INVESTIGATIONS ON CHEMICAL AND CULTURAL PRACTICES FOR WEED CONTROL IN WHEAT

By

JEFFREY ALLEN KOSCELNY

Bachelor of Science
Oklahoma State University
Stillwater, Oklahoma
1987

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1989

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF PHILOSOPHY
December, 1995

INVESTIGATIONS ON CHEMICAL
AND CULTURAL PRACTICES
FOR WEED CONTROL
IN WHEAT

Thesis Approved:

Thomas F. Peeper
Thesis Adviser

Eugene G. Krenzer, Jr.

John B. Solie

James H. Stiegler

Thomas C. Collins
Dean of the Graduate College

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to my major adviser, Dr. Thomas F. Peeper, for giving me the opportunity to study and learn under his guidance, and for his immense help and friendship throughout my graduate program. I would also like to extend a special thanks to Dr. Eugene Krenzer, Dr. John Solie, and Dr. James Stiegler for their assistance and suggestions as members of my graduate committee.

I would like to thank my lovely, understanding wife Angie and son Jacob, for their love, encouragement, and help during the course of my studies. Also, I would like to thank my parents, John and Pat, for the example which they set for me to follow, and for their love, support, and encouragement throughout my life. And to the rest of my family, thank you for your support and encouragement.

I would also like to thank my friends and fellow graduate students Bob, Case, Lori, Jackie, Kenny, David, Kent, Greg, Jason, and Brandy and undergraduate students Darrin, Amanda, and Michelle for their help and fellowship throughout my research.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

CHAPTER I

CHAPTER II

CHAPTER III

Table Page

CHAPTER IV

APPENDIX

INTRODUCTION

Each chapter of this thesis is a manuscript to be submitted for publication in Weed Technology, a Weed Science Society of America publication.

CHAPTER I

SULFONYLUREA HERBICIDES AFFECT WHEAT FORAGE, GRAIN YIELD AND ECONOMIC RETURNS

Sulfonylurea Herbicides Affect Wheat Forage, Grain Yield and Economic Returns[1]

JEFFREY A. KOSCELNY, THOMAS F. PEEPER, and EUGENE G. KRENZER, JR.[2]

Abstract. Field experiments were conducted to determine whether residual sulfonylurea herbicides affect wheat forage production, grain yield, and net economic return. All PRE and early POST herbicide treatments, applied at cheat (Bromus secalinus L.) suppression rates, decreased total forage production of weed-free wheat. Conversely, four of the five herbicide treatments increased grain yield. The benefit required from weed control to recover the cost of the herbicide treatment was greater than the actual cost of the PRE treatments and less than the actual cost of the POST treatments. **Nomenclature:** wheat, *Triticum aestivum* L.

---

[1] Received for publication _____ and in revised form _____. Approved for publication by the Director, Okla. Agric. Exp. Sta., Okla. State Univ., Stillwater, OK 74078.

[2] Sr. Agriculturist, and Profs., respectively, Dep. Agron., Okla. State Univ., Stillwater, OK 74078.

`Karl,' `2180.'

Additional index words: Chlorsulfuron, metribuzin, metsulfuron, triasulfuron.

INTRODUCTION

Income to Oklahoma farmers from wheat ranks second only to income from beef cattle (*Bos taurus* L.), which, in turn, depends heavily on wheat for winter pasture (5, 6, 7, 13). Approximately half of the wheat planted annually in Oklahoma is grazed by cattle from November to early March and then harvested for grain. Southern Great Plains wheat producers frequently utilize wheat forage during tillering for winter grazing and still obtain a normal grain crop (20). Producer interest in forage production has risen in recent years due to lower wheat grain prices. To increase wheat forage production, wheat is seeded earlier in the fall. The combination of early seeding for pasturing purposes and continuous wheat production frequently increases infestations of cheat and other winter annual grasses (25).

An estimated 33 to 44% of the 6 million acres of wheat harvested for grain annually in Oklahoma receive either chlorsulfuron (2-chloro-N-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]-carbonyl]benzenesulfonamide), a 5:1 w/w premix of chlorsulfuron plus metsulfuron (2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2- yl)amino]carbonyl]amino]sulfonyl] benzoic acid), or triasulfuron (2-(2-chloroethoxy)-N-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl] benzenesulfonamide) PRE or POST for winter annual grass and/or broadleaf weed control (5, 12, 19, 24, 26). Major targets include cheat and other weedy *Bromus* spp., winter annual broadleaf weeds, and Italian ryegrass (*Lolium multiflorum* Lam.).

These sulfonylurea herbicides, when properly applied, cause few visual injury symptoms on wheat other than occasional stunting (1, 11, 22). Thus, there is concern that crop injury might go unnoticed due to a lack of discoloration. Ferreira, et al. (12) reported no visual injury symptoms or grain yield reduction in grazed or ungrazed wheat with POST applications of chlorsulfuron, metsulfuron, and triasulfuron at 26, 8.8, and 29 g ai/ha, respectively. However, their research was conducted to determine whether grazing wheat prior to treatment affected wheat response to these herbicide treatments and thus, did not address whether these herbicides reduce forage production.

Chlorsulfuron plus metsulfuron and triasulfuron are registered for PRE cheat suppression in wheat (2, 4). The degree of suppression is variable depending on environmental conditions and cheat density (11). Metribuzin (4-amino-6-(1,1-di-methylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one) at 420 to 560 g/ha applied to tillered wheat effectively controls cheat. However, its use is limited by differential cultivar tolerance and soil characteristic restrictions (18, 23, 25). Triasulfuron or chlorsulfuron plus metsulfuron tank-mixed with reduced rates of metribuzin applied early POST suppress cheat and downy brome (*Bromus tectorum*) (17, 24). However, little is known about the effect of these tank-mix treatments on forage production and grain yield of foraged wheat. The objective was to determine the effect of PRE applied triasulfuron or chlorsulfuron plus metsulfuron and early POST applied metribuzin tank mixed with triasulfuron or chlorsulfuron plus metsulfuron on winter wheat forage production, grain yield, and net economic returns.

MATERIALS AND METHODS

During the 1992-93 and 1993-94 winter wheat growing seasons, six field experiments were conducted in Oklahoma to evaluate the effects of PRE applied triasulfuron or chlorsulfuron plus metsulfuron on wheat forage and grain production. Five sites were weed-free and one site had a light infestation (one plant per 4 m^2) of henbit (*Lamium amplexicaule* L.). The design for each experiment was a randomized complete block with eight (3 sites) or ten replicates. Plot size was 1.2 by 6.7 m or 1.5 by 7.6 m.

Hard red winter wheat cultivars (`Karl' in 1992 and `2180' in 1993) were seeded at 100 kg/ha in 15-, 17.5-, or 20-cm-wide rows with double disk opener drills.

Triasulfuron at 30 g/ha and chlorsulfuron plus metsulfuron at 26 g/ha (21.7 plus 4.3) were applied PRE immediately after seeding. An untreated control was included.

In the three 1993-94 field experiments, three additional treatments were applied when the wheat had three to five leaves (POST). These treatments were triasulfuron at 30 g/ha plus metribuzin at 158 g/ha, chlorsulfuron plus metsulfuron at 21 g/ha (17.5 plus 3.5) plus metribuzin at 210 g/ha, and metribuzin at 280 g/ha. All rates used are the maximum labeled rates for these application timings (2, 3, 4).

Herbicide treatments were applied with a CO_2 backpack sprayer in a total volume of 187 L/ha with water carrier. Fertilizer was broadcast according to soil test recommendations for maximum expected grain yield of 4000 kg/ha. Table 1 contains experiment designations, treatment dates, weekly rainfall for 3 wk following application, forage removal dates, and soil information.

Wheat injury was evaluated visually 3 wk after treatment. In the fall or winter, when the wheat canopy reached a height of 20 cm and again in the spring at the first indication of wheat jointing, a self-propelled sicklebar forage plot harvester was used to clip the forage about 6 cm above the soil surface from a 1.2 by 5.5 m or 1.5 by 6.4 m area from each plot to assess forage yields. Remaining forage was harvested and removed from all plots. Subsamples from each plot were dried to determine fall, spring, and total forage production on an oven-dry (35 C to constant weight) basis.

Additional nitrogen fertilizer was broadcast after the spring forage harvest to replace nitrogen removed with the harvested forage based on 30 kg nitrogen used for every 1000 kg of harvested forage (16). Grain yield was obtained by harvesting the plots at maturity with a small plot combine. Harvested samples were cleaned with a small commercial seed cleaner to remove the chaff and straw. Wheat grain yield, adjusted to 13.5% moisture, was determined after cleaning.

Net economic returns from these herbicide treatments were determined using standard enterprise budgets (8, 9, 10, 21). Prices used were the actual local prices for steer calves in November and March and wheat grain in June or July the year of harvest (27, 28). Input costs were average prices paid by producers in the production year (14, 15). Forage net returns are estimated as gross receipts (weight gain based on forage availability multiplied by the price difference between theoretical cattle bought and sold to use the available forage) less operating costs. No value from forage production was credited to the wheat grain enterprise. Stocking density was estimated from forage production based on a forage allocation of 12 kg of forage dry matter per kg of weight gain on steers weighing 180 to 270 kg (21).

Grain net returns are estimated as total receipts (June or July local cash price multiplied by the yield) less operating costs. Operating costs, including herbicide and herbicide application costs, were subtracted from estimates of wheat returns to obtain estimated net returns to grain.

Based on the net returns data and the herbicide treatment cost, the benefit required from weed control to break even on the investment in the herbicide treatment was calculated. All data were separated by application timing and statistically analyzed. Means were separated by Fisher's Protected Least Significant Difference Test. Injury data were subjected to arcsin transformations before analyses. Transformations did not affect data interpretation; thus, original data are reported. Data were pooled when there were no interactions.

RESULTS AND DISCUSSION

There were no significant treatment by location by year interactions for any parameter evaluated, so data from the

PRE treatments were pooled over locations and years. Wheat was not visibly injured by any PRE treatment in any experiment (data not shown). Fall forage production in the untreated check averaged 900 kg/ha. Chlorsulfuron plus metsulfuron reduced forage production 18% (Table 2). Both PRE herbicide treatments reduced spring and total forage production, although crop injury was not readily visible. Grain yield in the untreated check averaged 1750 kg/ha. Chlorsulfuron plus metsulfuron increased grain yield 5.7%.

Negative net returns were expected because the sites were essentially weed-free. However, because of the negative effects on forage yield, the benefit required from weed control to break even on the cost of the herbicide treatments exceeded the actual costs of buying and applying the PRE herbicides.

Pooled over locations, the POST treatments visually injured the wheat 5 to 10% (Table 3). Consequently, fall, spring, and total forage production were reduced by all three herbicide treatments. Grain yield in the untreated check averaged 1090 kg/ha while all three herbicide treatments increased grain yield.

All treatments again resulted in negative net returns. However, in contrast to the PRE treatments, the positive impact of the POST treatments on grain yield reduced the net cost of treatment below the cost of the herbicides and application.

Interpreting the yield data is complicated by the treatment effects on vegetative growth. Except with triasulfuron applied PRE, herbicide induced vegetative growth reduction resulted in higher grain yields.

LITERATURE CITED

1. Anderson, R. L. 1986. Metribuzin and chlorsulfuron effects on grain of treated winter wheat (Triticum aestivum). Weed Sci. 34:734-737.
2. Anonymous. 1993. Finesse Product Label. E.I. duPont de Nemours, Wilmington, DE 19898.
3. Anonymous. 1993. Lexone Product Label. E.I. duPont de Nemours, Wilmington, DE 19898.
4. Anonymous. 1993. Amber Product Label. Ciba Corporation, Greensboro, NC 27419.
5. Bloyd, B. L. and J. D. Cole. 1992. Oklahoma Agricultural Statistics. U.S. Dept. Agric. Natl. Agric. Stat. Ser. and Okla. State Dept. Agric. p. 27.
6. Cuperus, G., R. Johnson, B. Tucker, S. Coppock, E. Williams, J. Stiegler, P. Bloome, H. Greer, J. T. Pitts, and D. Fain. 1983. Wheat production and pest management in Oklahoma. Circ. E-831. Coop. Ext. Serv., Div. Agric., Okla. State Univ., Stillwater, OK. 35 p.
7. Denman, C. E. and J. Arnold. 1970. Seasonal forage production for small-grains species in Oklahoma. Okla. Agric. Exp. Stn. Bull. 680. 21 p.
8. Doye, D. G. and R. Jobes. 1988. The OSU livestock enterprise budget. OSU Ext. Fact Sheet No. 779. Oklahoma State Univ., Ext. Serv. 12 p.

9. Doye, D. G. and R. Jobes. 1988. The OSU crop enterprise budget. OSU Ext. Fact Sheet No. 780. Oklahoma State Univ., Ext. Serv. 8 p.

10. Doye, D. G. and E. G. Krenzer, Jr. 1987. Should I buy (or retain) stockers to graze wheat pasture? OSU Ext. Fact Sheet No. 212. Okla. State Univ., Ext. Serv. 6 p.

11. Driver, J. E., T. F. Peeper, and J. A. Koscelny. 1993. Cheat (Bromus secalinus) control in winter wheat (Triticum aestivum) with sulfonylurea herbicides. Weed Technol. 7:851-854.

12. Ferreira, K. L, T. K. Baker, and T. F. Peeper. 1990. Factors influencing winter wheat (Triticum aestivum) injury from sulfonylurea herbicides. Weed Technol. 4:724-730.

13. Harper, H. J. 1961. Grazing and clipping experiments with small-grain pastures in South Central Oklahoma. Okla. Agric. Exp. Stn. Bull. 585.

14. Jobes, R. and D. D. Kletke. 1993 (revision). Oklahoma farm and ranch custom rates, 1992-93. Current Rep. 205. Coop Ext. Serv., Div. Agric., Oklahoma State Univ., Stillwater, OK 4 p.

15. Jobes, R. and D. D. Kletke. 1994 (revision). Oklahoma farm and ranch custom rates, 1993-94. Current Rep. 205. Coop Ext. Serv., Div. Agric., Oklahoma State Univ., Stillwater, OK 4 p.

16. Johnston, R. A., G. V. Johnson, and B. B. Tucker. 1983. Guidelines for topdressing wheat in 1983. Current Rep. 2234. Coop. Ext. Serv., Div. Agric., Oklahoma State Univ., Stillwater, OK 4 p.

17. Koscelny, J. A. and T. F. Peeper. 1994. Early postemergence cheat (Bromus secalinus) suppression in wheat with sulfonylurea herbicides tank-mixed with metribuzin. Proc. South. Weed Sci. Soc. 47:26.

18. Koscelny, J. A. and T. F. Peeper. 1990. Herbicide-grazing interactions in cheat (Bromus secalinus)-infested winter wheat (Triticum aestivum). Weed Sci. 38:532-535.

19. Klingaman, T. E. and T. F. Peeper. 1989. Weed control in winter wheat (Triticum aestivum) with chlorsulfuron and CGA 131036 and comparison of mode of action. Weed Technol. 3:490-496.

20. Krenzer, E. and D. Doye. 1988. Economic evaluation of wheat varieties grown for forage plus grain. Current Rep. 2100. Coop. Ext. Serv., Div. Agric., Oklahoma State Univ., Stillwater, OK 7 p.

21. Krenzer, E. G. Jr., A. R. Tarrant, D. J. Bernardo, and G. W. Horn. 1995. Economic evaluation of wheat cultivars based on grain and forage production. J. Prod. Agric. 8:(accepted for publication).

22. Martin, D. A., S. D. Miller, and H. P. Alley. 1989. Winter wheat (Triticum aestivum) response to herbicides applied at three growth stages. Weed Technol. 3:90-94.

23. Peek, D. C. and A. P. Appleby. 1989. Phytotoxicity, adsorption, and mobility of metribuzin and its ethylthio analog as influenced by soil properties. Weed Sci. 37:419-423.

24. Stahlman, P. W. and M. A. El-hamid. 1994. Sulfonylurea herbicides suppress downy brome (Bromus tectorum) in winter wheat (Triticum aestivum). Weed Technol. 8:812-818.

25. Runyan, T. J., W. K. McNeil, and T. F. Peeper. 1982. Differential tolerance of wheat (Triticum aestivum) cultivars to metribuzin. Weed Sci. 30:94-97.

26. Thompson, C. R. and D. C. Thill. 1992. Interrupted windgrass and broadleaf weed control in soft white winter wheat. Res. Prog. Rep. West. Soc. Weed Sci. p. 175-176.

27. U. S. Dept. of Agric. Ag. Marketing Serv. 1993. Livestock detailed quotation. Livestock Division, Oklahoma City, OK 73108.

28. U. S. Dept. of Agric. Ag. Marketing Serv. 1993. Prices received by producers. Crops Division, Oklahoma City, OK 73108.

Table 1. Herbicide application dates, rainfall data, forage removal dates, and soil descriptions for the 6 experiments.

	Treatment	Rainfall (WAT[a])			Forage Removal		Soil		
Expt.	date	1	2	3	Fall	Spring	Classification	pH	OM
		cm							
C-93	09-22-92	0.0	0.0	0.0[b]	02-09-93	03-10-93	Dale, SiL (fine-silty, mixed, thermic Pachic Haplustolls)	6.4	1.8
P-93	09-21-92	0.4	0.0	1.1	12-21-92	03-11-93	Teller, SL (fine-loamy, mixed, thermic Udic Argiustolls)	6.5	0.7
S-93	09-21-92	1.2	0.0	0.8	12-23-92	03-17-93	Pulaski, SL (coarse-loamy, mixed, thermic Typic Ustifluvents)	6.2	0.6
L-94	09-10-93	1.3	0.1	0.2	12-20-93	03-17-94	Grant, L (fine, silty, mixed, thermic Udic Argiustolls)	6.0	1.2
	09-28-93[c]	0.0	0.4	0.1					
P-94	09-02-93	5.3	5.5	0.8	10-25-93	03-04-94	Teller, SL (fine-loamy, mixed, thermic Udic Argiustolls)	5.7	0.7
	09-17-93[c]	0.8	1.5	1.1					
S-94	09-02-93	3.1	7.0	0.7	10-21-93	03-04-94	Pulaski, SL (coarse-loamy, mixed, thermic Typic Ustifluvents)	5.8	0.6
	09-17-93[c]	0.7	1.1	1.2					

Table 1. (Continued.)

---

[a] Abbreviations: WAT = weeks after treatment; OM = organic matter.

[b] 2.8cm of rain fell 5 WAT.

[c] Treatment date and rainfall data for POST treatments.

Table 2. Effect of triasulfuron and chlorsulfuron plus metsulfuron applied PRE on fall, spring, and total forage production, grain yield, forage and grain net returns, and treatment breakeven benefit requirement, pooled over six locations[a].

		Forage production			Grain	Net returns		Treatment	
Treatment	Rate	Fall	Spring	Total	yield	Forage	Grain	Cost	Breakeven
	g/ha	kg/ha				$/ha			
Triasulfuron	30	800	780	1580	1790	87.40	-19.40	21.10	27.50
CLMT[b]	26	740	760	1510	1850	83.80	-14.00	24.00	25.70
Untreated	—	900	850	1740	1750	97.50	-2.00	0.00	0.00
LSD (0.05)		110	NS	150	90	9.60	9.20	—	10.00
LSD (0.10)		—	60	—	—	—	—	—	—

[a] See appendix for individual location data.

[b] Abbreviations: CLMT = a 5:1 w/w premix of chlorsulfuron plus metsulfuron.

Table 3. Crop injury from three POST herbicide treatments and effects on fall, spring, and total forage production, grain yield, forage and grain net returns, and treatment breakeven requirement, pooled over three locations in 1994[a] .

		Crop	Forage production			Grain	Net returns		Treatment	
Treatment[b]	Rate	Injury	Fall	Spring	Total	yield	Forage	Grain	Cost[c]	Breakeven[d]
	— g/ha —	%	kg/ha				$/ha			
TRIA + MET	30 + 158	5	720	910	1630	1300	79.30	-81.20	33.40	20.80
CLMT + MET	21 + 210	9	640	870	1510	1350	74.50	-78.10	36.40	22.50
MET	280	10	630	800	1430	1310	69.60	-69.00	21.70	18.30
Untreated	—	—	900	1010	1910	1090	90.90	-72.00	0.00	0.00
LSD (0.05)		3	100	130	130	100	6.70	8.50	—	10.80

[a] See appendix for individual location data.

[b] Abbreviations: TRIA = triasulfuron; MET = metribuzin; CLMT = a 5:1 w/w premix of chlorsulfuron plus metsulfuron.

[c] Cost of the herbicides plus $5.56/ha for application.

[d] Benefit from weed control required to recoup the cost of herbicide use.

CHAPTER II

EVALUATION OF HERBICIDE OPTIONS FOR CHEAT (*Bromus secalinus*) CONTROL IN WINTER WHEAT (*Triticum aestivum*)

Evaluation of Herbicides Options for Cheat (*Bromus secalinus*) control in Winter Wheat (*Triticum aestivum*)[1]

JEFFREY A. KOSCELNY and THOMAS F. PEEPER[2]

Abstract. Seven field experiments were conducted in Oklahoma to compare efficacy and crop response to currently registered cheat control herbicide options. Chlorsulfuron plus metsulfuron premix (5:1 w/w) at 26 g ai/ha, applied PRE, controlled cheat 20 to 61%, increased wheat grain yields at two of seven locations, and decreased dockage due to cheat at five of seven locations. Chlorsulfuron plus metsulfuron at 21 g/ha tank mixed with metribuzin at 210 g/ha, applied early POST, controlled cheat 36 to 98%. Metribuzin POST at 420 g/ha controlled cheat 56 to 98%. Both POST options increased wheat yields at five of seven locations and decreased dockage at all locations.

---

[1] Received for publication _____ and in revised form ____. Approved for publication by the Director, Okla. Agric. Exp. Sta., Okla. State Univ., Stillwater, OK 74078.

[2] Sr. Agriculturist and Prof., Okla. State Univ., Stillwater, OK 74078.

Nomenclature: Chlorsulfuron, 2-chloro-N-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]benzenesulfonamide; metribuzin, 4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one; metsulfuron, 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl] benzoic acid; cheat, Bromus secalinus L. #[3] BROSE; wheat, Triticum aestivum L. 'Karl', '2180'.

Additional index words: Chlorsulfuron, metribuzin, metsulfuron, BROSE.

INTRODUCTION

Chlorsulfuron plus metsulfuron, in a 5:1 w/w premix, has been registered for PRE and POST (when tank mixed with metribuzin) applications for cheat suppression in winter wheat (1). PRE applications of chlorsulfuron plus metsulfuron at 26 g/ha have suppressed cheat 0 to 61% and downy brome 42 to 75% with variable results on wheat yield (3, 8). In preliminary trials in Oklahoma, a tank mix of metribuzin at 158 g/ha with the chlorsulfuron plus metsulfuron premix at 18 to 28 g/ha controlled cheat from 7 to 89% and increased wheat yield at 3 of 7 locations (4). Downy brome control ranged from 63 to 64% when chlorsulfuron

---

[3] Letters following the symbol are WSSA-approved computer codes from Composite List of Weeds, Revised 1989. Available from WSSA, 1508 West University Ave., Champaign, IL 61821.

plus metsulfuron tank mixed with metribuzin were applied at 21 plus 158 g/ha and wheat yield was decreased 12% due to crop stunting (8).

Metribuzin, applied POST, is registered and has effectively controlled Bromus spp. in winter wheat (2, 5, 6). However, edaphic and variety restrictions and a narrow margin of crop safety have limited its widespread acceptance. On winter wheat, metribuzin cannot be applied to soils with less than 0.75% organic matter content and few popular cultivars are considered tolerant (2). This research compared the efficacy and crop safety of these three cheat suppression/control options applied at their respective application timings.

MATERIALS AND METHODS

Seven field experiments were conducted in Oklahoma during the 1992-93 and 1993-94 winter wheat growing seasons to compare three herbicide treatment options for cheat control in winter wheat. The design for each experiment was a randomized complete block with four replicates. Plot size was 2.1 by 7.6 m. Locally harvested cheat seed was broadcast at 50 kg/ha at all sites and incorporated 2.5 to 5 cm deep with an s-tine harrow with rolling baskets immediately prior to wheat seeding.

Hard red winter wheat cultivars were seeded at 67 kg/ha in 20 cm-wide rows with a single disk opener drill. Fertilizer was broadcast according to soil test recommendations for maximum expected grain yield of 4000 kg/ha. Experimental locations, seeding dates, wheat cultivar and stage, cheat stage and density, number of days from herbicide application to rainfall of 1 cm or more, and soil information are listed in Table 1.

Chlorsulfuron plus metsulfuron at 26 g/ha, chlorsulfuron plus metsulfuron at 21 g/ha tank mixed with metribuzin at 210 g/ha, and metribuzin at 420 g/ha were applied at their respective labeled timings. These treatments will be referred to as the PRE, early POST and late POST options, respectively. Herbicides were applied with a CO_2 backpack sprayer in a total volume of 187 L/ha.

Wheat stand reduction and cheat control were visually evaluated after wheat heading based on a scale of 0 to 100 where 0 = no effect or control and 100 = plant death. At wheat maturity, a 1.5- by 7.6-m area from each plot was harvested with a small plot combine adjusted to retain as much cheat seed with the harvested grain as possible for dockage determinations. Wheat grain was first separated from chaff and straw and then separated from the cheat seed using a seed cleaner. Weight lost during the second cleaning was considered dockage and was primarily cheat seed with some shriveled wheat seed. Grain dockage is presented on a percentage basis. Yield data are for cleaned grain adjusted to 13.5% moisture.

Analysis of variance was conducted on all data. Means were separated by Fisher's Protected Least Significant Difference Test. Wheat injury and cheat control data were subjected to arcsin transformations before analyses. Transformations did not affect data interpretation; thus, original data are reported. Data were pooled when interactions were absent. Pearson linear correlation coefficients were calculated between visual wheat injury and cheat control data and selected edaphic and environmental factors (7).

RESULTS AND DISCUSSION

There were no significant treatment by year interactions associated with visual wheat injury and cheat control ratings, grain yield, and grain dockage at Lahoma. Therefore, treatments effects were pooled across the two experiments. At Orlando and Perkins, results from the experiments varied, precluding pooling across experiments at these sites.

Wheat stand was not reduced by the PRE option in any experiment (Table 2). The early POST option reduced the wheat stand planted in the sandy loam soil at Perkins where the soil organic matter content is near the lower limit, but did not significantly reduce the stand of wheat at Lahoma or Orlando. The late POST option reduced wheat stands in four of the seven experiments.

Of the two cultivars used in these experiments, 2180 is considered more metribuzin tolerant than Karl (2). However, correlation analysis revealed no relationship between cultivar and wheat injury for the early POST and late POST options. Wheat injury from the early POST option was negatively correlated to soil texture ($r = -0.64$, $P < 0.001$) and soil organic matter content ($r = -0.78$, $P < 0.001$).

Cheat control varied by site. At Lahoma, pooled over 2 years, the PRE and early POST options controlled cheat 36% while the late POST option controlled 56% of the cheat at this site (Table 2). Poor control was attributed to marginal activating rainfall (Table 1). At Orlando-1, the PRE and early POST options controlled cheat 40 and 57%, respectively. Metribuzin, applied late POST, controlled cheat 90%. At Orlando-2, the PRE and early POST options controlled 61 and 58% of the cheat, respectively while the late POST option controlled cheat 95%. At Perkins, cheat control with the PRE option ranged from 20 to 55%. Much higher control was obtained with the early POST option (90 to 98%) compared to 75 to 98% control with the late POST option.

These differences in cheat control can be attributed to differing edaphic and climatic factors at each of the sites. Correlation analysis on the visual cheat control data from all experiments for the early POST option revealed several relationships. Negative correlations between cheat control and soil organic matter content ($r = -0.80$, $P < 0.001$) and texture ($r = 0.86$, $P < 0.001$) indicate that in low organic matter, coarse textured soils this early POST tank mix treatment is more efficacious. However, under these conditions, crop stand reductions become a major concern. These data also confirm that activity is partially attributable to root uptake even though the treatments are applied POST.

The number of days until an activating rainfall was negatively correlated ($r = -0.69$, $P < 0.001$) to cheat control indicating that the delays between herbicide application and an activating rainfall decrease cheat control. These relationships seem to be in agreement with previously described factors affecting either chlorsulfuron plus metsulfuron or metribuzin (3, 6). Another factor which could have influenced cheat control with the early POST option was the relatively slow cheat emergence rate recorded at Lahoma and Orlando compared to Perkins (Table 1).

Grain yield increases were not evident at Lahoma with any herbicide treatment. Low cheat densities, slow emergence relative to the wheat, and poor cheat control at this site did not provide conditions favorable for grain yield increases. Dockage, due primarily to cheat, in the untreated checks averaged 429 and 463 kg/ha at Lahoma-1 and Lahoma-2, respectively.

At Orlando-1, wheat yield was increased by the early and late POST options compared to the untreated check. At Orlando-2, all herbicide treatments increased grain yield. Although the estimated cheat densities at Orlando were still fairly low, the cheat was competitive. Dockage, due primarily to cheat, in the untreated checks averaged 900 and 1374 kg/ha at Orlando-1 and Orlando-2, respectively. Thus, conditions were favorable for yield increases when cheat control was attained. The late POST option controlled cheat 90 and 95% and thus, increased yield 32 and 105% at Orlando-1 and Orlando-2, respectively compared to the untreated check.

At Perkins, wheat yield varied with experiment. Dockage due to cheat in the untreated check averaged 1405, 1707, and 1150 kg/ha at Perkins-1, Perkins-2, and Perkins-3, respectively. At Perkins-1, grain yield was increased by all herbicide treatments with the early POST option increasing yield 116%. At Perkins-2, the late POST option increased wheat yield from 910 kg/ha in the untreated check to 2280 kg/ha. The early POST option also increased wheat yield compared to the untreated check, however, the injury associated with this treatment precluded it from yielding as high as the late POST option. At Perkins-3, the late POST option was the only treatment to increase yield above the untreated check. This yield increase was found even though substantial crop injury had occurred. However, yields with this treatment were not different from the other two herbicide options.

Grain dockage ranged from 27 to 65% in the untreated checks indicating moderate to severe weed pressure (Table 2). At five of the seven experiments, the PRE option reduced grain dockage. In all experiments, the early POST and late POST options reduced dockage compared to the untreated check. At Lahoma and Orlando, the late POST option reduced dockage more than the other two herbicide options. However, at Perkins, the early POST option reduced dockage as much or more than the late POST option.

Thus, chlorsulfuron plus metsulfuron applied PRE may be considered a viable option for cheat suppression only when lack of crop safety with metribuzin is a major concern. Chlorsulfuron plus metsulfuron tank mixed with metribuzin applied early POST has the potential to increase wheat grain yields and decrease dockage due to cheat given favorable edaphic and environmental conditions. However, crop safety is still a concern with this treatment and close attention to soil organic matter content and texture as well as cultivar selection are required. Metribuzin, applied late POST, consistently decreased dockage and increased grain yields. All of these options have limitations and better options for cheat control are needed.

LITERATURE CITED

1. Anonymous. 1994. Finesse Product Label. E.I. duPont de Nemours, Wilmington, DE 19898.
2. Anonymous. 1995. Sencor Product Label Amendment for Cereals. Bayer, Inc., Kansas City, MO 64120.
3. Driver, J. E., T. F. Peeper, and J. A. Koscelny. 1993. Cheat (Bromus secalinus) control in winter wheat (Triticum aestivum) with sulfonylurea herbicides. Weed Technol. 7:851-854.
4. Koscelny, J. A. and T. F. Peeper. 1994. Early postemergence cheat (Bromus secalinus) suppression in wheat with sulfonylurea herbicides tank-mixed with metribuzin. Proc. South. Weed Sci. Soc. 47:26.
5. Ratliff, R. L., B. F. Carver, and T. F. Peeper. 1991. Expression of metribuzin sensitivity in winter wheat (Triticum aestivum) populations. Weed Sci. 39:130-133.
6. Runyan, T. J., W. K. McNeil, and T. F. Peeper. 1982. Differential tolerance of wheat (Triticum aestivum) cultivars to metribuzin. Weed Sci. 30:94-97.
7. SAS Institute. 1985. SAS User's Guide. SAS Inst., Inc., Cary, NC, 5:864-871.
8. Stahlman, P. W. and M. Abd El-Hamid. 1994. Sulfonylurea herbicides suppress downy brome (Bromus tectorum) in winter wheat (Triticum aestivum). Weed Technol. 8:812-818.

Table 1. Seeding date, wheat cultivar and stage, cheat stage and density, days from herbicide application to rainfall, and soil description for the seven cheat control experiments.[a]

	Seeding	Wheat	Herbicide	Wheat	Cheat			Soil			
Location	Date	Cult.	Treatment	Stage	Stage	Dens.	Rain	Series	Tex.	pH	OM
						no./m^2	d[b]				%
Lahoma-1	09-16-92	2180	CLMT	PRE	PRE	0	56	Grant	SiL	5.8	1.4
			CLMT + MET	4-5 lf	2-3 lf	32	39				
			MET	4-10 tl	3-9 tl	65	12				
Lahoma-2	09-24-93	Karl	CLMT	PRE	PRE	0	48	Grant	SiL	6.5	1.4
			CLMT + MET	2-4 lf	1-3 lf	11	35				
			MET	4-12 tl	2-9 tl	22	11				
Orlando-1	09-24-92	2180	CLMT	PRE	PRE	0	36	Pulaski	L	6.3	1.5
			CLMT + MET	4-5 lf	0	0	18				
			MET	4-15 tl	1-3 lf	54	7				
Orlando-2	09-24-93	Karl	CLMT	PRE	PRE	0	1	McLain	L	5.9	1.4
			CLMT + MET	2-3 lf	1-2 lf	54	1				

Table 1. (continued.)

			MET	4-7 tl	3-6 tl	86	3				
Perkins-1	10-09-92	2180	CLMT	PRE	PRE	0	20	Teller	SL	5.5	0.8
			CLMT + MET	1-4 tl	1-3 lf	161	10				
			MET	3-7 tl	2-3 tl	161	3				
Perkins-2	11-06-92	Karl	CLMT	PRE	PRE	0	6	Teller	SL	6.5	0.8
			CLMT + MET	2-4 tl	2-4 lf	75	3				
			MET	3-5 tl	2-4 tl	75	13				
Perkins-3	09-29-93	Karl	CLMT	PRE	PRE	0	8	Teller	SL	5.4	0.7
			CLMT + MET	2-3 lf	1-2 lf	75	5				
			MET	4-6 tl	2-3 tl	215	2				

[a] Abbreviations: Cult. = cultivar; Dens. = density; Tex. = texture; OM = organic matter; no. = number; CLMT = chlorsulfuron plus metsulfuron; MET = metribuzin; lf =leaf; tl = tiller; SiL = silt loam; L = loam; SL = sandy loam.

[b] Number of days from application to rainfall of 1 cm or more.

Table 2. Wheat stand reduction, cheat control, grain yield, and grain dockage response to chlorsulfuron plus metsulfuron applied PRE at 26 g/ha, chlorsulfuron plus metsulfuron tank mixed with metribuzin applied early POST at 21 + 210 g/ha, and metribuzin applied late POST at 420 g/ha at seven locations.

		Location					
Response	Option	Lahoma[a]	Orlando-1	Orlando-2	Perkins-1	Perkins-2	Perkins-3
		% of check					
Std. red.	PRE	0	0	0	0	0	0
	EPOST[b]	2	0	3	18	10	45
	LPOST[b]	3	7	18	13	3	36
	LSD (0.05)	NS	6	5	8	5	16
		% of check					
Control	PRE	36	40	61	20	23	55
	EPOST	36	57	58	90	96	98
	LPOST	56	90	95	75	98	98
	LSD (0.05)	11	21	23	13	14	24

Table 2. (continued.)

		kg/ha					
Yield	PRE	1530	1510	1310	1730	1180	1750
	EPOST	1490	1800	1260	2900	1880	1840
	LPOST	1450	1990	1890	2210	2280	1950
	Check	1400	1510	920	1340	910	1510
	LSD (0.05)	NS	120	240	150	300	420
		%					
Dockage	PRE	19	26	49	40	58	30
	EPOST	20	19	49	5	5	7
	LPOST	11	8	19	15	4	3
	Check	27	29	64	47	65	41
	LSD (0.05)	5	5	10	4	8	5

[a] Pooled over two locations.

[b] Abbreviations: Std. red. = stand reduction; EPOST = early postemergence; LPOST = late postemergence.

CHAPTER III

HERBICIDES IMPREGNATED ONTO GRANULAR FERTILIZER CARRIERS FOR BROADLEAF WEED CONTROL

Herbicides Impregnated onto Granular Fertilizer Carriers for Broadleaf Weed Control.[1]

JEFFREY A. KOSCELNY and THOMAS F. PEEPER[2]

Abstract. Field experiments were conducted to compare the efficacy of sulfonylurea herbicides impregnated on granular fertilizers with broadcast spray applications for annual broadleaf weed control in winter wheat. Henbit and bushy wallflower were controlled by chlorsulfuron or triasulfuron impregnated onto diammonium phosphate granular fertilizer applied PPI. Granular urea fertilizer was not an acceptable carrier for POST applications of these sulfonylurea herbicides for annual broadleaf weed control. **Nomenclature:** Chlorsulfuron, 2-chloro-N-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]benzesulfonamide; triasulfuron, 2-(2-chloroethoxy)-N-[[(4-methoxy-6-methyl-1,3,5-triazin-2-

---

[1] Received for publication _____ and in revised form _____. Approved for publication by the Director, Okla. Agric. Exp. Sta., Okla. State Univ., Stillwater, OK 74078.

[2] Sr. Agriculturist and Prof., respectively, Dep. Agron., Okla. State Univ., Stillwater, OK 74078.

yl)amino]carbonyl]benzenesulfonamide; bushy wallflower, Erysimum repandum L. #[3] ERYRE; henbit, Lamium amplexicaule L. #LAMAM; winter wheat, Triticum aestivum L.

Additional index words: chlorsulfuron, triasulfuron, ERYRE, LAMAM, Polygonum convolvulus, POLCO.

INTRODUCTION

Broadleaf weeds are present in almost every wheat field in the Southern Region at varying densities (5). Bushy wallflower, henbit, and wild buckwheat (Polygonum convolvulus L.) are in the top ten most common weeds in wheat in Oklahoma (4). An estimated one million hectares of wheat in Oklahoma annually receive an application of herbicides, primarily sulfonylurea herbicides, for broadleaf weed control (3). The primary objective of these herbicide applications is to have weed-free fields at harvest and not to increase yield (11). Yield increases due to broadleaf weed control are atypical (11, 12).

Two sulfonylurea herbicides, chlorsulfuron and triasulfuron, effectively control most annual broadleaf weeds in winter wheat including bushy wallflower and wild

---

[3] Letters following this symbol are a WSSA approved computer code from Composite List of Weeds, Revised 1989. Available from WSSA, 1508 West University Ave., Champaign, IL 61821-3133.

buckwheat (9, 12, 13). However, triasulfuron is less effective in controlling henbit than chlorsulfuron when applied POST (9). These herbicides, when properly applied, cause few visual injury symptoms on wheat other than occasional stunting (2, 6, 10).

These herbicides are usually applied as liquid sprays with either water or liquid fertilizer as the herbicide carrier. When granular fertilizer is used in wheat, herbicide application requires a second trip across the field. If the herbicide could be applied with either granular or liquid fertilizer, then wheat growers who wanted to apply both herbicide and fertilizer simultaneously could choose the lower cost form of fertilizer.

Herbicide impregnated granular fertilizers have been successfully used in several row crops (1, 7, 8, 14). However, no research has been conducted in wheat to determine whether chlorsulfuron and triasulfuron can control broadleaf weeds when applied with granular fertilizer carrier. The objective of this research was to evaluate the efficacy of chlorsulfuron and triasulfuron impregnated on granular fertilizer applied PPI or POST for broadleaf weed control in winter wheat.

MATERIALS AND METHODS

General. Field experiments were conducted to compare the efficacy of chlorsulfuron and triasulfuron impregnated on granular diammonium phosphate (DAP)[4] fertilizer applied PPI or urea fertilizer applied POST with conventional spray applied POST broadcast herbicide treatments. The design for each experiment was a randomized complete block with a factorial arrangement of treatments and three or four replicates. Plot size was 2 by 7.6 m.

Fifteen hundred gram aliquots of granular DAP or urea fertilizer were spread evenly on a 0.5 by 1 m sheet of polyethylene. Appropriate amounts of the herbicides were applied in 30 ml of water to the dry fertilizer. The herbicide impregnated fertilizer was then thoroughly mixed and air-dried for approximately 30 minutes with occasional mixing.

A 1 m wide Gandy Turf Tender[5] fertilizer spreader was used to apply the herbicide impregnated fertilizer making two side-by-side passes through each plot. For comparison with a traditional practice, the same herbicides and rates were spray-applied POST. These treatments were applied with a CO_2 backpack sprayer in a total volume of 187 l/ha.

---

[4] Abbreviations: DAP = granular diammonium phosphate fertilizer.

[5] Gandy Co. Mfg., 528 Gandrud Rd., Owatonna, MN 55060.

Checks without herbicide were included in all experiments. Additional fertilizer was broadcast according to soil test recommendations for a maximum expected grain yield of 3360 kg/ha, with all plots receiving equal fertilizer.

Broadleaf weed control was visually evaluated based on a scale of 0 to 100 where 0 = no control and 100 = complete control. Grain yield was obtained by harvesting the plots at maturity with a small plot combine. Harvested samples were cleaned with a small commercial seed cleaner to remove the chaff and straw. Wheat grain yield, adjusted to 13.5% moisture, was determined after cleaning. All data were statistically analyzed and means separated with protected LSDs at the P = 0.05 level. Weed control data were subjected to arcsin square root transformations before analyses. These transformations did not affect data interpretation and original data are reported. Where possible, data were pooled across locations and years.

DAP carrier. Five experiments were conducted during the 1991-92 and 1994-95 winter wheat growing seasons. Chlorsulfuron at 9 and 18 g/ha and triasulfuron at 15 and 30 g/ha were applied PPI impregnated on 112 kg/ha of granular DAP. Untreated DAP was applied to all other plots at this rate. These treatments were then incorporated 2.5 to 5 cm deep with an s-tine harrow equipped with rolling baskets one to two weeks before final tillage and seeding. At all sites, an activating rainfall was received within 3 days after treatment.

Following final tillage with the above mentioned s-tine harrow operated approximately 5 cm deep, hard red winter wheat was seeded at 67 kg/ha in 20 cm rows. The same herbicide treatments were broadcast POST in water carrier. Table 1 lists the POST treatment application dates, rainfall, wheat and weed stages and soil information for each of the sites.

DAP carrier rate. Adjacent to each DAP carrier site, an experiment was established to compare DAP carrier rates. Chlorsulfuron at 9 g/ha was applied PPI using 56, 112, and 224 kg/ha of DAP carrier. Untreated DAP was applied at the same rates to plots which later received a POST treatment of chlorsulfuron at 9 g/ha and to untreated checks. Incorporation, seeding, and POST applications were as described above.

Urea carrier for POST treatments. Four experiments were conducted during the 1990-91 and 1991-92 winter wheat growing seasons to evaluate PRE wild buckwheat control with chlorsulfuron at 9 and 18 g/ha and triasulfuron at 15 and 30 g/ha applied prior to wild buckwheat emergence. The herbicide treatments were applied with fertilizer grade granular urea or with water carrier. The urea carrier rate was 112 kg/ha. Treatment dates, rainfall, wheat stage and soil information are listed in Table 1.

Fallow. Experiments were conducted during the 1990-91 and 1991-92 winter wheat growing seasons on fallow fields to evaluate the efficacy of chlorsulfuron at 9 and 18 g/ha and triasulfuron at 15 and 30 g/ha when applied POST either impregnated on prilled urea fertilizer or spray applied. Bushy wallflower and henbit were the target weed species. Treatment dates, rainfall, weed stages and densities and soil information are listed in Table 1.

RESULTS AND DISCUSSION

DAP carrier. An interaction between herbicide treatment and carrier was detected in the henbit control data pooled over locations (Table 2). Chlorsulfuron applied with either DAP or water was effective for henbit control. However, triasulfuron applied with DAP carrier was more efficacious for henbit control than the spray-applied POST treatments of triasulfuron. More effective control of henbit with chlorsulfuron than triasulfuron applied POST was expected and has been previously reported (9).

An interaction between location, herbicide treatment and carrier was detected in the bushy wallflower control data. At NARS-92, the herbicide impregnated on DAP was as effective or more effective than the spray-applied treatments. At Orlando, triasulfuron at 30 g/ha was the only treatment that was as effective when applied with DAP carrier as with water. There were no significant differences in bushy wallflower control at NARS-95 where the bushy wallflower population was only 4 plants/m^2.

Wheat yield was affected by broadleaf weed control at only one of the five sites. At Orlando, averaged over herbicide treatments, the herbicide impregnated DAP treatments averaged 950 kg/ha while the spray-applied POST treatments increased yield to 1080 kg/ha (LSD 0.05 = 90).

DAP carrier rate. An interaction between location and DAP rates was detected and data are presented by location. Averaged over DAP rates, henbit control was increased slightly when DAP carrier was used instead of water at NARS-92 (Table 3). However, at PARS-92 and SARS-92, henbit control was reduced when the DAP carrier was used. At PARS-92, 5.6 cm of rainfall was received in the five days following application of the DAP carrier treatments which could have resulted in movement of the herbicide downward in this coarse textured, low organic matter content soil below the germinating weed seeds. At SARS-92, a cloddy soil surface and wet, sticky soil underneath resulted in less than desirable soil flow for incorporation.

Henbit control was influenced by DAP rates at only one of the five sites. At PARS-92, henbit control was 80, 80, and 99% when 56, 112, or 224 kg/ha of DAP carrier was used, respectively. Henbit control did not differ with carrier or DAP rates at the NARS-95 or Orlando sites.

Bushy wallflower control was increased slightly at NARS-92 but decreased 5% at Orlando when herbicide impregnated DAP was used as the carrier instead of water. At NARS-95, bushy wallflower control did not differ between treatments. Wheat yield was unaffected by broadleaf weed control at all sites.

Urea carrier for POST treatments. Pooled over locations and herbicide treatments, wild buckwheat control was influenced by carrier. Herbicide impregnated urea controlled wild buckwheat only 40% while the spray-applied POST treatments controlled 60% (LSD 0.05 = 10).

Averaged over carriers, wild buckwheat control varied with herbicide treatment (Table 4). At all four sites, chlorsulfuron at 18 g/ha controlled wild buckwheat better than chlorsulfuron at 9 or triasulfuron at 15 g/ha. At two of the four sites, chlorsulfuron at 18 g/ha controlled wild buckwheat better than triasulfuron at 30 g/ha. Wheat yield was unaffected by any treatment or carrier at any site.

Fallow. An interaction between carrier and herbicide treatments was detected in the henbit and bushy wallflower control data (Table 5). At both sites, the herbicides applied with urea carrier were less effective than the spray-applied treatment for POST henbit control. At NARS-

91, henbit control with spray-applied triasulfuron at 15 g/ha was less than with spray-applied chlorsulfuron at either rate. At NARS-92, henbit control with triasulfuron applied with water carrier was less than control with chlorsulfuron at 18 g/ha applied with water.

Bushy wallflower control, pooled over the two sites, was reduced when urea carrier was used instead of water carrier. Within the urea carrier treatments, chlorsulfuron at 18 g/ha controlled bushy wallflower better than chlorsulfuron at 9 or triasulfuron at 15 g/ha, but was not more effective than triasulfuron at 30 g/ha.

Thus, PPI granular fertilizer applications were successful carriers for sulfonylurea herbicides applied for henbit and bushy wallflower control, except when the soil was very cloddy or excessive rainfall was received immediately after application. Rate of DAP did not affect the performance of these herbicides. POST treatments using granular urea fertilizer were less successful than broadcast sprays with water carrier. This difference was attributed to lack of foliar uptake when a granular carrier was used.

LITERATURE CITED

1. Achorn, F. 1982. Uniform application is essential with dry bulk impregnated fertilizer. Fert. Prog. 139(1):34-45.
2. Anderson, R.L. 1986. Metribuzin and chlorsulfuron effects on grain of treated winter wheat (Triticum aestivum). Weed Sci. 34:734-737.
3. Bloyd, B.L. and J.D. Cole. 1992. Oklahoma Agricultural Statistics. U.S. Dept. Agric. Natl. Agric. Stat. Ser. and Okla. State Dept. Agric. p. 27.
4. Dowler, C.C. 1994. Weed survey-southern states grass crops subsection. Proc. South. Weed Sci. Soc. 47:293.
5. Elmore, C.D. 1988. Weed survey-southern states grass crop subsection. Proc. South. Weed Sci. Soc. 41:406-408.
6. Ferreira, K.L, T.K. Baker, and T.F. Peeper. 1990. Factors influencing winter wheat (Triticum aestivum) injury from sulfonylurea herbicides. Weed Technol. 4:724-730.
7. Hackett, H. 1982. Dealer experiences in the plant and field. Fert. Prog. 139(1):29-34.
8. Janzen, K. 1982. Dry bulk impregnation in use over 10 years. Fert. Prog. 139(1):28-29.

9. Klingaman, T.E. and T.F. Peeper. 1989. Weed control in winter wheat (Triticum aestivum) with chlorsulfuron and CGA 131036 and comparison of mode of action. Weed Technol. 3:490-496.
10. Martin, D.A., S.D. Miller, and H.P. Alley. 1989. Winter wheat (Triticum aestivum) response to herbicides applied at three growth stages. Weed Technol. 3:90-94.
11. Scott, R.C. and T.F. Peeper. 1994. Economic returns from broadleaf weed control in hard red winter wheat (Triticum aestivum). Weed Technol. 8:797-806.
12. Scott, R.C., T.F. Peeper, and J.A. Koscelny. 1995. Winter wheat (Triticum aestivum) yield response to winter annual broadleaf weed control. Weed Technol. 9:(in press).
13. Thompson, C.R. and D.C. Thill. 1992. Interrupted windgrass and broadleaf weed control in soft white winter wheat. Res. Prog. Rep. West. Soc. Weed Sci. p. 175-176.
14. Wells, K.L. and J.D. Green. 1991. Using solid, bulk blended mixed-grade fertilizers. Univ. of Kentucky, Coop. Ext. Serv. Dept. of Agron. Soil Sci. News and Views. 12(4). 3 pp.

Table 1. POST treatment application dates, rainfall, wheat and weed growth stages and soil information for the 11 experiment sites.[a]

		POST treatment		Wheat	Henbit		Bushy wallflower		Soil			
Car.	Site	Date	Rain	tillers[b]	Stage[c]	Dens.	Stage[d]	Dens.	Series	Tex.	pH	OM
			DAT	no./plt	cm	no./m^2	cm	no./m^2				%
DAP	NARS-92	11-26-91	6	4 to 6	9	86	10	135	Norge	SCL	6.5	1.6
	NARS-95	11-26-94	10	6 to 10	10	32	5	4	Norge	SCL	6.6	1.6
	Orlando	11-26-94	10	4 to 10	10	54	5	54	Port	L	5.2	1.4
	PARS-92	11-26-91	6	2 to 6	4	54	—	0	Teller	SL	6.5	1.1
	SARS-92	11-26-91	6	3 to 9	4	38	—	0	Bethany	L	6.3	1.8
Urea	Kildare	02-06-91	39	2 to 4	—	0	—	0	Newtonia	L	5.2	2.3
	Newkirk	02-06-91	39	1 to 5	—	0	—	0	Kirkland	CL	5.6	2.2
	Ponca	02-13-92	11	2 to 8	—	0	—	0	Kirkland	CL	5.8	2.0
	SARS-91	11-30-90	17	3 to 5	—	0	—	0	Kirkland	CL	6.1	1.4
	NARS-91	11-30-90	17	—	9	43	12	323	Easpur	SCL	6.3	1.6
	NARS-92	12-18-91	1	—	9	54	12	108	Norge	SCL	6.1	1.5

Table 1. (continued.)

---

[a] Abbreviations: Car. = carrier; Tex. = texture; OM = organic matter; DAT = days after treatment; plt = plant; DAP = diammonium phosphate fertilizer; SCL = sandy clay loam; L = loam; SL = sandy loam; CL = clay loam; NARS = North Agronomy Research Station; PARS = Perkins Agronomy Research Station; SARS = Stillwater Agronomy Research Station.

[b] Urea carrier, NARS-91 and NARS-92 sites were in fallow fields.

[c] Henbit stem length.

[d] Bushy wallflower rosette diameter.

Table 2. Interaction of carrier and herbicide treatment on henbit control pooled over five sites and bushy wallflower control at two sites.

				Bushy wallflower			
		Henbit		NARS-92		Orlando	
Herbicide	Rate	DAP[a]	Water	DAP	Water	DAP	Water
	g/ha	%					
Chlorsulfuron	9	92	90	98	98	92	96
	18	95	97	100	99	89	97
Triasulfuron	15	87	78	99	91	89	94
	30	95	77	99	96	94	94
LSD (0.05)		7		4		4	

[a] DAP is granular diammonium phosphate fertilizer.

Table 3. Effect of carrier, averaged over diammonium phosphate rate, on henbit and bushy wallflower control with chlorsulfuron at 9 g/ha.[a]

	Henbit					Bushy wallflower		
Carrier	NARS-92	NARS-95	Orlando	PARS-92	SARS-92	NARS-92	NARS-95	Orlando
					%			
DAP	97	99	93	76	44	97	99	91
Water	94	98	92	93	91	95	100	96
LSD (0.05)	2	NS	NS	14	18	1	NS	3

[a] Abbreviations: NARS = North Agronomy Research Station; PARS = Perkins Agronomy Research Station; SARS = Stillwater Agronomy Research Station; DAP = granular diammonium phosphate fertilizer.

Table 4. Wild buckwheat control with chlorsulfuron or triasulfuron at four sites averaged over carrier.

Herbicide	Rate	Kildare	Newkirk	Ponca	SARS-91[a]
	g/ha		%		
Chlorsulfuron	9	39	30	59	42
	18	57	46	83	84
Triasulfuron	15	38	10	59	60
	30	47	10	79	91
LSD (0.05)		7	15	18	22

[a] SARS-91 = Stillwater Agronomy Research Station in 1991.

Table 5. Effect of carrier and herbicide treatment on POST henbit control each year and POST bushy wallflower control pooled over two years at the North Agronomy Research Station in 1991 and 1992.

		Henbit					
		NARS-91		NARS-92		Bushy wallflower	
Herbicide	Rate	Urea	Water	Urea	Water	Urea	Water
	g/ha	%					
Chlorsulfuron	9	30	100	50	83	47	100
	18	47	100	63	98	60	100
Triasulfuron	15	30	80	32	67	45	98
	30	47	89	40	70	53	99
LSD (0.05)		12		20		11	

CHAPTER IV

INFLUENCE OF WINTER WHEAT (*Triticum aestivum*) CULTIVAR AND ROW SPACING ON CHEAT (*Bromus secalinus*) INTERFERENCE

Influence of Winter Wheat (*Triticum aestivum*) Cultivar and Row Spacing on Cheat (*Bromus secalinus*) Interference.[1]

JEFFREY A. KOSCELNY, THOMAS F. PEEPER, EUGENE G. KRENZER, JR. and JOHN B. SOLIE[2]

Abstract. Five field experiments were conducted to determine whether wheat cultivar and row spacing influenced reductions in forage and grain yields due to cheat. Pooled over cultivars and locations, the fall forage data indicated that 7.5-, 15.0-, and 23.0-cm wide row spacings were suppressive, caused upright growth, and did not inhibit cheat vegetative growth, respectively. Pooled over locations, when wheat was seeded in 7.5-cm wide rows, cultivar selection had little influence on winter and total forage production as influenced by the presence of cheat. In wider rows,

---

[1] Received for publication _____ and in revised form _____. Approved for publication by the Director, Okla. Agric. Exp. Sta., Okla. State Univ., Stillwater, OK 74078.

[2] Sr. Agriculturist and Profs., respectively, Dep. Agron., and Prof., Dep. Biosys. and Agric. Eng., Okla. State Univ., Stillwater, OK 74078,

cultivar did influence the response to cheat. Pooled over three sites in one year, grain yield reductions due to cheat were less when 'Karl' wheat was seeded than with the other cultivars. Similarly, dockage due to cheat was lowest when Karl was seeded at these sites. Grain yields were inversely correlated to forage yields indicating that grain yield was reduced by the removal of forage. **Nomenclature:** Cheat, Bromus secalinus L.#[3] BROSE; wheat, Triticum aestivum L. 'AGSECO 7846', 'Cimarron', 'Karl', '2180'.

Additional index words: Winter wheat, forage production.

INTRODUCTION

Highly selective and reliable herbicides are unavailable for cheat control in wheat (1, 5, 14) thus, research on cultural control practices remains important. Moldboard plowing and stubble burning are often successful in reducing cheat infestations (6, 17), but these traditional practices are becoming less environmentally acceptable due to concerns about wind and water erosion and air pollution.

By 1995, conservation compliance guidelines will require the use of minimum tillage wheat farming on approximately 20 percent of the acreage available for wheat production in

---

[3] Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Revised 1989. Available from WSSA, 309 W. Clark St., Champaign, IL 61820.

Oklahoma. Earlier attempts to adopt alternative reduced tillage wheat production systems in Oklahoma have failed because weeds, particularly the Bromus species, have rapidly infested the fields (4). Thus, other cultural practices are needed to help mitigate yield loss from cheat.

Reduced wheat row spacing may mitigate yield losses associated with cheat infestations. Reducing wheat row spacing from the traditional 20.3 or 25.4 to 7.5 cm increased wheat yield by about 11% (9, 11, 16). A significant cultivar effect on grain yield and cheat seed yield was also found, with some cultivars more consistently suppressing cheat than others. However, this research was conducted under unforaged conditions and little is known about the effects of grazing on wheat seeded in narrow row spacings.

In Oklahoma, wheat is often used as a dual purpose crop. One-third to one-half of wheat planted annually is grazed by cattle (Bos spp.) from November to early March and harvested for grain in June. Grazing removes the wheat canopy, allowing greater light penetration, and could increase the competitive advantage of cheat, which is shorter in stature, during vegetative growth stages. In Oklahoma, grazing cheat infested wheat increased dockage, due to cheat, by 9% (10).

Wheat cultivars differ in the forage produced in a given year (7, 12, 13). These differences are usually a function of the variety itself as well as variations in growing conditions. Because early-emerging weeds usually interfere with crops more than late-emerging weeds (2, 15), winter wheat cultivars with considerable prostrate fall and winter growth may be more competitive with cheat than cultivars with erect vegetative growth habits. Winter wheat tillering ability, canopy diameter, and mature plant height affected the competitiveness of wheat cultivars with downy brome (*Bromus tectorum* L.) in Nebraska (3).

Thus, selecting a highly competitive wheat cultivar with good forage producing characteristics, and seeding it in ultranarrow rows to suppress cheat, could counteract some effects of cheat infestations on wheat yield. To test this hypothesis, this research compared the effect of cheat on forage and wheat grain yields of four popular, high yielding winter wheat cultivars with differing growth habits and forage producing characteristics that were seeded in three row spacings.

MATERIALS AND METHODS

Five field experiments were conducted during the 1991-92 and 1992-93 winter wheat growing seasons. A randomized complete block design with a factorial arrangement of treatments and six replicates was used for each experiment. The three factors included wheat cultivar, row spacing, and the presence or absence of cheat in the plot. Following conventional seedbed preparation, locally harvested cheat seed was hand broadcast at 50 kg/ha on appropriate plots. Cheat seed was incorporated with the grain drill as planting occurred.

The four hard red winter wheat cultivars 'AGSECO 7846', 'Cimarron', 'Karl', and '2180' were chosen for their different growth habits and forage production. AGSECO 7846 and Cimarron have semi-prostrate growth habits, Karl is intermediate, and 2180 has an upright growth habit. All are semi-dwarf cultivars adapted to the Southern Great Plains. Machine harvested forage production in the fall by 2180 typically exceeds production by Cimarron and Karl which in turn exceed AGSECO 7846 (13). Forage produced in the winter by 2180 usually exceeds that produced by the other cultivars. Grain yields of these cultivars are similar. In trials conducted statewide during the time this research was conducted, AGSECO 7846, Cimarron, Karl, and 2180 ranked 8, 6, 1, and 5, respectively, when compared to 14 other commonly grown cultivars (13).

The four cultivars were seeded with an experimental seeder with openers spaced 7.5 cm apart. Plugs were inserted into seed meter inlets to change row spacing by blocking rows. Each plot was 2.1 by 7.5 m and contained twenty-four 7.5-cm, twelve 15.0-cm, or eight 23.0-cm wide rows. The wheat was planted 2.5 or 3 cm deep at 67 kg/ha. Table 1 contains experiment designations, seeding and forage removal dates, and soil information for the five sites.

Fertilizer was incorporated before seeding in accordance with soil test recommendations to obtain nitrogen, phosphorus, and potassium levels in the topsoil at all locations adequate for 4000 kg/ha winter wheat grain yields. Additional nitrogen was broadcast over-the-top in January to replace soil nitrogen removed with the fall harvested forage, based on 30 kg of nitrogen required for every 1000 kg of harvested forage (8). No attempt was made to apply additional nitrogen after winter forage removal. It was estimated that sufficient nitrogen was available for the anticipated grain yields.

Propiconizol [1-[[2-(2,4-dichlorophenyl)-4-propyl-1,3-dioxolan-2-yl]methyl]-1H-1,2,4-triazole] at 130 g ai/ha was applied for powdery mildew (Erysiphe graminis DC f. sp. tritici E. Marchal) control in late March or early April.

Both forage and grain yields were determined for each plot. In the fall or winter when the wheat canopy reached a height of 20 cm and again at the first indication of jointing, a self-propelled sicklebar clipper was used to harvest forage about 6 cm above the soil surface from a 1.5 by 6.4 m area from each plot. After samples were taken, remaining forage was removed from all plots. No attempt was made to separate wheat forage from cheat forage. Fall, winter, and total forage yields were expressed on an oven-dry (35 C to constant weight) basis.

Grain yield was obtained by harvesting the plots in June with a small plot combine adjusted to retain most of the cheat seed with the grain. Harvested samples were cleaned with a small commercial seed cleaner to remove the chaff and straw, then recleaned to separate the cheat and wheat seeds. Wheat grain yield, adjusted to 13.5% moisture, was determined after recleaning. Material removed by the second cleaning operation was considered dockage and consisted of cheat seed and small amounts of very shriveled wheat seed. Dockage was determined as a percentage by weight of the sample after the chaff and straw were removed.

Percent change due to cheat was calculated for fall, winter and total forage and grain yields by comparing the yield of each cheat-infested plot with its respective cheat-free plot. Dockage due to cheat was calculated by subtracting the amount of shriveled wheat seed in the cheat-free plots from the dockage in the cheat-infested plots. Calculated data were subjected to analysis of variance and means separated with protected least significant differences. Data were pooled when interactions were absent. Correlation analyses were used to search for relationships between grain and forage yields.

RESULTS AND DISCUSSION

No interactions were detected in fall forage production data between any factors at any location. Mean fall forage yield in cheat-infested plots was 600 kg/ha. Pooled over cultivars and locations, the presence of cheat increased fall forage 37% when the wheat was seeded in 15-cm wide rows compared to increases of 10 and 8% when the wheat was seeded in 7.5- or 23-cm wide rows (LSD 0.1 = 24). These data suggest that the wheat seeded in 7.5-cm wide rows did suppress the cheat. Conversely, wheat in 23-cm wide rows was relatively uninhibiting to cheat growth allowing it to remain in its usual prostrate growth habit. Seeding the wheat in 15-cm wide rows may have caused a more upright cheat growth habit so more cheat was tall enough to be clipped by the forage harvester.

Row spacing did not influence winter forage yields among cultivars in cheat-free wheat (Table 2). However, pooled over locations, an interaction between cultivar and row spacing was detected in the reduction in winter forage due to cheat data. When the cultivars were seeded in 7.5-cm wide rows, no differences in forage yield among cultivars due to cheat were detected. However, when seeded in 15- or 23-cm wide rows the influence of cheat was cultivar dependent. Winter forage from cheat infested AGSECO 7846 seeded in 15-cm wide rows was 31% greater than forage from respective cheat-free plots. Since AGSECO 7846 is a poor forage producing cultivar, this increase was attributed to increased harvesting of cheat in these plots rather than to AGSECO 7846's competitiveness against cheat.

Similar results were found in the total forage production data for 1992 (Table 2). Row spacing did not influence total forage production in the cheat-free plots in 1992. Conversely, row spacing did influence the cheat-infested wheat. When the cultivars were seeded in 7.5-cm wide rows, cultivar selection did not influence the change in forage due to cheat. However, when seeded in 15- or 23-cm wide rows, cultivar selection had a greater impact on the amount of forage produced.

In 1993, mean total forage yield in cheat-infested plots was 1164 kg/ha. Pooled over locations and cultivars in 1993, the presence of cheat increased total forage production 14% when the wheat was seeded in 15-cm wide rows but reduced total forage production by 4 or 5% when the wheat was seeded in 7.5- or 23-cm wide rows, respectively (LSD 0.1 = 16).

Cheat-free grain yields varied by cultivar (Table 3). In 1992, pooled over row spacings and locations, Karl was the highest yielding cultivar. However, in both experiments in 1993, AGSECO 7846 was the highest yielding cultivar. At all sites, 2180 was the lowest yielding cultivar.

Grain yield reductions due to cheat also varied by cultivar (Table 3). Pooled over row spacings in 1992, Karl wheat was the least affected by the presence of cheat with a yield reduction of 31% while Cimarron was the least competitive with a yield reduction of 48%. At Perkins in 1993, reductions due to cheat did not differ among cultivars. At Stillwater in 1993, Karl and 2180 were the least competitive cultivars. At the 1993 sites, winter forage harvesting was unavoidedly delayed due to adverse weather conditions until mid-March which may have had a negative effect on the ability of the higher winter forage producers, Karl and 2180, to compete with the cheat. Wheat row spacing did not influence grain yield reductions due to cheat at any location.

There was no correlation between cheat-free grain yield and yield reductions due to cheat in the 1992 experiments (r = -0.06, P = 0.36) or at Stillwater in 1993 (r = 0.17, P = 0.16) indicating that the genetic potential of a cultivar alone does not determine its competitiveness with cheat. Cheat-free grain yield was positively correlated (r = 0.36, P = 0.002) with yield reduction due to cheat at Perkins in 1993. However, at this site, yield reductions due to cheat were not different.

Dockage due to cheat was also affected by cultivar selection. Pooled over three row spacings and three locations, Karl had the least amount of dockage in 1992, while Cimarron and 2180 had the highest amounts of dockage. At Perkins in 1993, Karl and AGSECO 7846 had the least dockage. At Stillwater in 1993, Karl and 2180 had higher dockage than did AGSECO 7846 or Cimarron. Dockage due to cheat was not affected by row spacing at any location.

Cultivar grain yields were inversely correlated to forage yields in 1992 (Table 4). Although the quantity of forage removed in both fall and winter influenced grain yield, the quantity removed in the winter seemed to have the greatest (larger correlation coefficients) influence. Karl wheat grain yield was negatively correlated with fall forage removal under cheat-infested conditions only. At Perkins in 1993 where grain yield reductions due to cheat did not differ among cultivars, fall forage removal affected only Karl in cheat-infested conditions and AGSECO 7846 in cheat-free conditions. Cheat-free 2180 was the only cultivar affected by winter forage removal. At Stillwater in 1993, there was a positive correlation between fall forage removal and grain yield on Karl and 2180. At this site, the fall forage was not removed until December 23 due to adverse weather conditions.

Thus, time of forage removal had a impact on the competitiveness of these cultivars against cheat. The delayed winter forage harvest demonstrated the devastating effects of late grazing on the competitiveness of high forage and/or grain yielding cultivars such as Karl and 2180. However, when the forage was harvested in a timely fashion, as in 1992, these cultivars were better able to compete with cheat.

There was no indication in these studies that wheat growth habit is a good indicator of competitiveness against cheat of a cultivar seeded in ultranarrow rows. At four of the five sites, the yield potential of the cultivar was not the only factor determining the effect of cheat on wheat after fall and winter forage was removed. In these experiments, row spacing had the largest impact on wheat forage production while cultivar selection and other undefined factors influenced grain yield and dockage due to cheat.

LITERATURE CITED

1. Baker, T.K. and T.F. Peeper. 1990. Differential tolerance of winter wheat (*Triticum aestivum*) to cyanazine and triazinone herbicides. Weed Technol. 4:569-575.
2. Carter, H.W., H.W. Norton, and G.H. Dungan. 1957. Wheat and cheat. Agron. J. 49:261-267.
3. Challaiah, R.E., O.C. Burnside, G.A. Wicks, and V.A. Johnson. 1986. Competition between winter wheat (*Triticum aestivum*) cultivars and downy brome (*Bromus tectorum*). Weed Sci. 34:689-693.
4. Davidson, J.M. and P.W. Santlemann. 1973. An evaluation of various tillage systems for wheat. Okla. Agric. Expt. Stn. Bull. B-711. 17 pp.
5. Driver, J.E., T.F. Peeper, and J.A. Koscelny. 1993. Cheat (*Bromus secalinus*) control in winter wheat (*Triticum aestivum*) with sulfonylurea herbicides. Weed Technol. 7:851-854.
6. Fenster, C.R. and T.M. McCalla. 1970. Tillage practices in western Nebraska with a wheat-fallow rotation. Nebr. Agric. Exp. Stn. Bull. 507.
7. Huffine, W.W., N.J. Adams, C.L. Dewald, G.R. Waller, and D.L. Weeks. 1960. Production characteristics of Oklahoma forages: Small Grains. Okla. Agric. Exp. Stn. Bull. B-546.

8. Johnston, R.A., G.V. Johnson, and B.B. Tucker. 1983. Guidelines for topdressing wheat in 1983. Current Rep. 2234. Coop. Ext. Serv., Div. Agric., Oklahoma State Univ., Stillwater, OK 4 p.

9. Koscelny, J.A., T.F. Peeper, J.B. Solie, and S.G. Solomon, Jr. 1990. Effect of wheat (*Triticum aestivum*) row spacing, seeding rate, and cultivar on yield loss from cheat (*Bromus secalinus*). Weed Technol. 4:487-492.

10. Koscelny, J.A. and T.F. Peeper. 1990. Effect of grazing cheat (*Bromus secalinus*)-infested wheat (*Triticum aestivum*) on both species. Weed Technol. 4:565-568.

11. Koscelny, J.A., T.F. Peeper, J.B. Solie, and S.G. Solomon, Jr. 1991. Seeding date, seeding rate, and row spacing affect wheat (*Triticum aestivum*) and cheat (*Bromus secalinus*). Weed Technol. 5:707-712.

12. Krenzer, E. and D. Doye. 1988. Economic evaluation of wheat varieties grown for forage plus grain. Current Rep. 2100. Coop. Ext. Serv., Div. Agric., Oklahoma State Univ., Stillwater, OK 7 pp.

13. Krenzer, G., L. Littlefield, and R. Austin. 1992. Wheat variety trial results - 1992. Oklahoma State Univ., Coop. Ext. Serv., PT 92-3, vol. 4, no. 3.

14. Runyan, T.J., W.K. McNeil, and T.F. Peeper. 1982. Differential tolerance of wheat (*Triticum aestivum*) cultivars to metribuzin. Weed Sci. 30:94-97.

15. Rydrych, D.J. 1974. Competition between winter wheat and downy brome. Weed Sci. 22:211-214.

16. Solie, J.B., S.G. Solomon, Jr., K.P. Self, T.F. Peeper, and J.A. Koscelny. 1991. Reduced row spacing for improved wheat yields in weed-free and weed-infested fields. Trans. ASAE 34:1654-1660.

17. Wicks, G.A. 1984. Integrated systems for control and management of downy brome (_Bromus_ _tectorum_) in cropland. Weed Sci. 32, Suppl. 1:26-31.

Table 1. Seeding and forage removal dates and soil descriptions for the five sites.

		Forage removal		Soil		
Site	Seeding	Fall	Winter	Classification	pH	OM[a]
Lahoma	9-19-91	01-09-92	2-20-92	Pond creek, L (fine-silty, mixed, thermic Pachic Argiustoll)	5.6	1.7
Perkins-92	9-26-91	12-18-91	2-21-92	Teller, SL (fine-loamy, mixed, thermic Udic Argiustoll)	6.5	0.7
Stillwater-92	9-10-91	12-10-91	2-16-92	Easpur, L (fine-loamy, mixed, thermic Fluventic Haplustoll)	5.8	0.6
Perkins-93	9-11-92	12-03-92	3-11-93	Teller, SL (fine-loamy, mixed, thermic Udic Argiustoll)	6.4	1.4
Stillwater-93	9-04-92	12-23-92	3-16-93	Pulaski, SL (coarse-loamy, mixed thermic Typic Ustifluvents)	6.2	0.6

[a] Abbreviations: OM = organic matter.

Table 2. Interactions of row spacing and cultivar on forage yield cheat-free wheat and change due to cheat in winter forage production, pooled over locations in 1992 and 1993 and total forage production in 1992.

	Row	Winter forage				Total forage in 1992			
Response	spacing	AGSECO	Cimarron	Karl	2180	AGSECO	Cimarron	Karl	2180
	cm	kg/ha							
Cheat-free	7.5	750	790	800	1010	1440	1560	1530	2010
	15.0	730	800	830	1050	1460	1600	1570	1900
	23.0	700	720	840	1030	1470	1430	1730	1950
	LSD (0.05)	NS				NS			
		% change							
Due to cheat	7.5	2	5	7	0	2	-7	9	3
	15.0	31	- 9	-9	- 4	16	-9	-7	1
	23.0	13	-21	-3	-10	10	15	-3	-8
	LSD (0.05)	15				NS			
	LSD (0.10)					19			

Table 3. Cultivar grain yield in cheat-free plots and effect of cultivar, pooled over row spacing, on grain yield reduction and dockage due to cheat.

Response	Cultivar	1992	Perkins-93	Still-93
			kg/ha	
Cheat-free grain yield	AGSECO	2570	2780	2410
	Cimarron	2570	2490	2120
	Karl	2700	2400	2230
	2180	1950	2010	1980
	LSD (0.05)	120	200	130
			%	
Reduction due to cheat	AGSECO	43	20	22
	Cimarron	48	23	25
	Karl	31	23	31
	2180	41	24	31
	LSD (0.05)	4	NS	7
			%	
Dockage due to cheat	AGSECO	26	16	24
	Cimarron	32	22	29
	Karl	20	18	37
	2180	34	23	37
	LSD (0.05)	3	3	6

Table 4. Simple linear correlation coefficients of grain yields with fall and winter forage yield.[a]

		1992		Perkins-93		Stillwater-93	
Plots included	Cultivar	Fall	Winter	Fall	Winter	Fall	Winter
All	AGSECO 7846	-0.21*	-0.63***	-0.11	-0.13	0.04	0.21
	Cimarron	0.21*	-0.52***	0.18	0.18	0.00	-0.11
	Karl	-0.18	-0.16	-0.07	0.06	0.39*	0.45**
	2180	-0.22*	-0.46***	0.24	0.03	0.32*	0.36*
Cheat-infested	AGSECO 7846	0.11	-0.80***	0.31	0.14	0.09	0.31
	Cimarron	-0.02	-0.75***	-0.15	-0.19	-0.02	-0.15
	Karl	-0.43**	-0.25	-0.51*	0.15	0.68**	0.60**
	2180	-0.36**	-0.69***	-0.16	-0.41	0.74***	0.13
Cheat-free	AGSECO 7846	0.29*	-0.84***	-0.52*	-0.27	-0.40	0.07
	Cimarron	0.32*	-0.87***	0.29	0.19	-0.01	0.27
	Karl	-0.23	-0.27	0.15	-0.26	0.72***	0.49*
	2180	-0.47***	-0.76***	0.09	-0.49*	0.57***	0.51*

[a] *, **, *** indicate F test significance at $P \le 0.05$, 0.01, and 0.001, respectively.

APPENDIX

Table 1. Effect of triasulfuron and chlorsulfuron plus metsulfuron applied PRE on fall, spring, and total forage production, grain yield, forage and grain net returns, and treatment breakeven benefit requirement, at six experiments.

			Forage production			Grain	Net returns		Treatment	
Expt.	Treatment	Rate	Fall	Spring	Total	yield	Forage	Grain	Cost	Breakeven
		g/ha	kg/ha				$/ha			
C-93	Triasulfuron	30	920	860	1780	2330	45.70	11.30	21.10	42.80
	CLMT[a]	26	990	930	1920	2330	49.10	10.20	24.00	37.20
	Untreated	—	1370	1090	2460	2170	63.00	11.30	0.00	0.00
	LSD (0.05)		NS	NS	NS	NS	NS	NS	—	NS
S-93	Triasulfuron	30	1050	770	1820	2280	46.80	11.00	21.10	37.80
	CLMT[a]	26	1000	780	1780	2320	45.50	11.40	24.00	40.00
	Untreated	—	1220	870	2090	2310	53.50	19.60	0.00	0.00
	LSD (0.05)		NS	NS	220	NS	5.50	3.70	—	11.60
	LSD (0.10)		150	70	—	NS	—	—	—	—
S-94	Triasulfuron	30	600	1230	1830	1360	36.30	-28.10	21.10	19.80

Table 1. (continued.)

	CLMT[a]	26	580	1180	1760	1450	34.90	-24.70	24.00	14.60
	Untreated	—	760	1190	1950	1280	38.50	-22.40	0.00	0.00
	LSD (0.05)		NS	NS	NS	NS	NS	NS	——	NS
	LSD (0.10)		120	NS	110	NS	2.70	NS	——	NS
L-94	Triasulfuron	30	390	400	790	800	15.70	-44.60	21.10	19.00
	CLMT[a]	26	360	300	660	840	13.10	-42.70	24.00	20.80
	Untreated	—	370	420	790	740	15.80	-37.00	0.00	0.00
	LSD (0.05)		NS	NS	NS	NS	NS	5.40	——	14.60
P-93	Triasulfuron	30	450	320	770	2470	19.80	23.30	21.10	35.00
	CLMT[a]	26	400	260	660	2610	16.80	28.70	24.00	29.30
	Untreated	—	420	340	760	2610	19.50	37.80	0.00	0.00
	LSD (0.05)		NS	NS	80	NS	2.10	8.90	——	23.40
	LSD (0.10)		NS	50	——	NS	——	——	——	——
P-94	Triasulfuron	30	1540	1270	2810	1440	55.50	-27.80	21.10	9.90

Table 1. (continued.)

CLMT[a]	26	1330	1380	2710	1490	53.60	-26.30	24.00	10.80
Untreated	—	1540	1460	3000	1250	59.20	-27.50	0.00	0.00
LSD (0.05)		140	NS	NS	170	NS	NS	—	NS

[a] Abbreviations: CLMT = a 5:1 w/w premix of chlorsulfuron plus metsulfuron.

Table 2. Crop injury from three POST herbicide treatments and effects on fall, spring, and total forage production, grain yield, forage and grain net returns, and treatment breakeven requirement, at Stillwater in 1994.

		Crop	Forage production			Grain	Net returns		Treatment	
Treatment[a]	Rate	Injury	Fall	Spring	Total	yield	Forage	Grain	Cost[b]	Breakeven[c]
	– g/ha –	%	kg/ha				$/ha			
TRIA + MET	30 + 158	7	550	1120	1670	1490	33.10	-25.90	33.40	22.10
CLMT + MET	21 + 210	10	470	1020	1490	1540	29.50	-23.40	36.40	24.80
MET	280	13	450	990	1440	1450	28.40	-22.40	21.70	25.00
Untreated	—	——	760	1190	1950	1280	38.50	-22.40	0.00	0.00
LSD (0.05)		4	120	130	190	130	3.80	NS	——	14.80

[a] Abbreviations: TRIA = triasulfuron; MET = metribuzin; CLMT = a 5:1 w/w premix of chlorsulfuron plus metsulfuron.

[b] Cost of the herbicides plus $5.56/ha for application.

[c] Benefit from weed control required to recoup the cost of herbicide use.

Table 3. Crop injury from three POST herbicide treatments and effects on fall, spring, and total forage production, grain yield, forage and grain net returns, and treatment breakeven requirement, at Lahoma in 1994.

		Crop	Forage production			Grain	Net returns		Treatment	
Treatment[a]	Rate	Injury	Fall	Spring	Total	yield	Forage	Grain	Cost[b]	Breakeven[c]
	— g/ha —	%	kg/ha				$/ha			
TRIA + MET	30 + 158	6	220	350	570	930	11.30	-42.40	33.40	24.30
CLMT + MET	21 + 210	6	200	430	630	970	12.50	-43.80	36.40	24.90
MET	280	9	190	300	490	900	9.60	-40.60	21.70	23.90
Untreated	—	—	370	420	790	740	15.80	-37.00	0.00	0.00
LSD (0.05)		4	100	NS	210	90	4.30	4.70	—	10.70

[a] Abbreviations: TRIA = triasulfuron; MET = metribuzin; CLMT = a 5:1 w/w premix of chlorsulfuron plus metsulfuron.

[b] Cost of the herbicides plus $5.56/ha for application.

[c] Benefit from weed control required to recoup the cost of herbicide use.

Table 4. Crop injury from three POST herbicide treatments and effects on fall, spring, and total forage production, grain yield, forage and grain net returns, and treatment breakeven requirement, at Perkins in 1994.

		Crop	Forage production			Grain	Net returns		Treatment	
Treatment[a]	Rate	Injury	Fall	Spring	Total	yield	Forage	Grain	Cost[b]	Breakeven[c]
	– g/ha –	%	kg/ha				$/ha			
TRIA + MET	30 + 158	3	1370	1250	2620	1460	51.90	-30.60	33.40	25.50
CLMT + MET	21 + 210	8	1250	1190	2440	1530	48.30	-27.90	36.40	27.60
MET	280	7	1240	1110	2350	1590	46.50	-21.70	21.70	17.00
Untreated	—	—	1580	1420	3000	1250	59.30	-27.60	0.00	0.00
LSD (0.05)		2	100	180	240	150	4.70	5.90	—	16.50

[a] Abbreviations: TRIA = triasulfuron; MET = metribuzin; CLMT = a 5:1 w/w premix of chlorsulfuron plus metsulfuron.

[b] Cost of the herbicides plus $5.56/ha for application.

[c] Benefit from weed control required to recoup the cost of herbicide use.

Table 5. Machine harvesting efficiency as influenced by four cultivars in three row spacings in the absence of cheat at Perkins in 1995.

Cultivar	Row spacing	Rep	Before forage 11-15-94	Machine forage 11-15-94	Machine efficien 11-15-94	Before forage 03-09-95	Machine forage 03-09-95	Machine efficien 03-09-95	Wheat yield 6-13-95
	inches		—— lbs/acre ——		%	—— lbs/acre ——		%	bu/a
Cimarron	3	1	1565.10	1258.5	80.41	3688.05	625.35	16.96	15.8
		2	2509.54	1262.4	50.30	3813.18	394.51	10.35	12.1
		3	1877.20	1152.0	61.37	3411.15	614.18	18.01	16.8
		4	2154.43	1132.2	52.55	2166.11	264.50	12.21	15.2
		5	2919.37	1116.5	38.24	3481.25	775.58	22.28	12.5
		6	1943.58	1167.7	60.08	3610.13	470.73	13.04	13.9
		Mean	2161.54	1181.5	57.16	3361.65	524.14	15.47	14.4
	6	1	2630.46	1108.6	42.14	3699.88	703.85	19.02	17.0
		2	1935.80	1084.9	56.04	4090.05	407.96	9.97	16.3
		3	2376.77	1087.2	45.74	4644.33	515.56	11.10	19.5
		4	2341.54	1021.8	43.64	2974.07	403.48	13.57	15.9

Table 5. (continued.)

		5	2333.94	1223.0	52.40	3941.88	712.81	18.08	15.3
		6	2388.46	998.1	41.79	3918.51	367.61	9.38	12.7
		Mean	2334.49	1087.3	46.96	3878.12	518.54	13.52	16.1
	9	1	2205.06	1254.5	56.89	3239.44	596.25	18.41	14.9
		2	2041.13	1158.3	56.75	3754.41	345.20	9.19	19.5
		3	1756.29	1077.0	61.32	4191.49	555.90	13.26	17.0
		4	1647.07	1155.9	70.18	2653.82	578.32	21.79	15.7
		5	1931.91	1144.1	59.22	4277.35	587.29	13.73	15.5
		6	1748.50	1159.8	66.33	3286.17	560.39	17.05	14.5
		Mean	1888.33	1158.3	61.78	3567.11	537.23	15.57	16.2
Karl	3	1	2056.71	1167.7	56.78	5268.88	650.05	12.34	11.8
		2	1787.45	1077.0	60.25	4199.28	520.04	12.38	14.2
		3	2181.69	1084.9	49.73	4925.27	497.62	10.10	15.0
		4	2142.57	1140.1	53.21	2177.80	479.69	22.03	12.7
		5	1986.60	1080.2	54.37	4289.21	735.23	17.14	11.9

Table 5. (continued.)

	6	2213.02	1230.9	55.62	3883.28	457.28	11.78	12.1
	Mean	2061.34	1130.1	54.99	4123.95	556.65	14.29	13.0
6	1	4484.29	1183.5	26.39	4808.25	627.63	13.05	12.9
	2	2201.17	1117.2	50.75	4866.85	475.21	9.76	16.1
	3	2095.66	958.6	45.74	4995.52	554.87	11.11	14.6
	4	2458.74	1191.4	48.46	3192.34	390.03	12.22	10.9
	5	2735.79	1045.4	38.21	5912.73	524.52	8.87	16.0
	6	2341.73	1207.2	51.55	3664.66	560.39	15.29	12.8
	Mean	2719.56	1117.2	43.52	4573.39	522.11	11.72	13.9
9	1	1627.59	1250.6	76.84	4835.51	780.06	16.13	12.8
	2	1568.82	1124.3	71.67	3832.65	551.42	14.39	14.5
	3	2212.85	1057.3	47.78	3867.71	551.42	14.26	12.9
	4	1959.17	1108.6	56.59	2665.69	407.96	15.30	11.3
	5	1998.11	1065.2	53.31	3059.75	627.63	20.51	12.7
	6	1732.93	1021.8	58.96	4008.08	560.39	13.98	14.7

Table 5. (continued.)

		Mean	1849.91	1104.6	60.86	3711.57	579.81	15.76	13.1
2180	3	1	1955.45	1345.3	68.80	3976.94	950.42	23.90	19.2
		2	2575.94	1282.1	49.77	3586.58	806.96	22.50	17.2
		3	1810.99	1080.9	59.69	4558.46	972.83	21.34	17.4
		4	2891.92	1514.9	52.38	3188.63	762.13	23.90	13.0
		5	1537.67	1369.9	89.09	4445.17	847.31	19.06	14.0
		6	2478.21	1542.5	62.24	3192.52	806.96	25.28	14.7
		Mean	2208.36	1355.9	63.66	3824.72	857.77	22.66	15.9
	6	1	2614.88	1309.8	50.09	4410.73	908.69	20.60	17.2
		2	1920.22	1290.0	67.18	3828.58	699.36	18.27	19.2
		3	1506.51	1073.1	71.23	4488.19	883.17	19.68	19.0
		4	3102.77	1290.0	41.58	3609.95	650.05	18.01	13.7
		5	2013.87	1175.6	58.38	4183.88	972.83	23.25	15.3
		6	1974.75	1171.7	59.33	3984.72	730.75	18.34	14.6
		Mean	2188.83	1218.4	57.96	4084.34	807.48	19.69	16.5

Table 5. (continued.)

9	1	1467.39	1258.5	85.76	3715.46	936.97	25.22	17.7
	2	1748.51	1256.9	71.88	3438.42	869.72	25.29	14.1
	3	2099.73	1175.6	55.99	3422.66	1017.66	29.73	16.9
	4	2540.88	1211.1	47.66	2817.75	829.37	29.43	12.3
	5	2181.69	1349.2	61.84	4710.53	1147.67	24.36	15.8
	6	2209.13	1290.0	58.39	3379.81	986.28	29.18	15.0
	Mean	2041.22	1256.9	63.59	3580.77	964.61	27.20	15.3
	LSD (.05)	547.99	92.3	12.44	561.38	90.66	3.70	1.9
	Std Dev.	469.64	79.1	10.66	481.12	77.70	3.17	1.6
	CV	21.73	6.71	18.79	12.48	11.92	18.33	10.7
	Treatment F	1.838	7.133	2.722	3.449	30.157	14.562	4.419
	Trt Prob(F)	0.098	0.0001	0.0170	0.0041	0.0001	0.0001	0.001

Table 6. Machine harvesting efficiency as influenced by four cultivars in three row spacings in the absence of cheat at Stillwater in 1995.

Cultivar	Row spacing	Rep	Before forage 11-18-94	Machine forage 11-18-94	Machine efficien 11-18-94	Before forage 03-10-95	Machine forage 03-10-95	Machine efficien 03-10-95	Wheat yield 6-19-95
	inches		—— lbs/acre ——		%	—— lbs/acre ——		%	bu/a
Cimarron	3	1	1705.48	996.29	58.42	3411.15	484.17	14.19	5.5
		2	2181.52	731.57	33.53	2372.88	421.41	17.76	4.7
		3	2119.20	783.08	36.95	2670.58	331.23	12.40	5.0
		4	2205.06	757.45	34.35	3001.33	372.10	12.40	8.1
		5	1771.88	646.99	36.51	2724.29	260.02	9.54	3.4
		6	1744.61	783.08	44.89	3000.54	333.97	11.13	3.3
		Mean	1954.63	783.08	40.77	2863.46	367.15	12.90	5.0
	6	1	2271.45	1015.54	44.71	3235.36	618.67	19.12	6.6
		2	1842.15	784.51	42.59	2458.74	327.27	13.31	4.5
		3	2052.81	842.26	41.03	2310.57	363.13	15.72	3.7
		4	1966.96	650.93	33.09	2665.69	260.02	9.75	8.2

Table 6. (continued.)

		5	2025.56	792.96	39.15	2216.75	363.13	16.38	5.6
		6	1756.11	714.06	40.66	2548.49	161.39	6.33	5.1
		Mean	1985.84	800.04	40.21	2572.60	348.93	13.44	5.6
	9	1	1693.80	567.93	33.53	2794.39	555.90	19.89	6.1
		2	1639.10	596.81	36.41	2095.66	273.47	13.05	4.5
		3	1260.61	813.39	64.52	2517.33	349.68	13.89	3.1
		4	1510.40	469.46	31.08	2521.23	246.57	9.78	4.6
		5	1529.87	504.97	33.01	2767.12	277.95	10.04	3.6
		6	1764.08	623.32	35.33	1990.50	233.12	11.71	3.6
		Mean	1566.31	595.98	38.98	2447.70	322.78	13.06	4.3
Karl	3	1	2041.13	539.06	26.41	2642.14	667.98	25.28	8.0
		2	2107.52	601.62	28.55	2482.10	555.90	22.40	6.0
		3	2419.79	851.90	35.21	2852.98	336.23	11.79	5.7
		4	1705.49	402.40	23.59	3641.29	385.55	10.59	6.2
		5	1857.73	658.82	35.46	2634.35	363.13	13.78	4.5

Table 6. (continued.)

	6	1889.06	840.30	44.48	3141.72	412.45	13.13	5.2
	Mean	2003.45	649.02	32.28	2899.10	453.54	16.16	5.9
6	1	1522.08	588.04	38.63	3446.28	542.24	15.73	6.6
	2	1717.17	519.81	30.27	2802.35	255.54	9.12	5.6
	3	1928.01	798.95	41.44	2895.82	407.96	14.09	6.3
	4	1846.04	406.34	22.01	2462.64	304.85	12.38	6.3
	5	1764.08	497.08	28.18	2739.69	233.12	8.51	4.8
	6	1865.70	718.00	38.48	3711.56	569.35	15.34	7.0
	Mean	1773.85	588.04	33.17	3009.72	385.51	12.53	6.1
9	1	1760.19	558.31	31.72	3723.25	421.41	11.32	7.7
	2	1646.89	418.73	25.43	2439.27	309.33	12.68	4.3
	3	2298.71	794.13	34.55	3875.49	403.48	10.41	5.5
	4	1861.63	512.86	27.55	3543.74	309.33	8.73	7.4
	5	1697.70	445.79	26.26	2848.91	233.12	8.18	5.3
	6	1779.66	556.25	31.26	3071.44	434.86	14.16	3.5

Table 6. (continued.)

		Mean	1840.80	547.68	29.46	3250.35	351.92	10.91	5.6
2180	3	1	1908.36	800.53	41.95	2997.66	730.59	24.37	8.1
		2	1951.38	851.90	43.66	2447.06	699.36	28.58	7.6
		3	1857.73	977.04	52.59	2509.37	381.06	15.19	4.8
		4	1748.33	615.43	35.20	2454.85	600.74	24.47	7.2
		5	2380.67	690.38	29.00	2630.46	524.52	19.94	5.1
		6	2033.34	867.91	42.68	2326.15	506.59	21.78	5.3
		Mean	1979.97	800.53	40.85	2560.92	573.81	22.39	6.4
	6	1	2048.92	842.26	41.11	4043.31	784.54	19.40	8.1
		2	2107.52	880.78	41.79	2587.44	708.33	27.38	6.8
		3	2322.08	981.84	42.28	1764.08	452.79	25.67	6.0
		4	2029.45	882.62	43.49	3266.31	541.64	16.58	5.7
		5	2041.13	883.69	43.29	3754.41	457.28	12.18	5.6
		6	1740.71	824.52	47.37	3992.51	560.39	14.04	6.0
		Mean	2048.30	882.62	43.22	3234.68	584.16	19.21	6.4

Table 6. (continued.)

9	1	1674.33	712.32	42.54	3258.90	560.39	17.20	8.6
	2	1479.24	827.83	55.96	3013.01	672.46	22.32	9.7
	3	2661.79	1020.35	38.33	2470.43	600.74	24.32	3.2
	4	1580.69	536.53	33.94	2349.52	551.42	23.47	7.3
	5	1971.03	852.13	43.23	2536.98	573.84	22.62	4.3
	6	2166.11	879.75	40.61	3071.44	443.83	14.45	5.7
	Mean	1922.20	804.82	42.44	2783.38	567.11	20.73	6.5
	LSD (.05)	274.40	111.91	7.87	497.01	105.99	4.55	1.3
	Std Dev.	235.17	95.91	6.74	425.95	90.83	3.90	1.1
	CV	12.40	13.38	17.78	14.96	20.67	24.84	19.6
	Treatment F	2.45	9.62	3.26	2.74	8.46	6.68	2.5
	Trt Prob(F)	0.0293	0.0001	0.0060	0.0164	0.0001	0.0001	0.0252

Table 7. Effects of row spacing or cultivar on fall, spring, and total forage and machine efficiency.

			Hand-harvested		Machine-harvested		Machine efficiency	
Variable	Treatment	Season	Perk-95	Stil-95	Perk-95	Stil-95	Perk-95	Stil-95
	cm		kg/ha				%	
Row spacing	7.5	Fall	2400	2220	1370	830	57	37
	15.0		2700	2180	1280	850	47	39
	22.5		2160	1990	1300	730	61	37
LSD (0.05)			350	180	60	70	7	NS
	7.5	Spring	4220	3110	720	520	17	17
	15.0		4680	3290	690	490	14	15
	22.5		4050	3170	770	460	20	15
LSD (0.05)			360	NS	60	NS	2	NS
	7.5	Total	6620	5330	2090	1350	32	25
	15.0		7380	5460	1970	1340	27	25
	22.5		6210	5160	2090	1190	33	23
LSD (0.05)			510	NS	90	110	2	1

Table 7. (continued.)

Cultivar	Cimarron	Fall	2380	2060	1280	810	54	40
	Karl		2480	2100	1250	670	50	32
	2180		2400	2220	1430	930	60	42
LSD (0.05)			NS	NS	60	70	7	5
	Cimarron	Spring	4030	2940	590	390	15	13
	Karl		4630	3420	620	440	14	13
	2180		4290	3200	980	640	23	21
LSD (0.05)			360	320	60	70	2	3
	Cimarron	Total	6420	5000	1870	1200	30	24
	Karl		7110	5520	1870	1110	27	20
	2180		6690	5420	2410	1570	36	29
LSD (0.05)			510	350	90	110	2	2
Cheat-only		Fall	1180	1490	102	53	9	4
		Spring	5170	4215	188	507	4	12
		Total	6350	5705	290	560	5	10

Table 8. Effects of wheat cultivar averaged over cheat presence and row spacing and cheat presence averaged over cultivar and row spacing on fall forage in five experiments.

Variable	Treatment	Lahoma	Perk-92	Perk-93	Stil-92	Stil-93
		kg/ha				
Cultivar	AGSECO	300	360	480	740	620
	Cimarron	300	480	470	660	690
	Karl	240	410	560	880	520
	2180	330	460	800	1140	910
LSD (0.05)		NSD	90	60	100	120
Cheat present	Yes	300	450	550	790	690
	No	290	400	600	920	680
LSD (0.05)		NSD	NSD	44	70	NSD

Table 9. Interaction of cultivar or cheat presence and row spacing on spring forage.

		Spring forage											
		Perk-92			Perk-93			Still-92			Still-93		
		Row spacing (cm)											
Variable	Treatment	7.5	15.0	22.5	7.5	15.0	22.5	7.5	15.0	22.5	7.5	15.0	22.5
		kg/ha											
Cultivar	AGSECO	390	460	480	290	300	260	570	760	650	590	610	420
	Cimarron	490	510	500	270	290	220	610	590	550	640	600	570
	Karl	460	480	500	260	340	320	790	690	760	600	640	540
	2180	460	440	400	480	630	530	1410	1340	1370	780	880	780
LSD (0.05)		NSD			60			115			NSD		
Cheat present	Yes	450	400	480	320	350	330	850	870	850	640	700	520
	No	450	550	460	330	440	340	840	810	820	670	660	630
LSD (0.05)		90			50			NSD			80		

Table 10. Interaction of cultivar or cheat presence and row spacing on total forage.

		Total forage					
		Perk-93			Still-92		
		Row spacing (cm)					
Variable	Treatment	7.5	15.0	22.5	7.5	15.0	22.5
		kg/ha					
Cultivar	AGSECO	790	730	760	1300	1310	1370
	Cimarron	630	760	690	1340	1260	1140
	Karl	790	920	880	1700	1510	1670
	2180	1260	1510	1310	2650	2380	2500
LSD (0.05)		140			200		
Cheat present	Yes	830	940	870	1700	1630	1620
	No	940	1020	940	1800	1710	1720
LSD (0.05)		NSD			NSD		

Table 11. Interaction of cheat presence and cultivar averaged over row spacing on spring and total forage yield.

	Spring forage				Total forage			
	Perk-93		Still-92		Perk-93		Still-92	
	Cheat present							
Cultivar	Yes	No	Yes	No	Yes	No	Yes	No
	kg/ha							
AGSECO	290	280	760	760	750	570	1430	1360
Cimarron	250	270	690	750	610	560	1230	1270
Karl	290	320	840	890	800	690	1660	1600
2180	490	610	1240	1470	1270	1470	2280	2740
LSD (0.05)	60		110		90		190	

Table 12. Interaction of cheat presence and cultivar averaged over row spacing on grain yield.

	Grain yield						
	Lahoma	Perk-92		Perk-93	Still-92		Still-93
	Cheat present						
Cultivar	Mean	Yes	No	Mean	Yes	No	Mean
	kg/ha						
AGSECO	1440	1810	2950	2490	1640	2940	2140
Cimarron	1370	1670	3000	2210	1400	3010	1870
Karl	2220	2150	2960	2120	1610	2580	1890
2180	1430	1560	2410	1760	950	1670	1670
LSD (0.05)	100	140		130	160		110

Table 13. Cultivar by cheat presence interactions in dockage removed from harvested grain at 5 sites.

	Lahoma		Perk-92		Perk-93		Stil-92		Stil-93	
	Cheat present									
Cultivar	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
	%									
AGSECO	45	18	30	6	24	7	35	6	32	10
Cimarron	42	9	30	3	24	3	38	3	35	6
Karl	20	6	19	3	20	3	31	3	41	4
2180	47	16	31	3	25	2	49	6	45	8
LSD (0.05)	4		2		2		2		5	

2

VITA

Jeffrey Allen Koscelny

Candidate for the Degree of

Doctor of Philosophy

Thesis: INVESTIGATIONS ON CHEMICAL AND CULTURAL PRACTICES FOR WEED CONTROL IN WHEAT

Major Field: Crop Science

Biographical:

Personal Data: Born in Nowata, Oklahoma, August 1, 1965, the son of John and Patricia Koscelny.

Education: Graduated from Delaware High School, Delaware, Oklahoma, in May 1983; received Bachelor of Science in Agronomy from Oklahoma State University, Stillwater, Oklahoma in December, 1987; received Master of Science degree in Agronomy from Oklahoma State University, Stillwater, Oklahoma in December, 1989; Completed the requirements for the Doctor of Philosophy degree at Oklahoma State University in December, 1995.

Experience: Raised on a ranch near Delaware, Oklahoma; employed as a farm laborer during summers; undergraduate research assistant, Oklahoma State University Department of Agronomy from September 1984 to December 1987; graduate research assistant, Oklahoma State University Department of Agronomy from January 1988 to December 1989; Senior Agriculturist, Oklahoma State University Department of Agronomy from April 1990 to present.

Professional Memberships: Southern Weed Science Society, Weed Science Society of America.