This is a “preproof” accepted article for Weed Science. This version may be subject to change in the production process, *and does not include access to supplementary material*.
DOI: 10.1017/wet.2024.95

Short title: PREs on New Blackberries

Evaluation of Newly-transplanted Blackberry Tolerance to a Selection of Preemergence Herbicides

Kayla Knepp[1], Matthew B. Bertucci[2], Aaron J. Cato[3], Amanda L. McWhirt[3], and Nilda R. Burgos[4]

[1]Graduate Research Assistant, Department of Horticulture, University of Arkansas, Fayetteville, AR, USA; [2]Assistant Professor (ORCID 0000-0002-0661-8990), University of Arkansas, Department of Horticulture, University of Arkansas, Fayetteville, AR, USA; [3]Extension Specialist (ORCID 0000-0003-4156-1878), Department of Horticulture, University of Arkansas Cooperative Extension Service, Little Rock, AR, USA; and [4]Professor (ORCID 0000-0002-6977-6873), Department of Crop, Soil, and Environmental Sciences, University of Arkansas, Fayetteville, AR, USA.

Author for correspondence: Matthew B. Bertucci; email: bertucci@uark.edu

Abstract

This trial assessed the effect of preemergence herbicides on newly transplanted blackberries. A two-year field trial was initiated in 2021 and conducted at two locations: Fayetteville, AR 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 (var. '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 was 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% - Fayetteville, 29% - Clarksville) did not fully recover by 84 days after treatment (DAT). Napropamide, *S*-metolachlor, oryzalin, and pendimethalin did not cause crop injury over 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 *S*-metolachlor would be safe for registration for use in blackberries, regarding crop injury and blackberry yield.

Nomenclature: Flumioxazin; mesotrione; napropamide; oryzalin; pendimethalin; *S*-metolachlor; blackberry, *Rubus* L. subgenus *Rubus* Watson

Keywords: caneberry, horticulture, perennial, specialty crop, weed control

https://doi.org/10.1017/wet.2024.95 Published online by Cambridge University Press

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; Meyers et al. 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 blackberries because growers must address weed pressures year-round (Mitchem and Czarnota 2023).

To maintain a WFSW, landscape fabric, mulches, and chemical controls are utilized in the field (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 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 in mature and newly planted blackberries (Meyers et al. 2014; Meyers et al. 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 in blackberries often carry label restrictions based on crop growth stage and establishment status, limiting herbicide options for newly planted blackberries. Thus, there is a need for expanded labels for currently registered herbicides or registration of new products, 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 herbicides and other preemergence herbicides is needed to identify any herbicides that may be suitable for expanded labeling, supplemental labeling under a section 24(c) special local need (SLN) label, 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 utilized for regional recommendations and applications for supplemental labels for herbicides for blackberries grown in the southern region of the continental United States of America.

Materials and Methods

A two-year field trial was initiated in 2021 and conducted at two University of Arkansas System Division of Agriculture experiment stations: Milo J. Shult Research and Extension Center in Fayetteville, AR on a Captina silt loam (fine-silty, siliceous, active, mesic Typic Fragiudults) consisting of 26% sand, 60% silt, and 14% clay, with an organic matter content of 1.6% and an pH of 6.9 and the Fruit Research Station in Clarksville, AR on a Linker fine sandy loam (Fine-loamy, siliceous, semiactive, thermic Typic Hapludults) consisting of 55% sand, 34% silt, and 11% clay, with an organic matter of 1.9% and a pH of 6.3. Tissue propagated blackberry cuttings (var. 'Ouachita') were received on Apr 22, 2021, from a commercial nursery (Agri-Starts, Apopka, FL, USA) in 72-cell trays then repotted five days later into 0.6 L containers with PRO-MIX BX Mycorrhizae potting substrate (Pro-Mix, Quakertown, PA, USA) and kept in a greenhouse until transplanting in the field. Blackberry plants were retained in containers for less than one month, and plants were approximately 30 cm tall with six expanded leaves at the time of transplanting in the field. Blackberries were transplanted onMay 7 andMay 14 of 2021 at Clarksville and Fayetteville, AR, 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 8002 VS flat fan nozzle tips (TeeJet® Technologies, Springfield, IL, USA), calibrated to deliver 187 L ha^{-1} at 276 kPa, covering a 1 m swath on each side of the planting rows. Herbicide applications were completed in two passes, one on each side of the plant row, ensuring an overlap of spray coverage of the

https://doi.org/10.1017/wet.2024.95 Published online by Cambridge University Press

soil beneath blackberry transplants and their canopies. Herbicide treatments were applied on the day of transplanting, on May 7 and May 14 of 2021 at Clarksville and Fayetteville, AR, respectively. Herbicide treatments were applied to the same plots in the second year at the typical time for spring preemergent herbicide applications: March 16 and 24 for Clarksville and Fayetteville, respectively.

At the time of this trial, flumioxazin, mesotrione, napropamide, and oryzalin were labeled for use in blackberries (Anonymous 2011, 2012, 2018, 2021). The formulation of pendimethalin used in this trial, Prowl® H2O (3.8 lb/gal pendimethalin; BASF Corporation, Research Triangle Park, NC), is not labeled for use in blackberries (Anonymous 2021b); however, another product with the same concentration of pendimethalin, Satellite HydroCap® (455 g L^{-1} pendimethalin; United Phosphorus, Inc., King of Prussia, PA) is labeled for surface application prior to transplanting blackberries (Anonymous 2017b). *S*-metolachlor is not labeled for use in blackberries with a section 3 label; however, a section 24(c) SLN label exists for Georgia, North Carolina, Oregon, and Washington (Anonymous 2017a, 2021a, 2022b; Anonymous 2023). Arkansas acquired the same SLN label for *S*-metolachlor in 2022 (Anonymous 2022a). Napropamide and oryzalin are recommended for use in blackberries of all growth stages (Burgos et al. 2014; Mitchem and Czarnota 2023). While oryzalin is labeled for use in 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 in 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 (UGA 2022). Preplant fertilizer was applied to 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, USA) and trellis ties (Klipon, Mt Maunganui, New Zealand) to promote upright growth. End-of-season pruning in 2021 removed extraneous primocanes, leaving 3 to 5 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

https://doi.org/10.1017/wet.2024.95 Published online by Cambridge University Press

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 1 m swath on each side of blackberry canes on Mar 9, 2022, and Mar 15, 2022, in Clarksville and Fayetteville, 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 (Fusilade® DX; 1× = 210 g ai ha^{-1} Syngenta Crop Protection, Greensboro, NC, USA) plus 0.25% v/v nonionic surfactant (Induce, Helena Holding Company, Collierville, TN, USA) 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.

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 only fruits 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 due to 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 (Model: NV3202; OHAUS Corporation, Parsippany, NJ, USA). 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, Inc., Bellevue, WA, USA), and pH was measured using a Fisherbrand^{TM} accument^{TM} AE150 benchtop pH meter (Fisher Scientific, Waltham, MA, USA).

All data were subjected to ANOVA as a randomized complete block design using the GLIMMIX procedure in SAS, version 9.4 (SAS Institute Inc., Cary, NC, USA). 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 only analyzed 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 Honest 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 MJS (Table 2). Injury symptoms in 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 and 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 to the nontreated check. Oryzalin, *S*-metolachlor, pendimethalin, and napropamide never caused above 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 plus simazine, and *S*-

https://doi.org/10.1017/wet.2024.95 Published online by Cambridge University Press

metolachlor plus 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 the results for second year plants. Reduction in plant height was only reported 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 non-injured 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 was 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, promoting yield (Basinger et al. 2017; Meyers et al. 2014; Meyers et al. 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 weed interference.

Postharvest quality.

No detrimental effects of herbicides on fruit quality were observed (Tables 4, 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 work, which has 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 (Threlfall et al. 2016). Thus, it is critically important to assess quantitative traits

https://doi.org/10.1017/wet.2024.95 Published online by Cambridge University Press

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 work was conducted in hopes of expanding preemergent chemical control options for blackberry production and producing data that informs recommendations for herbicide use 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 the 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.

Acknowledgments

Authors would like to acknowledge Drew Kirkpatrick and Rachel Woody-Pumford for efforts to maintain field plots in each location. We would also like to acknowledge Dr. Jackie Lee for guidance and assistance at the Fruit Research Station in Clarksville, AR.

Funding

This work was supported in part by the USDA National Institute of Food and Agriculture, Hatch Project no. 102445. It was also supported by the Southern Region Small Fruit Consortium.

Competing Interests

The authors declare none.

https://doi.org/10.1017/wet.2024.95 Published online by Cambridge University Press

References

Anonymous (2011) Surflan® herbicide product label. United Phosphorous, King of Prussia, PA. Accessed: Sept 23, 2023.

Anonymous (2012) Devrinol® DF-XT herbicide product label. United Phosphorous Publication No. 70506-36. King of Prussia, PA: United Phosphorus, Inc. 9 p

Anonymous (2017a) Dual Magnum herbicide section 24(c) special local need label – state of North Carolina. Syngenta Publication No. NC0816036CA0217. Greensboro, NC: Syngenta Crop Protection. 7 p

Anonymous (2017b) Satellite HydroCap® herbicide product label. United Phosphorous, King of Prussia, PA. Accessed: Sept 23, 2023.

Anonymous (2018) Callisto® herbicide product label. Syngenta Crop Protection, Greensboro, NC. Accessed: Sept 23, 2023.

Anonymous (2020) Dual Magnum herbicide product label. Syngenta Crop Protection, LLC,

Anonymous (2021) Chateau® herbicide product label. Valent U.S.A. Publication No. 2380-A. San Ramon, CA: Valent U.S.A. 52 p.

Anonymous (2021a) Dual Magnum herbicide section 24(c) special local need label – state of Oregon. Syngenta Publication No. OR0816136CA1121. Greensboro, NC: Syngenta Crop Protection. 5 p

Anonymous (2021b) Prowl® H2O herbicide product label. BASF Corporation, Research Triangle, NC

Anonymous (2022a) Dual Magnum herbicide section 24(c) special local need label – state of Arkansas. Syngenta Publication No. AR0816054AA0622. Greensboro, NC: Syngenta Crop Protection. 3 p

Anonymous (2022b) Dual Magnum herbicide section 24(c) special local need label – state of Washington. Syngenta Publication No. WA0816107CA1021. Greensboro, NC: Syngenta Crop Protection. 5 p

Anonymous (2023) Dual Magnum herbicide section 24(c) special local need label – state of Georgia. Syngenta Publication No. GA0816060AA0323. Greensboro, NC: Syngenta Crop Protection. 3 p

https://doi.org/10.1017/wet.2024.95 Published online by Cambridge University Press

Basinger NT, Jennings KM, Monks DW, Mitchem WE, Perkins-Veazie PM (2017) In-row vegetation-free trip width effect on established 'Navaho' blackberry. Weed Technol 32:85-89

Burgos NR, Rouse C, Scott RC (2014) Blackberry weed management. Fayetteville, AR: Division of Agriculture, Research and Extension, University of Arkansas System. 3 p

Fernandez-Salvador J, Strik BC, Bryla DR (2015) Response of blackberry cultivars to fertilizer source during establishment in an organic fresh market production system. HortTechnol 25:277-292

Harkins RH, Strik BC, Bryla DR (2013) Weed management practices for organic production of trailing blackberry: I. plant growth and early fruit production. HortSci 48:1139-1144

Makus DJ (2011) Use of synthetic ground covers to control weeds in blackberries. Int J of Fruit Sci 11:286-298

Meyers SL, Jennings KM, Monks DW, Mitchem WE (2014) Effect of weed-free strip width on newly established 'Navaho' blackberry growth, yield, and fruit quality. Weed Technol 28:426-431

Meyers SL, Jennings KM, Monks DW, Mitchem WE (2015) Herbicide-based weed management programs in erect, thornless blackberries. Int J Fruit Sci 15:456-464

Mitchem WE and Czarnota M (2023) Weed Management, p 51-60. In Oliver JE (ed.) 2023 Southeast regional caneberry integrated management guide. Univ Georgia Coop Ext 121-3. https://secure.caes.uga.edu/extension/publications/files/pdf/AP%20121-3_1.PDF

Neal J (2021) Surflan (oryzalin) — limited supplies and uncertain future? NC Coop Ext website: http://go.ncsu.edu/readext?769107 Accessed: Sept 12, 2024

Nelson E and Martin LW (1986) The relationship of soil-applied N and K to yield and quality of "thornless evergreen" blackberry. HortSci21:1153-1154

Peachey E (2012) Pendimethalin performance on commercial caneberries. Corvallis, OR: Oregon State University Horticultural Weed Control Rep 25-29 p

Threlfall RT, Hines OS, Clark JR, Howard LR, Brownmiller CR, Segantini DM, Lawless LJR (2016) Physiochemical and sensory attributes of fresh blackberries grown in the southeastern United States. HortSci 51:1351-1362

https://doi.org/10.1017/wet.2024.95 Published online by Cambridge University Press

[UGA]University of Georgia, Extension (2022) 2022 Southeast Regional Caneberry Integrated Management Guide https://smallfruits.org/files/2022/01/2022-Caneberry-Spray-Guide.pdf

Worthington M, Coe M, Herrera L, McWhirt A (2020) Research and extension priorities of the U.S. blackberry industry identified through a national stakeholder survey. HortSci 55 Supplement:S75

Zhang H, Miles C, Ghimire S, Benedict C, Zasada I, DeVetter L (2019) Polyethylene and biodegradable plastic mulches improve growth, yield, and weed management in floricane red raspberry. Scientia Hort 250:371-379

Table 1. Herbicides tested in field experiments on newly planted blackberries in Fayetteville, AR and Clarksville, AR from 2021 to 2022.

Common name	Trade name	Application rate	Manufacturer	Manufacturer location	Manufacturer website
		g ai ha^{-1}			
Mesotrione	Callisto®	158	Syngenta Crop Protection, LLC	Greensboro, NC	https://www.syngenta-us.com/home.aspx
Flumioxazin	Chateau®	210	Valent U.S.A., LLC	San Ramon, CA	https://www.valent.com
Oryzalin	Surflan®	4483	United Phosphorous, Inc.	King of Prussia, PA	https://www.upl-ltd.com/us
S-metolachlor	Dual Magnum®	1597	Syngenta Crop Protection, LLC	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, Inc.	King of Prussia, PA	https://www.upl-ltd.com/us

https://doi.org/10.1017/wet.2024.95 Published online by Cambridge University Press

Table 2. Crop injury ratings of blackberry plots in response to preemergence herbicide treatments at Fayetteville, AR and Clarksville, AR at 7, 14, 28, 42, 56, and 84 days after treatment (DAT) in 2021.[a]

	Blackberry injury[b]									
	7 DAT		14 DAT		28 DAT		42 DAT	56 DAT	84 DAT	
Herbicide	MJS[c]	FRS[c]	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]Means were separated using Tukey's Honest Significant Difference at a α=0.05 significance level and means followed by the same letter are not significantly different. Means were compared by date (DAT).

[b]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.

[c]Abbreviations: MJS, Milo J. Shult – Fayetteville location; FRS, Fruit Research Station – Clarksville location.

Table 3. Blackberry heights in response to herbicide treatments for 2021 at Fayetteville, AR and Clarksville, AR at 7, 14, 28, 42, 56, and 84 DAT.

Herbicide	Blackberry plant height[b]											
	7 DAT[c]	14 DAT		28 DAT	42 DAT		56 DAT		84 DAT			
	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]Means were separated using Tukey's Honest Significant Difference at a α=0.05 significance level and means followed by the same letter are not significantly different.

[b]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.

[c]Abbreviations: DAT, days after treatment; MJS, Milo J. Shult – Fayetteville location; FRS, Fruit Research Station – Clarksville location.

https://doi.org/10.1017/wet.2024.95 Published online by Cambridge University Press

Table 4. Blackberry yield by harvest, initiated at Fayetteville, AR Jun 28, 2022, and Clarksville, AR Jun 20, 2022. Harvested twice a week and final harvests took place in Fayetteville, AR Jul 29, 2022, and Clarksville, AR Jul 21, 2022. Cumulative marketable, cull yields, and average berry weight for 2022 blackberry harvest.[a]

	Blackberry yield, by harvest									Cumulative blackberry yield		
Herbicide	1	2	3	4	5	6	7	8	9	Marketable[c]	Cull[d]	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 Honest Significant Difference at a α=0.05 significance level and means followed by the same letter are not significantly different. Means should be compared by date (DAT).

[b]Harvests reflect only marketable berry yields.

[c]Marketable yields were defined as ripe berries without blemish.

[d]Cull yields were defined as berries that did not meet marketable standards through damage or malformation.

https://doi.org/10.1017/wet.2024.95 Published online by Cambridge University Press

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

Herbicide	Postharvest fruit quality[b]							
	Harvest 2[a]	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 Honest Significant Difference at a α=0.05 significance level and means followed by the same letter are not significantly different. Means should be compared by date (DAT).

[b]Quality data were collected on a subset of harvest throughout the season. Harvests are indicated chronologically with harvests 2, 5, and 7 occurring on July 2, 12, and 19 or Jun 23, July 5, and 11 for Fayetteville and Clarksville, respectively.

https://doi.org/10.1017/wet.2024.95 Published online by Cambridge University Press