## Chapter IV

## Mesotrione combinations in glyphosate-resistant corn (*Zea mays*)

**Abstract:** Field studies were conducted in 1999, 2000, and 2001 to investigate weed control and corn tolerance to postemergence (POST) combinations of mesotrione at 70, 105, and 210 g ai/ha applied with and without glyphosate at 560 g ai/ha. Mesotrione alone and tank-mixed with glyphosate controlled smooth pigweed greater than 97% and controlled common lambsquarters 93 to 99%. Control of common ragweed and morningglory species was variable. Common ragweed control was generally better when mesotrione was applied at 105 or 140 g/ha and control was increased with the addition of glyphosate only in 2000. Giant foxtail control was below 25% with all rates of mesotrione, but tank-mixtures of mesotrione plus glyphosate controlled giant foxtail 65 to 75%. Mesotrione injured glyphosate-resistant corn 4 to 24% when averaged over glyphosate rates. Mesotrione injury in glyphosate-resistant corn usually increased with higher mesotrione rates, with rainfall after herbicide applications, and in tank-mixtures with glyphosate. Injury was transient, however, and did not reduce corn yields.

**Nomenclature:** Glyphosate; mesotrione; common lambsquarters, *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.

**Key words:** Transgenic crops, bleaching herbicides, triketone, total postemergence.

**Abbreviations:** COC, crop oil concentrate; DAT, days after treatment; 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 in 1989. Available from WSSA, 810 East 10$^{th}$ Street, Lawrence, KS 66044-8897.

# INTRODUCTION

Glyphosate is a non-selective herbicide that controls many annual and perennial broadleaf weeds and grasses (Yonce and Skroch 1989; Ahrens 1994; Krausz et al. 1996; Hagood et al. 2001). Previously, glyphosate use was limited to burndown applications prior to crop emergence for control of existing vegetation in no-till crops (Wilson et al. 1985; Wilson and Worsham 1988). With the introduction of glyphosate-resistant corn, weed control options have increased for corn producers. Glyphosate resistance is conferred through insertion of a mutant EPSPS gene derived from Agrobacterium sp. strain CP4 allowing postemergence (POST) over-the-top glyphosate applications (Harrison et al. 1996; Hetherington et al. 1999).

Full-season weed control with POST herbicides in glyphosate-resistant corn involves several considerations. Planting techniques, such as narrow-row spacing, can allow early canopy closure and reduce weed competition (Murphy et al. 1996). POST glyphosate applications must be applied early to control certain weed species, such as giant foxtail (*Setaria faberi* Herrm.), common lambsquarters (*Chenopodium album* L.), ivyleaf morningglory [*Ipomoea hederacea* (L.) Jacq.], and velvetleaf (*Abutilon theophrasti* Medicus) (Krausz et al. 1996; Jordan et al. 1997; Grower et al. 1999). Several researchers have reported that total POST herbicide applications should be made to weeds less than 10 cm tall in conventional or herbicide-resistant corn (Carey and Kells 1995; Krausz and Kapusta 1998; Grower et al. 1999).

Glyphosate has no soil activity and may require residual herbicides or sequential applications for consistent weed control in corn (Etheridge and Mueller 1998; Sparks et al. 1999; Tharp and Kells 1999; Hagood et al. 2001; Johnson et al. 2000). However, antagonism of glyphosate with other herbicides has been reported (Selleck et al. 1981; Wilson et al. 1985; Lich et al. 1997; Jordan et al. 1997; File et al. 1998; Starke and Oliver 1998). Therefore, herbicides with new chemistry should be evaluated alone and in combinations with glyphosate for weed control and crop safety in glyphosate-resistant corn.

Mesotrione is a recently registered herbicide for preemergence and POST control of broadleaf weeds in field corn (Anonymous 2001c). 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 triketone herbicides, 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).

POST mesotrione applications have controlled several annual broadleaf weeds, large crabgrass, and barnyardgrass in corn (Johnson and Young 1999; Sutton et al. 1999; Beckett and Taylor 2000; Johnson and Young 2000; Ohmes et al. 2000; Armel et al. 2001). However, POST applications will not control most grass species (Ohmes et al. 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).

The effects of mesotrione and mesotrione plus glyphosate on glyphosate-resistant corn and weed control by these herbicide combinations have not been reported. Therefore, the objective of this study was to evaluate mesotrione alone and in combinations with a reduced rate of glyphosate for corn tolerance and weed control in glyphosate-resistant corn. The glyphosate rate selected for this study was 560 g ai/ha since this rate has controlled several weed species when applied to weeds less than 10 cm tall (Krausz et al. 1996).

## MATERIALS AND METHODS

**Field study.** 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 according to current Virginia Polytechnic Institute and State University recommendations (Donohue and Heckendorn 1994). Corn ‘Dekalb 626RR’[2] was planted 3.8 cm deep at a rate of

[2] Monsanto Co., 800 North Lindbergh Boulevard, St. Louis, MO 63167.

56,800 seeds/ha on May 6, 1999 and April 14, 2000. In 2001, the corn variety was 'Dekalb 5863RR' and it was planted at the same population and depth as in previous years on April 27.

Plots were established to receive 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; a 0.9 m untreated buffer was maintained between plots. Herbicides were applied POST with a tractor-mounted sprayer delivering 235 L/ha at 210 kPa through flat fan nozzles[3]. Herbicides were applied POST May 17, 1999, May 12, 2000, and May 14, 2001 at 11, 28, and 17 days after planting, respectively. Herbicide treatments were arranged in a 3 by 2 factorial design that included mesotrione at 70, 105, and 210 g ai/ha and 0 or 560 g ai/ha of glyphosate. Glyphosate at 1120 g/ha and an untreated check were included for comparison. All POST mesotrione treatments included an adjuvant system of 1% v/v COC[4] and 2.5% v/v UAN.

Weed species varied between years, but each was present at least two years in this study. Herbicides were applied to weed species less than 10 cm in height. Common ragweed (*Ambrosia artemisiifolia* L.) was present in all three years at less than 50 plants / $m^2$. Common lambsquarters, smooth pigweed (*Amaranthus hybridus* L.), and morningglory species were each present in only two years and at densities generally below 40 plants / $m^2$. In 1999, morningglory species were mixed, but were predominantly pitted morningglory (*Ipomoea lacunosa* L.). In 2001, morningglory species were a mixture of tall morningglory [*Ipomoea purpurea* (L.) Roth], ivyleaf morningglory, and pitted morningglory. Giant foxtail was also present in only two years and was at densities generally exceeding 80 plants / $m^2$. Corn was 12 to 18 cm tall at POST herbicide applications and in approximately the V3 to V4 stage of growth.

Corn injury was evaluated 1 week after treatment (WAT) and weed control ratings were visually assessed 9 WAT. Corn yields were determined by harvesting grain from the center two

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

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

rows of each plot with a commercial combine modified for small plots. Yields were adjusted to 15.5% moisture prior to analysis.

**Greenhouse study.** A greenhouse study was conducted to evaluate corn injury from mesotrione and mesotrione plus glyphosate. Four 'Dekalb 626RR' corn seeds were planted into 9.5 cm by 9.5 cm pots[5] filled with a high organic matter commercial potting mix[6]. Plants were watered and fertilized[7] as needed to facilitate maximum plant growth and vigor. Prior to herbicide application, plants were thinned to 3 corn plants per pot. Herbicides were applied using a greenhouse cabinet sprayer at 220 L/ha with a pressure of 210 kPa. A single even flow nozzle[8] was placed 30 cm above the highest part of the treated plants. Applications included mesotrione alone at 105 and 210 g/ha. Mesotrione at 105 g/ha was also applied in combination with glyphosate at 560 or 1120 g/ha. Glyphosate at 1120 g/ha and an untreated check were included for comparison. Corn plants were 12 to 18 cm tall at herbicide application which was similar to corn height when field applications were made.

Corn injury was visually rated 6 days after treatment (DAT). Corn heights were measured and shoot biomass was harvested 11 DAT. Corn plants were measured from the lowest point at the soil surface to the highest point on the corn plant and the heights were averaged over three plants per pot. After harvest, plants were dried to similar moisture and weighed. Heights and biomass ratings are presented as percent reduction in comparison to the untreated check.

**Experimental design, data collection, and data analysis**. Treatments in the field study were replicated three times while greenhouse treatments were replicated four times. All studies were

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[5] T.O. Plastics 4" Fill Pots. Inside dimensions 9.5 cm by 9.5 cm by 8.1 cm. Wetzel, Inc., 1345 Diamond Springs Road, Virginia Beach, VA 23455.

[6] Pro-Mix BX. Premier Horticulture, Inc., Red Hill, PA 18076.

[7] Excel All Purpose 21-5-50. Wetzel, Inc., 1345 Diamond Springs Road, Virginia Beach, VA 23455.

[8] Teejet 8002 EVS flat fan spray tip. Spraying Systems Co., North Avenue, Wheaton, IL 60188.

organized in a randomized complete block design and repeated. Crop injury and weed control were visually rated on a scale of 0 to 100% where 0 = no injury or weed control and 100 = crop death or complete weed control. 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. In addition, when a mesotrione by glyphosate interaction occurred in the field study, all weed control data are presented by treatment. The untreated check and the comparison treatment of glyphosate at 1120 g/ha were not included in the analysis.

## RESULTS and DISCUSSION

**Field study.** No year by treatment interactions occurred for control of common lambsquarters, smooth pigweed, and giant foxtail; therefore these data were pooled over years. All other data are presented by years.

There was more corn injury in 1999 and 2001 than observed in 2000 (Table 4.1). In 1999, corn injury was 10% to 20% from mesotrione averaged over glyphosate rates. Corn injury was 20% when glyphosate was averaged over mesotrione rates, but only 9% when no glyphosate was included in mesotrione treatments. Similar corn injury resulted from mesotrione and mesotrione plus glyphosate applications in 2001. However, corn injury was lower in 2000 and corn was injured only 4 to 7 % when averaged over glyphosate or mesotrione rates. POST applications of mesotrione resulted in corn injury each year, with generally higher injury present in 1999 and 2001 (Table 1). Injury generally appeared during the first week after POST applications and started as white areas in the whorl of glyphosate-resistant corn plants which usually disappeared within 1 to 2 wk. These white areas were visible in 1999, but in 2000 and 2001 injury was generally mild chlorosis with moderate plant stunting. Conversely, corn injury in non-transgenic corn varieties has been reported to be minimal with mesotrione applications (Lackey et al. 1999; Beckett and Taylor 2000; Ohmes et al. 2000; Armel 2002).

Sprague et al. (1999) found differences in corn injury from isoxaflutole in different corn hybrids due to variations in rates of herbicide metabolism. However, in our studies, the same glyphosate-resistant corn was used in 1999 and 2000 and corn injury varied in these years. Injury differences may be explained on the basis of rainfall after application. Rainfall accumulated 1.3 and 3.1 cm by 8 DAT in 1999 and 2001, respectively (data not presented). However, in 2000, when corn injury from mesotrione was low, only trace amounts of rainfall were received within 8 DAT after herbicide applications. Other researchers have reported increased crop injury with rainfall following herbicide applications (Griffin et al. 1994; Wright et al. 1995).

Common ragweed control with mesotrione was variable. In 1999, mesotrione alone controlled common ragweed 75 to 85% and control was not increased by increasing mesotrione rate or by the addition of glyphosate (Table 4.2). Similarly, in 2000, all treatments controlled common ragweed 75 to 86%, except 70 g/ha mesotrione, which controlled common ragweed only 41%. However, when 560 g/ha glyphosate was tank-mixed with 70 g/ha mesotrione, common ragweed control improved to 80%. In 2001, common ragweed was controlled 78 to 88% when mesotrione rates were averaged across glyphosate rates (data not presented). As in 2000, mesotrione at 105 and 210 g/ha controlled common ragweed better than mesotrione at 70 g/ha in 2001. The comparison treatment of glyphosate at 1120 g/ha controlled common ragweed 76 to 89% in all years (data not presented).

Common lambsquarters was controlled 93 to 99% with all mesotrione treatments (Table 4.2). Additions of glyphosate did not improve common lambsquarters control over that by mesotrione alone. Similar control of common lambsquarters has been reported by other researchers with POST mesotrione alone (Lackey et al. 1999; Beckett and Taylor 2000; Menbere and Ritter 2001). The comparison treatment of glyphosate at 1120 g/ha controlled common lambsquarters 87% and 54% in 2000 and 2001, respectively (data not presented). Differences in common lambsquarters control with glyphosate alone are likely due to a dense weed canopy and poor coverage of common lambsquarters below that canopy in 2001.

Smooth pigweed was controlled with all mesotrione treatments in 1999 and 2001. Mesotrione alone and with glyphosate controlled smooth pigweed 98 to 99% (Table 4.2). Increasing rates of mesotrione or tank-mixtures with glyphosate did not improve smooth pigweed control. Effective control of other *Amaranthus* species with mesotrione POST has been reported previously (Lackey et al. 1999; Becket and Taylor 2000; Ohmes et al. 2000). The comparision treatment of glyphosate at 1120 g/ha controlled smooth pigweed 82 and 94% in 1999 and 2001, respectively (data not presented).

Control of morningglory species was variable with mesotrione in 1999 and 2001 (Table 4.3). In 1999, when pitted morningglory was the predominant species, mesotrione alone controlled morningglory species 51%, while mesotrione tank-mixtures with glyphosate increased control of morningglory species to 65% (data not presented). However, in 2001, when a mixture of tall morningglory, ivyleaf morningglory, and pitted morningglory was present, all mesotrione treatments controlled morningglory species 76 to 86% (Table 3). The comparison treatment of glyphosate at 1120 g/ha controlled morningglory species 54 and 58% in 1999 and 2001, respectively (data not presented). Johnson et al. (2000) also reported that glyphosate alone did not control morningglory species and that a tank-mixture of glyphosate plus atrazine was necessary for adequate control.

Giant foxtail control was poor with POST mesotrione applications. Mesotrione alone controlled giant foxtail 7 to 24% in 1999 and 2000 (Table 4.3). Ohmes et al. (2000) also reported poor control of giant foxtail with mesotrione. Additions of glyphosate improved giant foxtail control to 65 to 75%. The comparison treatment of glyphosate at 1120 g/ha controlled giant foxtail 94% and 69% in 1999 and 2000, respectively (data not presented).

Corn was not harvested in 1999 because of high corn disease levels which caused lodging of the crop. In 2000, corn yields were 9.74 Mg/ha with glyphosate averaged over mesotrione rates, however corn produced only 0.71 Mg/ha when treated with mesotrione alone (data not presented). Highest yields in 2000 were generally obtained from corn where giant foxtail control was highest. In 2001, there was no difference in yields between corn treated with mesotrione or mesotrione plus glyphosate. These treatments produced corn yields of 7.37 to 9.16 Mg/ha (Table 4.3). The comparison treatment of glyphosate at 1120 g/ha alone produced corn yields of 9.01 and 9.07 Mg/ha in 2000 and 2001, respectively (data not presented).

**Greenhouse study.** In the greenhouse, all POST applications of mesotrione injured corn 1 to 9% (Table 4.4). Corn injury was highest with mesotrione plus glyphosate combinations. Symptoms from mesotrione treatments generally included bleached areas and chlorosis near the whorl. These symptoms developed during the week after herbicide application but usually disappeared within a few days. Mesotrione alone injured corn only 2 to 3%, while mesotrione plus glyphosate injured corn 8 to 9%. All mesotrione treatments reduced corn heights 4 to 8% with no significant differences between treatments. Corn shoot biomass was reduced 9 to 23% by mesotrione treatments, while glyphosate alone reduced shoot biomass by 4%.

These studies suggest that combinations of mesotrione plus glyphosate may provide effective weed control in glyphosate-resistant corn. Mesotrione and mesotrione plus glyphosate combinations applied POST controlled smooth pigweed and common lambsquarters at least 93%. Common ragweed control was most consistent when mesotrione was applied at 105 or 140 g/ha. Mesotrione activity on morningglory species was variable in 1999 and 2001 and improved only with tank-mixtures of glyphosate in 1999. Giant foxtail control was best with treatments containing glyphosate. The comparison treatment of glyphosate at 1120 g/ha was not always effective for control of common lambsquarters, smooth pigweed, common ragweed, or giant foxtail. Mesotrione injury in glyphosate-resistant corn usually increased with higher mesotrione rates, rainfall after herbicide application, or tank-mixtures with glyphosate. However, injury was usually transient and did not reduce corn yields.

Others have reported that low rates of atrazine tank-mixed with mesotrione improved control of 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). Therefore, it is likely that combinations of mesotrione, atrazine, and glyphosate may increase control of morningglory species, common ragweed, and giant foxtail as compared to two-way combinations of mesotrione plus glyphosate.

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*Table 4.1.* Glyphosate-resistant corn injury from postemergence mesotrione and mesotrione plus glyphosate treatments in 1999, 2000, and 2001.

| Treatments[b] | Rate | Corn injury[a] | | |
|---|---|---|---|---|
| | | 1999 | 2000 | 2001 |
| | — g ai/ha — | | % | |
| Mesotrione[c] | 70 | 10 | 4 | 10 |
| | 105 | 15 | 7 | 19 |
| | 140 | 20 | 6 | 24 |
| | $LSD_{0.05}$ | 4 | 2 | 5 |
| Glyphosate[d] | 0 | 9 | 4 | 13 |
| | 560 | 20 | 7 | 23 |
| | $LSD_{0.05}$ | 3 | 2 | 4 |

[a] Corn injury was evaluated 1 week after postemergence herbicide applications in 1999, 2000, and 2001.
[b] All treatments contained 1% v/v crop oil concentrate and 2.5% v/v urea ammonium nitrate.
[c] Mesotrione rates pooled over glyphosate rates.
[d] Glyphosate rates pooled over mesotrione rates.

*Table 4.2*. Common ragweed, common lambsquarters, and smooth pigweed control from postemergence mesotrione and mesotrione plus glyphosate combinations in 1999, 2000, and 2001.[a]

| | | Weed control[b] | | | | |
|---|---|---|---|---|---|---|
| | | Common ragweed | | | Common lambsquarters | Smooth pigweed |
| Treatments[d] | Rate | 1999 | 2000 | 2001 | 2000 + 2001[c] | 1999 + 2001 [c] |
| | — g ai/ha — | % | | | | |
| Mesotrione | 70 | 82 | 41 | 75 | 98 | 98 |
| Mesotrione | 105 | 85 | 75 | 87 | 98 | 99 |
| Mesotrione | 140 | 76 | 86 | 87 | 97 | 99 |
| Mesotrione + glyphosate | 70 + 560 | 83 | 80 | 82 | 93 | 99 |
| Mesotrione + glyphosate | 105 + 560 | 75 | 83 | 89 | 97 | 99 |
| Mesotrione + glyphosate | 140 + 560 | 80 | 83 | 88 | 99 | 98 |
| Untreated check | | 0 | 0 | 0 | 0 | 0 |
| $LSD_{0.05}$ | | NS | 23 | 12 | 4 | NS |
| Main effect of mesotrione | | NS | P = 0.0218 | P = 0.0457 | NS | NS |
| Main effect of glyphosate | | NS | P = 0.0324 | NS | NS | NS |
| Mesotrione by glyphosate interaction | | NS | P = 0.0477 | NS | NS | NS |

[a] Abbreviation: NS, not significant.

[b] Weed control rating were made 9 weeks after herbicide applications.

[c] No year by treatment interaction occurred for common lambsquarters or smooth pigweed control, therefore these data are pooled over years.

[d] All 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 4.3.* Morningglory species and giant foxtail control and corn yields from postemergence mesotrione and mesotrione plus glyphosate combinations in 1999, 2000, and 2001.[a]

| | | Weed control[b] | | | | |
|---|---|---|---|---|---|---|
| | | Morningglory species | | Giant foxtail | Corn yield | |
| Treatments[d] | Rate | 1999 | 2001 | 1999 + 2000[c] | 2000 | 2001 |
| | — g ai/ha — | — % — | | | — Mg/ha — | |
| Mesotrione | 70 | 37 | 81 | 7 | 0.19 | 7.37 |
| Mesotrione | 105 | 63 | 85 | 16 | 0.74 | 8.56 |
| Mesotrione | 140 | 53 | 80 | 24 | 1.20 | 8.46 |
| Mesotrione + glyphosate | 70 + 560 | 68 | 76 | 75 | 9.15 | 9.16 |
| Mesotrione + glyphosate | 105 + 560 | 65 | 83 | 73 | 10.33 | 9.06 |
| Mesotrione + glyphosate | 140 + 560 | 62 | 86 | 65 | 9.75 | 8.91 |
| Untreated check[e] | | 0 | 0 | 0 | 0.63 | 4.22 |
| $LSD_{0.05}$ | | 21 | 9 | 15 | 2.71 | NS |
| Main effect of mesotrione | | NS | NS | NS | NS | NS |
| Main effect of glyphosate | | P = 0.0279 | NS | P = 0.0001 | P = 0.0001 | NS |
| Mesotrione by glyphosate interaction | | NS | NS | P = 0.0418 | NS | NS |

[a] Abbreviation: NS, not significant.
[b] Weed control ratings were made 9 weeks after herbicide applications.
[c] No year by treatment interaction occurred with giant foxtail control, therefore these data are pooled 1999 and 2000.
[d] All 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 4.4.* Injury, height, and shoot biomass reductions of glyphosate-resistant corn treated postemergence with mesotrione or mesotrione plus glyphosate in the greenhouse.[ab]

| Herbicide treatment[c] | Rate | Injury 6 DAT | Height 11 DAT | Shoot biomass 11 DAT |
|---|---|---|---|---|
| | — g ai/ha — | —— % —— | —— % reduction | —— |
| Mesotrione | 105 | 2 | 4 | 9 |
| Mesotrione | 210 | 3 | 8 | 15 |
| Mesotrione + glyphosate | 105 + 560 | 8 | 2 | 15 |
| Mesotrione + glyphosate | 105 + 1120 | 9 | 4 | 23 |
| Glyphosate | 1120 | 1 | 0 | 4 |
| Untreated check[c] | | 0 | -- | -- |
| $LSD_{0.05}$ | | 3 | NS | 18 |

[a] Abbreviations: DAT, days after treatment; NS, not significant.

[b] No block by treatment interaction occurred, therefore both 4 replication studies are presented together.

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

[d] Untreated check not included in statistical analysis.