EVALUATION OF HERBICIDE PROGRAMS IN NO-TILL AND CONVENTIONAL TILLAGE CORN

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ABSTRACT

Experiments were conducted with corn at two sites in 2003 to compare glyphosate-based herbicide programs to conventional herbicide programs in conventional and no-till tillage systems. Herbicide treatments included: *s*-metolachlor plus atrazine preemergence (PRE) or no PRE; postemergence (POST) herbicide treatments were nicosulfuron plus rimsulfuron plus dicamba, glyphosate alone or with atrazine, and no POST herbicide; and postemergence-directed (PDIR) treatments included glyphosate, ametryn, or no PDIR herbicide. Entireleaf morningglory, ivyleaf morningglory, pitted morningglory, and tall morningglory where controlled 93% or greater 2 wk after POST herbicide application (WAP) with all treatments including POST herbicides. By 2 wk after PDIR herbicide treatment (WAPD), control was higher when a PDIR herbicides were applied. Broadleaf signalgrass, fall panicum, large crabgrass, and sicklepod were controlled 96% or greater 2 WAP with all treatments receiving a POST herbicide application. However, in the absence of a PDIR herbicide application, control was lower 2 WAPD. Palmer amaranth and common ragweed were controlled 99% or greater in the no-till tillage system by both herbicide programs, however in the conventional tillage system control was reduced with the conventional herbicide program compared to the glyphosate system. Smooth pigweed was controlled completely by both herbicide programs regardless of the tillage system used. Corn yield in the conventional tillage system was 1010 kg/ha higher than in the no-till. Net returns varied according to grain yield, which varied between tillage systems.

INTRODUCTION

Corn development and grain yield are influenced by the duration of weed interference, weed species, density, and the environment in which corn grows (Knake and Slife, 1961; Staniforth, 1957; Tapia et al., 1997; Vangessel et al., 1995; Young et al., 1984). Weeds compete with corn for sunlight, water, nutrients, and space. Numerous studies have shown that weed control early in the growing season is necessary to reduce yield losses in corn. Giant foxtail [*Setaria faberi* (L.) Herrm.], barnyardgrass [*Echinochloa cruss-galli* (L.) Beauvi.], and *Amaranthus* spp. emerging with corn reduced yields up to 13, 35, and 50%, respectively (Bosnic and Swanton, 1997; Fausey et al., 1997; Knake and Slife, 1965; Vizantinopoulos and Katranis, 1998). Carey and Kells (1995) found that a mixed weed population competing with corn until the weeds reached 20 cm tall reduced corn grain yield up to 20%.

Soil-applied herbicides, such as atrazine plus metolachlor or atrazine plus alachlor, have been used to control weeds in corn for many years, primarily because of their effectiveness and reasonable cost (Swanton et al., 2002). However, with reductions in atrazine use, due to limitations imposed because of atrazine found in ground water in areas of North Carolina and in other states (Cohen et al. 1986; Holden et al. 1992; Wade et al. 1998), growers are moving toward total POST weed management systems. Reduced tillage systems may help reduce growers' dependence on the use of PRE herbicides and help them transition into a total POST weed management program. In no-till tillage systems weed seedlings tend to emerge later, but at greater densities compared with conventional tillage systems (Halford et al., 2004). Also, in no-till systems, annual grass species often dominate the weed population (Johnson et al., 1998).

Applied POST, nicosulfuron is effective on many annual grass species (Tapia et al., 1997). However, there are limitations to using nicosulfuron. Nicosulfuron cannot be used on corn that has been treated with organophosphate insecticides because of the potential for interactions that negatively affect corn growth and development (Bailey and Kapusta, 1994; Kapusta and Krausz, 1992). However, glyphosate used in conjunction with glyphosate-resistant corn cultivars may allow growers to better control weeds in a no-till tillage system and still use organophosphate insecticides. Glyphosate-resistant (GR) corn would allow for a total POST herbicide program because of its broad spectrum of weed control, convenience of POST application without crop injury, and rotational crop flexibility (Ateh and Harvey, 1999; Culpepper and York, 1999; Culpepper et al., 2000).

Experiments were conducted to evaluate weed control, grain yield, and net economic returns in no-till and conventional tillage systems. Conventional and glyphosate-based herbicide programs were evaluated for each tillage system.

MATERIALS AND METHODS

The experiment was conducted in North Carolina at the Central Crops Research Station located near Clayton and at the Upper Coastal Plain Research Station located near Rocky Mount. Soils at Clayton and Rocky Mount were a Johns sandy loam (Fine-loamy over sandy or sandy skeletal, siliceous, thermic Aquic Hapludults) with 0.86% organic matter and pH 5.8 and a Goldsboro fine sandy loam (Fine-loamy, siliceous, thermic Aquic Paleudults) with 0.97% organic matter and pH 5.6, respectively.

Corn GR hybrids ‘DKC 69-71 RR/YG’ and ‘DKC 697' in 2003 were planted in mid-April. Plots were four rows 9 m long with row spaced 97 cm apart at Clayton and Goldsboro. Plots were conventionally tilled and bedded for the conventional tillage system or received a burndown herbicide application for the no-till system. No-till system was planted into a wheat cover crop after being bedded in the fall. Seed populations were 24,000 kernels per acre. No infurrow insecticide was applied. Soil amendments were applied according to North Carolina Department of Agriculture soil test recommendations.

Treatments are as follows: PRE herbicides were *S*-metolachlor plus atrazine at (1.1 + 1.4 kg ai/ha) or no PRE herbicide, POST herbicides were nicosulfuron plus rimsulfuron plus dicamba plus surfactant at [0.026+ 0.013 + 0.14 kg/ha + surfactant at 0.25% (V/V)], glyphosate at 0.8 kg ae/ha, or no POST herbicide; and PDIR herbicides were ametryn at 1.1 kg/ha, glyphosate at 0.8 kg/ha, or no PDIR herbicide treatment. Two non-treated checks were also included with each tillage system. PRE herbicides were applied at immediately after planting. PRE and POST herbicides were applied with a CO_2-pressurized backpack sprayer equipped with extended range flatfan nozzles delivering 140 L/ha at 160 kPa. Corn had 5 to 6 leaves when POST herbicides were applied. PDIR herbicide treatments were applied to 8- to 9-collar corn with a CO_2-pressurized backpack sprayer equipped with one flood nozzle per row calibrated to deliver 140 L/ha at 310 kPa.

The experimental design was a split split-block design with tillage systems as the main plot, hybrids as the sub-plot, and herbicide treatments as the sub sub-plot. Treatments at all locations were randomized four times except in Rocky Mount were treatments were replicated six times.

Morningglory species consisted of pitted morningglory (*Ipomoea lacunosa* L.), ivyleaf morningglory [*Ipomoea hederacea* (L.) Jacq.], and entireleaf morningglory (*Ipomoea hederacea* var. *integriuscula* Gray) in both tillage systems. Annual grass species consisted of fall panicum (*Panicum dichotomiflorum* Michx.), large crabgrass [*Digitaria sanguinalis* (L) Scop.], and broadleaf signalgrass [*Brachiaria platyphylla* (Griseb.) Nash]. Other weeds present included, Palmer amaranth [*Amaranthus palmeri* S. Wats.], smooth pigweed (*Amaranthus hybridus* L.), and common ragweed *(Ambrosia artemisiifolia* L.). Weed control was estimated visually 2 wk after POST application (WAP2), and 2 and 8 wk after PDIR application (WAPD) using a scale of 0 to 100 where 0 = no weed control and 100 = complete weed control or plant death (Frans et al., 1986). Annual grasses and morningglory species were evaluated as a category; no attempt was made to evaluate control of grasses and morningglories by species. The center two rows were harvested mechanically in mid-September and corn grain yields were adjusted to 15.5% moisture.

An enterprise budget for all herbicide inputs was calculated using prices from the HADSS[1] program for corn production in North Carolina. Additionally, available equipment from these budgets was used to calculate cost of disking land ($5.96/A), bedding land ($6.11/A), herbicide burndown, PRE, or POST application ($4.87/A), PDIR application ($3.71/A), planting crop ($6.57/A), and harvesting crop ($19.42/A) (Bullen, 2004). Costs were calculated for the 2003 growing seasons.

Data were subjected to analysis of variance, and treatment sums of squares were partitioned to reflect the split-plot design when evaluating herbicide system effects on GR corn. Non-transformed data for weed control are presented as arcsine square root transformation did not affect data interpretation. Means for all variables were separated using Fisher's Protected LSD Test at $P \leq 0.05$. Data from all non-treated checks were removed before analysis of variance was conducted.

RESULTS AND DISCUSSION

Corn Tests 2003.

There was a location by herbicide treatments within corn hybrid interaction for morningglory control 2 WAP, 2 WAPD, and 8 WAPD. The glyphosate herbicide system controlled morningglory 96 to 100% 2 WAP at both locations (data not shown). The conventional herbicide system controlled morningglory 72 to 100% 2 WAP. Differences among herbicides in the conventional program were due to treatments which only received *s*-metolachlor plus atrazine PRE and no POST herbicide. At Clayton, all glyphosate treatments controlled morningglory 97% or greater 2 WAPD except for the glyphosate POST only treatment. There were no differences in the glyphosate herbicide system at Rocky Mount. Trends remained the same for the conventional system at both locations , were the PRE herbicide only treatment was 22 to 24 percentage points lower than all other treatments.

There was a location by herbicide program interaction for control of annual grasses. Annual grass control was at least 80% (data not shown). However, the glyphosate POST only treatment and PRE herbicide only treatment controlled annual grasses less effectively than all other treatments 2 WAPD. Trends remained the same 8 WAPD.

Glyphosate controlled grasses completely 2 WAP at Rocky Mount. Additionally, *s*-metolachlor plus atrazine followed by nicosulfuron plus rimsulfuron plus dicamba controlled grasses 100%, which was better than all other conventional treatments 2 WAP. By 2 WAPD, glyphosate POST or glyphosate plus atrazine followed by glyphosate or ametryn PDIR controlled grasses 100%, which was greater than glyphosate or glyphosate applied POST alone. All conventional treatments

[1] HADSS, Herbicide Decision Support System. 2004. Web page: http://www.hadss.com/.

controlled annual grass 99% or greater 2 WAPD, except for the PRE herbicide only treatment. Trends for annual grass were similar 8 WAPD.

There was a tillage by herbicide system interaction for control of Palmer amaranth. Therefore, data were pooled over herbicides within a system and locations. There were no differences in Palmer amaranth control among herbicide programs in the no-till tillage system (data not shown). However, in the conventional tillage system, the conventional herbicide controlled Palmer amaranth 97%. There were no differences in control 2 WAPD or 8 WAPD for control of this weed (Data not shown).

There were no differences in control of smooth pigweed. Smooth pigweed was controlled 100% with both herbicide systems 2 WAP, 2 WAPD, and 8 WAPD (data not shown). Tillage systems had no effect on control of smooth pigweed.

There was a location by herbicide system interaction for control of common ragweed. Data were pooled over herbicides within a system and tillage systems. There were no differences in control of common lambsquarters at Clayton (data not shown). However, at Rocky Mount the glyphosate herbicide system controlled common lambsquarters 99% or greater 2 WAP, while the conventional herbicide system controlled common lambsquarters 96% 2 WAP. This small difference could be due to glyphosate being very good at controlling *Amaranthus* spp (York, 2004). No differences were found for control of common lambsquarters 2 WAPD or 8 WAPD among treatments.

There was a location by tillage system interaction for corn grain yield. Data were pooled over hybrid and herbicide systems due to lack of interaction or main effect. Corn grain yield at Rocky Mount averaged 6640 and 6570 kg/ha for no-till and conventional tillage systems, respectively, with no differences between tillage systems (data not shown). However, at Clayton the conventional tillage system yielded 175 bu/A, which was 15 bu/A higher than the average yield for the no-till system.

There was a tillage system by herbicides interaction for net return. Net returns in the conventional system were similar for all treatments, ranging from $210 to $230/A (Table 5), except for the s-metolachlor plus atrazine PRE herbicide treatment followed by nicosulfuron plus rimsulfuron plus dicamba. Trends were similar within the no-till tillage system. However, net returns from the no-till systems averaged $20/A less than with the conventional tillage system. This is a direct reflection in the differences observed from the yields when comparing tillage systems.

Results from these experiments indicate that herbicide programs that include glyphosate can control weeds as effectively as conventional herbicide programs in both conventional and no-till tillage systems. Corn grain yields did not differ among herbicide systems. However, in 2003 yields did vary by tillage systems. Net returns were similar in the fact that they only varied with yield. Combining herbicide programs which include glyphosate plus a conventional herbicide that will increase morningglory control and provide some residual control. Under similar weed complexes this would be a better system than trying to go with a total glyphosate herbicide system.

REFERENCES

Ateh, C. M. and R. G. Harvey. 1999. Annual weed control by glyphosate in glyphosate-resistant soybean (*Glycine max*). Weed Technol. 13:394-398.

Bailey, J. A. And G. Kapusta. 1994. Soil insecticide and placement influence corn (*Zea Mays*) tolerance to nicosulfuron. Weed Technol. 8:598-606.

Bosnic, A. C. and C. J. Swanton. 1997. Influence of barnyardgrass (*Echinochloa crus-galli*) time of emergence and density on corn (*Zea mays*). Weed Sci. 45:276-282.

Bullen, G. 2004. Personal communication. Department of Agricultural and Resource Economics, NC Cooperative Extension Service, Raleigh, NC.

Carey, J. B. and J. J. Kells. 1995. Timing of total postemergence herbicide application to maximize weed control and corn *(Zea mays*) yield. Weed Technol. 9:356-361.

Cohen, S. Z., C. Eiden, and M. N. Lorber. 1986. Monitoring ground water for pesticides. *In* R. C. Garner, and H. N. Higg, eds. Evaluation of Pesticides in Ground Water. Symposium Series 315. Washington, DC: American Chemical Society. pp. 170-197.

Culpepper, A. S. and A. C. York. 1999. Weed management and net returns with transgenic, herbicide-resistant, and nontransgenic cotton (*Gossypium hirsutum*). Weed Technol. 13:411-420.

Culpepper, A. S., A. C. York, R. B. Batts, and K. M. Jennings. 2000. Weed management in glufosinate- and glyphosate-resistant soybean (*Glycine max*). Weed Technol. 14:77-88.

Devine, M. D., S. O. Duke, and C. Fedtke. 1993. Inhibition of amino acid biosynthesis. *In* Physiology of Herbicide Action. Englewood Cliffs, NJ: Prentice Hall. pp. 252-263.

Fausey, J. C., J. J. Kells, S. M. Swinton, and K. A. Renner. 1997. Giant foxtail (*Setaria faberi*) interference in non-irrigated corn (*Zea mays*). Weed Sci. 45:256-260.

Franz, J. E., M. K. Mao, and J. A. Sikorski. 1997. Toxicology and environmental properties of glyphosate. *In* Glyphosate: A Unique Global Herbicide. Monogr. 189, Washington, DC: American Chemical Society. pp. 103-137.

Frans, R. E., R. Talbert, D. Marx, and H. Crowley. 1986. Experimental design and techniques for measuring and analyzing plant responses to weed control practices. *In* N. D. Camper, ed. Research Methods in Weed Science. Champaign, IL: Southern Weed Science Society. pp. 29-46.

Halford, C., A. S. Hamill, J. Zhang, and C. Doucet. 2001. Critical period of weed control in no-till soybean (*Glycine max*) and corn (*Zea mays*). Weed Technol. 15:737-744.

Holden, L. R., J. A. Graham, R. W. Whitmore, W. J. Alexander, R. W. Pratt, S. K. Liddle, and L. L. Piper. 1992. Results of the national alachlor well water survey. Environ. Sci. Technol. 26:935-943.

Johnson, W. G., J. S. Dilbeck, M. S. Defelice, and J. A. Kendig. 1998. Weed control with reduced rates of chlorimuron plus metribuzin and imazethapyr in no-till narrow-row soybean (*Glycine max*). Weed Technol. 12:32-36.

Kapusta, G. and R. F. Krausz. 1992. Interaction of terbufos and nicosulfuron on corn (*Zea mays*). Weed Technol. 6:999-1003.

Knake, E. L. and F. W. Slife. 1961. Competition of *Setaria Faberi* with corn and soybeans. Weeds 10:26-29.

Knake, E. L. and F. W. Slife. 1965. Giant foxtail seeded at various times in corn and soybeans. Weeds 13:331-334.

Malik, J. M., G. F. Barry, and G. M. Kishore. 1989. The herbicide glyphosate. Biofactors 2:17-25.

National Agricultural Statistics Service (NASS). 2003. Chemical usage. Web page: www.pestmanagement.info/nass/act_dsp_usage_multiple.cfm. Accessed: April 5, 2004.

National Agricultural Statistics Service (NASS). 2003. Average corn price. Web page: http/www.nass.usda.gov:81/ipedb/. Accessed: April 3, 2004.

Nida, D. L., K. H. Kolacz, R. E. Buehler, W. R. Deaton, W. R. Schulur, T. A. Armstrong, M. L. Taylor, C. C. Ebert, G. J. Rogan, S. R. Padgette, and R. L. Fuchs. 1996. Glyphosate-resistant cotton: genetic characterization and protein expression. J. Agic. Food Chem. 44:1960-1966.

Siehl, D. L. 1997. Inhibition of EPSP synthase, glutamine synthetase and histidine synthesis. In R. M. Roe ed., Herbicide activity: Toxicology, Biochemistry and Molecular Biology. IOS Press: Amsterdam, The Netherlands. pp. 37-67.

Staniforth, D. W. 1957. Effects of annual grass weeds on yield of corn. Agron. J. 49:551-554.

Swanton, C. J., A. Shrestha, D. R. Clements, and B. D. Booth. 2002. Evaluation of alternative weed management systems in a modified no-tillage corn-soybean-winter wheat rotation: weed densities, crop yields, and economics. Weed Sci. 50:504-511.

Tapia, L. S., T. T. Bauman, R. G. Harvey, J. J. Kells, G. Kapusta, M. M. Loux, W. E. Lueschen, M. D. Owen, L. H. Hageman, and S. D. Strachan. 1997. Postemergence herbicide application timing effects on annual grass control and corn (*Zea mays*) grain yield. Weed Sci. 45:138-143.

Vangessel, M. J., E. E. Schweizer, K. A. Garrett, and P. Westra.. 1995. Influence of weed density and distribution on corn (*Zea mays*) yield. Weed Sci. 43:215-218.

Vanzantinopoulos, S. and N. Katranis. 1998. Weed management of Amaranthus spp. in corn (*Zea mays*). Weed Technol. 12:145-150.

Wade, H. F., A. C. York, A. E. Morey, J. M. Padmore, and K. M. Rudo. 1998. The empact of pesticide use of groundwater in North Carolina. J. Environ. Qual. 27:1018-1026.

Wilcut, J. W., H. D. Coble, A. C. York, and D. W. Monks. 1996. The niche for herbicide-resistant crops in U. S. Agriculture. *In* S. O. Duke, ed. Herbicide-Resistant Crops: Agricultural, Environmental, Economic, Regulatory, and Technical Aspects. Boca Raton, FL: CRC Press, Inc. pp. 213-230.

York, A. C. 2004. Chemical weed control in field crops. *In* North Carolina Agricultural Chemicals Manual. Publ. AG-1. College of Agriculture and Life Sciences, North Carolina State University. Raleigh, NC. pp. 328-352.

Young, F. L., D. L. Wyse, and R. J. Jones. 1984. Quackgrass (*Agropyron repens*) interference on corn (*Zea mays*). Weed Sci. 32:226-234.