THE DIFFERENTIAL TOLERANCE OF WINTER WHEATS TO, AND THE EFFICACY OF *BROMUS* CONTROL HERBICIDES

By

THOMAS KENT BAKER

Bachelor of Science in Agriculture

Oklahoma State University

Stillwater, Oklahoma

1983

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
December, 1989

THE DIFFERENTIAL TOLERANCE OF WINTER WHEATS

TO, AND THE EFFICACY OF BROMUS

CONTROL HERBICIDES

Thesis Approved:

Thomas F. Peeper
Thesis Adviser

Eugene S. Krenzer, Jr.

Don S. Murray

Norman N. Durham
Dean of the Graduate College

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation to my major adviser, Dr. Thomas Peeper, for his advice, helpful criticism, time, and training throughout my graduate program. Your dedication and concern are admirable and greatly appreciated. Appreciation is also extended Dr. Don Murray and Dr. Eugene Krenzer for their suggestions and assistance as members of my graduate committee.

I would like to express my heartfelt thanks to wonderful my wife Sara Ann and my beautiful daughter Madalyn Kate for the loving kindness and understanding they have shown during the time spent conducting this research. I also offer thanks to my parents John and Jean Baker for their patience and encouragement. Thanks also goes to my friends and fellow graduate students Jeff, Kenneth, Birhanu, David, Shay, and Brent W. for their encouragement and support.

To J.A. Koscelny, K.L. Ferreira, D.C. Heering, and B. Kinfe I wish to express my overwhelming thanks. It has been an enjoyable experience getting to know and work with each of you.

Appreciation is extended to Dr. E. Smith, George Morgan and the Department of Agronomy at Oklahoma State University for the use of land, facilities, and equipment which made this research possible.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

APPENDIX

INTRODUCTION

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

PART I

THE DIFFERENTIAL TOLERANCE OF WINTER WHEAT TO CYANAZINE AND TRIAZINONE HERBICIDES

The Differential Tolerance of Winter Wheats to Cyanazine and Triazinone Herbicides[1]

THOMAS K. BAKER AND THOMAS F. PEEPER[2]

Abstract. Field experiments were conducted to evaluate the tolerance of 86 winter wheat (Triticum aestivum) cultivars to cyanazine, ethiozin, and metribuzin. Among the more cyanazine and ethiozin tolerant hard red winter wheats with known pedigrees, their pedigrees included 'Hope' and/or 'Cheyenne' parentage. However, the cultivars more sensitive to ethiozin, notably those with 'Vona' parentage, were not consistently sensitive to cyanazine. Among the white wheats, based on yield data, 'Hill 81' and 'Lewjain' were distinctly more sensitive to metribuzin and ethiozin than four other cultivars. As with the above classes of wheat, visual injury on the soft red wheats did not consistently correlate with yield reductions. In contrast to the hard red wheats, as a class the soft red wheats were generally more sensitive to cyanazine than ethiozin. Nomenclature: Cyanazine, 2-[[4-chloro-6-(ethylamino)-1,3,5-triazin-2-yl]amino]-2-methylpropanenitrile; ethiozin[3], 4-amino-6-(1,1-dimethylethyl)-3-(ethylthio)-1,2,4-triazin-5(4H)-one; metribuzin, 4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one;

---

[1] Received for publication _____ and in revised form _____ .

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

[3] Ethiozin is the proposed common name for BAY SMY 1500.

cheat, Bromus secalinus L. #[1] BROSE; winter wheat, Triticum aestivum L. Additional index words: BAY SMY 1500, cheat, hard red winter wheat, soft red winter wheat, white winter wheat.

INTRODUCTION

The failure of research to discover and/or develop highly selective herbicides for Bromus spp. control in wheat has led to continued interest in ways to decrease the risk of crop injury from marginally selective herbicides. Metribuzin was introduced a decade ago for selective control of Bromus spp. in more tolerant wheat cultivars, but cultivar and edaphic restrictions, a narrow margin of crop safety, and a relatively high price for the product have limited it's use. To improve the utility of metribuzin for Bromus spp. control in wheat, researchers have investigated the influence of soil characteristics, slow-release formulations, and the influence of application timing and seeding rates on yield losses (1,21,22,26). However, substantial research continues to focus on identification of more tolerant cultivars in order to reduce the potential for crop injury (7,15,17,19,24,30,33).

More recently the potential for use of cyanazine for selective Bromus control in wheat has been investigated. When applied to small cheat, cyanazine suppressed it enough to increase wheat yields 79% (8). Although metribuzin may be more effective on cheat, restrictions on metribuzin use and the lower cost of cyanazine serve to encourage research to improve it's utility (8). Crop safety from cyanazine is a

---

[1] Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Weed Sci. 32, Suppl.2, Available from WSSA, 309 W. Clark St., Champaign, IL 61820.

concern particularly on sandy soils or if heavy rainfall occurs soon after application (8,31). Differential tolerance of wheat cultivars to cyanazine is unknown. However, since cultivars differ in tolerance to metribuzin and atrazine, 6-chloro-N-(1-methylethyl)-1,3,5-triazine-2,4-diamine, differences in tolerance to cyanazine could exist, and could be exploited to reduce the potential of cyanazine injury (6,25). Bacon et al. (6) reported that as a group, HRW wheats were more atrazine tolerant than SRW wheats.

Ethiozin is being developed for cheat control in wheat (16). Ethiozin can selectively control Bromus spp. on a wider range of soil types than metribuzin, and it is more rapidly metabolized by tolerant cultivars than metribuzin (14,23). However, it's price has yet to be determined. Several researchers have evaluated various winter wheat cultivars for tolerance to ethiozin (7,9,14,16,32). However, levels of tolerance are not always well defined, nor is it always evident whether reported tolerance was based on visual injury or grain yield.

Our first objective was to determine the tolerance, by means of visual injury and yield reductions, of several winter wheat cultivars to early postemergence applications of ethiozin. A second objective was to determine whether wheats were differentially tolerant to cyanazine and, if so, to determine whether sensitivity to ethiozin would indicate sensitivity to cyanazine.

MATERIALS AND METHODS

The tolerance of 71 HRW[5] wheats and white winter wheats and 15 SRW wheats to cyanazine, ethiozin, and metribuzin was evaluated in field experiments during the 1986-1987 and 1987-1988 growing seasons. Cultivars were selected based on their popularity, use as parents

[5] HRW = hard red winter, SRW = soft red winter.

for other cultivars, previous inclusion in herbicide tolerance evaluations, or diverse origin. Tolerance was evaluated at two sites each season, with the soft wheats evaluated separately from the others. The locations and soil characteristics where the classes of wheat were evaluated and days from herbicide application until a rainfall of 0.5 cm or more are in Table 1. Prior to seeding, fertilizer was incorporated in accordance with soil tests recommendations for production of 3400 kg/ha of grain. Wheat was seeded at 80 kg/ha in 25 cm rows with a spiral cone seeder equipped with double disc openers and presswheels. In all cases the wheat was seeded into moist soil approximately 2.5 cm deep, between September 29, and November 4, at sites selected for low weed populations. The plot size was six rows by 4.2 m.

Herbicide treatments included cyanazine at 0.6 and 1.1 kg/ha and ethiozin at 1.1 and 2.2 kg/ha applied when the wheat had two to four leaves. Metribuzin at 0.4 kg/ha, applied when the wheat had six or more tillers, was included as a standard treatment along with an untreated check.

All herbicides were spray applied with either a tractor mounted compressed N_2 or a compressed air bicycle plot sprayer in a volume of 187 L/ha with 151 kPa of pressure. Wheat injury was visually evaluated approximately 2 weeks after the first activating rainfall. Effects on yield were determined by harvesting a 5 m^2 area from each plot with a small plot combine in June. The experimental design of all experiments was a split-plot in strips with herbicide treatments as the main plots and wheat cultivars as the subplots, and with two exceptions, four replications. Experiments on the Norge loam and Konawa sandy loam soils contained only two and three replications, respectively. Analyses of variance were conducted on all data and protected least significant differences were used to separate means.

RESULTS AND DISCUSSION

Hard red winter wheat tolerance. Herbicides treatment by cultivar interactions were found in visual injury ratings at all locations. Far more cultivars were injured by cyanazine at 0.6 kg/ha and ethiozin at 2.2 kg/ha on the Konawa sandy loam and Grant silt loam than on the Pulaski sandy loam of Dale silt loam soils (Table 2). The Konawa sandy loam has only 7% clay, and at this site 5 cm of rain fell 5 days after treatment. On the Konawa soil, mean wheat injury from the higher rate of cyanazine and ethiozin was 71 and 51%, respectively (data not shown). In contrast, the Pulaski sandy loam contains 15% clay, and rainfall did not occur until 17 days after treatment. At this site, mean injury from cyanazine and ethiozin at the higher rates was only 11 and 7%, respectively (data not shown). The Grant silt loam received 1.3 cm of rain 2 days after cyanazine was applied whereas 7 days elapsed before 2.3 cm of rain fell on the Dale silt loam. Mean wheat injury from the high rates of cyanazine and ethiozin on the Grant soil were 20 and 27%, respectively, versus 4 and 6%, respectively, on the Dale soil (data not shown). Ethiozin has been found to move readily through sandy soils and it's activity is higher when rainfall occurs soon after treatment, particularly when treated plants are small and rapid plant growth is occurring (21, 23). Thus, while soil characteristics may have influenced phytotoxicity of both herbicides, rainfall timing was probably as important as soil characteristics in determining crop injury.

Only three cultivars, 'OK 83398, 'Probrand 830', and 'Vona' were visually injured by cyanazine at 0.6 kg/ha at three of four locations (Table 3). However, 26 cultivars were injured by cyanazine at 1.1 kg/ha at three or all locations. In contrast, five cultivars were not

visually injured by cyanazine at 0.6 kg/ha at any location and 15 cultivars were visibly injured by cyanazine at 1.1 kg/ha only on the Konawa soil.

On the Konawa soil, where cyanazine injury was most evident, visual injury varied from 43 to 98% (data not shown). At this site, only 10 HRW wheats were injured less than 61% by cyanazine at 1.1 kg/ha. Of these 10, those with known pedigrees include 'Brule', 'Newton', 'OK 82377', 'Rocky', and 'TAM 101' (10,18,27). Comparison of parentage of these cultivars revealed some common parentage including the old cultivar 'Hope'. Four of the cultivars, 'Brule', 'Newton', 'OK 82377', and 'Rocky' also contain 'Cheyenne' breeding. The cultivars 'Texred' and 'Maverick', reported by Bacon (6)to be tolerant to atrazine, are 'Sturdy'/'Tascosa' crosses (4,5). Both 'Sturdy' and 'Tascosa' contain 'Hope' breeding and 'Sturdy' also contains 'Cheyenne' (3, 10). Unfortunately, we were unable to obtain sufficient seed to include 'Texred' or 'Maverick' in our research.

Visual injury was not a reliable indicator of yield losses. Five wheats, 'Arkan', 'Bounty XP 122', 'HW 1037', 'Quantum 522', and 'Wings' were visibly injured at all locations but their yields were only reduced on the Konawa sandy loam soil. In contrast, three cultivars, 'Garst 48', 'Osage', and 'Payne' exhibited chlorosis from cyanazine at 1.1 kg/ha at two or three locations without a yield loss at any location from either cyanazine rate.

Only three cultivars, 'Lindon', 'Vona', and 'Wings' were visibly injured by ethiozin at 1.1 kg/ha at all locations. It has previously been reported that these cultivars were sensitive to ethiozin and or metribuzin (16, 25). Only one cultivar, 'Redland' was visibly injured at three locations. In addition to these cultivars, 'Bounty XP 122', 'Brule', 'Colt', 'Milburn', NE 80413', 'OK 83201', 'Pony', 'Quantum

588', 'Redland', and 'Triumph 64' were visibly injured at three or all locations by ethiozin at 2.2 kg/ha. Of these cultivars, the female parent of 'OK 83201' is 'Vona'[6]. 'Redland' is a selection from reportedly ethiozin sensitive 'Brule', and 'Triumph 64' has been reported to be moderately sensitive to metribuzin (11, 25, 29). However, 'Colt' is genetically clustered with 'Scout', and 'Scout' type wheats have been considered metribuzin resistant (20, 25). 'Pony' is also derived from 'Scout', but contains 'Agent' breeding which is genetically clustered with 'Triumph 64'.

Examination of the yield data indicates that visual injury from ethiozin was not always a valid indication of grain yield reductions. For example, 'Colt' was visibly injured at three of four locations with ethiozin at 2.2 kg/ha, but as would have been expected of a 'Scout' type wheat, suffered no yield losses. Fifteen other cultivars were visibly injured at two locations without a yield loss.

Among the cultivars with yields more frequently reduced by ethiozin, the magnitude of the yield reductions varied with location. On the Konawa soil at Perkins, the yields of six HRW wheats were reduced 85 to 98% by ethiozin at 2.2 kg/ha (Table 4). In contrast, the yields of 'Brule' and 'Probrand 812' were reduced less than 50% by that treatment. On the Grant silt loam, yield reductions of six cultivars treated with the higher ethiozin rate exceeded 80%, but yield of 'Brule' was not reduced. The yield data from the other two locations also indicates that 'Brule' and 'Probrand 812', though not tolerant to ethiozin, are not as sensitive as 'Wings' and 'Vona'. In contrast, 27 HRW wheats had no yield losses due to ethiozin at either rate at any location.

---

[6] E. L. Smith. Personal communication. Dep. Agron., Oklahoma State Univ., Stillwater, OK 74078.

Of those 27 cultivars, 'Bennett', 'Buckskin', 'Colt', 'Newton', 'Osage', 'Roughrider','TAM 105', and 'TAM 107', are genetically clustered with 'Scout' and 'Carson' contains 'Scout' breeding (12, 20). Metribuzin tolerant 'TAM 101' is the male parent of 'OK 79257', 'OK 83396', and 'OK 83398' (25)[6]. Twelve cultivars are from private sources and their pedigrees are not public information. Thus, with the exceptions of 'Cody' and 'NE 80413', which have 'Centurk' parentage, higher levels of ethiozin tolerance were associated with 'Scout' and 'TAM 101' parentage (10, 28). However, caution must be used in extrapolating these genetic associations to new cultivars because relationships between cultivars are affected by selection, genetic drift, and other factors (12).

White winter wheat tolerance. Among the white wheats, only 'Daws' and 'Lewjain' were visibly injured by cyanazine at 0.6 kg/ha at two locations (Table 5). Only 'Augusta' and 'Hill 81' were not visibly injured at more than two locations with cyanazine at 1.1 kg/ha. As with the HRW wheats, the white wheats frequently recovered from early cyanazine induced chlorosis and had no yield loss. 'Daws' and 'Hill 81' were the only white wheats with yields reduced by cyanazine at any location other than on the Konawa soil.

'Hill 81' was distinctly more sensitive to ethiozin at 1.1 kg/ha than the other white wheats. The higher ethiozin rate reduced 'Hill 81' yields at all locations and reduced 'Lewjain' yields at three of four locations. 'Hill 81' and 'Lewjain' were the only white wheats with reduced yields in metribuzin treated plots. Interestingly, 'Hill 81' has been reported as ethiozin tolerant and metribuzin is registered for application on 'Hill 81' wheat as well as on 'Daws' and 'Stephen' in the Pacific Northwest (2,11). 'Frankenmuth' was the only white wheat with no yield reductions from ethiozin or metribuzin at any location.

However, 'Frankenmuth' was bred for use in the Northeast rather than the Pacific Northwest where metribuzin is used for weed control in wheat (13).

Soft red winter wheat tolerance. Direct comparisons between hard and soft wheats, as groups, are limited in our research because they were evaluated separately at all locations. However, in contrast to the HRW wheats, cyanazine at 0.6 kg/ha visually injured all of the SRW wheats at one or more locations, and all but four were injured at two or three locations (Table 6). Cyanazine at 1.1 kg/ha reduced the yields of only 9 of 65 HRW wheats at more than one location, whereas that treatment reduced the yield of all 15 SRW wheats at two or three locations.

All SRW wheats were visibly injured by ethiozin at 1.1 kg/ha at one location and five were injured at two locations. Of those five, Bacon and Frans (7) classified four of them, 'Massey', 'Nelson', 'Saluda', and 'Tyler' as intermediate in metribuzin tolerance. Of the 15 SRW wheats, ethiozin at 1.1 kg/ha did not reduce the yield of five, reduced the yield of 8 at one location and the yield of 'Coker 747' and 'Tyler' at two locations. Ethiozin at 2.2 kg/ha reduced the yield of five cultivars, including 'Coker 747', at two locations and reduced the yield of 'Tyler' at three locations. As noted with the HRW wheats, several cultivars, such as 'Magnum', 'Nelson', and 'Saluda' were frequently visibly injured by ethiozin but less frequently suffered yield reductions. In contrast, injury was not obvious on 'Coker 747' on occasions when ethiozin reduced it's yield. This discrepancy between visual injury and yield may be why different researchers have classified this cultivar as relatively tolerant, intermediately tolerant, and sensitive to metribuzin (7,24,30). In our research, metribuzin at 0.4 kg/ha reduced the yields of only 'Coker 747', 'Coker 916', and 'Massey' at more than one location. Other researchers agree that 'Coker 916' is

metribuzin sensitive while 'Massey' is reportedly intermediate in metribuzin tolerance (7,9,17). We could not distinguish between these cultivars because, on the Grant soil, where yields of untreated wheat averaged 2250 kg/ha, 'Coker 747', 'Coker 916', and 'Massey' yields were reduced 32, 45, and 38% respectively, by metribuzin at 0.4 kg/ha. Three researchers have reported that 'McNair 1003' is relatively tolerant to metribuzin and metribuzin did not reduce it's yield in our research (7,17,24). Although cultivars sensitive to metribuzin are typically consider to be sensitive to ethiozin (9), such was not always the case in our research. For example, 'McNair 1003' was less tolerant to ethiozin than it was to metribuzin. A difference between yield reductions due to ethiozin or metribuzin was also noted for 'Authur 71'.

Since substantial differences in tolerance to ethiozin were found and appeared to be related to genetic background, selection for greater ethiozin tolerance would seem possible. Cultivars of all three wheat classes were also found to differ in their response to cyanazine, and some common parentage was associated with tolerance. The 'Vona' type wheats, which were most sensitive to ethiozin, were not consistently sensitive to cyanazine.

Literature Cited

1. Anderson, R. L. and B. D. Riggle. 1988. Bioactivity of metribuzin in a controlled-release formulation on 'Vona' winter wheat and downy brome. Res. Prog. Rep. West. Soc. Weed Sci., p. 332.
2. Anonymous. 1989. Crop Protection Chemical Reference. 5 ed. Wiley and Sons, New York.
3. Atkins, I. M., K. B. Porter, and O. G. Merkle. 1967. Registration of Sturdy wheat. Crop Sci. 7:406.
4. Atkins, I. M. 1982. Registration of Maverick wheat. Crop Sci. 22:690.
5. Atkins, I. M. 1982. Registration of Texred wheat. Crop Sci. 22:689.
6. Bacon, R. K., F. C. Collins, and T. L. Lavy. 1986. Evaluation of wheat cultivars for seedling tolerance to atrazine. Field Crop Res. 14:135-139.
7. Bacon, R. K. and R. E. Frans. 1989. Genetic differences among wheat cultivars for tolerance to two herbicides. Ark. Farm Res. 38:9.
8. Baker, T. K. and T. F. Peeper. 1987. Performance of cyanazine applied early postemergence for Bromus control in winter wheat. Proc. South. Weed Sci. Soc. 40:8.
9. Cagle, J. E., J. Fortino, and M. W. Phillips. 1986. Tolerance of winter wheat to BAY SMY 1500 and metribuzin. Proc. South. Weed Sci. Soc. 39:100.
10. Carver, B. F., W. P. Inskeep, N. P. Wilson, and R. L. Westerman. 1988. Seedling tolerance to aluminum toxicity in hard red winter wheat germplasm. Crop Sci. 28:463-467.

11. Colgan, J. W., V. M. Sorensen, and A. C. Scoggean. 1987. Tycor (SMY 1500) herbicide: Wheat research update. Proc. West Soc. Weed Sci. 40:107-108.

12. Cox, T. S., G. L. Lookhart, D. E. Walker, L. G. Harrell, L. D. Albers, and D. M. Rogers. 1985. Genetic relationships among hard red winter wheat cultivars as evaluated by pedigree analysis and gliadin polyacrylamide gel electrophoretic patterns. Crop Sci. 25:1058-1063.

13. Everson, E. H., R. D. Freed, P. K. Zwer, L. W. Morrison, B. L. Marchetti, J. L. Clayton, R. L. Gallun, and W. T. Yamazaki. 1986. Registration of Frankenmuth wheat. Crop Sci. 26:202.

14. Fedtke, C. and R. R. Schmidt. 1988. Selective action of the new herbicide 4-amino-6-(1,1-dimethylethly)-3-(ethylthio)-1,2,4-triazin-5(4H)-one in different wheat, Triticum aestivum, cultivars. Weed Sci. 36:541-544.

15. Fischer, M. L. 1983. Investigations on the differential tolerance of wheat cultivars to metribuzin. Ph.D. thesis. Oklahoma State University.

16. Fortino, J., J. E. Cagle, and M. W. Phillips. 1986. Performance of BAY SMY 1500 herbicide for Bromus control in winter wheat. Proc. South. Weed Sci. Soc. 39:99.

17. Hayes, R. M., A. Y. Chambers, C. R. Graves, and G. N. Rhodes, Jr. 1986. Differential response of soft red winter wheat cultivars to metribuzin. Tenn. Farm Home Sci. 138:3-6.

18. Heyne, E. G. and C. L. Niblett. 1978. Registration of Newton wheat. Crop Sci. 18:696.

19. Krall, J. M., P. W. Stahlman, and S. D. Miller. 1989. Winter wheat cultivars response to SMY 1500 and metribuzin. Proc. West. Soc. Weed Sci. 42:85.

20. Murphy, J. P., T. S. Cox, and D. M. Rodgers. 1986. Cluster analysis of red winter wheat cultivars based upon coefficients of parentage. Crop Sci. 26:672-676.

21. Peek, D. C. and A. P. Appleby. 1987. Activity of ethyl-metribuzin and metribuzin as related to soil properties. Res. Prog. Rep. West. Soc. Weed Sci., p. 362.

22. Peek, D. C. and A. P. Appleby. 1987. Influence of soil pH on activity of ethyl-metribuzin and metribuzin. Res. Prog. Rep. West. Soc. Weed Sci., p. 367.

23. Ratliff, R. L. and T. F.Peeper. 1987. Bromus control in winter wheat (Triticum aestivum) with the ethylthio analog of metribuzin. Weed Technol. 1:235-241.

24. Retzinger, E. J. Jr. and P. Richard. 1983. Weed control in wheat with metribuzin. Proc. South. Weed Sci. Soc. 36:132.

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

26. Rydrych, D. J. 1986. The effect of rate of seeding on metribuzin and atrazine tolerance in wheat. Res. Prog. Rep. West. Soc. Weed Sci., p. 234.

27. Schmidt, J. W., V. A. Johnson, P. J. Mattern, A. F. Dreier, D. V. McVey, and J. H. Hatchett. 1983. Registration of Brule wheat. Crop Sci. 23:1223.

28. Schmidt, J. W., V. A. Johnson, P. T. Nordquist, P. J. Mattern, A. F. Dreier, D. V. McVey, and J. H. Hatchett. 1989. Registration of Cody wheat. Crop Sci. 29:490-491.

29. Schmidt, J. W., V. A. Johnson, P. J. Mattern, A. F. Dreier, D. V. McVey, and J. H. Hatchett. 1989. Registration of Redland wheat. Crop Sci. 29:491.

30. Schroeder, J., P. A. Banks and R. L. Nichols. 1985. Soft red winter wheat (Triticum aestivum) cultivar response to metribuzin. Weed Sci. 34:66-69.

31. Thacker, R. W. 1987. Effects of seeding method on Bromus spp. control with preplant applications of atrazine and cyanazine. M.S. thesis. Oklahoma State University.

32. Valverde, B. E., B. D. Brewster, A. P. Appleby, and R. L. Spinney. 1987. Winter cereal tolerance to herbicides. Res. Prog. Rep. West. Soc. Weed Sci., p. 338.

33. Wicks, G. A., P. T. Norquist, and J. W. Schmidt. 1987. Response of winter wheat (Triticum aestivum) to herbicides. Weed Sci. 35:259-262.

Table 1. Wheat classes evaluated, crop season, soil characteristics, and days from herbicide treatment to first 0.5 cm rainfall for the 8 cultivar tolerance experiments.

			Soil characteristics				Treatment to rain interval wheat stage	
Location	Class evaluated	Season	Series	Texture	Organic matter	pH	2 to 4 leaves	tillered
					(%)		(days	
Perkins	Hard red winter, white	1986-1987	Konawa	Sandy loam	1.4	6.3	5	12
Perkins	Soft red winter	1986-1987	Teller	Loam	1.0	5.0	5	12
Lahoma	All[a]	1986-1987	Grant	Silt loam	1.4	6.2	2	10
Stillwater	Hard red winter, white	1987-1988	Pulaski	Sandy loam	1.0	5.2	17	2
Stillwater	Soft red winter	1987-1988	Norge	Loam	1.3	5.9	17	3
Chickasha	All[a]	1987-1988	Dale	Silt loam	1.6	6.3	7	9

[a]Soft red winter wheats were evaluated separately in the proximity of the other wheats.

Table 2. Number of hard red winter wheat cultivars, out of 65 entries, with visual injury (P=0.05) from cyanazine, ethiozin, and metribuzin on four soils.

	Cyanazine		Ethiozin		Metribuzin
	kg/ha				
Soil	0.6	1.1	1.1	2.2	0.4
	(no.)				
Konawa sandy loam	43	65	10	64	6
Grant silt loam	50	47	11	43	0
Pulaski sandy loam	0	31	4	10	8
Dale silt loam	6	15	11	19	14

Table 3. Number of locations, out of four, where hard red winter wheats were visibly injured or yields were reduced (P=0.05) by each herbicide treatment.

	Cyanazine				Ethiozin				Metribuzin	
	kg/ha									
	0.6		1.1		1.1		2.2		0.4	
Cultivar	Injury	Yield	Injury	Yield	Injury	Yield	Injury	Yield	Injury	Yield
	(no.)									
AGC 101	1	0	2	1	0	0	2	1	0	0
AGC 106	2	0	3	1	0	0	1	0	0	0
AH-135	2	0	2	1	0	0	2	0	0	0
Arkan	2	0	4	1	0	0	2	2	1	1
Bennett	2	0	2	1	0	0	2	0	0	0
Bounty 205[a]	1	0	1	1	0	0	2	2	0	1
Bounty XP122[a]	2	1	4	1	1	0	3	1	0	0
Brule	2	0	2	2	0	1	4	3	0	0
Buckskin	2	0	2	2	1	0	2	0	0	0
Carson	1	0	2	1	0	0	2	0	0	1
Century	2	1	3	1	0	0	1	1	0	1
Chisholm	1	1	2	1	0	0	2	1	0	1
Cody	2	1	2	0	0	0	2	0	1	1
Garst 48	1	0	3	0	0	0	2	0	0	0
Hawk	1	0	2	1	0	0	2	2	0	0
HW 1037[a]	2	0	4	1	0	1	2	1	0	1
HW 3021[a]	1	1	1	1	0	0	1	1	0	0
HW 3022[a]	2	0	2	1	0	0	1	2	1	2

Table 3. Number of locations, out of four, where hard red winter wheats were visibly injured or yields were reduced (P=0.05) by each herbicide treatment, cont'd.

	Cyanazine				Ethiozin				Metribuzin	
	kg/ha									
	0.6		1.1		1.1		2.2		0.4	
Cultivar	Injury	Yield	Injury	Yield	Injury	Yield	Injury	Yield	Injury	Yield
	(no.)									
Lindon	2	1	3	1	4	4	4	4	2	1
Milburn	2	0	3	1	0	0	3	1	2	1
Mustang	1	0	3	1	1	0	2	1	0	1
Mesa	2	0	3	2	0	0	2	1	0	1
Ne 80413	1	0	2	2	0	0	3	0	0	0
Newton	1	1	3	1	0	0	2	0	0	0
OK 79257	2	0	3	1	0	0	2	0	1	0
OK 82377	1	0	2	1	0	0	1	1	0	1
OK 83201	1	0	3	2	2	3	4	4	2	1
OK 83396	2	1	2	1	0	0	1	0	0	0
OK 83398	3	0	3	2	0	0	1	0	0	1
Osage	1	0	2	0	0	0	1	0	0	0
Payne	2	0	3	0	0	1	2	2	0	0
Pioneer 2157	0	0	1	1	0	0	1	0	0	0
Pioneer 2165	0	0	1	1	0	0	1	0	0	0
Pioneer 2172	1	0	1	2	0	0	1	0	0	0
Pony	1	0	3	1	0	0	3	2	0	0
Probrand 812	2	1	3	2	1	1	2	3	1	2
Probrand 830	3	1	3	1	0	0	1	1	0	0

Table 3. Number of locations, out of four, where hard red winter wheats were visibly injured or yields were reduced (P=0.05) by each herbicide treatment, cont'd.

	Cyanazine				Bthiozin				Metribuzin	
	kg/ha									
	0.6		1.1		1.1		2.2		0.4	
Cultivar	Injury	Yield	Injury	Yield	Injury	Yield	Injury	Yield	Injury	Yield
	(no.)									
Quantum 588[a]	1	0	1	1	1	0	3	1	0	1
Quantum 522[a]	1	0	4	1	1	0	2	0	0	0
Ram	2	0	3	1	0	0	2	0	0	0
Redland	2	0	2	1	3	0	3	2	1	1
RH 7805	2	1	2	0	0	0	2	1	0	0
RH 7833	2	1	2	0	0	0	1	0	0	0
RH 7837	1	0	1	1	2	3	4	4	0	1
RH 7846	0	0	1	1	0	0	1	0	0	0
RHH 8604[a]	2	0	2	1	0	0	2	0	0	0
Rocky	2	0	1	1	0	0	1	0	0	0
Rodeo	1	0	3	1	0	0	2	0	0	0
Roughrider	1	0	1	1	0	0	2	0	0	0
Scout 66	0	0	1	1	0	0	2	1	1	0
Siouxland	1	0	2	1	0	0	2	1	0	0
Stallion	1	0	3	1	0	0	2	1	0	0
TAM 101	1	0	3	1	0	0	1	0	0	1
TAM 105	2	0	2	1	1	0	2	0	0	1
TAM 107	1	0	2	1	0	0	2	0	0	1
TAM 108	2	0	2	1	0	0	1	1	0	1

Table 3. Number of locations, out of four, where hard red winter wheats were visibly injured or yields were reduced (P=0.05) by each herbicide treatment, cont'd.

	Cyanazine				Ethiozin				Metribuzin	
	kg/ha									
	0.6		1.1		1.1		2.2		0.4	
Cultivar	Injury	Yield	Injury	Yield	Injury	Yield	Injury	Yield	Injury	Yield
	(no.)									
TAM 200	2	0	2	1	2	2	2	2	0	1
Thunderbird	0	1	2	2	0	1	2	1	0	1
Triumph 64	1	1	2	1	1	1	4	2	2	1
Turkey	2	0	2	1	0	0	1	1	0	1
Victory	2	0	2	1	0	0	2	1	0	0
Vona	3	1	3	1	4	3	4	4	3	1
Wings	1	1	4	1	4	3	4	4	3	1
Wrangler	2	0	3	1	0	0	2	1	0	0

[a]Indicates a hybrid wheat.

Table 4. Yield reductions of cultivars less tolerant to ethiozin on four soils.

		Soil Series[a]							
		Dale		Grant		Konawa		Pulaski	
		ethiozin (kg/ha)							
Class[b]	Cultivar	1.1	2.2	1.1	2.2	1.1	2.2	1.1	2.2
		(%)							
HRW	Brule	20	30	NS	NS	NS	31	NS	21
	Lindon	33	45	78	88	86	97	21	51
	OK83201	33	52	60	80	64	85	NS	25
	Probrand 812	NS	22	55	58	NS	42	NS	NS
	RH7837	40	34	52	87	43	99	NS	22
	TAM 200	NS	NS	50	79	44	91	NS	NS
	Vona	48	55	73	88	75	97	NS	47
	Wings	38	64	70	83	77	98	NS	42
White	Hill 81	28	52	50	84	85	99	NS	27
	Lewjain	40	45	NS	NS	NS	36	22	25
	LSD (0.05)[c]	- 20 -		- 37 -		- 23 -		- 20 -	
SRW	Coker 747	17	NS	NS	NS	35	58	NS	31
	Tyler	15	29	NS	19	35	41	NS	NS
	LSD (0.05)[d]	- 14 -		- 19 -		- 20 -		- 31 -	

[a]The SRW wheat cultivars were evaluated on different soils than the other wheats at Perkins and Stillwater.

[b]HRW = hard red winter and SRW = soft red winter.

[c]LSDs (0.05) for comparing yield reductions of hard red winter and white cultivars at each location.

[d]LSDs (0.05) for comparing yield reductions of soft red winter cultivars at each location.

Table 5. Number of locations, out of four, where white wheats were visibly injured or yields were reduced (P=0.05) by each herbicide treatment.

	Cyanazine				Ethiozin				Metribuzin	
	kg/ha									
	0.6		1.1		1.1		2.2		0.4	
Cultivar	Injury	Yield	Injury	Yield	Injury	Yield	Injury	Yield	Injury	Yield
	(no.)									
Augusta	1	0	2	1	0	0	1	1	0	0
Daws	2	1	4	2	1	1	3	1	1	0
Frankenmuth	1	0	3	1	0	0	1	0	0	0
Hill 81	1	0	2	2	4	3	4	4	3	2
Lewjain	2	0	3	1	1	2	4	3	2	1
Stephens	1	1	3	1	0	0	2	1	1	0

Table 6. Number of locations, out of four, where soft red winter wheats were visibly injured or yields were reduced (P=0.05) by each herbicide treatment.

	Cyanazine				Ethiozin				Metribuzin	
	kg/ha									
	0.6		1.1		1.1		2.2		0.4	
Cultivar	Injury	Yield	Injury	Yield	Injury	Yield	Injury	Yield	Injury	Yield
	(no.)									
Author 71	2	1	2	2	1	1	2	2	2	0
Caldwell	1	1	3	2	1	0	2	1	1	0
Coker 68-15	1	1	2	2	1	1	2	1	1	0
Coker 747	1	1	3	3	1	2	1	2	1	2
Coker 916	3	0	3	3	1	0	2	1	2	2
Florida 301	1	1	3	2	1	0	2	1	2	1
Florida 302	2	1	3	2	1	0	2	1	1	0
Jessie	2	1	3	2	2	1	3	2	2	0
Magnum	3	0	3	3	1	1	3	1	2	1
Massey	2	0	3	2	2	1	3	2	1	2
McNair 1003	3	0	3	2	1	1	2	2	1	0
Nelson	2	0	3	2	2	1	3	1	2	0
Rosen	3	0	2	2	2	0	2	1	2	0
Saluda	2	1	3	2	1	1	3	1	1	0
Tyler	2	1	3	2	2	2	3	3	0	1

PART II

CHEAT (*BROMUS SECALINUS*) CONTROL WITH CYANAZINE AND METRIBUZIN IN WINTER WHEAT (*TRITICUM AESTIVUM*)

Cheat, *Bromus secalinus*, Control with Cyanazine and Metribuzin in Winter Wheat (*Triticum aestivum*)[1]

THOMAS K. BAKER and THOMAS F. PEEPER[2]

Abstract. Field experiments were conducted to evaluated the efficacy of cyanazine applied alone and in combination with metribuzin for control of cheat in winter wheat. Cheat control with cyanazine applied at 420 to 1400 g ai/ha to wheat with two leaves varied from 0 to 92%. The high rate increased wheat yields at two of three locations. Addition of metribuzin at 70 and 110 g/ha increased cheat control in 3 of 4 experiments. On a sand soil cyanazine caused significant crop injury. Nomenclature: Cyanazine, 2-[[4-chloro-6-(ethylamino)-1,3,5-triazin-2-yl]amino]-2-methylpropanenitrile; metribuzin, 4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one; cheat, *Bromus secalinus* L.#[3] BROSE; winter wheat, *Triticum aestivum* L.

Additional index words. Hard red winter wheat.

---

[1] Received for publication _____ and in revised form _____ .

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

[3] Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Weed Sci. 32,Suppl. 2. Available from WSSA, 309 W. Clark St., Champaign, IL. 61820.

INTRODUCTION

For several years, cheat has been the most troublesome weed problem facing Oklahoma wheat producers. Approximately 1.4 million hectares of winter wheat in Oklahoma are infested with cheat which reduces yields of grain and forage, increases dockage, and delays harvesting (5).

Currently, the only herbicide available for selective cheat control in Oklahoma wheat is metribuzin, which, when activated by rainfall soon after application, usually controls cheat. However, there are cultivar, soil texture, pH, and organic matter content restrictions and a narrow margin of crop safety that limit metribuzin use in Oklahoma.

Cyanazine is used alone or in combination with other herbicides for annual grasses and broadleaf control in corn (Zea mays L.), grain sorghum [Sorghum bicolor (L.)Moench.], and cotton (Gossypium hirsutum) L. (1). Early research indicated that cyanazine could also be selectively used both pre- and postemergence in wheat (3). In France cyanazine applied postemergence at 1.5 kg/ha did not injure wheat (2). However, under higher rainfall, cyanazine applied postemergence at 1.1 kg/ha effectively controlled weeds but caused unacceptable wheat injury (10). Other researchers reported only transient injury from a preemergence application (7). Fenster et al. (4) reported that cyanazine had activity on downy brome, Bromus tectorum L., but was less effective than metribuzin. However, in 1987, Thacker (11) reported 84 to 100% cheat control in wheat with preplant applications of 0.8 to 2.24 kg/ha of cyanazine. Rule (9) reported that cyanazine applied preemergence to winter wheat at 2.25 kg/ha controlled hairy chess, Bromus commutatus Schrad., 52% in a heavy clay soil, which was considered a useful reduction. In three northwestern Oklahoma locations, cyanazine applied to tillered wheat at 0.6 and 1.1 kg/ha caused 0 to 20 and 30 to 40% injury respectively, and visual injury remained apparent

until harvest (6). In three other experiments cyanazine plus metribuzin tank mixes at 0.6 plus 0.1 kg/ha and 1.1 plus 0.1 kg/ha caused 10 to 50% and 30 to 60% wheat injury, respectively (6). Cyanazine rates also vary with soil texture, pH, and organic matter. On sandy loam soils, the leaching rate of cyanazine was found to be comparable to atrazine (1).

Because of the expense and limitations of metribuzin use, this research was conducted to determine whether cyanazine applied alone or in combination with low rates of metribuzin, could be used for cheat control, thus reducing herbicide costs compared to the recommended rate of metribuzin.

MATERIALS AND METHODS

Field experiments were conducted at four locations in Oklahoma during the 1985-1986 and 1986-1987 growing seasons, to evaluate cheat control using cyanazine applied early postemergence. The sites were selected to provide a range of soil texture, organic matter, and pH (Table 1). Cyanazine was applied very early postemergence to cheat with 2 leaves at 0, 420, 670, and 1400 g/ha and early postemergence to cheat with 3 to 5 leaves at rates of 0, 330, 420, and 670 g/ha. The design of each experiment was a randomized complete block with three or four replications.

Four additional experiments were conducted in the 1987-1988 crop year, wherein cyanazine was applied alone and tankmixed with low rates of metribuzin. Application rates for cyanazine were 0, 330, 420, and 670 g/ha on cheat with 2 to 4 leaves. In the tankmix treatments, 70 and 110 g/ha of metribuzin were mixed with cyanazine. The experimental design was a factorial with cyanazine and metribuzin rate as factors with an added check, with three or four replications.

The plot size was 1.5 by 7.6 m. The cheat density, and number of days after application until an activating rainfall of at least 0.5 cm

was recorded are in Table 1. Cheat densities reported are the means of the number of plants within a 600 cm^2 area of each check plot at the time of treatment, plus or minus 10%. Metribuzin tolerant wheat varieties were used in all experiments. All herbicide applications were made with either a compressed air or compressed CO_2 plot sprayer in a total of 187 or 281 L/ha with 151 or 207 kPa of pressure. A 11.6 m^2 area of each plot was harvested with a small plot combine adjusted to retain the cheat seed with the wheat. Dockage was determined by cleaning the harvested samples with a small commercial seed cleaner. Some wheat chaff, straw, and small or broken wheat kernels were collected with the wheat. Therefore, complete weed control did not eliminate dockage completely. Dockage values less than 5% indicate weed free plots (8). The grain yields were based on the cleaned wheat. Analyses of variance were conducted on all data to test the significance of treatment effects, and protected least significant differences (LSDs) were used to separate means.

RESULTS AND DISCUSSION

Cyanazine applied alone. Cheat control with cyanazine spray-applied to cheat with 2 leaves was variable (Table 2). Cheat was not significantly controlled with any rate of cyanazine at C1. However, a significant increase in yield and a reduction of dockage, did occur with applications of 1400 g/ha at this location. Cheat was controlled 70 and 92%, with cyanazine at 420 g/ha and 1400 g/ha, respectively, at C2. There were no significant differences in clean grain yield or percent dockage at C2. The cheat population was comparatively light at both C1 and C2 (Table 1). The absence of any yield response or dockage reduction at C2 and the lack of visual control at C1, indicate that relatively higher populations of cheat are required to reduce wheat yields or visually determine the effects of the treatments. Application

of cyanazine at 1400 g/ha controlled cheat 90% and increased clean grain yields at C3, and dockage was reduced with all cyanazine applications.

At the sites where cyanazine applications were delayed until the cheat had 3 to 4 leaves no cheat control was obtained with 420 g/ha, and only 45% was obtained with 670 g/ha at one location. No increases in clean grain yield were obtained. However, at C1, cyanazine at 420 and 670 g/ha decreased dockage.

Tankmix applications. When metribuzin at 0, 70, and 110 g/ha was tankmixed with 330, 420, and 670 g/ha of cyanazine, no cyanazine by metribuzin interactions were detected in cheat control or yield except at CM1, where an interaction in cheat control was observed (Table 3). No wheat injury was observed at any locations except at CM3, (Table 4). At CM1, adding 70 g/ha of metribuzin to cyanazine at 330 g/ha did not increase cheat control. Adding 70 g/ha of metribuzin to 420 and 670 g/ha of cyanazine increased control 17 and 19%, respectively. Metribuzin at 110 g/ha plus 670 g/ha of cyanazine controlled cheat better than any other tank mix. In spite of the interaction in cheat control, there were no interactions in grain yield or dockage data. Averaged over cyanazine rates, adding metribuzin at 70 and 110 g/ha increased yield 17 and 28%, respectively. Yield increases were accompanied by dockage decreases in all cases.

At CM3, all cyanazine treatments, alone or in combination with metribuzin injured wheat 99 to 100%. The initial flush of cheat, like the wheat, was controlled by all treatments. However, differences in residual control were apparent by spring. Averaged over metribuzin rates, cyanazine at 330 g/ha controlled cheat 74%, and 670 g/ha controlled cheat 89%. Averaged over cyanazine rates, adding only 70 g/ha of metribuzin to cyanazine increased control from 69 to 86%.

Averaged over metribuzin rates only the two higher cyanazine rates control cheat significantly at CM2. Averaged over cyanazine rates, adding 70 g/ha of metribuzin did not increase control, but adding 110 g/ha did. At CM2, averaged over metribuzin rates, cyanazine at 670 g/ha increased wheat yield 25%. Averaged over cyanazine rates, adding metribuzin at 110 g/ha to cyanazine increased yield 28%.

At CM4, averaged over metribuzin rates, only 35 to 59% cheat control was obtained with cyanazine. Averaged over cyanazine rates, adding 70 g/ha of metribuzin increased cheat control. Averaged over metribuzin rates, cyanazine at 330 g/ha did not increase grain yield, but the two higher rates did. Adding metribuzin at either 70 or 110 g/ha to cyanazine did not increase yields, compared to cyanazine alone (metribuzin at 0).

Practical levels of cheat control required the higher rates of cyanazine when this herbicide was applied alone. Significant increases in grain yield and reductions in dockage occurred at 2 of 3 locations when cyanazine was applied at 1400 g/ha. Lower rates did not increase yield. In the experiments with metribuzin tank mixes, averaged over metribuzin rates, cyanazine at 330, 420, and 670 g/ha increased yield at 0, 2, and 3 of 3 locations, respectively. Averaged over cyanazine rates, adding metribuzin at 0, 70, and 110 g/ha increased yield at 0, 2,and 3 of 3 locations, respectively. Cyanazine up to 1400 g/ha, and tankmixes of cyanazine and metribuzin did not cause wheat injury on soil textures from clay loam to silt loam. Tankmixes provided variable control of cheat but at higher rates increased grain yields at all locations.

LITERATURE CITED

1. Anonymous. 1983. Herbicide Handbook. 5th ed. Weed Sci. Soc. Am., Champaign, IL p. 119-121.
2. Bouchet, A., A. De Butler, and J. Garon. 1971. Study of recent herbicides used pre- and post-em. in soft winter wheat. in Weed Abstr. 21:2152. C.A.B Intrn., Wallingford, U.K.
3. Chapman, T., D. Jordan, and D. H. Payne. 1968. WL-19805 a new triazine herbicide. Proc. 9th Brit. Weed Control Conf. 1018-1025. in Weed Abstr. 18:2881. C.A.B Intrn., Wallingford, U.K.
4. Fenster, C. R., L. A. Morrow, and M. K. McCarty. 1974. Downy brome control in native grass. Proc. North Cent. Weed Control Conf. 29:52.
5. Greer, H., T. Peeper, and D. Fain. 1984. Cheat control in wheat. Okla. State Univ. Extension Facts No. 2774.
6. Hill, L. V. 1976. Development, competition and control of tansy mustard, jointed goatgrass and field bindweed in winter wheat. Ph.D. Thesis. Oklahoma State Univ., Stillwater.
7. Jolie, H., M. De Jonge, and W. Hebers. 1969. Experiments with the herbicide 2-(4-chloro-6-ethyl-amino-s-triazin-2-ylamino)-2-methylpropionitrile in the Netherlands and Belgium. in Weed Abstr. 20:1368. C.A.B Intrn., Wallingford, U.K.
8. Ratliff, R. L. 1985. Investigations of BAY SSH 0860 for cheat control in wheat. M.S. Thesis. Oklahoma State Univ., Stillwater.
9. Rule, J. S. 1987. The incidence and control of Bromus commutatus, B. sterilis and Alopecurus myosuroides under different straw management regimes on a heavy soil. Proc. Brit. Crop Prot. Conf. 1:107-112.

10. Seeyave, J. 1970. Report tropical pesticide institute. p. 35. in Weed Abstr. 21:780. C.A.B Intrn., Wallingford, U.K.

11. Thacker, R. W. 1987. Effect of seeding method on Bromus spp. control with preplant applications of atrazine and cyanazine in no-till wheat. M.S. Thesis. Oklahoma State Univ., Stillwater.

Table 1. Soil characteristics, cheat populations, and days from treatment to the first rainfall greater than 0.5 cm at the 8 locations in Oklahoma from 1985 to 1988.

	Soil characteristics					Treatment to rain interval	
			Organic		Cheat	wheat growth stage	
Location	Series	Texture	matter	pH	population	2 leaves	3 to 5 leaves
			--- % ---		(no/m^2)	(days)	
C1	Pulaski	Loam	0.9	5.3	32	4	7
C2	Grant	Silt loam	0.8	7.4	13	2	-
C3	Port	Sandy loam	0.5	5.6	256	8	-
C4	Grant	Silt loam	0.8	7.4	213	-	15
CM1	Grant	Loam	1.0	7.1	30	-	11
CM2	Pulaski	Loam	0.9	5.3	150	-	23
CM3	Meno	Sand	0.6	6.3	15	-	10
CM4	Tillman	Clay loam	1.5	6.0	50	-	10

Table 2. Cheat control, wheat yield, and dockage with cyanazine applied to wheat with 2 leaves or 3 to 5 leaves at 3 locations.[a]

		Cheat control				Wheat yield				Dockage			
		Cyanazine rate (g/ha)											
Cheat stage	Location	0	420	670	1400	0	420	670	1400	0	420	670	1400
		(%)				(kg/ha)				(%)			
2 leaves	C1	0 a	0 a	0 a	38 a	610 a	1120 a	1080 a	1600 b	49 a	41 a	42 a	28 b
	C2	0 a	70 b	88 c	92 c	690 a	710 a	540 a	530 a	10 a	10 a	8 a	8 a
	C3	0 a	18 a	43 b	90 c	300 a	770 a	750 a	1060 b	28 a	18 b	10 b	13 b
3 to 5	C1	0 a	0 a	45 b	-	610 a	1020 a	1000 a	-	49 a	34 b	33 b	-
leaves	C4	0 a	0 a	0 a	-	820 a	700 a	770 a	-	29 a	34 a	31 a	-

[a]Means within each row and parameter followed by the same letter are not statistically different according to the protected LSD 0.05.

Table 3. Interactions of cyanazine and metribuzin on cheat control on the Grant loam soil at CM1.[a]

	Metribuzin (g/ha)		
Cyanazine	0	70	110
(g/ha)	-------- (%) --------		
330	23 a	35 ab	65 cd
420	36 ab	53 cd	50 cd
670	49 bc	68 d	90 e

[a]Means followed by the same letter are not statistically different according to the protected LSD 0.05.

Table 4. Cheat control, wheat yield, and dockage for each herbicide treatment averaged over rates of the other herbicide in the tank mix.[a]

		Locations								
		Cheat control			Wheat yield			Dockage		
Treatment	Rate	CM2	CM3	CM4	CM2	CM1	CM4	CM2	CM1	CM4
	(g/ha)	----- (%) -----			--- (kg/ha) ----			---- (%) -----		
Check	0	0	0	0	1150	1990	2260	24	25	19
Cyanazine	330	11	74	35	1140	2020	2450	24	24	14
	420	29	79	51	1140	2270	2750	22	20	12
	670	19	89	59	1530	2630	2590	26	16	12
Metribuzin	0	12	69	31	1210	2050	2530	27	25	15
	70	10	86	63	1290	2320	2690	23	19	11
	110	37	87	52	1610	2550	2580	23	16	12
LSD (0.05)		18	12	NS	161	263	NS	NS	4	4
LSD (0.10)		-	-	23	-	-	314	-	-	-

[a]No cyanazine by metribuzin interactions were detected in either yield or control data.

APPENDIX

Table 1. Wheat injury from herbicides applied at Perkins.

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
AGC 101	7	27	15	97	5	0
AGC 106	4	48	23	91	5	0
AH 135	15	48	45	98	10	0
Arkan	8	73	22	83	2	0
Augusta[b]	7	48	10	58	17	0
Bennett	17	33	23	77	3	0
Bounty 205[a]	10	58	8	62	3	0
Bounty XP122[a]	12	57	32	85	2	0
Brule	17	77	30	62	3	0
Buckskin	12	43	30	88	5	0
Carson	8	25	13	76	0	0
Century	10	62	45	78	0	0
Chisholm	10	58	17	77	2	0
Cody	10	35	23	67	0	0
Colt	12	32	28	69	2	0
Daws[b]	7	62	22	90	45	3
Frankenmuth[b]	5	45	23	77	17	0
Garst 48	10	45	17	60	5	0
Hawk	7	38	12	69	2	0

Table 1. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
Hill 81 [b]	98	100	12	68	30	0
HW 1037 [a]	12	55	25	87	14	0
HW 3021 [a]	7	65	25	60	2	0
HW 3022 [a]	5	75	18	55	13	0
Lewjain [b]	13	62	35	73	32	0
Lindon	98	100	20	68	2	0
Milburn	7	53	18	67	15	0
Mustang	22	68	13	95	7	0
Mesa	5	35	22	62	2	0
Ne 80413	10	45	17	83	7	0
Newton	3	20	7	55	10	0
OK 79257	5	38	23	62	0	0
OK 82377	2	30	15	57	5	0
OK 83201	94	100	25	83	8	0
OK 83396	13	67	32	92	13	2
OK 83398	8	38	18	81	7	0
Osage	12	35	15	62	10	0
Payne	10	67	33	83	0	0
Pioneer 2157	3	52	17	87	0	0
Pioneer 2165	3	20	13	68	8	0

Table 1. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
Pioneer 2172	7	35	10	83	10	0
Pony	10	61	30	88	7	0
Probrand 812	5	67	27	57	8	0
Probrand 830	7	60	38	88	5	0
Quantum 588 [a]	10	77	25	90	3	0
Quantum 522 [a]	10	35	12	86	10	0
Ram	5	32	20	59	10	0
Redland	47	76	22	82	2	0
RH 7805	12	27	18	87	7	0
RH 7833	10	15	22	72	8	0
RH 7837	66	100	18	57	7	0
RH 7846	3	32	13	43	13	0
RHH 8604[a]	5	33	18	78	5	0
Rocky	8	28	23	56	7	0
Rodeo	8	32	17	73	7	0
Roughrider	5	20	15	58	7	0
Scout 66	5	23	13	83	10	0
Siouxland	12	68	13	66	7	0
Stallion	7	57	17	83	7	2
Stephens[b]	6	55	12	77	18	2

Table 1. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
TAM W-101	10	38	10	57	10	0
TAM 105	10	43	27	85	8	2
TAM 107	7	18	10	88	3	0
TAM 108	7	45	20	72	3	0
TAM 200	92	100	22	78	18	0
Triumph 64	7	58	30	82	7	0
Thunderbird	10	47	13	68	13	2
Turkey	3	40	18	65	2	0
Victory	3	18	28	73	13	0
Vona	92	100	22	78	18	0
Wings	99	100	17	67	28	0
Wrangler	8	57	20	78	13	2
LSD 0.05 = 18						

[a] Indicates a hybrid winter wheat.

[b] Indicates a white winter wheat.

Table 2. Effects of herbicides on wheat yield at Perkins.

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
AGC 101	2604	2074	1930	419	2381	2403
AGC 106	2272	1812	1747	662	2257	2068
AH 135	2014	1601	1586	525	1955	1981
Arkan	2130	1444	1897	1095	2224	2131
Augusta[b]	2426	1631	2128	1299	2429	2397
Bennett	2334	2045	1894	1457	2196	2174
Bounty 205[a]	1982	1480	2289	1259	2337	2338
Bounty XP122[a]	2224	1715	1969	1114	2591	2575
Brule	1938	1506	1778	1467	2125	2193
Buckskin	2105	1695	1846	1262	2021	2011
Carson	2062	1945	2013	1394	2058	1959
Century	2067	1253	1754	1332	2459	2583
Chisholm	2562	2131	2295	1806	2778	3034
Cody	2280	2031	2226	2012	2437	2321
Colt	2058	1968	1735	1398	2058	2060
Daws[b]	1166	1059	1084	565	1387	1264
Frankenmuth[b]	2440	1733	2063	1269	2337	2145
Garst 48	2197	1693	2087	1623	2071	1992
Hawk	2837	1785	2709	1874	2841	2801

Table 2. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
Hill 81 [b]	213	20	1381	1002	1415	1424
HW 1037 [a]	2430	1841	2148	804	2518	2485
HW 3021 [a]	3034	1808	2163	1632	2859	2905
HW 3022 [a]	2449	901	2409	1831	2370	2358
Lewjain [b]	965	610	935	567	892	951
Lindon	324	70	1846	1180	2265	2393
Mesa	2608	2213	2502	1805	2580	2784
Milburn	1906	1567	1745	1193	1786	1969
Mustang	1843	772	1954	549	1971	2199
Ne 80413	2246	2201	2104	1418	2293	2291
Newton	2090	1983	2317	1600	2163	2251
OK 79257	2386	2028	1942	1529	2393	2327
OK 82377	2070	1851	2239	1555	2184	2193
OK 83201	905	363	2071	1131	2344	2488
OK 83396	2184	1812	1822	960	2032	2403
OK 83398	2583	1988	2237	1456	2246	2403
Osage	2054	1795	1829	1637	2049	2069
Payne	1793	1598	1921	1432	2426	2381
Pioneer 2157	2961	1935	2312	942	2858	2712
Pioneer 2165	2650	2347	2524	1778	2539	2607

Table 2. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
Pioneer 2172	2370	1989	2571	932	2487	2509
Pony	2008	1299	2169	1094	2342	2317
Probrand 812	2300	1264	1809	1394	2092	2186
Probrand 830	2547	1340	1474	763	2141	2309
Quantum 588 [a]	2457	1441	2497	1253	2902	2980
Quantum 522 [a]	2258	1842	2499	518	2559	2264
Ram	2201	1824	1859	1487	2074	2332
Redland	2365	1403	2071	868	2105	2141
RH 7805	1321	2016	2330	1201	2185	2326
RH 7833	2319	2167	2564	1300	2703	2692
RH 7837	1334	26	2066	1607	2124	2343
RH 7846	2241	2122	2129	1791	2426	2657
RHH 8604 [a]	2623	2150	2290	1520	2577	2687
Rocky	2406	2235	2366	1765	2374	2531
Rodeo	2465	2310	2457	1302	2385	2545
Roughrider	1651	1479	1735	1167	1691	1657
Scout 66	2041	1697	1848	1255	1956	2346
Siouxland	2229	1300	2191	1409	2361	2453
Stallion	3765	1600	2346	1204	2843	2732
Stephens [b]	1071	820	917	607	1094	1286

Table 2. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
IAM W-101	2602	2150	2437	1716	2450	2545
IAM 105	2335	2056	2058	1276	2522	2308
IAM 107	2838	2540	2563	1438	2768	2573
IAM 108	2431	1887	2089	1216	2561	2591
IAM 200	1212	203	1797	593	2048	2152
Triumph 64	2382	1638	1721	1111	2357	2490
Thunderbird	1415	1322	1495	1141	1682	1853
Turkey	2356	1642	2081	1672	2408	2267
Victory	2345	2151	1942	1386	2382	2298
Vona	644	65	1849	972	2309	2523
Wings	591	50	1546	1201	1984	2530
Wrangler	2190	1225	2020	1000	2032	2030
LSD 0.05 = 508						

[a] Indicates a hybrid winter wheat.

[b] Indicates a white winter wheat.

Table 3. Wheat injury from herbicides applied at Lahoma.

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
AGC 101	9	16	21	20	1	4
AGC 106	8	13	24	14	10	3
AH 135	5	18	14	25	10	4
Arkan	6	18	25	29	0	1
Augusta [b]	9	68	14	13	10	0
Bennett	14	38	38	38	6	13
Bounty 205 [a]	6	29	14	13	0	0
Bounty XP122 [a]	6	29	14	13	0	0
Brule	13	58	25	14	0	11
Buckskin	33	45	31	41	6	13
Carson	9	16	23	16	0	1
Century	6	9	24	34	0	4
Chisholm	4	14	97	16	0	0
Cody	9	21	14	9	4	3
Colt	8	16	21	16	0	4
Daws [b]	13	16	28	24	43	4
Frankenmuth [b]	6	6	13	15	0	3
Garst 48	6	44	13	13	0	0
Hawk	3	28	15	16	0	0

Table 3. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
Hill 81[b]	50	99	26	24	31	3
HW 1037[a]	6	20	25	30	11	11
HW 3021[a]	13	24	16	19	4	4
HW 3022[a]	8	13	98	13	10	0
Lewjain[b]	25	41	29	53	36	14
Lindon	55	96	20	18	0	1
Milburn	3	14	16	23	0	4
Mustang	9	26	24	29	0	4
Mesa	5	4	18	20	1	1
Ne 80413	9	19	15	19	1	9
Newton	4	14	20	16	11	1
OK 79257	9	19	18	21	3	1
OK 82377	5	11	23	28	0	1
OK 83201	26	83	11	14	0	4
OK 83396	5	11	19	10	1	1
OK 83398	5	11	16	18	0	1
Osage	11	15	23	31	3	4
Payne	3	38	19	24	0	4
Pioneer 2157	1	63	13	11	0	4
Pioneer 2165	8	13	13	10	3	0

Table 3. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
Pioneer 2172	8	53	16	11	0	3
Pony	6	25	11	25	1	4
Probrand 812	3	13	10	13	0	0
Probrand 830	9	13	24	14	0	0
Quantum 588 [a]	5	24	25	80	0	3
Quantum 522 [a]	8	15	13	11	10	1
Ram	4	18	20	25	0	1
Redland	29	49	18	14	1	1
RH 7805	11	16	19	14	0	8
RH 7833	9	31	15	14	0	4
RH 7837	34	98	10	98	0	1
RH 7846	3	81	56	13	0	0
RHH 8604 [a]	6	8	14	25	4	1
Rocky	6	81	18	81	0	14
Rodeo	9	21	16	19	1	1
Roughrider	8	31	16	11	1	15
Scout 66	8	14	11	83	1	3
Siouxland	6	23	21	11	4	4
Stallion	8	20	20	23	0	0
Stephens [b]	9	16	33	48	11	3

Table 3. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
TAM W-101	13	13	20	31	13	30
TAM 105	14	40	31	33	6	10
TAM 107	6	26	19	96	1	4
TAM 108	8	13	18	16	3	1
TAM 200	38	86	15	13	10	3
Triumph 64	10	23	13	15	1	4
Thunderbird	9	21	10	18	10	1
Turkey	9	10	20	34	0	3
Victory	6	11	15	21	10	1
Vona	62	96	30	21	11	0
Wings	61	97	15	25	20	0
Wrangler	4	31	20	26	11	1
LSD 0.05 = 14						

[a] Indicates a hybrid winter wheat.

[b] Indicates a white winter wheat.

Table 4. Effects of herbicides on wheat yield at Lahoma.

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
AGC 101	2524	2251	2017	1839	2456	2556
AGC 106	2452	2371	2215	2060	1871	1950
AH 135	2125	2281	2198	1841	1891	1734
Arkan	2185	1622	1847	1475	1825	2222
Augusta [b]	2691	2453	2235	2188	2458	2166
Bennett	2245	2136	2003	1824	1925	1680
Bounty 205 [a]	2452	1625	2487	2541	2616	2673
Bounty XP122 [a]	2518	2108	2244	2087	2356	2337
Brule	2026	1754	2229	2338	2265	1822
Buckskin	2022	1844	1645	1745	1866	1649
Carson	1693	1904	1530	1794	1955	1864
Century	2462	2865	2506	2233	2332	2519
Chisholm	2773	2458	2629	2415	2494	2542
Cody	2596	2425	2813	2444	2261	2193
Colt	2353	1908	1960	2065	2091	1704
Daws [a]	1005	845	962	862	995	917
Frankenmuth [a]	1679	1856	1698	1610	1669	1808
Garst 48	2137	1363	1878	1911	1815	1921
Hawk	2118	1720	1936	1810	2117	1891

Table 4. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
Hill 81[b]	466	148	973	946	1025	936
HW 1037[a]	2562	2258	1802	2212	2194	2017
HW 3021[a]	2751	2816	2817	2884	2676	2904
HW 3022[a]	3171	2891	2404	2236	2777	2870
Lewjain[b]	761	602	511	429	695	621
Lindon	493	271	1764	1683	1752	2280
Milburn	2469	2283	1971	1864	2380	2332
Mustang	2594	1903	2127	1773	2060	1978
Mesa	2925	2874	2527	2068	2384	2403
Ne 80413	2387	2261	2142	2017	2077	1835
Newton	2332	2107	2043	1980	2081	2091
OK 79257	2825	1829	2507	2104	2406	2359
OK 82377	2670	2379	2221	1692	2292	2047
OK 83201	911	466	2092	2054	2109	2271
OK 83396	2758	2702	2301	2085	2443	2284
OK 83398	2879	2706	2426	2410	2442	2533
Osage	2629	2416	2152	2054	2134	1990
Payne	2570	1340	2431	2283	2317	2147
Pioneer 2157	2201	2146	2437	2179	2262	2138
Pioneer 2165	2452	2328	2201	2350	1814	2304

Table 4. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
Pioneer 2172	2713	2706	2296	2310	2251	2350
Pony	2716	2052	2462	2243	2410	2201
Probrand 812	2800	2578	2368	1928	2125	6216
Probrand 830	2003	1919	1608	1596	1976	1666
Quantum 588 [a]	2557	2266	2527	2340	2283	1741
Quantum 522 [a]	2207	1819	2330	2436	2715	2348
Ram	2125	2007	1837	1914	1973	1620
Redland	2178	2187	2324	2442	2353	2239
RH 7805	2488	2336	2221	2396	2129	2172
RH 7833	2373	2113	2043	2045	2170	1826
RH 7837	1171	313	2119	2085	2014	2462
RH 7846	2804	2599	2512	2394	2344	2913
RHH 8604 [a]	2626	2555	2335	2294	2458	2247
Rocky	2246	2328	2118	2237	2003	2083
Rodeo	2409	1973	2113	2001	2176	2023
Roughrider	2312	1644	1951	2076	1924	1765
Scout 66	2137	2012	1886	2182	2176	1750
Siouxland	2798	2623	2550	2774	2773	2511
Stallion	2695	2440	2346	2008	2521	2348
Stephens [b]	1229	1236	910	923	1290	1017

Table 4. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
TAM W-101	2326	2488	2296	1936	2279	2477
TAM 105	1832	1608	1806	1376	1605	1722
TAM 107	2320	1794	2118	2252	2026	1984
TAM 108	2061	1847	1822	1988	1917	1595
TAM 200	1337	1559	2463	2412	2212	2654
Triumph 64	2611	2574	2479	2395	2195	2535
Thunderbird	2005	1717	2063	1899	1981	2028
Turkey	2440	2340	2098	1962	2244	2261
Victory	2059	2544	2000	1996	2329	2402
Vona	509	232	5404	1823	1852	1888
Wings	654	372	2082	1567	1698	2203
Wrangler	2375	1704	1979	1859	2229	2250

LSD 0.05 = 850

[a] Indicates a hybrid winter wheat.

[b] Indicates a white winter wheat.

Table 5. Wheat injury from herbicides applied at Stillwater.

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
AGC 101	0	0	0	9	0	1
AGC 106	0	0	0	20	0	0
AH 135	0	0	0	3	0	0
Arkan	0	0	0	13	1	0
Augusta [b]	0	1	0	14	0	0
Bennett	1	1	0	8	0	0
Bounty 205 [a]	0	0	0	5	0	0
Bounty XP122 [a]	0	0	0	23	0	0
Brule	0	15	0	28	0	0
Buckskin	0	0	0	1	0	0
Carson	0	0	0	1	0	0
Century	0	0	0	18	0	0
Chisholm	0	0	0	9	1	0
Cody	1	0	0	1	11	0
Colt	0	0	0	3	0	0
Daws [b]	0	5	0	48	0	0
Frankenmuth [b]	0	0	0	15	0	0
Garst 48	4	0	0	30	0	0
Hawk	0	1	0	1	0	0

Table 5. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
Hill 81 [b]	19	51	0	8	11	0
HW 1037 [a]	0	0	0	23	0	0
HW 3021 [a]	0	0	0	4	0	0
HW 3022 [a]	0	1	0	9	4	0
Lewjain [b]	1	11	0	13	10	0
Lindon	26	80	1	14	65	0
Milburn	0	0	0	14	14	0
Mustang	0	0	0	16	0	0
Mesa	0	3	0	20	0	0
Ne 80413	3	0	0	3	1	0
Newton	0	8	0	16	0	0
OK 79257	0	0	0	20	3	0
OK 82377	0	0	0	3	1	0
OK 83201	3	38	0	19	23	0
OK 83396	0	0	0	25	0	1
OK 83398	0	1	3	24	0	0
Osage	0	0	0	4	0	0
Payne	0	0	0	13	0	0
Pioneer 2157	0	0	0	9	0	0
Pioneer 2165	0	0	0	4	0	0

Table 5. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
Pioneer 2172	0	0	0	4	0	0
Pony	3	3	0	30	0	0
Probrand 812	0	0	0	11	3	0
Probrand 830	0	1	0	21	0	0
Quantum 588[a]	5	0	0	10	1	0
Quantum 522[a]	0	0	0	13	0	1
Ram	0	0	0	9	0	0
Redland	5	14	0	1	3	0
RH 7805	0	0	0	1	0	0
RH 7833	0	1	0	9	0	0
RH 7837	9	53	1	8	0	0
RH 7846	3	0	0	3	0	0
RHH 8604[a]	0	0	0	5	0	0
Rocky	0	0	0	6	0	0
Rodeo	0	0	0	10	0	0
Roughrider	0	3	0	10	0	0
Scout 66	0	0	0	3	1	0
Siouxland	0	0	0	0	0	0
Stallion	0	0	0	12	0	0
Stephens[b]	1	1	0	19	0	0

Table 5. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
TAM W-101	1	0	0	15	0	0
TAM 105	0	0	0	0	0	0
TAM 107	0	4	0	1	0	0
TAM 108	0	0	0	9	0	0
TAM 200	0	0	1	14	0	0
Triumph 64	0	30	1	9	39	0
Thunderbird	0	0	0	8	0	0
Turkey	0	1	0	10	0	0
Victory	0	0	0	8	0	0
Vona	36	75	0	30	33	0
Wings	24	75	0	11	55	0
Wrangler	3	0	0	5	0	0

LSD 0.05 = 11

[a] Indicates a hybrid winter wheat.

[b] Indicates a white winter wheat.

Table 6. Effects of herbicides on wheat yield at Stillwater.

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
AGC 101	2024	2438	2363	2083	2061	2372
AGC 106	2165	2616	2348	1936	1919	1988
Arkan	2041	2352	2010	1965	1636	2144
AH 135	2435	2621	2599	2498	2035	2017
Augusta [b]	2677	2937	2681	2629	2371	2410
Bennett	2138	2718	2328	2071	2123	2319
Bounty 205 [a]	2469	2467	2236	2488	1831	2322
Bounty XP122 [a]	2645	2704	2846	2732	2202	2714
Brule	2331	1941	2198	1938	2028	2469
Buckskin	1668	1675	1628	1513	1647	2020
Carson	2514	2636	2620	2497	2170	2714
Century	2343	2569	2622	2307	2007	2581
Chisholm	2305	2865	2697	2390	1933	2578
Cody	2174	2451	2534	2133	1709	2305
Colt	2118	2355	1700	1905	2028	2156
Daws [b]	830	1178	1031	708	1454	1408
Frankenmuth [b]	2337	2399	2118	1978	2208	1981
Garst 48	2121	2364	2356	2166	2180	2407
Hawk	2414	2741	2686	2815	2350	2445

Table 6. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
Hill 81 [b]	1707	1265	1671	1299	1251	1737
HW 1037 [a]	3017	2602	2410	2492	2213	2887
HW 3021 [a]	3005	3073	2980	2857	2667	3216
HW 3022 [a]	2989	2751	3187	2714	1966	2902
Lewjain [b]	1546	1476	2133	1950	1038	1969
Lindon	1854	1149	2345	2053	491	2356
Milburn	2299	2677	2571	2305	1289	2826
Mustang	2138	2266	2097	1951	1847	2393
Mesa	2655	3087	2557	2142	2217	2867
Ne 80413	2065	2536	2098	2487	1948	1958
Newton	2394	2675	2414	2068	1889	2319
OK 79257	2396	2554	2535	2387	2275	2662
OK 82377	2262	2483	2283	2161	1745	2293
OK 83201	2274	1871	2534	2189	1026	2493
OK 83396	2538	2874	2494	2268	2252	2359
OK 83398	2436	2606	2410	2111	2198	2738
Osage	1617	1834	1796	1779	1657	1943
Payne	2242	2325	2211	2253	1862	1990
Pioneer 2157	2300	2687	2308	2370	2559	2342
Pioneer 2165	2429	2564	2567	2632	2419	2315

Table 6. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
Pioneer 2172	2454	2445	2401	2596	2334	2399
Pony	2386	2666	2672	2415	2241	2006
Probrand 812	2583	2578	2566	2401	1889	2625
Probrand 830	2062	2470	2272	2211	1921	2364
Quantum 588[a]	2793	2654	2344	2481	1681	2678
Quantum 522[a]	2641	2723	2434	2243	2297	2587
Ram	2133	2452	2413	2227	1925	2256
Redland	2092	2057	2671	2343	1876	2569
RH 7805	2137	2631	2666	2295	2103	2126
RH 7833	2534	2216	2360	2314	2318	2435
RH 7837	2062	1824	2557	2228	1570	2335
RH 7846	2744	2761	2633	2528	2213	2523
RHH 8604[a]	2308	2788	2445	2615	2302	2297
Rocky	2327	2554	2579	2446	2071	2538
Rodeo	2294	2633	2660	2368	2447	2274
Roughrider	843	960	1014	1036	934	926
Scout 66	1707	1975	1893	1952	1501	1734
Siouxland	1848	2012	1943	1810	1775	1961
Stallion	2539	3029	2444	2406	2437	2659
Stephens[b]	2161	2220	2106	1899	2064	2144

Table 6. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
TAM W-101	2458	2889	2518	2575	2040	2303
TAM 105	2884	2796	2368	2537	2046	2392
TAM 107	2603	2860	2716	2443	2061	2694
TAM 108	2288	2646	2443	2277	1346	2596
TAM 200	2646	2854	2940	2428	2188	2375
Triumph 64	1892	1799	1824	1748	879	2080
Thunderbird	2545	2553	2718	2388	1781	2437
Turkey	1470	1544	1639	1201	1128	1420
Victory	2573	2672	2711	2722	2408	2663
Vona	1763	1117	2427	2002	405	2109
Wings	1903	1305	2309	2075	547	2232
Wrangler	1960	2387	23087	2143	1928	2197
LSD 0.05 = 469						

[a] Indicates a hybrid winter wheat.

[b] Indicates a white winter wheat.

Table 7. Wheat injury from herbicides applied at Chickasha.

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
AGC 101	1	5	3	4	0	0
AGC 106	1	0	3	1	0	0
AH 135	2	3	3	3	1	0
Arkan	1	0	1	6	9	0
Augusta [b]	3	5	4	0	0	0
Bennett	4	3	1	4	1	0
Bounty 205 [a]	2	3	0	4	0	0
Bounty XP122 [a]	8	6	6	9	0	0
Brule	5	8	1	3	0	0
Buckskin	1	1	4	2	1	0
Carson	4	1	3	4	0	0
Century	1	1	0	2	1	0
Chisholm	3	5	6	4	5	0
Cody	0	4	3	6	0	0
Colt	3	10	5	5	0	0
Daws [b]	11	10	5	15	0	0
Frankenmuth [b]	1	2	0	4	0	0
Garst 48	3	3	4	3	5	0
Hawk	4	3	2	4	0	0

Table 7. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
Hill 81 [b]	10	29	3	3	18	0
HW 1037 [a]	3	3	5	8	0	0
HW 3021 [a]	0	1	0	3	1	0
HW 3022 [a]	0	1	1	0	13	0
Lewjain [b]	3	13	0	4	19	0
Lindon	15	29	3	4	86	0
Milburn	4	15	1	5	28	0
Mustang	4	3	1	5	0	0
Mesa	4	6	3	3	0	0
Ne 80413	5	7	5	11	0	0
Newton	2	3	0	4	0	0
OK 79257	3	3	1	5	9	0
OK 82377	1	4	2	1	4	0
OK 83201	5	25	5	4	46	0
OK 83396	1	3	0	0	0	0
OK 83398	3	2	8	3	0	0
Osage	1	3	3	4	0	0
Payne	0	2	4	1	0	0
Pioneer 2157	0	1	4	1	0	0
Pioneer 2165	1	0	1	4	0	0

Table 7. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
Pioneer 2172	1	2	1	4	0	0
Pony	5	6	4	5	0	0
Probrand 812	8	10	15	9	6	0
Probrand 830	5	3	7	3	0	0
Quantum 588 [a]	6	7	4	5	5	0
Quantum 522 [a]	6	5	6	6	0	0
Ram	3	4	1	8	0	0
Redland	7	5	1	4	9	0
RH 7805	1	3	3	3	1	0
RH 7833	0	2	0	5	0	0
RH 7837	13	17	1	5	0	0
RH 7846	3	3	5	5	0	0
RHH 8604 [a]	3	3	3	6	0	0
Rocky	0	4	5	4	0	0
Rodeo	1	2	1	7	0	0
Roughrider	1	3	5	4	0	0
Scout 66	2	1	3	3	6	0
Siouxland	0	4	4	6	0	0
Stallion	3	5	4	3	0	0
Stephens [b]	3	5	5	5	0	0

Table 7. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
TAM W-101	2	4	1	1	0	0
TAM 105	5	4	4	1	0	0
TAM 107	3	4	4	7	0	0
TAM 108	2	5	5	3	0	0
TAM 200	2	3	1	3	1	0
Triumph 64	7	8	0	3	74	0
Thunderbird	4	3	0	3	0	0
Turkey	3	5	4	3	0	0
Victory	3	8	4	3	0	0
Vona	12	30	6	4	78	0
Wings	17	50	5	8	73	0
Wrangler	4	5	3	6	1	0
LSD 0.05 = 6						

[a] Indicates a hybrid winter wheat.

[b] Indicates a white winter wheat.

Table 8. Effects of herbicides on wheat yield at Chickasha.

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
AGC 101	3122	2154	3036	2805	2767	2925
AGC 106	2755	2847	2870	3033	3071	3118
AH 135	3162	2973	3032	2852	3083	3275
Arkan	3045	2904	3105	3025	3064	3700
Augusta [b]	3011	2785	3118	3182	2835	3007
Bennett	2874	2747	3133	2523	2827	2945
Bounty 205 [a]	3136	3010	3554	2817	3151	2724
Bounty XP122 [a]	3244	3139	3349	2964	3398	3534
Brule	2852	2541	3335	3297	3203	3621
Buckskin	2871	2568	2957	2766	2590	2637
Carson	3411	3273	3050	3257	3131	3528
Century	3313	3116	3677	3312	3272	3594
Chisholm	3385	3413	3400	3185	3206	3642
Cody	2534	2798	3586	2348	3067	2777
Colt	2890	2534	2644	2860	3042	2571
Daws [b]	2318	1577	2246	2032	2402	2048
Frankenmuth [b]	2694	2517	2833	2609	2686	2667
Garst 48	2532	2893	3304	3341	3209	3057
Hawk	3277	2664	3313	2988	3148	3548

Table 8. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
Hill 81 [b]	1737	1342	2569	2392	2213	2799
HW 1037 [a]	3180	3198	3397	3514	3441	3952
HW 3021 [a]	4020	3643	3752	3476	3493	4102
HW 3022 [a]	3941	3162	3844	3263	3169	3934
Lewjain [b]	1929	1783	2902	2975	2978	3235
Lindon	2256	1861	2952	3022	2781	3345
Milburn	3479	2548	3548	3303	2952	3264
Mustang	3298	2963	3415	2985	3245	3650
Mesa	3421	2822	3918	3600	3331	3791
Ne 80413	3245	3441	3467	2717	3356	3598
Newton	3125	3098	2385	3252	3138	3731
OK 79257	3363	3420	3501	3533	3331	3472
OK 82377	2893	2359	2860	2906	2698	2991
OK 83201	2522	1819	3265	2566	3229	3751
OK 83396	3693	3714	2790	3551	3125	3804
OK 83398	3299	2959	3401	3014	3502	3384
Osage	2835	2984	2572	2535	2360	2821
Payne	3230	3011	3484	3088	3303	3549
Pioneer 2157	3641	3273	3240	3247	3434	2973
Pioneer 2165	3149	3673	3494	3360	3236	3600

Table 8. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
Pioneer 2172	3520	3634	3626	2932	3738	2665
Pony	3135	2925	3410	3121	3203	3736
Probrand 812	3441	2925	3596	3787	3025	3753
Probrand 830	2810	3026	2662	2703	3147	3042
Quantum 588 [a]	3309	3517	3875	3413	3477	3693
Quantum 522 [a]	3023	3228	2912	3345	2925	3355
Ram	3466	3136	3254	3165	2904	3208
Redland	3019	2923	2953	2801	3051	3575
RH 7805	3674	3529	3675	3177	3275	3390
RH 7833	3706	3221	3328	3146	3173	3284
RH 7837	1921	2135	3554	3235	3064	3195
RH 7846	3825	3720	3357	3767	3802	3440
RHH 8604 [a]	2623	3366	3554	2994	2858	2736
Rocky	3717	3578	3690	3542	3652	3809
Rodeo	3645	3794	3444	3156	3509	3297
Roughrider	2369	2233	2219	2028	2199	2188
Scout 66	3113	2756	2541	2652	2419	2908
Siouxland	2932	2760	3323	3042	3262	3081
Stallion	3106	3111	3323	3042	3262	3081
Stephens [b]	3186	2752	3304	2700	3497	2866

Table 8. (Continued.)

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
TAM W-101	3693	3756	3467	3425	2370	3920
TAM 105	3256	3164	3663	3060	2809	3699
TAM 107	3595	3751	3610	3140	3594	3835
TAM 108	3605	2895	3432	3201	3257	3457
TAM 200	3965	3498	3831	3664	3267	4232
Triumph 64	2540	2546	3110	2600	2628	3161
Thunderbird	3699	3779	3894	3229	3817	4113
Turkey	2289	2152	2249	1788	1404	1877
Victory	3508	2978	3755	3398	3546	3931
Vona	1813	1587	3324	3091	2937	3466
Wings	1988	1138	3269	2672	2656	3187
Wrangler	3550	3170	3211	3160	2912	3134
LSD 0.05 = 627						

[a] Indicates a hybrid winter wheat.

[b] Indicates a white winter wheat.

Table 9. Soft red winter wheat injury from herbicides applied at Perkins.

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
Author 71	26	80	39	83	16	0
Caldwell	28	89	58	89	32	0
Coker 68-15	38	78	51	89	29	0
Coker 747	51	80	43	89	41	0
Coker 916	39	85	38	84	18	0
Florida 301	29	78	31	85	54	0
Florida 302	33	86	50	86	33	0
Jessie	83	89	58	76	26	0
Magnum	40	79	39	83	34	0
Massey	29	67	40	76	15	0
McNair 1003	28	85	39	85	28	0
Nelson	88	89	40	81	25	0
Rosen	30	82	44	88	29	0
Saluda	46	87	51	88	26	0
Tyler	38	77	43	87	9	0

LSD 0.05 = 16

Table 10. Effects of herbicides on soft red winter wheat yield at Perkins.

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
Author 71	1729	1241	1897	952	2016	2413
Caldwell	2088	675	1809	686	2349	2499
Coker 68-15	1996	1349	1864	635	2252	2674
Coker 747	1665	1075	1969	524	2071	2552
Coker 916	2072	1152	2199	878	2470	2553
Florida 301	1731	1165	1881	986	1683	2027
Florida 302	2332	1253	1996	1442	2110	2495
Jessie	1080	392	1927	1587	2462	2444
Magnum	2198	1497	2396	1564	2326	2926
Massey	2250	1822	2354	1443	2616	2467
McNair 1003	1847	1220	1905	1035	2359	2361
Nelson	730	97	2403	1656	2394	2557
Rosen	1950	1493	1975	530	2089	2371
Saluda	1872	1117	1774	730	2108	2588
Tyler	1960	1792	2371	942	2790	3040

LSD 0.05 = 490

Table 11. Soft red winter wheat injury from herbicides applied at Lahoma.

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
Author 71	4	11	13	31	3	0
Caldwell	4	5	6	53	0	1
Coker 68-15	5	6	10	48	0	0
Coker 747	4	4	10	45	0	0
Coker 916	1	6	11	49	0	0
Florida 301	1	3	5	24	0	0
Florida 302	1	8	3	20	0	0
Jessie	14	38	8	33	1	1
Magnum	6	20	15	55	6	3
Massey	10	18	9	34	6	1
McNair 1003	4	6	11	34	3	0
Nelson	10	20	11	34	3	1
Rosen	8	4	14	28	1	0
Saluda	6	23	9	34	46	0
Tyler	2	11	5	41	1	0

LSD 0.05 = 11

Table 12. Effects of herbicides on soft red winter wheat yield at Lahoma.

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
Author 71	2233	1602	1985	1550	1943	2183
Caldwell	2585	2176	2163	1520	2306	2433
Coker 68-15	2321	2120	2239	1408	2235	2173
Coker 747	2233	1977	1932	1336	1985	1962
Coker 916	3069	2273	2439	1452	2603	2628
Florida 301	2517	2347	2434	1981	2293	2427
Florida 302	2820	2858	2612	2399	2731	2804
Jessie	2295	1096	2468	1712	2441	2372
Magnum	2445	2130	2090	1267	2223	2013
Massey	1996	1665	1987	1662	1855	1868
McNair 1003	2223	1788	1979	1621	1954	2120
Nelson	1715	1566	1775	1472	1814	1718
Rosen	2470	1976	2109	1708	2309	2265
Saluda	2063	1596	2155	1679	1898	1908
Tyler	3097	2303	2973	1928	3217	2829

LSD 0.05 = 392

Table 13. Soft red winter wheat injury from herbicides applied at Stillwater.

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
All Varieties	0	0	0	0	0	0

Table 14. Effects of herbicides on soft red winter wheat yield at Stillwater.

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
Author 71	2430	1942	2234	2449	2241	2004
Caldwell	3206	2904	3131	3360	2521	3488
Coker 68-15	3165	2699	2572	2918	2120	2997
Coker 747	2278	2164	2494	2863	1820	3157
Coker 916	2436	2580	2032	2402	1293	2402
Florida 301	906	1214	1756	1512	109	1025
Florida 302	3209	3071	2960	2996	2653	3103
Jessie	2716	3068	3257	3303	2868	2745
Magnum	2271	2771	2233	2863	2382	2591
Massey	2342	2179	2801	3101	1605	2775
McNair 1003	2735	2687	3023	2853	2376	2885
Nelson	3145	2485	2507	3100	2362	2810
Rosen	2354	2181	2111	2799	2261	2827
Saluda	2949	3219	3131	2709	2823	3477
Tyler	2948	2282	2996	3083	2667	3242

LSD 0.05 = 772

Table 15. Soft red winter wheat injury from herbicides applied at Chickasha.

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(%)					
Author 71	4	4	4	3	11	0
Caldwell	3	6	4	5	3	0
Coker 68-15	0	6	5	4	1	0
Coker 747	4	4	4	6	4	0
Coker 916	3	7	7	11	5	0
Florida 301	1	6	4	5	19	0
Florida 302	3	6	6	5	1	0
Jessie	4	8	8	8	9	1
Magnum	3	5	6	6	4	0
Massey	13	16	5	6	6	0
McNair 1003	3	5	5	6	4	0
Nelson	8	5	4	6	9	0
Rosen	6	8	5	4	9	3
Saluda	4	5	6	7	1	0
Tyler	8	10	5	8	1	0

LSD 0.05 = 5

Table 16. Effects of herbicides on soft red winter wheat yield at Chickasha.

	Ethiozin		Cyanazine		Metribuzin	Check
	(kg/ha)					
Cultivar	1.1	2.2	0.6	1.1	0.4	-
	(kg/ha)					
Author 71	3008	2579	2791	2581	2775	2661
Caldwell	3591	3433	3405	3605	3380	3824
Coker 68-15	4127	3270	4282	4058	3779	4269
Coker 747	3565	3887	3667	3401	3640	4272
Coker 916	3772	3520	3721	3082	3301	3903
Florida 301	2675	2849	2505	2564	2177	2422
Florida 302	4254	2895	3084	3759	3785	4417
Jessie	3425	3475	3593	3412	2983	3428
Magnum	3837	3368	3315	3119	3140	3726
Massey	2811	2419	3289	2952	3128	3776
McNair 1003	3806	3337	3645	3482	3566	4020
Nelson	3353	3298	3345	3348	3162	3647
Rosen	3311	2939	3233	3250	2979	3418
Saluda	4707	4224	4352	4460	4647	4358
Tyler	3639	2636	3724	3838	3491	4309

LSD 0.05 = 556

VITA 2

THOMAS KENT BAKER

Candidate for the Degree of

Master of Science

Thesis: THE DIFFERENTIAL TOLERANCE OF WINTER WHEATS TO, AND THE EFFICACY OF BROMUS CONTROL HERBICIDES

Major field: Agronomy

Biographical:

Personal Data: Born in Lindsay, Oklahoma, November 30, 1956, the son of John and Jean Baker.

Education: Graduated from Lindsay High School, Lindsay, Oklahoma, in May 1975. Received Bachelor of Science Degree in Agricultural Education, from Oklahoma State University, Stillwater, Oklahoma in December 1983. Completed the requirements for the Master of Science Degree with a major in Agronomy at Oklahoma State University in December, 1989.

Experience: Assistant plant manager, Gay Seeds Incorp., Lindsay, Oklahoma, 1979 to 1981. Student laborer, Okla. Foundation Seeds Inc., 1981 to 1983. Asst. Agronomist, Rohm and Haas Seeds Inc., 1983 to 1985. Sr. Agriculturalist, Oklahoma State University Agronomy Department, October 1985 to present.

Professional Memberships: Southern Weed Science Society, North Central Weed Science Society