THE EFFECTS OF 4 AMINO 3,5,6-TRICHLOROPICOLINIC ACID ON SEEDLING AND ESTABLISHED NATIVE GRASSES AND PERENNIAL FORBS

By

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INTRODUCTION

Various herbicides have been used as management tools in the past to control undesirable plants on both crop and non-crop land. As a group, the deep rooted perennial herbaceous weeds constitute a problem of widespread and economical importance. Grass production is suppressed by the competition of undesirable vegetation. According to Lambert and Janike (9), the elimination of weeds is one of the most important steps taken toward producing the maximum forage production in a given area. Hormay et. al. (8) states that the fastest, easiest, and cheapest way of increasing the grazing capacity of rangelands on a specific range-site is through the use of herbicides.

The phenoxy type herbicides (such as 2,4,5 trichlorophenoxyacetic acid), introduced in the early 1940's, provide control for a wide range of species; however, there were problems due to herbicide volatilization and to the presence of resistant species. The chemical 4 amino 3,5,6-trichloropicolinic acid (picloram) has been found to be a new systemic growth-regulating herbicide. The characteristic growth responses resemble effects produced by the phenoxy herbicide 2,4-dichlorophenoxy-acetic acid (2,4-D).

The purpose of this study was to evaluate the effects of picloram on range grasses and weeds. Research was initiated to study its effects on native grass seedlings, established native grass plants, and perennial weeds.

LITERATURE REVIEW

Buck and Kelting (2) in a survey of the tall grass prairie in Northeastern Oklahoma found Aster ericoides to be one of the most frequent species on 68 excellent condition prairie sites. Sims (12) reported that perennial species Ambrosia psilostachya, Achellia lanulosa, Rudbeckia hirta, Cirsium undulatum and Vernonia baldwini increase in abundance as the grazing pressure becomes greater. Weaver and Hansen (15) found that A. psilostachya, V. baldwini and A. ericoides were the dominant forbs increasing in Nebraska when the bluestems degenerated past the point of competition. Elder (5) stated that the most harmful weed in Oklahoma is A. psilostachya. Dwyer (3) reported that rhizomatous forbs decrease the production of big bluestem by more than 50 per cent. Aster ericoides caused the greatest decrease in plant growth both above and below the soil surface. Ambrosia psilostachya was second. The grass production was decreased 60.5 and 53.6 per cent respectively due to competition.

Considerable research has been done on chemical weed control in rangeland. Most of the research is concerned with 2,4-D or 2,4,5-T; however, many weedy species are resistant or only moderately susceptible to these compounds. Picloram has shown promise as a means to control some deep rooted perennial herbaceous weeds in crop and non-crop areas. Laning (10) reported that generally one application of picloram at 2 lb./A. has given complete control of Convolvulus arvensis and Cirsium

arvensis. The herbicide is highly active when applied as a foliar application but it has been more effective in California experiments when leached into the root zone of these plants. Picloram is apparently more active than 2,4-D, 2,4,5-T, and 2,3,6-trichlorobenzoic acid (2,3,6-TBA) when used for weed control in crops and control of woody species in utility rights-of-way (7, 14).

Arnold and Santelmann (1) state that slight injuries to corn and grain sorghum caused by the potassium salt of picloram applied as pre- and post-emergence applications were overcome by the middle of the growing season. The pre-emergence application gave the best weed control. Studies on the persistence of picloram in soils showed that the residue disappeared within 31 days following the date of application when used at the rates of one-eighth and one-fourth pounds per acre. Picloram applied at one pound rates remained active for 96 to 294 days, depending on the soil type and at two pound rates the herbicide retained activity for 465 days.

The vapors from the potassium salt formulation of picloram were shown to have herbicidal activity in a closed system (6). Picloram vapors caused more injury to Pinto beans than did propylene glycol butyl ether esters of 2,4-D or the dimethylamine salt of dicamba. This new pyridine compound appears to be active at very low concentrations and is well adapted to certain bioassay methods which may be used for detecting it in minute amounts (11).

MATERIALS AND METHODS

The materials used for this investigation were the potassium salt of picloram and the propylene glycol butyl ether ester of 2,4-D. The commercial spray form of picloram is sold as Tordon 22K. The granular form is sold as Tordon 2K or 10K. Picloram is made as a potassium salt solution containing two pounds of active ingredient per gallon or as a granular formulation containing two or ten per cent acid equivalent per pound.

The investigation was conducted on a loamy prairie range site with the vegetation in "good" range condition (4). The loamy prairie range site is the dominant site in North Central Oklahoma. The topography is moderately sloping with deep loamy upland soils. The soils are neutral to slightly acid with a slow to medium permeability.

The experiment on the established native grass was designed as a randomized complete block with seven treatments per replication with five replications in 1963 and four replications in 1964. The plots were 27 by 15 feet with a three foot border to minimize the border effect. The treatments and rates used in pounds of active ingredient per acre were as follows: picloram liquid, one, two, and four; picloram 10K granular, one and two; 2,4-D, three-fourths. The dates of these applications were 6-13-63 and 6-7-64.

Forb count per treatment was determined by taking five random square foot counts per plot before and after treatment. Forbs occurring

in each square foot were identified and counted to determine the per cent kill.

The effects of picloram on native grass were measured in grass frequency and grass production. Grass frequency was determined by taking five random square foot counts per plot before and after treatment. Each grass species was recorded and expressed as a frequency of occurrence basis. The formula used was $\frac{\text{no. of samples in which the species occurred}}{\text{no. of samples taken}} \times 100$ Five occurrences in a plot would be maximum. The herbage production was determined by using a 11 1/2 by 24 inch clip quadrat. The vegetation occurring within the quadrat was separated into grasses and forbs and clipped at ground level approximately August 24 each year. Each sample was dried at 100° C. for 36 hours. Weights per acre for each treatment were calculated by multiplying the average weight in grams by the factor of 50.

In the greenhouse, each of four species, big bluestem (Andropogon gerardi Vitman), switchgrass (Panicum virgatum L.), blue grama (Bouteloua gracilis H. B. K. Lag. x Steud.), and sideoats grama (Bouteloua curtipendula Michx. Torr), was seeded in individual one-gallon cans. Forty seeds of each species were planted and later thinned to 15 uniform plants per container. The design used in this experiment was a 5 x 4 x 3 factorial randomized complete block. The first factor was the treatments applied: picloram at three-fourths, one and one half, and three pounds, 2,4-D at one pound of active ingredient per acre, and an untreated check. The second factor was the different species to which the rates of picloram were applied. The third factor was the different growth stages to which the rates of picloram were applied:

pre-emergence, two leaf stage and four leaf stage. Each block consisted of four replications. The survival of each species was determined by counting the number of plants remaining after 67 days. The plants were clipped at ground level and green weights per plant were determined.

The same species were planted in the field on a Norge loam soil. This experiment was designed as a 3 x 4 x 4 factorial split plot randomized complete block. The first factor was stage of growth; the second factor was the rate of chemical; the third factor was species treated. The herbicide was applied at the two leaf stage, four leaf stage and six leaf stage. The rates of picloram used were the same as the rates used in the greenhouse experiments except that 2,4-D was not used. The plot dimensions consisted of five, five foot rows seeded one foot apart with four replications. The number of seedlings per 30 inches in the center of the row were counted before and after the treatment to determine the per cent survival. The plants within the thirty inches in each plot were clipped at the ground level, dried at 100° C. for 36 hours, and converted to grams dry weight per plot.

RESULTS AND DISCUSSION

Greenhouse Experiments

Application of picloram pre-emergence to sideoats grama, big bluestem, switchgrass and blue grama prevented germination (Table I) at all rates used. The application of 2,4-D caused a significant reduction in the number of sideoats grama plants, but this was the only species in which 2,4-D reduced germination.

When treated during the two leaf stage, the stand of sideoats grama and switchgrass plants was significantly reduced by all treatments. Big bluestem was the most tolerant species to the low rate of picloram and 2,4-D. At 1.5 pounds of picloram per acre, the stand was significantly reduced. Blue grama stand was not reduced when sprayed with 2,4-D but the .75 and 1.5 pound rates of picloram did reduce the stand when compared to the check. There was no statistical difference between 2,4-D or the lower rates of picloram.

These species sprayed at the four leaf stage were not damaged to as large an extent as they were when sprayed at the two leaf stage. The stand of sideoats grama and big bluestem was not significantly reduced by the low rates of picloram or 2,4-D, but the stand was reduced at the high rate of picloram. The stand of switchgrass and blue grama was reduced when treated with 1.5 pounds of picloram; however, the blue grama stand was not damaged as much at the three pound rate as the switchgrass stand.

TABLE I

THE NUMBER OF SIDEOATS GRAMA, BIG BLUESTEM, SWITCHGRASS AND BLUE GRAMA PLANTS REMAINING AFTER TREATMENT WITH PICLORAM AND 2,4-D DURING PRE-EMERGENCE, TWO LEAF AND FOUR LEAF STAGES[1]

Species	Stages to Which Treatments as Pounds Per Acre Were Applied									
	Pre-Emergence					Two Leaf				
	Picloram/A.			2,4-D		Picloram/A.			2,4-D	
	.75	1.5	3.0	.75	Check	.75	1.5	3.0	.75	Check
Sideoats Grama	0	0	0	7 b	15 a	7.7bc	4.2c	0 d	9 b	14 a
Big Bluestem	0	0	0	15 a	14.5a	13 a	7.7b	1 c	12.7a	13.9a
Switchgrass	0	0	0	15 a	14.7a	8 b	5.2bc	2.7c	7.2b	14.5a
Blue Grama	0	0	0	14.7a	14.5a	7.5b	8.5b	1.5c	11 ab	14 a

Species	Four Leaf				
	Picloram/A.			2,4-D	
	.75	1.5	3.0	.75	Check
Sideoats Grama	11.7a	10.5ab	8 b	12.5a	13.2a
Big Bluestem	9.7a	10 a	1.7b	11.5a	10.2a
Switchgrass	11.5a	8.7b	3.5c	11.2a	13.5a
Blue Grama	11 ab	9.5b	9.7b	12.7a	10.5ab

[1]Figures shown are the mean of four replicates representing number of plants remaining of 15 initial plants per culture. Within each species and each growth stage figures followed by the same letter are not significantly different; figures followed by different letters are significantly different at the .05 level.

The increase in weight of the individual species (Table II) was reduced to a greater extent than the number of plant reductions would indicate because the plants that survived the treatments were stunted. When applied pre-emergence, 2,4-D significantly reduced the yield of sideoats grama, big bluestem and blue grama but did not reduce the yield of switchgrass. The 2,4-D treatment reduced the yield of sideoats grama when applied during the two leaf stage but did not reduce the yield of the other species in the two or four leaf stages. The yield of sideoats grama and big bluestem was reduced at .75 pound of picloram per acre whereas the yield of switchgrass and blue grama was not reduced until three pounds of picloram per acre were applied. This rate also decreased the yield of big bluestem and switchgrass in the four leaf stage.

Field Experiments

Survival and Yield of Seedling Sideoats Grama

Picloram significantly decreased the stand of sideoats grama at all rates when applied during the two and four leaf growth stages (Table III). In the six leaf stage the three pound rate caused the only significant reduction in stand, and even here the stand reduction was less than in the four leaf stage. As the concentration of picloram increased, the survival of sideoats grama was significantly decreased; but the plants were less susceptible as they approached maturity. With regard to yields, there was a significant reduction between the check and all rates of picloram, an effect which occurred at each leaf stage. There were significant differences in yield between the two and four leaf stages but not between the four and six leaf stages at .75 pound per acre.

TABLE II

THE YIELD OF SIDEOATS GRAMA, BIG BLUESTEM, SWITCHGRASS AND BLUE GRAMA PLANTS AFTER TREATMENT WITH PICLORAM AND 2,4-D APPLIED DURING PRE-EMERGENCE, TWO LEAF AND FOUR LEAF STAGES[1]

Species	Stages to Which Treatments as Pounds Per Acre Were Applied									
	Pre-Emergence					Two Leaf				
	Picloram/A.			2,4-D		Picloram/A.			2,4-D	
	.75	1.5	3.0	.75	Check	.75	1.5	3.0	.75	Check
Sideoats Grama	0	0	0	1.3b	2.7a	3.1c	.9d	0 d	6.7b	13.9a
Big Bluestem	0	0	0	1.9b	4.0a	4.7b	.4c	.4c	7.6a	9.3a
Switchgrass	0	0	0	2.3a	1.9a	3.1a	5.8a	.3b	3.8a	5.2a
Blue Grama	0	0	0	1.3b	2.3a	2.9a	3.6a	.3b	5.7a	5.1a

Species	Four Leaf				
	Picloram/A.			2,4-D	
	.75	1.5	3.0	.75	Check
Sideoats Grama	10.1a	15.0a	10.8a	13.7a	13.2a
Big Bluestem	8.3a	9.7a	1.4b	12.9a	8.5a
Switchgrass	10.6ab	9.4ab	5.9b	15.1a	9.9ab
Blue Grama	9.5a	9.0a	7.0a	8.5a	8.1a

[1]Figures shown are the mean of four replicates representing number of plants remaining of 15 initial plants per culture. Within each species and each growth stage figures followed by the same letters are significantly different at the .05 level. Yield is given in grams per plot.

TABLE III

THE PER CENT SURVIVAL AND YIELD OF SIDEOATS GRAMA AFTER TREATMENT WITH PICLORAM APPLIED AT THREE GROWTH STAGES[1]

Treatment Lbs./A.	Per Cent Survival — Growth Stages		
	2 Leaf	4 Leaf	6 Leaf
Check	100 a	100 a	100 a
.75	40.2b	68.0b	94.7ab
1.5	27.2c	56.2c	95.2ab
3.0	22.2c	41.2d	88.0b

Treatment Lbs./A.	Grams of Oven-Dry Forage Per Plot — Growth Stages		
	2 Leaf	4 Leaf	6 Leaf
Check	133.73a	126.42a	125.60a
.75	5.75b	38.65b	57.52b
1.5	3.82b	18.47b	73.72b
3.0	1.85b	8.6b	81.0 b

[1]Within each leaf stage figures followed by the same letter are not significantly different; figures followed by different letters are significantly different. Between leaf stages figures underlined by the same line are not significantly different; figures not underlined by the same line are significantly different.

Survival and Yield of Seedling Big Bluestem

Picloram sprayed at .75 pound per acre during the two and four leaf stages of big bluestem significantly decreased the stand (Table IV). In the two leaf stage there was no significant difference in survival between the two low rates but there was at the four leaf stage. In the six leaf stage picloram at the highest concentration did not reduce the stand of big bluestem. There was no significant difference in survival between the two and four leaf stages at any rate of picloram. The survival for the four leaf stage was significantly reduced when compared to the six leaf stage.

The average yield closely followed the pattern for plant survival. There was a significant reduction in yield at the two leaf stage with the .75 pound and higher rates. At the six leaf stage there was no reduction in yield for any concentration of picloram. When picloram was applied at the .75 pound rate, there was a significant reduction in yield between the two and four leaf stages but not between the four and six leaf stages. When applied at 1.5 and three pounds, there was no significant reduction in yield between the two and four leaf stages but there was between the four and six leaf stages.

Survival and Yield of Seedling Switchgrass

All rates of picloram reduced the stand of switchgrass when sprayed during the two and four leaf stages, but no rate reduced the stand when sprayed during the six leaf stage (Table V). There was significant reduction in survival between each leaf stage at each concentration of picloram.

Picloram significantly reduced the yield of switchgrass when applied in the two and four leaf stages but did not reduce yield at any

TABLE IV

THE PER CENT SURVIVAL AND YIELD OF BIG BLUESTEM AFTER TREATMENT WITH PICLORAM APPLIED AT THREE GROWTH STAGES[1]

Treatment Lbs./A.	Per Cent Survival — Growth Stages		
	2 Leaf	4 Leaf	6 Leaf
Check	100 a	100 a	100 a
.75	64.2b	71.7b	97.5a
1.5	66.7b	57.5c	98.5a
3.0	59.2b	53.5c	92.5a

Treatment Lbs./A.	Grams of Oven-Dry Forage Per Plot — Growth Stages		
	2 Leaf	4 Leaf	6 Leaf
Check	20.47a	24.27a	23.05a
.75	6.50b	14.15ab	19.80a
1.5	4.9 b	3.82c	22.77a
3.0	7.0 b	7.35bc	21.30a

[1]Within each leaf stage figures followed by the same letter are not significantly different; figures followed by a different letter are significantly different. Between leaf stages figures underlined by the same line are not significantly different; figures not underlined by the same line are significantly different.

TABLE V

THE PER CENT SURVIVAL AND YIELD OF SWITCHGRASS AFTER TREATMENT WITH PICLORAM APPLIED AT THREE GROWTH STAGES[1]

Treatment Lbs./A.	Per Cent Survival — Growth Stages		
	2 Leaf	4 Leaf	6 Leaf
Check	100 a	100 a	100 a
.75	42.7b	73.5b	99.7a
1.5	32.7c	64.2b	96.7a
3.0	33.0c	63.5b	93.5a

Treatment Lbs./A.	Grams of Oven-Dry Forage Per Plot — Growth Stages		
	2 Leaf	4 Leaf	6 Leaf
Check	125.22a	129.40a	127.30a
.75	23.42b	47.47b	88.97a
1.5	18.82b	44.37b	110.60a
3.0	8.40b	36.15b	109.07a

[1]Within each leaf stage figures followed by the same letter are not significantly different; figures followed by a different letter are significantly different. Between leaf stages figures underlined by the same line are not significantly different; figures not underlined by the same line are significantly different.

concentration when applied to the six leaf stage. There were significant differences in yield between the two and four leaf stages at the .75 pound rate, but the differences were not significant between the four and six leaf stages.

Survival and Yield of Seedling Blue Grama

In all growth stages of blue grama and at all concentrations of picloram there was significant reduction in stand (Table VI). In the two and four leaf stages the higher rates caused a greater reduction in stand, but in the six leaf stage all rates caused the same reduction. There were significant differences in stand between each leaf stage when treated with .75 and three pound rates.

The yield was reduced when the plants were treated during the two leaf stage at .75 pound per acre but was not reduced in the four leaf stage at the same rate. Higher rates in the four leaf stage significantly reduced yield but yield was not reduced in the six leaf stage at any rate. There were significant differences in yield between the two and four leaf stages at the two lower rates. There was no yield reduction between the four and six leaf stages at .75 pound; however, the two higher rates did significantly reduce yield in the four leaf stage when compared to the six leaf stage.

TABLE VI

THE PER CENT SURVIVAL AND YIELD OF BLUE GRAMA AFTER TREATMENT WITH PICLORAM APPLIED AT THREE GROWTH STAGES[1]

Treatment Lbs./A.	Per Cent Survival — Growth Stages		
	2 Leaf	4 Leaf	6 Leaf
Check	100 a	100 a	100 a
.75	59.0b	73.5b	85.7b
1.5	44.2c	75.5b	79.2b
3.0	21.5d	37.5c	84.7b

Treatment Lbs./A.	Grams of Oven-Dry Forage Per Plot — Growth Stages		
	2 Leaf	4 Leaf	6 Leaf
Check	12.80a	14.60a	18.12a
.75	2.63b	12.70ab	18.02a
1.5	1.05b	3.92b	9.77a
3.0	.70b	2.77b	16.30a

[1]Within each leaf stage figures followed by the same letter are not significantly different; figures followed by a different letter are significantly different. Between leaf stages figures underlined by the same line are not significantly different; figures not underlined by the same line are significantly different.

Established Native Grass

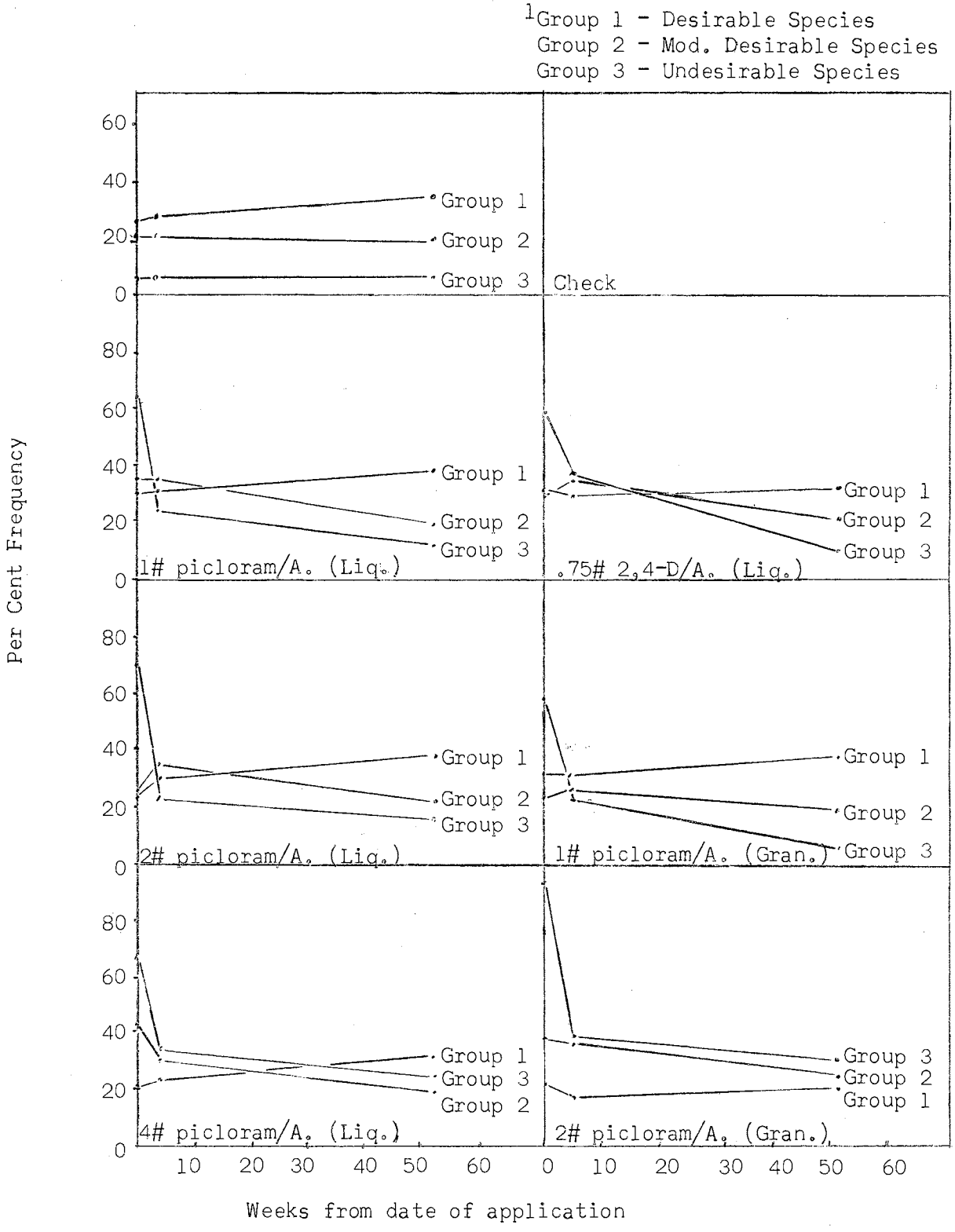
The frequency of occurrence of native grass has value only to indicate the distribution of a species to produce herbage and to influence herbage production in associated species. The frequency measurements are more consistent when measurements are taken once a year. Any major change in frequency will indicate a change in plant population (13).

The desirable species, little bluestem (Andropogon scoparius Michx.), big bluestem (A. gerardi), indiangrass (Sorghastrum nutans L. Nash), and switchgrass (Panicum virgatum) comprised 57 per cent of the basal composition in the area. The moderately desirable species, blue grama (Bouteloua gracilis), sideoats grama (B. curtipendula), hairy grama (B. hirsuta Lag.), tall dropseed (Sporobolus asper Michx.), scribners panicum (Panicum scribnerianum Nash), purple lovegrass (Erogrostis spectabilis Pursh Steud.) and Carex sp. comprised 35 per cent of the basal composition. The undesirable species, silver bluestem (Andropogon saccharoides Swartz.), threeawn (Aristida oligantha Michx.) and Paspalum spp. comprised 8 per cent.

A definite trend can be seen in the change of vegetative composition at all treatment levels (Figure 1). All rates of picloram, except the four pound liquid and two pound granular rates, produced a wider range in frequency between desirable and undesirable species when compared to 2,4-D. The high rate of picloram probably killed the desirable seedling species thus narrowing the frequency range to well established perennial plants. In general, the moderately desirable and undesirable species decrease in frequency as the desirable plants increase. This

FIGURE 1

THE FREQUENCY OF DESIRABLE, MODERATELY DESIRABLE AND UNDESIRABLE SPECIES FIVE AND FIFTY TWO WEEKS FOLLOWING TREATMENT OF PICLORAM AND 2,4-D[1]



effect may be due to the inability of the moderately desirable and undesirable species to compete with the desirable species in the tall grass prairie once the competition of forbs is eliminated.

Table VII shows the average grass and forb production at the different treatment levels. The difference in yield between treatments was not significant; however, the data indicates a trend of producing more forage when the non-herbaceous broadleaf weeds are controlled. As the pounds of forbs increase, the grass weights per acre decrease.

TABLE VII

EFFECTS OF PICLORAM AND 2,4-D ON GRASS AND FORB PRODUCTION[1]

Chemical	Form	Rate Lb./A.	Herbage Production in Pounds Per Acre			
			Area I	Area II	1963	1964
			Grass		Forbs	
Picloram	Liquid	2.00	4,340	2,203	5	45
Picloram	Liquid	1.00	3,755	2,372	30	77
2,4-D	Liquid	0.75	3,610	2,134	65	70
Picloram	Granular	2.00	3,510	1,463	145	373
Picloram	Liquid	4.00	3,475	2,282	2	13
Picloram	Granular	1.00	3,040	2,371	130	151
Control			3,160	1,891	280	283

[1]Figures followed by the same letter are not significantly different while figures followed by different letters are significantly different at the .05 level.

This holds true for both locations and all rates of picloram used except the four pound rate. Approximately 14 days following application, the plants sprayed with four pounds per acre appeared to be damaged. The perennial plants took on a light yellowish appearance but overcame these conditions toward the end of the growing season. The native grass plants did not appear to be abnormal during the following growing season.

The pounds of forbs per acre were less under liquid application as compared to granular application. Forb yields in location 1 were significantly different for all treatments when compared to the check. Between treatments there were significant differences between two pounds of active ingredient per acre as a granular application and two pounds of active ingredient applied as a liquid application. This difference is probably due to the uneven distribution of the granules. In location 2 the two and four pounds of active ingredient per acre applied as liquid were significantly different from the check or two pound granular treatment. Some of this difference could be explained from the distribution of Louisiana sagewort plants.

Perennial Weeds

Table VIII shows the reduction in forbs per square foot on location 1 five weeks and 53 weeks following treatment with liquid and granular picloram and 2,4-D. The data indicates a reduction in the number of western yarrow (Achillea millefolium L. subsp. lanulosa Nutt.), western ragweed (Ambrosia psilostachya DC.), heath aster (Aster ericoides L.), manyflower scurfpea (Psoralea tenuiflora pursh var. floribunda Nutt. Rydb.), and baldwin ironweed (Vernonia baldwini Torr.)

at all rates and formulations of picloram. The few Louisiana sagewort (Artemisia ludoviciana) plants that were in the plots on location 1 appeared resistant to picloram while the baldwin ironweed plants appeared susceptible.

Another location, ten miles west of location 1, was obtained for treatment in 1964 (Table IX). This area contained a greater abundance of Louisiana sagewort and baldwin ironweed plants but relatively the same composition of grasses. In this location, Louisiana sagewort and baldwin ironweed both showed resistance to 2,4-D. Baldwin ironweed was susceptible to picloram at one pound while Louisiana sagewort was resistant at the four pound rate. The sagewort plants were curled and damaged at the high rate but were not killed. Picloram applied as a liquid formulation gave better and faster control. Fifty three weeks following treatment there was no noticeable difference in per cent control between the granular and one pound of liquid (Table X). This indicates that picloram has a long soil residual content.

Picloram caused the broadleaf plants to exhibit a greater degree of twisting at the lower rates as compared to 2,4-D. Under the influence of picloram, broadleaf plants' terminal portion appeared to bend and grow toward the ground. The leaves formed a cup (usually downward). As the rates were increased, the leaves became rolled resembling drought stress. The leaves became slightly chlorotic with chlorosis starting at the tip and margins and spreading over the leaf. The stems and nodes showed extreme swelling in the apical regions. The main stems on some species showed a flattening appearance near the apex.

On some broadleaf species picloram caused whitish yellow "blisters" to form on the upper leaf surface. This occurs only at very minute

TABLE VIII

THE AVERAGE NUMBER OF FORBS PER SQUARE FOOT BEFORE TREATMENT, 5 WEEKS AND 53 WEEKS FOLLOWING TREATMENT IN 1963 ON LOCATION ONE[1]

	Picloram								
	1#/A. Liquid			2#/A. Liquid			4#/A. Liquid		
Species	Before	5 Weeks	53 Weeks	Before	5 Weeks	53 Weeks	Before	5 Weeks	53 Weeks
Western Yarrow	1.3	.2	0	.8	.1	0	.9	.1	0
Western Ragweed	1.6	0	.1	2.4	0	0	3.6	0	0
Louisiana Sagewort	---	.5	.3	---	.1	.2	.2	.1	.3
Heath Aster	1.2	.1	0	.4	.3	0	1.8	.4	0
Broomweed	.3	0	0	.1	0	0	.3	0	0
Manyflower scurfpea	1.1	0	.2	1.1	0	0	1.2	0	0
Baldwin Ironweed	.8	0	0	.1	0	0	.2	0	0
Others	.6	.1	.3	1.6	0	0	3.4	0	.1
Total	6.8	.9	.9	6.4	.5	.2	11.5	.6	.4

	Picloram						2,4-D		
	1#/A. Granular			2#/A. Granular			.75#/A. Liquid		
Species	Before	5 Weeks	53 Weeks	Before	5 Weeks	53 Weeks	Before	5 Weeks	53 Weeks
Western Yarrow	.9	.3	.1	1.2	.1	.2	1.0	.3	.3
Western Ragweed	2.4	1.8	.1	4.6	2.9	.4	1.1	.2	.3
Louisiana Sagewort	---	---	---	---	---	---	---	---	---
Heath Aster	.6	.8	.2	7.7	1.7	.6	1.1	.5	0
Broomweed	.4	.1	0	.1	.1	0	.2	0	0
Wild Alfalfa	1.2	.2	.5	1.1	.2	.6	1.7	.2	.2
Baldwin Ironweed	.1	.1	0	---	.1	.1	---	---	.1
Others	2.4	.1	.3	4.1	.2	.4	1.9	0	.1
Total	8.0	3.3	1.2	18.7	5.1	2.3	6.9	1.4	1.0

[1]Figures shown are averages of five replications.

TABLE IX

THE AVERAGE NUMBER OF FORBS PER SQUARE FOOT BEFORE TREATMENT AND 5 WEEKS FOLLOWING TREATMENT IN 1964 ON LOCATION TWO[1]

	Picloram										2,4-D	
	1#/A. Liquid		2#/A. Liquid		4#/A. Liquid		1#/A. Granular		2#/A. Granular		.75#/A. Liquid	
	Before	5 Weeks	Before	5 Weeks	Before	5 Weeks	Before	5 Weeks	Before	5 Weeks	Before	5 Weeks
Western Yarrow	.2	.1	.1	0	.2	0	---	---	---	---	.2	.1
Western Ragweed	.5	0	.3	0	.4	0	.9	.6	.8	.3	.6	.1
Louisiana Sagewort	1.5	1.2	1.8	1.2	2.1	3.1	1.9	1.0	2.0	1.5	1.0	1.2
Heath Aster	.5	0	---	---	.1	0	.1	---	.5	.2	.6	0
Baldwin Ironweed	.6	0	1.0	0	1.2	0	1.6	.7	.8	.3	.6	.4
Other	.3	0	.6	.1	.3	0	1.5	.8	.4	.2	1.0	.1
Total	3.6	1.3	3.8	1.3	4.3	3.1	6.0	3.1	4.5	2.5	3.4	1.9

[1]Figures shown are averages of four replications.

concentrations. When the "blister" had disappeared, a dead spot remained in the leaf surface.

TABLE X

THE AVERAGE PER CENT KILL OF BROADLEAF PLANTS USING PICLORAM AND 2,4-D FOR TWO YEARS AT DIFFERENT LOCATIONS[1]

		Per Cent Kill		
		Location One		Location Two
		Observation Date		
		7-16-63	6-19-64	8-14-64
Picloram	1#/A. Liquid	87.1	86.5	63.6
Picloram	2#/A. Liquid	93.1	95.0	64.6
Picloram	4#/A. Liquid	95.3	96.9	71.0
2,4-D	.75#/A. Liquid	80.6	81.5	48.0
Picloram	1#/A. Granular	58.7	85.5	50.0
Picloram	2#/A. Granular	72.6	88.3	47.0

[1]Figures for location one are the average of five replications and for location two they are the average of four replications.

DISCUSSION

Picloram in the greenhouse studies was found to be an effective pre- and post-emergence herbicide. It can prevent germination of grass and broadleaf weeds, or it can be translocated within either types of plant. The translocation was observed by the curling of the plants at the base and terminal portions. Picloram caused damage to seedlings both in the greenhouse and in the field. The least reduction in stand and yield came when sprayed at the four and six leaf growth stages. Three of the four species used--big bluestem, sideoats grama, and switchgrass were resistant to picloram in the six leaf stage. A reduction in stand did occur with blue grama; however, the stand reduction did not affect yield.

The effect of picloram on seedlings could explain the differences in frequency of established native grass. According to Weaver and Hansen (15) the plants in the desirable group make their greatest growth and radial spread in the spring months while using the food reserves of the previous summer. The desirable species, big bluestem, little bluestem, switchgrass and indiangrass, would thus be well above the leaf stage in which picloram would have a detrimental effect, while several species of the less desirable plants would not have this stature or ability to tolerate picloram.

Picloram is selective in the broadleaf plants that it controls. The herbicide apparently controls broadleaf plants when applied in

either the liquid or granular formulation, because both formulations gave 85 per cent control or better by the second year. The species controlled were western yarrow, western ragweed, heath aster, broomweed, manyflower scurfpea and baldwin ironweed. Picloram does not produce a topkill as rapidly as 2,4-D. Plants treated with picloram will live two to three weeks longer than plants treated with 2,4-D.

SUMMARY

Picloram in the greenhouse studies prevented germination of Bouteloua curtipendula, Andropogon gerardi, Panicum virgatum and Bouteloua gracilis when applied pre-emergence. When applied at 1.5 pound or higher during the two leaf stage, it significantly reduced plant numbers of all species as compared to the check. B. curtipendula was the most sensitive plant at this stage with A. gerardi and P. virgatum being the most tolerant. When picloram was applied during the four leaf stage, the three pound rate was the only rate which significantly reduced each species. The 2,4-D treatment reduced germination when applied pre-emergence to B. curtipendula and reduced the plant numbers of this species plus Panicum virgatum when sprayed at the two leaf stage. No species were reduced in plant numbers when treated with 2,4-D during the four leaf stage.

The greenhouse yield of all species was reduced when treated with three pounds of picloram in the two and four leaf stages. For the yield observation B. curtipendula and A. gerardi in the two leaf stage were the most sensitive plants to picloram at all rates. Treatment of 2,4-D reduced yield of B. curtipendula, A. gerardi and B. gracilis when used pre-emergence. In the two leaf stage the yield of B. curtipendula was reduced but this species did not have significant reduction in the four leaf stage.

Application of picloram in the field significantly decreased the stand of seedlings of the four grass species. The least stand reduction

for all species occurred when sprayed at the six leaf stage while the highest for all species occurred when sprayed at the two leaf stage. B. curtipendula was the most sensitive species to picloram with P. virgatum being the second most sensitive at the lower rates. At the three pound per acre rate B. gracilis showed a greater decrease than did P. virgatum. Of the four species A. gerardi appeared to have the best tolerance to picloram. The same can be said for yield as for stand. All species had better stand and yield when treated in the latter growth stages.

The application of picloram to established native range did not reduce desirable plant frequency. In general the desirable species increased in frequency and the moderately desirable and undesirable species decreased in frequency. The pounds of grass per acre were not significantly reduced by any treatment but all treatments reduced the pounds of forbs per acre. As the pounds of forbs decreased, there was an increase in pounds of grass except where the four pound rate was used.

Picloram gave very good control of Achillea lanulosa, Aster ericoides, psoralea tenuiflora, and Vernonia baldwini. The only species which indicated strong resistance was Artemisia ludoviciana. This species was resistant at four pounds of picloram per acre.

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