Rimsulfuron Controls Hairy Nightshade, but not Eastern Black Nightshade, in Tomato

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Abstract. Nightshade species are difficult to control in tomato production and their interference reduces both tomato yield and quality. Rimsulfuron can be used to control nightshades, but species and biotypes vary in their response to rimsulfuron. The objectives of this study were to evaluate control of hairy nightshade (*Solanum sarrachoides* Sendt.) and eastern black nightshade (*Solanum ptycanthum* Dun.) by rimsulfuron and compare North Dakota eastern black nightshade accession response to three acetolactate synthase (ALS)-inhibitor herbicides. In field studies conducted at Oakes, N. Dak., rimsulfuron at rates of 26 or 53 g·ha⁻¹ a.i. was applied within 1 week after transplanting tomato (EPOST) or 2 to 4 weeks after transplanting (POST). Rimsulfuron gave excellent control of hairy nightshade when applied POST, and poor to excellent control when applied EPOST, with control being much better when hairy nightshade had emerged before the EPOST application. Rimsulfuron at 53 g·ha⁻¹ provided greater control than at 26 g·ha⁻¹ only for the EPOST applications. Rimsulfuron controlled hairy nightshade which allowed eastern black nightshade (which was not controlled by rimsulfuron) to dominate tomato. Tomato yield was lower when dominated by hairy nightshade than by eastern black nightshade. This was due to the earlier emergence and faster growth of hairy nightshade compared to eastern black nightshade. Tomato yield was higher in the hand-weeded check than for all other treatments in 1999, the only year the hand-weeded check was included in the study. Greenhouse studies on plants grown from seed collected at the experimental site verified that eastern black nightshade was tolerant to rimsulfuron but was controlled by tribenuron and imazethapyr. Rimsulfuron can be used in tomato production to control hairy nightshade, but not the accession of eastern black nightshade found in this study. Chemical names used: N-((4,6-dimethoxypyrimidin-2-yl)aminocarbonyl)-3-(ethylsulfonyl)-2-pyridinesulfonamide (rimsulfuron); (α,α,α-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine)(trifluralin); methyl 2-[[[4-methoxy-6-methyl-1,3,5-triazin-2-yl)methylamino]carbonyl]amino]sulfonyl]benzoate (tribenuron methyl); (±)-2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-5-ethyl-3-pyridinecarboxylic acid (imazethapyr).

Nightshade species are difficult to control in tomato production and their interference reduces both tomato yield and quality. Weaver et al. (1987) reported that eastern black nightshade and hairy nightshade competition reduced transplanted tomato yields 30% to 60%. Perez and Masiunas (1990) showed that the longer and earlier eastern black nightshade were allowed to compete with tomato, the greater the reduction in yield and quality.

Rimsulfuron controlled hairy and eastern black nightshade, *Amaranthus* spp., common lambsquarters (*Chenopodium album* L.), shepherd's purse (*Capsella bursa-pastoris* L.), giant foxtail (*Setaria faberi* L.), and other weeds in potato and tomato (Ackley et al., 1996, 1997; Eberlein et al., 1994; Robinson et al., 1996).

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It did not injure tomato at recommended rates (Ackley et al., 1997; Bewick et al., 1995).

Nightshade species and accessions within species differ in response to rimsulfuron. Eberlein et al. (1994) reported that rimsulfuron controlled hairy nightshade but not cutleaf nightshade (*Solanum triflorum* Nutt.). Eastern black nightshade was found to be very susceptible (Robinson et al., 1997) or fairly tolerant (only 21% control, Mayo et al. 2002) to rimsulfuron applied postemergence, whereas hairy nightshade was moderately susceptible (50% to 99% injury) (Guttieri and Eberlein 1997), and black nightshade was tolerant (< 23% injury) (Ackley et al., 1998). Even within the same species, susceptibility to herbicides can differ. Bewick et al. (1995) found that a paraquat-resistant American black nightshade (*Solanum americanum* Mill.) biotype was 123 times more susceptible to rimsulfuron than a paraquat-sensitive American black nightshade biotype. Ogg (1986) and Bassett and Munro (1985) found accessions of eastern black, black, hairy, and American black nightshade from dif-

ferent locations differed in their susceptibility to herbicides.

Our objectives were to evaluate rimsulfuron for control of hairy and eastern black nightshade and injury to tomato, and to compare North Dakota eastern black nightshade accession response to three acetolactate synthase (ALS)-inhibitor herbicides.

Materials and Methods

Field research. Studies were conducted at the Oakes Irrigation Research Site near Oakes, N. Dak. (lat. 46°04'N, long. 98°06'W) from 1997 to 1999. A different field was used each year. The soil type was an Embden sandy loam (coarse-loamy, mixed, superactive, frigid Pachic Hapludoll) in 1997 and a Hecla sandy loam (sandy, mixed, frigid, Oxyaquic Hapludoll) in 1998 and 1999. Soil pH ranged from 6.9 to 7.7 and organic matter ranged from 2.6% to 3.0%. The experimental area was disked in 1997 and 1998 and worked with a coulter chisel in 1999. Each year it was then field cultivated three or four times to incorporate herbicides and smooth the seed bed.

'Sheriff' (1997) or 'Tuscany' (1998 and 1999) processing-type tomato were transplanted to the field on 13 June 1997, 26 May 1998, and 2 June 1999. Plots were 5 m long × 2.4 m wide. A single row of tomato with an in-row spacing of 45 cm was transplanted in each plot. Tomato was drip irrigated as needed to avoid moisture stress, sprayed with fungicides to control early and late blight, and fertilized following Minnesota Extension Service recommendations (Rosen and Eliason, 1996). No insect control was needed and no ripening aid was used. Tomatoes were hand harvested on 23 Sept. 1997, 1 Sept. 1998, and 13 Sept. 1999. Harvested tomato were graded using U.S. Department of Agriculture (USDA) guidelines (USDA, 1983), and then weighed. Only tomatoes meeting grade A standards were included in the reported tomato yields.

Trifluralin, pebulate (S-propyl butylethyl-carbamothioate), and trifluralin followed by metribuzin [4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one] treatments were included as standard controls for comparison to rimsulfuron treatments. Trifluralin at 560 g·ha⁻¹ or pebulate at 5000 g·ha⁻¹ was applied preplant incorporated 2, 0, and 1 d before transplanting tomato in 1997, 1998, and 1999, respectively. Metribuzin at 420 g·ha⁻¹ was applied early postemergence (EPOST). Rimsulfuron (26 or 53 g·ha⁻¹) was applied EPOST or postemergence (POST). An oil-surfactant adjuvant (Herbimax; Loveland Industries Inc., Greeley, Colo.) at 1.3 L·ha⁻¹ was used with all applications of rimsulfuron in 1997. No surfactant was used with the EPOST rimsulfuron applications in 1998 or 1999. A nonionic surfactant (NIS) (Activator 90; Loveland Industries Inc.) at 0.25% by volume was used with POST applications of rimsulfuron in 1998 and 1999. EPOST was at 6, 2, and 6 d after transplanting (DATP), and POST was at 26, 21, and 14 DATP in 1997, 1998, and 1999, respectively. The 1999 POST application was earlier due to faster weed growth. Herbicides

were applied in 430 L·ha⁻¹ water at 200 kPa pressure through 8004 flat fan nozzles (TeeJet nozzles; Spraying Systems Co., Wheaton, Ill.) at a walking speed of 5 km·h⁻¹ using a CO₂-pressurized backpack sprayer. At the EPOST application hairy nightshade had not emerged in 1998 and were just beginning to emerge and were <0.5 cm tall in 1997 and 1999. Eastern black nightshade had not emerged in any year at the EPOST application date. Hairy nightshade were 0.5 to 2, 1 to 4, and 1 to 15 cm tall and eastern black nightshade were <1, 1 to 3, and 2 to 10 cm tall at the POST application date in 1997, 1998, and 1999, respectively. A hand-weeded check was included in 1999. The experimental areas had a very high natural density of 60 to 400 hairy nightshade plants/m², while eastern black nightshade populations were 10 to 50 plants/m².

Visible weed and crop injury ratings were taken 60, 65, and 44 DATP in 1997, 1998, and 1999, respectively. The weed rating scale was from 0 to 10 where 0 = plot completely covered with weeds unrestricted in growth and 10 = no weeds in plot. It includes components of number of weeds and also vigor and size of those weeds. The higher the number of weeds, the bigger the weeds, and the more vigorous the weeds in the plot, the lower the rating received. This rating system was used because some of the plots treated with rimsulfuron had >10 times as many eastern black nightshade plants as the standard treatment plots not treated with rimsulfuron, making a percent control rating impractical. It should be noted that when using this rating system, a value greater than zero may indicate no weed control if the natural weed infestation would also merit a rating >0.

Statistical design was a randomized complete block with four replications. Means were separated using Fischer's protected LSD (0.05) (when there were no missing values in the data) or protected pairwise *t* tests (when the data had missing values) using the ANOVA or GLM (with the PDIFF option) procedures of SAS (SAS 1999). Each year was analyzed separately due to year by treatment interactions. Correlation coefficients between hairy nightshade

ratings and eastern black nightshade ratings were obtained using the CORR procedure of SAS. The hand weeded check ratings were not included in the correlation analysis. Data were not transformed because preliminary analysis showed it was not necessary.

Greenhouse confirmation. Eastern black nightshade response to ALS-inhibiting herbicides was evaluated in the greenhouse to confirm the response in field studies and eliminate the possibility that nightshade escaped treatment in the field. In fall 2002, eastern black nightshade berries were collected from a single plant in each of 14 different locations at the Oakes Irrigation Research Site, including the three locations where the field experiments were conducted in 1997 to 1999. Seeds from each plant were kept separate from seeds of other plants. Seed was extracted from berries using a slurry method, then dried and stored in a freezer at -7 °C for 1 week. Plants from these seeds were treated in a greenhouse at North Dakota State University, Fargo, to evaluate eastern black nightshade response to ALS-inhibiting herbicides. An eastern black nightshade accession, ND-1, retained at North Dakota State University was also included in the greenhouse evaluation. Accession ND-1 was susceptible to imazethapyr in previous studies but response to rimsulfuron had not been documented.

After soaking in water for 24 h, 15 seeds from each plant were seeded into peat-based growing medium (Sunshine Mix #1; Sun Gro Horticulture, Inc., Bellevue, Wash.) in 10 × 15 × 5-cm-deep pots (flat inserts; East Jordan Plastics, Inc., East Jordan, Minn.). Established seedlings were watered regularly and were fertilized once a week with nutrient solution (Miracle-Grow; Scotts Miracle-Gro Products, Inc., Port Washington, N.Y.) to enable vigorous growth. Eastern black nightshade seedlings were thinned to five seedlings per pot to ensure adequate spray coverage. Herbicides were applied to one- to three-leaf seedlings with a chain-driven moving-nozzle chamber sprayer delivering 93 L·ha⁻¹ at 210 kPa through a 650067 even flat-fan nozzle. Herbicide treatments included rimsulfuron at 26 g·ha⁻¹ with

0.25% by volume NIS, tribenuron at 13 g·ha⁻¹ with 0.25% by volume NIS, imazethapyr at 52 g·ha⁻¹ with 1.75 L·ha⁻¹ MSO (Scoil methylated seed oil; AGSCO Inc., Grand Forks, N. Dak.), and 4% by volume UAN (Nortrace urea and ammonium nitrate solution, 28% nitrogen by weight; Nortrace Ltd.), and an untreated control. Plant injury was visually evaluated as percent control (0 = no effect and 100 = total plant death) 7 d after treatment (DAT).

Data were subjected to ANOVA using SAS (SAS 1999). Experimental design was a randomized complete block with a split-block arrangement and three replications. Seedlings from seeds of each original plant (collection) were the main block effect and herbicide treatment was the subblock effect. Data were not transformed because preliminary analysis showed it was not necessary. Analysis was first conducted on the split-block arrangement. Then collections were combined and analysis was performed on combined data because collection by herbicide interactions were small compared to the effect of herbicide treatment. Sufficient germinable seed was not obtained to repeat the experiment. However, since response of eastern black nightshade to herbicides was consistent across collections, collections were considered repeated runs of the treatment list. Means were separated using Fisher's protected LSD (0.05).

Results and Discussion

Field research. Visible injury to tomato from rimsulfuron and other herbicides was <5% every year (data not shown) and did not affect tomato yield or quality. This is consistent with results reported by others (Ackley et al., 1997; Bewick et al., 1995).

Trifluralin does not control either hairy or eastern black nightshade (Zollinger, 2005) so this treatment can be equated to an untreated check as far as these two weeds are concerned. Trifluralin followed by metribuzin gave poor control of hairy nightshade (Table 1). Eastern black nightshade populations and vegetative growth with these treatments were low, resulting in high ratings, due to competition

Table 1. Hairy and eastern black nightshade control by rimsulfuron and other herbicides in transplanted tomato in North Dakota.

Treatment ^a	Rate (g·ha ⁻¹ a.i.)	Control (0 to 10%)					
		Hairy nightshade			Eastern black nightshade		
		1997	1998	1999	1997	1998	1999
Trifluralin PPI	560	2.5	0.8	1.0	9.0 ^b	9.8 ^b	9.6 ^b
Pebulate PPI	5000	6.3	5.0	6.0	6.5 ^b	6.8 ^b	6.5 ^b
Trifluralin PPI fb metribuzin EPOST	560 fb 420	5.3	1.3	0.8	7.3 ^b	9.0 ^b	8.8 ^b
Trifluralin PPI fb rimsulfuron EPOST	560 fb 26	8.0	3.5	6.0	4.0	6.8	5.0
Trifluralin PPI fb rimsulfuron EPOST	560 fb 53	9.5	5.3	8.4	4.0	6.8	5.8
Trifluralin PPI fb rimsulfuron POST	560 fb 26	9.8	9.4	10.0	4.0	5.8	4.8
Trifluralin PPI fb rimsulfuron POST	560 fb 53	9.8	9.9	10.0	5.8	6.3	6.0
Trifluralin + pebulate PPI fb rimsulfuron POST	560 + 5000 fb 26	10.0	10	10.0	4.5	7.0	6.3
Trifluralin PPI fb rimsulfuron EPOST fb rimsulfuron POST	560 fb 26 fb 26	10.0	9.9	10.0	4.3	5.0	5.8
Trifluralin fb hand weeding as needed (1999 only)	560	---	---	10.0	---	---	10.0
LSD (0.05)		1.8	1.7	1.3	2.1	1.9	1.6

^aPPI = preplant incorporated, 2 (1997), 0 (1998), or 1 (1999) d before transplanting tomato; EPOST = early postemergence, 2 (1998) or 6 (1997 and 1999) d after transplanting tomato; and POST = postemergence, 26, 21, and 14 d after transplanting in 1997, 1998, and 1999, respectively; fb = followed by.

^bRating scale: 0 = plot completely covered with vigorous weeds, 10 = no weeds in plot. The higher the rating is, the less the number, size and vigor of weeds in the plot.

^cWhen hairy nightshade rating is low, eastern black nightshade was controlled mostly by hairy nightshade competition and not by the applied herbicides. The coefficient of correlation between the hairy nightshade rating and the eastern black nightshade rating was -0.44, -0.27, and -0.35 for 1997, 1998, and 1999, respectively. We did not include the hand weeded check in the correlation analysis in 1999.

from hairy nightshade, which emerged first and covered the ground. Thus, the ratings for eastern black nightshade control were high even though these herbicides did not directly provide control.

Rimsulfuron applied POST gave excellent control of hairy nightshade, but applied EPOST gave poor to excellent control (Table 1). In 1997 and 1999, EPOST rimsulfuron was applied after the nightshade had begun to emerge and gave better hairy nightshade control than in 1998 when it was applied before hairy nightshade emergence. When applied EPOST, rimsulfuron at 53 g·ha⁻¹ controlled hairy nightshade better than at 26 g·ha⁻¹, but rimsulfuron rate did not affect hairy nightshade control when applied POST. Rimsulfuron at 26 g·ha⁻¹ applied EPOST followed by a POST application at the same rate did not improve hairy nightshade control when compared to rimsulfuron applied once POST at 26 g·ha⁻¹ because rimsulfuron applied POST gave almost complete hairy nightshade control.

Rimsulfuron gave little to no control of eastern black nightshade (Table 1). Eastern black nightshade plants were larger and occurred in higher densities in treatments that

included rimsulfuron opposed to treatments that did not include rimsulfuron. Rimsulfuron controlled hairy nightshade, which allowed eastern black nightshade to grow more vigorously. A correlation analysis showed that as hairy nightshade ratings decreased, eastern black nightshade ratings increased. Correlation coefficients were -0.44 ($P=0.001$), -0.27 ($P=0.052$), and -0.35 ($P=0.012$) for 1997, 1998, and 1999, respectively.

Tomato yield was generally greater when rimsulfuron was applied POST than when trifluralin, pebulate, or metribuzin were applied without rimsulfuron (Table 2). Tomato tended to produce higher yields when rimsulfuron was applied POST compared to EPOST, primarily because of improved hairy nightshade control. When rimsulfuron was applied POST, tomato yield in 1998 and 1999 was higher with the 53 g·ha⁻¹ rate than the 26 g·ha⁻¹ rate, which may have been due to slight suppression of eastern black nightshade by rimsulfuron at the higher rate. In 1999, competition from hairy and/or eastern black nightshade reduced tomato yields by 27% to 78% with all herbicide treatments compared to the hand-weeded check.

Hairy nightshade emerged earlier than east-

ern black nightshade and reached full height of about 50 to 60 cm in mid-July. Eastern black nightshade emerged later than hairy nightshade and was only about 30 cm tall by mid-July, but it was 130 cm tall by mid-August. Hermanutz and Weaver (1991) reported a similar growth pattern for hairy and eastern black nightshade under controlled environmental conditions. In their experiment, hairy nightshade emerged sooner and grew faster for the first 21 d, but eastern black nightshade equaled or exceeded hairy nightshade in leaf area and aboveground dry matter, but not in height, after 35 d. Tomato produced lower yields when dominated by hairy nightshade than by eastern black nightshade (Tables 1 and 2), therefore, the late growth by eastern black nightshade did not reduce tomato yield as much as the early competition by hairy nightshade, even though eastern black nightshade plants grew much larger than hairy nightshade plants. This is consistent with work by Perez and Masiunas (1990) which showed tomato yield reduction from eastern black nightshade competition decreased the later the eastern black nightshade was planted. Due to thick biomass from eastern black nightshade vegetation, tomato harvest was greatly impeded with some treatments.

Greenhouse confirmation. Fourteen collections of eastern black nightshade from the Oakes experiment site exhibited slight differences in injury when treated with rimsulfuron in the greenhouse, but control did not exceed 27% (Table 3). Differences in rimsulfuron activity within or among collections would not be important agronomically as unacceptable eastern black nightshade interference in crop production would occur. Individual seedling response varied within collection as much as among collections. Injury response of the seedlings from seed collected in areas where rimsulfuron had been applied in previous years, including the areas of the former field studies, did not differ from the response of seedlings from areas where rimsulfuron had not been applied previously. This shows that the eastern black nightshade had not developed resistance to rimsulfuron, but rather was naturally tolerant to rimsulfuron. Herbicide resistance is the inheritable ability of some weeds to survive a herbicide that should control the weed population. Exposure to a herbicide is the selective force for development of a resistant weed population. A resistant population usually develops after several years of use of the herbicide or similar herbicides. A population with the inherent ability to avoid injury when treated with a herbicide is tolerant of that herbicide.

Injury manifested as minor chlorosis of younger leaf tissue, but seedlings were not affected for long enough to exhibit stunting. Symptom expression and development of ND-1 was similar to the accessions from Oakes and control of ND-1 with rimsulfuron was similar to nine of the 14 Oakes accessions 7 DAT (Table 3). As time progressed from 7 to 14 DAT, differences in control with rimsulfuron among accessions disappeared. By 14 DAT, plants treated with rimsulfuron were not discernable from control plants regardless of accession (data not shown). This was in stark

Table 2. Grade A tomato yield as affected by rimsulfuron and other herbicides applied for hairy and eastern black nightshade control in North Dakota.

Treatment ^a	Rate (g·ha ⁻¹)	Tomato yield (Mg·ha ⁻¹)		
		1997	1998	1999
Trifluralin PPI	560	40 d ^b	14 f	26 f
Pebulate PPI	5000	42 d	45 cde	34 ef
Trifluralin PPI fb metribuzin EPOST	560 fb 420	68 abc	30 ef	30 f
Trifluralin PPI fb rimsulfuron EPOST	560 fb 26	52 cd	34 ef	52 cde
Trifluralin PPI fb rimsulfuron EPOST	560 fb 53	55 bcd	42 de	42 def
Trifluralin PPI fb rimsulfuron POST	560 fb 26	67 abc	60 bcd	61 cd
Trifluralin PPI fb rimsulfuron POST	560 fb 53	77 a	82 a	86 b
Trifluralin + pebulate PPI fb rimsulfuron POST	560 + 5000 fb 26	72 ab	79 ab	65 c
Trifluralin PPI fb rimsulfuron EPOST fb rimsulfuron POST	560 fb 26 fb 26	62 abc	64 abc	66 bc
Trifluralin PPI fb hand weeding as needed (1999 only)	560	---	---	118 a

^aPPI = preplant incorporated, 2 (1997), 0 (1998), or 1 (1999) d before transplanting tomato; EPOST = early postemergence, 2 (1998) or 6 (1997 and 1999) d after transplanting tomato; and POST = postemergence, 26, 21, and 14 d after transplanting in 1997, 1998, and 1999, respectively; fb = followed by.

^bValues in the same column followed by the same letter are not significantly different at $P=0.05$ using Fischer's protected LSD in 1997 and 1998 and pairwise t tests in 1999.

Table 3. Control of eastern black nightshade from 15 plant collections when treated with three acetolactate synthase-inhibiting herbicides in the greenhouse, evaluated 7 d after treatment.

Plant collection	Eastern black nightshade control (% control)		
	Rimsulfuron ^a	Tribenuron ^a	Imazethapyr ^b
1	23	94	93
2	27	94	94
3	13	92	93
4	17	97	97
5	20	99	95
6	17	92	90
7	23	95	96
8	10	95	96
9	10	96	92
10	10	94	91
11	13	96	95
12	7	94	94
13	13	94	93
14	13	95	94
ND-1	17	94	94
Average ^x	16	95	94
LSD (0.05)	7	NS	NS

^aRimsulfuron and tribenuron applied at 26 and 13 g·ha⁻¹, respectively, with nonionic surfactant at 0.25% by volume.

^bApplied at 52 g·ha⁻¹ with methylated seed oil at 1.75 L·ha⁻¹ and 28% nitrogen solution at 4% by volume.

^xNightshade response averaged across collections, LSD (0.05) = 1.

contrast to an earlier report that eastern black nightshade in North Carolina was susceptible to rimsulfuron (Robinson et al. 1997), but completely in agreement with Mayo et al. (2002) who showed eastern black nightshade sampled over 25 locations in the United States was mostly tolerant to rimsulfuron.

Tribenuron and imazethapyr provided at least 90% control of all eastern black nightshade collections 7 DAT (Table 3). Plants treated with tribenuron or imazethapyr were completely dead by 14 DAT (data not shown). Therefore, nightshade survival following rimsulfuron did not coincide with tolerance to tribenuron or imazethapyr, which have the same mode of action as rimsulfuron.

Fields where these experiments were conducted did not have a history of herbicide use that would select for eastern black nightshade resistance to rimsulfuron. Biotypes of eastern black nightshade from other areas have varied in response to herbicides, with a biotype from Minnesota being more tolerant to most of the 25 herbicides tested than a Kentucky biotype (Ogg, 1986). However, none of the herbicides Ogg (1986) tested were ALS inhibitors. Eastern black nightshade in North Carolina was susceptible to rimsulfuron (Robinson et al. 1997), but Mayo et al. (2002) reported eastern black nightshade control with rimsulfuron plus nicosulfuron (2-[[[(4,6-dimethoxy-2-pyrimidinyl)amino]carbonyl]amino]sulfonyl]-N,N-dimethyl-3-pyridinecarboxamide) of only 21% when averaged over 25 locations across the United States. The field histories and experimental results with these North Dakota samples indicate that the North Dakota accession of eastern black nightshade was tolerant to rimsulfuron rather than resistant as a result of herbicide selection.

Rimsulfuron can be used in tomato production to control hairy nightshade, but not the accession of eastern black nightshade found in this study. Hairy nightshade control was best when rimsulfuron was applied POST to weeds. Control of hairy nightshade resulted in increased tomato yield and eastern black nightshade growth. Tomato yields were higher in treatments dominated by eastern black nightshade than hairy nightshade, which was likely due to the fact that eastern black nightshade emerged later than hairy nightshade and competed with tomato for less time than hairy nightshade.

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