Chapter VI

Mesotrione combinations for postemergence control of horsenettle (*Solanum carolinense*) in corn (*Zea mays*)

Abstract: Field and greenhouse studies were conducted near Painter, VA in 1999, 2000, and 2001 to evaluate mesotrione postemergence for control of horsenettle in corn. Mesotrione at 105 g ai/ha controlled horsenettle at least 80% in all studies and in 2001, after two consecutive annual applications, mesotrione controlled horsenettle up to 91%. Additions of primisulfuron, dicamba, and 2,4-D to mesotrione did not increase horsenettle control. Occasionally, combinations of dicamba with mesotrione controlled horsenettle less than mesotrione alone and primisulfuron combinations with mesotrione delayed or reduced development of bleaching symptoms associated with mesotrione. Initial horsenettle response to mesotrione was increased by the addition of 280 g ai/ha atrazine, however late-season horsenettle control was not improved by atrazine. Two consecutive annual applications of mesotrione alone decreased horsenettle biomass >89%. Treatments of primisulfuron plus dicamba, primisulfuron plus CGA 152005 plus dicamba, and 2,4-D plus dicamba provided similar horsenettle control and biomass reductions as 105 g/ha mesotrione.

Nomenclature: Atrazine; CGA 152005 [1-(4-methoxy-6-methyl-triazin-2-yl)-3-[2-(3,3,3-trifluoropropyl)-phenylsulfonyl]-urea]; dicamba; halosulfuron; mesotrione; primisulfuron; 2,4-D; horsenettle, *Solanum carolinense* L. #[1] SOLCA; corn, *Zea mays* L.

Additional index words: Bleaching herbicides; perennial weeds; triketone herbicides.

Abbreviations: COC, crop oil concentrate; POST, postemergence; PRE, preemergence; UAN, urea ammonium nitrate; WAT, weeks after treatment; YAT, years after treatment.

[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

Horsenettle is a solaneceous perennial weed that is difficult to control in minimum tillage systems because its root system penetrates deep into the soil profile (Ilnicki et al. 1962). Further, horsenettle can regenerate from roots as small as 1 cm long and consistently emerge from depths of 16 cm (Wehtje et al. 1987). Horsenettle plants can also emerge from seed at depths over 10 cm. Each plant can produce 100 berries that can each contain about 86 seeds (Ilnicki et al. 1962). Mowing has little effect on root proliferation, but may reduce seed production (Nichols et al. 1991).

Horsenettle is difficult to control in many agronomic and vegetable crops since few herbicides control this weed and have crop selectivity (Banks and Santelmann 1978; Hackett et al. 1987; Frank 1990). Horsenettle impaired peanut harvest and decreased yield over 40%. Furthermore, contamination of harvested peanuts with horsenettle fruit can be an additional problem associated with horsenettle presence in peanuts (Hackett et al. 1987). Snapbean yields have been reduced as much as 55% depending on the age and number of horsenettle plants growing in close proximity to snapbean plants (Frank 1990). In pastures, horsenettle may proliferate due to lack of tillage. It is important to control horsenettle in pastures because foliage and berries are poisonous to livestock (Bassett and Munro 1986). The herbicides dicamba, picloram, and triclopyr controlled horsenettle in pastures after three annual applications (Gorrell 1981). These herbicides were effective because of high absorption and translocation to horsenettle root systems coupled with reduced metabolism of the parent compounds (Gorrell 1988).

Soil applied herbicides have little affect on horsenettle growth from roots. However, a few preemergence (PRE) herbicides registered for weed control in corn and soybean [*Glycine max* (L.) Merr.] may aid in control of seedling horsenettle (VanGessel 1999). The herbicide applied most often to field corn (63% of acreage) is atrazine, a triazine herbicide applied for control of annual broadleaf weeds and some grasses (Anonymous 2001b). Usually atrazine is applied in combination with a chloroacetamide herbicide for broad-spectrum PRE weed control (Ahrens 1994; Hagood et al. 2001). Often, PRE atrazine programs control most annual weed species, thereby reducing competition and allowing the proliferation of perennial weeds such as horsenettle.

Postemergence (POST) herbicides such as picloram, triclopyr, dicamba, and glyphosate have controlled horsenettle. Of these, only dicamba and glyphosate (glyphosate-resistant corn only) are registered for applications in corn (Hagood et al. 2001). However, herbicide rates, application timing, and the possible need for multiple applications may limit utility of these herbicides in corn (Gorrell 1981; Wehtje 1987; Fritz et al. 1992). The sulfonylurea herbicides primisulfuron and nicosulfuron also have activity on horsenettle (Fritz et al.1992; Marcelli and Glenn 1993; Prostko et al. 1994). Adding dicamba to nicosulfuron has increased horsenettle control over nicosulfuron alone. However, primisulfuron has better activity on horsenettle than nicosulfuron (Marcelli and Glenn 1993; Prostko et al. 1994). Treatments including sulfonylureas and/or dicamba reduced horsenettle biomass, but did not affect population densities the following year. However, horsenettle appears to have little affect on corn yields (Prostko et al. 1994). Since corn yields were not affected, corn could be a valuable rotational crop if herbicides were available to limit horsenettle seed production and root proliferation.

Mesotrione is a triketone herbicide recently registered for PRE and POST control of several broadleaf weeds in corn (Anonymous 2001a). Mesotrione and other triketones function 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 control many annual broadleaf weeds, large crabgrass [*Digitaria sanguinalis* (L.) Scop.], and barnyardgrass [*Echinochloa crus-galli* (L.)Beauv.] (Sutton et al. 1999; Beckett and Taylor 2000; Armel et al. 2001). POST applications should include an adjuvant system of 1% v/v crop oil concentrate (COC) and 2.5 v/v urea ammonium nitrate (UAN) (Wichert and Pastushok 2000). The addition of low rates of atrazine in POST applications enhances mesotrione efficacy on larger or more difficult to control weeds (Johnson and Young 1999; Armel et al. 2000; Beckett and Taylor 2000; Johnson and Young 2000a; Mueller 2000; Armel et al. 2001). POST mesotrione combinations with other corn herbicides may increase control of some perennial weed species (Armel et al. 2000; Armel et al. 2000a; Bradley et al. 2000). Jacobi and Brownell (personal communication, 1999) found mesotrione has activity on horsenettle.

Most herbicides currently registered in corn have insufficient activity against horsenettle. Therefore, the objective of this research was to determine if mesotrione POST, alone or in combination with other corn herbicides, would control horsenettle and to compare mesotrione with other POST corn herbicides for horsenettle control.

MATERIALS AND METHODS

Field studies. Two studies were conducted in grower fields between 1999 and 2001 near Painter, VA. The soil type was a Bojac sandy loam (Typic Hapludults) with less than 1% organic matter and a pH range of 6.0 to 6.1. Studies were initiated in a field (Kranz Farm) planted to soybean in 1998 and left untilled in the spring of 1999. Plots were established following emergence of horsenettle at an average population of 24 to 32 plants / m^2. Herbicide treatments were applied POST on May 18, 1999 to horsenettle with an average height of 16 cm, although height among individual plants varied between 5 and 28 cm. Herbicide treatments were mesotrione at 105 g/ha alone and combined with either 20 g ai/ha primisulfuron, 140 g ai/ha 2,4-D, or 140 g ai/ha dicamba. Three-way combinations of mesotrione plus primisulfuron plus either 2,4-D or dicamba were also evaluated. Additional treatments included primisulfuron alone and combined with 2,4-D or dicamba and 2,4-D and dicamba alone and an untreated check for comparison. All treatments contained the adjuvant system of 1% v/v COC[2] plus 2.5% v/v UAN. Horsenettle control was visually assessed 5 WAT at which time horsenettle shoot biomass was harvested from two 0.25 m^2 areas randomly selected within the plot.

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

The above treatments were applied in a second site (Mapp Farm) in 2000 that was located within 2 km of the Kranz Farm. Corn (Pioneer 33G26[3]) was no-till planted on May 15, 2000 at a rate of 56,800 seeds/ha in rows spaced 76 cm apart. Shoots of emerged horsenettle plants were killed on May 16, 2000 by a commercial application of 0.5 kg ai/ha paraquat plus 1.2 kg/ha atrazine plus 0.9 kg ai/ha metolachlor, which was suspended in 420 L/ha 30% liquid nitrogen fertilizer. POST herbicide treatments in 2000 were applied on June 8 to horsenettle with an average height of 13 cm although heights varied between 3 and 23 cm tall; the population was 25 to 35 plants / m^2 and emerged following burndown by the PRE herbicides. Horsenettle control ratings and shoot biomass harvests were performed in the same manner as done previously at the Kranz Farm.

At the Mapp Farm in 2000, a second study was initiated to compare three rates of mesotrione with additional treatments reported to have activity on horsenettle (Glenn 1999, Hagood 1999, VanGessel 1999, personal communications). Treatments in this study included mesotrione at 105, 140, and 210 g/ha and 105 g/ha mesotrione plus 280 g/ha atrazine, and 105 g/ha mesotrione plus 20 g/ha primisulfuron plus 140 g/ha 2,4-D. Comparison treatments were 26 g/ha primisulfuron plus 153 g/ha dicamba[4], 20 g/ha primisulfuron plus 20 g ai/ha CGA 152005[5] plus 140 g/ha dicamba, 36 g ai/ha halosulfuron plus 140 g/ha dicamba, 140 g/ha 2,4-D plus 280 g/ha dicamba, and an untreated check. All mesotrione treatments contained 1% v/v COC and 2.5% v/v UAN, while all other treatments except 2,4-D plus dicamba (no adjuvant) contained 0.25% v/v

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

[4] Northstar™ herbicide. Syngenta Crop Protection. 410 Swing Road, Greensboro, NC 27419-8300.

[5] Exceed® herbicide. Syngenta Crop Protection. 410 Swing Road, Greensboro, NC 27419-8300.

non-ionic surfactant (NIS)[6]. This study was repeated nearby (Lassiter Farm) in 2000 where procedures including application and data collection were the same. Horsenettle shoot populations at both sites were approximately 15 to 25 plants / m^2. The size of horsenettle plants at POST applications were as in the first study conducted at Mapp Farm in 2000. Application methods and date were the same as those in the first study. Horsenettle control was evaluated visually 8 WAT. Corn injury was evaluated 1 WAT in 2000. Corn was harvested by hand from the center two rows of each plot and yields were converted to 15.5% moisture.

Studies at Mapp and Lassiter were maintained and continued into 2001. Corn was planted into previous plots on May 12 and was sprayed with paraquat, atrazine, and *s*-metolachlor as in 2000. Herbicide treatments were applied to the same plots on June 13, 2001 to 2 to 38 cm tall horsenettle that emerged following the non-selective PRE treatment. Prior to POST herbicide treatments in 2001, emerged horsenettle shoots were counted to determine the effectiveness of treatments applied in 2000. Horsenettle shoots were counted from two 0.25 m^2 areas within each plot. Horsenettle control was visually rated 5 WAT in all studies in 2001. Horsenettle plants were again counted 8 WAT and shoot biomass was harvested from the same two 0.25 m^2 areas in each plot. Percent population reduction was calculated as the difference in initial horsenettle shoot counts as compared to counts taken 8 WAT in 2001. Corn injury was rated 1 WAT. As a result of an uneven stand however, corn was not harvested in 2001.

In all field studies, herbicides were applied POST with a propane-powered backpack sprayer calibrated to deliver 200 L/ha at a pressure of 215 kPa from flat fan nozzles[7]. Corn injury and weed control in all studies was evaluate on a scale from 0 to 100 percent

[6] Induce non-ionic low foam wetter/spreader adjuvant with 90% principal functioning agents as a blend of akyl aryl polyoxylkane ether free fatty acids. Helena Chemical Company, 51000 Poplar Avenue, Memphis, TN 38137.

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

where 0 = no injury or weed control and 100 = crop death or complete weed control. Horsenettle shoot biomass harvested from all plots was dried to constant moisture content prior to weighing. Percent shoot biomass reductions were calculated by comparing shoot biomass from treated plots with the untreated check.

Greenhouse study. A greenhouse experiment was conducted to further elucidate mesotrione alone at 105 and 210 g/ha and combinations of 105 g/ha mesotrione with dicamba at 70 g/ha, 2,4-D at 140 g/ha, and primisulfuron at 20 g/ha. Dicamba rates were reduced in comparison to rates applied in field studies since some growth regulator compounds usually exhibit more pronounced symptomology under greenhouse conditions (Glenn 1999, personal communication). All herbicides were also applied alone and each treatment contained 1% v/v COC and 2.5% v/v UAN.

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. Horsenettle plants were started from roots 2 to 5 cm in length planted in 9.5 cm by 9.5 cm pots[9] filled with a high organic matter commercial potting mix[10]. Plants were watered and fertilized[11] as needed to facilitate maximum plant growth and vigor. Horsenettle plants were 2.5 to 10 cm in height at herbicide application.

Horsenettle control was rated 6 WAT and plant heights were measured and shoot biomass was harvested and dried to constant moisture and weighed. Dry weights were represented as percent reduction in comparison to the untreated check. Harvested plants

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

[9] 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.

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

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

were allowed to re-grow and plant heights were measured again 3 wk after the original harvest.

Experimental design and data analysis. All studies were organized in a randomized complete block design with three replications in the field and six replications in the greenhouse. All studies were repeated. Field plots were 3 m by 6.1 m with a treated area of 2.1 m by 6.1 m; an untreated area 0.9 m wide was maintained between plots. All 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 interactions between years or locations, data were pooled. The untreated check was only included in the data analysis when comparing horsenettle heights in the greenhouse study.

RESULTS AND DISCUSSION

Field studies. In the first study conducted at the Kranz and Mapp Farms there were significant year by treatment interactions for all data except shoot biomass in 1999 and 2000. Therefore, only horsenettle shoot biomass data in 1999 and 2000 were pooled over years.

Horsenettle usually responded rapidly to mesotrione. In general, mesotrione symptoms appeared within 1 WAT as bleaching in the meristematic tissue. Necrosis of plant tissue and shoot death progressed over the next 2 wk. Bleached meristematic tissue became necrotic first and necrosis then developed in older plant tissue which failed to express bleaching symptoms. However, herbicide symptoms varied among treatments. Primisulfuron generally produced chlorosis and stunting of horsenettle plants within 1 WAT. The addition of primisulfuron to mesotrione delayed or prevented bleaching symptoms and in general, early symptoms were similar to primisulfuron applied alone. Dicamba and 2,4-D, even at low rates, caused pronounced epinasty, which is a typical response associated with growth regulator compounds (Ahrens 1994).

Mesotrione at 105 g/ha controlled horsenettle 81 and 83% in 1999 and 2000, respectively and 88% in 2001 following two consecutive annual applications (Table 6.1). Mesotrione plus primisulfuron, 2,4-D, or dicamba did not control horsenettle better than mesotrione alone. Horsenettle control from mesotrione plus primisulfuron plus dicamba was similar to that from mesotrione in 2000 and 2001, but was only 51% in 1999. Also, control with mesotrione plus dicamba was similar to control with mesotrione in 1999 and 2001, but in 2000 this treatment controlled horsenettle only 73%. The reason for lower control from the dicamba combinations in 1999 and 2000 can not be fully explained. Horsenettle control from dicamba, 2,4-D, and primisulfuron treatments was often lower than control from mesotrione although control from primisulfuron plus dicamba was similar to that from mesotrione in 1999 and 2001.

Prior to herbicide applications on June 13, 2001, initial horsenettle shoots were counted (approximately one year after initial POST herbicides were applied in 2000). At this time, there were 15 to 38 shoots / m^2 and no treatments from 2000 had significantly affected shoot number (data not presented). In previous studies, there were no reductions in horsenettle populations the year following applications of nicosulfuron, primisulfuron, and dicamba alone or in combinations (Prostko et al 1994).

Treatment effects on horsenettle shoot populations were variable at 8 WAT in 2001 (Table 6.2). However, with the exception of mesotrione plus primisulfuron, most mesotrione and primisulfuron combinations reduced horsenettle populations 58 to 84%. Herbicide effects on shoot dry weights are more similar to visual control ratings than shoot numbers because even when shoot numbers were high the growth of these late emerging shoots was usually low.

Averaged over 1999 and 2000, dry weight of horsenettle shoots were reduced 67 to 83% by mesotrione treatments and 61 to 79% by primisulfuron treatments (Table 6.2). Following two consecutive annual applications in 2000 and 2001, mesotrione treatments reduced horsenettle shoot biomass 85 to 90% and primisulfuron alone or with 2,4-D or dicamba reduced shoot biomass 79 to 88%. Dicamba and 2,4-D reduced shoot biomass

54 and 24% respectively averaged over 1999 and 2000. However, in 2001, following two consecutive annual applications shoot biomass was reduced only 23% by dicamba and increased 17% when treated with 2,4-D. Increased horsenettle populations and shoot biomass from low rates of 2,4-D may be partially explained by the Schultz-Arndt Law of 1888, which states that toxicants become stimulants when applied at low concentrations.

In the second study at Mapp and Lassiter Farms there was no location by treatment interaction, therefore all data were pooled over Mapp and Lassiter locations in 2000 and 2001. In 2000, horsenettle control was generally similar among treatments at 1 WAT at 31 to 42% (data not presented). Mesotrione at 105 g/ha alone controlled horsenettle 39% at 1 WAT. However, the addition of atrazine at 280 g/ha to mesotrione increased horsenettle control to 75% by 1 WAT and caused rapid shoot necrosis. In other studies, atrazine enhanced control of some annual weed species over that from mesotrione alone (Johnson and Young 1999; Beckett and Taylor 2000; Johnson and Young 2000a; Mueller 2000).

Horsenettle control 5 WAT was 80 to 88% from mesotrione in 2000 and 87 to 91% 8 WAT in 2001 following two annual applications and was not increased by the addition of atrazine or primisulfuron plus 2,4-D (Table 6.3). Horsenettle control with mesotrione treatments was generally similar to control by primisulfuron plus dicamba, primisulfuron plus CGA 152005 plus dicamba, or 2,4-D plus dicamba. In 2000 and 2001, horsenettle control was 66 and 71%, respectively, with halosulfuron plus dicamba.

Initial horsenettle shoot populations in 2001 were reduced by all herbicide treatments applied in 2000 (Table 6.3). These results differ with findings from Prostko et al. (1994) who concluded primisulfuron at 40 g/ha and dicamba at 280 g/ha alone and in combination did not reduce horsenettle populations the following year. These findings also conflict with those from our first study at Kranz and Mapp Farms. Possible differences could be attributed to differences in horsenettle shoot populations prior to application.

Horsenettle shoot numbers were reduced 23 to 77% after two consecutive annual applications of all treatments in 2001 (Table 6.3). Mesotrione at 140 and 210 g/ha reduced shoot numbers more than mesotrione at 105 g/ha. Two other treatments, mesotrione plus primisulfuron plus 2,4-D and primisulfuron plus CGA 152005 plus dicamba reduced horsenettle shoot numbers 77 and 68%, respectively. All other treatments reduced horsenettle shoot numbers 23 to 54%.

As in the previous study, two consecutive annual applications of all treatments reduced horsenettle shoot biomass at 8 WAT (Table 6.3). Mesotrione and primisulfuron treatments and 2,4-D plus dicamba reduced shoot biomass 95 to 98%; only halosulfuron plus dicamba was less effective, with biomass reductions of 86%. As before, the control of biomass data reflects a higher degree of control than percent reduction of horsenettle shoot numbers. These data reflect populations of emerged shoots which did not produce much subsequent top growth and usually emerged bleached or chlorotic.

Corn injury was low in both studies and mesotrione generally did not affect corn in 2000 or 2001 (data not presented). Injury from any treatment was usually not visible by 3 WAT. Corn yields in 2000 ranged from 6075 to 7858 kg/ha. No herbicide treatment significantly enhanced corn yields in comparison to the untreated check. Other studies concluded horsenettle did not significantly decrease corn yields (Prostko et al. 1994).

Greenhouse study. No study by treatment interaction occurred for data in this study; therefore all data were pooled. In the greenhouse, mesotrione at 105 and 210 g/ha controlled horsenettle 90 and 97%, respectively (Table 6.4). Additions of 2,4-D, dicamba, or primisulfuron did not improve horsenettle control over mesotrione at 105 g/ha. Mesotrione treatments controlled horsenettle similar to primisulfuron at 20 g/ha (83%). Dicamba at 70 g/ha or 2,4-D at 140 g/ha controlled horsenettle less than 40%.

Horsenettle height at 6 WAT was reduced by all mesotrione and primisulfuron treatments, but herbicide combinations were not more effective than mesotrione or primisulfuron alone. Neither 2,4-D alone nor dicamba reduced horsenettle height.

All treatments reduced horsenettle shoot biomass in comparison to the untreated check; however 2,4-D and dicamba were not as effective as mesotrione or primisulfuron treatments. The addition of other herbicides to mesotrione did not affect horsenettle shoot biomass compared to mesotrione alone. All mesotrione treatments and primisulfuron reduced horsenettle shoot biomass 76 to 95% (Table 6.4).

All treatments except 2,4-D and dicamba reduced the height of horsenettle regrowth (Table 6.4). Mesotrione combinations or primisulfuron did not reduce height of horsenettle regrowth more than mesotrione alone. There was no regrowth from horsenettle treated with mesotrione at 210 g/ha.

Previous research has not reported the effects of HPPD inhibiting herbicides and more specifically triketone herbicides for horsenettle control. Collectively, these experiments demonstrate that mesotrione controls horsenettle. Two consecutive annual applications of 105 g/ha mesotrione reduced horsenettle biomass 90% or greater. Prostko et al. (1994) reported that combinations of primisulfuron at 40 g/ha plus dicamba at 280 g/ha reduced horsenettle biomass 74% after one application. Similarly, in our studies primisulfuron at 20 g/ha and dicamba at 140 g/ha reduced horsenettle biomass 78%. However, primisulfuron, 2,4-D, or dicamba did not enhance mesotrione activity on horsenettle. Dicamba combinations with mesotrione occasionally reduced mesotrione activity against horsenettle. Previous research states that dicamba antagonizes imazethapyr and sethoxydim through reductions in foliar absorption (Hart and Wax 1996; Young et al. 1996). Since mesotrione (benzoylcyclohexandione) is structurally similar to cyclohexanedione graminicides such as sethoxydim (Mitchell et al 2001), it is possible that similar reductions in foliar uptake could explain reduced mesotrione activity against horsenettle when dicamba is added.

Horsenettle response to mesotrione was enhanced at 1 WAT by 280 g/ha atrazine, but this improved efficacy with atrazine was not evident at 5 to 8 WAT. Further, no treatment was better than mesotrione at 105 g/ha alone at reducing horsenettle biomass after two consecutive annual applications. In addition, the standard treatments of primisulfuron plus dicamba, primisulfuron plus CGA 152005 plus dicamba, and 2,4-D plus dicamba provided similar horsenettle control and biomass reductions as 105 g/ha mesotrione. According to these studies, mesotrione could be an important herbicide for horsenettle control in corn.

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Table 6.1. Horsenettle control from mesotrione alone and combinations of mesotrione with primisulfuron, dicamba, and 2,4-D 5 weeks after treatment at the Kranz Farm in 1999 and Mapp Farm in 2000 and 2001.

Herbicide treatments[c]	Rate	Horsenettle control[a]		
		1999	2000	2001
	— g ai/ha —		%	
Mesotrione	105	81	83	88
Mesotrione + dicamba	105 + 140	74	73	82
Mesotrione + 2,4-D	105 + 140	75	78	85
Mesotrione + primisulfuron	105 + 20	78	76	82
Mesotrione + primisulfuron + 2,4-D	105 + 20 + 140	92	89	87
Mesotrione + primisulfuron + dicamba	105 + 20 + 140	51	84	80
Dicamba	140	23	46	57
2,4-D	140	19	43	31
Primisulfuron	20	67	64	76
Primisulfuron + 2,4-D	20 + 140	71	60	70
Primisulfuron + dicamba	20 + 140	76	75	83
untreated check[d]		0	0	0
$LSD_{0.05}$		19	8	10

[a] Control in 2001 follows two years of consecutive annual applications in the same plot.
[b] All treatments contained 1% v/v crop oil concentrate and 2.5% v/v urea ammonium nitrate.
[c] Untreated check not included in statistical analysis.

Table 6.2. Horsenettle population counts, percent population reductions, and percent biomass reductions from mesotrione and mesotrione combinations with primisulfuron, dicamba, and 2,4-D at the Kranz Farm in 1999 and the Mapp Farm in 2000 and 2001.[a]

		Shoot population	Shoot biomass	
		8 WAT	5 WAT	8 WAT
Herbicide treatments[b]	Rate	2001	1999 + 2000	2001
	— g ai/ha —		— % reduction —	
Mesotrione	105	37	75	90
Mesotrione + dicamba	105 + 140	58	71	85
Mesotrione + 2,4-D	105 + 140	58	67	89
Mesotrione + primisulfuron	105 + 20	34	71	88
Mesotrione + primisulfuron + 2,4-D	105 + 20 + 140	80	83	93
Mesotrione + primisulfuron + dicamba	105 + 20 + 140	66	78	85
Dicamba	140	31	52	23
2,4-D	140	-12	24	-17
Primisulfuron	20	43	61	85
Primisulfuron + 2,4-D	20 + 140	73	79	88
Primisulfuron + dicamba	20 + 140	84	78	79
Untreated check[c]		--	0	0
$LSD_{0.05}$		36	34	54

[a] Abbreviations: WAT, weeks after treatment.
[b] All herbicide treatments contained 1% v/v crop oil concentrate and 2.5% v/v urea ammonium nitrate.
[c] Untreated check not included in the statistical analysis.

Table 6.3. Horsenettle control, and horsenettle population and biomass reductions data from mesotrione and standard herbicide treatments pooled over the Mapp and Lassiter Farms in 2000 and 2001.[a]

		Horsenettle control[b]		Horsenettle population	Horsenettle shoot biomass	
Herbicide treatments	Rate	2000	2001	Initial	8 WAT	2001
	— g ai/ha —	— % —		— no. / m^2 —	— % reduction —	
Mesotrione[c]	105	80	87	12	23	96
Mesotrione[c]	140	85	91	13	63	97
Mesotrione[c]	210	88	91	10	70	95
Mesotrione + atrazine[c]	105 +280	83	93	12	44	97
Mesotrione + primisulfuron + 2,4-D[c]	105 + 18 + 140	83	92	14	77	98
Primisulfuron + dicamba[d]	26 + 153	80	88	10	54	97
Primisulfuron + CGA 152005 + dicamba[d]	20 + 20 + 140	80	89	18	68	97
Halosulfuron + dicamba[d]	36 + 140	66	71	18	42	86
2,4-D + dicamba	140 + 280	78	86	13	35	97
Untreated check[e]		0	0	29	--	0
$LSD_{0.05}$		7	7	7	36	7

[a] Abbreviations: WAT, weeks after treatment.
[b] Horsenettle control was visually evaluated 8 WAT in 2000 and 5 WAT in 2001. The ratings in 2001 represent control after two annual applications in the same plot.
[c] Treatments contained 1% v/v crop oil concentrate and 2.5% v/v urea ammonium nitrate.
[d] Treatments contained 0.25% v/v non-ionic surfactant.
[e] Untreated check included in statistical analysis for initial horsenettle population counts only.

Table 6.4. Mesotrione combinations with primisulfuron, dicamba, and 2,4-D for horsenettle control in the greenhouse.[ab]

Herbicide treatment[d]	Rate	Control	Height[c]		Shoot biomass
		6 WAT	6 WAT	9 WAT	6 WAT
	— g ai/ha —	— % —	— cm —		— % reduction —
Mesotrione	105	90	3.6	0.9	90
Mesotrione	210	97	2.7	0	95
Mesotrione + dicamba	105 + 140	76	4.7	1.3	79
Mesotrione + 2,4-D	105 + 140	81	5.4	1.1	76
Mesotrione + primisulfuron	105 + 20	87	3.0	2.0	82
Dicamba	70	39	10.1	8.4	31
2,4-D	140	38	10.7	7.8	31
Primisulfuron	20	83	2.8	2.1	81
Untreated check[e]		0	11.5	9.2	0
$LSD_{0.05}$		16	2.4	2.4	17

[a] No block by treatment interaction occurred, therefore both 6 replication studies are presented together.

[b] Abbreviations: WAT, weeks after treatment.

[c] Heights of horsenettle plants were taken in cm from the lowest part along the soil surface to the highest part of the plant. After plants were measured and harvested for biomass 6 WAT, plant were allowed to regrow for 3 weeks and measured again.

[d] Included adjuvant system of 1% v/v crop oil concentrate and 2.5% v/v urea ammonium nitrate.

[e] Untreated check included in statistical analysis for horsenettle height only.