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Evaluation of newly transplanted blackberry tolerance to a selection of preemergence herbicides

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Research Article

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Abstract

This trial assessed the effect of preemergence herbicides on newly transplanted blackberries. A 2-yr field trial was initiated in 2021 and conducted at two locations in Fayetteville and Clarksville, AR. Seven treatments consisted of six preemergence herbicides (flumioxazin, mesotrione, napropamide, oryzalin, pendimethalin, and *S*-metolachlor) and one nontreated check. Preemergence herbicide treatments were applied to field plots of newly transplanted blackberry plugs ('Ouachita'), using a CO_2 backpack sprayer at 187 L ha^{-1} covering a 1-m swath, ensuring spray pattern overlap over newly planted blackberries in 2021 and reapplied in the same manner to established blackberries of the same plots in 2022. Data were collected on crop injury and plant height of blackberry plants in each plot. Yield data were collected in the second year, and fruit were analyzed for soluble solids content, pH, and average berry weight. In the first year, mesotrione and flumioxazin treatments caused injury to newly transplanted blackberries, and mesotrione-treated blackberries (58% in Fayetteville, 29% in Clarksville) did not fully recover by 84 d after treatment (DAT). Napropamide, *S*-metolachlor, oryzalin, and pendimethalin did not cause crop injury greater than 6% throughout the 2021 season. In the second year (2022), no crop injury was caused by any herbicide treatments. Results from these trials verify that flumioxazin, napropamide, oryzalin, and pendimethalin at the tested rates would be appropriate options for weed control in newly planted blackberries. These results corroborate regional recommendations against the use of mesotrione in first-year blackberry plantings. The findings from this trial indicate that *S*-metolachlor would be safe for registration for use on blackberries because of its limited effect on crop injury and blackberry yield.

Introduction

Blackberry yield and fruit size can be reduced if weeds are not controlled (Basinger et al. 2017; Meyers et al. 2014). Weeds may cause indirect losses to blackberry production by increasing pest management costs or reducing efficiency of harvest. Maintaining a weed-free field is paramount to success for blackberry growers (Burgos et al. 2014). Weed control was identified as a key area for research and extension according to a national stakeholder survey of blackberry growers across the United States (Worthington et al. 2020). Best management practices recommend a 0.9-m weed-free strip width (WFSW) for young, unestablished blackberries and a 1.2-m WFSW for older, established plantings (Basinger et al. 2017; Meyers et al. 2014, 2015). A WFSW is a minimum strip centered on blackberry plants where weeds must be controlled to prevent yield loss due to weed interference. A combination of weed management strategies is often used in blackberry production because growers must address weed pressures at all times of the year (Mitchem and Czarnota 2023).

To maintain a WFSW, producers use landscape fabric, mulches, and herbicides (Makus 2011; Zhang et al. 2019). Hand-weeding is not ordinarily an economic option due to the high cost of labor and its time-intensive nature (Harkins et al. 2013). When establishing a blackberry planting, it is customary to install polyethylene mulch or landscape fabric directly under and around young plants, and then use a herbicide to maintain the WFSW that is not covered with landscape fabric (Mitchem and Czarnota 2023). Herbicides are cost- and time-effective when applied to mature and newly planted blackberries alike (Meyers et al. 2014, 2015).

Due to crop sensitivity and the small number of in-season selective postemergence herbicide options for blackberry, preemergence herbicides are commonly used to prevent weed seed germination and emergence as spring temperatures rise. Preemergence herbicides prevent weed encroachment at the start of the season, but herbicide breakdown may occur, necessitating a sequential application of a preemergence herbicide or the use of a postemergence herbicide in summer or fall (Mitchem and Czarnota 2023). Herbicides registered for use on blackberries often carry label restrictions based on crop growth stage and establishment status, limiting herbicide options for newly planted blackberries. Thus, currently registered herbicides must be expanded to include their use on blackberries, or new products must be registered, particularly for new blackberry plantings.

First-year blackberry plantings are vulnerable to encroachment and competition by weed species, but newly planted blackberries are often sensitive to herbicides that would control weed populations. An assessment of the tolerance of newly planted blackberries to currently registered preemergence and other herbicides is needed to identify any herbicides that may be suitable for expanded labeling, supplemental labeling under a special local need exemption under on §24(c) of the Federal Insecticide, Fungicide and Rodenticide Act, or updated recommendations in regional production guides (Mitchem and Czarnota 2023). The objectives of this study were to determine the effect of preemergence herbicide applications on establishment and growth of newly transplanted blackberries in Arkansas and to generate data on weed control and crop response that can be used to establish regional recommendations for supplemental labeling of herbicides for blackberries grown in the southern region of the continental United States.

Materials and Methods

A 2-yr field trial was initiated in 2021 and conducted at two University of Arkansas agricultural experiment stations. One station is the Milo J. Shult Research and Extension Center in Fayetteville, AR, where the soil is a Captina silt loam (fine-silty, siliceous, active, mesic Typic Fragiudults) consisting of 26% sand, 60% silt, 14% clay, and 1.6% organic matter, pH 6.9. The other experimental location is the Fruit Research Station in Clarksville, AR, where the soil is a Linker fine sandy loam (Fine-loamy, siliceous, semiactive, thermic Typic Hapludults) consisting of 55% sand, 34% silt, 11% clay, and 1.9% organic matter, pH 6.3. Tissue-propagated blackberry cuttings ('Ouachita') were received on April 22, 2021, from a commercial nursery (Agri-Starts, Apopka, FL) in 72-cell trays, and then repotted 5 d later into 0.6-L containers with BX Mycorrhizae potting substrate (Pro-Mix, Quakertown, PA) and kept in a greenhouse until transplanting in the field. Blackberry plants were retained in containers for less than 1 mo, and plants were approximately 30 cm tall with six expanded leaves at the time of transplanting in the field. Blackberries were transplanted on May 7 and May 14, 2021, at the Clarksville and Fayetteville field trial locations, respectively. Plots measured 2.4 m in length and included four blackberry plants at a 0.6-m spacing with a 1.2-m in-row gap to separate each plot. Seven treatments were included: six preemergence herbicides and one nontreated weed-free check (Table 1). Immediately following transplanting, preemergence herbicide treatments were applied using a CO_2-powered backpack sprayer with TeeJet 8002 VS flat-fan nozzle tips (TeeJet® Technologies, Glendale Heights, IL), calibrated to deliver 187 L ha^{-1} at 276 kPa, covering a 1-m swath on each side of the planting rows. Herbicides were applied in two passes, one on each side of the plant row, ensuring an overlap of spray coverage of the soil beneath blackberry transplants and their canopies. Herbicides were applied on the day of transplanting, and on May 7 and May 14, 2021, at the Clarksville and Fayetteville locations, respectively. Herbicides were applied to the same plots in the second year at the typical time for spring preemergent herbicide applications: March 16 and 24 at Clarksville and Fayetteville, respectively.

At the time of this trial, flumioxazin, mesotrione, napropamide, and oryzalin were labeled for use on blackberries (Anonymous 2011, 2012, 2018, 2021a). The formulation of pendimethalin used in this trial, Prowl® H2O (0.46 kg L^{-1} pendimethalin; BASF, Research Triangle Park, NC), is not labeled for use in blackberry production (Anonymous 2021c); however, another product with the same concentration of pendimethalin, Satellite HydroCap® (455 g L^{-1} pendimethalin; United Phosphorus, King of Prussia, PA) is labeled for surface application prior to blackberries being transplanted (Anonymous 2017b). *S*-metolachlor is not labeled for use on blackberries with a §3 label (Anonymous 2020); however, a §24(c) special local need exemption exists for its use in Georgia, North Carolina, Oregon, and Washington (Anonymous 2017a, 2021b, 2022b, 2023). Arkansas acquired the same special local need exemption to use *S*-metolachlor in 2022 (Anonymous 2022a). Napropamide and oryzalin are recommended for use on blackberries at all growth stages (Burgos et al. 2014; Mitchem and Czarnota 2023). Although oryzalin is labeled for use on blackberries, it is no longer manufactured and has not been available for sale in recent years (Neal 2021). Flumioxazin and mesotrione are recommended for use on established plantings by the caneberry spray guide (Mitchem and Czarnota 2023).

Dormant and in-season fungicides and insecticides were applied for disease and insect management based on scouting and following regional recommendations (Oliver et al. 2022). Preplant fertilizer was applied to soil at both locations at 325 kg ha^{-1} of 19N-8P-8K in 2021, and 392 kg ha^{-1} of 20N-9P-9K in 2022. In 2021, fertilizer was applied preplant; in 2022, fertilizer was applied through the drip irrigation system. As blackberries grew, primocanes were trained to a trellis, tipped, and secured to the trellis wire with flagging tape (Presco, Sherman, TX) and trellis ties (Klipon, Mt Maunganui, New Zealand) to promote upright growth. End-of-season pruning in 2021 removed extraneous primocanes, leaving three to five primocanes per plant.

Nontreated weed-free plots were hand-weeded at least once weekly to keep weed populations from affecting plant growth and yield. The nontreated plots did not receive maintenance applications of fluazifop for in-season weed control; however, late-emerging winter weeds were chemically controlled across entire field sites using a burndown application of glufosinate (1.0 kg ai ha^{-1}) as a directed spray covering a 1-m swath on each side of blackberry canes on March 9 and March 15, 2022, at the Clarksville and Fayetteville locations, respectively. Weed populations were monitored in treated plots weekly. The emergence of annual weed species indicated that a preemergence herbicide was no longer effective (data not shown). When grassy weed species reached a target size of 5 to 20 cm tall, a shielded application of fluazifop (1× = 210 g ai ha^{-1}, Fusilade® DX; Syngenta Crop Protection, Greensboro, NC) plus 2.5 mL L^{-1} nonionic surfactant (Induce; Helena Holding Company, Collierville, TN) was sprayed in a 1-m swath on each side of the blackberry plots. Broadleaf weeds, sedges, and any remaining weeds were removed by hand after herbicide breakdown. Weed species observed during this trial included large crabgrass [*Digitaria sanguinalis* (L.) Scop.], eclipta (*Eclipta prostrata* L.), common groundsel (*Senecio vulgaris* L.), carpetweed (*Mollugo verticillata* L.), cutleaf evening primrose (*Oenothera laciniata* Hill), goosegrass [*Eleusine indica* (L.) Gaertn.], yellow nutsedge (*Cyperus esculentus* L.), and ladysthumb (*Persicaria maculosa* Gray) at both locations.

Table 1. Herbicides tested in field experiments on newly planted blackberries in 2021 and 2022.

Common name	Trade name	Application rate	Manufacturer	Manufacturer location	Manufacturer website
		g ai ha^{-1}			
Mesotrione	Callisto®	158	Syngenta Crop Protection	Greensboro, NC	–https://www.syngenta–us.com/home.aspx
Flumioxazin	Chateau®	210	Valent U.S.A.	San Ramon, CA	https://www.valent.com
Oryzalin	Surflan®	4483	United Phosphorous	King of Prussia, PA	https://www.upl-ltd.com/us
S–metolachlor	Dual Magnum®	1597	Syngenta Crop Protection	Greensboro, NC	–https://www.syngenta–us.com/home.aspx
Pendimethalin	Prowl® H2O	3362	BASF	Research Triangle Park, NC	https://www.basf.com/us/en.html
Napropamide	Devrinol®	4483	United Phosphorus	King of Prussia, PA	https://www.upl-ltd.com/us

Data were collected on blackberry injury and plant height throughout the season. Blackberry injury ratings were assessed based on visible plant symptoms such as leaf discoloration, bleaching, chlorosis, or necrosis, as well as overall plant stature and growth characteristics. Plant injury was visibly assessed on a 0% to 100% scale, with 0% representing a plant exhibiting no symptoms distinguishable from the nontreated check and 100% representing a dead plant.

Yield data were assessed only in the 2022 season because Ouachita is a floricane fruiting variety that fruits only on second-year canes. Yield data consisted of marketable, cull, and average berry weights. Marketable berries were designated as ripe black fruit that was unblemished and had no damage. Berries were designated as culls if they displayed insect damage, disease, malformation due to incomplete or improper fertilization or development, or environmental damage such as sun-scald. Berry weights were measured in the field using a portable balance scale (NV3202; OHAUS, Parsippany, NJ). A subsample of 25 representative marketable berries was weighed during each harvest to determine the average berry weight. Ten representative berries from each plot were harvested, placed on ice, and then frozen for analysis of pH and soluble solids content (Brix). Frozen berries were thawed, and juice was extracted. Soluble solids were measured using an Atago PAL-1 pocket refractometer (Atago-USA, Bellevue, WA), and pH was measured using a Fisherbrand accument AE150 benchtop pH meter (Fisher Scientific, Waltham, MA).

All data were subjected to ANOVA as a randomized complete block design using the GLIMMIX procedure with SAS (v. 9.4; SAS Institute Inc., Cary, NC). The main effects of herbicide and location and the interaction of herbicide × location were treated as fixed effects, while block (nested in location) was treated as a random effect. Assessments related to weed control included year as a main effect; thus, for those analyses, main effects of herbicide, year, and their interactions were treated as fixed effects, while block (nested in year × location) was treated as a random effect. The crop injury and plant height analysis was conducted separately by year, as plants from Year 1 and Year 2 represented distinct growth stages. Similarly, blackberry yield and fruit quality data were analyzed only for 2022 because no fruit was produced in the first year following planting. Data were checked for heteroscedasticity by reviewing residual plots from SAS, and means were separated using Tukey's honestly significant difference multiple comparisons adjustment ($\alpha = 0.05$).

Results and Discussion

Blackberry Injury and Plant Heights

Significant crop injury was observed in plants treated with flumioxazin at 7 and 14 DAT (both locations) and at 28 DAT at the Fayetteville location (Table 2). Injury symptoms to flumioxazin-treated plants included necrotic lesions, necrosis along leaf veins, and stunting. In the following weeks, flumioxazin-treated plants exhibited <5% injury at 42 DAT through the last rating at 84 DAT. Mesotrione-treated blackberries exhibited moderate to severe injury (5% to 58%) throughout all ratings at both locations (Table 2). Initial injury symptoms of mesotrione-treated plants were bleaching and chlorosis and were most apparent at 7 and 14 DAT rating timings. By 42 DAT, mesotrione-treated plants no longer exhibited bleaching symptoms but were severely stunted compared with the nontreated check. Oryzalin, *S*-metolachlor, pendimethalin, and napropamide never caused greater than 6% injury throughout the 2021 season. The present findings corroborate work by Peachey (2012), who observed no blackberry injury in response to pendimethalin (1.4 and 2.8 kg ai ha^{-1}) or *S*-metolachlor (0.6 kg ai ha^{-1}) on 'Marion' blackberries. Blackberry injury was not observed in response to any herbicide treatment at any rating timing during the 2022 season (data not shown). In previous field studies, flumioxazin, oryzalin + simazine, and *S*-metolachlor + simazine did not injure established blackberry plantings (Meyers et al. 2015). The younger plants in the first season experienced higher levels of injury than the older plants in the second season. The levels of injury observed were anticipated because the plants in the first year were expected to be more sensitive and vulnerable to the herbicide treatments. The findings of Meyers et al. (2015) agree with our results for second year plants. Reduction in plant height was reported only in response to mesotrione at 42 and 56 DAT (combined) and 84 DAT at both locations (Table 3).

Yield

The effect of herbicide or herbicide × location was nonsignificant on blackberry yield at any harvest timing, cumulative harvest, or average berry weight (Table 4). The nonsignificant response was a surprising considering the mesotrione treatment caused severe crop injury and reduced plant height in the 2021 season (Tables 2 and 3). This finding demonstrates that blackberry plants can recover from initial injury from mesotrione (158 g ai ha^{-1}) and produce yields similar to those of noninjured plants. A possible explanation of recovery could be that pruning activity between 2021 and 2022 brought all blackberry plots back to a similar growth status and plant stature before the second growing season; however, no data were collected on pruning weights to determine this for certain. Despite consistent yields, the high levels of blackberry injury caused by mesotrione support the current commercial recommendation to apply the product only to established blackberries (Mitchem and Czarnota 2023). Other studies and best practices have shown that maintaining the WFSW keeps plants healthy, thereby promoting yield (Basinger et al. 2017; Meyers et al. 2014, 2015). Throughout this trial, the WFSW was maintained for all plots, so any disparities in yield could be attributed to the effects of the preemergence herbicide rather than to weed interference.

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Table 2. Crop injury ratings of blackberry plots in response to preemergence herbicide treatments at 7, 14, 28, 42, 56, and 84 d after treatment in 2021[a,b,c].

	Blackberry injury									
	7 DAT		14 DAT		28 DAT		42 DAT	56 DAT	84 DAT	
Herbicide	MJS	FRS	MJS	FRS	MJS	FRS	Combined	Combined	MJS	FRS
	%									
Mesotrione	5 bc	6 b	10 abc	13 ab	31 a	13 b	56 a	41 a	58 a	29 b
Flumioxazin	10 a	10 a	7 bcd	15 a	13 b	3 bc	3 b	4 b	3 c	0 c
Oryzalin	2 cd	0 d	4 cde	0 e	5 bc	0 c	1 b	1 b	4 c	0 c
S–metolachlor	5 bc	0 d	0 e	0 e	0 c	1 c	0 b	1 b	1 c	0 c
Pendimethalin	1 d	0 d	1 de	1 de	3 bc	0 c	0 b	0 b	0 c	0 c
Napropamide	0 d	0 d	0 e	0 e	0 c	0 c	0 b	1 b	1 c	0 c
P–value	0.0004		0.0053		0.0005		<.0001	<.0001	0.0013	

[a]Abbreviations: DAT, days after treatment; MJS, Milo J. Shult, Fayetteville location; FRS, Fruit Research Station, Clarksville location.
[b]Means were separated using Tukey's honestly significant difference test at a $\alpha = 0.05$ significance level and means followed by the same letter are not significantly different. Means were compared by date (DAT).
[c]Herbicide and rate effects were tested for any interaction effect. Where no significant herbicide × location effect was detected, the main effect of herbicide is reported with location combined. In cases where a significant herbicide × location effect was detected; locations are presented as separate columns.

Table 3. Blackberry heights in response to herbicide treatments in 2021 at 7, 14, 28, 42, 56, and 84 d after treatment[a,b,c].

	Blackberry plant height						
	7 DAT	14 DAT	28 DAT	42 DAT	56 DAT	84 DAT	
Herbicide	Combined	Combined	Combined	Combined	Combined	MJS	FRS
	cm						
Mesotrione	11	11 a	12	13 b	21 b	79 ef	60 f
Flumioxazin	11	9 b	12	19 a	34 a	133 a-d	118 b-e
Oryzalin	11	11 a	14	23 a	35 a	135 a-d	109 cde
S-metolachlor	10	11 a	19	21 a	39 a	142 a-d	110 cde
Pendimethalin	11	12 a	13	22 a	36 a	147 abc	106 de
Napropamide	11	11 ab	13	23 a	39 a	156 ab	108 cde
Nontreated	10	11 ab	13	23 a	35 a	165 a	104 de
P-value	0.5268	0.0042	0.3748	<.0001	<.0001	0.0455	

[a]Abbreviations: DAT, days after treatment; MJS, Milo J. Shult (Fayetteville) location; FRS, Fruit Research Station (Clarksville).
[b]Means were separated using Tukey's honestly significant difference test at a significance level of $\alpha = 0.05$, and means followed by the same letter are not significantly different.
[c]Herbicide and rate effects were tested for any interaction effect. Where no significant herbicide × location effect was detected, the main effect of herbicide is reported with location combined. When a significant herbicide × location effect was detected, locations are presented as separate columns.

Table 4. Blackberry yield by harvest initiated at the Fayetteville location on June 28, 2022, and the Clarksville location on June 20, 2022[a,b].

	Blackberry yield, by harvest[c]									Cumulative blackberry yield[d]		
Herbicide	1	2	3	4	5	6	7	8	9	Marketable[e]	Cull[f]	Avg. weight
	kg plant^{-1}											g berry^{-1}
Mesotrione	0.26	0.21	0.48	0.34	0.37	0.15	0.17	0.11	0.12	2.22	0.25	5.28
Flumioxazin	0.29	0.29	0.57	0.37	0.33	0.15	0.18	0.13	0.14	2.45	0.35	5.30
Oryzalin	0.29	0.27	0.49	0.36	0.38	0.15	0.20	0.15	0.17	2.47	0.35	5.21
S-metolachlor	0.31	0.24	0.60	0.44	0.45	0.16	0.21	0.15	0.17	2.72	0.29	5.19
Pendimethalin	0.31	0.28	0.51	0.39	0.39	0.16	0.22	0.16	0.16	2.59	0.31	5.28
Napropamide	0.27	0.28	0.55	0.42	0.40	0.17	0.22	0.17	0.22	2.70	0.27	5.28
Nontreated	0.27	0.25	0.52	0.39	0.40	0.17	0.20	0.15	0.18	2.55	0.28	5.23
P-value	0.9310	0.1446	0.4356	0.5635	0.7187	0.9150	0.4806	0.1450	0.3097	0.6332	0.4494	0.9902

[a]Means were separated using Tukey's honestly significant difference test at a significance level of $\alpha = 0.05$. Means followed by the same letter are not significantly different. Means should be compared by date (i.e., days after treatment).
[b]Blackberries were harvested twice a week. Final harvests took place at the Fayetteville location on July 29, 2022, and the Clarksville location on July 21, 2022.
[c]Harvests reflect only marketable berry yields.
[d]Cumulative marketable, cull yields, and average berry weight for 2022 blackberry harvest.
[e]Marketable yields were defined as ripe berries without blemish.
[f]Cull yields were defined as berries that did not meet marketable standards through damage or malformation.

Postharvest Quality

No detrimental effects of herbicides on fruit quality were observed (Tables 4 and 5). Blackberry pH varied more greatly between harvests than among herbicide treatments. No substantial pH or soluble solids content variation was observed among treatments or harvests. These findings are consistent with previous studies that have demonstrated that soluble solids content or pH measures are generally maintained under stress from weed competition (Basinger et al. 2017; Meyers et al. 2014). Fruit quality is important for consumers, particularly for fresh market crops like blackberry

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Table 5. Blackberry fruit quality data assessed on bulked samples of 10 marketable quality macerated berries from each plot at the Fayetteville and Clarksville locations[a,b].

Herbicide	Postharvest fruit quality[c]							
	Harvest 2	Harvest 5	Harvest 7	All harvests	Harvest 2	Harvest 5	Harvest 7	All harvests
	pH				Brix			
Mesotrione	3.42	3.71	3.63	3.58	10.62	10.96	10.85	10.81
Flumioxazin	3.40	3.67	3.55	3.54	10.71	10.75	11.20	10.88
Oryzalin	3.42	3.47	3.53	3.56	10.82	10.91	10.81	10.85
S-metolachlor	3.40	3.74	3.62	3.58	10.41	10.71	11.37	10.83
Pendimethalin	3.41	3.62	3.56	3.53	10.96	10.77	11.10	10.94
Napropamide	3.36	3.70	3.59	3.55	10.40	10.11	10.92	10.47
Nontreated	3.37	3.72	3.52	3.53	11.27	11.25	10.91	11.14
P-value	0.9573	0.1806	0.1223	0.6606	0.6082	0.1901	0.7670	0.2985

[a]Means were separated using Tukey's honestly significant difference test at a significance level of $\alpha = 0.05$. Means followed by the same letter are not significantly different. Means should be compared by date (i.e., days after treatment).
[b]Harvests are indicated chronologically, with harvests 2, 5, and 7 occurring on July 2, 12, and 19, respectively, at the Fayetteville location; and on June 23, July 5, and July 11, respectively, at the Clarksville location.
[c]Quality data were collected on a subset of harvest throughout the season.

(Threlfall et al. 2016). Thus, it is critically important to assess quantitative traits that characterize the fruit quality of blackberries in response to the selected herbicides. Fruit quality such as soluble solids and firmness are often determined by cultivar selection, or the rate of fertilizers applied (Fernandez-Salvador et al. 2015; Nelson and Martin 1986). Therefore, herbicides in this trial had no negative effects on any measurable trait associated with fruit quality and would offer no cause for concern for commercial blackberry production.

Practical Implications

This study was conducted in hopes of expanding preemergent chemical control options for blackberry production and producing data to inform recommendations for herbicide use on newly established blackberries. Based on results from this trial, mesotrione and flumioxazin would not be recommended for use as a broadcast application with potential foliar interception in first-year blackberry plantings due to unacceptable injury levels. In general, treatments caused little to no blackberry injury or reduced plant heights, and no yield or fruit quality reductions were observed in response to any treatment. Unfortunately, the manufacture of oryzalin has been discontinued, so the herbicide has not been available in recent years (Neal 2021). These findings validate many regional recommendations and provide new evidence to consider expanding registration and labeled usage requirements for materials such as *S*-metolachlor, with registrant support.

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Competing Interests. The authors declare they have no competing interests.

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