ROADSIDE VEGETATION MANAGEMENT

FINAL REPORT

for the Period
July 1986 to June 1991

by

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L. M. Cargill, Co-Principal Investigator

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MP - 135

Department of Horticulture and Landscape Architecture
Oklahoma Cooperative Extension Service
Oklahoma Agricultural Experiment Station
Division of Agricultural Sciences and Natural Resources
Oklahoma State University

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. FHWA/OK 91(10)

2. GOVERNMENT ACCESSION NO. NA

3. RECIPIENT'S CATALOG NO. NA

4. TITLE AND SUBTITLE

ROADSIDE VEGETATION MANAGEMENT

5. REPORT DATE December 1991

6. PERFORMING ORGANIZATION CODE NA

7. AUTHOR(S)
Dr. D. L. Martin, L. M. Cargill, and
D. P. Montgomery

8. PERFORMING ORGANIZATION REPORT 86-03-03

9. PERFORMING ORGANIZATION AND ADDRESS
Department of Horticulture & L.A.
Oklahoma State University
Stillwater, OK 74078

10. WORK UNIT NO. NA

11. CONTRACT OR GRANT NO.

12. SPONSORING AGENCY NAME AND ADDRESS
Oklahoma Department of Transportation
Research and Development Division
200 N.E. 21st Street
Oklahoma City, OK 73105

13. TYPE OF REPORT AND PERIOD COVERED
Final Report
July 1986 to June 1991

14. SPONSORING AGENCY CODE Item 2147

15. SUPPLEMENTARY NOTES Conducted in cooperation with the Federal Highway Administration and the Oklahoma Department of Transportation.

16. ABSTRACT

The information contained within this report addresses: (1) Research -- involving the use of herbicides and plant growth regulators for roadside vegetation management; (2) Maintenance -- implementing research results into an operational phase of the Oklahoma Department of Transportation (ODOT) maintenance program; and (3) Training -- conducting pesticide applicator certification programs and providing continuing educational programs for these certified applicators. The following are recommendations and/or conclusions based upon the research results. (1) Roundup rates may be reduced from 0.75 to 0.62 lb. ai./A in the western and central portions of Oklahoma while maintaining 90% control of johnsongrass. In the eastern one-third of the state, rates of Roundup should be maintained at 0.75 lb. ai./A to achieve the 90% level of control. (2) When applied at equal rates, SC-0224 and Roundup provide equal control of johnsongrass. (3) The additive Frigate, significantly i creases the activity of Roundup and Roundup plus Oust treatments. (4) A single application of Arsenal applied at 1.2 lb. ai. in combination with Oust at 0.047 lb. ai. applied in 40 gallons of water per acre will effectively control bermudagrass encroachment into paved roadside shoulders and seams when applied in late May or June to actively growing bermudagrass. (5) Musk thistle can be effectively controlled with Transline at 0.125 to 0.25 lb. ai. in 25 to 50 gallons of water per acre applied during March through April when thistle plants are actively growing and prior to bolting (flowering). (6) Vision, a plant growth regulator, applied under an EUP label suppresses of bermudagrass growth along roadsides.

Several large-scale demonstrations were initiated throughout the duration of this project and are described as follows: Musk thistle control with Transline; johnsongrass control with Roundup + Oust and/or Frigate; control of Kudzu with Arsenal; bermudagrass encroachment control with Arsenal; silver bluestem control with Roundup, alone, or in combination with Oust and/or Frigate; bermudagrass canopy height suppression with Vision or Poast plus a crop oil.

Training activities included certification of 591 new ODOT herbicide applicators and providing continuing educational programs for 1354 ODOT certified applicators.

17. KEY WORDS bermudagrass, weed control, brush control, plant growth regulators, spray adjuvants

18. DISTRIBUTION STATEMENT No Restrictions

19. SECURITY CLASSIF. (OF THIS REPORT) None

20. SECURITY CLASSIF. (OF THIS PAGE) None

21. NO. OF PAGES 135

22. PRICE NA

Oklahoma Project No. 86-03-3

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and

The Federal Highway Administration

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Oklahoma Department of Transportation and the Federal Highway Administration.

In order that the information in this publication may be more useful, it was sometimes necessary to use tradenames of products, rather than chemical names. As a result it is unavoidable in some cases that similar products which are on the market under other tradenames may not be cited. No endorsement of products is intended, nor is criticism implied of similar products which are not mentioned.

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

LENGTH

Symbol	When You Know	Multiply By	To Find	Symbol
in	inches	2.54	millimetres	mm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km

AREA

Symbol	When You Know	Multiply By	To Find	Symbol
in^2	square inches	645.2	millimetres squared	mm^2
ft^2	square feet	0.0929	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
mi^2	square miles	2.59	kilometres squared	km^2
ac	acres	0.395	hectares	ha

MASS (weight)

Symbol	When You Know	Multiply By	To Find	Symbol
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg

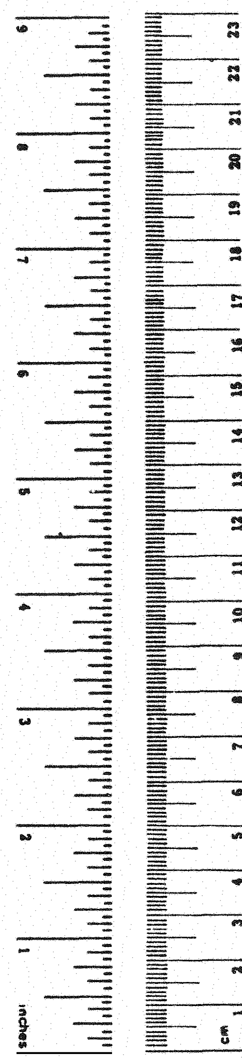
VOLUME

Symbol	When You Know	Multiply By	To Find	Symbol
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft^3	cubic feet	0.0328	metres cubed	m^3
yd^3	cubic yards	0.0765	metres cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

TEMPERATURE (exact)

Symbol	When You Know	Multiply By	To Find	Symbol
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



APPROXIMATE CONVERSIONS TO SI UNITS

LENGTH

Symbol	When You Know	Multiply By	To Find	Symbol
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi

AREA

Symbol	When You Know	Multiply By	To Find	Symbol
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
km^2	kilometres squared	0.39	square miles	mi^2
ha	hectores (10 000 m^2)	2.53	acres	ac

MASS (weight)

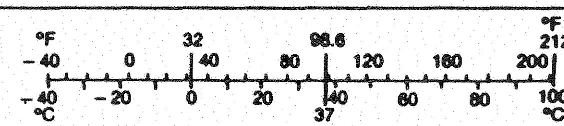
Symbol	When You Know	Multiply By	To Find	Symbol
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T

VOLUME

Symbol	When You Know	Multiply By	To Find	Symbol
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres cubed	1.308	cubic yards	yd^3

TEMPERATURE (exact)

Symbol	When You Know	Multiply By	To Find	Symbol
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



These factors conform to the requirement of FHWA Order 5190.1A.

* SI is the symbol for the International System of Measurements

EXECUTIVE SUMMARY OF THE FINAL REPORT CONCERNING ROADSIDE VEGETATION MANAGEMENT

In 1986, a "Roadside Vegetation Management" project was initiated as a cooperative agreement between Oklahoma State University and the Oklahoma Department of Transportation (ODOT). The objectives of this project were to optimize the expenditure of maintenance resources and enhance the environment by investigations or education in the following three areas:

(1) Research -- initiate research involving the use of herbicides and plant growth reg lators for the most effective and economical means of managing roadside vegetation;

(2) Maintenance -- implement research results into an operation phase of ODOT's maintenance program by initiating large-scale demonstration areas; and

(3) Training -- conducting pesticide applicator certification programs and providing continuing educational programs for certified applicators.

The following reports the results of each of the three subject matter areas mentioned above:

1. **RESEARCH**

a. Roundup rates may be reduced from 0.75 to 0.62 lb. ai./A in the western and central portions of Oklahoma while maintaining 90% control of johnsongrass. In the eastern one-third of the state, rates of Roundup should be maintained at 0.75 lb. ai./A to achieve the 90% level of control.

b. When used at equivalent rates, SC-0224 when compared with Roundup provides equal control of johnsongrass.

c. Frigate, when added to treatments of Roundup or Roundup plus Oust appears to significantly enhance the activity of these particular treatments when compared to like treatments without it.

d. A single application of Arsenal applied at 1.2 lb. ai. in combination with Oust at 0.047 lb. ai. in 40 gallons of water per acre will effectively control bermudagrass encroachment into paved roadside shoulders and seams when applied in late May or June to actively growing bermudagrass.

e. Musk thistle can be effectively controlled with Transline at 0.125 to 0.25 lb. ai. in 25 to 50 gallons of water per acre applied anytime March through April when thistle plants are actively growing but prior to bolting (flowering).

f. Vision, a plant growth regulator applied under an EUP label, suppresses bermudagrass growth along highway roadsides.

2. MAINTENANCE

Several large scale demonstrations were initiated throughout the duration of this project in an effort to implement current research information into an operational phase of ODOT's roadside vegetation management program. The following are descriptions of the many demonstrations conducted statewide:

a. Musk thistle control with Transline in Divisions 4 and 8.

b. Johnsongrass control with Roundup + Oust with and without the spray additive Frigate in Divisions 1, 4 and 8.

c. Kudzu control with a handgun application of Arsenal in Division 1.

d. Bermudagrass encroachment control with Arsenal in Divisions 1, 3, 4, 5, 6, 7 and 8.

e. Control of silver bluestem with Roundup, alone, or in combination with Oust and Frigate in Division 4.

f. Bermudagrass growth suppression with Vision and Poast plus a crop oil in Division 4.

3. TRAINING

Applicator training for ODOT has changed dramatically in the past five years. In 1987, pesticide appl cator recertification through continuing education became an integral part of the pesticide applicator training program. In 1989-90 ODOT implemented an in-house equipment operators certification program in which the certified herbicide applicator was included. These two major changes resulted in herbicide applicator training programs becoming a vital part of ODOT's roadside vegetation management program.

The following is a summary of highlights for the training programs:

a. A total of 38 pesticide applicator certification schools were conducted resulting in 591 new herbi ide applicators being certified.

b. A total of 32 continuing education programs have been conducted with 1354 ODOT certified applicators attending.

c. The "Roadside Vegetation Management Manual" (OSU Extension publication number E-885) was produced covering many major topics with emphasis on plant identification and equipment calibration.

d. "Suggested Herbicides for Roadside Weed Problems" (OSU Extension publication number CR-6424) was produced to give applicators specific information about herbicides, application rates, carrier rates, time of application and important comments.

ACKNOWLEDGEMENTS

The research personnel from Oklahoma State University involved in this project express their appreciation to the personnel of the Oklahoma Department of Transportation and the Federal Highway Administration for their interest, suggestions, and cooperation in these investigations. Special recognition is due Mr. Curtis Hayes, project liaison, 1986-1991, and Dr. Mike Kenna, Principal Investigator, 1986-1989. Acknowledgements are also expressed to Dr. A. D. Brede, who initiated this project, and to Dr. Joel Barber, Principal Investigator, 1990-91.

Grateful acknowledgement is extended for the excellent cooperation and assistance in furtherance of these investigations given to us by all Division Engineers, Maintenance Engineers, and their employees. Without the complete support of these people, much of these research results would not have been possible.

Highest appreciation and acknowledgment is given to the late Dr. W. W. Huffine, Professor Emeritus at OSU, who originated this project and whose support and wisdom made this project possible.

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1. INTRODUCTION

The Oklahoma Department of Transportation's (ODOT) roadside vegetation management program along the state highway system is among the most advanced and progressive in the nation. Their commitment and understanding of the importance of sound roadside vegetation management practices will most assuredly keep them near the top.

Roadsides are currently being managed using both mechanical (mowing) and chemical (herbicides) means. Recent trends show an increase in mechanical management which can easily tie up the shrinking numbers of main enance personnel for most of the growing season, limiting their use for other maintenance activities. Chemical management, if properly used, can provide for a timely and cost efficient roadside vegetation management program.

This research project was a five-year investigation into several roadside vegetation management areas that were of interest to research, maintenance, and training personnel. Research was conducted to provide new information and also to refine current recommendat ons. Through research efforts, new recom endations for bermudagrass encroachment control and musk thistle control were made. Refinement of johnsong ass control recommendations now allows for the most cost effective treatment to be employed.

An integral part of this project was an ongoing implementation effort. Information on the use of new products and methods was relayed to highway personnel through demonstrations at an operational level. Also, yearly tours were provided to demonstrate current research results to ODOT personnel.

An important part of this project which has continued to expand is the initial training and continuing education of the numerous herbicide applicators. Programs for pesticide applicator certification have been implemented and they supply new personnel with the basic knowledge of proper herbicid application techniques. Continuing education workshops are conducted yearly to keep certified personnel current with all relevant information that would enefit both their chemical and mechanical management programs.

2. Incremental Rates of Roundup in Combination with Oust for Johnsongrass Control

L. M. Cargill, D. P. Montgomery, and D. L. Martin

2.1 INTRODUCTION

Johnsongrass (Sorghum halepense (L.) Pers.) is considered a persistent, noxious weed in most of the southern states and has been previously reported as a major roadside weed problem in Oklahoma (17). Johnsongrass has been found as far north as New York, New Ha pshire and Vermont and westward into the states of California, Oregon and Washington. By 1957, only ten of the northernmost states were not infested with johnsongrass (19). Variations in appearance occur primarily in color, height and vigor due to differences mainly in climate and fertility. In the southern states, reported heights can range from three to ten feet with the average being about six feet (3). Because of its unsightly morphological characteristics, unmanaged johnsongrass can create sight distance problems for motorists along roadside situations.

The use of Roundup (glyphosate) and Oust (sulfometuron), alone or in combination, has been evaluated for several years to control or manage undesirable roadside vegetation in Oklahoma (4, 5, 6, 22, 25, 27) and other states (1, 3, 8, 10, 18, 20, 21, 23, 29, 30, 31, 32). Tank mixing Roundup with Oust has been reported to provide excellent control of johnsongrass while simultaneously releasing bermudagrass in non-cropland situations and ditch-banks in Louisiana (14). Combination treatments of Roundup and Oust have been used for herbaceous weed control in newly established pine plantations, increasing pine diameter growth by 11 to 105 percent during the first growing season (9). Season-long (up to 6 months) control of johnsongrass growing along railroad rights-of-way has been reported with the use of Oust (15).

Bermudagrass release along Texas roadsides with combination treatments of Roundup and Oust was successful while obtaining significant superior control of johnsongrass (1). Similar results were obtained in experiments conducted in several other southern states utilizing Roundup and Oust combinations to control johnson rass and certain winter annual weeds in dormant roadside bahiagrass and bermudagrass turf, thus eliminating the need for a spring mowing (30). Results from additional research conducted throughout the southeastern United States with Roundup and Oust combinations indicated good control of both winter annual grasses, broadleaf weeds, and tall fescue (Festuca arundinacea) when applied to the dormant bermudagrass roadside turf. Long-term control of rhizome johnsongrass was also achieved with combination treatments of Roundup and Oust when applied to actively growing bermudagrass (8). Studies in the south have shown that Oust will reduce the number of mowings by controlling many undesirable weeds while suppressing the vigorous growth of bermudagrass and bahiagrass (Paspalum notatum Flugge) (10). Similar results have been repo ted with the use of Oust and/or Roundup, for suppression of bahiagrass and bermudagrass resulting in a reduction or elimination of mowing (3, 17, 20, 30, 31).

The mode of action of Roundup has been reported by several investigators (2, 12, 13, 24, 28) as protein synthesis inhibition. Steinrucken and Amrhein (26) reported the more probable site of Roundup activity is the inhibition of 5-enolpyruvyl-shikimate-3-phosphate EPSP) synthase, the enzyme completing the second step in the shikimic acid pathway between shikimate and chorismate. The site of action of Oust is unknown presently, however, Green et al. (11) have reported that mechanistic studies have shown that Oust stops plant cell division, resulting in rapid growth inhibition and eventual plant death. La Rossa and Schloss (16) reported that Oust inhibits the branched-chain amino acid biosynthetic enzyme acetolactose synthase isozyme II in the growth of the bacteria Salmonella typhimurium.

The objective of this research was to evaluate the efficacy of incremental rates of Roundup in combination with Oust for the selective control of johnsongrass in roadside bermudagrass turf.

2.2 MATERIALS AND METHODS

Six field studies were conducted from 1986 to 1988 in western (ODOT Division 5), north-central (Division 4) and northeastern (Division 8) Oklahoma. In 1986, research was located near Stillwater, Oklahoma (Division 4) on a Coyle fine loamy soil (fine-loamy, siliceous, thermic Udic Argiustolls). Two studies were initiated in 1987 with one located near Ripley, Oklahoma (Division 4) on a Yahola fine sandy loam soil (coarse-loamy, mixed (calcareous), thermic Typic Ustifluvents) and near Owasso, Oklahoma (Division 8) on a Summit silty clay loam soil (fine, montmorillonitic, thermic Vertic Argiudolls). Three field studies were initiated during 1988 near Weatherford, Oklahoma (Division 5), on a St. Paul silt loam soil (fine-silty, mixed thermic Pachis Argiustolls), near Ripley, Oklahoma (Division 4) on a Yahola fine sandy loam soil (coarse, loa y, mixed (calcareous), thermic Typic Ustifluvents), and near Vera, Oklahoma (Division 8) on a B tes-Collinsville loamy prairie complex soil (fine-loamy, mixed, thermic Typic Argiudolls and loamy, mixed, thermic Lithic Hapludolls, respectively).

Roundup was applied at rates of 0.25, 0.50, 0.56, 0.59, 0.62, 0.66, 0.69, 0.72, 0.75, 0.78, 0.81, 0.84, 0.87, 0.90. 0.93, 1.0 and 1.25 lb. ai./A combined with Oust at 0.094 lb. ai./A in each of the six experiments. The experimental design of each study was a randomized complete block with three replications. The individual plot size was 5 feet by 10 feet.

Treatments were applied on 12 May 1986, 13 May 1987 and 11 May 1988 (Division 4), 26 May 1987 and 19 May 1988 (Division 8), and 13 May 1988 (Division 5) using a CO_2-powered, hand-held boom sprayer equipped with flat fan nozzle tips calibrated to deliver 20 gallons per acre at 30 PSI. When treatments were applied, the bermudagrass was actively growing and the johnsongrass ranged from 12 to 20 inches in height. Treatments were visually evaluated on a monthly basis for johnsongrass control where 1 equalled no control and 10 equalled complete control; and for bermudagrass phytotoxicity where 1 equalled no effect and 10 equaled complete yellowing or brownout.

2.3 RESULTS AND DISCUSSION

For several years, Roundup was used at rates between 0.75 to 1.0 lb. a.i./A, alone, and in combination with Oust for johnsongrass and silver bluestem (Andropogon saccharoides) control. It became apparent after the first few years of use that there were several factors which can influence the efficacy of such a treatment. Differences were noticed primarily as one moves from western Oklahoma to the eastern portions of the state. Rates of Roundup providing successful johnsongrass control in western Oklahoma were unsatisfactory in eastern Oklahoma. Annual rainfall and soil type and texture are probable factors affecting the performances of Roundup plus Oust treatments.

For a johnsongrass control treatment to be considered successful or satisfactory, 90% control for the entire season is needed. All studies conducted in Divisions 4 and 5 showed satisfactory johnsongrass control with Roundup rates between 0.50 and 0.62 lb. a.i./A (Tables 1-4). This rate of Roundup is a reduction of 0.13 to 0.25 lb. a.i./A over the traditional 0.75 lb. a.i./A rate. It was also found that rates closer to 0.62 lb. a.i./A were needed to consistently provide the 90% level of johnsongrass control. Studies conducted in Division 8 required higher rates of Roundup to maintain satisfactory johnsongrass control. Roundup rates between 0.62 and 0.75 lb. a.i./A were needed to provide and maintain satisfactory johnsongrass control (Tables 1-4). Roundup rates closer to 0.75 lb. a.i./A were required to consistently provide 90% or better control of johnsongrass. In the eastern one-third of the state 0.75 to 1.0 lb. a.i./A of Roundup is necessary for 90% johnsongrass control. Reducing Roundup rates even one to two ounces per acre will decrease johnsongrass control.

One of the negative effects of Roundup plus Oust combinations is phytotoxicity to the desirable roadside bermudagrass. The level of phytotoxicity from Roundup plus Oust combinations is dependent upon rate of herbicide(s), time of application, location within the state, annual summer temperatures and rainfall. With our rating scale used to evaluate bermudagrass phytotoxicity, a value of 5.0 or less is considered an acceptable level of injury. This level of injury early in the growing season allows for full recovery before the typically hot and dry summer months occur. In Divisions 4 and 5, rates of Roundup in excess of 0.69 lb. a.i./A consistently produced an unsatisfactory level of phytotoxicity at 1 month after treatment (MAT) (Table 1). These same treatments produced some phytotoxic symptoms at 2 MAT, however, the diminished level was acceptable for roadside turf areas (Table 2). Studies in Division 8 have shown that much higher rates of Roundup are required before significant injury to bermudagrass will occur. Unacceptable bermudag ass injury was observed at Roundup rates of 0.81 (1987) and 1.0 lb. a.i./A (1988) and higher when mixed with Oust (Table 1). As with johnsongrass control, it was evident that higher rates of Roundup are required in the eastern areas of Oklahoma to produce unacceptable levels of bermudagrass phytotoxicity. Phytotoxicity diminished by 2 MAT ratings.

2.4 CONCLUSIONS

Roundup and Oust combinations have proven over the last several years to be an effective and efficient means of controlling johnsongrass and silver bluestem. Through these research efforts it was found that Roundup rates may be reduced from 0.75 lb. a.i./A to 0.62 lb. a.i./A in the western and central portions of Oklahoma while maintaining 90% control of johnsongrass. In the eastern one-third of the state, rates of Roundup should be maintained at 0.75 lb. a.i./A to achieve the 90% level of control. The refinement of Roundup rates will allow for a more cost efficient program. It should be known, however, that reducing Roundup ra es below the newly refined rates will result in unsatisfactory johnsongrass control.

Table 1. Effect of varying rates of Roundup in combination with Oust on Johnsongrass control 1 month after treatment in six field studies in Oklahoma[1].

Roundup Rate lb. ai./A	Oust Rate lb. ai./A	Johnsongrass Control 1 MAT[2]					
		4-H-34-86	4-H-39-87	4-H-44-88	5-H-3-88	8-H-13-87	8-H-16-88
0	0	1.00*e	1.00*d	1.00*c	1.00*e	1.00*e	1.00*d
0.25	0.094	3.00d	3.33c	6.50b	6.67d	2.33e	7.50c
0.50	0.094	8.43c	6.67b	9.53a	9.00bc	2.67e	9.07b
0.56	0.094	9.13abc	9.13a	9.33a	9.50ab	5.00d	9.23ab
0.59	0.094	8.93bc	8.67a	9.63a	9.17abc	6.33cd	9.33ab
0.62	0.094	9.10abc	9.17a	9.63a	8.67c	6.00cd	9.33ab
0.66	0.094	9.73ab	9.37a	9.70a	9.17abc	7.17bc	9.43ab
0.69	0.094	9.87a	9.70a	9.60a	9.27abc	7.83abc	9.50ab
0.72	0.094	9.77ab	9.90a	9.73a	9.60ab	7.83abc	9.50ab
0.75	0.094	9.83a	9.87a	9.87a	9.17abc	7.67abc	9.50ab
0.78	0.094	9.87a	9.47a	9.90a	9.60ab	8.50ab	9.70a
0.81	0.094	9.90a	9.23a	9.57a	9.43ab	8.83ab	9.70a
0.84	0.094	9.60ab	9.77a	9.77a	9.60ab	8.33ab	9.70a
0.87	0.094	9.93a	9.40a	9.87a	9.70a	8.67ab	9.70a
0.90	0.094	9.90a	9.90a	9.77a	9.33ab	8.50ab	9.60ab
0.93	0.094	9.93a	9.43a	9.87a	9.73a	8.50ab	9.70a
1.00	0.094	9.93a	9.40a	9.73a	9.47ab	8.67ab	9.70a
1.25	0.094	9.93a	9.60a	9.77a	9.43ab	9.33a	9.70a
LSD[3]		0.90	1.24	0.82	0.66	1.89	0.57

[1]Study locations were Stillwater, 1986 (4-H-34-86); Ripley, 1987 (4-H-39-87); Ripley, 1988 (4-H-44-88); Weatherford, 1988 (5-H-88); Owasso, 1987 (8-H-13-87); and Vera, Oklahoma, 1988 (8-H-16-88). The first digit in an experimental study designation represents the Oklahoma Department of Transportation Division the study was conducted in. Example: Study 5-X-X-XX was conducted in Division 5.

[2]Johnsongrass control was scored on a 1 to 10 scale, where 1 = no control and 10 = complete control. 1 MAT = 1 month after treatment.

[3]Means followed by the same letter are not significantly different at p = 0.05.

Table 2. Effect of varying rates of Roundup in combination with Oust on Johnsongrass control 2 months after treatment in six field studies in Oklahoma[1].

Roundup Rate lb. ai./A	Oust Rate lb. ai./A	Johnsongrass Control 2 MAT[2]					
		4-H-34-86	4-H-39-87	4-H-44-88	5-H-3-88	8-H-13-87	8-H-16-88
0	0	1.00*g	1.00*d	1.00*c	1.00*c	1.00*e	1.00*e
0.25	0.094	4.33f	3.00c	6.67b	7.67b	2.00e	7.50d
0.50	0.094	7.60e	6.67b	9.00a	9.17a	2.33e	8.83c
0.56	0.094	8.27cde	9.13a	9.00a	9.07a	4.67d	9.00bc
0.59	0.094	7.97de	8.33a	9.10a	8.83ab	6.67bcd	9.23abc
0.62	0.094	8.43b-e	8.67a	8.60a	8.33ab	5.00d	9.27abc
0.66	0.094	9.23a-d	9.27a	9.10a	8.33ab	6.33cd	9.43abc
0.69	0.094	9.70abc	9.43a	9.00a	8.93ab	7.83abc	9.50ab
0.72	0.094	9.73ab	9.87a	9.43a	9.43a	7.67abc	9.40abc
0.75	0.094	9.63abc	9.40a	9.27a	8.50ab	6.67bcd	9.50ab
0.78	0.094	9.77ab	9.43a	9.50a	9.17a	7.33abc	9.70a
0.81	0.094	9.83ab	9.53a	9.10a	8.67ab	8.67ab	9.80a
0.84	0.094	9.27a-d	9.70a	9.53a	9.10a	8.67ab	9.50a
0.87	0.094	9.87ab	9.47a	9.70a	9.27a	8.33abc	9.70a
0.90	0.094	9.83ab	9.77a	9.33a	8.17ab	8.17abc	9.60ab
0.93	0.094	9.87ab	9.63a	9.60a	9.20a	8.50ab	9.80a
1.00	0.094	9.90a	9.47a	9.27a	8.50ab	9.17a	9.70a
1.25	0.094	9.87ab	9.87a	9.53a	8.50ab	9.00a	9.70a
LSD[3]		1.46	1.62	1.31	1.34	2.00	0.62

[1]Study locations were Stillwater, 1986 (4-H-34-86); Ripley, 1987 (4-H-39-87); Ripley, 1988 (4-H-44-88); Weatherford, 1988 (5-H-88); Owasso, 1987 (8-H-13-87); and Vera, Oklahoma, 1988 (8-H-16-88). The first digit in an experimental study designation represents the Oklahoma Department of Transportation Division the study was conducted in. Example: Study 5-X-X-XX was conducted in Division 5.
[2]Johnsongrass con rol was scored on a 1 to 10 scale, where 1 = no control and 10 = complete control. 2 MAT = 2 months after treatment.
[3]Means followed by the same letter are not significantly different at p = 0.05.

Table 3. Effect of varying rates of Roundup in combination with Oust on Johnsongrass control 3 months after treatment in six field studies in Oklahoma[1].

Roundup Rate lb. ai./A	Oust Rate lb. ai./A	Johnsongrass Control 3 MAT[2]					
		4-H-34-86	4-H-39-87	4-H-44-88	5-H-3-88	8-H-13-87	8-H-16-88
0	0	1.00*e	1.00*d	1.00*c	1.00*d	1.00*f	1.00*e
0.25	0.094	3.33d	4.67c	6.67b	7.67c	1.67f	7.00d
0.50	0.094	7.30c	7.33b	8.53a	9.07abc	2.33ef	8.50c
0.56	0.094	8.33abc	8.93ab	9.00a	8.90abc	4.00de	9.00bc
0.59	0.094	8.27abc	8.67ab	8.83a	8.93abc	6.33abc	9.23ab
0.62	0.094	7.67bc	8.50ab	8.33a	8.00bc	4.33cde	9.17ab
0.66	0.094	8.87abc	9.37a	9.00a	8.17abc	5.33bcd	9.33ab
0.69	0.094	9.43a	9.17a	8.60a	9.27ab	7.50ab	9.50ab
0.72	0.094	9.43a	9.83a	9.10a	9.43a	7.33ab	9.33ab
0.75	0.094	9.17ab	9.47a	9.17a	8.57abc	6.33abc	9.17ab
0.78	0.094	9.60a	9.63a	9.30a	9.07abc	7.33ab	9.53ab
0.81	0.094	9.73a	9.43a	8.80a	8.67abc	8.33a	9.60a
0.84	0.094	9.37ab	9.53a	9.10a	8.77abc	7.67a	9.27ab
0.87	0.094	9.70a	9.13a	9.50a	9.27ab	8.33a	9.60a
0.90	0.094	9.77a	9.60a	9.27a	8.17abc	7.33ab	9.50ab
0.93	0.094	9.87a	9.80a	9.50a	9.20ab	8.00a	9.70a
1.00	0.094	9.77a	9.40a	9.23a	8.50abc	8.00a	9.60a
1.25	0.094	9.60a	9.57a	9.53a	8.50abc	8.33a	9.50ab
LSD[3]		1.76	1.66	1.39	1.41	2.18	0.58

[1]Study locations were Stillwater, 1986 (4-H-34-86); Ripley, 1987 (4-H-39-87); Ripley, 1988 (4-H-44-88); Weatherford, 1988 (5-H-88); Owasso, 1987 (8-H-13-87); and Vera, Oklahoma, 1988 (8-H-16-88). The first digit in an experimental study designation represents the Oklahoma Department of Transportation Division the study was conducted in. Example: Study 5-X-X-XX was conducted in Division 5.
[2]Johnsongrass control was scored on a 1 to 10 scale, where 1 = no control and 10 = complete control. 3 MAT = 3 months after treatment.
[3]Means followed by the same letter are not significantly different at p = 0.05.

Table 4. Effect of varying rates of Roundup in combination with Oust on Johnsongrass control 4 months after treatment in six field studies in Oklahoma[1].

Roundup Rate lb. ai./A	Oust Rate lb. ai./A	Johnsongrass Control 4 MAT[2]					
		4-H-34-86	4-H-39-87	4-H-44-88	5-H-3-88	8-H-13-87	8-H-16-88
0	0	1.00*c	1.00*c	1.00*c	1.00*c	1.00*f	1.00*f
0.25	0.094	2.00c	5.33b	6.67b	8.00ab	2.33ef	6.83e
0.50	0.094	6.27b	8.00a	8.33a	9.13a	3.00ef	8.50d
0.56	0.094	8.00ab	9.27a	9.00a	8.50ab	3.33def	8.77cd
0.59	0.094	7.93ab	9.33a	8.67a	8.83ab	6.00a-d	9.03a-d
0.62	0.094	8.00ab	8.93a	8.17a	7.67b	3.67c-f	9.17abc
0.66	0.094	9.07a	9.27a	8.83a	8.23ab	5.00b-e	9.00bcd
0.69	0.094	9.43a	9.27a	8.17a	9.17a	7.17ab	9.37abc
0.72	0.094	8.83a	9.83a	9.00a	9.10a	6.50abc	9.37abc
0.75	0.094	8.50a	9.70a	8.73a	8.73ab	6.00a-d	8.93bcd
0.78	0.094	9.00a	9.73a	9.10a	9.00ab	7.67ab	9.37abc
0.81	0.094	9.57a	9.13a	8.67a	8.73ab	8.50a	9.53ab
0.84	0.094	9.07a	9.73a	8.90a	8.67ab	6.50abc	9.27abc
0.87	0.094	9.57a	9.10a	9.33a	9.00ab	6.83ab	9.53ab
0.90	0.094	9.43a	9.73a	9.10a	8.00ab	7.33ab	9.27abc
0.93	0.094	9.73a	8.97a	9.87a	9.10a	7.50ab	9.63a
1.00	0.094	9.20a	8.57a	8.83a	8.17ab	7.50ab	9.50ab
1.25	0.094	9.40a	9.70a	9.20a	7.90ab	7.33ab	9.20abc
LSD[3]		1.97	1.94	1.48	1.40	2.92	0.62

[1]Study locations were Stillwater, 1986 (4-H-34-86); Ripley, 1987 (4-H-39-87); Ripley, 1988 (4-H-44-88); Weatherford, 1988 (5-H-88); Owasso, 1987 (8-H-13-87); and Vera, Oklahoma, 1988 (8-H-16-88). The first digit in an experimental study designation represents the Oklahoma Department of Transportation Division the study was conducted in. Example: Study 5-X-X-XX was conducted in Division 5.
[2]Johnsongrass control was scored on a 1 to 10 scale, where 1 = no control and 10 = complete control. 4 MAT = 4 months after treatment.
[3]Means followed by the same letter are not significantly different at p = 0.05.

Table 5. Effect of varying rates of Roundup on bermudagrass phytotoxicity 1 month after treatment in six field studies in Oklahoma[1].

Roundup Rate lb. ai./A	Oust Rate lb. ai./A	Bermudagrass Phytotoxicity (1 MAT)[2]					
		4-H-34-86	4-H-39-87	4-H-44-88	5-H-3-88	8-H-13-87	8-H-16-88
0	0	1.00*g	1.00*f	1.00*e	1.00*g	1.00*g	1.00*f
0.25	0.094	2.67f	2.33ef	2.00e	1.67g	1.00g	2.00e
0.50	0.094	2.67f	3.33de	4.00d	3.00f	1.33g	2.00e
0.56	0.094	4.33cde	4.33bcd	3.67d	3.00f	2.00fg	2.00e
0.59	0.094	3.33ef	4.33bcd	4.00d	3.33ef	2.67ef	2.33de
0.62	0.094	3.67def	4.00cde	4.33cd	3.33ef	2.67ef	3.00cd
0.66	0.094	4.67b-e	4.67bcd	4.67cd	3.67def	2.67ef	3.00cd
0.69	0.094	4.67b-e	4.33bcd	4.33cd	4.00c-f	3.67cde	3.00cd
0.72	0.094	5.00bcd	5.33bc	5.00bcd	4.67bcd	3.33de	3.33c
0.75	0.094	4.67b-e	5.67abc	6.33ab	3.67def	3.00def	3.00cd
0.78	0.094	5.00bcd	4.00cde	6.33ab	4.33b-e	3.67cde	3.33c
0.81	0.094	4.67b-e	4.33bcd	5.67abc	5.00abc	4.67bc	3.33c
0.84	0.094	5.00bcd	5.00bcd	5.67abc	5.00abc	3.67cde	3.67bc
0.87	0.094	4.67b-e	6.00ab	4.67cd	4.67bcd	4.00cd	3.67bc
0.90	0.094	5.00bcd	6.00ab	6.67a	5.33ab	3.67cde	3.67bc
0.93	0.094	5.67abc	6.00ab	7.00a	5.00abc	4.67bc	3.67bc
1.00	0.094	6.67a	5.67abc	6.33ab	5.00abc	5.33ab	4.33b
1.25	0.094	6.00ab	7.33a	7.00a	6.00a	6.33a	6.00a
LSD[3]		1.60	1.81	1.35	1.14	1.30	0.83

[1]Study locations were Stillwater, 1986 (4-H-34-86); Ripley, 1987 (4-H-39-87); Ripley, 1988 (4-H-44-88); Weatherford, 1988 (5-H-88); Owasso, 1987 (8-H-13-87); and Vera, Oklahoma, 1988 (8-H-16-88). The first digit in an experimental study designation represents the Oklahoma Department of Transportation Division the study was conducted in. Example: Study 5-X-X-XX was conducted in Division 5.

[2]Bermudagrass phytotoxicity was scored on a 1 to 10 scale where 1 = no phytotoxicity and 10 = complete brownout. 1 MAT = 1 month after treatment.

[3]Means followed by the same letter are not significantly different at p = 0.05.

Table 6. Effect of varying rates of Roundup on bermudagrass phytotoxicity 2 months after treatment in six field studies in Oklahoma[1].

Roundup Rate lb. ai./A	Oust Rate lb. ai./A	Bermudagrass Phytotoxicity (2 MAT)[2]					
		4-H-34-86	4-H-39-87	4-H-44-88	5-H-3-88	8-H-13-87	8-H-16-88
0	0	1.00*e	1.00*c	1.00*g	1.00*c	1.00*a	1.00*c
0.25	0.094	1.00e	1.00c	1.00g	1.00c	1.00a	1.00c
0.50	0.094	1.67cde	2.00b	2.00fg	2.67ab	1.00a	1.00c
0.56	0.094	1.67cde	2.67ab	2.67def	1.67bc	1.00a	1.00c
0.59	0.094	1.33de	2.00b	2.00fg	2.67ab	1.00a	1.00c
0.62	0.094	1.67cde	2.00b	2.00fg	2.33ab	1.00a	1.00c
0.66	0.094	2.00bcd	2.67ab	2.33ef	2.33ab	1.00a	1.00c
0.69	0.094	1.33de	2.00b	2.00fg	2.33ab	1.00a	1.00c
0.72	0.094	1.67cde	2.67ab	2.67def	2.67ab	1.00a	1.00c
0.75	0.094	1.67cde	2.67ab	3.00def	2.33ab	1.00a	1.00c
0.78	0.094	2.00bcd	2.33ab	3.67cd	2.67ab	1.00a	1.00c
0.81	0.094	2.33abc	2.33ab	3.33cde	3.33a	1.00a	1.00c
0.84	0.094	1.67cde	2.67ab	2.33ef	3.33a	1.00a	1.00c
0.87	0.094	2.00bcd	2.67ab	3.67cd	3.00a	1.00a	1.00c
0.90	0.094	1.33de	3.00a	5.00ab	3.33a	1.33a	1.00c
0.93	0.094	2.00bcd	2.33ab	4.33bc	3.33a	1.00a	1.67b
1.00	0.094	3.00a	3.00a	3.33cde	3.33a	1.33a	1.67b
1.25	0.094	2.67ab	2.67ab	5.67a	3.33a	1.33a	2.67a
LSD[3]		0.94	0.81	1.27	1.14	0.39	0.39

[1]Study locations were Stillwater, 1986 (4-H-34-86); Ripley, 1987 (4-H-39-87); Ripley, 1988 (4-H-44-88); Weatherford, 1988 (5-H-88); Owasso, 1987 (8-H-13-87); and Vera, Oklahoma, 1988 (8-H-16-88). The first digit in an experimental study designation represents the Oklahoma Department of Transportation Division the study was conducted in. Example: Study 5-X-X-XX was conducted in Division 5.
[2]Bermudagrass phytotoxicity was scored on a 1 to 10 scale where 1 = no phytotoxicity and 10 = complete brownout. 2 MAT = 2 months after treatment.
[3]Means followed by the same letter are not significantly different at p = 0.05.

Table 7. **Effect of varying rates of Roundup on bermudagrass phytotoxicity 3 months after treatment in six field studies in Oklahoma[1].**

Roundup Rate lb. ai./A	Oust Rate lb. ai./A	Bermudagrass Phytotoxicity (3 MAT)[2]					
		4-H-34-86	4-H-39-87	4-H-44-88	5-H-3-88	8-H-13-87	8-H-16-88
0	0	1.00*b	1.00*a	1.00*a	1.00*b	1.00*a	1.00*a
0.25	0.094	1.00b	1.00a	1.00a	1.00b	1.00a	1.00a
0.50	0.094	1.00b	1.00a	1.00a	1.00b	1.00a	1.00a
0.56	0.094	1.00b	1.00a	1.00a	1.00b	1.00a	1.00a
0.59	0.094	1.33b	1.00a	1.00a	1.33ab	1.00a	1.00a
0.62	0.094	1.00b	1.00a	1.00a	1.67ab	1.00a	1.00a
0.66	0.094	1.00b	1.00a	1.00a	1.00b	1.00a	1.00a
0.69	0.094	1.00b	1.00a	1.00a	1.00b	1.00a	1.00a
0.72	0.094	1.33b	1.00a	1.00a	1.33ab	1.00a	1.00a
0.75	0.094	1.00b	1.00a	1.00a	1.00b	1.00a	1.00a
0.78	0.094	1.33b	1.00a	1.00a	1.00b	1.00a	1.00a
0.81	0.094	1.33b	1.00a	1.00a	2.00a	1.00a	1.00a
0.84	0.094	1.00b	1.00a	1.00a	1.67ab	1.00a	1.00a
0.87	0.094	1.33b	1.00a	1.00a	1.67ab	1.00a	1.00a
0.90	0.094	1.33b	1.00a	1.00a	1.33ab	1.00a	1.00a
0.93	0.094	1.00b	1.00a	1.00a	1.67ab	1.00a	1.00a
1.00	0.094	2.00a	1.00a	1.00a	1.33ab	1.00a	1.00a
1.25	0.094	1.33b	1.00a	1.00a	1.67ab	1.00a	1.00a
LSD[3]		0.62	0.00	0.00	0.67	0.00	0.00

[1]Study locations were Stillwater, 1986 (4-H-34-86); Ripley, 1987 (4-H-39-87); Ripley, 1988 (4-H-44-88); Weatherford, 1988 (5-H-88); Owasso, 1987 (8-H-13-87); and Vera, Oklahoma, 1988 (8-H-16-88). The first digit in an experimental study designation represents the Oklahoma Department of Transportation Division the study was conducted in. Example: Study 5-X-X-XX was conducted in Division 5.
[2]Bermudagrass phytotoxicity was scored on a 1 to 10 scale where 1 = no phytotoxicity and 10 = complete brownout. 3 MAT = 3 months after treatment.
[3]Means followed by the same letter are not significantly different at p = 0.05.

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3. Sulfosate, Glyphosate and Sulfometuron Combinations for Johnsongrass Control

L. M. Cargill, D. P. Montgomery, and D. L. Martin

3.1 INTRODUCTION

Johnsongrass [(Sorghum halepense (L.)] Pers. is a widely distributed, perennial grass which has been a major weed problem along Oklahoma roadsides (25). SC-0224 (sulfosate), generally referred to as a non-selective, postemergence herbicide, has been reported to be equivalent in efficacy when compared with Roundup (glyphosate) for control of johnsongrass and other weed species in non-crop areas (6,7,21,22,23,25). Other researchers have reported similar results in efficacy in comparative studies with SC-0224 and Roundup for weed control in reduced tillage systems (2), no-till cropping systems (8,17,29) and other crops (5,13).

The addition of Oust (sulfometuron) to Roundup has increased weed control on rights-of-way (14,28). The combination treatment of Roundup and Oust has controlled johnsongrass along ditchbanks (19) and herbaceous weeds in pine plantations (15). The combination treatments of SC-0224 plus Oust, and Roundup plus Oust, have been reported to provide johnsongrass control (21) and bermudagrass [(Cynodon dactylon (L.) Pers.)] encroachment control along roadsides (7).

The mode of action of Roundup has been reported by several investigators (1,12,16,18,24,27) as protein synthesis inhibition. Steinrucken and Amrhein (26) reported the more probable site of Roundup activity is the inhibition of 5-enolpyruvyl-shikimate-3-phosphate (EPSP) synthase, the enzyme completing the second step in the shikimic acid pathway between shikimate and chorismate.

Several studies on the mode of action of SC-0224 have been reported (3,9,10,11,12). Bellinder et al. (4) found that protein synthesis was sensitive to SC-0224 and appears to be involved as a target site of its herbicidal action.

The mode of action of Oust is unknown presently, however, LaRossa and Schloss (20) reported Oust inhibits the branched-chain amino acid biosynthetic enzyme acetolactose synthase isozyme II in the growth of the bacteria (Salmonella typhimurium).

The objectives of these studies were to compare the efficacy of equivalent rates of SC-0224 or Roundup in combination with two rates of Oust for the selective control of perennial and seedling johnsongrass.

3.2 MATERIALS AND METHODS

Five field experiments were conducted over a two year period in western (Division 5), north-central (Division 4), and north-eastern (Division 8) Oklahoma on bermudagrass highway rights-of-way to compare herbicide treatments for control of perennial and seedling johnsongrass. Located within the rolling red plains, the soil in Division 5 (Experiment 5-H-4-88) was a St. Paul silt loam (Pachic Argiustolls; fine-silty, mixed, thermic) and received 11.92 inches of rainfall throughout the duration of the experiment. In Division 4, located within the reddish prairie, the soil at the 1987 experimental site (Experiment 4-H-40-87) was a Port silt loam (Cumulic Haplustol; fine-silty, mixed, thermic) and received 26.15 inches of rainfall throughout the duration of the experiment. Located within the cross-timbers, the soil at the 1988 site, in Division 4 (Experiment 4-H-

45-88), was a Coyle loam (Udic Argiudolls; fine-loamy, siliceous, thermic) and received 14.30 inches of rainfall throughout the duration of the experiment. In Division 8, both experimental sites were located within the Cherokee prairies. The soil at the 1987 site (Experiment 8-H-14-87) was a Dennis silt loam (Aquic Paleudolls; fine, mixed, thermic) and received 26.47 inches of rainfall; the soil at the 1988 site (Experiment 8-H-17-88) was a Mason silt loam (Typic Argiudolls; fine-silty, mixed, thermic) and received 15.94 inches of rainfall throughout the duration of the experiment.

Roundup and SC-0224 were applied at rates of 0.5,0.56,0.63,0.69, and 0.75 lb.ai./A combined with Oust at 0.047 and 0.094 lb.ai./A. The experimental design of each study was a randomized complete block with a factorial arrangement of treatments and three replications.

Treatments were applied to 5 by 10 ft. plots on 13 May 1988 (Division 5), 14 May 1987 and 25 May 1988 (Division 4), 3 June 1987 and 19 May 1988 (Division 8), with a CO_2 powered, hand-held, boom sprayer equipped with flat fan nozzles calibrated to deliver 20 gallons per acre at 30 PSI. When treatments were applied, the bermudagrass was actively growing and the johnsongrass was 12 to 20 inches in height. Treatments were visually evaluated on a monthly basis for johnsongrass control, where 1 equalled no control and 10 equalled complete control; and bermudagrass phytotoxicity, where 1 equalled no effect and 10 equalled complete yellowing or brownout.

3.3 RESULTS AND DISCUSSION

Means for johnsongrass control indicated, in most instances, no significant differences in the level of control when SC-0224 was compared with Roundup at equivalent rates during 1987 and 1988 (Table 8). Rates of SC-0224 at 0.69 and 0.75 lb. ai./A performed significantly better than the lowest rate of 0.5 lb. ai./A for 1, 2, and 3 months after treatment (MAT). However, at 4 MAT, only the 0.75 lb. ai./A rate of SC-0224 was significantly better than the 0.5 lb. ai./A rate. Roundup rates of 0.62, 0.69 and 0.75 lb. ai./A performed significantly better than 0.5 lb. ai./A for 1, 2 and 3 MAT. By 4 MAT, Roundup at 0.75 lb. ai./A was the only treatment with significantly greater control than the other three rates of Roundup (0.5, 0.56 and 0.62 lb. ai./A). During 1988, the three higher rates of SC-0224 and Roundup (0.62, 0.69 and 0.75 lb. ai./A) exhibited significantly better johnsongrass control when compared to the lower rate of 0.5 lb. ai./A for 1, 2, 3 and 4 MAT.

When averaged over all herbicide rates, the only significant difference in the level of johnsongrass control occurred during 1988 in Division 4, where SC-0224 out-performed Roundup when ratings were made at 1, 2, 3 and 4 MAT (Table 9). During 1987, in Division 4 and 8, johnsongrass control with equivalent rates of Roundup and SC-0224 were very similar. In 1988, the performance of SC-0224 and Roundup were almost identical in Division 5 and 8 for the control of johnsongrass when averaged over all herbicide rates.

When averaged over both chemicals (Roundup and SC-0224) and both rates of Oust, the level of johnsongrass control appeared to be better in Division 5 and 8 when compared with Division 4 for all rates tested (Table 10). This trend was observed in all ratings made 1, 2 and 3 MAT.

As a significant rate * year interaction was present, rate * year means for johnsongrass control were separated using the LSD test (Table 11). When averaged over chemicals (Roundup and SC-0224), both rates of Oust and all three Divisions (4, 5 and 8), significant differences for the control of johnsongrass were observed for 2, 3 and 4 MAT ratings when comparing 1987 data with the 1988 test results. This same trend was not seen for 1 MAT ratings. The level of johnsongrass control was significantly better during 1988 when compared to 1987 data.

A significant division * year interaction was also observed among the five experiments evaluating johnsongrass control (Table 12). During 1987, ratings for johnsongrass control were significantly higher in Division 8 when compared to Division 4. This same trend was observed during 1988. Observations made in Division 8 were significantly higher when compared with ratings in Division 4 and 5. Evaluations for johnsongrass control in Division 5 during 1988 were also significantly higher than ratings made in Division 4.

When averaged over years (1987 and 1988) and chemicals (SC-0224 and Roundup), a significant difference in the level of johnsongrass control was observed for 1, 2 and 3 MAT ratings taken in Division 4, dependent upon the rate of Oust used (Table 13). Better control of johnsongrass was achieved with 0.094 lb. ai./A of Oust when compared with 0.047 lb. ai./A. However, no significant differences were observed between the 0.047 and 0.094 lb. ai./A rates of Oust for the control of johnsongrass when ratings wer made in Divisions 5 and 8 at 1, 2 and 3 MAT.

When johnsongrass control means were averaged over chemicals (Roundup and SC-0224), years (1987 and 1988) and (Divisions 4, 5 and 8), the treatment of 0.5 lb. ai./A of either Roundup or SC-0224 combined with 0.047 lb. ai./A of Oust, provided significantly less control of johnsongrass when compared with the same treatment (0.5 lb. ai./A) combined with 0.094 lb. ai./A of Oust (Table 14) for 1, 2, 3 and 4 MAT. No significant differences in the control of johnsongrass were observed among the remainder of the treatments (0.56, 0.62, 0.69 and 0.75 lb. ai./A) when comparing equivalent rates of either Roundup or SC-0224 combined with either 0.047 or 0.094 lb. ai./A of Oust.

A significant Division * rate * year interaction was observed for bermudagrass phytotoxicity among the five experiments (Table 15). Ratings made 1 MAT indicated significant differences in the amount of bermudagrass phytotoxicity observed both years in all experiments, with one exception. The experiment conducted in Division 4 during 1988 exhibited no significant differences among treatments for bermudagrass phytotoxicity. In each of the other experiments, the highest rate tested (0.75 lb. ai./A) of either SC-0224 or Roundup was significantly more phytotoxic to the bermudagrass when compared with the lowest rate used (0.5 lb. ai./A). However, with one exception, by 2 MAT all bermudagrass phytotoxicity had diminished to non-significant and acceptable levels. The only exception was the experiment initiated in Division 5 during 1988 which still had significantly more bermudagrass phytotoxicity at 2 MAT, but this was judged to be an acceptable level.

3.4 CONCLUSIONS

Studies conducted during a two-year period (1987-1988) indicated that SC-0224, when compared with Roundup at equivalent rates, provided equal (four out of five experiments), or better (1 experiment), control of johnsongrass.

Based upon the research results of these experiments, there appears to be no significant difference between Roundup and SC-0224, when compared at equivalent rates, for the level of bermudagrass phytotoxicity.

Table 8. Chemical * rate * year means for johnsongrass control ratings using Roundup/Oust and SC-0224/Oust combinations[1].

YEAR	CHEM	RATE lb. ai./A	1 MAT	2 MAT	3 MAT	4 MAT
1987	SC-0224	0.5	7.8	5.8	5.9	5.1
	SC-0224	0.56	8.0	6.0	5.6	4.0
	SC-0224	0.62	8.3	6.4	6.2	6.2
	SC-0224	0.69	8.9	7.4	7.2	5.2
	SC-0224	0.75	9.1	8.5	8.1	7.7
1987	Roundup	0.5	7.4	5.5	5.0	5.0
	Roundup	0.56	7.9	5.7	5.2	4.3
	Roundup	0.62	9.0	7.5	7.4	5.9
	Roundup	0.69	9.2	7.3	6.9	5.5
	Roundup	0.75	9.2	8.3	7.8	7.3
CV %			10.7	13.3	15.9	19.7
$LSD_{0.05}$			0.72	0.83	0.95	1.19
1988	SC-0224	0.5	7.7	7.5	7.2	7.2
	SC-0224	0.56	8.1	8.3	8.1	8.0
	SC-0224	0.62	8.5	8.8	8.7	8.8
	SC-0224	0.69	9.2	9.1	9.0	9.1
	SC-0224	0.75	9.2	8.9	8.6	8.7
1988	Roundup	0.5	7.4	7.4	7.1	7.2
	Roundup	0.56	8.3	8.0	7.8	7.7
	Roundup	0.62	8.4	8.4	8.0	8.0
	Roundup	0.69	8.9	8.6	8.4	8.3
	Roundup	0.75	9.0	9.0	8.7	8.6
CV %			10.7	13.3	15.9	19.7
$LSD_{0.05}$			0.59	0.68	0.78	0.97

[1]Treatments were rated for johnsongrass control using a 1 to 10 scale, where 1 = no control and 10 = complete control.

Table 9. Division * chemical * year means for johnsongrass control ratings using Roundup/Oust and SC-0224/Oust combinations[1].

Year	CHEM	DIV	1 MAT	2 MAT	3 MAT	4 MAT
1987	Roundup	4	8.1	4.3	3.9	5.6
1987	SC-0224	4	7.8	4.2	3.9	5.6
1987	Roundup	8	9.0	9.3	9.0	--
1987	SC-0224	8	9.1	9.4	9.3	--
1988	Roundup	4	7.2	7.3	7.2	7.1
1988	SC-0224	4	7.8	7.9	7.9	7.9
1988	Roundup	5	8.8	8.4	8.0	8.1
1988	SC-0224	5	8.7	8.6	8.4	8.7
1988	Roundup	8	9.2	9.1	8.7	8.7
1988	SC-0224	8	9.1	9.1	8.6	8.5
CV%			10.7	13.3	15.9	19.7
$LSD_{0.05}$			0.46	0.52	0.60	0.75

[1]Treatments were rated for johnsongrass control using a 1 to 10 scale, where 1 = no control and 10 = complete control.

Table 10. Rate * division means for johnsongrass control ratings using Roundup/Oust and SC-0224/Oust combinations[1].

RATE	DIV 4			DIV 5			DIV 8		
lb. ai./A	1 MAT	2 MAT	3 MAT	1 MAT	2 MAT	3 MAT	1 MAT	2 MAT	3 MAT
0.5	6.1	4.0	3.9	8.4	8.3	8.0	8.5	8.6	8.3
0.56	6.9	4.9	4.5	9.0	8.7	8.5	8.9	8.8	8.5
0.62	7.9	6.1	6.2	8.3	8.6	8.2	9.3	9.4	9.1
0.69	8.6	6.7	6.5	9.1	8.7	8.5	9.4	9.6	9.4
0.75	8.9	8.0	7.6	8.9	8.2	7.9	9.5	9.6	9.4
CV %	10.7	13.3	15.9	10.7	13.3	15.9	10.7	13.3	15.9
$LSD_{0.05}$	0.51	0.58	0.67	0.72	0.83	0.95	0.51	0.58	0.67

[1]Treatments were rated for johnsongrass control using a 1 to 10 scale, where 1 = no control and 10 = complete control.

Table 11. Rate * year means for johnsongrass control ratings using Roundup/Oust and SC-0224/Oust combinations[1].

YEAR	RATE lb. ai./A	1 MAT	2 MAT	3 MAT	4 MAT
1987	0.5	7.6	5.7	5.5	5.0
1987	0.56	8.0	5.8	5.4	4.1
1987	0.62	8.7	6.9	6.8	6.0
1987	0.69	9.0	7.3	7.0	5.3
1987	0.75	9.2	8.4	7.9	7.5
CV %		10.7	13.3	15.9	19.7
$LSD_{0.05}$		0.51	0.58	0.67	0.84
1988	0.5	7.5	7.4	7.1	7.2
1988	0.56	8.2	8.2	7.9	7.9
1988	0.62	8.5	8.6	8.4	8.4
1988	0.69	9.1	8.9	8.7	8.7
1988	0.75	9.1	8.9	8.6	8.7
CV %		10.7	13.3	15.9	19.7
$LSD_{0.05}$		0.42	0.48	0.55	0.69

[1]Treatments were rated for johnsongrass control using a 1 to 10 scale, where 1 = no control and 10 = complete control.

Table 12. Division * year means for johnsongrass control ratings using Roundup/Oust and SC-0224/Oust combinations[1].

YEAR	DIV.	1 MAT	2 MAT	3 MAT
1987	4	7.9	4.3	3.9
1987	8	9.1	9.4	9.2
1988	4	7.5	7.6	7.5
1988	5	8.7	8.5	8.2
1988	8	9.2	9.1	8.7
CV %		10.7	13.3	15.9
$LSD_{0.05}$		0.32	0.37	0.43

[1]Treatments were rated for johnsongrass control using a 1 to 10 scale, where 1 = no control and 10 = complete control.

Table 13. Division * Oust means for johnsongrass control ratings[1].

OUST lb. ai./A	DIV 4			DIV 5			DIV 8		
	1 MAT	2 MAT	3 MAT	1 MAT	2 MAT	3 MAT	1 MAT	2 MAT	3 MAT
0.047	7.3	5.5	5.3	8.4	8.4	8.3	9.1	9.2	8.8
0.094	8.1	6.4	6.2	9.1	8.5	8.2	9.2	9.3	9.0
CV %	10.7	13.3	15.9	10.7	13.3	15.9	10.7	13.3	15.9
$LSD_{0.05}$	0.32	0.37	0.43	0.46	0.52	0.60	0.32	0.37	0.43

[1]Treatments were rated for johnsongrass control using a 1 to 10 scale, where 1 = no control and 10 = complete control.

Table 14. **Oust * rate means for johnsongrass control ratings[1].**

OUST lb. ai./A	RATE lb. ai./A	1 MAT	2 MAT	3 MAT	4 MAT
0.047	0.5	7.2	6.3	5.9	5.8
0.047	0.56	7.9	7.1	6.8	6.9
0.047	0.62	8.1	7.5	7.5	7.5
0.047	0.69	8.9	8.1	7.9	7.8
0.047	0.75	9.1	8.7	8.3	8.4
0.094	0.5	7.9	7.1	7.0	7.6
0.094	0.56	8.3	7.4	7.0	7.0
0.094	0.62	9.0	8.3	8.0	8.2
0.094	0.69	9.2	8.4	8.1	7.9
0.094	0.75	9.2	8.7	8.4	8.3
CV %		10.7	13.3	15.9	19.7
$LSD_{0.05}$		0.46	0.52	0.60	0.75

[1]Treatments were rated for johnsongrass control using a 1 to 10 scale, where 1 = no control and 10 = complete control.

Table 15. Division * rate * year means for johnsongrass control ratings using Roundup/Oust and SC-0224/Oust combinations[1].

YEAR	DIV.	RATE lb. ai./A	1 MAT	2 MAT
1987	4	0.5	2.6	1.0
		0.56	2.8	1.1
		0.62	3.3	1.3
		0.69	3.4	1.2
		0.75	3.4	1.2
1987	8	0.5	2.8	1.0
		0.56	2.8	1.1
		0.62	3.4	1.0
		0.69	3.5	1.0
		0.75	3.6	1.0
1988	4	0.5	2.0	1.0
		0.56	2.0	1.0
		0.62	2.0	1.0
		0.69	2.0	1.0
		0.75	2.0	1.0
1988	5	0.5	2.8	2.1
		0.56	2.8	2.1
		0.62	3.2	2.1
		0.69	3.1	2.2
		0.75	3.3	2.3
1988	8	0.5	2.3	1.0
		0.56	2.6	1.0
		0.62	2.9	1.0
		0.69	3.3	1.0
		0.75	3.9	1.0
CV %			17.5	23.0
$LSD_{0.05}$			0.40	0.23

[1]Treatments were rated for johnsongrass control using a 1 to 10 scale, where 1 = no control and 10 = complete control.

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4. Increased Efficacy in Johnsongrass Control from Roundup/Oust Combinations Using the Additive Frigate

L. M. Cargill, D. L. Martin, and D. P. Montgomery

4.1 INTRODUCTION

Considered a persistent, noxious weed in most southern states, johnsongrass (Sorghum halepense L. Pers.) has been reported as a major roadside weed problem in Oklahoma (18). Variations in appearance of this species (color, height and vigor) occur primarily due to differences in climate and fertility. Total plant heights can range from three to ten feet with the aver ge being about six feet throughout the southern states (2). Due to its unsightly morphological characteristics, unmanaged johnsongrass can create sight d stance problems for motorists along roadside situations.

The use of Roundup (glyphosate) and Oust (sulfometuron), alone or in combination, has been evaluated for the control of unwanted roadside vegetation including johnsongrass not only in Oklahoma (5, 13, 18, 20) but in several other states as well (1, 2, 6, 7, 12, 15, 22). Significant control of Johnsongrass and subsequent release of bermudagrass (Cynodon dactylon (L.) Pers.) through reduced weed competition has been reported in Texas (1).

The phytotoxicity of Roundup may be influenced by several application factors, including the addition of surfactants (3, 4, 8, 9, 10, 11, 14, 16, 17, 19, 21, 23). The addition of the product Frigate (a fatty amine ethoxylate) to a Roundup spray mixture at a concentration of 0.5% v/v consistently enhanced the herbicidal activity of Roundup to control sugarcane (16). Roundup at four rates (0.25, 0.5, 1.0, and 2.0 lbs. ai./A) applied in three spray volumes (10, 20, and 40 GPA) plus Frigate (0.5% v/v) was more effective than Roundup alone for controlling quackgrass eight days after application (14). Roundup combined with Frigate significantly reduced johnsongrass regrowth as compared to Roundup alone (11). However, the addition of a surfactant to Roundup has been reported to have no effect on the control of several selected perennial weed speci s (24) with similar results being reported in an experiment evaluating the control of tall fescue with Roundup plus Frigate (17).

The objectives of this research were to evaluate the effectiveness of a spray adjuvant, Frigate, when used with reduced rates of Roundup, alone and in combination with Oust, for the selective control of johnsongrass and subsequent release of bermudagrass along roadsides.

4.2 MATERIALS AND METHODS

Five field studies were conducted from 1986 to 1989 in north-central (Division 4) and in northeastern (Division 8) Oklahoma. In 1986, research was loc ted near Drumright, Oklahoma (Division 4, Experiment 4-H-33-86) on a Seminole loam soil (fine, mixed, thermic Typic Natrustolls). Two experiments were initiated in 1987, with one located near Collinsville, Oklahoma (Division 8, Experiment 8-H-15-87) on a Dennis silt loam soil (fine, mixed, thermic Aquic Paleudolls) and near Drumright, Oklahoma (Division 4, Experiment 4-H-37-87) on a Seminole loam soil (fine, mixed, thermic Typic Natrustolls). In 1988, one field study was located near Perkins, Oklahoma (Division 4, Experiment 4-H-46-88) on a Minco very fine, sandy loam soil (coarse-silty, mixed, thermic Udic Haplustolls). One field experiment was initiated in 1989 near Cushing, Oklahoma (Division 4, Experiment 4-H-52-89) on a Easpur loam soil (fine-loamy, mixed, thermic Fluventic Haplustolls).

Roundup was applied at rates of 0.25, 0.375, 0.5, and 0.75 lbs.ai./A, alone, and in combination with Frigate at 0.5% v/v, in combination with Oust at 0.094 lbs. ai./A, and in combination with Frigate at 0.5% v/v plus Oust at 0.094 lbs. ai./A in each of the five experiments. However, in 1989, treatments of Roundup at 0.25 lb.ai./A, alone, or in combination with other products were deleted, therefore results from these treatments will not be discussed in this report. The experimental design of each study was a randomized complete block with three replications. The individual plot size was 5 ft x 10 ft.

Treatments were applied on 14 May 1986, 4 June 1987, 2 June 1988, 6 June 1989 (Division 4) and 3 June 1987 (Division 8), using a CO_2 powered, hand-held boom sprayer equipped with flat-fan nozzle tips calibrated to deliver 20 GPA at 30 PSI. The bermudagrass was actively growing and johnsongrass ranged from 12 to 24 inches in height when treatments were applied.

Treatments were evaluated for johnsongrass control, where 1 equalled no control and 10 equalled complete control; and bermudagrass phytotoxicity, where 1 equalled no effect and 10 equalled complete yellowing or brownout.

Due to rainfall occurring within four hours after herbicide application, Experiment 4-H-33-86 was terminated one month after treatment. Difficulties arising from data collections in Experiment 8-H-15-87 resulted in no data being presented for this study.

4.3 RESULTS AND DISCUSSION

The addition of Frigate to a particular herbicide treatment significantly increased bermudagrass phytotoxicity 1 month after treatment (MAT) during the two studies conducted in 1987 and 1989, with the only exception being the one treatment of Roundup plus Oust (0.375 + 0.094 lb.ai./A) (Table 16). However, this trend was not apparent in the experiment initiated in 1988, where no significant differences in bermudagrass phytotoxicity at 1 MAT were evident between a particular treatment with or without the addition of Frigate. Ratings made 2 MAT indicated the only treatments which continued to exhibit a significant level of bermudagrass phytotoxicity were those which had the highest rates of Roundup (0.75 lb.ai./A) with or without Oust and/or Frigate. By 2 MAT the phytotoxic effects had usually diminished for the remaining treatments.

The level of johnsongrass control was significantly increased by the addition of Frigate during 1987 and 1989 for 1 and 2 MAT evaluations (Table 17). Frigate also enhanced activity for the 0.375 lb.ai./A rate of Roundup during 1988, but no significant effects were observed in treatments of 0.5 and 0.75 lb.ai./A rates of Roundup, with or without the addition of Frigate. Ratings made 3 MAT in 1987 and 1989 indicated treatments with Frigate controlled johnsongrass significantly better when compared with the same treatments without it. The only exceptions to this trend were the four treatments of the lowest rates of Roundup (0.375 lb.ai./A) alone, or in combination with or without Oust and/or Frigate.

4.4 CONCLUSIONS

The additive Frigate, when added to treatments of Roundup or Roundup plus Oust, appears to significantly enhance the activity of these treatments. A significant increase in bermudagrass phytotoxicity was usually observed by the addition of Frigate for 1 MAT evaluations, however, these effects usually diminish by 2 MAT. The addition of Frigate to Roundup or Roundup plus Oust significantly increased the level of johnsongrass control.

Table 16. Means for Frigate Studies for Bermudagrass Phytotoxicity [4-H-37-87 (1987); 4-H-46-88 (1988); 4-H-52-89 (1989)].

Rates lbs. ai./A			Bermudagrass Phytotoxicity[1]					
			1 MAT			2 MAT		
Roundup	Oust	Lo-Dose	1987	1988	1989	1987	1988	1989
0.375	0	0	1.0	1.3	2.0	1.0	1.0	1.0
0.375	0	0.5% v/v	4.0	2.7	3.7	1.0	1.0	1.0
0.375	0.094	0	1.3	3.3	3.7	1.0	1.0	1.0
0.375	0.094	0.5% v/v	5.3	2.3	3.7	1.7	1.0	1.0
0.5	0	0	1.0	3.0	3.0	1.0	1.0	1.0
0.5	0	0.5% v/v	5.0	3.0	4.0	1.0	1.0	1.0
0.5	0.094	0	1.3	3.7	3.7	1.0	1.0	1.0
0.5	0.094	0.5% v/v	5.3	4.0	5.0	1.3	1.0	1.7
0.75	0	0	1.0	3.3	4.0	1.0	1.0	1.0
0.75	0	0.5% v/v	6.0	3.3	5.7	1.7	1.0	2.3
0.75	0.094	0	3.7	4.0	4.0	1.0	1.0	1.0
0.75	0.094	0.5% v/v	5.7	4.3	6.0	2.0	1.7	2.3
$LSD_{0.05}$			1.3	1.6	0.8	0.8	0.3	0.5
C.V. %			22.6	29.3	12.0	37.5	15.8	23.3

[1]Bermudagrass Phytotoxicity, where 1 = no effect and 10 = complete yellowing or brownout.

Table 17. Means for Frigate Studies for Johnsongrass Control [4-H-37-87 (1987); 4-H-46-88 (1988); 4-H-52-89 (1989)].

Rates lbs. ai./A			Johnsongrass Control[1]								
			1 MAT			2 MAT			3 MAT		
Roundup	Oust	Lo-Dose	1987	1988	1989	1987	1988	1989	1987	1988	1989
0.375	0	0	1.0	4.7	1.3	1.0	4.0	1.0	1.0	4.0	1.0
0.375	0	0.5% v/v	5.0	8.3	5.3	5.7	8.2	5.3	4.7	7.7	4.3
0.375	0.094	0	1.0	9.5	5.0	1.0	9.4	4.7	4.0	9.2	4.7
0.375	0.094	0.5% v/v	8.2	9.5	7.5	9.0	8.9	7.0	8.3	8.5	5.7
0.5	0	0	1.0	9.0	3.0	1.0	9.2	2.0	1.0	8.8	1.3
0.5	0	0.5 % v/v	6.0	8.8	6.7	6.7	8.3	6.7	6.3	7.8	6.0
0.5	0.094	0	1.7	9.7	5.3	1.0	9.3	5.0	1.0	9.2	4.7
0.5	0.094	0.5% v/v	8.7	9.5	8.8	8.7	9.5	8.8	8.2	9.4	8.5
0.75	0	0	1.0	9.3	6.5	1.0	8.3	6.7	1.0	7.7	5.8
0.75	0	0.5% v/v	9.0	8.8	9.0	9.4	8.8	9.0	9.4	8.5	8.4
0.75	0.094	0	7.2	9.8	7.3	6.3	9.6	7.7	6.7	9.4	6.7
0.75	0.094	0.5% v/v	9.4	9.8	9.4	9.4	9.7	9.3	9.5	9.7	9.0
$LSD_{0.05}$			1.5	1.9	1.9	1.0	1.8	2.1	1.2	1.9	2.6
C.V. %			17.8	12.4	17.8	12.2	12.3	20.3	14.6	13.2	27.3

[1]Johnsongrass control, where 1 = no control and 10 = complete control.

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5. Bermudagrass (Cynodon dactylon L. Pers.) Encroachment Control Along Oklahoma rights-of-way

D. P. Montgomery, L. M. Cargill, D. L. Martin, and J. F. Barber

5.1 INTRODUCTION

In many Southern states the predominant desirable roadside grass species is common bermudagrass (Cynodon dactylon (L.) Pers.). The prostrate growth habit, extensive root system, and aggressive growth of common bermudagrass make it a good choice for an erosion resistant ground cover. The aggressive behavior of common bermudagrass can become a problem when it begins to encroach into asphalt shoulders and concrete seams. If bermudagrass encroachment is allowed to continue in these ar as, the shoulders and pavement seams will fail prematurely and require replacement. Therefore, bermudagrass encroachment control is an economic requirement on roadside shoulders or concrete seams infested with common bermudagrass.

For more than thirty years many state highway maintenance programs have been using soil sterilants to provide bermudagrass encroachment control. Successful control of common bermudagrass has been accomplished with Hyvar (bromacil), Spike (tebuthiuron), Pramitol (prometone), and TCA (4, 6). The disadvantages of using soil sterila ts on roadside shoulders is the documented characteristics of long-term persistence of these materials in the soil and lateral movement to non-target areas (1, 5). Since roadway design includes the lateral movement of wa er off of the road surface to the roadside, there is potential for herbicide damage to desirable roadside grasses. Over-application of soil sterilants could potentially eliminate the vegetation from any adjacent sloped areas for long periods of time.

Current research has shifted to less persistent products which no longer are termed "soil sterilants". Treatments of less persistent and less mobile p oducts have proven to be effective in controlling common bermudagrass encroachment (2, 3, 7).

The objective of this study was to evaluate treatments of Arsenal (imazapyr) and Roundup (glyphosate), alone, and in combination with Oust (sulfometuron) for control of common bermudagrass growing on or in asphalt shoulders or concrete seams.

5.2 MATERIALS AND METHODS

Field studies were conducted in 1988 (studies 4-H-47-88, 5-H-5-88, and 8-H-18-88) and 1989 (studies 4-H-51-89, 5-H-8-89, and 8-H-23-89) at three locations on highway rights-of-way shoulders in Oklahoma. Experimental sites were selected on the basis of abundant, actively growing bermudagrass on the highway shoulder. Treatments in 1988 studies included Velpar (hexazinone) at 0.9, 1.2, and 1.6 lb. a.i./A., alone, and in combination with Oust (sulfometuron) at 0.141 and 0.235 lb. a.i./A. Treatments of Roundup (glyphosate) at 1.0 and 2.0 lb. a.i./A or Arsenal (imazapyr) at 0.9, 1.2 and 1.6 lb. a.i./A were tested alone and in combination with Oust at 0.235 lb. a.i./A. Treatments were applied using a CO_2 pressurized sprayer calibrated to deliver 20 gal/A at 28 psi using a single TK-SS-5 floodjet nozzle tip. The nozzle tip was mounted on the rear bumper of a pickup approximately six inches above the target. Treatments were applied to actively growing bermudagrass on 3 June (4-H-47-88), 13 June (5-H-5-88), and 7 June (8-H-18-88), 1988. Plots were 3 by 100 ft. and were replicated three times in a randomized complete block design.

The 1989 experiments were conducted at three different locations along highway rights-of-way shoulders in the same three maintenance Divisions. Experimental sites were selected using the same criteria as in 1988 studies. Results from 1988 studies were used to determine herbicides and rates evaluated in 1989. Treatments in 1989 included Arsenal at 0.9, 1.2, and 1.6 lb. a.i./A, alone, and in combination with Oust at 0.047 and 0.094 lb. a.i./A. Treatments were applied in s udies 4-H-51-89 and 5-H-8-89 using the same sprayer as in 1988 with the carrier increased to 40 gal/A. Treatments were a plied at the 8-H-23-89 study using a CO_2 powered hand-held boom equipped with a single 80015E flat-fan nozzle tip deliv ring 40 gal/A at 22 psi. Treatments were applied to actively growing bermudagrass on 19 June (4-H-51-89), 22 June (5-H-8-89), and 16 June (8-H-23-89), 1989. Plots were 3.3 by 9.1 ft (4-H-51-39), 3 by 50 ft. (5-H-8-89), and 1.5 by 13 ft. (8-H-23-89) and were replicated three times in a randomized complete block design.

All studies were evaluated on a monthly basis for bermudagrass control and bermudagrass phytotoxicity. Total vegetation control was also evaluated in 1988. Bermudagrass control was visually rated on a scale of 1=no control and 10=complete control. Bermudagrass phytotoxicity was visually rated on a scale of 1=green bermudagrass, 5=yellow bermudagrass, and 10=brown bermudagrass. Total vegetation control was visually rated on a scale of 1=no control and 10=complete control.

Since herbicides and rates varied in this work, separate analysis of variance was conducted on data from each year's research. Data was analyzed as a split plot in both space (location of study) and time (rating date). Since location, treatment, and location by treatment interactions were found significantly different ($p = 0.05$), treatment means within locations and rating dates were separated using Fisher's Least Significant difference test at the $p = 0.05$ level of significance.

5.3 RESULTS AND DISCUSSION

Several of the best treatments had a 30 day dela before an acceptable level of control was achieved. During the delay period, bermudagrass growth was suppressed and phytotoxicity was observed. An acceptable level of bermudagrass control in roadside situations corresponds to a rating of 9 or higher. Bermudagrass control at 3 months after treatment (MAT) was considered the critical rating to determine if a treatment was successful.

In 1988, Velpar, Roundup, and Arsenal, alone, and in combination with Oust, were applied at 3 locations in the state. Velpar and Roundup treatments never provided acceptable control at any time or location for the rates evaluated in this study (Table 18). Arsenal, alone, and in combination with Oust, were the best treatments in 1988. Higher rates of Arsenal, alone, and in combination with Oust, required 30-60 days before achieving acceptable and consistent bermudagrass control (Table 18). The addition of Oust did not significantly increase bermudagrass control; however, there was a trend for Oust to improve bermudagrass control and to maintain this level of control.

Total vegetation control was rated in 1988. The Arsenal treatments in combination with Oust demonstrated better preemergent control of annual weeds, compared with Roundup or Velpar (Table 19). Study 5-H-81-89 had a low population of annual weeds.

In 1989, treatments providing unacceptable control in preceding years were eliminated from the study. Arsenal combination treatments were expanded to include 0.047 and 0.094 lb. ai./A of Oust for each rate of Arsenal used in the 1988 experiment. Oust rates were reduced from 0.235 to 0.047 and 0.094 lb. a.i./A to lower the treatment cost per acre. Roadside treatment recommendations must include economic considerations as well as control. Total vegetation control was not rated in 1989.

Bermudagrass control in 1989 was higher than 1988 experiments due primarily to climatic differences. In 1988, the summer was typical of Oklahoma weather with hot and dry conditions during June, July and August. In 1989, numerous timely rainfalls occurred in conjunction with lower temperatures. The bermudagrass in the 1989 experiments remained actively growing throughout the summer, and was more susceptible to the herbicide treatments.

All treatments with Arsenal alone provided acceptable bermudagrass control at 3 MAT (Table 20). There was a trend for higher and more consistent bermudagrass control with Arsenal at 1.2 lb. a.i./A and at higher rates. As with 1988 experiments, the addition of Oust tended to increase the level of bermudagrass control, but not significantly. There were no differences in bermudagrass control between t e 0.047 and 0.094 lb. a.i./A rates of Oust.

5.4 CONCLUSIONS

A single application of Arsenal applied at 1.2 lb. a.i./A in combination with 0.047 lb. a.i./A of Oust is recommended. This application should be made in Oklahoma in late May or June to actively growing bermudagrass using a minimum of 40 gal/A of carrier.

Table 18. Effects of Several Herbicides for Control of Bermudagrass Encroachment in 1988[1].

Treatment	Rate (lb. ai/A)	4-H-47-88			5-H-5-88			8-H-18-88		
		BC1	BC2	BC3	BC1	BC2	BC3	BC1	BC2	BC3
Velpar	2.0	3.0	1.0	1.0	7.8	4.0	2.7	5.0	1.3	1.0
Velpar + Oust	2.0 0.141	6.3	1.3	1.0	8.5	6.0	7.0	8.0	1.7	1.3
Velpar + Oust	2.0 0.235	6.3	1.7	1.0	7.5	4.7	3.3	8.0	4.3	3.7
Roundup	1.0	3.0	1.0	1.0	4.7	1.3	1.7	3.0	1.0	1.0
Roundup	2.0	6.7	2.0	1.3	7.3	5.0	4.7	3.7	2.0	1.0
Roundup + Oust	1.0 0.235	5.3	1.3	1.0	7.0	6.0	6.3	5.3	3.3	2.0
Roundup + Oust	2.0 0.235	8.0	2.7	2.0	8.0	9.2	8.7	5.7	6.3	6.0
Arsenal	0.9	7.0	8.8	7.5	8.0	9.6	9.6	4.7	7.0	7.7
Arsenal	1.2	7.3	9.5	9.4	7.7	9.7	9.7	4.3	7.0	8.0
Arsenal	1.6	8.3	9.4	9.5	7.7	9.7	9.8	6.3	8.0	9.2
Arsenal + Oust	0.9 0.235	7.3	9.9	8.6	7.7	9.7	9.8	5.3	8.0	8.0
Arsenal + Oust	1.2 0.235	8.7	9.8	9.5	7.0	9.7	9.8	5.0	8.3	9.0
Arsenal + Oust	1.6 0.235	9.0	9.9	9.9	8.0	9.6	9.7	6.0	8.8	9.6
Check	---	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
$LSD_{0.05}$		1.3	0.7	0.9	2.0	1.7	1.7	1.4	2.0	2.1

[1]Bermudagrass Control was rated visually on a 1 to 10 scale where 1 = no control and 10 = complete control. BC1, BC2, and BC3 are mean bermudagrass control values 1, 2 and 3 months after treatment.

Table 19. Effects of Several Herbicides for Total Vegetation Control in 1988[1].

Treatment	Rate (lb. ai./A)	4-H-47-88			5-H-5-88			8-H-18-88		
		TV1	TV2	TV3	TV1	TV2	TV3	TV1	TV2	TV3
Velpar	2.0	3.0	2.3	2.3	7.8	6.7	2.3	5.0	4.0	2.7
Velpar + Oust	2.0 0.141	6.3	2.3	5.0	8.5	8.5	5.7	8.0	5.3	4.3
Velpar + Oust	2.0 0.235	6.3	2.7	6.0	7.5	7.8	2.3	8.0	7.3	6.7
Roundup	1.0	3.0	2.3	2.7	4.7	5.3	1.3	3.0	2.7	1.7
Roundup	2.0	6.7	2.7	4.7	7.3	6.7	3.3	3.7	1.0	2.3
Roundup + Oust	1.0 0.235	5.3	2.3	6.0	7.0	8.2	5.0	5.3	7.0	5.0
Roundup + Oust	2.0 0.235	8.0	3.3	6.0	8.0	9.6	7.0	5.7	8.0	7.3
Arsenal	.09	7.0	8.5	7.7	8.0	9.7	9.3	4.7	8.2	8.0
Arsenal	1.2	7.3	9.3	7.7	7.7	9.7	9.4	4.3	7.3	7.7
Arsenal	1.6	8.3	9.1	7.7	7.7	9.8	9.7	6.3	8.3	9.0
Arsenal + Oust	0.9 0.235	7.3	9.9	9.3	7.7	9.8	9.6	5.3	8.5	8.8
Arsenal + Oust	1.2 0.235	8.7	9.8	9.5	7.0	9.8	9.8	5.0	9.0	9.0
Arsenal + Oust	1.6 0.235	9.0	9.9	9.7	8.0	9.7	9.7	6.0	9.6	9.6
Check	----	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
$LSD_{0.05}$		1.3	2.0	1.9	2.0	1.4	1.5	1.4	2.1	1.6

[1]Total vegetation control was rated on a 1 to 10 scale, where 1 = no control and 10 = complete control. TV1, TV2 and TV3 are mean total vegetation control 1, 2 and 3 months after treatment.

Table 20. Effects of Several Herbicides for Control of Bermudagrass Encroachment in 1989[1].

Treatment	Rate (lb. ai./A)	4-H-51-89			5-H-8-89			8-H-23-89		
		BC1	BC2	BC3	BC1	BC2	BC3	BC1	BC2	BC3
Oust	0.047	1.3	1.0	1.0	3.3	3.9	4.0	3.7	1.3	1.0
Oust	0.094	1.7	1.0	1.0	1.0	1.0	1.0	3.7	1.0	1.0
Arsenal	0.9	8.3	9.0	8.4	8.0	9.6	9.8	5.7	9.6	9.
Arsenal	1.2	8.7	9.6	9.4	8.3	9.8	9.8	5.7	9.3	9.3
Arsenal	1.6	8.3	9.7	9.7	8.7	9.9	10.0	6.0	9.9	9.6
Arsenal + Oust	0.9 0.047	8.7	9.5	9.3	7.7	9.8	9.9	6.0	9.8	9.6
Arsenal + Oust	1.2 0.0 7	8.7	9.9	9.9	8.3	9.8	9.9	6.0	9.8	9.5
Arsenal + Oust	1.6 0.0 7	9.0	9.9	9.9	8.0	9.9	9.9	6.7	9.8	9.7
Arsenal + Oust	0.9 0.094	8.7	9.6	9.4	8.7	9.8	9.9	6.0	9.7	9.3
Arsenal + Oust	1.2 0.094	9.0	9.9	9.9	8.3	9.9	9.9	6.0	9.7	9.6
Arsenal + Oust	1.6 0.094	9.0	9.9	9.9	8.0	9.7	9.9	6.7	9.9	9.6
Check	---	1.3	1.0	1.0	1.0	1.0	1.0	3.3	1.0	1.0
$LSD_{0.05}$	0.05 =	1.0	0.5	1.0	2.1	2.5	2.5	1.7	0.5	0.4

[1]Bermudagrass Control was rated visually on a 1 to 10 scale, 1 = no control and 10 = complete control. BC1, BC2 and BC3 are mean bermudagrass control values 1, 2 and 3 months after treatment.

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6. Suppression of Common Bermudagrass (Cynodon dactylon) Growth and Development.

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6.1 INTRODUCTION

For many years plant growth r gulators (PGR) have been used to suppress the growth of roadside grasses throughout the eastern, north eastern, and north central regions of the United States. States located in these regions have roadsides composed primarily of cool-season grass species. Cool-season species such as Festuca spp., Lolium spp., or Poa spp. treated with a PGR have shown significant reductions in grass height and seedhead production (8,9). Growth suppression of cool-season roadside grasses has allowed roadside managers to reduce mowing frequencies (3), thus stretching manpower, equipment and budgets. PGR's such as Embark (mefluidide), Limit (amidochlor), TGR (paclobutrazol), and Cutless (flurprimidol) are proving to be excellent tools for managing cool-season turfgrasses (1,2,4).

Roadside managers in the Southern one-half of the United States have few PGR's available which will suppress the growth of the predominantly warm-season species in the rights-of-way without causing adverse affects. Warm-season species such as Cynodon spp., Paspalum spp., Buchloe spp., and Eremochloa spp. are found on most roadside rights-of-way in Southern states, with Cynodon dactylon being the most common. Management of warm-season species, which typically have a lower growth habit than cool-season species, could benefit from a PGR that suppress growth and seedhead formation, thereby as well as providing a more aesthetically pleasing roadside turf. Cool-season PGR's have shown short-term suppression of warm-season species, requiring multiple applications to reduce mowing frequencies (10). In recent years researchers have found a few products which significantly reduce the growth and development of warm-season turf on roadsides with single applications.

Our objectives were 1) to evaluate several herbicides and PGR's for their ability to suppress the growth and development of common bermudagrass growing along Oklahoma roadside rights-of-way, 2) to determine if the duration of suppression could potentially reduce the number of mowing cycles required by the various common bermudagrass roadsides situations, and 3) to determine if any of the products tested produce any adverse phytotoxicity to common bermudagrass.

6.2 MATERIALS AND METHODS

Six field studies were conducted in 1988 (studies 4-PGR-48-88, 5-PGR-6-88, and 8-PGR-19-88) and 1989 (studies 4-PGR-49-89, 5-PGR-9-89, and 8-PGR-24-89) at three locations in Oklahoma. In 1990, two additional studies (studies 4-PGR-55-90 and 8-PGR-26-90) were conducted in two locations. Locations were in west-central, north-central, and north-eastern Oklahoma. Experimental sites were selected on the basis of uniform, dense, common bermudagrass cover. Treatments were applied to actively growing common bermudagrass during late May or early June. Studies were mowed at a height of 2.5 inches immediately prior to treatment. Treatments were applied to the entire plot using a CO_2-pressurized sprayer calibrated to deliver 20 gal/A at 30 psi through a hand-held spray boom with three 80015 spray tips spaced 20 inches apart. Plots measured 5 by 10 ft. and wer re licated three times in a randomized complete block design.

Treatments included in 1988 studies were uniconazole at 1.0, 1.5, and 2.0 lb. a.i./A, Select (clethodim) at 0.05, 0.1, and 0.2 lb. a.i./A, Vision (cimectacarb) at 0.6, 0.8, and 1.0 lb. a.i./A, Embark at 1.0 lb. a.i./A, and Poast (sethoxydim) at 0.28 lb. a.i./A. In 1989, identical treatments of uniconazole, Select, and Vision were tested a ong with Poast at 0.28, 0.34, and 0.4 lb. a.i./A. The two low rat s of Poast were also tested in combination with Oust at 0.047 lb. a.i./A. In 1990, treatments of Vision at 0.6, 0.8, and 1.0 lb. a.i./A and Poast at 0.28, 0.34, and 0.4 lb. a.i./A, alone, and in combination with Oust at 0.47 lb. a.i./A, were tested. All treatments of Poast, Select, and Poast plus Oust included a crop oil at a rate of 0.5% V/V.

Treatments at all locations were evaluated on a monthly basis for bermudagrass canopy height, seedhead suppression, phytotoxicity, and annual weed control (1990 studies only). Bermudagrass canopy heights were taken by measuring three randomly selected areas in each plot. Bermudagrass seedhead suppression was visually rated on a scale of 0 to 100, where 0=no seedhead suppression and 100=complete seedhead suppression. Bermudagrass phytotoxicity was visually rated on a scale of 1 to 10, where 1=no phytotoxicity and 10=completely brown turf. In 1990 stu ies, annual weed control was visual y rated on a scale of 1 to 10, where 1=no control and 10=complete control. Plots were harvested three months-after-treatment (MAT) using a Toro rotary mower cutting at a height of 2.5 inches. Fresh clippings were collected and weighed for each plot. A fresh sub-sample from each plot was also weighed and then allowed to dry at 45 degrees for seven days. Dry weights were then taken on sub-samples and initial fresh weights were adjusted for moisture content and recorded as total dry matter.

Data was analyzed by two-way analysis of variance by location and year. Mean separat on was accomplished by the Least Significant Difference Test at the 0.05% significance level.

6.3 RESULTS AND DISCUSSION

For a PGR to be successful in suppressing common bermudagrass growth and development it would need to maintain growth and seedhead suppression for a minimum of two months. This eliminates the need for mowing during this period and provide for a more aesthetically pleasing roadside. A PGR would also need to be able to suppress growth without any significant side effects, such as yellowing or off-coloring, to the roadside turf. With roadside turf being classified as a low maintenance turf area, some temporary discoloration is acceptable as long as it is not otherwise detrimental to the common bermudagrass roadsides.

At the time of the 1988 and 1989 studies, treatments of uniconazole and Select were showing promise as successful PGR's for bermudagrass. In late 1989 it became apparent that their manufacturer did not wish to pursue registration for use on roadside turf, therefore, results are presented in Tables 22 through 26 but will not be discussed in the text of this report. In 1988 studies, Embark demonstrated little if any activity in suppressing bermudagrass growth. Vision provided excellent canopy height suppression for up to three months. The level of seedhead suppression from Vision at 0.8 lb. a.i./A varied from 25% (Table 23) to 80% (Table 21) at 3 MAT. Higher rates of Vision did provide slightly more canopy height suppression. These same treatments of Vision provided fair to good seedhead suppression for two months (Tables 21, 22, and 23). Vision treatments caused temporary phytotoxicity of bermudagrass which lasted for approximately one month. For roadside turf areas, the level and duration of discoloration from Vision treatments was cceptable.

In 1989 studies, Vision at 0.8 lb. a.i./A suppressed bermudagrass canopy heights for up to three months. Suppression ranged from 37% (Table 25) to 72% (Table 24) at 3 MAT for Vision at 0.8 lb. a.i./A. Excellent seedhead suppression was maintained for two months with Vision treatments in two of the three studies. Little if any seedhead suppression was observed at later ratings. Vision treatments did temporarily discolor the bermudagrass for four to six weeks. The level of discoloration would be acceptable for roadside turf areas. Treatments of Poast, alone, and in combination with Oust were evaluated in 1989. Poast at 0.28 lb. a.i./A suppressed bermudagrass canopy heights from 23% (Table 25) to 39% (Table 26) at 3 MAT. Higher rates of Poast, alone, and in combination with Oust did not significantly increase bermudagrass suppression. All treatments of Poast, alone, and in combination with Oust provided excellent seedhead suppression for two months.

Oust provided annual weed control during the 1989 studies. Tre tments of Poast at 0.34 lb. a.i./A and higher, and all Oust combination treatments, produced significant bermudagrass phytotoxicity for a minimum of one month (Tables 24, 25, and 26). The level of discoloration from these treatments would be unacceptable under most roadside situations.

In 1990, treatments of Vision and Poast alone and in combination with Oust were evaluat d at two locations. As in the 1988 and 1989 studies, Vision demonstrated the best results. Vision was tested in 1990 in combination with Oust to provide weed control, as Vision had demonstrated little ability to suppress plants other than bermudagrass. All treatments of Vision significantly reduced canopy heights for a minimum of three months (Table 27) and two months (Table 28) in studies 4-PGR-55-90 and 8-PGR-26-90, respectively. The level of suppression varied between locations more in 1990 than in either of the two previous years. This was probably due to the fact that the two experimental sites had extremely different soil texture, type, and fertility. Bermudagrass grew vigorously at one location (4-PGR-55-90) while it grew very little at the other location (8-PGR-26-90). In order to detect PGR activity, there must be at least a moderate level of bermudagrass growth. Bermudagrass roadsides producing little growth will mask the effects of most PGR's. Vision treatments produced good to excellent seedhead suppression for a minimum of two months (Table 27), but only moderate suppression in the 8-PGR-26-90 study. All Vision treatments produced only a small amount of temporary bermudagrass phytotoxicity. The addition of Oust did seem to increase the discoloration but not to a significant level. Poast, alone, and in combination with Oust provided good canopy height suppression in the 4-PGR-55-90 study for two months (Table 27). Height suppression in the 8-PGR-26-90 study was nominal. Poast at 0.34 lb. a.i./A or higher caused significant phytotoxicity to the bermudagrass. Even though the discoloration was temporary, the higher rates of Poast caused an unacceptable level of injury (Table 27 and 28). Poast treatments did provide good to excellent seedhead suppression for a minimum of two months (Table 27) and one month (Table 28) in studies 4-PGR-55-90 and 8-PGR-26-90, respectively.

The benefit of combining Oust with Vision is due to the annual weed control provided by Oust. Weeds of primary concern include summer annual weeds such as crabgrass, foxtails, marestail and sunflower. Vision alone has no effect on the annual weeds but suppresses the surrounding bermudagrass. This could potentially create a very unattractive roadside. All treatments of Vision combined with Oust did show significant levels of annual weed control. Some weeds were controlled (crabgrass) while others were only suppressed (foxtails). Annual weed control was also somewhat inconsistent between Divisions (Table 27 and 28). Annual weeds were controlled for a minimum of one month and suppressed for an additional month. It is possible that slightly higher rates of Oust, or tank-mixing Vision with other residual herbicides could increase the level of annual weed control.

6.4 CONCLUSIONS

It was apparent from three years of research with multiple study locations each year that Vision demonstrat d the most promise as a bermudagrass plant growth regulator. Vision at 0.8 lb. a.i./A showed consistent ability to suppress bermudagrass height by 40 to 50% for a period of two to three months. Current data indicate that Vision and Vision/Oust combinations have the potential to be a useful tool to aid bermudagrass management programs in high mowing frequency or hazardous mowing areas.

Table 21. Effect of PGRs on bermudagrass growth and development in 1988 in northcentral Oklahoma (study 4-PGR-48-88).

Treatment	Rate (lb. a. i./A)	Seedhead Suppression			Bermuda Phyto[1]			Canopy heights			Clip weights
		1 MAT	2 MAT	3 MAT	1 MAT	2 MAT	3 MAT	1 MAT	2 MAT	3 MAT	3 MAT
		---%---						---mm---			grams
1. Uniconazole	1.0	17	43	65	1.7	2.7	3.3	94	90	94	186
2. Uniconazole	1.5	30	60	70	2.0	3.7	5.3	81	66	78	119
3. Uniconazole	2.0	30	60	88	2.3	4.0	6.0	86	71	53	136
4. Select	0.05	72	72	43	2.0	1.0	1.3	75	107	117	245
5. Select	0.1	93	91	75	2.7	1.0	1.3	71	103	140	229
6. Select	0.2	96	93	75	2.7	1.0	1.3	56	82	104	171
7. Vision	.06	77	80	60	2.7	1.3	1.7	61	68	102	192
8. Vision	0.8	90	67	80	4.0	1.7	3.0	53	59	87	157
9. Vision	1.0	93	87	75	4.0	1.7	2.7	54	48	63	148
10. Embark	1.0	0	0	8	1.0	1.0	1.0	121	181	234	448
11. Poast	0.28	95	83	58	2.7	1.0	1.3	72	113	157	289
12. Check	---	0	0	0	1.0	1.0	1.0	136	190	229	452
$LSD_{0.05}$		10	20	30	0.9	1.3	1.0	24	34	34	86

[1]Bermudagrass phytotoxicity was rated on a scale of 1 to 10 where 1 = no control and 10 = complete control.

Table 22. Effect of PGRs on bermudagrass growth and development in 1988 in southwest Oklahoma (study 5-PGR-6-88).

Treatment	Rate (lb. a. i./A)	Seedhead Suppression 1 MAT	Seedhead Suppression 2 MAT	Seedhead Suppression 3 MAT	Bermuda Phyto[1] 1 MAT	Bermuda Phyto[1] 2 MAT	Canopy heights 1 MAT	Canopy heights 2 MAT	Canopy heights 3 MAT	Clip weights 3 MAT
		%					mm			grams
1. Uniconazole	1.0	7	7	13	1.0	1.0	491	556	626	630
2. Uniconazole	1.5	27	13	33	1.0	1.0	482	572	619	561
3. Uniconazole	2.0	28	22	25	1.3	1.3	421	510	553	459
4. Select	0.05	82	73	52	2.0	1.3	444	504	590	568
5. Select	0.1	95	80	68	2.7	1.0	412	443	533	513
6. Select	0.2	94	85	72	3.3	1.0	404	409	494	482
7. Vision	0.6	91	68	48	2.3	2.0	366	373	410	360
8. Vision	0.8	82	67	53	2.3	1.7	401	363	431	360
9. Vision	1.0	95	65	48	3.0	1.7	393	389	411	526
10. Embark	1.0	13	13	25	1.0	1.0	538	592	566	437
11. Poast	0.28	95	72	55	3.3	1.0	390	412	516	545
12. Check	---	0	0	0	1.0	1.0	613	614	626	468
$LSD_{0.05}$		19	25	28	0.8	0.5	94	96	65	290

[1]Bermudagrass phytotoxicity was rated on a scale of 1 to 10 where 1 = no control and 10 = complete control.

Table 23. Effect of PGRs on bermudagrass growth and development in 1988 in northeast Oklahoma (study 8-PGR-19-88).

Treatment	Rate (lb. a. i./A)	Seedhead Suppression 1 MAT	Seedhead Suppression 2 MAT	Seedhead Suppression 3 MAT	Bermuda Phyto[1] 1 MAT	Bermuda Phyto[1] 2 MAT	Canopy heights 1 MAT	Canopy heights 2 MAT	Canopy heights 3 MAT	Clip weights 3 MAT
		%	%	%			mm	mm	mm	grams
1. Uniconazole	1.0	50	32	45	2.7	1.0	310	288	363	721
2. Uniconazole	1.5	38	37	25	2.0	1.0	297	332	443	718
3. Uniconazole	2.0	23	52	25	2.3	1.0	307	349	500	807
4. Select	0.05	72	77	43	4.0	1.0	282	286	429	669
5. Select	0.1	81	90	30	5.0	1.0	319	326	431	785
6. Select	0.2	96	83	38	6.0	1.0	266	297	392	667
7. Vision	0.6	97	80	25	3.0	1.3	279	313	406	793
8. Vision	0.8	98	60	25	4.0	1.7	313	291	429	797
9. Vision	1.0	96	87	52	3.7	2.0	259	243	342	651
10. Embark	1.0	48	30	17	3.0	1.0	294	318	463	786
11. Poast	0.28	98	92	0	6.3	1.3	289	331	589	1197
12. Check	---	0	10	0	1.0	1.0	352	381	583	1152
$LSD_{0.05}$		33	36	34	1.6	0.5	62	71	153	350

[1]Bermudagrass phytotoxicity was rated on a scale of 1 to 10 where 1 = no control and 10 = complete control.

Table 24. Effect of PGRs on bermudagrass growth and development in 1989 in northcentral Oklahoma (study 4-PGR-49-89).

Treatment[1]	Rate (lb. a. i./A)	Seedhead Suppression 1 MAT	Seedhead Suppression 2 MAT	Seedhead Suppression 3 MAT	Bermuda Phyto[2] 1 MAT	Canopy heights 1 MAT	Canopy heights 2 MAT	Canopy heights 3 MAT	Clip weights 3 MAT
		---------------%---------------				---------------mm---------------			grams
1. Uniconazole	1.0	20	10	7	1.0	191	312	452	659
2. Uniconazole	1.5	30	23	7	1.0	231	375	444	614
3. Select	0.05	99	90	8	1.3	148	257	345	550
4. Select	0.1	98	96	33	1.3	166	300	423	575
5. Select	0.2	96	98	43	2.3	148	308	417	677
6. Vision	0.6	95	92	0	1.3	134	193	249	356
7. Vision	0.8	92	93	0	2.2	135	175	234	224
8. Vision	1.0	95	95	0	1.3	127	175	185	229
9. Poast	0.28	99	93	0	2.2	159	294	427	582
10. Poast	0.34	98	98	17	2.3	176	365	464	757
11. Poast	0.40	94	99	0	4.2	174	357	536	623
12. Poast + Oust	0.28 + 0.047	96	98	0	3.7	156	338	484	797
13. Poast + Oust	0.34 +0.047	96	98	0	3.8	193	409	777	1076
14. Check	----	0	0	0	1.0	284	536	665	1076
$LSD_{0.05}$		6	6	23	1.2	58	82	107	180

[1] All Poast treatments included a crop oil at 0.5% v/v.

[2] Bermudagrass phytotoxicity was rated on a scale of 1 to 10 where 1 = no control and 10 = complete control.

Table 25. Effect of PGRs on bermudagrass growth and development in 1989 in southwest Oklahoma (study 5-PGR-9-89).

Treatment[1]	Rate (lb. a. i./A)	Seedhead Suppression 1 MAT	Seedhead Suppression 2 MAT	Seedhead Suppression 3 MAT	Bermuda Phyto[2] 1 MAT	Canopy heights 1 MAT	Canopy heights 2 MAT	Canopy heights 3 MAT	Clip weights 3 MAT
		---------------%---------------				--------------mm--------------			grams
1. Uniconazole	1.0	42	27	33	2.0	156	262	264	166
2. Uniconazole	1.5	62	48	68	2.0	161	197	161	118
3. Select	0.05	90	30	7	2.3	171	392	512	443
4. Select	0.1	99	40	7	4.0	171	297	425	263
5. Select	0.2	99	88	7	5.7	147	258	426	247
6. Vision	0.6	85	23	7	2.8	140	213	329	209
7. Vision	0.8	96	43	7	2.7	167	290	337	172
8. Vision	1.0	99	85	0	3.0	157	254	239	129
9. Poast	0.28	99	23	0	3.2	150	327	410	286
10. Poast	0.34	98	60	0	4.7	150	306	408	271
11. Poast	0.4	99	88	30	5.3	156	235	388	227
12. Poast + Oust	0.28 + 0.047	96	17	7	3.7	153	278	460	277
13. Poast + Oust	0.34 + 0.047	99	83	7	5.2	166	277	371	238
14. Check	---	0	0	7	1.0	208	376	533	452
$LSD_{0.05}$		17	35	21	1.5	51	105	104	135

[1]All Poast treatments included a crop oil at 0.5% v/v

[2]Bermudagrass phytotoxicity was rated on a scale of 1 to 10 where 1 = no control and 10 = complete control.

Table 26. Effect of PGRs on bermudagrass growth and development in 1989 in northeast Oklahoma (study 8-PGR-24-89).

Treatment[1]	Rate (lb. a. i./A)	Seedhead Suppression			Bermuda Phyto[2]			Canopy heights			Clip weights
		1 MAT	2 MAT	3 MAT	1 MAT	2 MAT	3 MAT	1 MAT	2 MAT	3 MAT	3 MAT
		--------------%	--------------					--------------mm	--------------		grams
1. Uniconazole	1.0	98	96	88	3.7	3.7	3.0	162	119	112	54
2. Uniconazole	1.5	95	99	93	3.2	4.3	3.5	155	124	125	44
3. Select	0.05	99	93	30	1.5	1.0	1.0	170	164	190	125
4. Select	0.1	96	83	5	1.2	1.0	1.0	205	194	237	193
5. Select	0.2	99	99	25	1.8	1.0	1.0	187	189	209	137
6. Vision	0.6	95	85	23	3.0	3.0	1.0	131	94	122	61
7. Vision	0.8	99	85	35	2.5	2.7	1.7	148	124	145	72
8. Vision	1.0	99	93	45	2.5	3.0	2.5	139	128	123	68
9. Poast	0.28	98	90	13	2.2	1.0	1.0	167	158	158	105
10. Poast	0.34	99	96	23	3.0	1.0	1.0	156	148	184	104
11. Poast	0.4	99	96	28	3.2	1.0	1.7	164	192	207	97
12. Poast + Oust	0.28 + 0.047	99	93	0	2.8	1.0	1.0	157	184	206	123
13. Poast + Oust	0.34 + 0.047	99	96	7	3.2	1.0	1.0	159	160	175	125
14. Check	---	0	0	0	1.0	1.0	1.0	180	203	259	192
LSD $_{0.05}$		4	11	32	1.4	0.6	0.6	37	45	60	77

[1]All Poast treatments included a crop oil at 0.5% v/v.

[2]Bermudagrass phytotoxicity was rated on a scale of 1 to 10 where 1 = no control and 10 = complete control.

Table 27. Effect of several herbicides on annual weed control and bermudagrass growth and development in 1990 in northcentral Oklahoma (study 4-PGR-55-90).

Treatment[1]	Rate (lb. a. i./A)	Annual Weed Control[2] 1 MAT	2 MAT	3 MAT	Bermuda Seedhead Suppression 1 MAT	2 MAT	Bermuda Phyto[3] 1 MAT	2 MAT	Canopy heights 1 MAT	2 MAT	3 MAT	Clip weights 3 MAT
					-------%--------				-------------mm-------------			grams
1. Vision	0.6	1.0	1.0	1.0	90	65	1.5	1.7	93	114	264	458
2. Vision + Oust	0.6 + 0.047	8.7	5.3	5.2	94	72	1.8	3.7	84	115	329	399
3. Vision	0.8	3.8	1.0	1.0	96	88	2.2	2.3	90	102	240	521
4. Vision + Oust	0.8 + 0.047	8.2	7.3	5.3	96	68	2.2	3.0	89	107	345	342
5. Vision	1.0	1.7	1.0	1.3	96	90	1.7	2.0	92	103	285	449
6. Vision + Oust	1.0 + 0.047	8.5	5.7	2.7	94	63	1.7	1.0	99	128	386	390
7. Poast	0.28	6.8	3.8	7.7	95	96	5.5	2.3	102	234	498	583
8. Poast + Oust	0.28 + 0.047	8.3	4.0	5.3	93	83	2.2	1.0	112	197	526	468
9. Poast	0.34	6.7	4.0	6.3	95	96	6.8	4.7	98	220	505	468
10. Poast + Oust	0.34 + 0.047	8.3	6.3	6.7	95	88	2.0	4.0	139	242	556	646
11. Poast	0.4	6.6	8.7	6.8	95	98	7.8	7.3	109	165	486	318
12. Poast + Oust	0.4 + 0.047	8.8	6.2	6.2	95	88	5.3	4.3	102	184	579	636
13. Check	---	1.0	3.3	3.3	0	0	1.0	1.0	238	344	608	925
$LSD_{0.05}$		4.4	5.2	4.0	4	21	2	3.8	40	87	155	249

[1]All Poast treatments included a crop oil at 0.5% v/v.
[2]Annual Weed control was scored using a scale of 1 to 10 where 1 = no control and 10 = complete control
[3]Bermudagrass phytotoxicity was rated on a scale of 1 to 10 where 1 = no control and 10 = complete control.

Table 28. Effect of several herbicides on annual weed control and bermudagrass growth and development in 1990 in northeast Oklahoma (study 8-PGR-26-90).

Treatment[1]	Rate (lb. a. i./A)	Annual Weed Control[2] 1 MAT	Annual Weed Control[2] 2 MAT	Annual Weed Control[2] 3 MAT	Bermuda Seedhead Suppression 1 MAT	Bermuda Seedhead Suppression 2 MAT	Bermuda Phyto[3] 1 MAT	Canopy heights 1 MAT	Canopy heights 2 MAT	Canopy heights 3 MAT	Clip weights 3 MAT
					---------%--------			---------------mm-------------			grams
1. Vision	0.6	1.0	1.0	1.0	50	32	1.0	104	109	147	1 2
2. Vision + Oust	0.6 + 0.047	4.0	4.7	1.0	50	12	1.5	101	95	149	54
3. Vision	0.8	1.3	1.0	3.8	50	25	1.2	93	99	141	62
4. Vision + Oust	0.8 + 0.047	7.5	8.0	7.0	33	20	1.5	90	91	129	45
5. Vision	1.0	1.0	1.0	1.0	55	12	1.3	86	100	133	89
6. Vision + Oust	1.0 + 0.047	1.7	3.7	4.0	58	13	2.0	89	89	150	54
7. Poast	0.28	1.3	1.7	2.7	78	60	1.7	120	124	159	80
8. Poast + Oust	0.28 + 0.047	6.3	6.3	6.5	67	25	1.8	110	122	146	65
9. Poast	0.34	2.7	3.3	3.3	98	52	2.3	123	119	173	77
10. Poast + Oust	0.34 + 0.047	7.7	7.5	6.3	98	45	3.7	103	97	149	60
11. Poast	0.40	6.0	4.5	3.7	95	67	2.8	115	122	150	86
12. Poast + Oust	0.40 + 0.047	7.7	6.5	7.0	91	60	3.3	99	105	138	57
13. Check	---	2.3	1.0	1.0	0	0	1.0	108	137	154	101
$LSD_{0.05}$		3.2	4.0	3.1	38	42	1.0	16	32	30	37

[1]All Poast treatments included a crop oil at 0.5% v/v.
[2]Annual Weed Control was scored using a 1 to 10 scale where 1 = no control and 10 = complete control.
[3]Bermudagrass phytotoxicity was rated on a scale of 1 to 10 where 1 = no control and 10 = complete control.

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7. Maintenance Program

An active vegetation management program integrates research, maintenance, and training efforts into a single program. One important transition between research and maintenance phases is the implementation of research findings into an operational phase. During the past five-year project, numerous large-scale demonstrations were conducted. Following are short descriptions of each demonstration.

7.1 DEMONSTRATION 1

In cooperation with Dow Che ical Company, a musk thistle control demonstration was initiated on 6-28-88. The demonstration was located on SH-28 one mile south of SH-60. A single treatment of XRM-3972 (Transline) at 0.5 lb. a.i./A combined with the spray adjuvant X-77 at 0.5% V/V was applied to fully d velope musk thistles using OSU's roadside sprayer equipped with an OC-40 nozzle. Evaluations at 1 MAT demonstrated 80% control of musk thistle and annual sunflower.

7.2 DEMONSTRATION 2

At the request of the ODOT Division One Division Engineer, a johnsongrass control demonstration was initiated on 5-21-88. The demonstration was located 1.5 miles east of the junction of SH-16 and SH-51 east of Wagoner. A single application of

Roundup at 0.75 lb. a.i./A (24 oz. prod./A) combined with Oust at 0.09 lb. a i./A (2 oz. prod./A) was applied using OSU's roadside sprayer equipped with an OC-40 nozzle. Evaluations showed 95% control of johnsongrass at 1 MAT but control dropped off to 60% by 2 MAT. An error in sprayer ground speed was later found to be responsible for the marginal johnsongrass control achieved late in the season.

7.3 DEMONSTRATION 3

In cooperation with American Cyanamid Company, a kudzu control demonstration was initiated on 8-8-89. The demonstration was located in Division 1 on SH-80, approximately 0.75 miles south of the east end of Fort Gibson Lake Dam. A single application of Arsenal in a 1% solution combined with X-77 at 0.5% V/V was applied with a handgun on a spray-to-wet basis. Evaluations showed 75% control of kudzu at 1 MAT but near complete control (99%) at 2 MAT ratings.

7.4 DEMONSTRATION 4

After three years of field research, the implementation of a new bermudagrass encroachment control treatment was initiated during June 1989. A total of seven ODOT Divisions participated. Arsenal at 1.0 lb a.i./A (4 pts. p od./A) was applied to actively growing bermudagrass growing in or on asphalt or concrete roadside shoulders. Treatments were applied using OSU's roadside sprayer equipped with a single flood-jet nozzle tip. Locations of the seven demonstrations are summarized in Table 29.

As the observations indicate (Table 30), excellent control of bermudagrass encroachment was observed in each of the seven monstrations. Arsenal has typically demonstrated a delay of approximately 4 to 6 weeks before phytotoxic symptoms occur on the target species. No lateral off-target movement was observed from the Arsenal treatments at any of the seven demonstrations.

7.5 1990 ODOT ROADSIDE RESEARCH BUS-TOUR

On 27 June 1990 a one-day roadside bus tour was conducted by OSU's Roadside Vegetation Management Program to demonstrate various vegetation management techniques to ODOT personnel. Demonstra ons included treatments for johnsongrass control, silver bluestem control, bermudagrass encroachment control and bermudagrass plant growth regulation. All treatments were applied using OSU's roadside sprayer. Products, rates of application, and dates of application of each of the four demonstration areas are summarized in Table 31. The tour was attended by approximately 70 people, two-thirds of which were ODOT personnel with the remainder being either OSU personnel or industry representatives. The bus tour also included a demonstration of small plot research techniques, research equipment, and a tour of research facilities. OSU publication E-896, Roadside Research Summary, was produced for the tour and distributed to attendees. The primary intent of the tour was to provide many of the new ODOT maintenance personnel with an opportunity to observe demonstrations of OSU's suggested practices for roadside weed control.

7.6 DEMONSTRATION 6

In cooperation with ODOT and ISK-BIOTECH Corporation, johnsongrass control demonstrations were conducted in Divisions 4 and 8 during the 1991 summer. Research conducted at OSU demonstrated that the ISK-BIOTECH product Frigate, when added to reduced rates of Roundup/Oust tank mixes, could maintain significant season-long control of johnsongrass and silver bluestem. Treatments were applied using ODOT personnel and spray equipment on 6-6-91 and 6-10-91, in Divisions 8 and 4, respectively. The Division 4 treatment consisted of Roundup at 0.38 lb. a.i./A (12 oz. prod./A) + Oust at 0.047 lb. a.i./A (1 oz. prod./A)+ Friga e at 0.5% V/V and was located on the west side of SH-77, south from the SH-11 junction. The Division 8 treatment consisted of Roundup at 0.35 lb. a.i./A (11 oz. prod./A) + Oust at 0.038 (0.8 oz. prod./A) + Frigate at 0.5% V/V and was located on the east side of US-169, from the junction of SH-20 in Collinsville to Oologah. Results from the two demonstrations have shown 90% or better control of johnsongrass and silver bluestem with an acceptable level of bermudagrass discoloration. Reducing Roundup rates below 0.75 lb. a.i./A (24 oz. prod./A) will usually resulted in johnsongrass suppression instead of control. The addition of Frigate increased the effects from Roundup allowing for lower use rates while maintaining an acceptable level of weed control.

7.7 DEMONSTRATION 7

In cooperation with ODOT and the Dow-Elanco Chemical Company, musk thistle control demonstrations were conducted in Divisions 4 and 8 during the spring of 1991. Demonstrations were conducted using ODOT personnel and spray equipment on 4-4-91 and 4-17-91, Divisions 4 and 8, respectively. Divisions used identical treatments of Transline at 0.25 lb. a.i./A (11 fl. oz. prod./A), plus a non-ionic surfactant at 0.5% V/V. The Division 8 demonstration was locat d on the south side of SH-20, west of Claremore. In Division 4, the demonstration areas were located on the south side of SH-11, west off SH-77 to Kaw City and spot treated in the center median of US-60, between I-35 and Ponca City. Results from the musk thistle demonstrations have shown that the 0.25 lb. a.i./A treatment of Transline was successful in controlling all thistles which were treated.

Table 29. Locations of bermudagrass encroachment control demonstrations in 1989.

Division	Location
1	Muskogee, on SH-165, beginning 0.7 mile south of Chandler Roa Exit, continuing northbound and treating the east outside shoulder for 0.8 mile.
3	Ada, on SH-99, beginning at the entrance to the Ada Airport, treating the inside shoulder next to the center median, northbound for 0.8 mile.
4	I-35, north of Perry, between Mile Markers 189-190, going southbound on the inside shoulder next to the center median for 0.7 mile.
5	Clinton, on I-40B, beginning at Coffman's Furniture Store, treating both inside shoulders next to the center median (northbound and southbound) to one-half block south of Jct. SH-73 west.
6	Southeast of Woodward on SH-34, starting 0.3 mile south of Jct. US-270, treating both sides of mainline for approximately 0.4 mile.
7	Lawton, on SH-7, 0.1 mile east of Jct. I-44, treating both inside shoulders (westbound and eastbound) for approximately 0.4 mile east.
8	US-64, 0.3 mile northwest of Jct. SH-151, going northwest and treating the inside shoulder next to the center median for approximately 0.8 mile.

Table 30. **Results from the demonstrations with Arsenal for bermudagrass encroachment control in 1989.**

		Percent Brownout[1]			Percent Control[2]		
Division	Date Treated	1 MAT	2 MAT	3 MAT	1 MAT	2 MAT	3 MAT
1	7-07-89	95	100	100	90	99	99
3	7-10-89	95	100	100	90	99	100
4	7-18-89	85	100	--	75	99	--
5	7-12-89	80	99	--	75	99	--
6	7-17-89	95	100	--	90	99	--
7	7-12-89	85	98	--	80	95	--
8	7-11-89	90	99	--	80	98	--

[1]Percent Brownout, where 0 = no effect and 100 = complete yellowing or brownout.
[2]Percent Control, where 0 = no control and 100 = complete control.

Table 31. **Summary of 1990 Bus-Tour Demonstration Areas.**

Treatment		Rate (lb. a.i./A)	Rate (prod./A.)
Johnsongrass Control. (Treated on 5-17-90)			
1.	Roundup + Oust + Frigate	0.5 + 0.047 + 0.5% v/v	1 pint + 1 oz. + 0.5% v/v
2.	Roundup + Oust	0.6 + 0.047	1.25 pint + 1 oz.
3.	Roundup + Oust	0.75 + 0.09	1.5 pint + 2 oz.
Silver Bluestem Control. (Treated on 5-31-90)			
1.	Roundup	1.0	2 pint
2.	Roundup + Oust	0.75 + 0.09	1.5 pint + 2 oz.
3.	Roundup + Oust + Frigate	0.6 + 0.047 + 0.5% v/v	1.0 pint + 1 oz. + 0.5% v/v
Bermudagrass Encroachment Control. (Treated on 5-17-90)			
1.	Arsenal	1.0	4 pint
2.	Arsenal + Oust	1.0 + 0.09	4 pint + 2 oz.
Bermudagrass Plant Growth Regulators. (Treated on 5-21-90)			
1.	Vision	0.8	3.2 pint
2.	Poast + Crop oil	0.28 + 0.5% v/v	1.5 pint + 0.5% v/v

8. TRAINING PROGRAM

8.1 Pesticide Applicator Certification

Applicator training for ODOT has changed dramatically in the past five years. In 1987, recertification through continuing education became an integral part of the pesticide applicator training program. In 1989/90, ODOT implemented an in-hou e equipment operators certification program in which the certified herbicide applicator was included. These two major changes resulted in herbicide app icator training programs becoming a vital part of ODOT's roadside vegetation management program.

Since 1986 the two-phase herbicide applicator training program has increased in popularity and attendance. The initial phase of applicator training involves learning the basic principles and practices of herbicide use. A key to the success of the initial training of applicators was in the development of various study guides. The two study guides were developed in 1986 and have been modified numerous times. Initial training involves two days of classes during which the study guides are covered thoroughly. The primary advantage of the study guides is that it gives the employee the opportunity to give his/her full attention to the lecturer without having to spend the majority of his/her time taking notes. It also gives the employee an excellent source of information to study on his/her own time.

During the past five years, OSU has conducted 38 pesticide applicator certification schools to help prepare ODOT employees for their pesticide applicator certification exams (Table 32). During this five year period, the certification schools have continued to be an effective means of p oviding initial training. In the past two years, herbicide applicator certification schools have provided the training for ODOT employees requiring the herbicide sprayer portion of the new ODOT equipment operators certification program.

8.2 Continuing Education Pesticide Applicator Workshops

The second phase of applicator training involves continual education of certified applicators. A con inuing education workshop offered to pesticide applicators on a yearly basis has two major benefits. First, the yearly program is designed to provide new and precise information to ODOT applicators; secondly, certified applicators who attend the yearly workshop receive continuing education credits toward recertification. In 1988, at the request of the Oklahoma Department of Transportation, the Roadside Vegetation Management Manual, publication number E-885 was produced. The manual covered the major topics of concern for roadside managers with emphasis on plant identification and equipment calibration. The manual was designed to be specific for ODOT employee needs and was to serve as their basic reference manual. In 1989 another publication was produced to supplement the information covered in the manual. "Suggested Herbicides for Roadside Weed Problems", publication number CR-6424, was produced to give applicators specific information about herbicides, rates, carrier rates, timing of applica ion, and important comments. Both publications were distributed and discussed in detail during the 1988 and 1989 continuing education workshops. Since the workshop's inception in 1987, OSU has conducted 32 approved continuing education workshops for certified ODOT applicators, with attendance growing by an average of 26% per year (Table 33).

Table 32. Summary of ODOT Pesticide Applicator Certification Schools during 1986-1991.

ODOT Division Location and Number		Number of New Certified Applicators*					
		1986/87	1987/88	1988/89	1990	1991	Total
Muskogee	1	13	12	14	11	27	77
Antlers	2	0	9	18	13	8	48
Ada	3	31	19	14	21	23	108
Perry	4	13	17	20	23	12	85
Clinton	5	--	14	16	24	2	56
Buffalo	6	8	3	9	21	19	60
Duncan	7	4	17	17	21	20	79
Tulsa	8	3	10	23	25	17	78
Total		72	101	131	159	128	591

*Certified applicators have passed both the general and right-of-way certification exams successfully.

Table 33. Summary of ODOT Continuing Education Pesticide Applicator Workshops during 1987-1990.

ODOT Division Location and Number		Number of Certified Applicators Attending*				
		1987	1988	1989	1990	Total
Muskogee	1	29	40	48	62	179
Antlers	2	14	17	33	27	91
Ada	3	35	41	52	77	205
Perry	4	52	60	80	77	269
Clinton	5	44	46	61	72	223
Buffalo	6	24	17	34	38	113
Duncan	7	10	21	33	47	111
Tulsa	8	27	19	58	59	163
Total		235	261	399	459	1354

*Each certified applicator received continuing education credit towards automatic recertification.

APPENDIX A

Experiment: Preemergent Control of Annual Grasses and Broadleaf Weed Control Study (Experime 4-H-53-90).

Objective: To compare the efficacy of twenty-three herbicide treatments for the control of annual grasses and broadleaf weeds.

Date of Treatments: March 5, 1990.

Plot Size: 5 ft. by 10 ft.

Dates Scored: April 5, 1990, 1 month after treatment (MAT) and May 7, 1990, 2 MAT.

Methods of Scoring: Annual Grass Control, where 1 = no effect and 10 = complete control. Annual Broadleaf Weed Control, where 1 = no effect and 10 = complete control. Bermudagrass Phytotoxicity, where 1 = no effect and 10 = complete yellowing.

Discussion: The experiment is the first of several in a study to screen potential products for replacement(s) of the loss of the product, atrazine (Table 34).

For annual grass control at 1 MAT and 2 MAT the best treatments were: Aatrex (2 lbs. ai./A), Rifle (0.14 lb. ai./A), Lexone + Oust (0.19 lb. ai. + 0.024 lb. ai.), Oust + Pendimethalin (0.024 lb. ai./A + 0.5 lb. ai./A), Oust + Telar (0.024 lb. ai./A + 0.083 lb. ai./A), Oust + Escort (0.024 lb. ai./A + 0.104 lb. ai.), and Spike (1.0 lb. ai./A). For broadleaf weed control at 1 MAT and 2 MAT the best treatments were: Aatrex (2 lbs. ai./A), Rifle (0.14 lb. ai./A), Lexone + Telar (0.19 lb. ai. + 0.083 lb. ai./A), Lexone + Oust (0.19 lb. ai./A + 0.024 lb. ai./A), Oust + Telar (0.024 lb. ai./A + 0.083 lb. ai./A), Oust + Escort (0.024 lb. ai./A + 0.104 lb. ai./A), and Pendimethalin + Escort (0.5 lb. ai./A + 0.104 lb. ai./A).

Only one treatment (Oust + Telar) had any phytotoxic effect on bermudagrass at 1 MAT. However, by 2 MAT phytotoxicity had diminished.

The data from this preliminary experiment indicates that the best potential treatments for both annual grass and broadleaf weed control are: Rifle, Lexone + Oust, Oust + Telar, and Oust + Escort.

Table 34. Preemergent Study: (Experiment 4-H-53-90), annual grass and broadleaf weed control of 10 herbicide treatments.

Treatments	Rate(s) lb. ai./A	Annual Grass Control		Broadleaf Control	
		1 MAT	2 MAT	1 MAT	2 MAT
Aatrex	2.0	8.1	7.4	7.6	5.5
Rifle	0.14	7.7	8.3	8.9	9.6
Spike	1.0	7.2	9.3	1.7	1.0
Lexone + Telar	0.19 + 0.083	6.8	5.3	7.6	8.3
Lexone + Oust	0.19 + 0.024	8.8	9.6	8.0	8.3
Oust + Pendimethalin	0.024 + 0.5	8.7	9.4	4.3	5.2
Oust + Telar	0.024 + 0.083	7.7	6.8	9.5	9.8
Oust + Escort	0.024 + 0.104	8.8	8.7	9.5	9.2
Pendimethalin + Telar	0.5 + 0.083	3.7	1.7	9.3	9.8
Pendimethalin + Escort	0.5 + 0.104	5.3	3.3	9.0	9.7
$LSD_{(0.05)}$		3.5	2.7	3.5	2.9
CV%		41	37	45	40

Note: The table includes the 10 best treatments of the 23 tested.

APPENDIX B

Experiment: Preemergent Herbicide Study on Common Bermudagrass (Experiment 5-H-1-88).

Date of Treatments: March 11, 1988.

Plot Size: 5 ft. by 10 ft.

Dates Scored: April 12, 1988; May 13, 1988; June 14, 1988; and July 14, 1988.

Methods of Scoring: Annual grass control where 1 = no control and 10 = complete control.

Discussion: An experiment was initiated in Western Oklahoma (5-H-1-88, a duplicate study of experiment 4-H-42-88) to evaluate several preemergence herbicides for the control of winter annual grasses. Statistical analyses indicated that the following treatments provided the best control of winter annual grasses: Aatrex, both rates of Oust, Bicep, and Princep, alone and in combination with Cotoran and Premier (Table 35). Treatments of Karmex, Prodiamine, Stomp, both rates of EL-107, and Dual, alone or in combination with Princep, Cotoran, and Premier, failed to provide an acceptable level of annual weed control.

Table 35. Annual grass control for 19 herbicide treatments (Experiment 5-H-1-88).

Treatments	Rate(s) lb. ai./A	Annual Grass Control[1] 4-12-88	5-13-88	6-14-88	7-14-88
Check	---	1.0	1.0	1.0	1.0
Aatrex 4 L	2.0	9.8	9.9.	9.9	9.9
Karmex 80 WP	2.4	9.4	8.9	7.5	7.5
Prodiamine 65% DG	0.25	6.2	4.0	3.7	2.7
Prodiamine 65% DG	0.5	3.0	2.0	1.7	3.0
Prodiamine 65% DG	0.75	5.8	3.0	3.0	3.0
Prodiamine 65% DG	1.0	5.2	3.3	2.0	2.7
Stomp 4 EC	3.0	6.0	4.3	2.7	3.0
Oust 75% DG	0.024	9.8	9.6	9.8	9.8
Oust 75% DG	0.047	9.9	9.9	9.9	9.9
Dual 8 E	1.0	6.3	5.5	3.7	3.0
Bicep 6 FL	2.0	9.5	9.8	9.8	9.6
Princep 4 L	1.0	8.5	9.6	9.3	9.0
Princep 4 L + Dual 8 E	1.0 1.0	9.1	9.4	8.2	8.1
Princep 4 L + Cotoran 4 L	1.0 1.0	9.6	9.7	9.4	9.4
Cotoran 4 L	1.0	6.6	6.9	5.6	6.0
Premier 1.25 EC	1.0	3.7	2.7	1.7	1.7
Princep 4 L + Premier 1.25 EC	1.0 1.0	9.5	9.7	9.5	9.4
EL-107 75% DF	0.5	8.0	7.5	4.7	5.0
EL-107 75% DF	1.0	5.5	3.0	2.0	3.3
$LSD_{(0.05)}$		3.5	3.1	2.9	3.2
CV%		29.8	28.2	30.7	33.1

[1]Ratings made for annual grass control include cheat and downy brome (Bromus spp.).

APPENDIX C

Experiment:	Preemergent Herbicide Study on Guymon Bermudagrass (Experiment 4-H-42-88).
Date of Treatment:	February 26, 1988.
Plot Size:	5 ft. by 10 ft.
Dates Scored:	April 7, 1988; May 25, 1988; July 29, 1988.
Methods of Scoring:	Annual Grass Control, where 1 = no effect and 10 = complete control. Annual Broadleaf Weed Control, where 1 = no control and 10 = complete control. Bermudagrass Phytotoxicity, where 1 = no effect and 10 = complete yellowing or brownout. Little barley plants present in plots on 25 May 1988 were count d.
Discussion:	Experiment 4-H-42-88 evaluated several preemergence herbicides for the control of annual grasses and broadleaf weeds in 'Guymon' bermudagrass. Treatments were applied February 26, 1988, to 5 ft. by 10 ft. plots using a carrier rate of 20 GPA. The experimental area was maintained as a low maintenance turf area throughout the growing season. One mowing was performed during mid-summer at a height of two inches. Fertilizer was applied once during early spring at a rate of one pound of nitrogen per 1000 sq. ft. The area was irrigated three times during mid-summer to keep the turf alive. Evaluations were made for annual grass control, bro dleaf weed control and bermudagrass phytotoxicity.

The superior treatments for annual grass control (Bromus spp.) 41 days after treatment (DAT) included Aatrex, both rates of Oust, Bicep and Princep (Table 36). The least amount of little barley at 89 DAT occurred in plots treated with Aatrex, Karmex and Dual. Prodiamine at 0.5, 0.75 and 1.0 lb. a.i./A and Stomp were the best treatments for crabgrass control when the last evaluation was made 154 DAT.

Broadleaf weeds (including henbit and chickweed) were best controlled by treatments of Aatrex, Karmex, Stomp, Bicep and the combination treatment of Princep and Dual for evaluations made 41 DAT. This same trend continued until the last evaluation was made 89 DAT, with the exc ption of Princep + Cotoran which also provided good broadleaf weed control.

Both Oust treatments exhibited significantly more bermudagrass phytotoxicity than the other treatments when evaluations were made 89 DAT. However, since that time the bermudagrass has outgrown the phytotoxic effects.

Table 36. Annual grass and broadleaf weed control for 19 herbicide treatments (Experiment 4-H-42-88).

	Rate(s)	Annual Grass Control			Annual Broadleaf Control		Bermudagrass Phytotoxicity
Treatments	lb. ai./A	4-7-88[1]	5-25-88[2]	7-29-88[3]	4-7-88[4]	5-25-88	5-25-88
Check	---	1.0	13.7	1.0	1.0	1.0	1.0
Aatrex 4 L	2.0	9.9	6.3	3.0	9.9	9.9	1.0
Karmex 80 WP	2.4	8.3	8.7	4.7	9.2	9.4	1.0
Prodiamine 65% DG	0.25	4.7	29.7	8.3	5.8	6.3	1.0
Prodiamine 65% DG	0.5	5.8	25.3	9.4	7.8	7.8	1.0
Prodiamine 65% DG	0.75	6.3	20.3	9.6	3.7	4.3	1.0
Prodiamine 65% DG	1.0	5.3	27.0	9.5	5.3	5.3	1.0
Stomp 4 EC	3.0	8.5	21.7	9.5	9.2	9.0	1.0
Oust 75% DG	0.024	9.7	12.7	3.3	3.7	7.7	2.7
Oust 75% DG	0.047	9.9	12.3	3.3	6.3	8.3	2.0
Dual 8 E	1.0	8.0	8.3	3.3	6.0	6.5	1.0
Bicep 6 FL	2.0	9.1	10.7	4.5	9.3	9.0	1.0
Princep 4 L	1.0	9.7	12.3	6.0	8.4	7.8	1.0
Princep 4 L + Dual 8 E	1.0 1.0	8.8	25.7	6.3	9.3	8.8	1.0
Princep 4 L + Cotoran 4 L	1.0 1.0	7.0	17.3	3.0	8.3	9.0	1.0
Cotoran 4 L	1.0	5.7	16.7	6.3	4.3	6.5	1.0
Premier 1.25 EC	1.0	4.3	26.3	4.7	6.7	6.7	1.0
Princep 4 L + Premier 1.25 EC	1.0 1.0	7.8	13.3	5.3	8.3	8.2	1.0
EL-107 75% DF	0.5	5.0	20.3	4.3	5.3	7.0	1.0
EL-107 75% DF	1.0	8.3	16.3	6.6	3.0	4.0	1.0
$LSD_{(0.05)}$		3.2	15.6	3.9	3.7	3.4	0.2
CV%		27.2	54.4	41.3	33.6	28.6	11.4

[1]Ratings made 4-7-88 for annual grass contr l include Japanese brome.
[2]Ratings made 5-25-88 for annual grass contr l included number of little barley plants present per plot.
[3]Ratings made 7-29-88 for annual grass c ntrol included crabgrass, foxtail and bermudagrass.
[4]Ratings made 4-7-88 and 5-25-88 for annual broadleaf control includ d henbit and chickweed.

APPENDIX D

Experiment: Preemergent Herbicide Study on Bison Buffalograss (Experiment 4-H-43-88).

Date of Treatments: February 26, 1988.

Plot Size: 5 ft. by 10 ft.

Dates Scored: April 7, 1988; May 25, 1988; July 29, 1988.

Methods of Scoring: Annual Grass Control, where 1 = no control and 10 = complete control. Annual Broadleaf Weed Control, where 1 = no control and 10 = complete control. Bermudagrass Phytotoxicity, where 1 = no effect and 10 = complete yellowing or brownout. On 25 May 1988, the number of little berley plants present per plot were assessed.

Discussion: The objective of Experiment 4-H-43-88 was to evaluate several preemergence herbicides for the control of annual grasses and broadleaf weeds in a sward of Bison Buffalograss.

Buffalograss is a perennial grass native to Oklahoma and is found primarily in the northwestern part of the state. In the past, very little information has been available concerning the use of preemergent herbicides for annual weed control in buffalograss.

Treatments were applied on February 26, 1988, to 5 ft. by 10 ft. plots using a carrier rate of 20 GPA. The experimental area was maintained as a low maintenance turf throughout the growing season. One application of fertilizer was made during the early spring at a rate of one pound of nitrogen per 1000 sq. ft. The area was irrigated three times during mid-summer to keep the turf alive and mowed once at a height of four inches. Annual grassy wee control was evaluated 41 DAT, 89 DAT, and 154 DAT. Annual broadleaf weed control was evaluated 41 and 89 DAT and buffalograss phytotoxicity was evaluated 89 DAT.

Treatments providing the best annual grass control (Bromus spp.) 41 DAT were Aatrex, the high and low rates of Oust, Princep and EL-107 (Table 37). The best control of little barley 89 DAT were those plots treated with Aatrex, the high rate of

Oust, the combination treatments of Princep + Dual, Princep + Cotoran and Cotoran alone. When evaluations were made for crabgrass control 154 DAT, the best treatmen s were prodiamine at 1.0 lb. a.i./A, Cotoran and Premier.

All treatments were providing excellent control of broadleaf weeds (henbit and chickweed) when evaluations were made 41 DAT. Ratings made 89 DAT indicated the only treatments which were not providing accept ble broadleaf weed control were the wo combination treatments of Princep + Dual, Princep + Cotoran, Cotoran alone, and Premier.

Buffalograss phytotoxicity was observed 89 DAT in only those plots treated with Oust. Oust at 0.047 lb. a.i./A (1 oz. product/A) was significantly more phytotoxic than any of the other treatments. However, the buffalograss later recovered and all phytotoxicity diminished.

Table 37. Annual grass and broadleaf weed control in buffalograss for 19 herbicide treatments (Experiment 4-H-43-88).

Buffalograss Phytotoxicity	Rate(s)	Annual Grass Control			Annual Broadleaf Control		
Treatments	lb. ai./A	4-7-88[1]	5-25-88[2]	7-29-88[3]	4-7-88[4]	5-25-88	5258
Check	---	1.0	33.3	1.0	1.0	1.0	10
Aatrex 4 L	2.0	9.8	5.0	2.3	9.9	9.8	10
Karmex 80 WP	2.4	9.1	13.0	5.3	9.6	9.5	10
Prodiamine 65% DG	0.25	9.3	15.0	7.8	9.6	9.2	10
Prodiamine 65% DG	0.5	9.0	19.3	8.8	9.6	9.3	10
Prodiamine 65% DG	0.75	9.6	9.3	8.9	9.8	9.3	10
Prodiamine 65% DG	1.0	8.5	11.7	9.3	9.8	9.3	10
Stomp 4 EC	3.0	9.0	20.0	8.8	9.5	9.3	10
Oust 75% DG	0.024	9.6	24.0	2.3	9.6	9.3	13
Oust 75% DG	0.047	9.9	9.0	4.0	9.9	9.6	23
Dual 8 E	1.0	8.1	16.3	4.3	9.6	9.3	10
Bicep 6 FL	2.0	9.3	10.0	7.7	9.7	9.3	10
Princep 4 L	1.0	9.6	10.3	8.9	9.6	9.3	10
Princep 4 L + Dual 8 E	1.0 1.0	8.3	8.0	7.5	9.0	8.8	10
Princep 4 L + Cotoran 4 L	1.0 1.0	9.3	8.3	8.3	9.3	8.9	10
Cotoran 4 L	1.0	9.4	5.7	9.2	9.2	8.9	10
Premier 1.25 EC	1.0	8.5	11.3	9.0	9.4	8.8	10
Princep 4 L + Premier 1.25 EC	1.0 1.0	8.5	9.3	6.8	9.3	9.0	10
EL-107 75% DF	0.5	9.8	10.7	8.3	9.9	9.3	10
EL-107 75% DF	1.0	8.6	13.0	8.8	9.7	9.3	10
$LSD_{(0.05)}$		1.6	16.4	3.3	0.7	0.7	05
CV%		10.8	75.0	28.0	4.5	4.4	272

[1]Ratings made 4-7-88 for annual grass control include japanese brome.
[2]Ratings made 5-25-88 for annual grass control included number of little barley plants present per plot.
[3]Ratings made 7-29-88 for annual grass control included crabgrass.
[4]Ratings made 4-7-88 and 5-25-88 for annual broadleaf control included henbit and chickweed.

APPENDIX E

Experiment: Pine Control Study (Experiment 2-H-3-86).

Dates of Treatments: October 16, 1986 (trmts. 6-12); June 10, 1987 (trmts. 1-5).

Plot Size: 20 ft. by 50 ft.

Dates Scored: June 17, 1987; July 15, 1987, August 18, 1987, September 17, 1987.

Method of Scoring: Percent pine control where 100 = complete control and 0 = no control.

Discussion: Eleven herbicide treatments were evaluated for selective pine control in southeastern Oklahoma. When evaluated on 17 June 1987, Tordon 101 Mixture and Roundup applied as a 2 percent solution were exhibiting the best pine control (Table 38). The Tordon 101 mixture and the combination treatment of Tordon K plus Garlon 4 were exhibiting the best pine control when ratings were made on 7 July 1987. August and September 1987 evaluations indicated that the following treatments provided the most acceptable pine control: Garlon 4 + Tordon K, Tordon 101 Mixture, and both rates of Graslan 40% P (3 and 4 lb. a.i./A). Pine control with Krenite S was 78% in September 1987. The remaining treatments of Rodeo, Roundup, and Banvel failed to provide acceptable pine control in this study.

Table 38. Pine control from 11 herbicide treatments (Experiment 2-H-3-86).

Treatments	Rate(s) lb. ai./A	Percent Pine Control			
		6-17-87	7-15-87	8-18-87	9-17-87
1. Garlon 4 + Tordon K	4.0 + 2.0	0 c*	88 a	93 a	92 a
2. Tordon 101 Mixture	7.62	70 a	93 a	93 a	93 a
3. Graslan 40% P	3.0	0 c	31 cd	64 ab	85 ab
4. Graslan 40% P	4.0	0 c	43 bc	93 a	95 a
5. Krenite S + Crop Oil	12.0 + 0.5% v/v	61 a	64 ab	67 ab	78 ab
6. Rodeo + X-77	0.75% soln. + 0.5% soln.	51 ab	48 bc	58 b	78 ab
7. Rodeo + X-77	1.5% soln. + 0.5% soln.	50 ab	72 ab	63 b	66 b
8. Banvel	2.0	6 c	2 d	1 c	4 c
9. Banvel	4.0	23 bc	23 cd	13 c	10 c
10. Roundup	1 % soln.	13 c	6 d	6 c	6 c
11. Roundup	2 % soln.	76 a	67 ab	66 ab	66 b
12. Check	------	0 c	0 d	0 c	0 c
$LSD_{(0.05)}$		33	31	30	26
CV%		67	41	34	27

*Means followed by the same letter are not significantly different as indicated by $LSD_{(0.05)}$.

APPENDIX F

Experiment: Brush Control Study (Experiment 2-H-4-87).

Date of Treatments: June 16, 1987 (2-5; 7-8).

Plot Size: 20 feet by 100 feet.

Date Scored: July 15, 1987.

Method of Scoring: Percent brush control where 100 = complete control and 0 = no control.

Discussion: This experiment was evaluated one month after the herbicide treatments were applied. Unfortunately, a prisoner crew clearing the roadside right-of-way for ODOT, cut down all the brush in the experimental area. The area was also treated with MSMA by ODOT. This burned back the brush as indicated by the scores given for the untreated Krenite S plots and the check plots.·

Although these problems occurred, some trends are still evident as to the herbicide activity of some of the treatments affecting the brush. Tordon 101 Mixture exhibited the best brush control when evaluated one month after herbicide treatments were applied (Table 39). This treatment was followed closely by both ates of Arsenal, and the higher rate of Escort at 0.094 lb. ai./A. One interesting observation was that the grass understory in all plots treated with either rate of Arsenal were severely burned (total br wnout and possibly killed). This may indicate that Arsenal is unaccep able when applied as a broadcast treatment for brush control along roadsides.

Table 39. Brush control from 7 herbicide treatments (Experiment 2-H-4-87).

Treatments	Rate(s) lb. ai./A	Brush Control (%) 7-15-87
Check	----	18
Escort	0.063	30
Escort	0.094	53
Tordon 101 Mixture	7.62	87
Graslan 40% P	3.0	47
Krenite S + Crop Oil	12.0 + 0.5% v/v	15
Arsenal	0.75	67
Arsenal	1.0	73
$LSD_{(0.05)}$		23
CV%		27

APPENDIX G

<u>Experiment</u>: Brush Control Study (Experiment 8-H-20-88).

<u>Objective</u>: To evaluate the efficacy of six herbicide treatments for roadside brush control.

<u>Dates of Treatments</u>: June 21, 1988 (treatments 2-4 and 6-8).

<u>Plot Size</u>: 20 ft. by 100 ft.

<u>Dates Scored</u>: June 20, 1989; July 19, 1989; August 21, 1989; September 19, 1989.

<u>Method of Scoring</u>: Percent brush control, where 0 = no control and 100 = complete control.

<u>Discussion</u>: Garlon 4 + Tordon K and Garlon 3A + Tordon K were the only treatments to provide acceptable brush control (Table 40). The herbicides Escort, Arsenal and Krenite failed to provide acceptable control of brush throughout the duration of this experiment.

Table 40. Brush control from 7 herbicide treatments (Experiment 8-H-20-88).

Treatments	Rate(s) lb. ai./A	Percent Brush Control[1] 6-20-89	7-19-89	8-21-89	9-19-89
1. Escort + Surfactant WK	0.063 + 0.25% v/v	47	42	32	15
2. Escort + Surfactant WK	0.094 + 0.25% v/v	60	55	45	37
3. Garlon 4 + Tordon K	4.0 + 2.0	90	90	90	88
4. Arsenal + X-77	0.75 + 0.5% v/v	50	43	35	30
5. Arsenal + X-77	1.0 + 0.5% v/v	70	67	67	52
6. Garlon 3A + Tordon K	3.0 + 2.0	90	90	87	73
$LSD_{(0.05)}$		35	33	34	37
CV%		38	37	43	57

[1]Percent Brush Control, where 0 = no control and 100 = complete control.

APPENDIX H

Experiment:	Brush Control Study (Experiment 3-H-2-87).
Dates of Treatments:	June 17, 1987 (trmts. 2-5; 7-8); September 23, 1987 (trmt. 6).
Plot Size:	20 ft. by 100 ft.
Dates Scored:	July 16, 1987; August 18, 1987; September 17, 1987.
Method of Scoring:	Percent brush control where 100 = complete control and 0 = no control.
Discussion:	One month after herbicide treatments were applied, Tordon 101 Mixture was exhibiting significantly better brush control than all other treatments except Escort at 0.094 lb. ai. per acre (Table 41). This trend continued for both August and September ratings. Graslan and both rates of Arsenal continued to have increased scores for brush control as the 1987 growing season progressed. No scores were noted for the treatment of Krenite S as it was applied after the last evaluation was made during 1987.

Evaluations made during 1988 indicated the better brush control treatments were Tordon 101 Mixture, Graslan and the higher rate of Arsenal. The remainder of the treatments tested in this experiment did not provide an acceptable level of brush control.

Table 41. Brush control from 7 herbicide treatments (Experiment 3-H-2-87).

Treatments	Rate(s) lb. ai./A	Brush Control (%)						
		7-16-87	8-18-87	9-17-87	6-16-88	7-18-88	8-17-88	9-23-88
Check	----	0.0 e*	0.0 d	0.0 d	0.0	0.0	0.0	0.0
Escort + Surfactant WK	0.063 + 0.5% v/v	46.7 bc	30.0 c	35.0 c	16.7	20.0	16.7	15.0
Escort + Surfactant WK	0.094 + 0.5% v/v	70.0 ab	58.3 b	56.7 bc	50.0	45.0	35.0	28.3
Tordon 101 Mixture	7.62	92.7 a	96.0 a	98.0 a	93.3	90.0	83.3	75.0
Graslan 40% P	3.0	11.7 de	33.3 c	50.0 bc	86.7	88.3	85.0	78.3
Krenite S + Crop Oil	12.0 + 0.5% v/v	---	---	---	63.3	53.3	51.7	51.7
Arsenal + X-77	0.75 + 0.5% v/v	21.7 cde	25.0 c	48.3 bc	75.0	63.3	55.0	46.7
Arsenal + X-77	1.0 + 0.5% v/v	40.0 bcd	41.7 bc	65.0 b	91.7	81.7	73.3	66.7
$LSD_{(0.05)}$		30.2	24.3	23.7	31.3	30.7	29.6	28.0
CV%		48.9	39.0	30.7	30.0	31.8	33.8	35.3

*Means followed by the same letter are not significantly different.

APPENDIX I

Experiment: Tall Fescue PGR Study (Experiment 8-PGR-12-87)

Date of Treatments: April 16, 1987.

Plot Size: 20 ft. by 300 ft.

Dates Scored: May 21, 1987, June 26, 1987 and July 28, 1987.

Methods of Scoring: Bermudagrass Phytotoxicity where 1 = no effect and 10 = complete yellowing. Tall Fescue Phytotoxicity where 1 = no effect and 10 = complete yellowing. Tall Fescue Seedhead Suppression where 0 = no suppression and 100 = co plete suppression.

Discussion: Seven plant growth regulator (PGR) treatments were applied on a predominantly bermudagrass roadside area intermixed with tall fescue to determine the phytotoxic effects on both grass species, and the ability to supp ess tall fescue seedheads. Phytotoxic effects were not observed on bermudagrass for ratings made one and two months after PGR treatments were applied. Significant tall fescue phytotoxicity was observed for all three scoring dates (Table 42). Embark displayed the most phytotoxicity on tall fescue one month after treatments were applied, followed by the higher rate of Manage (0.24 lb. ai.), Manage + Oust at 0.18 lb. ai. + 0.024 lb. ai., and EL-500. Tall fescue phytotox ci y was still evident, but considerably reduced, for all treatments during June and July. Tall fescue seedhead formation was significantly suppressed by all PGR treatments except the lowest rate of Manage (0.14 lb. ai./A) for all three scoring dates. Embark exhibited the best tall fescue seedhead suppression throughout the duration of this experiment. However, none of the PGR treatments provided an accep able level of tall fescue seedhead suppr ssion.

Table 42. **Plant growth regulator effects on tall fescue from several chemical treatments (Experiment 8-PGR-12-87).**

	Rate(s)	Phytotoxicity			Seedhead Suppression		
Treatments	lb. ai./A	5-21-87	6-26-87	7-28-87	5-21-87	6-26-87	7-28-87
Manage	0.14	2.3 bc*	1.3 cd	1.7 ab	23.3 bc	6.7 cd	8.3 cd
Manage	0.19	3.3 bc	1.7 bc	1.7 ab	30.0 ab	23.3 bc	23.3 bc
Manage	0.24	4.0 ab	2.0 ab	2.0 a	33.3 ab	26.6 bc	26.7 bc
Manage + Oust	0.18 + 0.012	3.3 bc	2.3 a	2.3 a	46.7 ab	36.7 ab	36.7 ab
Manage + Oust	0.18 + 0.024	3.7 b	2.3 a	2.3 a	43.3 ab	36.7 ab	38.3 ab
EL-500	1.0	3.7 b	2.0 ab	2.0 a	41.7 ab	33.3 b	30.0 b
Embark	0.38	6.3 a	2.0 ab	2.0 a	56.7 a	58.3 a	55.0 a
Check	---	1.0 c	1.0 d	1.0 b	0.0 c	0.0 d	0.0 d
$LSD_{(0.05)}$		2.6	0.6	0.8	27.3	22.0	21.5
CV%		42.6	18.3	23.3	45.3	45.3	45.1

*Means followed by the same letter are not significantly different.

APPENDIX J

<u>Experiment</u>: Musk Thistle Control Study (Experiment 8-H-25-90).

<u>Objective</u>: To compare the efficacy of ten herbicide treatments for the control of musk thistle.

<u>Date of Treatments</u>: March 22, 1990.

<u>Plot Size</u>: 5 ft. by 10 ft.

<u>Dates Scored</u>: April 23, 1990, 1 month after treatment (MAT); May 22, 1990, 2 MAT; and June 25, 1990, 3 MAT.

<u>Method of Scoring</u>: Percent Thistle Control, where 0 = no control and 100 = complete control.

<u>Discussion</u>: Musk thistle is a biennial, broadleaf plant which is a major roadside weed problem in northeastern Oklahoma and poses a hreat to roadsides across the entire state. Ten herbicide treatments were applied in March 1990 to plots containing musk thistle plants which ranged in stages of growth from seedling (2 leaf stage) plants to t e rosette (vegetative) stage.

At 1 MAT, the best treatments for musk thistle control were Tordon K and all three treatments of Transline (Table 43). By 2 MAT, these same four treatments wer providing 100% control of musk thistle, followed closely by Banvel providing 95.3% control. All herbicide treatments except Escort and Telar provided 90% or greater musk thistle control at 3 MAT. Escort and Telar failed to exhibit acceptable control of musk thistle throughout the experiment.

Table 43. Musk Thistle Control Study (Experiment 8-H-25-90).

Treatments*	Rate lb. ai./A	Percent Musk Thistle Control 1 MAT	2 MAT	3 MAT
Check	----	0	0	0
Escort	0.104	23.3	49.7	59.3
Telar	0.083	36.7	36.7	36.7
Banvel	1.0	58.3	95.3	99.0
Transline**	0.125	83.7	100	100
Transline	0.25	82.7	100	100
Transline	0.50	91.3	100	100
Tordon K	0.5	85.7	100	100
Garlon 4	1.0	57.3	79.7	98.7
Garlon 3A	1.0	55.7	82.0	90.0
$LSD_{0.05}$		25.6	22.2	20.0
CV%		26	17	15

*All herbicide treatments included surfactant X-77 added at 0.25% v/v.
**Transline is the trade name for clopyralid alone.

APPENDIX K

Experiment: Musk Thistle Contr 1 Study (Experiment 8-H-21-89).

Objective: To compare the efficacy of twelve herbicide treatments (4 products) for the control of musk thistle.

Date of Treatments: May 11, 1989.

Plot Size: 5 ft. by 10 ft.

Dates Scored: June 9, 1989 (1 MAT); July 11, 1989 (2 MAT).

Methods of Scoring: Bermudagrass Phytotoxicity, where 1 = no effect and 10 = complete yellowing or brownout. Percent Thistle Control, where 0 = no control and 100 = complete control.

Discussion: Musk thistle is a biennial, broadleaf weed which is becoming a major roadside weed problem across the entire state of Oklahoma. Twelve herbicide treatments (4 different herbicides) were applied in May 1989 to musk thistle pla ts which ranged in stages of growth from seedlings (2 leaf stage) to plants which were bolting (sending up flower stalks).

One month after treatment (1 MAT), must thistle control ranged from 54% with Escort at 0.104 lb. ai./A to 90% control with Clopyralid + 2, 4-D at 0.51 + 2.5 lb. ai. per acre (Table 44). The two higher rates of Clopyralid + 2, 4-D (0.38 + 2.0 and 0.51 + 2.5 lb. ai./A) were significantly better than the two lower rates (0.19 and 0.26 lb. ai./A) for musk thistle control 1 MAT. However, significant differences among these four treatments were not evident at 2 MAT. No significant differences were det cted among the three Banvel treatments for both 1 and 2 MAT. The effects of the Banvel and Escort treatments were slow during the first 4 to 6 weeks after treatment, but by 2 MAT, musk thistle control was acceptable. The 2 MAT evaluation indicated no significant differences among any of the herbicides tested and all treatments were providing acceptable control of mu k thistle.

Bermudagrass phy otoxicity was not evident from any herbicide treatment throughout the durat on of this experiment.

Table 44. Musk thistle control for 12 herbicide treatments (Experiment 8-H-21-89).

Treatment [1]	Rate(s) lb. ai./A	Percent Thistle Control[2]		Bermuda Phytotoxicity[3]	
		1 MAT	2 MAT	1 MAT	2 MAT
Check	----	0	0	1.0	1.0
Clopyralid + 2, 4-D	0.19 + 1.0	75.7	98.7	1.0	1.0
Clopyralid + 2, 4-D	0.26 + 1.5	70.3	94.7	1.0	1.0
Clopyralid + 2, 4-D	0.38 + 2.0	87.0	99.3	1.0	1.0
Clopyralid + 2, 4-D	0.51 + 2.5	90.0	99.0	1.0	1.0
Banvel	1.0	66.3	91.7	1.0	1.0
Banvel	2.0	79.7	92.0	1.0	1.0
Banvel	4.0	73.7	95.7	1.0	1.0
Escort	0.104	54.0	96.7	1.0	1.0
$LSD_{0.05}$		13.6	4.9	N/A	N/A
CV%		10.6	3.2	N/A	N/A

[1]All treatments included X-77 at 0.25% v/v

[2]Percent Thistle Control, where 0 = no control and 100 = complete control.

[3]Bermuda Phytotoxicity, where 1 = no effect and 10 = complete yellowing or brownout.

APPENDIX L

Experiment:	Musk Thistle Control Study, Preliminary Experiment (Non-replicated).
Objective:	To compare the efficacy of ten herbicide treatments for the control of musk thistle.
Date of Treatment:	April 23, 1990.
Plot Size:	5 ft. by 30 ft.
Dates Scored:	May 22, 1990, 1 month after treatment (MAT) and June 25, 1990, 2 MAT.
Method of Scoring:	Percent Thistle Control, where 0 = no control and 100 = complete control.
Discussion:	At 1 MAT, the two higher rates of Transline provided 100% musk thistle control, followed by the combination treatments of Transline + XRM-5114 (0.225 + 0.25 oz.), and all Transline + XRM-5237 treatments. When the last evaluation was made at 2 MAT, all herbicide treatments were provid ng 100% musk thistle control except the low rate of Transline (0.112 lb. ai.) (Table 45).

Table 45. Musk Thistle Control Study: Preliminary experiment (Non-replicated), percent musk thistle control for 9 herbicide treatments.

Treatments[1]	Rate(s) lbs. ai./Acre	Percent Musk Thistle Control 1 MAT	Percent Musk Thistle Control 2 MAT
Check	----	0	0
Transline[2]	0.112	36	50
Transline	0.225	100	100
Transline	0.487	100	100
Transline + XRM-5114	0.112 + 0.12 oz.	50	100
Transline + XRM-5114	0.112 + 0.5 oz.	69	100
Transline + XRM-5114	0.225 + 0.25 oz.	96	100
Transline + XRM-5237	0.112 + 0.12 oz.	96	100
Transline + XRM-5237	0.112 + 0.5 oz.	92	100
Transline + XRM-5237	0.225 + 0.25 oz.	87	100

[1]All herbicide treatments included X-77 surfactant at 25% v/v.
Transline is the brand name for clopyralid alone.

APPENDIX M

Experiment: Johnsongrass Control Study (Experiment 4-H-56-90).

Objective: To compare the efficacy of el ven herbicide treatments for the control of johnsongrass.

Date of Treatments: May 23, 1990 (Johnsongrass 18"-20" tall).

Plot Size: 5 ft. by 10 ft.

Dates Scored: June 22, 1990, 1 month after treatment (MAT); July 23, 1990, 2 MAT; August 23, 1990, 3 MAT; and September 24, 1990, 4 MAT.

Methods of Scoring: Johnsongrass Control, where 1 = no effect and 10 = complete control. Bermudagrass Phytoto icity, where 1 = no effect and 10 = complete yellowing.

Discussion: The combination treatments of Roundup + Rifle, Rifleplus, or CGA-131036 provided slightly less johnsongrass control than the combination treatments of Roundup + Oust (Table 46). CGA-131036 when combined with Roundup appears to have the least johnsongrass control. XRM-5237 and XRM-5237 + XRM-5114 treatments did not have significant johnsongrass control until 2 MAT. At 4 MAT, the level of control from both of these treatments remained constant. The Roundup + Oust treatments h the best johnsongrass control in this experiment. Significant bermudagrass phytotoxicity was observed for each treatment at 1 MAT. At 2 MAT, XRM-5237, alone or in combination with XRM-5114, were the only two treatments exhibiting significant bermudagrass phytotoxicity. When the experiment was evaluated at 3 MAT, no bermudagrass phytotoxicity was observed.

Table 46. **Johnsongrass Control Study: Experiment (4-H-56-90), johnsongrass control and phytotoxicity for 10 herbicide treatments.**

Treatments	Rate(s) lb. ai./A	Johnsongrass Control				Bermudagrass Phytotoxicity		
		1 MAT	2 MAT	3 MAT	4 MAT	1 MAT	2 MAT	3 MAT
Check	----	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Roundup + Oust	0.624 + 0.047	9.3	9.2	9.1	9.1	3.3	1.0	1.0
Roundup + Oust	0.75 + 0.094	9.7	9.4	9.2	9.1	3.3	1.0	1.0
Roundup + Rifle + X-77	0.75 + 0.095 + 0.25% v/v	9.0	8.7	8.5	8.3	3.0	1.0	1.0
Roundup + Rifle + X-77	0.75 + 0.143 + 0.25% v/v	9.3	9.0	8.7	8.6	3.7	1.7	1.0
Roundup + RiflePlus + X-77	0.75 + 0.095 + 0.25% v/v	9.3	8.8	8.2	8.2	4.0	1.0	1.0
Roundup + RiflePlus + X-77	0.75 + 0.143 + 0.25% v/v	9.2	8.4	8.3	8.3	4.0	1.0	1.0
Roundup + CGA-131036 + X-77	0.75 + 0.047 + 0.25% v/v	8.8	8.4	8.1	8.1	3.7	1.0	1.0
Roundup + CGA-131036 + X-77	0.75 + 0.095 + 0.25% v/v	8.8	7.9	7.3	7.3	4.3	1.0	1.0
XRM-5237 + X-77	0.25 + 0.25% v/v	3.3	8.5	8.3	8.3	2.7	3.3	1.0
XRM-5237 + XRM-5114 + X-77	0.19 + 0.63 + 0.25% v/v	4.0	8.5	8.3	8.3	2.7	3.3	1.0
$LSD_{0.05}$		0.8	1.2	1.5	1.5	1.3	1.5	NA
CV%		6	9	12	12	24	12	NA

APPENDIX N

Experiment:	Johnsongrass Control Study (Experiment 8-H-27-90).
Objective:	To compare the efficacy of eleven herbicide treatments for the control of johnsongrass.
Date of Treatments:	May 24, 1990.
Plot Size:	5 ft. by 10 ft.
Dates Scored:	June 24, 1990, 1 month after treatment (MAT); July 24, 1990, 2 MAT; August 24, 1990, 3 MAT; and September 25, 1990, 4 MAT.
Methods of Scoring:	Johnsongrass Control, where 1 = no effect and 10 = complete control. Bermudagrass Phytotoxicity, where 1 = no effect and 10 = complete yellowing.
Discussion:	At 1 MAT, no significant differences were measured among the treatments of Roundup combined with Oust, Rifle, Rifleplus, or CGA-131036; however, the high rate of Roundup + Oust (0.75 + 0.094 lb. ai.) was better than the low rate of Roundup + CGA-131036 (0.75 + 0.047 lb. ai.), (Table 47). No significant differences in johnsongrass control were measured among any of these combination treatments at 2, 3, and 4 MAT. The experimental treatments of XRM-5237 and XRM-5237 + XRM-5114 had unacceptable johnsongrass control for the duration of the experiment.

Bermudagrass phytotoxicity was observed for all treatments except XRM-5237 and XRM-5237 + XRM-5114 at 1 MAT. At 2 MAT, phytotoxicity had diminished in all treatments.

Table 47. Johnsongrass Control Study (Experiment 8-H-27-90). Johnsongrass control and phytotoxicity for 10 herbicide treatments.

Treatments	Rate lb. ai./A	Johnsongrass Control 1 MAT	2 MAT	3 MAT	4 MAT	Bermudagrass Phytotoxicity 1 MAT	2 MAT
Check	----	1.0	1.0	1.0	1.0	1.0	1.0
Roundup + Oust	0.624 + 0.047	9.1	8.5	7.8	7.5	3.3	1.0
Roundup + Oust	0.75 + 0.094	9.6	9.4	9.2	9.2	3.7	1.0
Roundup + Rifle + X-77	0.75 + 0.095 + 0.25% v/v	9.0	8.8	8.7	8.5	4.3	1.0
Roundup + Rifle + X-77	0.75 + 0.143 + 0.25% v/v	8.7	7.7	7.3	6.5	3.3	1.0
Roundup + RiflePlus + X-77	0.75 + 0.095 + 0.25% v/v	9.1	8.1	7.7	7.3	4.0	1.0
Roundup + RiflePlus + X-77	0.75 + 0.143 + 0.25% v/v	8.8	8.7	8.3	8.3	3.3	1.0
Roundup + CGA-131036 + X-77	0.75 + 0.047 + 0.25% v/v	8.5	8.2	8.1	8.0	4.0	1.0
Roundup + CGA-131036 + X-77	0.75 + 0.095 + 0.25% v/v	9.0	8.4	7.8	7.7	3.7	1.0
XRM-5237 + X-77	0.25 + 0.25% v/v	4.0	4.3	5.3	5.0	1.0	1.0
XRM-5237 + XRM-5114 + X-77	0.19 + 0.63 + 0.25% v/v	3.3	3.3	3.7	3.7	1.0	1.0
$LSD_{0.05}$		0.9	1.7	2.3	2.5	1.3	NA
CV%		7	15	20	23	25	NA

APPENDIX O

Experiment: Johnsongrass Control Studies (Experiments 4-H-50-89; 5-H-7-89; 8-H-22-89).

Objective: To evaluate the efficacy of nine herbicide treatments (five products) for the selective control of Johnsongrass.

Dates of Treatments: May 15, 1989 (4-H-50-89); May 24, 1989 (5-H-7-89); May 19, 1989 (8-H-22-89).

Plot Size: 5 ft. x 10 ft.

Dates Scored: 1 month after treatment (MAT); 2 MAT; 3 MAT.

Methods of Scoring: Bermudagrass Phytotoxicity, where 1 = no effect and 10 = complete yellowing or brownout. Johnsongrass Control, where 1 = no control and 10 = complete control.

Discussion: Three identical studies were initiated in three Divisions (4, 5 and 8) to evalua e the efficacy of nine herbicide treatments (5 products) for the postemergence control of johnsongrass. As expect d, the relative performance of some of the treatments tested varied slightly with the varying soil type, climatic conditions, or other characteristics within the three Divisions (Table 48).

Significant bermudagrass phytotoxicity was observed 1 MAT with the treatment of Roundup plus Oust and all three treatments of Select plus Crop Oil. Treatments of Rifle and Horizon did not exhibit significant bermudagrass phytotoxicity at 1 MAT. At 2 MAT, Roundup plus Oust was the only treatment showing significant bermudagrass phytotoxicity, and this effect later diminished.

At 1 MAT, Roundup plus Oust and the three treatments of Select wer significantly better than the other treatments for johnsongrass control. At 2 and 3 MAT, Roundup plus Oust and the two higher rates of Select were significantly better than all other treatments for johnsongrass control. When the last evaluation was made for johnsongrass control at 4 MAT, this same trend was observed, however, the treatment of Roundup plus Oust was significantly better than Select at 0.2 lb ai. per acre.

Table 48. **Johnsongrass Control Studies: (Experiments 4-H-50-89; 5-H-7-89; 8-H-22-89), johnsongrass control and phytotoxicity of 9 herbicide treatments.**

Treatments	Rate(s) lb. ai./A	Bermudagrass Phytotoxicity[1] 1 MAT	2 MAT	Johnsongrass Control[2] 1 MAT	2 MAT	3 MAT	4 MAT
Check	---	1.0	1.0	1.0	1.0	1.0	1.0
Roundup + Oust	0.75 + 0.094	3.6	3.0	8.7	8.1	7.6	7.6
Horizon + X-77	0.125 + 0.25% v/v	1.9	1.2	4.8	2.4	1.8	1.8
Horizon + X-77	0.188 + 0.25% v/v	2.0	1.1	5.9	3.4	2.4	2.1
Rifle + X-77	0.018 + 0.25% v/v	1.0	1.0	2.2	1.7	1.3	1.3
Rifle + X-77	0.036 + 0.25% v/v	1.0	1.2	2.8	1.9	1.7	1.6
Rifle + X-77	0.071 + 0.25% v/v	1.1	1.4	4.3	2.8	1.6	1.3
Select + Crop Oil	0.1 + 0.25% v/v	2.4	1.7	7.5	4.6	3.0	2.1
Select + Crop Oil	0.2 + 0.25% v/v	3.3	1.8	8.9	7.1	5.5	4.9
Select + Crop Oil	0.3 + 0.25% v/v	4.4	2.0	9.2	8.0	6.6	5.9
$LSD_{0.05}$		1.3	1.8	2.1	2.1	2.1	2.1
CV%		24.1	22.4	11.8	25.5	34.9	42.6
ANOVA[3]							
Div		***	***	***	NS	NS	NS
Rep (Div)		NS	***	NS	NS	NS	NS
Tmt		***	***	***	***	***	***
Div*Tmt		***	***	***	***	***	**

[1]Bermudagrass Phytotoxicity, where 1 = no effect and 10 = complete yellowing or brownout
[2]Johnsongrass Control, where 1 = no control and 10 = complete control.
[3]Analysis of Variance, where NS, *, **,and *** indicate not significant or significant at P = 0.05, 0.01, and 0.001, respectively.

APPENDIX P

Experiment: Kochia Control Study (Experiment 4-H-54-90).

Objective: To compare the efficacy of twelve herbicide treatments (3 products) for the control of Kochia.

Da e of Treatments: April 11, 1990 (Kochia 0.5 - 1.0 inches tall).

Plot Size: 5 ft. by 10 ft.

Dates Scored: April 25, 1990, 2 weeks after treatment (WAT); May 5, 1990, 4 WAT; June 6, 1990, 8 WAT; July 3, 1990, 12 WAT; and August 1, 1990, 16 WAT.

Methods of Scoring: Kochia Control, whe e 1 = no control and 10 = complete control. Bermudagrass Phytotoxicity, where 1 = no effect and 10 = complete yellowing.

Discussion: The 0.13, 0.25 and 0.38 lb. ai./A treatments of XRM-5114 had the best Kochia control (Table 49). The 0.06 lb. ai./A rate of XRM-5114, all treatments of XRM-5237, and the combination treatment of XRM-5114 + XRM-5237 did not provide satisfactory Kochia control. Oust treatments provided acceptable Kochia control, but the bermudagrass phytotoxicity was unacceptable.

Bermudagrass phytotoxicity was observed in all treatments. XRM-5237 had a trend to exhibit more phytotoxicity than XRM-5114, however, phytotoxicity minished to an acceptable level by 16 WAT. The bermudagrass phytotoxicity observations in the Oust treatments were unacceptable for the duration of the experiment.

Table 49. Kochia Control Study: Experiment (4-H-54-90), Kochia control and bermudagrass phytotoxicity for 11 herbicide treatments.

	Rate(s)	Kochia Control					Bermudagrass Phytotoxicity				
Treatments	lb. ai./A	2 WAT	4 WAT	8 WAT	12 WAT	16 WAT	2 WAT	4 WAT	8 WAT	12 WAT	16 WAT
Check	----	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
XRM-5114	0.06	4.3	4.7	3.8	3.5	3.5	1.7	2.3	1.0	1.0	1.0
XRM-5114	0.13	7.7	7.3	7.5	7.5	7.5	2.0	2.3	1.0	1.0	1.0
XRM-5114	0.25	7.9	9.1	8.8	8.6	8.6	2.7	2.7	1.3	1.3	1.0
XRM-5114	0.38	7.6	7.6	7.5	7.3	7.3	2.3	3.0	1.3	1.0	1.0
XRM-5237	0.06	4.7	4.7	2.7	2.0	1.3	2.3	2.3	1.0	1.0	1.0
XRM-5237	0.13	2.0	2.0	1.3	1.3	1.3	2.7	3.0	1.0	1.0	1.0
XRM-5237	0.25	2.3	2.7	2.7	2.7	2.7	4.0	4.0	2.3	1.7	1.7
XRM-5237	0.38	3.7	4.0	2.3	2.0	2.0	2.7	2.7	1.7	1.3	1.3
XRM-5114 + XRM-5237	0.05 + 0.16	2.3	4.3	3.0	3.0	3.0	3.3	3.0	2.3	2.3	1.3
Oust	0.125	5.3	7.3	8.0	6.3	5.3	3.7	9.5	9.2	7.3	4.7
Oust	0.25	4.7	8.2	9.3	8.8	8.7	4.3	9.9	9.7	7.0	4.3
$LSD_{0.05}$		2.7	3.5	3.3	3.0	3.0	1.1	0.9	1.0	1.7	0.9
CV%		36	39	40	39	41	24	14	21	46	32

*All treatments (except Oust) included surfactant X-77 added at 0.25% v/v.

APPENDIX Q

<u>Experiment</u>: Multi-Year Study (Experiment 4-H-36-87).

<u>Objective</u>: Evaluate which herbicides and rates, and for what duration (up to four years), will effectively control undesirable vege tion and enhance release of bermudagrass.

<u>Dates of Treatments</u>:

(1987) March 19, 1987, Aatrex 4L at 2 lbs. ai./A or Karmex 80W at 3 lbs. product/A; May 15, 1987, Roundup + Oust at 1.5 pts. + 2 oz./A (entire experimental area treated).

(1988) February 19, 1988, Aatrex 4L at 2 lbs. ai./A and Karmex 80W at 2.4 lb. ai./A; May 16, 1988, Roundup + Oust.

(1989) March 1, 1989, Atrazine and Karmex; May 15, 1989, Roundup + Oust.

(1990) February 9, 1990, Atrazine and Karmex; May 23, 1990, Roundup + Oust.

<u>Plot Size</u>: 12 ft. by 100 ft.

<u>Dates Scored</u>: May 15, 1987; June 15, 1987; July 14, 1987; August 14, 1987; September 15, 1987; March 30, 1988; May 18, 1988; June 17, 1988; July 20, 1988; August 16, 1988; September 19, 1988; April 17, 1989; June 30, 1989; July 29, 1989; August 28, 1989; September 29, 1989; April 10, 1990; May 30, 1990; June 22, 1990; July 23, 1990; August 23, 1990; and September 24, 1990.

<u>Methods of Scoring</u>: Annual Weed Control, where 1 = no control and 10 = complete control. Bermudagrass Phytotoxicity, where 1 = no effect and 10 = complete yellowing or brownout. Johnsongrass Control, where 1 = no control and 10 = complete control.

<u>Discussion</u>: This experiment is a long-t rm study with different treatments applied on a yearly basis for a four-year period. In the first year (1987), the entire experimental area was treated with essentially the same herbicides and rates. The treated areas were then subdivided in year two (1988), with some plots successively treated for two years and the remainder untreated. By year four (1990), there were plots which had been treated only the first year during the four year period, plots treated two

years successively, plots treated three years in succession, and plots which had been treated successively for four years. It will be determined which herbicide rates, and for what duration (up to four years), will effectively control undesirable vegetation and enhance release of bermudagrass.

In 1987, no significant differences were detected among treatments for control of johnsongrass for 1, 2 and 3 MAT (Table 50). In 1988, plots treated two years in succession with Roundup plus Oust were significantly better than those with one treatment applied in 1987, for all three johnsongrass control evaluations. In 1989, plots treated with Roundup plus Oust for three consecutive years exhibited significantly better johnsongrass control for 1, 2 and 3 MAT when compared to those plots which had been treated once, or for 2 consecutive years. It appears that plots treated for four consecutive years with Roundup plus Oust provided better johnsongrass control at 1, 2 and 3 MAT, when compared to plots treated for one, two or three consecutive years.

The same trend was evident for annual weed control evaluations. No significant differences were observed in 1989 among treatments for annual weed control. Evaluations in 1988 for 1, 2 and 3 MAT, resulted in significantly better annual weed control in plots treated for two consecutive years when compared to those plots treated just once in 1987. When plots were evaluated in 1988, those which had been treated for three consecutive years exhibited significantly better annual weed control for 1, 2 and 3 MAT when compared to plots treated only once or for two consecutive years.

Plots treated for four consecutive years with a preemergence herbicide (Atrazine or Karmex) provided better control of annual weeds at 1, 2 and 3 MAT, when compared to plots treated for one, two and three years in succession.

Bermudagrass phytotoxicity was usually evident for 1 MAT, but in most instances, had diminished by 2 MAT when evaluations were made during 1987, 1988 and 1989. This same trend was observed when ratings were made during 1990, however, bermudagrass phytotoxicity was evident for 2 MAT but had in most treatm nts diminished by 3 MAT.

Table 50. Means for Multi-Year Study (Experiment 4-H-36-87).

Application	1 MAT			2 MAT			3 MAT		
Times	1987	1988	1989	1987	1988	1989	1987	1988	1989
				Johnsongrass Control					
1	9.9	6.2	4.6	9.8	6.0	3.9	9.8	7.9	4.5
2	9.9	9.9	6.1	9.8	9.5	5.7	9.8	9.2	6.0
3	9.9	9.7	9.5	9.8	9.5	9.0	9.8	9.2	9.0
$LSD_{0.05}$	0.1	0.4	0.8	0.1	0.6	1.0	0.1	0.3	1.3
CV%	1.1	6.9	16.6	0.8	10.7	21.8	0.9	5.4	27.4
				Annual Weed Control					
1	9.6	1.0	1.0	--	1.6	1.0	--	1.0	1.0
2	9.7	9.7	1.5	--	8.9	1.4	--	9.7	1.2
3	9.7	9.7	9.2	--	8.9	9.7	--	9.7	9.4
$LSD_{0.05}$	0.1	0.1	0.7	--	0.9	0.6	--	0.1	0.4
CV%	1.8	2.5	18.6	--	18.3	16.9	--	1.7	10.7
				Bermudagrass Phytotoxicity					
1	3.4	1.0	1.0	2.4	1.0	1.0	1.0	1.0	--
2	2.9	6.4	1.0	2.5	5.7	1.0	1.0	1.8	--
3	2.7	6.3	2.8	2.3	5.9	1.0	1.0	1.9	--
$LSD_{0.05}$	0.6	0.3	0.4	0.3	0.6	--	--	0.2	--
CV%	29.1	8.9	29.9	17.7	18.0	--	--	16.3	--

APPENDIX R: APPENDIX OF TRADE, COMMON AND CHEMICAL NAMES OF HERBICIDES.

TRADE NAME	COMMON NAME	CHEMICAL NAME
Aatrex 4L	atrazine	6-Chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine
Banvel	dicamba	3,6-dichloro-2-methoxy-benzoicacid
Embark	mefluidide	N-(2,4-dimethyl-5-[[(trifluoromethyl) sulfonyl]amino]phenyl]-acetamide
Escort	metsulfuron methyl	{Methyl 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]-carbonyl]-amino]sulfonyl]benzoate}
Fusilade	fluazifop	(±)-2-[4-[[5-(trifluro-methyl)-2-pyridinyl]oxy]penoxy]propanoic acid
Garlon 3A, Garlon 4	triclopyr	[(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid
Karmex	diuron	N-(3,4-dichlorophenyl)-N,N-dimethylurea
Lexone	metribuzin	[4-Amino-6-(1,1dimethylethyl)-3-(methylthio)-1,2,4 triazin-5(4H)-one]
Oust	sulfometuron methyl	{Methyl 2-[[[[4,6-dimethyl-2-pyrimidinyl)-amino]carbonyl] amino]sulfonyl]benzoate}
Poast	sethoxydim	2-[1-ethoxyamino)-butyl]-5-[2-(ethylthio)-propyl]-3-hydroxy-2-cyclohexene-1-one

APPENDIX R (continued)

TRADE NAME	COMMON NAME	CHEMICAL NAME
Rifle	primisulfuron	3-[4,6-bis(difluromethyl)-pyrimidine-2-yl]-1-methoxy-carbonyl-phenyl)sulfonyl)-urea
Solicam	norflurazon	4-chloro-5-(methylamino)-2-(3-(trifluoromethyl)phenyl)-3(2H)-pyridazinone
Stomp	pendimethalin	N-(1-ethylpropyl)-3,4- imethyl-2,6-dinitrobenzene-amine
Surflan	oryzalin	4-(dipropylamino)-3,5-dinitrobenzenesulfonamide
Telar	chlorsulfuron	2-chloro-N-[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)-aminocarbonyl] benzenesulfonamide
Tordon K	picloram	4-amino-3,5,6-trichloro-2-pyridine carboxylic acid
Transline	clopyralid	3,6-dichloro-2-pyridine-carboxylic acid
Vision	cimectacarb	ethyl 4-cyclopropyl(hydroxy)methylene-3,5-dioxocyclohexanecarboxylate