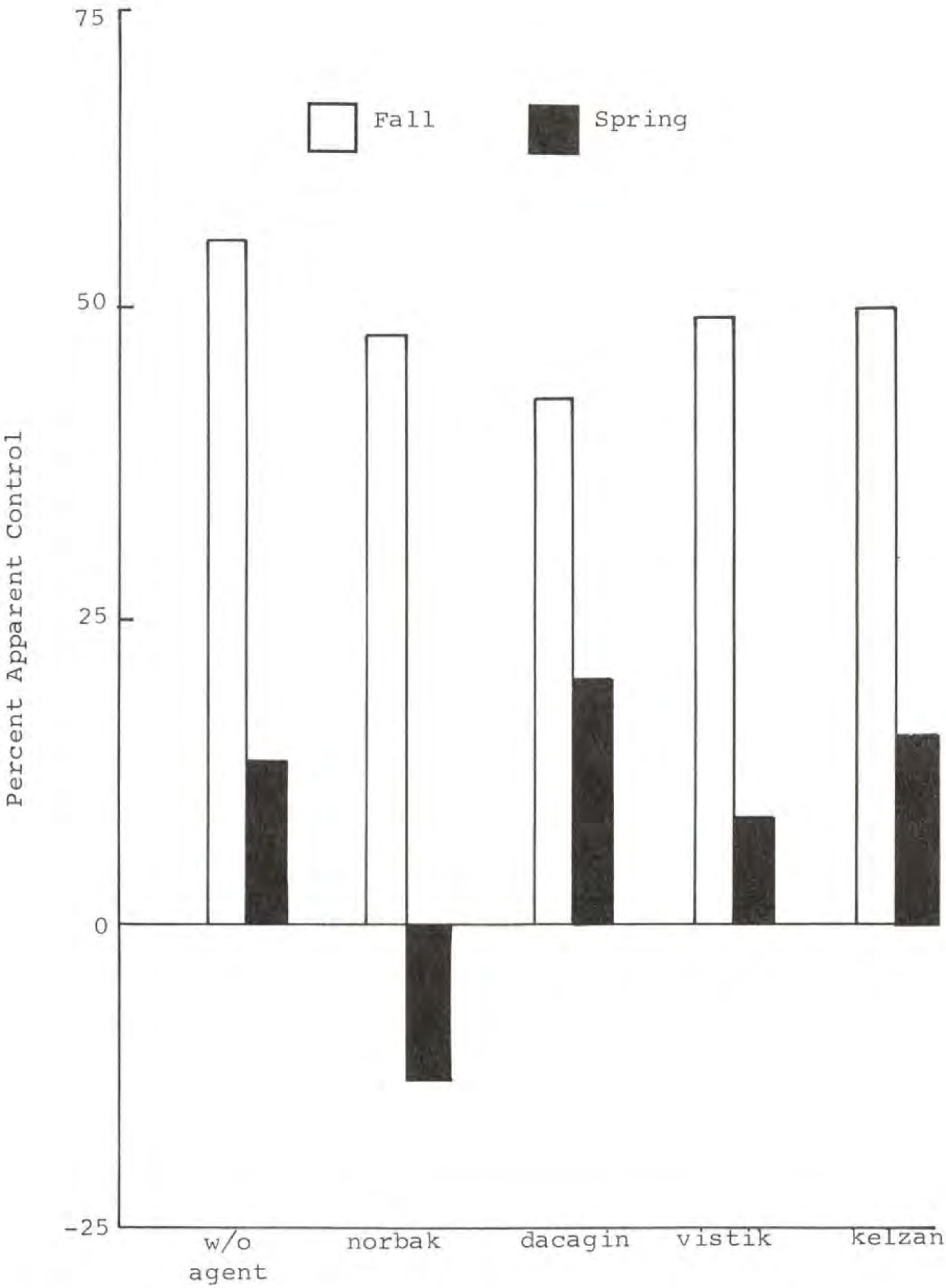


Figure 5. Percent apparent control of milkweeds treated with 2,3,6-TBA (Experiments one, two, three, and four)

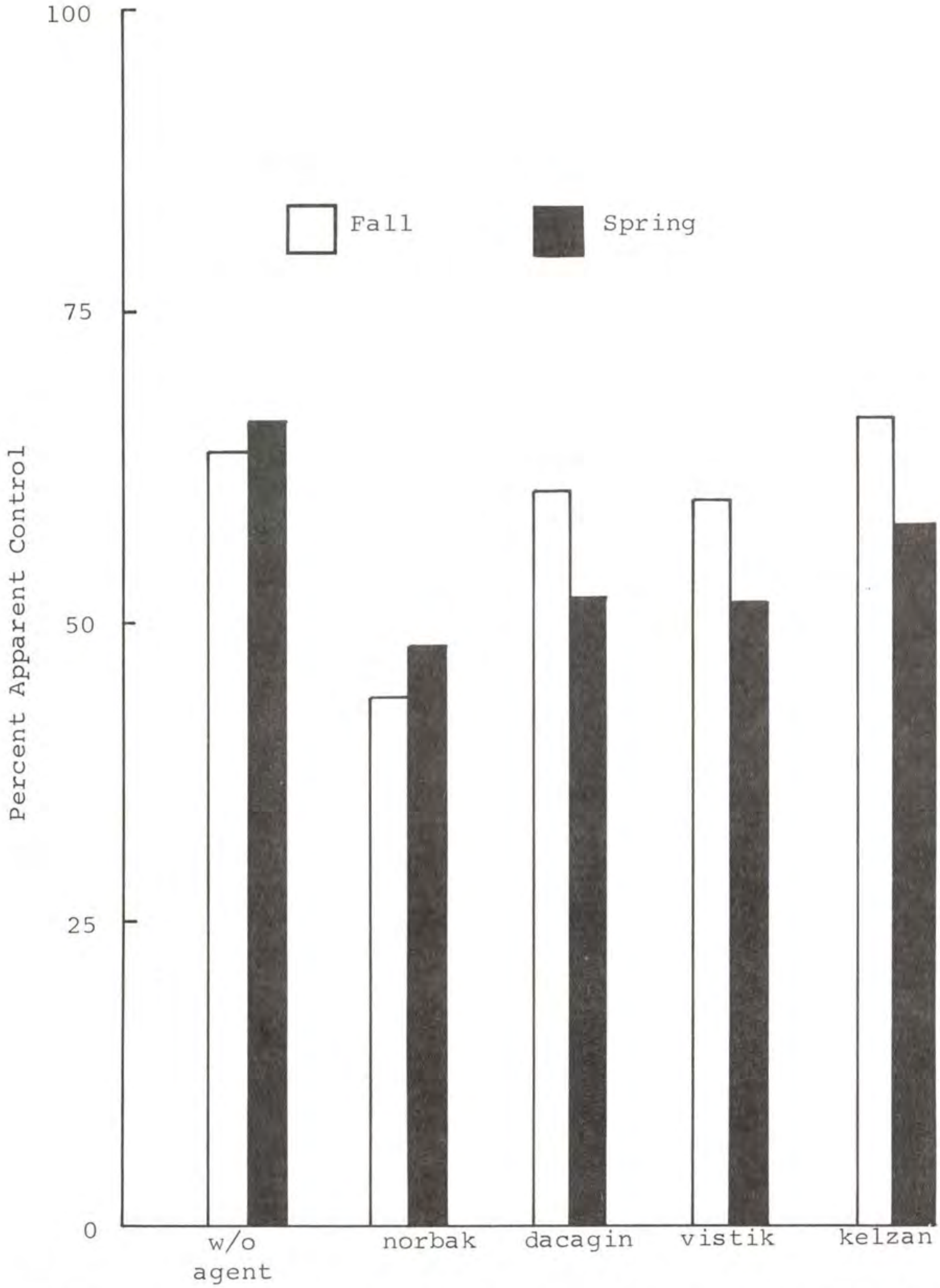


Figure 6. Percent apparent control of milkweeds treated with 2,3,6-TBA (Experiments five and six)

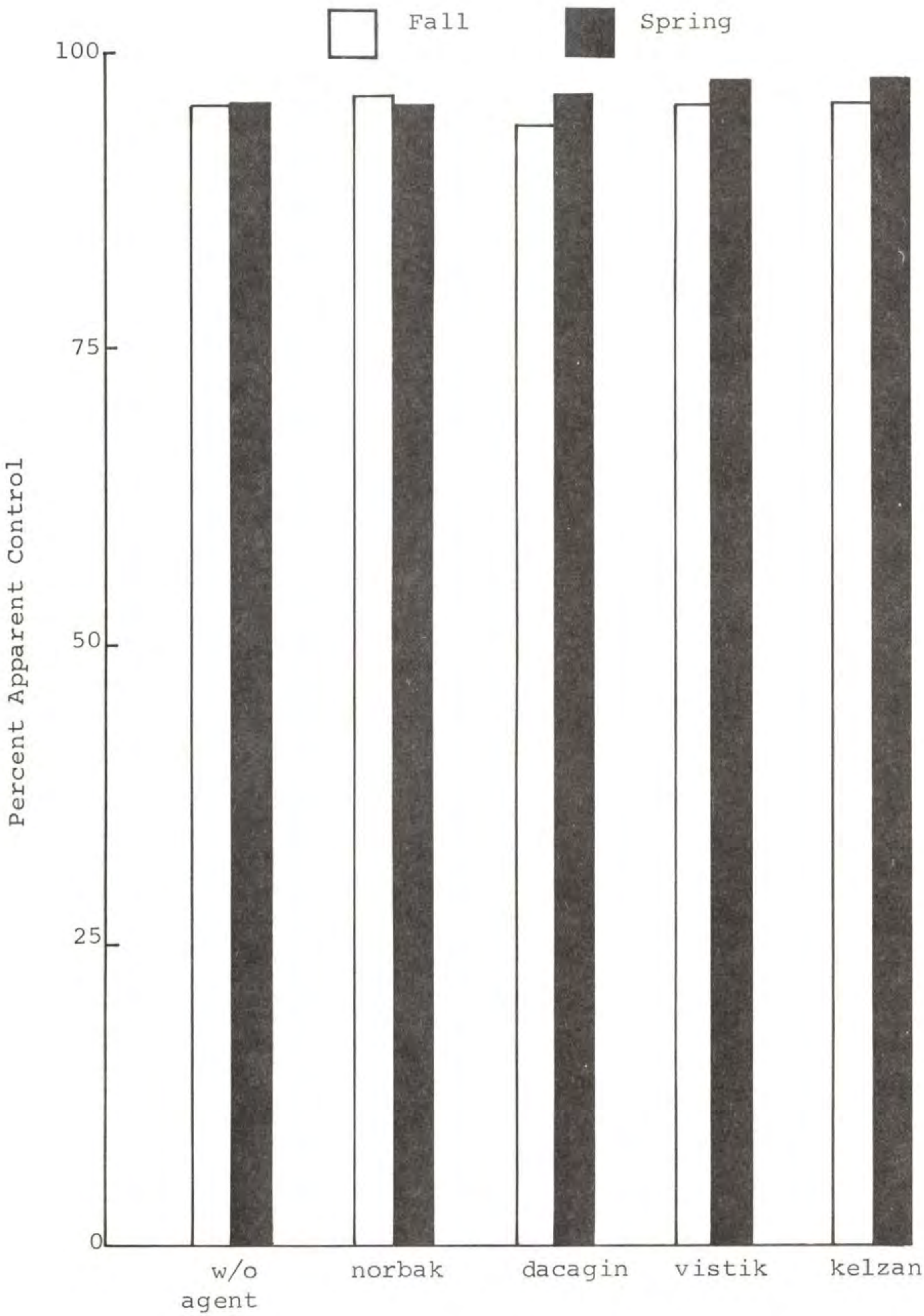


Figure 7. Percent apparent control of milkweed treated with picloram (Experiments one, two, three, and four)

Figure 8. Percent apparent control of milkweeds treated with picloram (Experiments five and six)

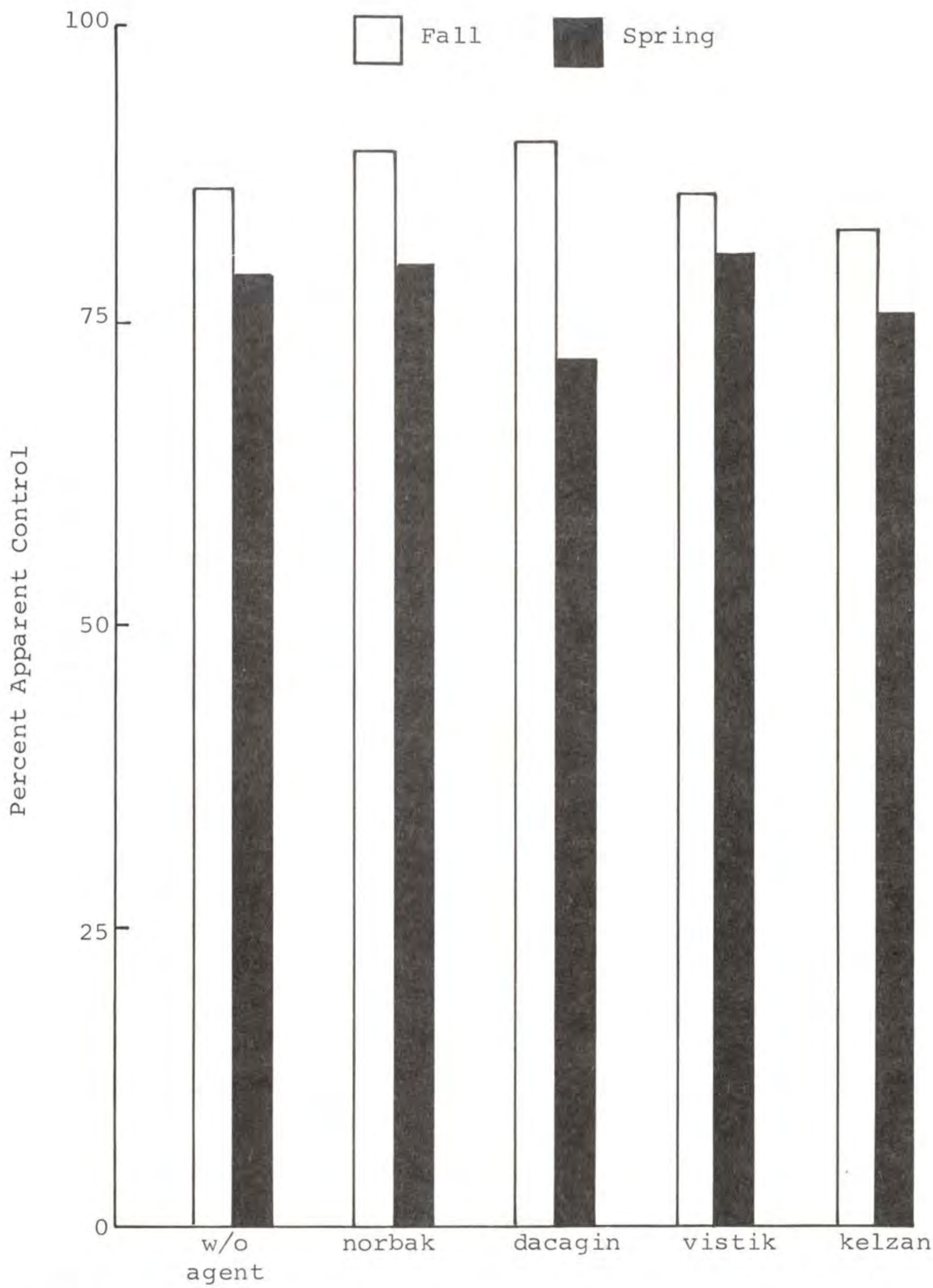
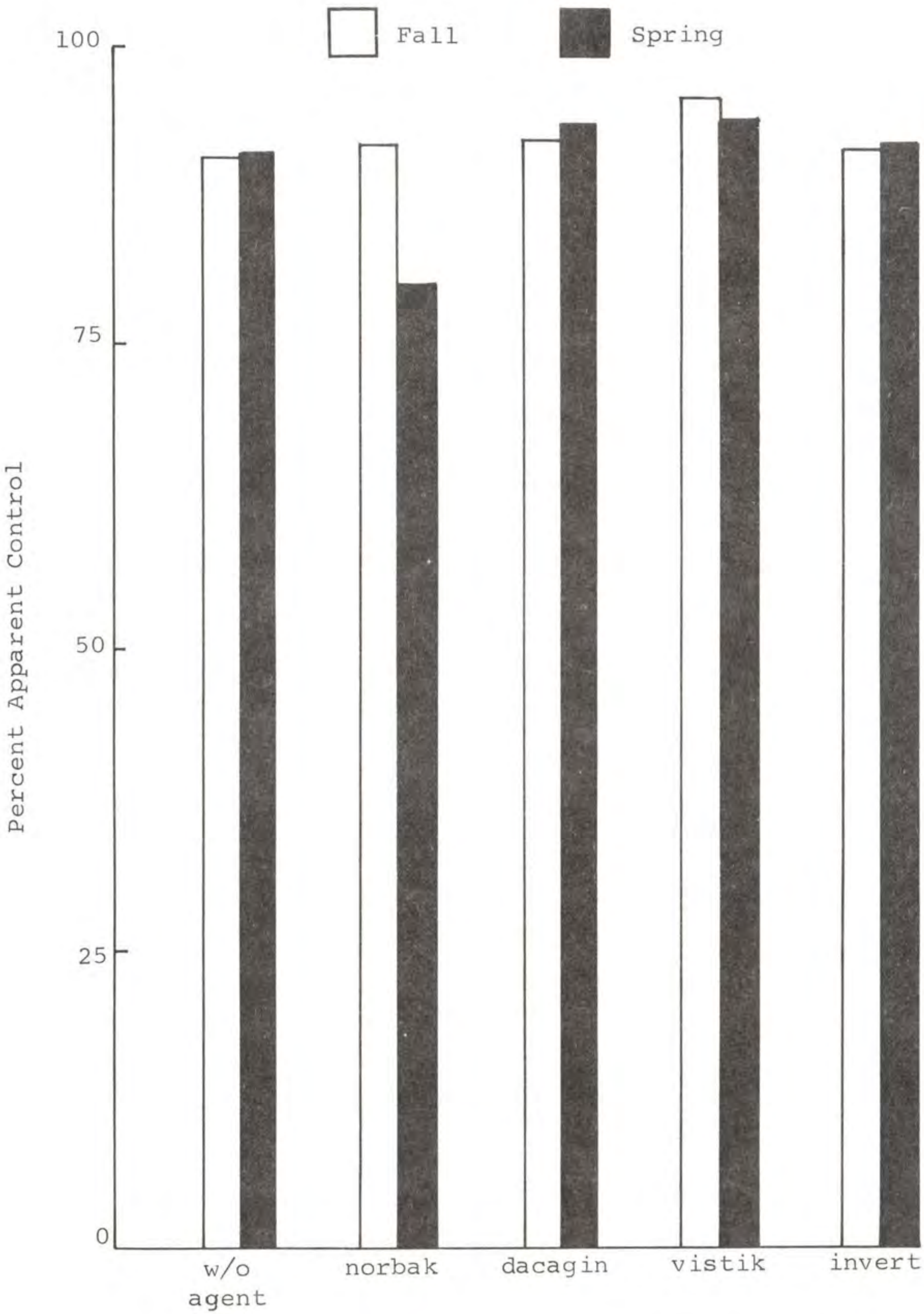


Figure 9. Percent apparent control of milkweeds treated with dicamba (Experiments one, two, three, and four)



Experiment 10. Percent apparent control of milkweed treated with dicamba (Experiments five and six)

CHAPTER VII

EQUIVALENT RATES OF SOIL STERILANTS

Eleven soil sterilants were compared in three experiments to estimate equivalent rates.

Materials and Methods:

LOCATION: Three studies were conducted on soil sterilants in Boone County, Missouri. Two studies were located at the University of Missouri South Farm, and the third study was located at the Bradford Farm.

SOIL TYPE: The soil was a Mexico silt loam which ranged in organic matter from 2.0 to 2.4 percent.

AREA PREPARATION: The areas had been kept mowed as needed before treatments were made. The vegetation ranged in height from 6 to 14 inches at the time of treatment.

PLOT SIZE: The plots were 13 feet wide and 20 feet long. Borders were located between all plots to keep leaching of herbicides from plot to plot to a minimum.

EXPERIMENTAL DESIGN: All studies were conducted in a randomized complete block design with four replications.

DATES TREATED: The first study was treated in July, 1970. The second study was treated in October, 1971. The third study was treated in May, 1972.

WEATHER CONDITIONS AT TREATMENT: Optimum rainfall followed each application. The temperature ranged from a low of 60 F in May to 80 F in July. There was a slight breeze out of the southwest on all three treatment dates.

METHOD OF APPLICATION: Treatments were applied with a small garden tractor mounted plot sprayer applying 100 gpa at 40 psi. A Teejet 8010 nozzle tip was used. The 40 lb/A rates were applied by operating the sprayer over the plots twice; whereas, the lower rates were applied with one trip over the plots with the sprayer.

METHODS OF DATA COLLECTION: Ratings were made on the percent bare ground and the percent acceptable vegetation control. Weeds were counted and identified as weed grasses and broad-leaved weeds.

LIST OF TABLES:

simazine at 20 lb/A)

Results and Discussion:

The rate of any herbicide to use for complete vegetation control depends on the length of control desired. Low rates of these herbicides can be used if one plans to reapply the herbicide each spring. Bromacil, diuron, simazine, prometone, secbumeton, karbutilate, fluometuron, and monuron could be used in this manner.

Vegetation control one year after application is reported in Tables 2 and 5. Those plots that contained more weeds than the check are not included in Table 6. Bromacil, simazine, diuron, secbumeton, prometone, and karbutilate gave adequate control at various rates. A regression analysis was performed with the model $y = \ln(x)$. The results appear in Table 5.

The ranking would change at different rates of simazine or different amounts of control. This ranking is only an indication of relative performance at 20 lb of simazine per acre or 80 to 85% control one year after treatment. This is an average of the 3 treatment dates (spring, summer, and late summer).

Two years after treatment, diuron showed the greatest control. Bromacil also showed good activity. Three years after treatment, bromacil and diuron at their highest rates still showed adequate control.

There were no significant differences between broadleaf and grass control by any of the herbicides except fenac. Fenac did not control the sod that existed before treatment.

Bromacil gave excellent control of the plot area and also the border between plots at high rates. The chemical apparently moves readily. It should not be used on a slope greater than 10 to 15%. The experiment that was treated in July had significantly better control than the experiments treated in May or October.

Table 1. Composition of materials

Common name	Trade name	Chemical name[1/]	Form and concentration	Source
bromacil	Hyvar X	5-bromo-3-*sec*-butyl-6-methyluracil	80 WP	du Pont
diuron	Karmex	3-(3,4-dichlorophenyl)-1,1-dimethylurea	80 WP	du Pont
monuron	Telvar	3-(*p*-chlorophenyl)-1,1-dimethylurea	80 WP	du Pont
simazine	Princep	2-chloro-4,6-bis (ethyl= amino)-*s*-triazine	80 WP	CIBA/ Geigy
karbutilate (Nia 11092)	Tandex	*m*-(3,3-dimethylureido) phenyl-*tert*-butylcar= bamate	80 WP	Niagara
fenac	Fenac	(2,3,6-trichlorophenyl) acetic acid, sodium salt	1.5 lb/gal	Amchem
metribuzin (Bay 94337)	Sencor	4-amino-6-*t*-butyl-3-(methylthio)-as-triazin-5-(4H)-one	70 WP	Chemagro
fluometuron	Cotoran	1,1-dimethyl-3-(a,a,a-trifluro-m-tolyl) urea	80 WP	CIBA/ Geigy
secbumeton (GS 14254)	Sumitol	2-*sec*-butylamino-4-ethyl= amino-6-methoxy-*s*-tria= zine	80 WP	CIBA/ Geigy
cyanazine (SD-15418)	Bladex	2-(4-chloro-6-ethylamino-*s*-triazine-2-ylamino)-2-methylpropionitrile	80 WP	Shell
prometone	Pramitol	2,4-bis(isoproplamino)-6-methoxy-*s*-triazine	2 lb/gal	CIBA/ Geigy

[1/] As tabulated in this report, a chemical name occupying two lines separated by an equal (=) sign is joined together without any separation if written on one line.

Table 2. Number of weeds per square yard one year after treatment[1/]

Herbicide	Rate lb/A	Weed grasses	Broadleaved weeds	Total weeds
Weedy check		243 f	33 a-f	275 i
Bromacil	5	28 ab	134 k	162 c-i
Bromacil	10	18 ab	29 a-f	47 abc
Bromacil	20	8 a	15 abc	23 ab
Diuron	10	36 ab	54 a-i	90 a-f
Diuron	20	15 ab	27 a-f	42 abc
Diuron	40	5 a	15 abc	20 a
Monuron	10	46 abc	69 b-j	115 a-g
Monuron	20	30 a	80 d-k	110 a-g
Monuron	40	50 abc	44 a-h	94 a-f
Simazine	10	54 abc	44 a-h	98 a-f
Simazine	20	34 ab	14 ab	48 abc
Simazine	40	3 a	6 a	9 a
Karbutilate	6	30 ab	86 f-k	116 a-g
Karbutilate	12	14 ab	94 g-k	108 a-g
Karbutilate	24	22 ab	22 a-d	44 a-d
Fenac	3	222 ef	44 a-h	266 hi
Fenac	6	251 f	14 ab	265 hi
Fenac	12	197 def	61 a-j	258 hi

Table 2. Continued

Herbicide	Rate lb/A	Weed grasses	Broadleaved weeds	Total Weeds
Metribuzin	5	128 b-e	74 b-j	202 f-i
Metribuzin	10	70 abc	106 ijk	176 d-i
Metribuzin	15	67 abc	83 e-k	150 b-h
Metribuzin	20	89 ab	99 g-k	188 e-i
Fluometuron	10	96 abc	71 b-j	167 c-i
Fluometuron	20	91 abc	58 a-j	149 b-h
Fluometuron	40	39 ab	28 a-f	67 a-e
Secbumeton	10	26 ab	69 b-j	95 a-f
Secbumeton	20	53 abc	32 a-f	85 a-f
Secbumeton	40	4 a	23 a-e	27 ab
Cyanazine	10	89 abc	76 c-j	165 c-i
Cyanazine	20	111 a-d	115 jk	226 ghi
Cyanazine	40	61 abc	104 h-k	165 c-i
Prometone	10	151 c-f	47 a-i	198 f-i
Prometone	20	30 ab	40 a-g	70 a-e
Prometone	40	9 a	30 a-f	39 abc

1/ Means followed by the same letter are not significantly different at the 5 percent level according to Duncan's New Multiple Range Test.

Table 3. Number of weeds per square yard two years after treatment[1/]

Herbicide	Rate lb/A	Weed grasses	Broadleaved weeds	Total weeds
Weedy check		97 b-g	57 a-f	154 b-j
Bromacil	5	57 a-e	133 ef	190 e-k
Bromacil	10	28 abc	80 a-f	108 b-h
Bromacil	20	47 a-e	28 ab	75 abc
Diuron	10	58 a-e	74 a-f	132 b-j
Diuron	20	36 a-d	48 a-e	84 a-d
Diuron	40	1 a	8 a	9 a
Monuron	10	88 b-g	81 a-f	169 c-k
Monuron	20	72 a-f	114 b-f	186 e-k
Monuron	40	108 d-g	64 a-f	172 d-k
Simazine	10	112 d-g	87 a-f	199 h-k
Simazine	20	109 d-g	76 a-f	185 e-k
Simazine	40	28 abc	69 a-f	97 a-e
Karbutilate	6	156 g	96 b-f	252 k
Karbutilate	12	104 c-g	91 a-f	195 f-k
Karbutilate	24	82 b-g	45 abc	127 b-i
Fenac	3	219 h	132 def	251 k
Fenac	6	141 fg	73 a-f	214 ijk
Fenac	12	125 efg	40 abc	165 c-k

Table 3. Continued

Herbicide	Rate lb/A	Weed grasses	Broadleaved weeds	Total weeds
Metribuzin	5	83 b-g	90 a-f	173 d-k
Metribuzin	10	87 b-g	139 f	226 jk
Metribuzin	15	105 c-g	93 a-f	198 b-k
Metribuzin	20	105 c-g	46 a-d	151 b-j
Fluometuron	10	67 a-f	108 b-f	175 c-k
Fluometuron	20	37 a-d	65 a-f	102 b-h
Fluometuron	40	72 a-f	28 ab	100 b-f
Secbumeton	10	116 efg	64 a-f	180 d-k
Secbumeton	20	122 efg	100 b-f	222 ijk
Secbumeton	40	57 a-e	85 a-f	142 b-j
Cyanazine	10	77 b-f	115 c-f	192 e-k
Cyanazine	20	78 b-f	95 b-f	173 d-k
Cyanazine	40	81 b-g	114 b-f	195 f-k
Prometone	10	106 d-g	86 a-f	192 e-k
Prometone	20	112 d-g	89 a-f	201 i-k
Prometone	40	47 a-d	72 a-f	119 b-h

1/ Means followed by the same letter are not significantly different at the 5 percent level according to Duncan's New Multiple Range Test.

Table 4. Number of weeds per square yard three years after treatment[1/]

Herbicide	Rate lb/A	Weed grasses	Broadleaved weeds	Total Weeds
Weedy check		166 a-f	128 a-e	294 a-f
Bromacil	5	150 a-f	368 f	518 ef
Bromacil	10	63 a-d	305 def	368 c-f
Bromacil	20	12 a-f	15 ab	27 ab
Diuron	10	168 a-f	219 a-f	387 c-f
Diuron	20	418 g	173 a-f	591 f
Diuron	40	2 a	15 ab	17 a
Monuron	10	218 a-g	197 a-f	415 c-f
Monuron	20	219 a-g	102 a-e	321 c-f
Monuron	40	266 c-g	112 a-e	378 c-f
Simazine	10	205 a-g	121 a-e	326 a-f
Simazine	20	287 d-g	49 abc	336 c-f
Simazine	40	257 c-g	141 a-e	398 c-f
Karbutilate	6	268 d-g	210 a-f	478 def
Karbutilate	12	157 a-f	222 a-f	379 c-f
Karbutilate	24	119 a-f	88 a-d	207 a-e
Fenac	3	181 a-f	157 a-f	338 c-f
Fenac	6	77 a-e	177 a-f	254 a-e
Fenac	12	99 a-f	136 a-e	235 a-e

Table 4. Continued

Herbicide	Rate lb/A	Weed grasses	Broadleaved weeds	Total Weeds
Metribuzin	5	77 a-e	141 a-e	218 a-e
Metribuzin	10	114 a-f	227 b-f	341 c-f
Metribuzin	15	110 a-f	138 a-e	248 a-e
Fluometuron	10	134 a-f	239 c-f	373 c-f
Fluometuron	20	161 a-f	314 ef	475 def
Fluometuron	40	34 abc	75 abc	109 abc
Secbumeton	10	243 b-g	84 a-d	327 b-f
Secbumeton	20	307 efg	140 a-e	447 def
Secbumeton	40	316 fg	207 a-f	523 ef
Cyanazine	10	136 a-f	136 a-e	272 a-e
Cyanazine	20	235 b-g	144 a-e	379 c-f
Cyanazine	40	158 a-f	226 b-f	384 c-f

1/ Means followed by the same letter are not significantly different at the 5 percent level according to Duncan's New Multiple Range Test.

Table 5. Equivalent rates of soil sterilants at 80 to 85 percent control one year after treatment (standard = simazine at 20.0 lb/A)

Herbicide	Rate (lb/A)
diuron	12.2
bromacil	8.2
karbutilate	14.7
simazine	20.0
secbumeton	44.6
monuron	58.5
fluometuron	59.8
prometone	82.6
metribuzin	$>$1200.0
cyanazine	$>$4800.0
fenac	∞

Table 6. Equivalent rates of herbicides for near equal vegetation control one year after treatment

CATEGORY	EQUIVALENT RATES OF HERBICIDES	
A	Bromacil 20 lb/A	Simazine 40 lb/A
	Diuron 40 lb/A	Secbumeton 40 lb/A
B	Bromacil 10 lb/A	Prometone 20 lb/A
	Diuron 20 lb/A	Karbutilate 24 lb/A
	Simazine 20 lb/A	Fluometuron 40 lb/A
C	Karbutilate 6 lb/A	Monuron 10 lb/A
	Diuron 10 lb/A	Secbutilate 10 lb/A
	Simazine 10 lb/A	
D	Bromacil 5 lb/A	Fluometuron 10 lb/A
	Metribuzin 5 lb/A	Prometone 10 lb/A
	Cyanazine 10 lb/A	
E	Fenac 3 lb/A	
	Cyanazine 20 lb/A	

Category	% Control
A	90 - 100
B	75 - 90
C	50 - 75
D	25 - 50
E	0 - 25

Table 7. Equivalent rates of herbicides for near equal vegetation control two years after treatment

CATEGORY	EQUIVALENT RATES OF HERBICIDES	
A	Diuron 40 lb/A	
B		
C	Bromacil 20 lb/A	
D	Bromacil 10 lb/A	Fluometuron 20 lb/A
	Diuron 20 lb/A	Simazine 40 lb/A
E	Diuron 10 lb/A	Prometone 40 lb/A
	Karbutilate 24 lb/A	Secbumeton 40 lb/A

Category	% Control
A	90 - 100
B	75 - 90
C	50 - 75
D	25 - 50
E	0 - 25

Table 8. Equivalent rates of herbicides for near equal vegetation control three years after treatment

CATEGORY	EQUIVALENT RATES OF HERBICIDES	
A	Bromacil 20 lb/A	
	Diuron 40 lb/A	
B		
C	Fluometuron 40 lb/A	
D	Fenac 3 lb/A	Karbutilate 24 lb/A
	Metribuzin 5 lb/A	
E	Fenac 6 lb/A	Simazine 10 lb/A
	Cyanazine 10 lb/A	Metribuzin 15 lb/A

Category	% Control
A	90 - 100
B	75 - 90
C	50 - 75
D	25 - 50
E	0 - 25

CHAPTER VIII

THE USE OF MH TO REDUCE THE HEIGHT OF ROADSIDE VEGETATION

The value of MH (maleic hydrazide) for reducing the height of tall fescue was studied in three experiments.

Materials and Methods:

LOCATION: Experiments one and three were located at the University of Missouri Bradford Farm; experiment two was located at the McCredie Research Farm just east of Kingdom City, Missouri.

EXPERIMENTAL DESIGN: Randomized complete block with four replication.

PLOT SIZE: 6.67 feet wide by 20 feet long

PLANTS STUDIED: Tall fescue, Kentucky 31.

DATES TREATED: Experiment 1 - April 24 and May 31, 1971; experiment 2 - May 10, 1972; experiment 3 - May 3 and July 10, 1973.

STAGE OF TALL FESCUE AT TREATMENT: The tall fescue ranged in height from 8 to 16 inches.

WEATHER CONDITIONS AT TREATMENT: Rainfall did not occur immediately following any of the treatments. Normal rainfall occurred in 1971. However, in 1972 and 1973, above normal rainfall occurred for the season. The temperature ranged from 55 to 68^{o}F for the April and May treatments but up to 80^{o}F for the July treatment. All spray treatments were made when the wind ranged from calm up to 8 mph. Spray drift did not seem to be a serious factor under the high wind conditions.

METHOD OF APPLICATION: Treatments were broadcast with a small garden tractor mounted plot sprayer. Treatments were applied in 40 gpa at 40 psi.

DATA TAKEN: Visual observations were made as to the effects of plant growth regulators on tall fescue. The height of tall fescue was measured in inches from the ground level to the top of the seed head.

LIST OF TABLES:

Results and Discussion:

In 1971, the plot area was mowed before treatment on April 24. The 3.0 and 4.0 lb/A rate had no effect on the growth of tall fescue. The 6.0 lb/A rate held the fescue back slightly. Apparently removing the majority of the leaf area before application made the treatments ineffective.

In 1972, the plot area was not mowed before treatment. Applications made on May 10 reduced the leaf height slightly and had various effects on the height of the head. Table 2 gives the distance from the ground to the seed head for each treatment.

Maintain CF 125 was not effective in retarding the growth when used alone. However, the effectiveness of Maintain 3 + Maintain CF 125 at 3.0 + 1.0 lb/A was equal to Maintain 3 at 6.0 lb/A. See Table 3 for the percent reductions in seed stalk height.

In 1973, the applications on May 3 were more effective (Table 2 and 3). Maintain 3 plus Maintain CF 125 at 3.0 + 1.0 lb/A was equal in effectiveness to Maintain 3 at 4.5 lb/A. The treatments on May 3, 1973 were more effective than those on May 10, 1972. It is probable that an earlier application date would result in more satisfactory results.

Table 1. Composition of materials applied

Common name	Trade name	Chemical name	Concentration	Source
MH	Maintain 3	diethanolamino salt of 6-hydroxy-3-(2H)-pyridazinone	3 lb/gal	U.S. Borax
(none)	Maintain CF 125	methyl 2-chloro-9-hydroxyfluorine-9-carboxylate + methyl-9-hydroxyfluorine-9-carboxylate + methyl-2,5-dichloro-9-hydroxyfluorine-9-carboxylate	1 lb/gal	U.S. Borax

Table 2. Height of tall fescue seed stalks in inches

Treatment	Rate (lb/A)	Application date	
		May 3, 1973	May 10, 1972
Check		35.0	30.7
Maintain 3	3.0	19.5	20.0
Maintain 3	4.5	17.5	---
Maintain 3	6.0	13.5	16.1
Maintain CF 125	3.0	---	29.3
Maintain CF 125	6.0	---	28.8
Maintain 3 + Maintain CF 125	3.0 + 1.0	17.5	16.0
Maintain 3 + Maintain CF 125	6.0 + 2.0	---	17.4

Table 3. Percent reduction in height of seed stalk of tall fescue by growth retardants

Treatment	Rate (lb/A)	Application date	
		May 3, 1973	May 10, 1972
Check		0	0
Maintain 3	3.0	44	35
Maintain 3	4.5	50	--
Maintain 3	6.0	61	48
Maintain CF 125	3.0	--	5
Maintain CF 125	6.0	--	6
Maintain 3 + Maintain CF 125	3.0 + 1.0	50	48
Maintain 3 + Maintain CF 125	6.0 + 2.0	--	43

CHAPTER IX

CONCLUSIONS AND RECOMMENDATIONS

Two,4-D will control most annual broadleaved weeds and give partial control of perennial broadleaved weeds. Repeated annual treatments improve control of perennials but some species such as common milkweed are not controlled well by them.

Picloram was very effective on common milkweed. Experience with this herbicide indicated that it also gives excellent control of a large number of broadleaved species. It also has a wide margin of selectivity between desirable grasses and broadleaved plants. There is an important disadvantage of picloram. Some desirable broadleaved plants are damaged by low dosages of picloram and thus may be injured by only moderate movement from the target area either by drift or by movement in surface water. It also cannot be used in the close proximity of most ornamental plants on the roadsides including woody ornamentals. Picloram can be used safely, however, by choosing the appropriate formulation and carefully following the labels.

For areas where picloram is not appropriate dicamba alone or in combination with 2,4-D should be considered.

Dicamba has some of the same disadvantages as picloram but to a lesser degree. Its toxicity to desirable plants is lower so the risk of damage from very small amounts contacting desirable plants would be less. This hazard is greater than that from 2,4-D, however. The addition of 2,4-D enhanced control by dicamba, but reduced control by picloram.

Two,4-DP and fenac showed promise for control of common milkweed. One of these herbicides would be expected to improve the control of weeds that tend to lack susceptibility to 2,4-D. In general use, these materials have not been considered as hazardous to plants outside the target area as picloram or dicamba.

The control from these herbicides used at high rates compared with low rates varied from a reduction to a small increase. This is because the high rates injure the tops of the plants more rapidly and result in less translocation to the underground parts of the plants. There is no advantage in using excessively high rates of these herbicides.

Spray loss in this research was measured by determining the difference between the amount of spray material delivered by the sprayer and the amount recovered in the target area. Thickened sprays did not cause a significant reduction in spray losses. However, experience indicated that thickened sprays reduce the number of tiny droplets produced. Perhaps the reduction in number of droplets within this size range could not be detected by our methods because of variability and the small proportion of spray drift that these droplets constitute. This leads one to believe that the tremendous spray losses were mainly due to volatility. Thickening agents are probably useful in reducing the hazard of injury from drift to near-by vegetation, but they probably do not significantly reduce the total loss of spray material between the nozzle tip and the target.

Thickening agents affected viscosity of spray mixtures but had less effect on surface tension and little effect on density. Surface tension and density of thickened sprays were significantly altered by varying the rate of the thickening agent or the rate or kind of herbicide. In addition, surface tension of the mixture was affected by the type of agitation. There was no indication in this research that the tendency for spray mixtures to drift could be estimated by measuring any of these physical properties.

The thickening agents used in this study have various advantages and disadvantages. Norbak is quite effective but extremely hard to mix. It is sensitive to changes in temperature, source of water, setting time, and herbicides, expecially the various salt formulations. Kelzan is extremely hard to mix, and it requires the use of alcohol for dispersion. Thickened sprays of Kelzan are not affected by setting time and high temperature. Dacagin is very easy to mix, but is sensitive to herbicide formulations. It will not work if high concentrations of salt formulations are used. Vistik is also easy to mix, but soda ash must be added in a separate operation. Vistik can be used with most herbicides and will give a wide range of viscosities depending on concentration. All of these can be used in conventional spraying equipment with little or no modification.

Thickening agents added to spray mixtures had no significant effect on weed control.

The OC 150 type of nozzle had the important advantage over booms with small nozzles of not requiring special arrangements for coping with roadsigns, mail boxes, and other obstructions near the spray swath. It is also cheaper and easier to maintain. However, its spray pattern tends to be erratic under field conditions and spray losses appear to be great.

Several soil sterilants could be used to control weeds for one season or one year. Bromacil, simazine, diuron, secbumeton, prometone, and karbutilate could be used. The preferred herbicide would depend on cost per unit area. If long-term control is desired, bromacil or diuron can be used. Bromacil moved the most with surface water resulting in the greatest amount of killing of vegetation outside the target area.

MH was erratic in its performance. There was some reduction in number and height of tall fescue seed stalks. Application earlier in the season might have given more satisfactory results. Mowing before the application of MH made the treatment ineffective.

Since the initiation of this research program, some new materials have been developed. In the area of thickening agents, liquid thickeners are being manufactured that are very easy to mix. Two of these are Nalcotrol by Nalco Chemical Company and Lo-Drift by Amchem. Du Pont, Chemagro, and Chipman Chemical Companies are actively researching soil sterilants and the Dow Chemical Company is seeking a herbicide with most of the advantages of bromacil but without some of the disadvantages. Further research in these areas is necessary to continue to advance in the technology of vegetation control.

Federal law requires that a pesticide be used only as specified on the label which may change from time to time. Herbicidal treatments mentioned in this report should be used only after verifying that they are provided for on the labels.