Chapter II

Mesotrione, acetochlor, and atrazine for weed management in corn (*Zea mays*)

Abstract: Field studies were conducted in 1999, 2000, and 2001 near Painter, VA to investigate weed control and crop safety with preemergence (PRE) and postemergence (POST) applications of mesotrione alone and in pre-package and tank-mix combinations with acetochlor and atrazine. Corn injury was low with all mesotrione applications. Mesotrione PRE at 0.16 and 0.24 kg ai/ha did not adequately control most broadleaf weeds or giant foxtail. Pre-package or tank-mix combinations of mesotrione plus acetochlor controlled smooth pigweed and giant foxtail but did not adequately control common ragweed, common lambsquarters, or morningglory species. Control from tank-mix combinations of mesotrione plus atrazine at 0.56 kg ai/ha was frequently low and varied with rainfall following PRE applications. All weed species were controlled 80% or more by mesotrione plus acetochlor PRE or atrazine plus acetochlor PRE followed by mesotrione at 0.11 kg/ha POST. PRE mesotrione treatments were most effective when 3.1 cm of rain was received within 7d after application.

Nomenclature: acetochlor; atrazine; mesotrione; common lambsquarter, *Chenopodium album* L. #[1] CHEAL; common ragweed, *Ambrosia artemisiifolia* L. # AMBEL; giant foxtail, *Setaria faberi* Herrm. # SETFA; morningglory species, *Ipomoea* spp. # IPOSS; smooth pigweed, *Amaranthus hybridus* L. # AMACH; corn, *Zea mays* L.

Additional index words: Bleaching herbicides, triketone herbicides.

Abbreviations: COC, crop oil concentrate; DAT, days after treatment; fb, followed by; PRE, preemergence; POST, postemergence; UAN, urea ammonium nitrate; WAT, weeks after treatment.

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

INTRODUCTION

Corn is grown on more hectares than any other crop in the United States with over 31 million hectares planted in both 2000 and 2001. Ninety-seven percent of this corn received some type of herbicide treatment (Anonymous 2001). The herbicide most heavily applied in corn weed management is atrazine (Anonymous 2001). Atrazine is a triazine herbicide applied for control of annual broadleaf weeds and some grasses (Ahrens 1994). Two chloroacetamide herbicides, acetochlor and metolachlor were applied on 41% of the corn for PRE control of grasses and some small-seeded broadleaf weeds (Anonymous 2001). Usually atrazine is applied in combination with a chloroacetamide herbicide for broad-spectrum weed control (Ahrens 1994).

There are currently 63 confirmed reports of weeds resistant to triazine herbicides, with 14 of these species having the potential to reduce corn yields (Heap 2002). The first weed reported to be resistant to triazine herbicides was common groundsel (*Senecio vulgaris* L.). This resistance followed 10 years of simazine and atrazine applications in a nursery (Ryan 1970). Some common species resistant to triazine herbicides include smooth pigweed (*Amaranthus hydridus* L.), common ragweed (*Ambrosia artemisiifolia* L.), common lambsquarters (*Chenopodium album* L.), jimsonweed (*Datura stramonium* L.), and giant foxtail (*Setaria faberi* Herrm.) (Heap 2002). Acetolactate synthase (ALS, EC 4.1.3.18) inhibitors have helped control triazine resistant weeds in corn (Ahrens 1994; Hagood et al. 2000). However, since their introduction in 1982, 70 reported cases of weed resistance to ALS-inhibitor herbicides have been documented (Heap 2002). Recently, biotypes of kochia [*Kochia scoparia* (L.) Schrad.] and common waterhemp (*Amaranthus rudis* Sauer) with resistance to both ALS inhibitors and triazine herbicides have been identified (Foes et al. 1998; Foes et al. 1999). On the Delmarva Peninsula, ALS resistant pigweed species, triazine resistant common lambsquarters and pigweed species, and recently glyphosate resistant horseweed [*Conyza canadensis* (L.) Cronq.] have been identified (VanGessel 2001; Heap 2002). Although these resistant biotypes do not exist in all locations, herbicides with other modes of action should be evaluated to reduce the selection of other resistant weed biotypes.

Mesotrione is a new herbicide registered for preemergence (PRE) and postemergence (POST) control of broadleaf weeds in field corn (Anonymous 2001a). This compound is the newest member of the triketone herbicide family, which also includes SC 0051, a herbicide registered in Europe for broadleaf weed control in corn (Beraud et al. 1993). Mesotrione, like other triketones, functions through inhibition of the enzyme p-hydroxyphenylpyruvate dioxygenase (HPPD, EC1.13.11.27) (Norris et al. 1998; Pallet et al. 1998; Viviani et al. 1998; Mitchell et al. 2001).

In previous research, mesotrione PRE controlled large crabgrass [*Digitaria sanguinalis* (L.) Scop.], barnyardgrass [*Echinochloa crus-galli* (L.) Beauv.], and broadleaf signalgrass [*Brachiaria platyphylla* (Griseb.) Nash] (Ohmes et al. 2000). However, control of giant foxtail, shattercane [*Sorghum bicolor* (L.) Moench], and johnsongrass [*Sorghum halepense* (L.) Pers.] was lower (Ohmes et al. 2000). Also, the broadleaf weeds smooth pigweed, prickly sida (*Sida spinosa* L.), velvetleaf (*Abutilon theophrasti* Medicus), pitted morningglory (*Ipomoea lacunosa* L.), and ivyleaf/entireleaf morningglory [*Ipomoea hederacea* (L.) Jacq.] can be controlled at least 85% from PRE mesotrione applications (Ohmes 2000). Currently, little information is available on control of other broadleaf weeds by mesotrione PRE.

PRE mesotrione applications will likely be applied with a chloroacetamide or atrazine plus chloroacetamide mixture to increase weed control (Lackey et al. 1999; Ohmes et al. 2000). Mesotrione plus acetochlor is a pre-packaged herbicide mixture in a 1:11 ratio that controls selected annual broadleaf weeds and grasses PRE in field corn[2]. PRE mesotrione plus acetochlor mixtures control pigweed species, common lambsquarters, common ragweed, jimsonweed, ivyleaf morningglory, entireleaf morningglory, common

[2] Syngenta Crop Protection (formerly Zeneca Ag. Products), 2 Righter Parkway, P.O. Box 15458, Wilmington, DE 19850-5458.

cocklebur (*Xanthium strumarium* L.) and giant foxtail (Lackey et al. 1999; Ohmes et al. 2000).

POST mesotrione applications have controlled several annual broadleaf weeds, large crabgrass, and barnyardgrass (Sutton et al. 1999; Beckett and Taylor 2000; Armel et al. 2001). Additions of low rates of atrazine in POST applications have enhanced mesotrione efficacy for larger or more difficult-to-control weeds (Johnson and Young 1999; Armel et al. 2000; Beckett and Taylor 2000; Johnson and Young 2000; Mueller 2000; Armel et al. 2001). POST applications should include 1% v/v crop oil concentrate (COC) and 2.5% v/v urea ammonium nitrate (UAN) (Wichert and Pastushok 2000).

Limited information is available on weed control with mesotrione. The main objective of this research was to evaluate mesotrione for control of annual broadleaf and grass weeds in corn grown on the Coastal Plain soils of eastern Virginia. Of particular interest was to determine the effectiveness of mesotrione PRE alone and in tank-mix combinations with acetochlor and atrazine and as a POST treatment following PRE herbicides. An additional objective was to evaluate the proposed pre-package mix of mesotrione plus acetochlor.

MATERIALS AND METHODS

Studies were conducted at the Eastern Shore Agricultural Research and Extension Center near Painter, VA in 1999, 2000, and 2001. The soil type was a Bojac sandy loam (Typic Hapludults) with less than 1% organic matter and a pH of 6.1. A conventional seedbed was prepared by chisel plowing followed by tandem disking. Prior to planting, seedbeds were tilled with an S-tine field cultivator with double rolling baskets. Fertilizer was applied in accordance with current recommendations from Virginia Polytechnic Institute and State University (Donohue and Heckendorn 1994). 'Pioneer 33G26'[3] corn

[3] Pioneer Hi-Bred International, Inc., 400 Locust Street, Suite 800, Des Moines, IA 50306-3453.

was planted 3.8 cm deep at a rate of 56,800 seeds/ha on May 7, 1999, April 21, 2000, and May 1, 2001.

Plots were established to receive PRE and POST herbicide treatments. Each plot consisted of four rows spaced 0.76 m apart with a herbicide treated area of 2.5 m by 6.1 m, leaving a 0.9 m untreated buffer between plots. Herbicides were applied with a tractor-mounted sprayer delivering 235 L/ha at 210 kPa through flat fan nozzles[4]. PRE herbicides were applied on the day of planting. POST herbicides were applied June 7, 1999, June 8, 2000, and May 22, 2001 which was approximately 4, 6, and 3 weeks after PRE applications in 1999, 2000, and 2001, respectively. All POST mesotrione treatments included of 1% v/v COC[5] and 2.5% v/v UAN.

Weed species varied with year, but each was present at least two years out of three. Weed heights for POST applications were generally similar over years although some differences occurred. Heights of common ragweed, common lambsquarters, and smooth pigweed (*Amaranthus hybridus* L.) were generally 13 to 18 cm tall at POST application, however common ragweed in 2000 was 26 cm tall. Annual morningglory populations were mixed and included tall morningglory [*Ipomoea purpurea* (L.) Roth.], pitted morningglory (*Ipomoea lacunosa* L.), and ivyleaf morningglory. Morningglory species were up to 7 cm tall in 2000 and 16 cm tall in 2001. Giant foxtail was the only annual grass present in these studies and was up to 13 cm tall in 1999 and 36 cm tall in 2000. Corn height was up to 46 cm tall in 1999 and in approximately the V6 to V7 growth stage. In 2000 and 2001, corn was up to 67 and 61 cm in height, respectively and in approximately the V9 to V11 growth stages.

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[4] Teejet 8003 flat fan nozzle. Spraying Systems Company, North Avenue, Wheaton, IL 60188.

[5] Agridex, a mixture of 83% paraffinic mineral oil and 17% polyoxyethylene sorbitan fatty acid ester, Helena Chemical Company, 5100 Poplar Avenue, Memphis TN 38137.

Rainfall during the 28 d after PRE herbicides were applied differed between years. Rainfall accumulations were considered adequate in the first 7 days following PRE herbicide applications only in 2000 (Table 2.1).

Two studies were conducted between 1999 and 2001. In the first study (mesotrione pre-package mix), conducted in 1999 and 2000, the objective was to determine the activity of the pre-package mix of mesotrione plus acetochlor (mesotrione : acetochlor ratio of 1:11) PRE and to compare the results from this mix with those from acetochlor PRE followed by (fb) either mesotrione POST or by mesotrione plus atrazine POST. Also included in this study was the commercial pre-package mix of atrazine plus acetochlor[6] PRE fb mesotrione POST.

A second study (mesotrione tank-mixes and sequential applications) was conducted in 1999, 2000, and 2001 to compare PRE applications of mesotrione alone at 0.16 and 0.24 kg/ha and combined with acetochlor at 1.8 kg/ha (mesotrione : acetochlor ratios of 1:11 and 1:7.5 respectively). Additional PRE treatments included mesotrione at 0.16 and 0.24 kg/ha plus 0.56 kg/ha atrazine (mesotrione : atrazine ratios of 1:3.5 and 1:2.3 respectively). Other treatments in this study were PRE applications of mesotrione at 0.16 kg/ha plus acetochlor at 1.8 kg/ha or atrazine at 0.56 kg/ha plus acetochlor at 0.83 kg/ha[8] fb mesotrione POST at 0.11 kg/ha. All treatments were compared to atrazine plus acetochlor[8] PRE.

Sites selected for this study contained mostly common ragweed (less than 60 plants / m^2) and giant foxtail (greater than 40 plants / m^2) in 1999 and 2000. Populations of smooth pigweed, common lambsquarters, morningglory species, and common ragweed were generally mixed in 2001 and each species was present at less than 50 plants / m^2.

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[6] Fultime® Herbicide, Zeneca Ag. Products, 2 Righter Parkway, P.O. Box 15458, Wilmington, DE 19850-5458.

Treatments in both studies were replicated three times and arranged in a randomized complete block design. Crop injury and weed control were visibly rated on a scale of 0 to 100% where 0 = no injury or weed control and 100 = crop death or complete weed control. Injury was rated 3 wk after treatment (WAT) with PRE herbicides and again 1 WAT with POST herbicides.

Weed control was rated 8 WAT with POST herbicides. Corn yields were determined by harvesting grain from the center two rows of each plot with a commercial combine modified for small plots and adjusting weight to 15.5% moisture prior to analysis. Data were subjected to analysis of variance (ANOVA) and means were separated using Fisher's Protected LSD test at the $\alpha = 0.05$ significance level. When ANOVA revealed no significant year by treatment interaction, data were pooled over years.

RESULTS AND DISCUSSION

Control of all weed species except giant foxtail in the pre-package mix study differed among years. Therefore, data for all species, except giant foxtail in the pre-package mix study, are presented separately for each year. Injury ratings and corn yields in the pre-package mix study were also pooled over years. However, in the mesotrione tank- mixes and sequentials study only injury ratings in 1999 and 2001 were pooled over years.

Mesotrione pre-package mix study. Common ragweed control with the pre-package mix of mesotrione plus acetochlor was dependent on rainfall within 7 days after treatment (DAT) (Table 2.1), especially at the low rate of the pre-mix (Table 2.2). No rainfall during the 7 DAT in 1999 resulted in only 58% control of common ragweed from mesotrione at 0.16 kg/ha plus acetochlor at 1.8 kg/ha, but 81% control from the same treatment in 2000 when 3.1 cm of rainfall was received within 7 DAT. Dependence on rainfall was less at the higher rate of mesotrione plus acetochlor, as common ragweed was controlled 80 and 83% in 1999 and 2000, respectively (Table 2.2).

In 1999, PRE acetochlor at 2.2 kg/ha fb mesotrione at 0.11 kg/ha POST controlled common ragweed 92% (Table 2.2). However in 2000, common ragweed plants were larger at application and the same treatment controlled common ragweed only 59%. When acetochlor at 2.2 kg/ha was fb mesotrione at 0.11 kg/ha plus atrazine at 0.28 kg/ha POST common ragweed was controlled 99% in 1999 and 95% in 2000. Similar results have been reported with mesotrione plus atrazine combinations in other weed species, including ivyleaf morningglory and common cocklebur (Johnson and Young 1999; Beckett and Taylor 2000; Johnson and Young 2000; Mueller 2000). Common ragweed control was also high from atrazine at 1.3 kg/ha plus acetochlor at 2.0 kg/ha PRE fb mesotrione at 0.11 kg/ha POST; this treatment controlled common ragweed 99% in 1999 and 97% in 2000.

Giant foxtail control was generally similar among most treatments. The pre-package mix of mesotrione plus acetochlor controlled giant foxtail 75 to 76% regardless of herbicide rate (Table 2.2). Acetochlor PRE at 2.2 kg/ha fb either mesotrione at 0.11 kg/ha POST or mesotrione at 0.11 kg/ha plus atrazine at 0.28 kg/ha POST controlled giant foxtail 76 and 82%, respectively. However, giant foxtail control with atrazine at 1.3 kg/ha plus acetochlor at 2.0 kg/ha PRE fb mesotrione POST was more than control from the pre-packaged mix of mesotrione plus acetochlor. Giant foxtail control with this treatment was greater than 90% prior to the POST mesotrione application; therefore mesotrione POST probably added little to giant foxtail control (data not presented). In previous studies, atrazine plus chloroacetamide herbicides applied PRE controlled giant foxtail (Buhler 1988; Johnson et al. 1997; Krauz et al. 2000).

Corn injury was transient and similar among treatments and data are presented as an average over 1999 and 2000. Symptoms generally included mild chlorosis or stunting. Injury from PRE treatments was 4 to 6% from mesotrione plus acetochlor and was 8% from atrazine plus acetochlor (Table 2.2). Corn was not injured by POST applications.

Corn yields were generally similar in response to most mesotrione treatments although corn treated with atrazine plus acetochlor PRE fb mesotrione POST produced higher yields than corn treated with acetochlor PRE fb mesotrione plus atrazine POST (Table 2.2). Corn yields most likely reflected differences in weed control among treatments.

Mesotrione tank mixes and sequential applications. Common ragweed control with PRE mesotrione was 71 and 83% from 0.16 and 0.24 kg/ha respectively in 2000 when 3.1 cm of rain was received by 7 DAT (Tables 2.1 and 2.3). However, common ragweed control by 0.24 kg/ha mesotrione PRE was only 30% in 1999 and 45% in 2001 when no rainfall occurred within 7 DAT. Tank-mixes of mesotrione plus acetochlor controlled common ragweed 67 to 68% in 1999 and 52 to 63% in 2001. However, in 2001 when 3.1 cm of rain occurred within 7 DAT, control by mesotrione plus acetochlor was similar to control by mesotrione alone. In 2000 and 2001, tank-mixes of mesotrione plus atrazine at 0.56 g/ha increased common ragweed control compared to PRE mesotrione alone but this did not occur in 1999 when rainfall was lowest. Higher rates of atrazine would likely be more effective in combinations with mesotrione for common ragweed control (Hagood et al. 2001).

All PRE herbicides fb mesotrione POST controlled common ragweed 79% or greater. The only treatment that controlled common ragweed more than 90% in all three years, however, was mesotrione plus acetochlor PRE fb mesotrione POST at 0.11 kg/ha. This treatment controlled common ragweed better than the atrazine plus acetochlor standard in two years out of three.

Smooth pigweed and common lambsquarters were present in 1999 and 2000, coinciding with years in which rainfall did not occur for 7 DAT (Table 2.1). Mesotrione PRE did not control either species more than 62% at 0.16 or 0.24 kg/ha (Table 2.4). However, mesotrione plus acetochlor treatments controlled smooth pigweed 95 to 99%. Acetochlor has been used to control Amaranthus species in other studies (Sweat et al. 1998; Vizantinopoulos and Katranis 1998). Common lambsquarters control by mesotrione plus acetochlor was 40 to 68% and was increased by acetochlor over that afforded by 0.24 kg/ha mesotrione in 1999 and at both rates of mesotrione in 2001.

These data conflict with those of Menbere and Ritter (2001) who reported control of triazine-resistant common lambsquarters with PRE mesotrione in no-till corn.

Smooth pigweed and common lambsquarters control by mesotrione plus atrazine was higher than with mesotrione alone at 0.24 kg/ha in 1999 and with either rate of mesotrione in 2001 (Table 2.4). Differences in control between years may result from more rainfall 8 to 28 DAT in 2001 compared to lower rainfall in 1999 (Table 2.1). Smooth pigweed and common lambsquarters control by PRE treatments of mesotrione, mesotrione plus acetochlor, or atrazine plus acetochlor fb mesotrione POST was 98 to 99% (Table 2.4). Control of these species was more consistent with PRE herbicides fb POST mesotrione than with the commercial pre-package mix of atrazine plus acetochlor. The high level of common lambsquarters control from mesotrione POST agrees with reports by Lackey et al. (1999), Beckett and Taylor (2000), and Menbere and Ritter (2001).

Control of morningglory species was 69 to 76% by mesotrione at 0.24 kg/ha PRE and by combinations of either rate of mesotrione plus acetochlor or atrazine in 2000 (Table 2.5). However, none of these treatments controlled annual morningglories more than 35% in 2001. These differences between years related to the rainfall received within 7 DAT in 2000, relative to the lack of rainfall during that time in 2001 (Table 2.1). However, in both years morningglory control was 87% or above with PRE herbicide treatments fb mesotrione POST at 0.11 kg/ha compared to 16 to 29% control from the pre-package mix of atrazine plus acetochlor.

Giant foxtail control by PRE or POST mesotrione was generally below 40% unless acetochlor was included PRE (Table 2.5). The one exception was 77% giant foxtail control with mesotrione plus atrazine PRE in 2000 when rainfall was 3.1 cm within 7 DAT (Table 2.1 and 2.5). These results are similar to those of Ohmes et al. (2000) who reported low control of giant foxtail by mesotrione. All treatments that contained mesotrione plus acetochlor controlled giant foxtail at least 80% and were similar to the pre-package mix of atrazine plus acetochlor.

Corn injury data in 1999 and 2001 were pooled over years since there was not a significant year by treatment interaction (Table 2.6). Injury in these years did not exceed 3% from any PRE treatment, but was 8 to 20% in 2000 when rainfall occurred within 7 DAT. All treatments that contained acetochlor in 2000 injured corn 15 to 20%. However, PRE mesotrione alone or with atrazine at 0.56 kg/ha did not injure corn more than 13% in any year. Corn injury from POST mesotrione applications did not exceed 3%.

Corn yields varied with year and were affected by weed control and rainfall (Tables 2.1 and 2.6). In 1999, rainfall was low in June and July (22 cm) and grain yields did not exceed the 3.95 Mg/ha produced by corn treated with the pre-package mix of atrazine plus acetochlor. Corn treated with mesotrione at 0.24 kg/ha plus acetochlor at 1.8 kg/ha or PRE herbicides fb mesotrione POST produced yields similar to corn treated with the atrazine plus acetochlor standard. Yields of corn receiving other herbicide treatments were lower.

In 2000 and 2001, rainfall during June and July was 30 and 37 cm respectively and corn yields were more in these years in comparison to 1999. In 2000, corn treated with the pre-package mix of atrazine plus acetochlor produced 9.89 Mg/ha and only corn treated with mesotrione PRE at 0.16 kg/ha produced lower yields (Table 2.6). In 2001, corn treated with mesotrione at 0.24 kg/ha plus atrazine, and corn treated with PRE herbicides fb mesotrione POST produced grain yields higher than those treated by atrazine plus acetochlor. Other treatments resulted in yields similar to that produced by corn treated with atrazine plus acetochlor.

Mesotrione can be an effective component of herbicide programs for broadleaf weed control in corn. Mesotrione plus acetochlor PRE controlled smooth pigweed and giant foxtail. However, mesotrione alone or as a component of a pre-package mix or tank-mix with acetochlor or in tank-mixes with atrazine may not adequately control common ragweed, morningglory species, or common lambsquarters. Higher rates of atrazine in these mixtures would likely increase control of these weed species (Hagood et al. 2001). As with most PRE herbicides, rainfall following application is likely the most important factor influencing control.

Herbicide programs which included PRE applications of mesotrione, mesotrione plus acetochlor or atrazine plus acetochlor fb POST mesotrione treatments generally controlled most broadleaf weeds, although acetochlor was required for giant foxtail control. Sutton et al. (1999) and Beckett and Taylor (2000) also concluded that POST mesotrione treatments controlled many annual broadleaf weeds. However, in our studies mesotrione POST did not always control common ragweed unless atrazine was included at 0.28 kg/ha. Improved control of annual broadleaf weeds with the addition of low rates of atrazine to mesotrione has been reported previously (Johnson and Young 1999; Beckett and Taylor 2000; Johnson and Young 2000; Mueller 2000).

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Table 2.1. Rainfall at 7-day intervals for 28 days after preemergence applications in 1999, 2000, and 2001.

Days after application	1999	2000	2001
		cm	
0 to 7	0	3.1	0
8 to 14	0.6	0	1.3
15 to 21	0.7	0	2.3
22 to 28	0	0.6	6.4
Total	1.3	3.7	10

Table 2.2. Corn injury, weed control, and corn yield from the pre-package mix of mesotrione plus acetochlor in 1999 and 2000.[a]

Herbicide treatment	Application timing	Rate	Weed control: Common ragweed 1999	Weed control: Common ragweed 2000	Weed control: Giant foxtail 1999 + 2000[c]	Corn injury[b] 1999 + 2000[c]		Corn yield 1999 + 2000
			8 WAT	8 WAT	8 WAT	3 WAT	1 WAT	
		— kg ai/ha —	— % —					— Mg/ha —
Mesotrione + acetochlor	PRE	0.16 + 1.8	58	81	76	4	2	5.97
Mesotrione + acetochlor	PRE	0.20 + 2.2	80	83	75	6	4	5.77
Acetochlor fb	PRE	2.2	92	59	82	5	5	5.74
mesotrione[d]	POST	0.11						
Acetochlor fb	PRE	2.2	99	95	76	7	6	5.71
mesotrione + atrazine	POST	0.11 + 0.28						
Atrazine + acetochlor fb	PRE	1.3 + 2.0	99	97	91	8	3	6.91
mesotrione	POST	0.11						
Untreated check[e]	---		0	0	0	0	0	0.25
$LSD_{0.05}$			10	15	13	3	NS	1.18

[a] Abbreviations: PRE, preemergence; POST, postemergence; WAT, weeks after treatment; NS, not significant; fb, followed by.
[b] Corn injury was rated 3 weeks after treatment with PRE herbicides and 1 week after treatment with POST herbicides.
[c] No year by treatment interaction occurred with corn injury and giant foxtail control ratings in 1999 and 2000, therefore data are pooled over years.
[d] All postemergence treatments included 1% v/v crop oil concentrate and 2.5% v/v urea ammonium nitrate.
[e] Untreated check not included in statistical analysis.

Table 2.3. Common ragweed control with preemergence and postemergence applications of mesotrione treatments in 1999, 2000, and 2001.[a]

Herbicide treatment	Application timing	Rate	Common ragweed control[b] 1999	2000	2001
		— kg ai/ha —	%		
Mesotrione	PRE	0.16	20	71	37
Mesotrione	PRE	0.24	30	83	45
Mesotrione + acetochlor	PRE	0.16 + 1.8	68	72	52
Mesotrione + acetochlor	PRE	0.24 + 1.8	67	84	63
Mesotrione + atrazine	PRE	0.16 + 0.56	37	90	70
Mesotrione + atrazine	PRE	0.24 + 0.56	39	93	68
Mesotrione fb	PRE	0.16	79	86	88
mesotrione[c]	POST	0.11			
Mesotrione + acetochlor fb	PRE	0.16 + 1.8	93	94	91
Mesotrione	POST	0.11			
Atrazine + acetochlor fb	PRE	0.56 + 0.83	80	93	97
Mesotrione	POST	0.11			
Atrazine + acetochlor	PRE	1.1 + 1.7	74	93	44
Untreated check[d]	---		0	0	0
$LSD_{0.05}$			21	6	15

[a] Abbreviations: PRE, preemergence; POST, postemergence; fb, followed by.
[b] Common ragweed control was rated 8 weeks after postemergence herbicides were applied.
[c] All postemergence treatments included 1% v/v crop oil concentrate and 2.5% v/v urea ammonium nitrate.
[d] Untreated check not included in statistical analysis.

Table 2.4. Smooth pigweed and common lambsquarters control with preemergence and postemergence applications of mesotrione treatments in 1999 and 2001.[a]

			Weed control[b]			
			Smooth pigweed		Common lambsquarters	
Herbicide treatment	Application timing	Rate	1999	2001	1999	2001
		— kg ai/ha —	%			
Mesotrione	PRE	0.16	33	36	21	28
Mesotrione	PRE	0.24	52	62	33	30
Mesotrione + acetochlor	PRE	0.16 + 1.8	98	95	40	68
Mesotrione + acetochlor	PRE	0.24 + 1.8	99	95	68	62
Mesotrione + atrazine	PRE	0.16 + .56	32	79	19	60
Mesotrione + atrazine	PRE	0.24 + 0.56	68	91	85	60
Mesotrione fb	PRE	0.16	98	99	98	99
mesotrione[c]	POST	0.11				
Mesotrione + acetochlor fb	PRE	0.16 + 1.8	99	99	99	99
Mesotrione	POST	0.11				
Atrazine + acetochlor fb	PRE	0.56 + 0.83	98	99	99	99
Mesotrione	POST	0.11				
Atrazine + acetochlor	PRE	1.1 + 1.7	99	82	99	54
Untreated check[d]	----		0	0	0	0
$LSD_{0.05}$			15	23	21	22

[a] Abbreviations: PRE, preemergence; POST, postemergence; fb, followed by.
[b] Smooth pigweed and common lambsquarters control was rated 8 weeks after postemergence herbicides were applied.
[c] All postemergence treatments included 1% v/v crop oil concentrate and 2.5% v/v urea ammonium nitrate.
[d] Untreated check not included in statistical analysis.

Table 2.5. Morningglory species and giant foxtail control with preemergence and postemergence applications of mesotrione treatments in 1999, 2000, and 2001.[a]

Herbicide treatment	Application timing	Rate	Weed control[b] Morningglory spp. 2000	Morningglory spp. 2001	Giant foxtail 1999	Giant foxtail 2000
		— kg ai/ha —	%			
Mesotrione	PRE	0.16	41	17	9	23
Mesotrione	PRE	0.24	69	26	12	37
Mesotrione + acetochlor	PRE	0.16 + 1.8	73	20	81	80
Mesotrione + acetochlor	PRE	0.24 + 1.8	79	28	85	85
Mesotrione + atrazine	PRE	0.16 + .56	88	25	19	38
Mesotrione + atrazine	PRE	0.24 + 0.56	76	35	25	77
Mesotrione fb	PRE	0.16	92	88	39	37
mesotrione[c]	POST	0.11				
Mesotrione + acetochlor fb	PRE	0.16 + 1.8	92	87	95	96
mesotrione	POST	105				
Atrazine + acetochlor fb	PRE	0.56 + 0.83	93	93	80	93
mesotrione	POST	0.11				
Atrazine + acetochlor	PRE	1.1 + 1.7	29	16	91	85
Untreated check[d]	---		0	0	0	0
$LSD_{0.05}$			22	23	14	15

[a] Abbreviations: PRE, preemergence; POST, postemergence; fb, followed by.
[b] Morningglory species and giant foxtail control were rated 8 weeks after postemergence herbicides were applied.
[c] All postemergence treatments included 1% v/v crop oil concentrate and 2.5% v/v urea ammonium nitrate.
[d] Untreated check not included in statistical analysis.

Table 2.6. Corn injury and yields with preemergence and postemergence applications of mesotrione treatments in 1999, 2000 and 2001.[a]

Herbicide treatment	Application timing	Rate	Corn injury[b] 1999 + 2001[c] 3 WAT	Corn injury[b] 2000 3 WAT	Corn injury[b] 1999 + 2000 + 2001[c] 1 WAT	Corn yields 1999	Corn yields 2000	Corn yields 2001
		kg ai/ha	%			Mg/ha		
Mesotrione	PRE	0.16	0	8	1	1.70	6.16	7.19
Mesotrione	PRE	0.24	1	9	1	1.28	9.60	5.14
Mesotrione + acetochlor	PRE	0.16 + 1.8	1	17	3	2.32	9.99	6.39
Mesotrione + acetochlor	PRE	0.24 + 1.8	2	20	3	3.22	9.47	7.47
Mesotrione + atrazine	PRE	0.16 + 0.56	2	13	2	1.04	8.66	6.49
Mesotrione + atrazine	PRE	0.24 + 0.56	2	9	1	1.83	10.19	8.16
Mesotrione fb	PRE	0.16	1	11	2	2.87	8.32	10.98
mesotrione[d]	POST	0.11						
Mesotrione + acetochlor fb	PRE	0.16 + 1.8	1	15	3	3.77	11.68	11.22
mesotrione	POST	0.11						
Atrazine + acetochlor fb	PRE	0.56 + 0.83	3	10	1	3.26	11.38	11.57
mesotrione	POST	0.11						
Atrazine + acetochlor	PRE	1.1 + 1.7	2	16	2	3.95	9.89	5.70
Untreated check[e]	---		0	0	0	0.73	0.86	2.82
$LSD_{0.05}$			2	7	2	1.30	2.07	2.05

[a] Abbreviations: PRE, preemergence; POST, postemergence; fb, followed by.

[b] Corn injury was rated 3 weeks after treatment with preemergence herbicides and 1 week after treatment with postemergence herbicides.

[c] No year by treatment interaction occurred with corn injury 3 weeks after treatment in 1999 and 2001 or 1 week after treatment in 1999, 2000, and 2001, therefore these data are pooled over years.

[d] All postemergence treatments included 1% v/v crop oil concentrate and 2.5% v/v urea ammonium nitrate.

[e] Untreated check not included in statistical analysis.