Sweet Corn Cultivars Respond Differentially to the Herbicide Nicosulfuron

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Abstract. Twelve sweet corn (*Zea mays* L. var. *rugosa* Bonaf.) cultivars were tested for response to nicosulfuron at rates of 0, 18, 36, and 72 g a.i./ha. Weight of marketable ears indicated that five cultivars were intolerant to the herbicide. Three of the cultivars that were intolerant contained the *shrunk-2* endosperm mutant (*sh₂*) and two contained the *sugary enhancer* endosperm mutant (*se*). Cultivars that were most tolerant of nicosulfuron contained the *sh₂* gene. Incorporation of terbufos insecticide before planting led to decreased marketable yield when nicosulfuron was applied at 36 g·ha⁻¹ in all cultivars tested. Chlorpyrifos insecticide incorporated before planting did not affect tolerance to nicosulfuron. Neither soil-applied insecticide affected yield when nicosulfuron was not applied. Chemical names used: 2-[[[(4,6-dimethoxy-2-pyrimidinyl)amino]carbonyl]amino]sulfonyl-N,N-dimethyl-3-pyridinecarboxamide (nicosulfuron); S-[[[(1,1-dimethylethyl)thio]methyl] O,O-diethylphosphorodithioate (terbufos); O,O-diethyl O-(3,5,6-trichloro-2-pyridyl)phosphorothioate (chlorpyrifos).

Nicosulfuron is a sulfonylurea herbicide being considered for registration for post-emergence weed control in sweet corn (Williams and Gilham, 1990). Sulfonylureas are a class of herbicides that inhibit the activity of acetohydroxyacid synthase (AHAS; also known as acetolactate synthase, E.C. 4.1.3.18), decreasing the synthesis of branched chain amino acids (Ray, 1984). Although other herbicides, such as atrazine, are available for control of broadleaf weeds, residual carryover can cause yield reductions in subsequent crops. Since nicosulfuron is degraded by hydrolysis and microbial activity, problems with rotation to susceptible vegetable crops would be reduced.

There is ample evidence that corn cultivars differ in susceptibility to sulfonylurea herbicides (Dekker et al., 1986; Eberline and Miller, 1989; Eberline et al., 1989). Dekker et al. (1986) found 37% to 45% initial corn injury with thiameturon, a sulfonylurea used in wheat. However, Amuti et al. (1985) reported that corn was tolerant of this herbicide. Eberline and Miller (1989) found that corn yield was reduced as much as 35 kg·ha⁻¹ for each 1 g of thiameturon applied per hectare. In an evaluation of corn inbred lines, it was determined that some tolerated thiameturon, whereas others were either highly sensitive or intermediate in their response (Eberline et al., 1989). The major factor involved in herbicide tolerance was the rate of metabolism of the herbicide to nonphyto-toxic metabolites. Preliminary reports have

indicated differential sensitivity of sweet corn cultivars to nicosulfuron (Monks et al., 1990; Stall and Bewick, 1990), particularly among cultivars containing the *sh₂* endosperm mutant. A large percentage of the sweet corn grown in the United States has a *sh₂* genetic background. Other reports have indicated that there can be an interaction between nicosulfuron and soil-applied organophosphate insecticides, which results in corn yield reductions as high as 60% (Williams et al., 1990). This negative interaction was not observed between nicosulfuron and other classes of soil-applied insecticides (Harrison et al., 1990; Reynolds et al., 1990).

We determined whether the endosperm mutant carried by a cultivar could be used to predict the response of that cultivar to nicosulfuron at several rates and whether there was a detrimental interaction between nicosulfuron and soil-applied insecticides to sweet corn.

Sweet corn cultivar tolerance to nicosul-

furon. Twelve sweet corn cultivars were tested to determine their tolerance to application of nicosulfuron. Nine cultivars carried the *sh₂* endosperm mutant, two carried the *se* endosperm mutant, and one carried the *sugary (su)* gene (Table 1). The cultivars were planted ≈3 cm deep with 23 cm between plants on 30 Mar. 1989 and 10 Apr. 1990 in 22-cm-high beds that were spaced 1.2 m apart. The soil was a fine sand (Ona fine sand; 96% sand, 2% silt) with a pH of 6.3 and an organic matter content of 2%. The experimental area was fumigated with 1,3-dichloropropene at 106 kg·ha⁻¹ 1 month before cultivation. A complete fertilizer (13N-4P-13K) was applied at the rate of 1210 kg·ha⁻¹ before bed formation, and an additional 560 kg·ha⁻¹ was applied as a sidedressing at lay-by. 2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)acetamide (metolachlor) was applied before emergence at 1.7 kg a.i./ha for early weed control. Irrigation was supplied by overhead sprinklers, as needed during the season, for optimal growth, and pyrethroid insecticides were applied two to three times per week.

Nicosulfuron was applied as a post-emergence spray over sweet corn plants when they were ≈25 cm tall, as measured from the bed surface to the last expanded leaf. A CO₂ pressurized backpack sprayer, which delivered 280 l of herbicide solution/ha at 210 kPa, was used for the application. Ortho

Table 1. Sweet corn cultivars evaluated for tolerance to nicosulfuron.

Cultivar	Genetic background	Kernel color
Even Sweeter	<i>sh₂</i>	Yellow
Zenith	<i>sh₂</i>	Yellow
Ultimate	<i>sh₂</i>	Yellow
Landmark	<i>sh₂</i>	Yellow
Pinnacle	<i>sh₂</i>	Yellow
Summersweet 7200	<i>sh₂</i>	Yellow
Summersweet 7210	<i>sh₂</i>	Yellow
Summersweet 8701	<i>sh₂</i>	White
Upmost	<i>sh₂</i>	Yellow
Snowbelle	<i>se</i>	White
Silverado	<i>se</i>	White
Silver Queen	<i>su</i>	White

Table 2. Marketable yield of sweet corn cultivars treated with nicosulfuron.^a

Cultivar	1989				1990			
	Nicosulfuron applied (g·ha ⁻¹)							
	0	18	36	72	0	18	36	72
	<i>t·ha⁻¹</i>							
Even Sweeter	21.4 abc	20.1 ab	22.3 a	18.8 a	16.8 a	20.3 ab	19.7 ab	15.0 abc
Zenith	14.4 c	18.3 ab	14.8 ab	8.2 cde	16.1 a	19.2 ab	21.3 ab	18.3 ab
Ultimate	19.9 bc	19.6 ab	18.9 ab	13.0 bcd	21.5 a	18.3 ab	24.3 a	22.1 a
Landmark	30.7 a	26.6 a	25.0 a	26.4 a	16.0 a	18.9 ab	14.6 bc	17.8 abc
Pinnacle	29.4 ab	25.2 ab	20.3 ab	25.0 a	20.1 a	22.1 a	21.3 ab	18.6 ab
Summersweet 7200	19.6 bc	23.4 ab	19.5 ab	15.9 bc	14.6 a	16.2 ab	10.7 cd	7.3 de
Summersweet 7210	22.7 abc	18.8 ab	21.5 a	19.3 ab	19.0 a	19.8 ab	18.8 abc	16.9 abc
Summersweet 8701	15.3 c	5.4 c	0.0 c	0.0 e	18.6 a	17.0 ab	5.5 d	2.0 e
Upmost	15.3 c	14.9 b	15.1 ab	15.8 bc	12.9 a	11.8 b	14.6 bc	11.5 bcd
Snowbelle	21.9 abc	18.8 ab	10.3 b	14.9 bc	16.7 a	15.9 ab	11.0 cd	10.7 bcd
Silverado	26.6 ab	22.8 ab	17.0 ab	6.3 de	14.1 a	13.9 ab	13.2 bc	10.0 cd
Silver Queen	14.9 c	19.4 ab	16.4 ab	19.0 ab	18.5 a	13.9 ab	17.5 abc	16.6 abc

^aMean separation in columns by Duncan's new multiple range test, *P* = 0.05.

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Table 3. Orthogonal comparisons of the effects of nicosulfuron on sweet corn cultivars.^a

Cultivar	Yield as affected by nicosulfuron application (g·ha ⁻¹)			No herbicide vs. herbicide application
	18	36	72	
		<i>t·ha⁻¹</i>		
Zenith	18.8 a	18.1 a	13.2 b	NS
Summersweet 7210	19.8 a	15.1 ab	11.6 b	NS
Summersweet 8701	11.2 a	2.7 b	1.0 b	*
Snowbelle	17.4 a	10.7 a	12.8 a	*
Silverado	18.3 a	15.1 a	8.2 b	*

Twelve cultivars were tested. Only cultivars for which orthogonal comparisons were significant are shown. Mean separation within rows by linear orthogonal comparison at $P = 0.05$. No orthogonal comparisons exhibited significant quadratic effects.

NS, *Nonsignificant or orthogonal comparison significant at $P = 0.05$.

Table 4. Interaction of nicosulfuron, soil insecticide, and sweet corn cultivar.^a

Cultivar	Nicosulfuron application (g·ha ⁻¹)					
	0			36		
	Insecticide ^y					
	N	C	T	N	C	T
	<i>t</i> ·ha ⁻¹					
Summersweet 7210	15.3 a	19.5 a	18.7 a	17.8 a	16.5 a	5.8 b
Sweet Belle	10.9 a	12.1 a	10.9 a	12.1 a	11.8 a	2.5 b
XPH-2659	7.2 a	10.3 a	7.1 a	0.0 b	0.0 b	0.0 b

^aMean separation within a row by Duncan's new multiple range test at $P = 0.05$. Yields averaged for two experiments.

^bN = none; C = chlorpyrifos applied at the rate of 14.5 kg·ha⁻¹; T = terbufos applied at the rate of 14.5 kg·ha⁻¹.

X-77 nonionic surfactant (Chevron Chemical, San Francisco) was included in the herbicide solution at 0.25% (v/v). Rates of nicosulfuron used were 0, 18, 36, and 72 g a.i./ha.

The experiments were arranged as randomized complete blocks with four replications. Each replication was one bed wide and 6 m long. At commercial maturity, the ears were harvested, graded, and weighed. Marketable weight was used as the dependent variable for statistical analysis. Two-way analysis of variance (ANOVA) was used to determine interactions and treatment effects on marketable weight, and means across cultivars were separated using Duncan's multiple range test at $P = 0.05$. Orthogonal comparisons were used to determine whether there was an effect of nicosulfuron vs. the nontreated control and the effect of herbicide rate within a cultivar. For the latter comparison, both linear and quadratic models were considered. The data were pooled across experiments because there was not a cultivar $\times$ year interaction when individual cultivars were considered. A significance level of 0.05 was used for these comparisons.

Interaction of nicosulfuron, insecticide, and cultivar. Sweet corn cultivars that have been reported as tolerant ('Sweet Belle'), intermediate ('Summer Sweet 7210'), or sensitive ('XPH-2659') to nicosulfuron (data not shown) were planted using the same bed system, depth, and spacing as on 13 Apr. and 23 Aug. 1990. The soil was a fine sand (Kanapaha fine sand; 96% sand, 2% silt) with an organic matter content of 2% and a pH of 6.5. A complete fertilizer (6N-8P-8K) at 2240 kg·ha⁻¹ was broadcast before bedding. Metolachlor herbicide was applied at 1.7

kg·ha⁻¹ before crop emergence, and irrigation and foliar insecticides were applied as noted before.

Nicosulfuron was applied at rates of 0 and 36 kg·ha⁻¹, as before. Granular chlorpyrifos and terbufos were applied at 14.5 kg·ha⁻¹ 3 cm below the seed furrow in a 15-cm band. Treatments that had each rate of nicosulfuron but no soil insecticide were included for each cultivar.

Each experiment was arranged as a randomized complete block with four replications. Each plot was 1 bed wide and 6 m long. At commercial maturity, the ears were harvested, graded, and weighed. Marketable weight was used as the dependent variable for statistical analysis. Two-way ANOVA was used to determine interactions. Since there were no interactions between experiments, the data were pooled across experiments. Two-way ANOVA was used to determine treatment effects on marketable weight, and means across herbicide and insecticide treatments within a cultivar were separated using Duncan's multiple range test at $P = 0.05$.

Because there was a significant interaction between cultivar and year, the data for the experiments testing sweet corn cultivar tolerance to nicosulfuron are presented for the individual years (Table 2). This interaction probably occurred because, in 1989, there was significant variation in yield among the nontreated controls that did not occur in 1990. This yield variation was probably due to a high population of purple nutsedge (*Cyperus rotundus* L.) that was not completely controlled by the preemergence application of metolachlor.

In both 1989 and 1990 (Table 2) the trends in marketable yield were similar. There were

some cultivars that yielded well regardless of the rate of nicosulfuron applied. Other cultivars yielded well only at lower rates of the herbicide. In 1989, 'Summersweet 8701' yielded poorly at all rates of nicosulfuron, while in 1990 this cultivar was tolerant when nicosulfuron was applied at 18 g·ha⁻¹. There was a continuum in yield among the cultivars tested, making it difficult to draw distinctions between cultivars in terms of their tolerance to nicosulfuron.

Trends in yield reduction within a cultivar were detected when orthogonal comparisons with a single degree of freedom were made. 'Zenith', 'Summersweet 7210', 'Summersweet 8701', 'Snowbelle', and 'Silverado' showed significant response to nicosulfuron rate (Table 3). Neither 'Zenith' nor 'Summersweet 7210' showed a significant response to nicosulfuron when marketable yield was averaged across all herbicide rates and compared to the untreated control. In 'Zenith' there was an increase in yield when nicosulfuron was applied at 18 or 36 g·ha⁻¹, compared to the nontreated control, and then a decline at 72 g·ha⁻¹. For 'Summersweet 7210' marketable yield was the same as the nontreated control when nicosulfuron was applied at 18 g·ha⁻¹, and there was a continuum between the rates of nicosulfuron. 'Summersweet 8701', 'Snowbelle', and 'Silverado' yielded less when marketable yield was averaged across all herbicide rates and compared to the nontreated control. Yield of 'Summersweet 8701' decreased sharply when nicosulfuron was applied at rates > 18 g·ha⁻¹. Yield of 'Silverado' was the same at 18 or 36 g·ha⁻¹, but decreased sharply when nicosulfuron was applied at 72 g·ha⁻¹. 'Snowbelle' did not exhibit a rate response to nicosulfuron in terms of marketable yield.

Results of the experiments testing the interaction of nicosulfuron, sweet corn cultivar, and insecticide indicated that sweet corn responded similarly to field corn (Williams et al., 1990) to nicosulfuron in the presence of soil-applied insecticides (Table 4). In both 'Sweet Belle' (tolerant) and 'Summersweet 7210' (intermediate) the choice of soil-applied insecticide dramatically impacted marketable yield; it was the same for both cultivars when no nicosulfuron was applied, regardless of soil-applied insecticide treatment. Marketable yield was not affected when nicosulfuron was applied at 36 g·ha⁻¹ when no soil-applied insecticide was used, or when chlorpyrifos was applied in a band below the seed furrow at 14.5 kg·ha⁻¹. Marketable yield of both cultivars was drastically reduced when terbufos was applied in the same manner and at the same rate as chlorpyrifos. There was no marketable yield of 'XPH-2659' (sensitive) when nicosulfuron was applied, regardless of soil-applied insecticide treatment.

These experiments indicate the use of nicosulfuron for weed control in sweet corn may cause reduction in marketable yield, depending on the cultivar selected. There was no correlation between sensitivity to nicosulfuron and the endosperm mutant gene of the cultivar. Thus, the endosperm mutant carried by a sweet corn cultivar cannot be

used to predict whether it is sensitive to this herbicide. In addition, the sensitivity of certain sweet corn cultivars can be altered by the choice of soil-applied insecticide. In at least some sweet corn cultivars, sensitivity to nicosulfuron is increased when certain soil-applied insecticides are used. This change in sensitivity makes prediction of cultivar response to this herbicide difficult.

Only 'Ultimate' and 'Silverado' in 1989 and 'Summersweet 8701' in 1990 had reduced total yield (weight of marketable yield + weight of culls) when nicosulfuron was applied (data not shown). In 1989 only 'Summersweet 8701' and in 1990 only 'Summersweet 7200' had reduced vigor, as measured by plant height, when nicosulfuron was applied (data not shown). These results suggest that the effect of nicosulfuron on certain sweet corn cultivars may be more a

quality response than a total growth response.

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