EFFECT OF SELECTED HERBICIDES ON ITALIAN RYEGRASS (*LOLIUM MULTIFLORUM*) AND RETURNS FROM HARD RED WINTER WHEAT (*TRITICUM AESTIVUM*)

By

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EFFECT OF SELECTED HERBICIDES ON

ITALIAN RYEGRASS (*LOLIUM MULTIFLORUM*)

AND RETURNS FROM HARD RED WINTER

WHEAT (*TRITICUM AESTIVUM*)

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This thesis is a manuscript to be submitted for publication in Weed Technology, a Weed Science Society of America Publication.

EFFECT OF SELECTED HERBICIDES ON ITALIAN RYEGRASS (*LOLIUM MULTIFLORUM*) AND RETURNS FROM HARD RED WINTER WHEAT (*TRITICUM AESTIVUM*)

Effect of Selected Herbicides on Italian ryegrass (*Lolium multiflorum*) and Returns From Hard Red Winter Wheat (*Triticum aestivum*)[1]

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Abstract: Field experiments were conducted to evaluate the effects of selected herbicides on Italian ryegrass, forage production, and returns from hard red winter wheat grain. Herbicides included BAY FOE 5043 + metribuzin (4:1 w/w premix), BAY MKH 6562, chlorsulfuron, chlorsulfuron + metsulfuron (5:1 w/w premix), clodinafop, diclofop, MON 37560, pendimethalin, tralkoxydim, and triasulfuron. Italian ryegrass was controlled greater than 90 % by 27 of 39 treatments at one site, and by 20 of 39 treatments at a second site. Grain dockage was reduced by 38 and 36 treatments at the two sites, and grain yield was improved by 35 and 36 treatments. Forage yield was frequently decreased by controlling Italian ryegrass. No treatment decreased forage protein content. Gross returns from wheat grain were not improved over the untreated check by

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seven treatments at Site 1, and by one treatment at Site 2. resulted in a negative gross return at Site 1. All treatments other than pendimethalin at 840 g/ha applied 3 days after seeding improved gross returns at both sites.

Nomenclature: BAY FOE 5043, *N*-(4-fluorophenyl)-*N*-(1-methylethyl)-2-[[5-trifluoromethyl)-1,3,4-thiadiazol-2-yl]oxy]acetamide; BAY MKH 6562, 1H-1,2,4-Triazole-carboxamide,4,5-dihydro-3-methoxy-4-methyl-5-oxo-N-[[2-(trifluoromethoxy)phenyl]sulfonyl]-sodium salt; chlorsulfuron, 2-chloro-N-[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)aminocarbonyl] benzenesulfonamide; clodinafop, 2-propynyl (R)-2-[4-(5-chloro-3-fluoro-2-pyridinyloxy)phenoxy]-propionate; diclofop, methyl 2-[4-(2,4-dichlorophenoxy)phenoxy]propanoate; metribuzin, 4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4*H*)-one; metsulfuron, 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino] sulfonyl] benzoate; MON 37560, 1-(4,6-dimethoxypyrimidin-2-yl)-3-[(ethanesulfonyl-imidazo[1,2-a]-pyridine-3-yl)sulfonyl]urea; pendimethalin, N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitro-benzenamine; tralkoxydim, 2-cyclohexen-1-one,2-[1-(ethoxyimino)propyl]-3-hydroxy-5-(2,4,6-trimethylphenyl)-(9Cl); triasulfuron, 3-(6-methoxy-4-methyl-1,3,5-triazin-2-yl)-1-[2-(2-chloroethoxy)-phenylsulfonyl]-urea; Italian ryegrass, *Lolium multiflorum* Lam., 'Marshall,' #[3], LOLMU, wheat, *Triticum aestivum* L, '2137'.

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[3]Letters following this symbol are a WSSA-approved computer code from *Composite List of Weeds*, Revised 1989. Available only on computer disk from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

Additional index words: BAY FOE 5043, BAY MKH 6562, chlorsulfuron, clodinafop, diclofop, metribuzin, metsulfuron, MON 37560, pendimethalin, tralkoxydim, triasulfuron, forage.

INTRODUCTION

Cultivars of Italian ryegrass, such as 'Marshall,' have been developed and released that are more cold hardy, later maturing, and disease resistant than earlier cultivars (Arnold et al. 1981). The widespread promotion of these cultivars as forage species has greatly increased the incidence of Italian ryegrass infestations in winter wheat throughout the Southeastern United States, Southern Great Plains and Pacific Northwest. Italian ryegrass has historically been the most significant weed problem in winter wheat in the Willamette Valley in Oregon (Brewster et al. 1991). In contrast, it is a more recent problem weed in winter wheat production in Oklahoma.

Management techniques investigated for Italian ryegrass control include increasing tillage, delaying fall wheat planting, increasing wheat seeding rate, seeding wheat in narrow rows, rotating crops, and using herbicides (Aldrich-Markham 1992; Anderson and Staska 1994; Appleby and Brewster 1992; Brewster et al. 1991; Brewster et al. 1997; Heap 1993; Justice et al. 1994).

Although considered a weed in wheat, like wheat, Italian ryegrass is a high quality forage, and protein content is usually about 20% (Jung et al. 1982). Wheat forage typically contains over 20 % protein (Apple and Lusby 1989). With adequate fertility, Italian ryegrass infested wheat is high quality forage. However, little is known about forage quality when herbicides are applied to control the Italian ryegrass component.

Reductions in wheat yield have been attributed to Italian ryegrass interference during wheat tillering, to severe lodging, and to interference with wheat harvest because this weed matures later than wheat (Justice et al. 1994). In Oklahoma, wheat grain yield was reduced 4.2 percent for each 10 Italian ryegrass plants per m^2 (Justice et al. 1994). Wheat yield was reduced 38 % in Oregon by 20 Italian ryegrass plants per m^2 (Appleby and Brewster 1992).

Several herbicides are registered or are under development for control or suppression of Italian ryegrass in wheat. BAY FOE 5043, a cell division inhibitor, controlled Italian ryegrass 97 to 100 % when applied in 2:1 and 3:1 ratios of BAY FOE 5043:metribuzin PRE and to one-leaf Italian ryegrass in wheat (Mallory-Smith et al. 1996). BAY FOE 5043 plus metribuzin (4:1 w/w premix) applied PRE at 303 and 449 g/ha controlled Italian ryegrass in wheat in Idaho 79 and 89 % (Rauch and Thill 1999). A PRE treatment of 303 g/ha of a BAY FOE 5043 plus metribuzin (4:1 w/w premix) followed by 30 g/ha of MKH 6562 applied to 2- to 3-leaf wheat controlled Italian ryegrass 88 %. The same PRE treatment followed by 30 g/ha of BAY MKH 6562 applied to 6- to 8- leaf wheat controlled Italian ryegrass 96 %.

BAY MKH 6562, an ALS inhibitor, is being developed to control or suppress annual grass and broadleaf weeds in durum, spring, and winter wheat (Anonymous 1999e). In Idaho, 30 g/ha of MKH 6562 applied to 2- to 3-leaf and 6- to 8-leaf wheat controlled Italian ryegrass 66 and 52 % (Rauch and Thill 1999).

Chlorsulfuron is registered for suppression of Italian ryegrass in wheat when applied PRE at 35 g/ha (Anonymous 1999b). Chlorsulfuron controlled Italian ryegrass from 73 to 98 % when applied at 18 and 35 g/ha PRE, and from 45 to 71 % when applied at 35 g/ha to 2- to 4- leaf Italian ryegrass (Griffin 1986). Variable control of Italian ryegrass was reported in Oklahoma (10 to 70 %) with 18 and 26 g/ha applied PRE (Justice et al. 1994). Control was poor when Italian ryegrass emerged before rainfall activated the herbicide. In other research, chlorsulfuron applied PRE at 26 g/ha controlled Italian ryegrass 88 to 94 % (Klingaman and Peeper 1989).

A premix of chlorsulfuron plus metsulfuron (5:1 w/w) is registered for suppression of Italian ryegrass when applied PRE at 26 g/ha (Anonymous 1999b). This premix applied at 26 g/ha controlled 1-leaf Italian ryegrass 96 % in wheat in Oregon (Brewster et al. 1994). Chlorsulfuron plus metsulfuron at 21 g/ha plus metribuzin at 157 g/ha controlled 2-leaf Italian ryegrass 53 to 95 % (Brewster et al. 1997). Herbicide resistance was a suspected cause of the poor control at one site (53 %). Rotating herbicide modes of action has been recommended for resistance management (Mallory-Smith et al. 1999).

Clodinafop, an acetyl coenzyme A carboxylase (ACCase) inhibitor, is used in Canada to control several grasses in wheat, including Persian darnel (*Lolium persicum* Boiss. & Hohen. ex Boiss.) (Anonymous 1999c). In Idaho, clodinafop applied at 56 g/ha controlled 3-leaf to 2-tiller wild oat 100 % in small grains (Wille and Morishita 1999a, 1999b). Clodinafop applied at 70 g/ha controlled spike to

1-leaf green foxtail [*Setaria glauca* (L.) Beauv.] 95 % in wheat (Jenks and Ellefson 1999).

Diclofop is registered for Italian ryegrass control; however it has a full-season grazing restriction and may injure wheat if temperatures are low following application (Anonymous 1999b). Also, resistance to diclofop has emerged in ten states in the United States, as well as in France, Italy, South Africa, and the United Kingdom (Heap 1997). Diclofop applied to 2- to 4-leaf Italian ryegrass at 500 to 1500 g/ha controlled Italian ryegrass 81 to 100 % in Arkansas, but did not increase winter wheat yield because the Italian ryegrass emerged approximately seven days after the wheat and density was low (Khodayari et al. 1983).

Diclofop applied to 2- to 4-leaf Italian ryegrass at 560 g/ha controlled Italian ryegrass in Louisiana 99 to 100 % and improved wheat yield one of two years (Griffin 1986). In Oklahoma, Italian ryegrass was controlled 90 to 100 % with diclofop at 560 and 840 g/ha applied POST in the fall to tillered wheat (Justice et al. 1994).

In Louisiana, metribuzin applied to 2- to 4- leaf Italian ryegrass at 420 g/ha controlled it 97 to 98 % but increased wheat yield in one of two years because of wheat injury (Griffin 1986). When applied to 3- to 5- tiller Italian ryegrass using soil carrier at 420, 560, and 700 g/ha, Italian ryegrass was controlled 81 to 97 % in wheat (Kinfe and Peeper 1991). Wheat yield was not increased with metribuzin applications at any rate at one site because of crop injury, but yield was increased with the two lowest rates at a second site.

MON 37560, an ALS inhibitor, was registered in 1999 to control Italian ryegrass and other weeds in spring and winter wheat (Anonymous 1999d). In Idaho, MON 37560 applied POST at 35 g/ha to 2- to 3- and 6- to 8-leaf wheat controlled Italian ryegrass in wheat 45 and 65 % (Rauch and Thill 1999). MON 37560 applied at 26 g/ha to 2- and 4-leaf wheat controlled Italian ryegrass 28 to 84 and 18 to 91 % at six sites and increased yield at five of six sites in Oregon (Brewster et al. 1997).

In Arkansas, pendimethalin at 1110 g/ha applied PRE and 5 days after wheat was planted controlled Italian ryegrass 84 and 74 % (Scott and French 1999). Pendimethalin at 2220 g/ha applied at the same timings controlled Italian ryegrass 86 to 87 %. In later research, pendimethalin applied PRE at 1120 g/ha controlled Italian ryegrass less than 40 % unless tank-mixed with chlorsulfuron at 26 g/ha, which increased control to 68 to 82 % (Barber et al. 1999).

Tralkoxydim, an ACCase inhibitor, was registered in 1998 for control of Italian ryegrass and other weeds in wheat (Anonymous 1999a). Tralkoxydim applied in the spring at 202 g/ha controlled a mixture of 1-leaf to fully-tillered Italian and perennial ryegrass 86 to 95 % in timothy (*Phleum pratense* L.) (Yenish and Eaton 1999).

Triasulfuron applied PRE at 18 and 30 g/ha controlled Italian ryegrass 69 and 81 % in wheat in Idaho (Rauch and Thill 1999). Yield was increased with both treatments. In Oklahoma, triasulfuron applied PRE at 26 and 53 g/ha controlled Italian ryegrass 77 and 91 % (Klingaman and Peeper 1989). In 1991, Kinfe and Peeper reported Italian ryegrass control of 95 to 98 % at two sites with triasulfuron applied PRE at 18 to 35 g/ha. Control was less at a third site (47 to 83 %) due to lack of activating rainfall for 25 days. In South Africa, triasulfuron applied POST at 10 g/ha controlled Italian ryegrass 80 % (Van Biljon et al. 1988). Thus, none of the herbicides registered or in development for Italian ryegrass control in wheat has consistently controlled the weed. Therefore, wheat growers often have difficulty in choosing between various Italian ryegrass control options.

The objectives of this research were to (a) evaluate the efficacy of selected herbicide treatments and application timings for control of an aggressive cold-hardy cultivar of Italian ryegrass in hard red winter wheat, (b) identify the effects of those treatments on forage yield. quality, and value, and (c) quantify the effect on gross returns from wheat grain when various herbicides are applied to manage Italian ryegrass.

MATERIALS AND METHODS

Field experiments were conducted at the South Central Research Station near Chickasha and at the Agronomy Research Station near Perkins in north central Oklahoma during the 1998-99 winter wheat growing season to evaluate the effects of selected herbicides on Italian ryegrass and their effects on returns from wheat. The herbicides investigated are either currently registered or in development for Italian ryegrass control in wheat.

To ensure uniform infestations, 'Marshall' Italian ryegrass was broadcast onto each plot at 22 kg/ha at Chickasha (Site 1) and 18 kg/ha at Perkins (Site 2) and incorporated with an S-tine cultivator with rolling baskets. Hard red winter wheat

'2137' was planted at Chickasha and Perkins at 75 and 67 kg/ha using a grain drill equipped with disk openers and press wheels on 20-cm row spacing. Plot size was 2.1 by 6.1 or 7.6 m. The experimental design was a randomized complete block with four replications.

Experiment locations, seeding dates, wheat and Italian ryegrass growth stages at herbicide application, and days from treatment to rainfall are listed in Table 1. Soil at Chickasha was a Dale loam (fine-silty, mixed, thermic Pachic Haplustoll) with pH of 6.4 and 0.9 % organic matter. Soil at Perkins was a Teller sandy loam (fine-loamy, mixed, thermic Udic Argiustoll) with pH of 5.6 and 0.7 % organic matter.

Herbicides evaluated were a premix of BAY FOE 5043 plus metribuzin (4:1 w/w), BAY MKH 6562, chlorsulfuron, a premix of chlorsulfuron plus metsulfuron (5:1 w/w), clodinafop, diclofop, metribuzin, MON 37560, pendimethalin, tralkoxydim, and triasulfuron. Herbicides were applied in 187 L/ha water carrier using a CO_2 pressurized backpack sprayer equipped with flat fan nozzles spaced 51 cm apart. Wheat and Italian ryegrass growth stages were determined at each application by examining ten randomly selected plants of each species.

Forage samples were harvested from the same 0.2 m^2 quadrat in each plot in December and February to estimate forage production for the typical grazing season in a wheat forage plus grain system. Forage consisted of both wheat and Italian ryegrass. After quantifying oven-dry forage yield, protein content of each sample was determined using the Dumas dry combustion method (Schepers et al. 1989).

Wheat injury and Italian ryegrass control were visually estimated before grain was harvested using a scale of 0 to 100 % where 0 % = no injury or control and 100 % = plant death or complete control. Grain was harvested using a small plot combine adjusted to retain the Italian ryegrass seed.

To determine dockage in the harvested grain, the harvested samples were first cleaned with a seed cleaner to remove chaff and straw, then cleaned a second time to separate the wheat seed from the Italian ryegrass seed. Material removed by the second cleaning was considered dockage and consisted of Italian ryegrass seed and shriveled wheat seed. Wheat volume weight and moisture content were then determined, and wheat yields were adjusted to 13.5 % moisture.

Gross revenue was calculated for each treatment, and grain quality penalties were subtracted from the local price. The wheat grain price ($0.096/kg) used in gross revenue calculations included the local price at harvest plus the Loan Deficiency Payment (LDP) that would be received by farmers who participated in federal price support programs. Penalties were subtracted from the price for dockage in the grain and low grain volume weight. Discounts applied were those used by Farmland Grain Division, Enid, Oklahoma (Dunn 1996).

A difference in gross returns was calculated for each treatment. This difference is an estimate of expected return from a herbicide investment over the return from the untreated check. The difference in gross returns was calculated by multiplying the grain price, adjusted for penalties, by wheat grain yield, and then subtracting the gross return of the untreated check, the herbicide cost, and the herbicide application cost. Herbicide prices were obtained from local distributors (Table 2). Net returns may be determined by subtracting the crop's cost of production (costs other than herbicide and herbicide application) from the desired herbicide's gross return. Cost of production may be determined by using a crop enterprise budget (Doye and Jobes 1989).

Wheat forage value was determined by multiplying the estimated forage yield by $4.85/100 kg (Baker 1999). The forage value was calculated based on the price received by wheat growers who lease their wheat pasture with payments based on the weight gain of the grazing cattle. Since forage was removed from only a 0.2 m^2 quadrat in each plot, forage values were not included in gross return calculations and are intended to demonstrate differences in potential value to the producer when herbicides are used to control Italian ryegrass.

All data were subjected to analyses of variance and treatment means were separated with protected least significant differences at the $P = 0.05$ level. Italian ryegrass control estimates were arcsine transformed prior to analysis, but data are presented in original form for clarity.

RESULTS AND DISCUSSION

Treatment by location interactions prevented data pooling across locations, thus data are reported by site. Italian ryegrass control ranged from 45 to 98 % at Site 1 and from 3 to 100 % at Site 2 (Table 3). Of the 38 herbicide treatments applied, 29 treatments at Site 1 and 18 treatments at Site 2 controlled Italian ryegrass over 90 %. Control with clodinafop at both rates was 99 % at Site 1 but a complete failure at Site 2. MON 37560 failed to control Italian ryegrass greater than 80 % regardless of application timing. Pendimethalin also failed to consistently control Italian ryegrass, with control ranging from 10 to 65 %.

Diclofop at either rate controlled more Italian ryegrass when applied 17 or 18 days after seeding (DAS) than at 114 or 124 DAS, but control was at least 80 % with both rates applied early or late in the growing season. Tralkoxydim applied 18 DAS at Site 2 at both rates did not control Italian ryegrass greater than 74 %. Tralkoxydim has no residual activity, and late-emerging weeds may have escaped as a result (Anonymous 1999a).

The sulfonylurea herbicides applied PRE controlled Italian ryegrass 83 to 93 % at both sites. Rainfall was received soon after treatment, which is required for good control with these herbicides (Justice et al. 1994).

At both sites, controlling Italian ryegrass increased wheat yield as much as 58 %. Only a few treatments failed to increase yield. Wheat yield was improved by BAY FOE 5043 plus metribuzin at all rates and timings except for 350 g/ha applied 9 DAS at Site 1 (Table 3). Diclofop at both rates and timings except for 1120 g/ha applied 114 DAS increased yield at Site 1. Clodinafop at either rate did not increase yield at Site 2. Pendimethalin did not increase yield at Site 1. Tralkoxydim at 200 g/ha applied 17 DAS did not increase yield at Site 1.

Grain dockage was greatly reduced at Site 1 by all treatments except pendimethalin at 840 g/ha. Pendimethalin at 1680 g/ha reduced dockage, but not as much as all other herbicide treatments. Severe lodging, which increases shriveled wheat seeds, contributed to increased grain dockage at Site 1. Thus, grain dockage remained above 3 % with all herbicide treatments, regardless of Italian ryegrass control. At Site 2, dockage in treatments that killed all of the Italian ryegrass ranged from 2.1 to 2.8 %. MON 37560 at 35 g/ha applied 18 and 124 DAS, and pendimethalin at 840 and 1680 g/ha applied 3 DAS reduced dockage, but not as much as the treatments that eliminated Italian ryegrass at Site 2.

At Site 2, clodinafop at 56 g/ha did not reduce dockage compared to other treatments, and when applied at 70 g/ha, did not reduce dockage compared to the untreated check. Italian ryegrass control was also poor with both rates of clodinafop at Site 2. This is in contrast to excellent control and dockage reduction with both rates of clodinafop at Site 1. There was no apparent reason for the difference in clodinafop performance between sites. Soil moisture was very good, temperatures were well above freezing for several days before and after treatment, and the treatments were applied the same day at both sites, approximately four hours apart. At Site 1, where control was excellent, 0.13 cm of rain fell approximately 24 hrs after application, whereas no rain fell for eight days after application at Site 2. Thus, the rewetting of leaf surfaces may have increased herbicide uptake and control.

Affects on forage protein content were minimal, and no treatment reduced the protein content below that of the untreated check. Forage yield included both wheat and Italian ryegrass; therefore, effects on forage yield resulted from Italian ryegrass control and/or reducing wheat growth (Koscelny et al. 1996). Forage yield in the untreated check was 4400 and 4000 kg/ha at Sites 1 and 2, and no treatment increased forage yield (Table 4).

Most treatments decreased forage yield at both sites. Forage yield was not decreased by pendimethalin at 840 g/ha at Site 2. Diclofop at 840 g/ha applied 114 or 124 DAS at either site did not decrease forage yield, and diclofop at 1120 g/ha applied 124 DAS also did not decrease forage yield at Site 2. BAY FOE 5043 plus metribuzin at 477 g/ha applied 17 DAS did not decrease forage yield at Site 1. At Site 2, forage yield was not decreased by clodinafop at 56 and 70 g/ha 41 DAS, MON 37560 at 35 g/ha 124 DAS, tralkoxydim at 200 g/ha 18 DAS, triasulfuron at 29 g/ha 0 DAS, and triasulfuron at 15 g/ha 0 DAS followed by clodinafop at 56 g/ha 41 DAS.

Forage value was not decreased at either site by MON 37560 at 35 g/ha applied 114 or 124 DAS or by diclofop at 840 g/ha applied 114 or 124 DAS. Diclofop at 1120 g/ha applied 124 DAS , clodinafop at 56 or 70 g/ha applied 41 DAS, tralkoxydim at 200 g/ha applied 18 DAS, triasulfuron at 29 g/ha applied 0 DAS, and triasulfuron at 15 g/ha applied 0 DAS followed by clodinafop at 56 g/ha applied 41 DAS did not reduce forage value at Site 2.

Gross return of the untreated check at Site 1 was $41/ha and $93/ha at Site 2. Most herbicide treatments improved gross returns over the untreated check at both sites (Table 3). BAY FOE 5043 plus metribuzin at 350 g/ha applied 9 DAS, diclofop at 1120 g/ha applied 17 and 114 DAS, pendimethalin applied 3 DAS, and tralkoxydim at 200 g/ha applied 17 DAS did not improve gross returns over the untreated check at Site 1. Gross return with pendimethalin at 840 g/ha applied 3 DAS was negative at Site 1. Gross returns at Site 2 were improved by all herbicides except MON 37560 at 35 g/ha applied 124 DAS.

Although Italian ryegrass control was excellent with most treatments, the high cost of some herbicides coupled with a low market price for wheat caused variation in gross returns from the herbicide treatments. Thus, several options are available to control Italian ryegrass greater than 90 %, reduce grain dockage, and improve gross returns. However, resistance to several of these herbicides should be expected to emerge after repeated annual application (Mallory-Smith et al. 1999). Controlling Italian ryegrass decreased forage production, and further study of a system where Italian ryegrass in wheat is controlled after the grazing season is necessary to determine how to maximize returns in a grain plus forage system.

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Table 1. Experiment locations, seeding dates, growth stages at herbicide application, and days from application to rainfall for the Italian ryegrass control experiments.

			Growth stage at herbicide appliction[a]		First post-treatment rainfall	
Location	Seeding date	Application timing	Wheat	Italian ryegrass	Days after treatment	Quantity
		days after seeding				cm
Site 1	10-13-98	0	PRE	PRE	3	1.09
		3	PRE	PRE	0	1.09
		9	1 leaf	1 leaf	6	0.03
		17	1 leaf	1-3 leaves	0	0.13
		36	3-5 tillers	2-5 tillers	1	0.13
		114	4-16 tillers	2-8 tillers	2	3.18
Site 2	10-08-98	0	PRE	PRE	8	0.13
		4	PRE	PRE	4	0.13
		10	1-2 leaves	1 leaf	2	0.13
		18	1-2 tillers	1-3 leaves	2	1.45

Table 1. Continued.

41	2-4 tillers	3-5 tillers	11	1.45
124	4-10 tillers	4-9 tillers	2	0.08

[a]PRE = preemergence

Table 2. Herbicide prices and herbicide cost for each treatment used in gross return calculations.

Herbicide	Unit price	Application rate low	Application rate high
	— $/g —	— $/ha —	
BAY FOE 5043 + metribuzin	0.04	14.00	19.08
BAY MKH 6562[a]	0.51		15.30
Chlorsulfuron	0.59		15.34
Chlorsulfuron + metsulfuron	0.44		11.44
Diclofop	0.02	16.82	22.44
Metribuzin	0.06	9.48	12.60
MON 37560	0.51		17.85
Pendimethalin	0.007	5.89	11.78
Tralkoxydim	0.08	16.16	21.52
Triasulfuron	0.36	5.40	10.44

[a]Price not yet established. Priced was assumed to be the same as MON 37560.

Table 3. Effect of herbicide treatment on Italian ryegrass, wheat grain yield, grain dockage, and difference in gross returns.

		Timing		Control		Yield		Dockage		Difference in gross returns[a]	
Treatment	Rate	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
	—g/ha—	—DAS[b]—		—%—		—kg/ha—		—%—		—$/ha—	
Chlorsulfuron	26	0	0	91	93	4100	4200	3.0	2.9	256	160
Chlor + met	21.7 + 4.3	0	0	93	89	4200	4400	4.4	3.0	271	150
Chlor + met, metribuzin	21.7 + 4.3, 210	0,17	0,18	98	93	4400	4000	3.1	3.3	266	103
Triasulfuron	29	0	0	86	83	3300	4500	5.8	3.0	177	177
Triasulfuron, metribuzin	15, 158	0,17	0,18	78	79	3600	4000	5.8	4.9	198	111
	29, 158	0,17	0,18	96	86	3400	4400	5.9	5.3	172	129
Triasulfuron, BAY MKH 6562	29, 30	0,17	0,18	98	100	3800	4000	3.4	2.8	208	93
		0,114	0,124	97	98	4000	4600	4.3	2.2	218	155

Table 3. Continued.

Triasulfuron, clodinafop	15, 56	0,17	0,41	98	64	3800	4400	4.4	3.8	——[c]	——
	29, 56	0.17	0,41	97	83	3500	4400	4.5	2.9	——	——
Triasulfuron, MON 37560	15, 35	0,17	0,18	95	89	3600	4200	3.8	3.0	192	118
	29. 35	0,17	0,18	98	95	3100	4000	6.9	2.4	127	92
BAY	350	0	0	89	95	4000	4000	3.1	2.5	248	119
		3	4	93	96	3100	3800	8.0	2.7	149	94
		9	10	98	99	2500	3800	9.1	2.6	74	99
		17	18	98	97	4000	3600	3.7	2.5	243	87
	477	0	0	96	99	3800	3500	5.3	2.7	211	59
		3	4	98	99	3200	3500	4.4	2.8	158	56
		9	10	99	100	3200	3800	5.0	2.6	158	89
		17	18	98	99	3400	4000	6.1	2.4	172	115
BAY MKH 6562	30	17	18	93	83	3700	4000	4.3	3.8	218	137

Table 3. Continued.

BAY, BAY MKH 6562	350, 30	9, 114	0, 124	99	100	3800	3700	4.3	2.4	195	58
	477, 30	9, 114	0, 124	99	100	3500	3800	7.1	2.4	140	73
Clodinafop	56	36	41	99	8	3600	3000	5.9	9.4	——	——
	70	36	41	99	3	3100	2900	7.3	9.9	——	——
Diclofop	840	17	18	99	100	3900	4400	4.3	2.3	207	137
		114	124	94	81	3400	4000	7.3	3.5	154	94
	1120	17	18	99	100	3200	4200	6.2	2.1	120	106
		114	124	96	85	2700	3800	9.4	3.3	60	64
MON 37560	35	9	10	78	80	3600	4100	6.1	3.1	198	128
		17	18	64	74	3100	4100	5.5	4.6	161	121
		114	124	78	8	3700	3400	5.5	7.6	224	41
Pendimethalin	840	3	4	45	10	1600	3500	22.3	7.7	(17)	54
	1680	3	4	65	49	2100	4000	13.9	5.3	31	102

Table 3. Continued.

Tralkoxydim	200	17	18	97	71	2800	4300	7.6	3.7	100	127
		36	41	95	89	4200	4200	3.9	2.4	249	121
	270	17	18	88	74	4000	4400	4.4	3.5	213	120
		36	41	94	93	4200	4500	4.0	2.1	230	138
Untreated				0	0	1600	2700	19.3	11.4	0	0
LSD (0.05)				10	9	1200	500	4.9	1.7	121	49

[a]Difference calculated by: (treatment gross revenue) - (untreated gross revenue) - (herbicide cost) - (herbicide application cost). Untreated gross revenue was $41/ha at Site 1 and $93/ha at Site 2. Numbers in ( ) denote negative differences. Production costs for inputs other than herbicide and herbicide application were not subtracted from gross revenue. These costs were approximately $193/ha at Site 1 and $298/ha at Site 2. (Doye and Jobes 1989).

[b]DAS = days after seeding; Chlor + met = chlorsulfuron + metsulfuron; BAY = BAY FOE 5043 + metribuzin.

[c]Price of clodinafop not yet established in USA.

Table 4. Forage yield, protein content, and value.

Treatment	Rate	Timing		Protein content		Forage yield		Forage value	
		Site 1	Site 2	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
	g/ha	DAS[a]		%		kg/ha		$/ha	
Chlorsulfuron	26	0	0	30	27	2300	2700	111	131
Chlor + met	21.7 + 4.3	0	0	29	25	2600	2600	126	124
Chlor + met, metribuzin	21.7 + 4.3, 210	0,17	0,18	28	27	2200	2000	106	98
Triasulfuron	29	0	0	29	24	3400	3100	165	148
Triasulfuron, metribuzin	15, 158	0,17	0,18	29	26	3000	2000	145	97
	29, 158	0,17	0.18	29	26	2800	2400	135	115
Triasulfuron, BAY MKH 6562	29, 30	0,17	0,18	28	25	2800	1900	134	92
		0,114	0.124	29	25	2900	2800	141	135
Triasulfuron, MON 37560	15. 35	0,17	0,18	29	25	3500	2100	168	101
	29. 35	0,17	0,18	29	26	3100	2000	151	99

Table 4. Continued.

BAY	350	0	0	29	26	3300	2200	160	108
		3	4	28	25	3200	2500	156	123
		9	10	29	28	3200	1800	156	86
		17	18	28	25	3300	2100	159	102
	477	0	0	29	28	2700	2000	133	96
		3	4	29	28	2700	2500	131	122
		9	10	28	26	3300	2100	162	102
		17	18	28	25	3600	2000	176	97
BAY MKH 6562	30	17	18	28	26	2900	2200	141	108
BAY, BAY MKH 6562	350, 30	9, 114	10, 124	28	26	3500	2000	168	95
	477, 30	9, 114	10, 124	28	27	3100	1700	150	85
Clodinafop	56	36	41	28	27	3200	4100	154	199
	70	36	41	29	27	3300	4100	162	199

Table 4. Continued.

Diclofop	840	17	18	28	24	3200	2900	154	140
		114	124	28	25	3600	3100	173	152
	1120	17	18	29	24	3400	2600	166	128
		114	124	28	25	3300	3500	158	168
MON 37560	35	9	10	28	26	2400	2100	114	100
		17	18	28	26	2900	1800	142	85
		114	124	28	26	3700	3300	178	160
Pendimethalin	840	3	4	30	25	3400	4000	163	195
	1680	3	4	29	26	3300	2700	161	130

Table 4. Continued.

Tralkoxydim	200	17	18	29	25	3100	3100	151	149
		36	41	28	23	3100	2900	149	139
	270	17	18	29	26	3000	2500	144	122
		36	41	27	23	2900	2900	139	139
Untreated				28	25	4400	4000	211	196
LSD (0.05)				2	3	800	1000	39	49

[a]DAS = days after seeding; Chlor + met = chlorsulfuron + metsulfuron; BAY = BAY 5043 + metribuzin.

VITA

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