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Effects of Nicosulfuron on Quackgrass (*Elytrigia repens*) Control in Corn (*Zea mays*)[1]

PRASANTA C. BHOWMIK, BETSEY M. O'TOOLE, and JOHN ANDALORO[2]

Abstract. Four field experiments were conducted during 1988 and 1989 to determine the effects of POST application of nicosulfuron on quackgrass control in conventional field corn. A single application of nicosulfuron at 35 to 70 g ha^{-1} applied to four- to six-leaf quackgrass controlled over 90% of quackgrass five weeks after treatment. Nicosulfuron at 35 g ha^{-1} applied at the one- to three-leaf stage was not as effective as the same rate applied at the four- to six-leaf stage. When nicosulfuron at 35 g ha^{-1} was applied to four- to six-leaf quackgrass, over 80% of the quackgrass regrowth was controlled one year later. Nicosulfuron did not injure 'Agway 584S' corn at the highest rate (140 g ha^{-1}) tested and did not reduce silage or grain yield. **Nomenclature:** Nicosulfuron, 3-pyridinecarboxamide, 2-(((4,6-dimethyoxy-pyrimidin-2-yl)aminocarbonyl))aminosulfonyl)))-*N,N*-dimethyl; corn, *Zea mays* L. 'Agway 584S'; quackgrass, *Elytrigia repens* (L.) Nevski. #[3] AGRRE.

Additional index words: Application timing, perennial grass, postemergence, *Agropyron repens*, AGRRE.

INTRODUCTION

Quackgrass is a major perennial weed found in the temperate regions of the world, including United States and Canada (1, 7) and is one of the ten worst weeds in the world (7). Quackgrass infests many hectares of cropland in the United States (1, 7, 17) and can reduce crop yields (1, 4, 7, 19). Depending on the crop and the environment, quackgrass may reduce crop yields by competition for nutrients (2), light (18), and moisture (18), and by allelopathy (13, 16).

Ivany (8) reported that light infestations (30% ground cover) of quackgrass reduced silage corn yield when allowed to compete with corn for 6 wk. Dense infestations (90% ground cover) of quackgrass reduced yields if allowed to compete for 3 wk. Young et al. (19) found that a quackgrass density of 745 shoots per m^2 reduced corn yields an average of 37% and significantly reduced corn height, ear length, ear-fill length, kernels per row, rows per ear, and seed weight.

Quackgrass is a successful weed largely because of its ability to generate new crowns from axillary buds along rhizomes (7). Werner and Rioux (17) reported that rhizome buds contributed largely to the persistence of quackgrass. The persistent and vigorous rhizome system of quackgrass makes control extremely difficult.

There are several herbicides that control quackgrass in dicotyledonous crops (3, 9, 15). However, with the exception of triazine herbicides, selective postemergence quackgrass control in corn has not been available until recently.

Nicosulfuron is a new highly selective, sulfonylurea herbicide for POST use at low rates to selectively control quackgrass (4, 5, 10) and johnsongrass (*Sorghum halepense* (L.) Pers.) in corn (12). Preliminary studies have shown excellent activity of nicosulfuron in controlling quackgrass (4, 5) and annual grass species in general in corn (11).

This study was conducted to: a) evaluate how timing of POST applications of nicosulfuron affect quackgrass control, b) determine the extent of quackgrass regrowth control the second year, and c) determine tolerance of 'Agway 584S' corn to nicosulfuron.

MATERIALS AND METHODS

General procedures. Experiments were conducted at the University of Massachusetts Experiment Station at South Deerfield, on a Hadley fine sandy loam (Typic Udifluvents) containing 3.2% organic matter with a pH of 6.5. The area was heavily infested with quackgrass. The initial quackgrass population was 1550 shoots per m^2 in 1988 compared with 1366 shoots per m^2 in 1989. A tank-mix combination of alachlor [2-chloro-*N*-(2,6-

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

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Table 1. Effects of nicrosulfuron rates on quackgrass control in 1988 and 1989 following application at the four- to six-leaf stage.

Treatment	Rate	Quackgrass control, WAT					
		1988			1989		
		3	5	52	3	5	48
	g ha^{-1}	%					
Untreated	–	0	0	0	0	0	0
Nicosulfuron	17.5	70	95	60	81	98	98
Nicosulfuron	35	78	99	80	87	100	100
Nicosulfuron	70	78	99	85	90	100	99
Nicosulfuron	105	88	100	88	96	100	99
Nicosulfuron	140	92	100	97	98	100	99
LSD (0.05)		13	3	20	12	2	11

diethylpenyl)-*N*-(methoxymethyl)acetamide] and linuron [*N′*-(3,4-dichlorophenyl)-*N*-methoxy-*N*-methylurea] at 1.5 and 1.0 kg ha^{-1} was applied preemergence for the control of annual weeds in all experiments.

Agway 584S corn was planted in 3 by 6-m sub-plots on May 11, 1988 and on April 27, 1989 at a density of 62 000 plants per ha in 75-cm rows in a conventional-till system. Conventional-tillage consisted of moldboard plowing followed by two diskings. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 189 L ha^{-1} at 152 kPa by 8002 flat fan nozzles.

Corn injury was rated 2 weeks after treatment (WAT)[4] on a scale of 0 to 100, where 0 = no injury and 100 = dead plants. Corn height was measured 7 and 8 WAT in 1988 and 1989, respectively. Quackgrass control was rated on a scale of 0 to 100 where 0 = no control and 100 = complete control. In all trials, visual control ratings were made 3, 5, and 6 WAT. Quackgrass shoot numbers were also counted per m^2 area in each plot 6 and 9 WAT. Silage and grain yields of corn were determined on Oct. 14, 1988 and Oct. 21, 1989. Grain yields were adjusted to 15% moisture.

Data were subjected to analysis of variance procedures of SAS (14). Means were separated by Fisher's Least Significant Difference (LSD) Test at P = 0.05, using the appropriate error terms.

Rate study. Five rates (17.5, 35, 70, 105, and 140 g ha^{-1}) of nicosulfuron were evaluated in 1988. The non-ionic surfactant, X-77[5] at 0.25% (v/v) was added to each treatment. Treatments were applied on June 21, 1988 and in an adjacent area on June 19, 1989. The experiments were arranged in a randomized complete block design with three replications. All treatments were applied at the four- to six-leaf stage of quackgrass in both years.

Application timing study. Nicosulfuron was applied at 0, 35, 70, and 105 g ha^{-1} applied at the one- to three-leaf, four- to six-leaf, and seven- to 10-leaf stage of quackgrass, corresponding to approximately 3, 5, and 7 wk after corn planting, respectively. All treatments were applied with the non-ionic surfactant X-77 at the rate of 0.25% (v/v) of total spray solution. This study was repeated in 1989 on an adjacent area. The experiments were conducted in a split-plot design having time of application as the main plot and rates as the sub-plots. Treatments were arranged in randomized blocks with three replications.

Control of quackgrass regrowth. Quackgrass regrowth one year following nicosulfuron application was measured quantitatively by counting quackgrass shoots per m^2 at 52 and 48 WAT in 1989 and 1990, respectively. Percent reduction of quackgrass shoots was determined by calculating shoot density with respect to the untreated check plot.

RESULTS AND DISCUSSION

Rate study. Nicosulfuron, at the lowest rate (17.5 ha^{-1}), applied to four- to six-leaf quackgrass controlled 70 to 81% of quackgrass 3 WAT in 1988 and 1989, respectively (Table 1). Quackgrass control increased to 95% and above 5 WAT in both years. Quackgrass control, in general, was higher in 1989 than in 1988.

Nicosulfuron at 35 g ha^{-1} and higher rates controlled 80% of quackgrass regrowth 52 WAT following the 1988 treatment application, but controlled 100% of regrowth 48 WAT following the 1989 treatment (Table 1). Control of regrowth one year after 1989 application,

[4]Abbreviation: WAT, weeks after treatment.
[5]Ortho X-77 Spreader, alkylarylpolyoxyethylene, glycols, free fatty acids, and isopropanol.

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Table 2. Corn height and yields in 1988 and 1989 following applications of nicosulfuron.

Treatment	Rate	Height, WAT 1988 7	Height, WAT 1989 8	Yield Silage 1988	Yield Silage 1989	Yield Grain 1988	Yield Grain 1989
	g ha^{-1}	cm		1000 kg ha^{-1}			
Untreated	–	199	183	22.95	25.27	4.15	3.72
Nicosulfuron	17.5	127	197	54.23	62.05	9.89	11.64
Nicosulfuron	35	131	188	51.97	60.40	9.89	11.63
Nicosulfuron	70	128	175	46.90	57.27	9.01	10.88
Nicosulfuron	105	119	163	53.42	60.18	10.06	11.11
Nicosulfuron	140	122	187	45.69	63.47	8.49	12.47
LSD (0.05)		NS	NS	10.90	19.17	2.28	3.54

in general, was better than the control one year after the 1988 application at all herbicide rates.

The lowest rate (17.5 g ha^{-1}) of nicosulfuron reduced quackgrass shoot numbers 71% 6 WAT in 1988, and over 95% 6 WAT in 1989 (Figure 1). In 1988, nicosulfuron at 35 g ha^{-1} reduced quackgrass shoots 94% compared with those of the untreated plot (1550 plants per m^2). Similar results were obtained in 1989. All other rates controlled quackgrass shoots over 95% in both years.

No corn injury was observed in either year with any of the nicosulfuron treatments based on visual damage ratings (Table 2). In addition, there was no significant variation in corn height among nicosulfuron treatment rates. All nicosulfuron treatments increased corn silage and grain yields compared with yields of the untreated check (Table 2). Nicosulfuron at the highest rate (140 g ha^{-1}) did not reduce silage or grain yield. Corn plants can metabolize sulfonylureas (3) and thereby corn plants were tolerant to the highest rate of nicosulfuron used in this study.

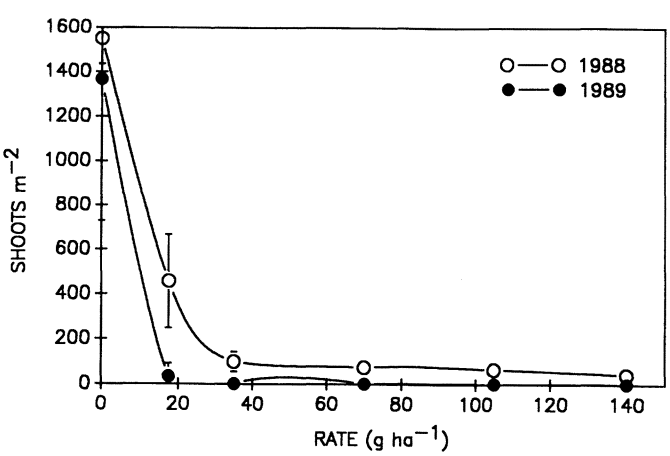

Figure 1. Effect of various rates of nicosulfuron on quackgrass shoot density 6 WAT in 1988 and 1989. Vertical bars represent standard error of the means. Where standard error bars are not represented, the means are not significant.

Application timing study. The interaction between timing and rate of nicosulfuron application on quackgrass control was significant. When nicosulfuron was applied at the one- to three-leaf stage of quackgrass, a significant rate response was noted (Table 3). Quackgrass control improved with the 70 g ha^{-1} rate compared to the 35 g ha^{-1} rate of nicosulfuron.

Nicosulfuron was most effective in controlling quackgrass when it was applied to four- to six-leaf quackgrass compared with one- to three-leaf or seven- to 10-leaf quackgrass (Table 3). Nicosulfuron applied at 35 g ha^{-1} in the four- to six-leaf stage controlled quackgrass 97 and 85% in 1988 and 1989, respectively, 6 WAT.

Regrowth evaluations of quackgrass made 52 and 48 WAT in 1988 and 1989, respectively, indicated that nicosulfuron (35 g ha^{-1} or higher rate) applied at the four- to six-leaf stage of quackgrass controlled over 80% of the population in 1989 and over 95% in 1990 (Table 3). However, the same treatments when applied at the one- to three-leaf stage controlled only 40 to 53% and 47 to 72% of quackgrass regrowth in 1989 and 1990, respectively. Similar regrowth control of johnsongrass with nicosulfuron has been reported earlier (6, 12).

Nicosulfuron, in general, reduced quackgrass shoot density 9 WAT in 1988 and 1989 (Table 3). Nicosulfuron at 35 to 105 g ha^{-1} was most effective in reducing quackgrass shoots when it was applied at the four- to six-leaf stage of quackgrass compared with the other leaf stages.

None of the nicosulfuron treatments had any effect either on corn height or yields either year (Table 4). The 70 g ha^{-1} rate of nicosulfuron applied at either one-

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Table 3. Effects of timing and rate of nicosulfuron application on quackgrass control and shoot density in 1988 and 1989.

Application		Quackgrass control, WAT				Shoot density, 9 WAT	
		1988		1989			
Timing leaf stage	Nicosulfuron rate	6	52	6	48	1988	1989
	g ha^{-1}	%				No per m^2	
1 to 3 leaf	0	0	0	0	0	1517	542
	35	32	43	67	47	1150	200
	70	70	42	88	67	658	108
	105	88	53	97	72	442	66
Average		63	46	84	62	750	125
4 to 6 leaf	0	0	0	0	0	1558	792
	35	97	83	85	96	325	26
	70	100	85	87	98	83	26
	105	99	87	94	98	50	26
Average		99	85	87	97	153	26
7 to 10 leaf	0	0	0	0	0	1842	692
	35	40	15	48	73	1033	116
	70	55	55	53	92	800	116
	105	62	68	68	99	842	50
Average		52	46	56	88	892	94
LSD (0.05)[a]		26	19	9	26	357	90
LSD (0.05)[b]		18	27	18	28	347	240

[a]LSD for comparing means of application times.

[b]LSD for comparing means of nicosulfuron rates within an application time.

to three-leaf or four- to six-leaf increased both corn silage and grain yields both years. The highest rate (105 g ha^{-1}) of nicosulfuron did not reduce corn yields compared with the untreated check plot.

These results indicate that quackgrass can be controlled with nicosulfuron applied to four- to six-leaf quackgrass. Application made at other growth stages of quackgrass would also be effective if higher rates are used. Nicosulfuron has potential for selective POST quackgrass control in field corn with no evidence of corn injury. Control of quackgrass regrowth the second year following nicosulfuron application would be an

Table 4. Effect of timing and rate of nicosulfuron application on corn height and silage and grain yields in 1988 and 1989.

Application		Corn					
				Yield			
		Height		Silage		Grain	
Timing leaf stage	Nicosulfuron rate	1988	1989	1988	1989	1988	1989
	g ha^{-1}	cm		1000 kg ha^{-1}			
1 to 3 leaf	0	129	158	29.68	29.83	5.92	4.49
	35	130	141	43.88	46.28	8.07	9.36
	70	131	172	47.25	68.03	8.64	13.38
	105	133	173	40.44	59.43	7.10	12.26
Average		131	162	43.86	57.91	7.94	11.67
4 to 6 leaf	0	121	151	27.44	28.18	4.83	4.28
	35	132	141	47.02	43.66	8.81	8.77
	70	129	150	41.72	53.30	7.88	10.43
	105	119	141	37.38	48.59	7.41	9.66
Average		127	144	42.04	48.52	8.03	9.62
7 to 10 leaf	0	132	146	27.89	33.64	4.91	5.34
	35	125	129	30.65	39.62	5.93	7.80
	70	132	138	37.60	45.23	6.63	8.33
	105	129	146	34.39	52.26	6.67	10.72
Average		129	138	34.21	45.70	6.41	8.95
LSD (0.05)[a]		NS	15	4.70	8.28	0.91	1.58
LSD (0.05)[b]		NS	NS	10.81	15.17	2.40	1.77

[a]LSD for comparing means of application times.

[b]LSD for comparing means of nicosulfuron rates within an application time.

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attractive feature in a cropping system where the objective is to reduce pesticide residues.

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