CHAPTER 4.0

EVALUATION OF THE EFFECT OF GRAMINICIDES IN SETHOXYDIM-TOLERANT CORN (ZEA MAYS) HYBRIDS

4.1 ABSTRACT

Field experiments were conducted in 1995 and 1996 to evaluate the effect of sethoxydim and other graminicides on the growth and yield of sethoxydim-tolerant corn hybrids. The specific objective of this research were: (1) to determine the response of sethoxydim-tolerant corn hybrids to clethodim, fluazifop-P, quizalofop-P and sethoxydim in the absence of the competitive effects of weeds; and (2) to evaluate corn yield of sethoxydim-tolerant hybrids when subjected to these treatments. Treatments included broadcast postemergence applications of sethoxydim, fluazifop-P, quizalofop-P, and clethodim. Sethoxydim was applied at 1X (.21, .08, and .14 kg/ha), 2X, 4X, and 8X rates to four sethoxydin-tolerant hybrids, while fluazifop-P, quizalofop-P, and clethodim applications were made to the same hybrids at 1X, 4X, and 8X rates. Sethoxydim-tolerant hybrids were unaffected by all rates of sethoxydim and 1X rates of quizalofop-P. Significant crop injury was observed with 2X and 4X rates of quizalofop-P and 1X, 2X, and 4X rates of fluazifop-P and clethodim. **Nomenclature:** clethodim, (E,E)-(+/-)-2-[1-[[(3-chloro-2-propenyl)oxy]imino]propyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one; fluazifop, (+/-)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanoic acid; quizalofop, (+/-)-2-[4-[(6-chloro-1,4-dihydro-1,4-

dioxo-2-naphthalenyl)acetamide; sethoxydim, 2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one; corn, *Zea mays* L.

Additional Index Words: Clethodim, fluazifop-P, quizalofop-P.

Abbreviations: DAT, days after treatment.

4.2 INTRODUCTION

In the past 15 years, several herbicides, members of the aryloxyphenoxy propionates and the cyclohexanedione families of chemistry, have been developed and registered. They provide selective, postemergence control of annual and perennial grass weeds in broadleaf crops (Ware 1994). These herbicides, which are collectively referred to as graminicides due to their specificity for grass weeds, act on the lipid synthesis pathway by inhibiting acetyl-CoA carboxylase (ACCase) (Ahrens 1996). Both classes of chemistry afford high activity against many grasses at economical rates, and can be applied to most broadleaf crops with little risk of injury (Meister 1996).

Recently, sethoxydim tolerant corn plants have been regenerated from tissue cultures selected for callus growth in the presence of sethoxydim (Parker et al. 1990a; Parker et al. 1990b). These plants exhibited a 40-fold increase in tolerance to sethoxydim relative to plants regenerated from tissue not exposed to the herbicide. The resistance originates from a nuclear mutation resulting in an altered form of the acetyl-coenzyme A carboxylase enzyme (Marshall et al. 1992). Sethoxydim applied at 0.88 kg/ha, approximately four times the recommended field use rate, was non-injurious to the sethoxydim-resistant (SR) corn line in field studies (Dotray et al. 1993).

Previous research has demonstrated excellent tolerance of sethoxydim-tolerant corn hybrids to field applications of sethoxydim (Dotray et al. 1993). Little research, however, has been conducted with regard to sethoxydim-tolerant corn susceptibility to other graminicides. It is unlikely that other graminicides would be labeled for use on these hybrids due to patents held by companies developing this technology. It is likely, however, that grower preference for specific herbicides, or inadvertent application of a graminicide other than sethoxydim to sethoxydim-tolerant corn, will require that this information be available to agricultural professionals.

The objectives of this research were to evaluate the effects of sethoxydim and other graminicides, applied as postemergence broadcast treatments, on sethoxydim-tolerant corn vigor and yield.

4.3 MATERIALS AND METHODS

Field experiments to evaluate the effects of sethoxydim and other graminicides applied as postemergence broadcast treatments to sethoxydim-tolerant corn vigor and corn yield were conducted in Montgomery County, VA in 1995 and 1996. Experiments were conducted on a Ross silt loam soil (fine-loamy, mixed, mesic cumulic Hapludolls) with 2% organic matter and pH 6.1.

Corn was grown using conventional tillage methods and a commercial planter delivering approximately 79,000 seeds/ha. The experiment utilized five sethoxydim-tolerant hybrids, two in 1995 and four in 1996, where one hybrid was in both years. Dekalb 592 was planted in 1995 and 1996, and an unnamed experimental Cargill variety was also planted in 1995. Cargill 4800, Cargill 7800, and the experimental variety RX 680 were planted in 1996. For all experiments, atrazine [6-chloro-*N*-ethyl-*N'*-(1-methylethyl)-1,3,5-triazine-2,4-diamine] at 1.7 kg ai/ha plus metolachlor [2-chloro-*N*-(2-ethyl-6-methylphenyl)-*N*-(2-methoxy-1-methylethyl)acetamide] at 2.2 kg ai/ha were applied preemergence for control of annual broadleaf weeds and grasses.

Individual plots consisted of four 76-cm corn rows 7.6 meters in length. In each plot 2 rows of one sethoxydim-tolerant hybrid were planted adjacent to 2 rows of another sethoxydim-tolerant hybrid. Herbicide applications were made to an area 1.8 m wide centered over the two treated rows, containing one row of each of the two sethoxydim-tolerant hybrids. Two corn rows which did not receive treatment were located between each treated experimental unit, and served as buffer rows and untreated reference rows for the determination of crop response.

Graminicide treatments were applied at 1X, 2X, 4X, and 8X rates for sethoxydim and 1x, 4X, and 8X for fluazifop-P, quizalofop-P, and clethodim. Herbicide applications were made using a CO_2-pressurized backpack sprayer delivering 210 L/ha of water at 220 kPa through flat fan spray tips[1]**.** The 1X application rates for each graminicide were determined using label recommendations for perennial grass control in soybeans (Hagood 1995; Hagood 1996) All herbicides treatments included crop oil concentrate[2] at 1.0 % (v/v).

Broadcast postemergence applications were made using a 4-nozzle boom with a 1.8 meter effective swath width. In the 1995 experiment, applications were made to 5 to 7- leaf corn, 20 to 26-cm in height. In the 1996 experiment, applications were made to 6 to 8-leaf corn, 21 to 27-cm in height.

All experiments were arranged in a randomized complete block design with four replications. The dependent variables evaluated included corn injury across hybrids and corn yield. Observations were made at 7 d intervals and utilized visual estimates of crop response. Visual estimates used a scale of 0 to 100, where 0 signifies no crop injury and 100 signifies death of the crop. For each experiment, data from two evaluation dates are presented, including representative data from one early and one late-season evaluation. For all studies, crop response data taken at harvest did not differ appreciably with data

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[1] Teejet 8003 flat fan spray tips. Spraying Systems Co., North Ave., Wheaton, IL 60222
[2] Crop-Surf Oil Concentrate, 83% Parrafin Base Oil. Marketed by Universal Cooperatives, Inc., 7801 Metro Pkwy., Minneapolis, MN.

from the later evaluation presented. Corn yields were obtained by hand harvesting treated rows and yields were adjusted to 15.5 % moisture content. All data were subjected to analysis of variance and means separated using Fishers Protected LSD with a significance level of $\alpha = 0.05$.

4.4 RESULTS AND DISCUSSION

Significant effects of graminicides on corn injury and corn yield were observed in all experiments. Crop injury of 0 to 30% was observed on both DK 592 and Cargill hybrids across all graminicides and all rates in observations taken at 35 DAT (Table 4.1). Sethoxydim at 1X, 2X, and 4X rates did not cause significant crop response in either DK 592 or the Cargill variety while producing injury of only 7 and 10%, respectively, at the 8X rate of application. Fluazifop-P at the 1X rate on both varieties did not cause significant crop injury. The 4X rate of fluazifop-P on DK 592 and Cargill caused injury of 17 and 22% respectively. Fluazifop-P applied at the 8X rate on DK 592 and Cargill caused crop injury of 25 and 30%, respectively. The application of quizalofop-P at the 1X rate caused minimal damage with injury ratings of 0 and 5% on DK 592 and Cargill, respectively. The 4 and 8X rates caused 18% injury to both varieties at these application rates. Clethodim caused the most damage across varieties with crop injury ratings of 17 and 30% at the 1X rate, 30 and 27% at 4X rate, and 17 and 23% when applied at the 8X rate on DK 592 and Cargill, respectively.

Observations at 72 DAT demonstrated that all graminicides caused severe crop response with the exception of sethoxydim (Table 4.1). Sethoxydim caused no significant crop injury at any application rate on either hybrid. Fluazifop-P caused 25, 43, and 57% crop injury at 1X, 4X, and 8X rates, respectively, for Dekalb 592. Crop injury with applications of fluazifop-P on Cargill resulted in 18, 50, and 67% injury with rates of 1X, 4X, and 8X, respectively. Quizalofop-P at 1X rates caused insignificant damage to both hybrids at 72 DAT. Injury to DK 592 and Cargill with the 4X application of quizalofop-P was 57 and 65%, respectively, while 8X rates resulted in death of both hybrids. Treatment with clethodim resulted in injury that ranged from 52 to 98% across all rates and varieties. At rates of 1X, 4X, and 8X injury was 52, 80, and 65% on DK 592. The same rates when applied to Cargill hybrids resulted in 97, 98, and 78% crop response.

Corn yields in the 1995 experiment were negatively influenced in direct response to increasing dosage of graminicide (Table 4.1), except in sethoxydim treatments. Sethoxydim-tolerant varieties produced commercially acceptable yields without regard to increasing dose of sethoxydim. Yields in response to sethoxydim application on DK 592 were 7760, 8090, 6980, and 7550 kg/ha with application rates of 1X, 2X, 4X, and 8X respectively, while Cargill produced 5900, 7340, 6330, and 7630 kg/ha in response to application of the same treatments, respectively. Corn yields were reduced substantially in response to fluazifop-P applications, and were less than 50% of yields with sethoxydim where 1X fluazifop-P application was made. Corn yield responses of 690 to1510 kg/ha were observed in response to 4X and 8X fluazifop-P applications. No corn yield reduction was observed with 1X quizalofop-P on the DK 592 hybrids, but yield with the Cargill hybrid was reduced to 4620 kg/ha. With 4X and 8X quizalofop-P, yields ranged from 0 to 1110 kg/ha. Clethodim at all application rates resulted in severe yield loss with both hybrids, where yields of 0 to 1960 kg/ha were observed across both hybrids and rates.

In 1996, at 24 DAT, sethoxydim caused no significant crop response at any application rate on any of the four sethoxydim-tolerant hybrids evaluated (Table 4.2). These results were essentially identical to those obtained in the 1995 experiment. Fluazifop-P injury ranged from 24 to 95% across hybrids and rates at 24 DAT (Table 4.2). Crop response of 41% was observed with application of the 1X rate to DK 592 and 34, 24, and 38% when applied at the same rate on Cargill 7800, Cargill4800, and RX 680 respectively. Application of fluazifop-P at 4X and 8X rates on these same hybrids produced crop injury ratings two to three times the magnitude of those from 1X rates. This crop response is slightly higher than that observed at 35 DAT in 1995 with fluazifop-P. At 24 DAT, quizalofop-P at the 1X rate caused a crop response that was 10, 11, 10, and 15% on hybrids DK 592, Cargill 7800 and 4800, and RX 620 respectively. The 4X rate produced injury from 81 to 93% across all hybrids while the 8X rate caused severe crop injury among treated hybrids,with 97 to 99% injury. The 1X rate of quizalofop-P in 1996 produced injury across all hybrids nearly equal to the crop response observed in 1995. Clethodim injury ranged from 69 to 99% at 24 DAT in 1996. Rates of 1X produced crop response of 69, 73, 84, and 84% when applied to DK 592, Cargill 7800 and 4800, and RX620 respectively (Table 4.1). Injury of 93 to 99% was observed with applications of 4X and 8X rates.

In observations at 53 DAT, sethoxydim caused essentially no crop injury to sethoxydim-tolerant corn hybrids tested (Table 4.3). Fluazifop-P at 1X rates produced only slight injury, while 4X and 8X rates produced crop response of 51 to 100%. The 8X rate on RX 620 caused death of this hybrid at 72 DAT and 97, 99, and 95% injury on DK 592, Cargill 7800, and Cargill 4800 respectively. Quizalofop-P caused little or no injury with application of the 1X across the hybrids tested. Injury from 4X and 8X rates ranged from 77 to 100%, with 8X application causing death of all hybrids evaluated. Clethodim produced severe crop response in all 4X and 8X treatments and death of all hybrids evaluated. Rates of 1X produced injury that ranged from 39 to 73%.

Corn yield response to graminicide applications in the 1996 experiments was similar to that observed in 1995 (Table 4.4). Corn yield decreased with increasing rate of graminicide, except in sethoxydim treatments. In those treatments, sethoxydim-tolerant varieties produced commercially acceptable yields ranging from 7540 to 8690 kg/ha with the 1X rate and yields from 6900 to 8050 kg/ha in the 8X applications. Corn yields were slightly reduced in response to the 1X rate of fluazifop-P, where DK 592, Cargill 7800 and 4800, and RX 620 produced yields of 7010, 7540, 7390, and 7280 kg/ha, respectively. Corn yield was substantially reduced with 4X rates, with 3780, 3250, 4430, and 1460 kg/ha produced by DK 592, Cargill 7800 and 4800, and RX 620 respectively. Yields in 8X rate treatments ranged from 25 to 500 kg/ha. Sethoxydim-tolerant corn hybrid response to fluazifop-P at 1X rates in 1996 with DK 592, Cargill 7800, Cargill 4800, and RX 620 was 7760, 8200, 6800, and 5950 kg/ha, respectively. Rates of 4X and 8x severely injured corn and affected yield in a similar manner. Yields from clethodim treatments ranged from 2370 to 5580 at the 1X rate. No yield was produced with 4X and 8X rates.

The overall results of these experiments indicate excellent crop tolerance of sethoxydim-tolerant corn hybrids to elevated application rates of sethoxydim. These hybrids also demonstrated excellent tolerance to 1X application rates of quizalofop-P, and marginal tolerance to 1X application rates of fluazifop-P. Higher application rates of quizalofop-P and fluazifop-P, and all application rates of clethodim provided unacceptable crop injury and yield reduction.

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