INVESTIGATIONS ON THE DIFFERENTIAL TOLERANCE OF WHEAT CULTIVARS TO METRIBUZIN

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INTRODUCTION

Each of the three parts of this thesis is a separate manuscript to be submitted for publication; Parts I and III in *Agronomy Journal*, an American Society of Agronomy publication, and Part II in *Weed Science*, the journal of the Weed Science Society of America.

PART I

DIFFERENTIAL RESPONSE OF WHEAT (*TRITICUM AESTIVUM* L.) GENOTYPES TO METRIBUZIN

DIFFERENTIAL RESPONSE OF WHEAT (TRITICUM AESTIVUM L.) GENOTYPES TO METRIBUZIN

Abstract. In response to reports of differential tolerance to winter wheat (*Triticum aestivum* L.) cultivars to metribuzin, field and greenhouse experiments were conducted to determine the range of metribuzin tolerance in a representation of available winter wheat germplasm resources. The effect of postemergence applications of metribuzin at 1.12 kg/ha, on 317 wheat genotypes of diverse genetic background was investigated by determining the number of heads produced from treated vs. untreated field plots. Ninety-six of these genotypes were further evaluated a second year in the field. Twenty-nine genotypes were compared to 'TAM W 101' for response to metribuzin at 0.42 and 0.84 kg/ha by measuring dry foliage production in the greenhouse. Ten genotypes were compared to TAM W 101 for response to metribuzin at 0.07 to 0.84 kg/ha in the greenhouse.

Results from the field experiments indicated a wide range of genotypic response to metribuzin, varying from 0 to greater than 50% reduction in head production. Genotypes which exhibited high levels of metribuzin tolerance in two consecutive years of screening included those with 'Osage', Osage-C.I. 15321 combinations, *T. vavilovi*/Sdy and At166/Naphal in their pedigrees.

Dry foliage production of all genotypes was reduced more than 50% in the initial greenhouse experiment where metribuzin at 0.42 and 0.84 kg/ha was applied. There were some differences among genotypes treated with metribuzin at 0.42 kg/ha, but not at 0.84 kg/ha. Threee genotypes (CO535926, 'Rendidor', and *T. vavilovi*/Sdy//Bezostaia) were more

tolerant than TAM W 101 when treated with metribuzin at 0.07 kg/ha in the second greenhouse screening.

INTRODUCTION

Differential tolerance to metribuzin has been discovered in a number of crops including soybeans (*Glycine max* (L.) Merr) (4, 5), tomatoes (*Lycopersicon esculentum* Mill.) (7), potatoes (*Solanum tuberosum* L.) (2), and more recently in winter wheat (6) and barley (*Hordeum vulgare* L.) (3). Differential metabolism has been reported as a source of differential tolerance in soybeans (5) and barley (3). Runyan et al. (6) observed differential tolerance to metribuzin in 15 hard red winter wheat cultivars in Oklahoma. Gigax (1) also found that winter wheat cultivars responded differently to metribuzin in Kansas.

Since the discovery of differential response among wheat cultivars to metribuzin, federal registration has been granted for metribuzin use in the Pacific Northwest and in three Great Plains states. Its use in Oklahoma and Texas is restricted to three cultivars, TAM W 101, 'Newton', and 'TAM 105', and in Kansas is restricted to these three cultivars plus 'Eagle'.

Metribuzin is primarily used to control *Bromus* sp. in wheat but it also typically controls henbit (*Lamium amplexicaule* L.) and annual *Cruciferae* spp. Metribuzin could possibly control other weeds, such as jointed goatgrass (*Aegilops cylindrica* Host), at higher application rates, but currently the margin of crop safety is too small. Crop injury with metribuzin has been observed at rates from 0.6 to 1.1 kg/ha (6).

The objectives of this research were to examine the range of metribuzin tolerance in a representation of available germplasm sources utilizing both field and greenhouse experiments and to identify genotypes with useful levels of tolerance for use as parents in wheat breeding programs.

MATERIALS AND METHODS

A collection of 317 winter wheat genotypes were selected for investigation. This collection supplied a diverse source of genotypes which included, old 'Turkey-type' hard red winter wheats (HRWW), improved genotypes of HRWW, soft red winter wheat (SRWW) genotypes, Pacific Northwest white winter wheats (WWW) and HRWW genotypes, Northeast WWW genotypes, winter/spring derivatives, Agrotricum lines, genotypes from Eastern Europe, Japan, Canada and South America, germplasm lines of interest because of special characteristics such as high protein and pest resistance, and alien gene translocation lines

Each genotype was seeded on October 27, 1979 at 67 kg/ha in a single 4 m row. Rows were spaced 30 cm apart on Kirkland silt loam (Udertic Paleustolls, fine, mixed, thermic), with a pH of 7.0 and O.M. content of 1.1% at the Agronomy Research Station, Stillwater, Oklahoma. Alternate rows were seeded with TAM W 101 to provide each genotype with a common cultivar border row. Metribuzin at 1.12 kg/ha was applied to 1.5 m of each row, with a small-plot compressed air sprayer, on March 31, 1980, when the wheat was at stages 30 to 31 (8). The experiment was arranged in a split-plot in strips (genotype rows were split by application of metribuzin in a strip across each replication) in a randomized complete block design with four replications.

The number of heads in the center 1 m of each row was determined in both the treated and untreated sections of each genotype in June, 1980. The response of each genotype to metribuzin was determined by comparing head counts in the treated and untreated sections of the row and calculating percent head production for the treated section.

Ninety-six genotypes, based on their performance in the first field screening, were selected for further evaluation in the field. Forty-seven of the more tolerant genotypes and 22 of the least tolerant genotypes in the initial screening were selected. The other 25 had intermediate tolerance values and were further evaluated because they were either commercially available cultivars or had genetic backgrounds similar to some of the tolerant genotyes. These genotypes were seeded at 34 kg/ha in two 6 m rows spaced 30 cm apart on October 30, 1980 at the same location as the initial screening. TAM W 101 was planted in every third row as a common cultivar border row. Metribuzin at 1.12 and 2.24 kg/ha was applied to 1.5 m of both rows of each genotype on March 20, 1981, when wheat was at stages 30 to 31 (8). The design was the same as in the first field screening and head production was determined in June, 1981 by the same method used in the initial screening test. In both field screenings, the soil was at or near saturation at time of treatment.

Greenhouse screening. A greenhouse experiment was conducted in 1982 to compare 29 genotypes with 'TAM W 101' for response to metribuzin at 0.42 and 0.84 kg/ha. Nineteen of the more tolerant and four of the least tolerant in both years of field screening were selected for evaluation in this study. The other six were a Naphal selection and the cultivars TAM 105, Newton, 'Vona', 'Sage', and Osage. Seedlings of each genotypes were established in 250 g of Norge loam soil (Udic Paleustoll, fine silty, mixed, thermic) in pots 7 cm in diameter. The pots were sub-irrigated initially and surface watered as needed thereafter. A factorial arrangement of treatments (three metribuzin rates by 30 genotypes) in a randomized complete block design with four replications was utilized for this experiment.

Metribuzin at 0, 0.42, and 0.84 kg/ha (based on surface area) was applied to the soil surface in 10 ml aliquots 19 days after planting, when the wheat was at stages 13 to 14 (8). Ten days after treatment, the plants were clipped at the soil surface and the foliage was oven dried. Response to metribuzin was determined by comparing foliage dry weight of metribuzin treated and untreated plants. The data were subjected to statistical analysis.

Additional greenhouse experiments were conducted to further compare ten of these wheat genotypes with TAM W 101 for response to metribuzin at 0, 0.07, 0.14, 0.28, 0.42, 0.56, and 0.84 kg/ha. Eight of the more tolerant and two of the least tolerant genotypes previously screened in field and greenhouse tests were selected for evaluation. Treatment procedures were the same as in the earlier greenhouse screening. Treatments were applied 18 days after planting, when wheat was at stages 13 to 14 (8). Eleven days after treatment, the plant tops were clipped at the soil surface and the foliage was oven dried. Response to metribuzin was determined by comparing foliage dry weight of metribuzin treated and untreated plants. A factorial arrangement of treatments (seven metribuzin rates by 11 genotypes) in a randomized complete block design with six replications were utilized for the experiment. The experiment was repeated and the data were subjected to statistical analysis.

RESULTS AND DISCUSSION

Field screenings. Application of metribuzin at 1.12 kg/ha to the 317 genotypes resulted in a wide range of metribuzin tolerance among the germplasm lines investigated. The genotypic response to metribuzin at 1.12 kg/ha in 1979-80 ranged from 39 to 130% of untreated head production (Appendix, Table 1).

The majority of the 317 genotypes tested fell into either the 70 to 80% or 80 to 90% head production category with 95 and 97 genotypes being placed in each of these two categories (Table 1). Twenty of the genotypes had over 100% of untreated head production. Head production was less than 50% of untreated in three of the genotypes tested.

Of the 96 genotypes investigated in 1980-81, response to metribuzin at 1.12 and 2.24 kg/ha ranged from 55 to 130% of untreated head production for 92 of the genotypes with the other four exceeding 130% and from 15 to 107% of untreated head production for 94 of the genotypes with the other two exceeding 130%, respectively (Appendix, Table 1).

After application of metribuzin at 1.12 kg/ha, head production of 25 genotypes exceeded the untreated (Table 1). There were 18, 20, and 22 genotypes in the 90 to 100%, 80 to 90% and 70 to 80% groupings, respectively, and 10 genotypes with less than 70% head production.

Treatment with metribuzin at 2.24 kg/ha resulted in an overall shift in the distribution of the number of genotypes in the various groupings so that a reduction in the number of genotypes which were classed in the upper groupings occurred. The majority of the genotypes had less than 70% head production, and 26 had less than 50% head production. It was anticipated that metribuzin at 2.24 kg/ha would completely destroy the majority of the genotypes. The lack of complete destruction was attributed to the wet soil at the time of metribuzin application. Runyan et al. (6) reported that metribuzin activity was reduced when applied to saturated soils.

Greenhouse screening. There was a significant difference in dry foliage production among the 30 genotypes treated with metribuzin at 0.42 kg/ha (Table 2). Only one genotype, a Naphal selection, was significantly higher than TAM W 101, however, it did not perform well in two years of field screening. Dry foliage production was less than 40% of check for all genotypes except the Naphal selection. There was no absolute tolerance in any of the genotypes to metribuzin at 0.42 kg/ha. There was no significant difference in dry foliage production between genotypes treated with metribuzin at 0.84 kg/ha.

In the second greenhouse screening study, using lower metribuzin rates, there was a wheat genotype by metribuzin rate interaction on dry foliage production (Table 3). The major differences occurred at the three lowest applications rates. When treated with metribuzin at 0.07 kg/ha, Vona produced less dry foliage, as a percent of untreated, than any other genotype. Three genotypes treated with metribuzin at 0.07 kg/ha, Rendidor, T. vavilovi/Sdy//Bezostaia, and C0535926 produced more dry foliage as a percent of untreated than TAM W 101. The genotypes, Vona, germplasm line OK78R8194, and C.I. 15321/TAM W-103//Caprock treated with 0.07 kg/ha metribuzin produced less dry foliage as a percent of untreated than TAM W 101. Vona, and C.I. 15321/TAM W-

103//Caprock also yielded less than TAM W 101 when treated with metribuzin at 0.14 and 0.28 kg/ha. None of the genotypes treated with metribuzin at 0.14 and 0.28 kg/ha yielded significantly higher than TAM W 101. There were only minor differences in dry foliage production at the three highest rates with no genotypes yielding significantly higher than TAM W 101.

The field and greenhouse screenings indicated that there was a wide range of variability in response to metribuzin in currently available germplasm sources. There were a few groups of genotypes that had high levels of metribuzin tolerance in both years of field screening. Genotypes with Osage and C.I. 15321-Osage combinations in their pedigree appeared to have high levels of tolerance to metribuzin. Four genotypes with T. vavilovi/Sturdy in their pedigree exhibited high levels of metribuzin tolerance. Sturdy was not tolerant to metribuzin, therefore T. vavilovi may be a potential source of metribuzin tolerance. Also, genotypes with At166/Naphl in their pedigrees exhibited high levels of metribuzin tolerance.

C0535926, Rendidor, 'Red Chief', and 'Early Blackhull' exhibited tolerance to metribuzin in both field and greenhouse screenings. Vona and germplasm line OK78R8194 were two of the least metribuzin-tolerant genotypes in both field and greenhouse screenings.

Additional research is needed to further identify the genetic basis for and the heritability of metribuzin tolerance in wheat breeding programs.

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Table 1. The response categories of 317 genotypes in 1979-80 and 96 genotypes in 1980-81 in response to metribuzin.

Response category	1979-80	1980-81	
	Metribuzin (kg/ha)		
Heads produced	1.12 Frequency	1.12 Frequency	2.24
(% of untreated)	- - -(Number of genotypes) - - -		
>130	0	4	2
120-130	2	1	0
110-120	4	7	0
100-110	14	13	2
90-100	52	18	2
80-90	97	20	4
70-80	95	22	18
60-70	40	8	22
50-60	10	3	20
40-50	2	0	10
<40	1	0	16
No. of genotypes evaluated	317	96	96
% head production mean	81.2	93.5	63.3
SD	12.7	27.0	27.3

Table 2. The effect of metribuzin on head production in field screenings during 1979-80 and 1980-81 and dry foliage production in a greenhouse screening of 30 wheat genotypes.

Entry Number	Genotype	Head production FS1†	Head production FS2†		Dry foliage production GS†	
		Metribuzin (kg/ha)				
		1.12	1.12	2.24	0.42	0.84
		(% of untreated)				
192	CO 535926	121	116	76	30	32
60	15321/TAM W-103//Osage 76G1035	111	257	218	30	26
62	T. vavilovi/Sdy 7251-31	106	98	45	28	32
65	T. vavilovi/Sdy//Bezo 1 9127B	104	82	86	30	28
235	Atl66/Naphal//TX62A2522-1-4 10836	101	101	78	38	34
95	15321 Sib (V77-8)	100	88	71	29	25
308	Sage	99	93	61	25	32
309	Osage	99	104	70	32	23
105	15321/TAM W-103//Crc	98	111	55	29	23
317	TAM W 101	98	105	73	27	26
245	Kiszombori-1//Naphal/13449	97	153	108	20	29
89	Rendidor	97	104	82	39	34
236	Atl66/Naphal//SKS35/NE701137	96	78	67	33	35
66	T. vavilovi/Sdy//Bezo 1 9129B	94	114	135	32	32
13	Red Chief	94	85	70	39	31
118	T. vavilovi/Sdy 7251-64	94	97	31	22	23
37	Plainsman V	93	106	102	33	31
42	Newton	83	152	79	31	30
2	Ey Blackhull	81	121	83	17	27
61	15321/TAM W-103//Osage	81	105	71	34	25
28	Arthur 71	80	59	66	32	31

Table 2. Continued.

Entry Number	Genotype	Head production: FS1†			Dry foliage production: GS†	
		FS1†	FS2†		GS†	
		Metribuzin (kg/ha)				
		1.12	1.12	2.24	0.42	0.84
		(% of untreated)				
98	15321/TAM W-103//Osage 1035	78	--	--	19	19
11	Comanche	76	74	68	26	31
238	Atl66/Naphal//Norde Deprez 2	75	55	34	29	28
314	TAM 105	68	93	77	19	22
16	Naphal selection	66	63	38	50	44
113	CI8286/Parker	58	66	39	33	31
63	OK695033/T. macha 7252-72	51	79	59	24	11
209	OK78R8194	39	106	25	35	29
318	Vona	--	71	31	27	24
	L.S.D. 0.05	30	57	45	14	n.s.

†FS1 = Field screening during 1979-80, FS2 = Field screening during 1980-81, GS = Greenhouse screening.

Table 3. Dry foliage production of 11 wheat genotypes, 30 days old, 11 days after treatment with metribuzin.

Wheat genotype	Metribuzin (kg/ha)					
	0.07	0.14	0.28	0.42	0.56	0.84
	(% of untreated)					
TAM W 101	74	58	52	49	47	46
Vona	46	46	43	44	43	44
Rendidor	84	60	53	48	50	47
Red Chief	78	63	51	52	46	46
T. vavilovi/Sdy//Bezostaia	82	61	54	53	48	52
Germplasm line OK78R8194	65	52	49	51	47	45
C.I. 15321/TAM W-103//Osage 76G1035	79	61	52	51	50	49
Naphal selection	71	54	47	50	47	47
CO 535926	85	57	57	50	52	51
Early Blackhull	79	57	46	50	45	44
C.I. 15321/TAM W-103//Caprock	65	47	43	41	39	41
L.S.D. 0.05						
Genotype X Rate	7.8					

PART II

INVESTIGATIONS ON THE DIFFERENTIAL TOLERANCE OF WHEAT (TRITICUM AESTIVUM L.) GENOTYPES TO METRIBUZIN

INVESTIGATIONS ON THE DIFFERENTIAL TOLERANCE TO WHEAT (*TRITICUM AESTIVUM* L.) GENOTYPES TO METRIBUZIN

Abstract. There was no differential absorption or translocation of metribuzin [4-amino-6-*tert*-butyl-3-(methylthio)-*as*-triazine-5(4*H*)-one] by two metribuzin-tolerant wheat (*Triticum aestivum* L.) genotypes ('TAM W 101' and '76G1035') and two metribuzin-intolerant genotypes ('Vona' and 'OK78R8194'). Oxygen evolution, after treatment of isolated leaf discs of the four wheat genotypes was not differentially affected by metribuzin. Metribuzin differentially affected chlorophyll fluorescence in leaves of intact plants of TAM W 101 and Vona at 24 h after root application, indicating that electron transport was inhibited to a greater degree in Vona than in TAM W 101.

INTRODUCTION

Differential cultivar tolerance to metribuzin has been reported in tomatoes (*Lycopersicon esculentum* Mill.) (15), potatoes (*Solanum tuberosum* L.) (6), and soybeans (*Glycine max* (L.) Merr.) (8, 9), and more recently in hard red winter wheat (13) and barley (*Hordeum vulgare* L.) (7). Metribuzin has been successfully used for weed control in metribuzin-tolerant wheat cultivars in some states, however, the margin of crop safety is limited (13). Metribuzin is absorbed by the roots and translocated to its active site in the upper foliage. There is a current need for determining metribuzin tolerance in wheat genotypes.

A number of researchers have utilized chlorophyll fluorescence as an indicator of photosynthetic activity (2, 10, 14). Ahrens et al. (1) investigated the technique of chlorophyll fluorescence analysis as a potential assay system for triazine resistance in six weed species and three crop species, including wheat. They used chlorophyll fluorescence analysis to monitor the onset of photosynthesis inhibition in atrazine-treated leaf sections. Since metribuzin inhibits photosynthesis by inhibiting electron transport near photosystem II (16, 17), its activity in wheat should be detectable using chlorophyll fluorescence measurements.

The objectives of this research were to examine the ^{14}C-metribuzin absorption and translocation in intolerant and tolerant genotypes of wheat and to determine the effect of metribuzin on O_2 evolution and chlorophyll fluorescence in efforts to develop a suitable technique for screening wheat genotypes for tolerance to metribuzin.

MATERIALS AND METHODS

Uptake and translocation. Two tolerant genotypes (TAM W 101 and 78G1035) and two intolerant genotypes (Vona and OK78R8194) were used to determine whether differential uptake and translocation of ^{14}C-metribuzin occurred among the genotypes. Seeds of these four genotypes were germinated in a vertical aerated column filled with water. Individual seedlings were transferred into 25 ml vials containing half-strength Hoagland's nutrient solution. Each vial was wrapped with aluminum foil to exclude light. The plants were maintained in a growth chamber with conditions of 14 h, 33 C, 120 um/m^2/s days, and 10 h, 29 C nights. The nutrient solution was changed every 48 h. A factorial arrangement of treatments (two exposure periods by three metribuzin concentrations by four wheat genotypes) in a randomized complete block design with eight replications was used in the experiment.

After 8 days the plants were treated via the nutrient solution with 0.7 uM metribuzin-5-^{14}C (26.8 Ci/M). Technical grade metribuzin was added to the solution to provide concentrations of 0.7, 2.1, and 7.7 uM metribuzin in the growing solution. After 4 and 48 h the plants were harvested and sectioned into four pieces (the root, the area enclosed by the first leaf sheath, the first leaf blade, and the portion of the second leaf blade protruding above the collar of the first leaf). These sections will be referred to hereafter as root, midsection, leaf 1 and leaf 2, respectively. The plant sections and the nutrient solution were then lyophilized. Plant sections were weighed and combusted in a Harvey Biological Material Oxidizer[1]. The $^{14}CO_2$ was trapped for ^{14}C analysis in 25 ml scintillation fluid[2]. After lyophilization, the nutrient solution vials were filled with 25 ml scintillation fluid for determination of unabsorbed ^{14}C. ^{14}C in each sample was quantified by a liquid scintillation counter. Distribution of ^{14}C was calculated for each plant section and the nutrient solution based on the quantity of ^{14}C recovered. The data were subjected to statistical analysis.

Oxygen evolution. The effect of metribuzin on O_2 evolution by the four wheat genotypes was determined by polargraphic measurements of oxygen in a double-walled reaction vessel using a YSI53 oxygen monitor adapted with a YSI Clark electrode[3]. The temperature of the reaction vessel was

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[1] R.J. Harvey Instrument Corp.

[2] $^{14}CO_2$unt Sorb, Research Products International Corp.

[3] Yellow Springs Instrument Co.

maintained at 30 C by a circulating water bath. A total of 40 leaf discs (4 mm in diameter) from four plants of each genotype were placed in the reaction vessel along with 3 ml of distilled water saturated with oxygen. After dark respiration depleted the solution to 40% oxygen saturation, the reaction vessel was illuminated with a light intensity of approximately 1200 uE/m^2/s. After a constant rate of O_2 evolution was established, 30 ul of metribuzin solution was injected to establish a concentration of 1.66 uM metribuzin in the vessel. Oxygen evolution and its induced metribuzin change were monitored on a strip chart recorder. The rate of leaf-disc oxygen evolution over time was calculated for both before and after the introduction of metribuzin. The rate in the presence of metribuzin was then calculated as a percent of the initial control rate to determine the effect of metribuzin (1.66 uM) on oxygen evolution. Three replicates of the study were performed and the data were subjected to statistical analysis.

Chlorophyll fluorescence. A portable plant productivity fluorometer[4] was utilized to investigate the effect of metribuzin on relative chlorophyll fluorescence response of both metribuzin-treated and untreated intact plants of TAM W 101 and Vona wheat. The opening of the sensing probe was partially occluded leaving a 1 by 3 mm slit to facilitate its use on the narrow leaves of wheat. The light-emitting diode of the probe, centered around 670 nm, was adjusted to an intensity of 7 uE/m^2/s. Seed of TAM W 101 and Vona were germinated and grown in pots of soil in an open room under fluorescent light with a light intensity of 300 uE/m^2/s for 14 h followed by a 10 h dark period. After

[4]Model SF-10, Richard Brancker Research Ltd.

two weeks, when the plants had 3 to 4 leaves, they were transplanted tinted glass jars containing 60 ml of half-strength Hoagland's nutrient solution plus 0.0, 0.3, 0.4, 0.5, and 0.6 uM metribuzin. A factorial arrangement of treatments (two wheat genotypes by five metribuzin concentrations) in a randomized complete block design with four replications was used in the experiment.

Chlorophyll fluorescence curves of each plant were obtained 24 h after treatment. In each case, the adaxial surface of the second leaf was covered with the sensing probe and the plants remained in this dark environment for 4 minutes. The samples were then illuminated for 30 s while relative chlorophyll fluorescence was recorded on a strip chart recorder. The percent fluorescence decay from the initial peak to fluorescence after 30 s of illumination was determined for each concentration by genotype combination. The experiment was repeated and the data were subjected to statistical analysis.

RESULTS AND DISCUSSION

Uptake and translocation. A metribuzin concentration by time of exposure interaction was found to occur with both metribuzin absorption and translocation (Table 1). There was neither a genotype main effect nor genotype interaction with the other factors. After 4 h exposure, approximately 98% of applied ^{14}C-metribuzinn was recovered from the nutrient solution indicating that initial uptake into the root was independent of metribuzin concentration. There was no significant effect due to concentration after 4 h exposure in any of the sections tested.

Increasing the exposure time to 48 h resulted in a significant increase in uptake of ^{14}C-metribuzin into the roots and its movement to other plant parts. The concentration by exposure time interaction was the result of the concentration effect after 48 h exposure and the absence of concentration effect at 4 h. A larger percentage of total ^{14}C applied was absorbed by plants exposed to the lower concentration than by those exposed to the higher concentrations. There was also a larger percentage of total ^{14}C translocated to the upper plants in those exposed to the lower concentration in comparison to those exposed to the higher concentrations. The higher concentrations may have resulted in stomatal closure which would have reduced the transpiration rate. Willis et al. (18) reported that atrazine closed stomates of corn, cotton, and soybean leaves and reduced transpiration rates in each species.

Oxygen evolution. Although metribuzin reduced oxygen evolution in each of the four genotypes tested (Table 2), there was no significant difference among genotypes. Ahrens et al. (1) reported that photosynthesis in isolated leaf sections of wheat cultivars with a variation in relative atrazine tolerance was not differentially affected by atrazine over a 5 h period.

Chlorophyll fluorescence. As a result of the apparent lack of differential tolerance at the isolated leaf disc level, investigations utilizing chlorophyll fluorescence were conducted on whole plants. After induction of chlorophyll fluorescence in untreated plants of TAM W 101 and Vona, there was a rapid rise to peak fluorescence followed by a rapid partial decay in fluorescence (Figure 1). This was followed, in most instances, by a slight secondary rise in fluorescence and then a slow decay to near steady-state fluorescence. Physiological activities regulating these fluorescence changes have been reviewed by Papageorigiou (12). Chlorophyll fluorescence of metribuzin (0.5 uM) treated plants of TAM W 101 and Vona were different. For Vona, there was only a slight decay of fluorescence after a rapid rise to the initial peak indicating a blockage of electron transport, whereas for TAM W 101 the decay from the peak was similar in shape to untreated plants.

Components of the initial peak have been used by other researchers (3, 4, 5, 11, 16) as criteria for studying photsystem II electron transport, including time elapsed between onset of illumination and peak fluorescence.

At the highest metribuzin concentration (0.6 uM), time required to reach peak fluorescence in Vona was 0.4 s and in TAM W 101 was 0.8 s. However, with the use of a strip-chart recorder to monitor relative fluorescence, chlorophyll fluorescence decay was considered a more accurate measure of electron transport inhibition.

The quenching of chlorophyll fluorescence was determined by dividing the difference between the relative intensities of the initial peak and relative intensity after 30 s of illumination by the relative intensity of the initial peak. At concentrations of 0.3 and 0.4 uM metribuzin, no differences in fluorescence quenching occurred between TAM W 101 and Vona (Figure 2). However, at concentrations of 0.5 and 0.6 uM metribuzin, only limited fluorescence quenching occurred in Vona after the initial peak, indicating that electron transport had been inhibited.

The absence of differences between the intolerant and tolerant wheat genotypes in metribuzin absorption or translocation suggested that differential tolerance in wheat was due to either a differential effect on photosynthesis or differential metabolism. Metribuzin did not differentially alter photosynthesis in isolated leaf discs of intolerant and tolerant genotypes when using oxygen evolution measurement but differentially affected electron transport in intact plants of TAM W 101 and Vona as evidenced in the chlorophyll fluorescence work. The fact that metribuzin differentially affects photoreactions in intact plants but not in isolated leaf discs, along with reports of differential metabolism of metribuzin in soybeans (9) and more recently in barley (7) suggests that differential metribuzin metabolism may be a factor in differential tolerance of wheat to metribuzin.

This view is supported by the research of Ahrens et al. (1). They reported that chlorophyll fluorescence was not differentially affected by atrazine in isolated leaf sections of wheat genotypes. They also suggested that differential detoxification or atrazine metabolism may be the source of triazine tolerance in wheat.

The technique using chlorophyll fluorescence of metribuzin-treated intact plants provided a non-destructive method for rapid screening for metribuzin tolerance in wheat. This method appears to have potential for screening, not only for metribuzin tolerance in plants, but also for tolerance to other photosythetic inhibitors.

ACKNOWLEDGMENTS

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Table 1. Distribution of ^{14}C activity in wheat plants 4 and 48 h after application of ^{14}C-metribuzin.

		^{14}C recovered†				
Metribuzin concentration	Exposure time	Nutrient Solution	Root	Mid-section	Leaf 1	Leaf 2
(uM)	(h)	- - - - - - - - - - -	- -	(%) - - - -	- - - - -	- - - - -
0.7	4	98.0	0.9	0.7	0.1	0.2
2.1	4	98.0	0.8	0.6	0.2	0.3
7.7	4	98.1	0.9	0.6	0.2	0.3
0.7	48	77.5	2.5	4.0	2.9	9.8
2.1	48	90.5	1.4	1.9	1.7	4.4
7.7	48	91.2	1.8	1.9	1.8	3.4
L.S.D. 0.05		3.7	0.7	0.3	0.5	0.9

†Values are averaged over wheat genotypes and do not total to 100% because of rounding error.

Table 2. Effect of metribuzin (1.66 uM) on oxygen evolution in isolated discs of four wheat genotypes.

Genotype	O_2 evolution
	(% of control)
TAM W 101	58
OK78R8194	53
Vona	46
76G1035	42
L.S.D. 0.05	n.s.

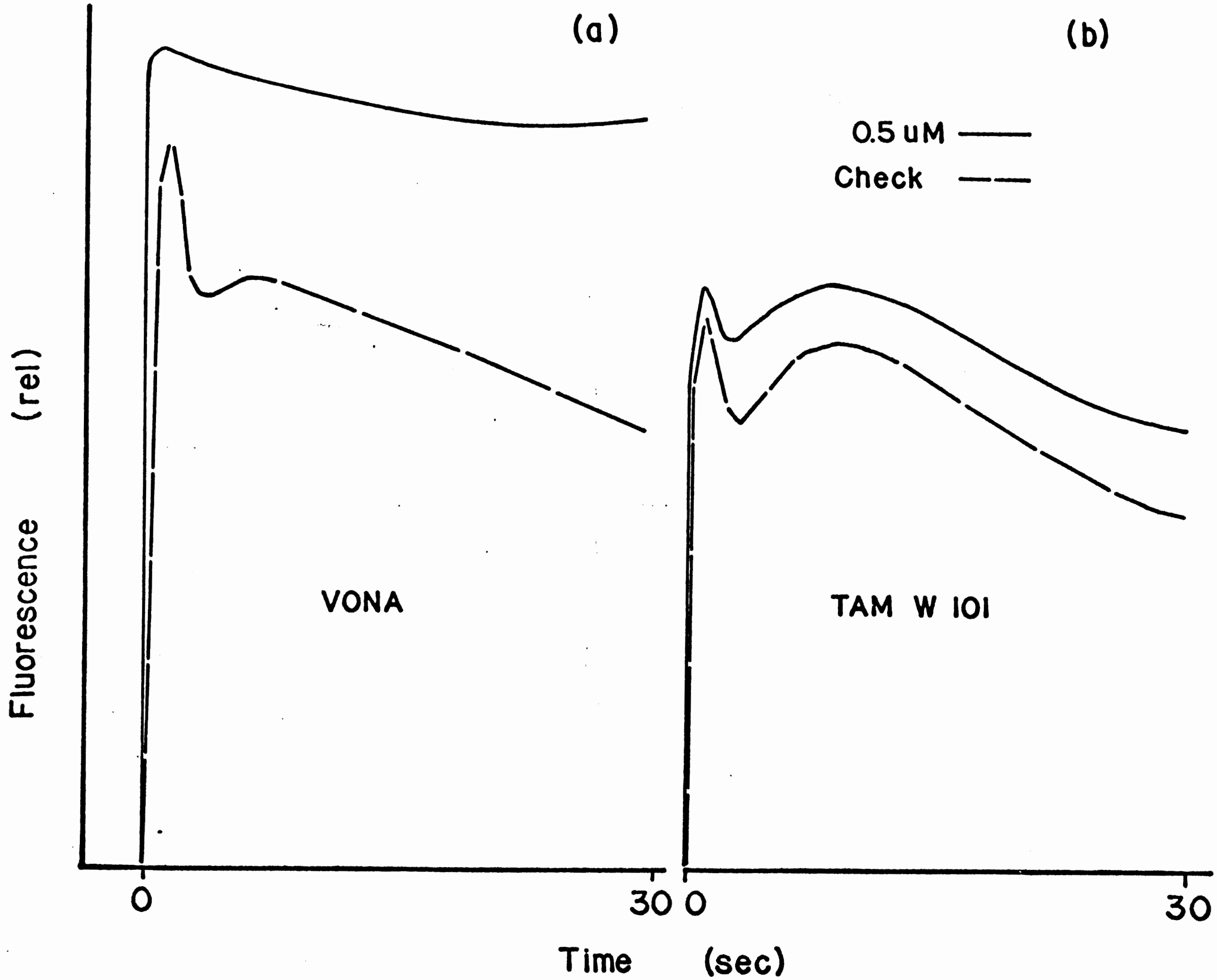

Figure 1. Relative chlorophyll flourescence of untreated and metribuzin-treated plants of Vona (a) and TAM W 101 (b).

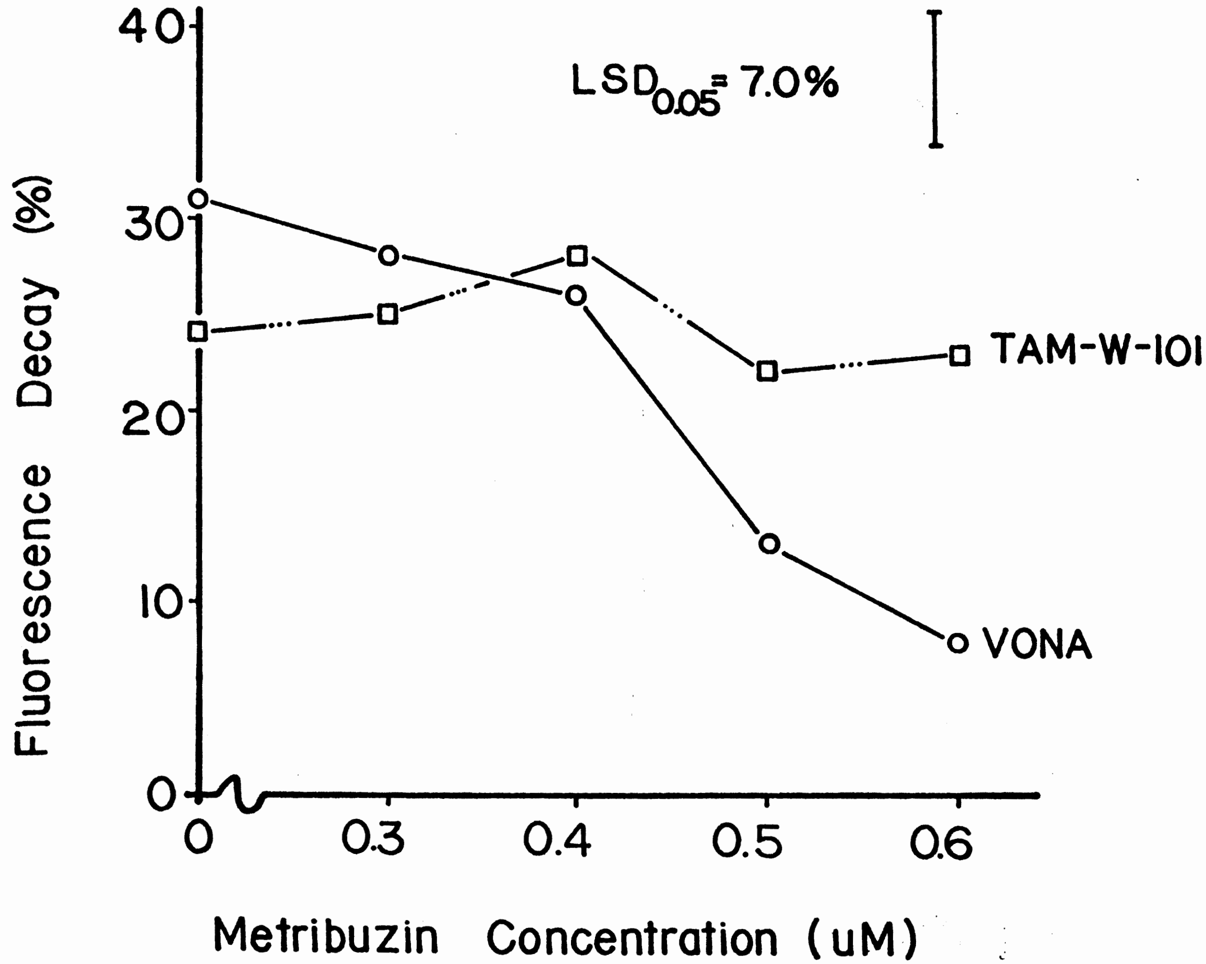

Figure 2. The effect of metribuzin on fluorescence decay in TAM W 101 and Vona.

PART III

EFFECT OF WHEAT GROWTH STAGE AND APPLICATION RATE ON RESPONSE OF CHEAT (*BROMUS SECALINUS* L.) AND WINTER WHEAT (*TRITICUM AESTIVUM* L.) TO METRIBUZIN

EFFECT OF WHEAT GROWTH STAGE AND APPLICATION RATE ON RESPONSE OF CHEAT (BROMUS SECALINUS L.) AND WINTER WHEAT (TRITICUM AESTIVUM L.) TO METRIBUZIN

Abstract. Cheat (Bromus secalinus L.) is a severe weed problem in winter wheat production in the southern Great Plains. Five field experiments were conducted during the 1979-80 and 1980-81 crop years to determine the effect of wheat growth stage and application rate on response of cheat and winter wheat (Triticum aestivum L.) cultivars, 'TAM W 101', 'Newton', and 'TAM 105', to metribuzin [4-amino-6-tert-butyl-3-(methylthio)-as-triazine-5(4H)-one]. Metribuzin was applied postemergence at four wheat growth stages (20 to 23, 24 to 29, 30, and 31 to 32 using Zadok et al. decimal code). Application rates ranged from 0.14 to 0.56 kg/ha at stages 20 to 23 and 24 to 29, 0.28 to 0.70 kg/ha at stage 30, and 0.42 to 0.84 kg/ha at stage 31 to 32. Cheat control was evaluated by visual ratings and dockage in the harvested grain. Wheat responses was determined by visual estimation of vigor reduction, grain yield, grain test weight, and grain protein measurements.

Metribuzin at 0.42 and 0.56 kg/ha applied at stages 20 to 23 and 24 to 29 provided 75 to 100% cheat control and increased grain yield by 400 to 1400 kg/ha. Dockage of 26.4% in the experiment with the most severe cheat infestation (500 to 700 plants/m^2) was reduced by metribuzin applications to as low as 1.5%. Application of metribuzin at stage 31 to 32 reduced grain yield in four of five experiments.

Grain test weight and protein content were not adversely affected by metribuzin applications.

INTRODUCTION

Increased usage of stubble mulch and other minimum tillage seedbed preparation practices and early seeding of wheat for forage production have increased Bromus spp. infestations in winter wheat (2, 7). As recently as 1977 there were no herbicides available to farmers for selective control of cheat in winter wheat (7). During the late 1970's several researchers (1, 2, 6, 10, 11, 14) initiated investigations on the use of metribuzin for selective Bromus spp. control in winter wheat. This early work indicates that excellent control of downy brome (*Bromus tectorum* L.) could be obtained by postemergence application of metribuzin at 0.28 to 1.66 kg/ha. Gigax (4) reported that metribuzin at 0.42 kg/ha applied postemergence controlled both cheat and downy brome. However, response of wheat to metribuzin varied from complete kill (1) to over 100% grain yield increases compared to an untreated weedy check (10, 11).

In experiments conducted from 1976 through 1978, Runyan et al. (9) found differential tolerance among wheat cultivars to metribuzin. Gigax (4), in Kansas, also observed differential tolerance among wheat cultivars to metribuzin. Their research indicated that wheat does not have a high level of physiological tolerance to metribuzin.

In 1979, a 24(c) registration was granted for use of metribuzin (at 0.42 to 0.84 kg/ha, dependent on soil characteristics) in Oklahoma as a spring application to tillered TAM W 101 winter wheat. While TAM W 101 was a widely used cultivar, Newton, a cultivar with resistance to soilborne wheat mosaic virus (5), was becoming popular in areas where the disease was prevalent. TAM 105, released in 1979 (8), exhibited a potential to become an accepted cultivar in Oklahoma.

The objectives of this research were to compare reduced metribuzin rates (0.14 to 0.56 kg/ha) applied in the fall at growth stages 20 to 23 and 24 to 29 to recommended rates (0.42 to 0.84 kg/ha) applied in the spring for selective control of cheat in TAM W 101, Newton, and TAM 105 winter wheat. Additional objectives were to determine the effect of these metribuzin treatments on grain test weight and grain protein content.

MATERIALS AND METHODS

Field experiments were conducted during the 1979-80 crop season at the Agronomy Research Stations near Perkins, Stillwater, and Lahoma, Oklahoma, and during the 1980-81 crop season only at the Perkins and Stillwater Stations. The experiments will be referred to hereafter as Exp. 1, 2, 3, 4, and 5 (Table 1). TAM W 101 and Newton were seeded in Exp. 1 and these two plus TAM 105 were seeded at Exp. 2, 3, 4, and 5 at 88$\pm$4 kg/ha with a hoe-type drill in rows spaced 25 cm apart. During 1979-80, in Exps. 1 and 3, the cultivars were grown under cheat-infested conditions for evaluation of selective control by metribuzin and Exp. 2 was located on a cheat-free site in order to compare the effects of metribuzin on the three cultivars when no cheat was present to intercept part of the herbicide. During 1980-81, in Exps. 4 and 5, metribuzin was applied to each of the three cultivars grown under both cheat-free and cheat-infested conditions.

Exp. 1 was arranged in a split-plot in strips (cultivar main plots were stripped with metribuzin treatments) in a randomized complete block design with four replications. Exps. 2 and 3 were arranged in a split-plot (cultivar main plots with metribuzin subplots in a randomized complete block design with four and three replications, respectively. Exps. 4 and 5 were arranged in a split-split-plot in strips (cultivar main plots were split by weed situation subplots and these subplots were stripped with metribuzin treatment sub-subplots) in a randomized complete block design with four replications. Individual plot size in all experiments was 2.5 by 6.9 m.

Metribuzin was applied postemergence at growth stages 20 to 23 (early tillering), 24 to 29 (continued tillering), 30 (leaf sheaths erect), and 31 to 32 (node formation). Application rates were 0.14, 0.28, 0.42, and 0.56 kg/ha at stages 20 to 23 and 24 to 29. At stage 30, application rates were 0.28, 0.42, 0.56, and 0.70 kg/ha and at stage 31 to 32, metribuzin rates were 0.42, 0.56, 0.70, and 0.84 kg/ha. Mid-fall planted wheat in Oklahoma reaches stage 20 to 23 in October, stage 24 to 29 from November to February, stage 30 in early to mid March, and stage 31 to 32 in late March and April. All treatments were applied with a small-plot compressed-air sprayer which delivered 280 l/ha.

In the spring of 1981, greenbug (Schizaphis graminum) infestations developed in Exps. 4 and 5. They were controlled by two applications of malathion [O,O-dimethyl-S-(1,2-dicarbethoxyethyl) phosphorodithioate] at 1.12 kg/ha in Exp. 4 and by acephate (O, S-dimethyl acetylphosphoramidothioate) at 1.12 kg/ha followed by methyl parathion [O,O-dimethyl-O-p-nitrophenyl phosphorithioate] at 1.12 kg/ha in Exp. 5.

Cheat control and crop vigor reduction were determined by visual evaluation in June 1980 and in April 1981. Grain yields were determined by harvesting the center 1.5 m of each plot with a small-plot combine. Grain samples were cleaned with an air-screen cleaner and weight loss as a result of cleaning was considered dockage. The clean grain test weights for Exps. 1 and 3 and the cheat-free section of Exps 4 and 5 and harvested grain weight for Exp. 2, were determined using standard weight per volume testing procedures. Grain protein content was determined, using a procedure described by Udy (12), for all samples in Exps. 1, 3, 4, and 5. All data were subjected to statistical analysis.

RESULTS AND DISCUSSION

Cheat control and dockage. All metribuzin treatments, in Exp. 1, provided significant cheat control and reduced dockage (Table 2). However, application of metribuzin at 0.14 kg/ha at stages 20 to 23 and 24 to 29 controlled less than 50% of the cheat. This relatively poor control of cheat is evident in the higher dockage obtained with metribuzin at 0.14 kg/ha compared to treatments with higher metribuzin rates. In Exp. 3, 94% and higher cheat control and lower dockage were obtained with 0.42 kg/ha or greater application rates of metribuzin at all stages. Metribuzin at 0.28 kg/ha or greater applied at stages 20 to 23 and 24 to 29 provided 85% or greater cheat control in Exp. 4. In Exps. 4 and 5, there was no significant rainfall between metribuzin applications at stages 31 to 32 and the visual evaluation. Only minimal cheat control was evident from these treatments at this time. Other research has indicated that rainfall is required for metribuzin activation (9) and it would appear that the low control noted was the result of inadequate rainfall. Although both Exps. 4 and 5 had moderate cheat infestations initially (200 to 350 plants/m^2), the cheat did not appear to be severely competitive with the wheat. This apparent low level of interference with the wheat was attributed to the greenbug infestation in the spring which greatly reduced the cheat infestations in Exp. 4 and to a lesser degree in Exp. 5. In Exp. 4, most of the remaining cheat had shattered prior to wheat harvest, and only minor differences in dockage were observed. Foreign matter other than cheat contributed to dockage in Exp. 4. In Exp. 5, cheat control was accompanied by decreased dockage.

Metribuzin effects on wheat vigor. There was no significant vigor reductions of TAM W 101 and Newton, in Exp. 1, after application of metribuzin at 0.14 to 0.56 kg/ha at stages 20 to 23 and 24 to 29 (Table 3). Crop injury was apparent after application of metribuzin at 0.56 and 0.70 kg/ha at stage 30. At stage 31 to 32, the wheat was more susceptible to injury from metribuzin than at earlier growth stages. No cultivar by metribuzin treatment interaction occurred in Exp. 1. In Exps. 2, 3, 4, and 5 there were both metribuzin treatment and cultivar effects or cultivar by metribuzin treatment interaction effects on vigor reduction. In each of these experiments, the wheat was more susceptible to vigor reduction when metribuzin was applied at stage 31 to 32. It should be noted that in Exp. 3 the cheat infestation was so severe (500 to 700 plants/m^2) it caused an obvious vigor reduction in the untreated checks and in metribuzin treatments which did not control cheat. As mentioned earlier, in Exps. 4 and 5, no significant rainfall occurred between metribuzin application at stage 31 to 32 and the date the evaluations were conducted, therefore, the low vigor reductions were attributed to foliar uptake.

Grain yield. In Exp. 1, applications of metribuzin at 0.42 and 0.56 kg/ha at stages 20 to 23 and 24 to 29 increased grain yield (Table 4). Yield increases were attributed to elimination of cheat interference prior to cessation of tiller production. Metribuzin at 0.70 kg/ha applied at stage 30 and at 0.70 and 0.84 kg/ha applied at stage 31 to 32 reduced the grain yield of Newton more than TAM W 101. Grain yields of both cultivars were decreased to some degree by all rates of metribuzin applied at stage 31 to 32.

In Exp. 2, with no cheat present, there was no cultivar by metribuzin treatment interaction, and the yield data are presented as the mean of the three cultivars. Grain yields were reduced by metribuzin at 0.56 kg/ha applied at stage 24 to 29, at 0.56 and 0.70 kg/ha applied at stage 30, and all rates applied at stage 31 to 32.

As in Exp. 2, no cultivar by metribuzin treatment interaction was found in Exp. 3. Exp. 3 had the most severe cheat infestation (500 to 700 plants/m^2) encountered which is reflected in an average grain yield of only 280 kg/ha in the untreated checks. Metribuzin at 0.14 kg/ha applied at stage 20 to 23 controlled only 21% of the cheat and the grain yield from this treatment was only 540 kg/ha. All other treatments at stage 20 to 23 significantly increased grain yields. All metribuzin treatments applied at stage 30 resulted in significant grain yield increases, however, metribuzin at 0.70 kg/ha caused crop injury which reduced yields compared to other metribuzin treatments at this stage. While all metribuzin treatments applied at stage 31 to 32 caused some wheat injury, rates of 0.42 and 0.56 kg/ha significantly increased yield as a result of cheat control.

There was a cultivar by metribuzin treatment interaction and a cultivar by weed situation interaction in grain yield in Exp. 4. These interactions are the result of metribuzin induced yield reductions of Newton and TAM 105 in the cheat-free plots and greater metribuzin induced yield reductions of these two cultivars in cheat-infested plots by metribuzin treatments applied at stages 30 and 31 to 32.

Although there were both metribuzin treatment and weed situation main effects on grain yield in Exp. 5, there was no interactions and the yield data are presented as the cultivar mean for both cheat-free and weedy plots. Metribuzin at all rates applied at stage 31 to 32 reduced average grain yield in both cheat-free and cheat-infested plots.

The initial moderate cheat infestation (200 to 350 plants/m^2), at Exps. 4 and 5, resulted in only approximately 300 kg/ha yield difference between cheat-free and weedy untreated checks.

Grain test weight. In Exp. 1, the average grain test weight of TAM W 101 and Newton was reduced by application of 0.84 kg/ha of metribuzin at stage 31 to 32 (Table 5). This reduction was attributed to shriveled grain. In Exp. 2, test weights were of harvested grain and were generally lower as a result of chaff in the samples. There were no metribuzin treatment effects and no interactions in Exp. 2. In Exp. 4, there was a cultivar by metribuzin treatment interaction in test weight due to test weight increases in Newton and TAM 105 after application of metribuzin at stage 31 to 32. None of the metribuzin treatments reduced grain test weight in any of the cultivars when compared to their respective untreated check. There were no metribuzin treatment or cultivar effects on grain test weight in Exp. 5.

Grain protein content. In Exp. 1, grain protein increased with metribuzin, at 0.70 kg/ha, was applied at stage 30, and by all rates applied at stage 31 to 32 (Table 6). This may have been the result of the late season removal of cheat and elimination of some wheat tillers by metribuzin late in the season which would increase nitrogen availability to remaining wheat tillers after tillering had ended. Increased nitrogen availability early in the growing season has been shown to increase yield while increased nitrogen availability late in the season increases grain protein (3).

In Exp. 3, there was a cultivar by metribuzin treatment interaction. The interaction resulted from larger differences among treatments in Newton and TAM 105 than in TAM W 101. The high protein content observed in the untreated checks was attributed to shriveled grain as a result of severe cheat competition. In Exp. 4, there were no cultivar, weed situation, or metribuzin treatment effects on grain protein, even though grain yields were reduced in some instances. In Exp. 5, the trends were similar to those in Exp. 1 where protein tended to increase with the late application of metribuzin. There was no weed effect on grain protein and the increases were attributed to near 800 kg/ha reductions in yield.

CONCLUSION

The research indicated that metribuzin at 0.28, 0.42, and 0.56 kg/ha applied at stages 20 to 23 and 24 to 29 increased grain yields by releasing wheat from cheat interference earlier in the season.

Metribuzin applications at these two earlier growth stages had no detrimental effect on grain test weight or grain protein content. Metribuzin applied at stage 30 provided significant yield increases when cheat infestations were from 500 to 700 plants/m^2. Application of metribuzin at stage 31 to 32 resulted in significant crop injury. This delay of application allowed cheat to compete with wheat for available moisture and nutrients for a large portion of the growing season.

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Table 1. Soil characteristics and treatment particulars for the five field experiments.

Experiment	Soil characteristics				Seeding Date	Cheat Population	Trt. Date	Growth stage	
	Texture	pH	O.M.	Nitrogen†				Wheat	Cheat
			(%)	(kg/ha)		(plants/m^2)			
Exp. 1	Sandy clay loam	5.3	1.2	30	9-13-79	300-500	10-11-79	20-23	10
							11-12-79	24-29	20-23
							3-5-80	30	30
							3-20-80	31-32	31-32
Exp. 2	Loam	6.3	0.7	30	9-20-79	0	11-14-79	24-29	-----
							3-20-80	30	-----
							4-15-80	31-32	-----
Exp. 3	Loam	6.0	1.0	30	10-6-79	500-700	3-7-80	20-23	10
							3-21-80	30	20-23
							4-22-80	31-32	31-32
Exp. 4	Loam	6.4	0.7	85	10-9-80	200-350	11-6-80	20-23	10
							12-17-80	24-29	20-23
							3-10-81	30	24-29
							4-2-81	31-32	31-32
Exp. 5	Silty clay loam	6.4	0.8	85	10-8-80	200-350	11-6-80	20-23	10
							12-17-80	24-29	20-23
							3-12-81	30	24-29
							4-2-81	31-32	31-32

†Total nitrogen applied as fertilizer.
Zadok et. al. decimal code at time of metribuzin treatment.

Table 2. Effect of wheat growth stage and metribuzin application rate on cheat control and dockage in harvested grain.

Wheat Growth Stage†	Metribuzin Rate	Exp. 1		Exp. 3		Exp. 4		Exp. 5	
		Control§	Dockage	Control§	Dockage	Control¶	Dockage	Control¶	Dockage
	(kg/ha)	%							
-----	0	0	8.5	0	26.4	0	4.5	0	5.7
20-23	0.14	47	4.2	21	18.9	58	4.4	18	5.0
	0.28	76	2.9	67	6.0	98	3.7	51	4.0
	0.42	93	3.1	94	3.2	100	3.4	75	3.1
	0.56	93	2.9	96	3.6	100	3.1	90	1.9
24-29	0.14	42	4.4	--	--	39	4.1	21	4.5
	0.28	72	2.8	--	--	85	4.1	42	3.6
	0.42	91	3.4	--	--	99	4.1	65	3.1
	0.56	95	2.7	--	--	100	3.9	81	2.3
30	0.28	63	3.7	83	4.6	48	4.8	63	2.8
	0.42	88	2.4	100	3.8	69	4.2	79	1.9
	0.56	95	2.4	99	4.7	82	4.5	90	1.8
	0.70	96	2.6	99	4.8	84	6.2	91	1.8

Table 2. (Continued).

Wheat Growth Stage†	Metribuzin Rate	Exp. 1		Exp. 3		Exp. 4		Exp. 5	
		Control§	Dockage	Control§	Dockage	Control¶	Dockage	Control¶	Dockage
	(kg/ha)	%							
31-32	0.42	96	2.1	51	5.5	18	4.6	17	3.8
	0.56	96	2.6	99	2.4	13	3.9	16	3.3
	0.70	96	3.5	99	1.5	14	3.7	--	--
	0.84	98	3.2	99	8.7	18	4.2	13	2.3
L.S.D. 0.05		9.7	0.9	9.0	0.7	9.6	1.9	10.5	0.8

†Zadok et. al. decimal code at time of metribuzin application.

§Visual rating relative to untreated check in June, 1980.

¶Visual rating relative to untreated check in April, 1981.

Table 3. Effect of wheat growth stage and metribuzin application rate on vigor reduction of 'TAM W 101', 'Newton', and 'TAM 105' wheat.

Wheat Growth Stage†	Metribuzin Rate	Wheat Cultivar Vigor Reduction §,¶													
		Exp. 1	Exp. 2			Exp. 3			Exp. 4			Exp. 5			
		Avg	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3	
	(kg/ha)	%													
--	0	0	0	0	0	83	80	90	0	0	0	0	0	0	
20-23	0.14	2	--	--	--	67	70	88	0	0	0	0	2	0	
	0.28	2	--	--	--	20	3	10	0	6	0	0	0	3	
	0.42	3	--	--	--	7	7	3	0	0	1	0	1	0	
	0.56	0	--	--	--	17	0	20	1	14	23	0	1	0	
24-29	0.14	2	0	0	0	--	--	--	0	1	0	1	3	0	
	0.28	4	--	--	--	--	--	--	0	0	0	0	0	0	
	0.42	2	3	3	3	--	--	--	0	3	0	0	0	0	
	0.56	5	8	15	3	--	--	--	1	0	0	0	0	0	
30	0.28	5	0	5	0	7	30	33	0	1	4	0	0	5	
	0.42	5	13	5	3	10	3	13	0	4	4	1	0	0	
	0.56	10	10	8	5	20	13	30	3	26	20	3	3	0	
	0.70	16	13	20	13	47	63	43	3	23	25	0	13	6	
31-32	0.42	25	18	23	13	63	57	63	0	8	3	3	13	10	
	0.56	21	13	28	13	47	53	67	0	8	6	--	--	--	
	0.70	36	13	38	15	50	70	77	0	8	8	3	11	10	
	0.84	56	23	33	20	43	73	83	0	12	5	8	15	13	

Table 3. (Continued).

Wheat Growth Stage†	Metribuzin Rate	Wheat Cultivar Vigor Reduction , Exp. 1	Exp. 2			Exp. 3			Exp. 4			Exp. 5		
		Avg	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3
L.S.D. 0.05														
Cultivar (C)		n.s.	--			6.0			--			--		
Treatment (T)		9.7	--			12.5			--			--		
C X T		n.s.	9.9			n.s.			8.0			5.6		

†Zadok et. al. decimal code at time of metribuzin application.

§Cultivars C1, C2, and C3 represent 'TAM W 101', 'Newton', and 'TAM 105', respectively.

¶Visual evaluations of Exps. 1, 2, and 3 were conducted in June, 1980 and of Exps. 4 and 5 were onducted in April, 1981.

#Due to severe infestations of cheat, vigor reduction was also reduced due to cheat competition in untreated and treatments which did not contol cheat.

Table 4. Effect of wheat growth stage and metribuzin application rate on wheat grain yield.

		Exp. 1		Exp. 2	Exp. 3	Exp. 4						Exp. 5	
						TAM W 101		Newton		TAM 105		Cultivar Mean	
Wheat Growth Stage†	Metri-buzin Rate	TAM W 101	Newton	Cultivar Mean	Cultivar Mean	Cheat Free	Weedy	Cheat Free	Weedy	Cheat Free	Weedy	Cheat Free	Weedy
	(kg/ha)	(kg/ha)											
-----	0.0	2010	2260	3520	280	2220	1830	1890	1500	2100	1900	3000	2710
20-23	0.14	2270	2580	----	540	2090	1880	1720	1570	2120	2100	2940	2740
	0.28	2200	2570	----	1670	2060	1970	1760	1660	2020	1970	3000	2630
	0.42	2500	2820	----	1770	1980	1760	1790	1680	1980	1790	3110	2980
	0.56	2500	2710	----	1480	1870	1750	1490	1410	1830	1740	2980	2860
24-29	0.14	2170	2450	3600	----	2140	1800	1630	1470	1980	1830	2770	2490
	0.28	2230	2610	----	----	2020	1750	1810	1700	1880	1900	2790	2810
	0.42	2590	2820	3410	----	2060	1710	1680	1610	1920	1900	2980	2520
	0.56	2630	2620	3080	----	2040	1830	1850	1650	1850	1900	2940	2750
30	0.28	2100	2310	3360	1490	1960	1670	1730	1490	1760	1800	2790	2690
	0.42	2010	2240	3270	1730	1680	1530	1490	1460	1610	1710	2780	2650
	0.56	2010	2150	3140	1370	1910	1720	1230	1160	1340	1420	2760	2340
	0.70	1710	1920	2840	860	1850	1560	1260	1140	1290	1300	2460	2530
31-32	0.42	1610	1760	2560	700	1980	1710	1450	1330	1670	1640	2460	2250
	0.56	1630	1870	2530	770	1960	1630	1460	1380	1770	1610	2300	2200
	0.70	1330	1220	2320	560	1960	1690	1430	1320	1630	1490	----	----
	0.84	1260	710	2070	540	1830	1620	1220	1080	1610	1420	2200	1960

Table 4. (Continued).

Wheat Growth Stage†	Metribuzin Rate	Exp. 1 TAM W 101	Exp. 1 Newton	Exp. 2 Cultivar Mean	Exp. 3 Cultivar Mean	Exp. 4 § TAM W 101 Cheat Free	Exp. 4 § TAM W 101 Weedy	Exp. 4 § Newton Cheat Free	Exp. 4 § Newton Weedy	Exp. 4 § TAM 105 Cheat Free	Exp. 4 § TAM 105 Weedy	Exp. 5 Cultivar Mean Cheat Free	Exp. 5 Cultivar Mean Weedy
L.S.D. 0.05													
Treatment		----	----	270	300							330	330
Treatment X Cultivar		320	320	n.s.	n.s.							n.s.	n.s.

†Zadok et. al. decimal code at time of metribuzin application.

§L.S.D. 0.05 for comparison of treatments within a single column = 210, L.S.D. 0.05 for comparison of cultivars at same weed situations and treatment = 280, L.S.D. 0.05 for comparison of cheat-free vs. weedy in same variety for same or different treatment = 350.

Table 5. Effect of wheat growth stage and metribuzin application rate on wheat grain test weight.

Growth Stage†	Metribuzin Rate	Grain Test Weight Exp. 1 Cultivar Mean	Exp. 2 Cultivar Mean	Exp. 4 TAM W 101	Exp. 4 Newton	Exp. 4 TAM 105	Exp. 5 Cultivar Mean
	(kg/ha)	----------	----------	---------- %	----------	----------	----------
-----	0	80.0	70.7	72.8	74.7	72.0	74.5
20-23	0.14	80.4	--	72.8	74.7	73.4	72.5
	0.28	80.4	--	72.1	75.0	73.7	73.2
	0.42	80.5	--	72.8	74.7	73.1	73.1
	0.56	80.4	--	72.8	74.4	73.7	74.3
24-29	0.14	80.4	71.0	73.1	74.7	73.1	73.3
	0.28	80.4	--	73.1	75.0	72.5	74.1
	0.42	79.9	71.7	72.5	74.1	73.1	73.7
	0.56	80.4	71.7	73.1	74.7	72.8	74.4
30	0.28	80.9	70.8	72.5	74.1	72.5	74.6
	0.42	80.4	70.1	72.8	74.7	72.5	75.1
	0.56	81.3	70.6	73.1	74.7	72.8	74.8
	0.70	80.8	70.6	72.5	74.4	73.1	73.2
31-32	0.42	80.9	70.3	72.5	75.7	73.7	74.6
	0.56	80.2	69.3	72.8	76.0	74.7	74.7
	0.70	79.7	70.6	72.5	76.0	74.4	--
	0.84	76.8	68.7	71.8	76.0	73.1	73.1

Table 5. Continued.

Growth Stage†	Metribuzin Rate	Grain Test Weight Exp. 1 Cultivar Mean	Exp. 2 Cultivar Mean	Exp. 4 TAM W 101	Exp. 4 Newton	Exp. 4 TAM 105	Exp. 5 Cultivar Mean
L.S.D. 0.05							
Treatment		1.0	n.s.	--			n.s.
Treatment X Cultivar		n.s.	n.s.	0.9			n.s.

†Zadok et. al. decimal code at time of metribuzin application.

Table 6. Effect of wheat growth stage and metribuzin application rate on grain protein content.

Growth Stage†	Metribuzin Rate	Grain Protein Content: Exp. 1 Cultivar Mean	Exp. 3 TAM W 101	Exp. 3 Newton	Exp. 3 TAM 105	Exp. 4 Cultivar Mean	Exp. 5 Cultivar Mean
	(kg/ha)	%					
--	0	11.4	15.2	14.7	16.3	17.6	12.9
20-23	0.14	11.9	14.9	14.9	15.2	17.7	13.3
	0.28	10.8	14.7	15.6	15.6	17.5	12.5
	0.42	11.8	15.3	15.9	15.7	17.6	12.5
	0.56	12.1	15.4	16.0	15.6	17.2	12.6
24-29	0.14	11.4	--	--	--	17.5	13.3
	0.28	11.2	--	--	--	17.8	12.5
	0.42	12.2	--	--	--	17.5	12.5
	0.56	12.1	--	--	--	17.4	12.8
30	0.28	12.1	15.4	15.4	15.6	17.6	12.5
	0.42	12.2	15.0	15.4	15.4	17.4	13.5
	0.56	12.5	15.0	16.0	15.6	17.8	12.8
	0.70	12.9	15.6	16.1	15.9	17.3	13.2
31-32	0.42	12.9	15.4	14.9	14.8	17.7	13.4
	0.56	13.5	15.4	15.8	15.3	17.9	14.4
	0.70	14.7	15.7	15.6	15.2	17.7	--
	0.84	14.7	15.6	15.5	15.3	18.0	13.6

Table 6. Continued.

Growth Stage†	Metribuzin Rate	Grain Protein Content Exp. 1 Cultivar Mean	Exp. 3 TAM W 101	Exp. 3 Newton	Exp. 3 TAM 105	Exp. 4 Cultivar Mean	Exp. 5 Cultivar Mean
L.S.D. 0.05							
Treatment		1.3	--			n.s.	0.9
Treatment X Cultivar		n.s.	0.6			n.s.	n.s.

†Zadok et. al. decimal code at time of metribuzin application.

APPENDIX

Table 1. Effect of metribuzin application on head production of winter wheat genotypes during 1979-80 and 1980-81.

Entry Number	Genotype	1979-80 Metribuzin (kg/ha) 1.12	1979-80 Metribuzin (kg/ha) 0	1979-80 Metribuzin (kg/ha) 1.12	1980-81 Metribuzin (kg/ha) 1.12	1980-81 Metribuzin (kg/ha) 2.24	1980-81 Metribuzin (kg/ha) 0	1980-81 Metribuzin (kg/ha) 1.12	1980-81 Metribuzin (kg/ha) 2.24
		(% CK)†	(Heads/m)		(% CK)†		- - - (Heads/m) - -		
53	HD832/HRW Comp 4836	130	142	153	118	77	101	118	75
192	CO535926	121	166	184	116	76	150	161	98
211	GAT72-4145	115	114	130	91	55	114	102	62
151	Agrotricum Seln	115	87	98	84	50	121	104	61
121	McCall/Cnf 6115-1	112	146	136	---	---	---	---	---
60	15321/TAM W-103//Osage 76G1035	111	152	165	257	218	48	99	85
149	Agrotricum Seln Blue	109	68	63	87	63	155	129	98
248	Dekalb 582 R-line	109	142	136	81	63	154	124	102
21	Hand	107	177	181	86	75	164	135	115
36	Flex	106	212	223	76	71	204	156	147
62	T. vavilovi/Sdy 7251-31	106	153	149	98	45	150	143	67
199	NY 6298	104	209	210	71	71	205	143	142
153	Agrotricum Seln	104	129	135	91	66	133	123	89
65	T. vavilovi/Sdy//Bezo 1 9129D	104	146	142	82	86	99	81	85
83	Quequen	104	141	132	91	67	119	101	76
206	OK75R3611	102	158	158	---	---	---	---	---
260	WD71340-08H	102	156	154	95	40	149	127	63
14	Scout 66	101	193	180	74	60	169	127	97
235	Atl66/Naphal//TX62A2522-1-4 11050	101	157	156	101	77	138	137	104
197	GAT 763793	100	185	168	83	59	178	145	103

Table. 1. (Continued).

Entry Number	Genotype	1979-80 Metribuzin (kg/ha) 1.12	0	1.12	1980-81 Metribuzin (kg/ha) 1.12	2.24	0	1.12	2.24
		(% CK)†	(Heads/m)		(% CK)†		- - - (Heads/m) - -		
95	15321 Sib (V77-8)	100	127	127	88	71	119	107	84
232	Atl66/Naphal//TX62A2522-1-4 10994	100	161	159	99	54	117	106	59
120	McCall/Danne 6107	99	182	175	---	---	---	---	---
46	Bezo 1//N. Deprez/2*Pul Sel 101	99	156	150	74	53	143	106	77
283	Slavyanka	99	117	113	72	52	107	76	55
309	Sage	99	138	122	104	70	124	133	84
308	Osage	99	180	172	93	60	157	143	92
124	Nugaines/TX651682	98	148	143	---	---	---	---	---
105	15321/TAM W-103//Crc	98	156	134	111	56	109	114	56
79	PI349031	98	96	91	73	43	94	64	37
317	TAM W 101	98	173	165	105	73	150	158	109
91	PI351651	98	154	135	---	---	---	---	---
297	Martonvasari 5	97	132	126	92	52	120	102	57
102	Stoddard Seln 3	97	135	127	---	---	---	---	---
245	Kiszombori-1//Naphal/13449 11428	97	104	102	152	107	79	101	73
196	GAT 4357	97	144	138	78	56	164	127	89
246	Kiszombori-1//Naphal/13449 11433	97	92	87	108	97	97	104	91
89	Rendidor	97	115	105	104	82	128	121	103
264	SWD 70469-04W	96	176	112	---	---	---	---	---
236	Atl66/Naphal//SKS35/NE701137	96	152	146	107	81	138	123	99
288	Blueboy	96	149	141	---	---	---	---	---
231	Atl66/Naphal//NB68570/CTK	95	138	132	91	58	98	81	54

Table 1. (Continued).

Entry Number	Genotype	1979-80 Metribuzin (kg/ha) 1.12	1979-80 Metribuzin (kg/ha) 0	1979-80 Metribuzin (kg/ha) 1.12	1980-81 Metribuzin (kg/ha) 1.12	1980-81 Metribuzin (kg/ha) 2.24	1980-81 Metribuzin (kg/ha) 0	1980-81 Metribuzin (kg/ha) 1.12	1980-81 Metribuzin (kg/ha) 2.24
		(% CK)†	(Heads/m)		(% CK)†		- - - (Heads/m) - -		
233	At166/Naphal//TX62A2522-1-4 10836	95	183	170	66	49	176	115	85
239	Naphal/At166//NB68510/Hyslop	95	156	148	111	76	143	142	105
110	CI9294/Scout	95	168	146	85	53	201	169	100
160	Anz/Sdy	95	169	156	---	---	---	---	---
313	Baca	95	180	170	96	54	162	153	85
66	T. vavilovi/Sdy//Bezo 1 9129B	94	133	124	114	135	78	79	93
13	Red Chief	94	176	159	85	70	134	114	95
287	Bezostaia 1	94	139	130	89	57	137	118	76
118	T. vavilovi/Sdy 7251-64	94	158	148	97	31	138	125	39
228	Bezo-NE69655 Cross	94	162	145	75	67	146	111	97
37	Plainsman V	93	163	139	106	102	92	91	95
84	Lemaire 26	93	138	129	---	---	---	---	---
18	Lancota	93	185	167	---	---	---	---	---
244	Burgas 2/3/N-H/Lcr//NE701136/Ctk	93	136	126	---	---	---	---	---
168	15322/2*Osage	92	158	141	---	---	---	---	---
172	CI15322/2*Osage-708	92	173	150	---	---	---	---	---
175	Stoddard	92	152	139	---	---	---	---	---
289	NE7060	92	168	151	---	---	---	---	---
281	Partizanka	92	155	139	90	72	142	126	102
311	Larned	92	186	155	---	---	---	---	---
229	Cmn/II-54-58//CRC	92	143	131	---	---	---	---	---
266	OWW 71264-1	91	112	101	---	---	---	---	---

Table 1. (Continued).

Entry Number	Genotype	1979-80 Metribuzin (kg/ha) 1.12	0	1.12	1980-81 Metribuzin (kg/ha) 1.12	2.24	0	1.12	2.24
		(% CK)†	(Heads/m)		(% CK)†		- - - (Heads/m) - -		
85	Massaux 3	91	131	120	---	---	---	---	---
152	Agrotricum Seln OK7211590	91	179	159	73	28	204	141	56
202	Lovrin 29	91	143	126	---	---	---	---	---
178	DS28A/Pnc	91	181	160	---	---	---	---	---
64	T. vavilovi/Sdy//Bezo 1 9127B	91	149	130	96	71	114	109	78
7	Danne	90	201	173	76	90	119	81	98
293	Clement	90	109	102	---	---	---	---	---
74	Plainsman V	90	164	144	---	---	---	---	---
30	Winter Transec	90	134	122	---	---	---	---	---
155	Perennial Wht	90	113	98	106	75	130	136	98
295	JO 3057	90	113	94	---	---	---	---	---
262	SWD 71854-04H	89	132	118	---	---	---	---	---
275	CI 13449/Centurk	89	176	149	---	---	---	---	---
250	SWD 70025-07W	89	179	156	---	---	---	---	---
171	TX WSMV Comp Seln	89	177	157	---	---	---	---	---
219	OK78R8188	89	172	148	---	---	---	---	---
78	TAM W-103	89	188	168	---	---	---	---	---
261	SWD 71483D-03H	89	129	110	---	---	---	---	---
52	HD832/HRW Comp 4835	89	153	135	---	---	---	---	---
27	Osage Alein gene	89	206	175	83	68	159	130	107
271	OWW 68007-3M6	89	138	121	---	---	---	---	---
303	Caprock	89	196	170	---	---	---	---	---

Table 1. (Continued).

Entry Number	Genotype	1979-80 Metribuzin (kg/ha) 1.12	0	1.12	1980-81 Metribuzin (kg/ha) 1.12	2.24	0	1.12	2.24
		(% CK)†	(Heads/m)		(% CK)†		- - - (Heads/m) - -		
221	OK78R8041	89	139	121	---	---	---	---	---
90	T-1698	89	93	79	---	---	---	---	---
185	Sdy//Cof/Cre 4890-4	89	155	137	---	---	---	---	---
137	Krasnadarshaga 39	89	139	122	---	---	---	---	---
75	Payne	88	179	156	---	---	---	---	---
163	WWP 7147	88	144	122	---	---	---	---	---
156	Perennial Wht Hays 22034	88	99	81	110	83	92	98	76
315	Agate	88	167	147	---	---	---	---	---
177	Cerco	88	150	128	---	---	---	---	---
243	Naphal/Lcr//CB96/Naz/3/F73-71	88	141	123	---	---	---	---	---
25	Bordenave Puan Sag	88	175	151	---	---	---	---	---
256	SWH 72475-1H	87	132	113	---	---	---	---	---
71	Blueboy	87	155	136	---	---	---	---	---
220	OK73R4735	87	116	96	---	---	---	---	---
31I	Purdue 6615D	87	162	133	---	---	---	---	---
282	Samson	87	142	121	---	---	---	---	---
259	SWD71233-01H	87	130	113	---	---	---	---	---
215	OK78R8001	87	162	138	---	---	---	---	---
294	Hackiman-Komigi	87	126	106	---	---	---	---	---
277	Newton	86	158	134	---	---	---	---	---
17	Atlas 66	86	153	131	---	---	---	---	---
278	Martonvasari 4	86	143	122	---	---	---	---	---

Table 1. (Continued).

Entry Number	Genotype	1979-80 Metribuzin (kg/ha) 1.12	0	1.12	1980-81 Metribuzin (kg/ha) 1.12	2.24	0	1.12	2.24
		(% CK)†	(Heads/m)		(% CK)†		- - - (Heads/m) - -		
299	F80-73 (Donia)	86	152	130	---	---	---	---	---
252	MON 753715	86	167	141	---	---	---	---	---
179	5*Kaw//DS28A/Pnc	85	188	151	---	---	---	---	---
39	GB120-23-13	85	176	148	---	---	---	---	---
240	Naphal/Atl66//NB68510/Hyslop 10820	85	146	126	---	---	---	---	---
207	D 70/263	85	184	150	---	---	---	---	---
58	PI Comp Seln 4844	85	138	115	---	---	---	---	---
8	Nicoma	85	188	156	71	66	109	76	67
194	Wanser	85	156	125	---	---	---	---	---
3	Kharkof	85	179	153	82	64	181	147	110
205	F 51-68	85	174	149	---	---	---	---	---
34	CI15322	85	152	129	---	---	---	---	---
286	Atlas 66	84	131	111	---	---	---	---	---
203	OK77R6327	84	159	133	---	---	---	---	---
136	Miron-Jubilay 50	84	128	105	---	---	---	---	---
56	PI Comp Seln 4841	84	168	135	---	---	---	---	---
38	GB 88-13-7-B	84	204	169	---	---	---	---	---
162	P101/Anza	84	178	145	---	----	---	---	---
173	Crc/70R104-15 X7	84	172	142	---	---	---	---	---
42	Newton	83	182	147	152	79	120	176	93
300	Adam	83	141	116	---	---	---	---	---
268	FW 72176-39	83	135	114	---	---	---	---	---

Table 1. (Continued).

Entry Number	Genotype	1979-80 Metribuzin (kg/ha) 1.12	1979-80 Metribuzin (kg/ha) 0	1979-80 Metribuzin (kg/ha) 1.12	1980-81 Metribuzin (kg/ha) 1.12	1980-81 Metribuzin (kg/ha) 2.24	1980-81 Metribuzin (kg/ha) 0	1980-81 Metribuzin (kg/ha) 1.12	1980-81 Metribuzin (kg/ha) 2.24
		(% CK)†	(Heads/m)		(% CK)†		- - - (Heads/m) - -		
251	MON 753684	83	116	97	---	---	---	---	---
193	NE75809	83	185	151	---	---	---	---	---
302	Pioneer 915-A	83	251	208	---	---	---	---	---
161	Anza/Sdy	83	179	142	---	---	---	---	---
169	Wi/P3-19 (OK65C77-6)	83	158	124	---	---	---	---	---
92	Rosso Di Salmour	83	126	104	---	---	---	---	---
49	Lovrin 6	83	159	129	---	---	---	---	---
208	OK78R8331	82	184	149	---	---	---	---	---
50	CO-C-1	82	210	168	---	---	---	---	---
274	Absolvent	82	145	118	---	---	---	---	---
130	NE701132/Cerco	82	168	137	---	---	---	---	---
22	Favorite-Velvet Cross	82	177	145	---	---	---	---	---
214	OK78R8017	82	177	145	---	---	---	---	---
117	T. vavilovi/Sdy 7251-58	82	164	129	67	35	112	76	37
189	OK74R2653	82	152	115	---	---	---	---	---
312	Stephen	82	178	146	---	---	---	---	---
158	Psenicno-Purejnyi G1	82	120	97	---	---	---	---	---
142	NR391-76	82	138	110	---	---	---	---	---
115	T. vavilovi/Sdy 7251-24	81	180	140	73	42	152	111	65
133	Rannaya	81	123	99	---	---	---	---	---
126	TX62A4793-7/VH70548	81	154	127	---	---	---	---	---
237	Atl66/Naphal//Likafen/NE701134	81	179	146	77	66	165	127	109

Table 1. (Continued).

Entry Number	Genotype	1979-80 Metribuzin (kg/ha) 1.12	0	1.12	1980-81 Metribuzin (kg/ha) 1.12	2.24	0	1.12	2.24
		(% CK)†	(Heads/m)		(% CK)†		- - - (Heads/m) - -		
47	I.D. 0033/Purd 4930//Moldova	81	177	141	---	---	---	---	---
2	Ey Blackhull	81	207	167	121	83	145	158	113
61	15321/TAM W-103//Osage	81	158	127	105	71	99	100	70
204	CI15587	81	175	139	---	---	---	---	---
69	Predgornaia	81	110	9	---	---	---	---	---
267	OWW71266-2	81	90	69	---	---	---	---	---
24	Bezostaia 1	81	136	108	---	---	---	---	---
4	Triumph	81	204	157	58	50	123	73	60
87	Martonvasari	81	163	124	---	---	---	---	---
241	Naphal/Atl66//Sort 12-13	81	142	110	---	---	---	---	---
140	NR57-76	81	152	122	---	---	---	---	---
187	Inia 67/OM//Hbgn/Hn IV	80	144	112	---	---	---	---	--
186	D630/Hn VII/Era	80	139	109	---	---	---	---	---
170	Wi/P3-19 (OK65C93-8)	80	152	118	---	---	---	---	---
183	Sdy//Cof/Crc 4890-4	80	154	124	---	---	---	---	---
28	Arthur 71	80	164	125	59	66	135	79	85
129	NE701132/Nugaines	80	187	147	---	---	---	---	---
132	Odesskaya 52	80	175	137	---	---	---	---	---
10	Ponca	80	210	162	70	54	177	122	93
212	OK78R8050	80	144	114	---	---	---	---	---
103	Cajeme 71/Crc//TAM W-102	79	176	140	---	---	---	---	---
100	Stoddard Seln 1	79	171	133	---	---	---	---	---

Table 1. (Continued).

Entry Number	Genotype	1979-80 Metribuzin (kg/ha) 1.12	0	1.12	1980-81 Metribuzin (kg/ha) 1.12	2.24	0	1.12	2.24
		(% CK)†	(Heads/m)		(% CK)†		- - - (Heads/m) - -		
93	Onatrache Hacal	79	162	126	---	---	---	---	---
253	OCB750455	79	148	107	---	---	---	---	---
166	NR20-76	79	155	123	---	---	---	---	---
6	Triumph 64	79	176	138	73	45	136	95	59
265	OWW71114-3	79	168	131	---	---	---	---	---
116	T. vavilovi/Sdy 7251-37	79	168	131	89	45	162	141	72
51	HD832/HRW Comp 4832	78	169	128	---	---	---	---	---
143	Lovrin 11	78	146	109	---	---	---	---	---
182	Sdy//Cof/Crc 4890-2	78	161	126	---	---	---	---	---
98	15321/TAM W-103//Osage 1035	78	208	163	---	---	---	---	---
181	Sdy//Cof/Crc 4890-1	78	163	128	---	---	---	---	---
131	Odessakaya 51	78	180	136	115	60	123	141	74
188	Cofn/Pch//P101/Vogal	78	110	79	---	---	---	---	---
226	Favorit-Velvet Cross	78	150	116	---	---	---	---	---
210	OK75R3708	78	151	117	---	---	---	---	---
99	KS75216	78	193	151	---	---	---	---	---
301	Purdue 6922A1-16	78	203	157	---	---	---	---	---
88	Portugez 94571	78	141	110	---	---	---	---	---
55	PI Comp Seln 4840	78	169	127	---	---	---	---	---
12	Cheyenne	78	177	138	85	74	175	133	111
146	NS12-72	77	115	86	---	---	---	---	---
141	NR231-76	77	151	115	---	---	---	---	

Table 1. (Continued).

Entry Number	Genotype	1979-80 Metribuzin (kg/ha) 1.12	0	1.12	1980-81 Metribuzin (kg/ha) 1.12	2.24	0	1.12	2.24
		(% CK)†	(Heads/m)		(% CK)†		- - - (Heads/m) - -		
191	OR7075	77	200	155	---	---	---	---	---
298	NSR-1	77	117	90	---	---	---	---	---
234	Atl66/Naphal//TX62A2522-1-4 10836	77	177	135	84	30	149	124	43
108	CI8287/Gage	77	185	142	---	---	---	---	---
29	Aurora	76	121	93	---	---	---	---	---
19	Plainsman V	76	216	165	---	---	---	---	---
11	Comanche	76	206	150	74	68	184	129	115
33	Amigo	76	211	160	70	78	159	128	70
198	LA707	76	196	147	---	---	---	---	---
227	Sava//Purd 4930/NB69655	76	177	128	---	---	---	---	---
304	Dekalb 589	76	195	143	---	---	---	---	---
174	Stadler	76	180	125	---	---	---	---	---
216	OK78R8008	76	167	128	---	---	---	---	---
43	NE701154/Jubileinaia	76	170	121	---	---	---	---	---
213	OK78R8116	76	137	103	---	---	---	---	---
40	TAM W-102	76	194	147	---	---	---	---	---
59	PI Comp Seln 4845	75	159	119	---	---	---	---	---
176	Oasis	75	177	134	---	---	---	---	---
41	F23-71	75	121	85	---	---	---	---	---
109	CI9294/Scout CI17455	75	165	124	---	---	---	---	---
32	Payne	75	176	130	70	40	187	129	72
150	Agrotricum Seln OK7211676	75	114	86	---	---	---	---	---

Table 1. (Continued).

Entry Number	Genotype	1979-80 Metribuzin (kg/ha) 1.12	0	1.12	1980-81 Metribuzin (kg/ha) 1.12	2.24	0	1.12	2.24
		(% CK)†	(Heads/m)		(% CK)†		- - - (Heads/m) - -		
125	NE701132//CI13645/PI178383	75	175	133	---	---	---	---	---
238	Atl66/Naphal//Norde Deprez 2	75	153	107	55	34	151	88	50
167	NR231-76	75	166	121	---	---	---	---	---
257	SWH72475-3H	75	139	102	---	---	---	---	---
97	HD832/HRW Comp	75	176	131	---	---	---	---	---
147	Blue wht/Agent	75	151	112	---	---	---	---	---
222	OK78R8043	75	155	113	---	---	---	---	---
134	Rannaya 12	75	151	111	---	---	---	---	---
230	Atlas 66	75	145	107	91	66	145	131	94
290	Odessa 4	74	148	108	---	---	---	---	---
94	Blue wht/Agent	74	140	103	---	---	---	---	---
82	Bucaresti 1	74	141	104	---	---	---	---	---
184	Sdy//Cof/Crc 4890-7	74	185	136	---	---	---	---	---
123	C59287/CI13438//TX65A1626	74	206	153	---	---	---	---	---
144	F95-71	74	158	115	---	---	---	---	---
258	SWH72479-2H	74	128	93	---	---	---	---	---
107	Olasen/HRW Comp	74	144	109	---	---	---	---	---
48	Favorit-Velvet 5319	73	181	132	---	---	---	---	---
68	T. macha/OK695033//Bezo 9134D	73	169	120	---	---	---	---	---
106	TRS-287	73	169	122	---	---	---	---	---
280	NR-72/837	73	129	97	---	---	---	---	---
112	CI9320/Gage	73	217	160	---	---	---	---	---

Table 1. (Continued).

Entry Number	Genotype	1979-80 Metribuzin (kg/ha) 1.12	0	1.12	1980-81 Metribuzin (kg/ha) 1.12	2.24	0	1.12	2.24
		(% CK)†	(Heads/m)		(% CK)†		- - - (Heads/m) - -		
255	SWH72009-2H	73	193	139	---	---	---	---	---
70	Sadovo 1	73	164	119	---	---	---	---	---
135	Predgornaya 2	73	114	83	---	---	---	---	---
128	NE701132/Hyslop	73	176	128	---	---	---	---	---
54	PI Comp Seln 4837	72	172	123	---	---	---	---	---
139	NR31-74	72	126	91	---	---	---	---	---
77	Sturdy	72	169	120	130	52	73	90	39
279	Naphal/At166	72	190	137	86	61	117	100	61
15	(Sel 14/50-3) Seln 9 (H. lysine)	72	142	98	---	---	---	---	---
154	Agrotricum Seln OK7211525	72	124	90	---	---	---	---	---
292	Lovrin 24	71	144	101	---	---	---	---	---
86	Sarmiento	71	187	133	---	---	---	---	---
291	Gk-Protein	71	139	97	---	---	---	---	---
67	T. macha/OK695033//Bezo 9133A	71	160	109	---	---	---	---	---
242	Naphal/At166//2*Aurora	71	132	94	---	---	---	---	---
76	Triumph 64	71	215	148	---	---	---	---	---
165	NR365-76	71	167	113	---	---	---	---	---
284	Slavia (ST-VUR-37)	71	153	105	---	---	---	---	---
272	ABYT76365	71	178	127	---	---	---	---	---
217	OK78R8017	70	178	123	---	---	---	---	---
307	Concho	70	205	141	---	---	---	---	---
72	NR173-75	70	136	95	---	---	---	---	---

Table 1. (Continued).

Entry Number	Genotype	1979-80 Metribuzin (kg/ha) 1.12	0	1.12	1980-81 Metribuzin (kg/ha) 1.12	2.24	0	1.12	2.24
		(% CK)†	(Heads/m)		(% CK)†		- - - (Heads/m) - -		
180	Sdy//Cof/Crc 4886-2	70	175	122	---	---	---	---	---
225	OK78R8275	70	159	112	---	---	---	---	---
249	SWD 70328-06W	70	181	124	---	---	---	---	---
296	Lethbridge 1327	69	158	108	---	---	---	---	---
306	Lindon	69	160	104	101	33	137	125	47
1	Turkey Red	69	202	137	104	59	175	183	106
111	CI9294/Scout	69	193	135	---	---	---	---	---
44	Rannaya/Lovrin 13	69	126	86	---	---	---	---	---
218	OK76R6394	69	128	189	---	---	---	---	---
145	NS12-53	69	124	85	---	---	---	---	---
73	Priboy	69	160	110	---	---	---	---	---
57	PI Comp Seln 4842	68	161	109	---	---	---	---	---
23	F26-70	68	126	87	---	---	---	---	---
200	AR 6	68	167	113	---	---	---	---	---
201	Lovrin 25	68	147	95	---	---	---	---	---
148	Blue wht-Bonnett	68	128	88	---	---	---	---	---
314	TAM 105	68	208	141	93	76	174	149	132
247	GB88-13-7-B	67	222	147	---	---	---	---	---
305	McCall	67	200	134	---	---	---	---	---
9	KanKing	67	221	153	88	66	152	131	99
114	CI8286/Parker	67	215	143	---	---	---	---	---
164	NR391-76	67	140	90	78	62	95	73	55

Table 1. (Continued).

Entry Number	Genotype	1979-80 Metribuzin (kg/ha) 1.12	1979-80 Metribuzin (kg/ha) 0	1979-80 Metribuzin (kg/ha) 1.12	1980-81 Metribuzin (kg/ha) 1.12	1980-81 Metribuzin (kg/ha) 2.24	1980-81 Metribuzin (kg/ha) 0	1980-81 Metribuzin (kg/ha) 1.12	1980-81 Metribuzin (kg/ha) 2.24
		(% CK)†	(Heads/m)		(% CK)†		- - - (Heads/m) - -		
138	Prikumskaya 22	66	141	92	---	---	---	---	---
81	PI349507	66	186	120	---	---	---	---	---
26	GB88-13-7-B	66	227	147	---	---	---	---	---
224	CI15921	66	150	97	---	---	---	---	---
127	TX62A4793-7/VJ2474	66	186	124	---	---	---	---	---
16	Nap Hal Seln	66	173	111	63	38	173	108	68
195	T.N. 1584	65	184	113	---	---	---	---	---
80	PI351233	65	99	64	---	---	---	---	---
273	OWW 72027-9	65	200	118	73	50	125	90	61
101	Stoddard Seln 2	65	193	123	94	65	156	142	98
119	T. vavilovi/Sdy 7251-73	63	209	132	81	43	135	105	60
310	Rocky	63	184	111	90	69	107	102	65
122	McCall/Cnf 6118-1	63	199	124	---	---	---	---	---
5	Imp. Triumph	62	217	135	101	44	103	82	44
223	CI14020	62	142	83	---	---	---	---	---
96	Ctk/Bezo//OK66C3190/Ey Sdy	62	176	112	98	78	74	69	50
254	SWW 731411-4H	62	132	81	---	---	---	---	---
104	OK75R3611	62	222	136	---	---	---	---	---
269	FW75401-601	60	160	98	---	---	---	---	---
45	NB68570/Bolal	58	220	126	---	---	---	---	---
113	CI8286/Parker	58	198	118	66	39	151	102	60
190	PI185302	57	148	82	85	17	80	64	13

Table 1. (Continued).

Entry Number	Genotype	1979-80 Metribuzin (kg/ha) 1.12	1979-80 Metribuzin (kg/ha) 0	1979-80 Metribuzin (kg/ha) 1.12	1980-81 Metribuzin (kg/ha) 1.12	1980-81 Metribuzin (kg/ha) 2.24	1980-81 Metribuzin (kg/ha) 0	1980-81 Metribuzin (kg/ha) 1.12	1980-81 Metribuzin (kg/ha) 2.24
		(% CK)†	(Heads/m)		(% CK)†		- - - (Heads/m) - -		
270	OWW 68007-1M6	56	158	80	63	35	125	78	45
276	Disponent	56	156	87	65	46	137	91	64
35	Salmon	55	182	96	77	15	154	110	26
285	Ticonderoga	54	156	88	---	---	---	---	---
316	Wings	52	218	112	---	---	---	---	---
263	SWD711002-07H	52	149	74	72	35	115	84	41
63	OK695033/T. macha 7252-72	51	67	30	79	59	99	79	58
159	Psenicno-Pyrejnyj G186	47	165	75	110	66	132	138	83
157	Psenicno-Pyrejnyj G599	44	130	53	---	---	---	---	---
209	OK78R8194	39	155	60	106	25	119	124	30
318	Vona	---	---	---	71	31	129	103	42
L.S.D. 0.05		30	42	35	57	45	49	46	40

†% CK = head production as a percent of untreated.

VITA

Marvin Leon Fischer

Candidate for the Degree of

Doctor of Philosophy

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