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Pearl millet hybrid tolerance and weed control with preemergence herbicides

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Research Article

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Acetochlor; atrazine; mesotrione; *S*-metolachlor; foxtail; *Setaria viridis* (L.) Beauv.; Palmer amaranth; *Amaranthus palmeri* S. Watson; Pearl millet; *Pennisetum glaucum*(L.)R. Br.

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Abstract

Weed management is a major challenge in pearl millet production. Limited herbicide options available for use with pearl millet further complicates weed control. To fill this knowledge gap, field experiments were conducted during the 2023 and 2024 growing seasons in Hays, Kansas, to investigate eight preemergence herbicides (labeled for use in sorghum production) for crop safety and weed control when applied to three pearl millet hybrids. Averaged across two growing seasons, *S*-metolachlor applied preemergence alone or in combination with atrazine, mesotrione, or atrazine + mesotrione resulted in >95% injury to all three pearl millet hybrids at 28 d after application (DAA). Visible injury with acetochlor + atrazine applied preemergence ranged from 50% to 96% among hybrids at 28 DAA. Atrazine or mesotrione applied alone or in combination were safe (<5% injury) on all hybrids. All tested preemergence herbicides provided effective (≥90%) control of Palmer amaranth at 28 DAA, except *S*-metolachlor, which provided 86% control. The greatest green foxtail control (≥99%) was achieved with mesotrione and acetochlor in combination with atrazine applied preemergence. All three hybrids recorded the highest grain yields (4,370 to 5,870 kg ha^{-1}) with atrazine and mesotrione applied separately, and when they were combined. These results suggested that atrazine, mesotrione, or a mixture of atrazine + mesotrione applied preemergence may be safely used for Palmer amaranth and green foxtail control with newly developed pearl millet hybrids.

Introduction

Pearl millet is one of the most important climate-resilient crops that can potentially sustain food and nutrition security in arid and semiarid regions (Perumal et al. 2024; Satyavathi et al. 2021). Around the world, pearl millet is the sixth most important cereal crop after rice (*Oryza sativa*), wheat (*Triticum aestivum* L.), maize (*Zea mays* L.), barley (*Hordeum vulgare* L.), and sorghum (*Sorghum bicolor* L.) (Prasad et al. 2017; Satyavathi et al. 2021). Pearl millet is a staple crop providing food, feed, and fuel for more than 90 million people around the world, particularly in Africa and India (Daduwal et al. 2024). Global pearl millet production in 2024 was 31 × 10^{8} kg, and India ranked first by producing 13 × 10^{8} kg, or approximately 43% of the total global production (USDA-FAS 2024). In contrast, millet production in the United States was 3189 × 10^{5} kg in 2024 (USDA-NASS 2025). Pearl millet is widely grown for grazing, hay, cover crops, feed, and fodder in the United States (Myers 2002). It is recognized as a potential forage and feed crop well-suited for double cropping in the United States (Wilson et al. 1996). Compared to other major cereals, pearl millet has high nutritional values for humans. It is a good source of carbohydrates, proteins (8% to 19%), fat (3% to 8%), and minerals (2.3 mg per 100 g), including iron; zinc; potassium; and phosphorus; and vitamins such as riboflavin, niacin, and thiamine (Satyavathi et al. 2021; Uppal et al. 2015). Pearl millet has strong potential to alleviate micronutrient deficiencies in developing countries and improve human nutrition and health (Rai et al. 2012).

Weed management poses a serious challenge in pearl millet production (Kumar et al. 2024). Pearl millet is a relatively poor competitor with weeds due to its slow growth early in the season, which can result in substantial yield losses (Cook et al. 2005). Therefore, early weed removal is critical to improve pearl millet competitiveness against weeds. The predominant weed species in the pearl millet growing region in the Central Great Plains include Palmer amaranth, redroot pigweed (*Amaranthus retroflexus* L.), kochia [*Bassia scoparia* (L.) A.J. Scott], green foxtail, yellow foxtail [*Setaria pumila* (Poir.) Roem. & Schult.], giant foxtail (*Setaria faberi* Herrm.), and johnsongrass [*Sorghum halepense* (L.) Pers.] (Kumar et al. 2024). Season-long interference from both grass and broadleaf weed species at various densities can reduce pearl millet grain yields by 16% to 94% (Balyan et al. 1993; Das and Yaduraju 1995; Sharma and Jain 2003).

Table 1. Preemergence herbicides tested on pearl millet hybrids.

Trade name	Common name	Rate	Adjuvant[a]	Manufacturer[b]
		g ae or ai ha^{-1}		
Atrazine 4L	Atrazine	2,240	–	Loveland
Dual II Magnum	*S*-metolachlor	1,740	–	Syngenta
Callisto	Mesotrione	210	COC	Syngenta
Bicep II Magnum	Atrazine + *S*-metolachlor	1,737 + 1,345	COC	Syngenta
Callisto Xtra	Atrazine + mesotrione	672 + 105	NIS	Syngenta
Degree Xtra	Acetochlor + atrazine	1,512 + 751	–	Bayer
Lumaz EZ	Atrazine + *S*-metolachlor + mesotrione	524 + 1,395 + 140	NIS	Syngenta
Coyote	*S*-metolachlor + mesotrione	1,872 + 185	NIS	UPL NA

[a]Adjuvants: COC, crop oil concentrate at 5 mL L^{-1}; NIS, nonionic surfactant at 2.5 mL L^{-1}.
[b]Manufacturer locations: Bayer CropScience, St. Louis, MO; Loveland Products, Inc., Greenville, MS; Syngenta Crop Protection, LLC, Greensboro, NC; UPL NA Inc., Cary, NC.

Previous studies have documented the effectiveness of various preemergence herbicides in controlling Palmer amaranth and green foxtail. For instance, Hay et al. (2019) reported 99% control of atrazine-resistant Palmer amaranth at 60 d after application (DAA) with acetochlor + atrazine applied preemergence to double-cropped grain sorghum in Kansas. Kohrt and Sprague (2017) reported 97% control of atrazine-resistant Palmer amaranth with preemergence applied atrazine + mesotrione when assessed 45 d after corn had been planted in Michigan. Currie and Geier (2016) reported ≥90% control of Palmer amaranth at 71 DAA with acetochlor + atrazine and *S*-metolachlor + atrazine + mesotrione applied preemergence to sorghum. Janak and Grichar (2016) reported 92% to 99% control of Palmer amaranth up to 109 d after a preemergence application of *S*-metolachlor + atrazine + mesotrione. Similarly, Armel et al. (2003) documented 85% to 91% control of another giant foxtail, *Setaria faberi* L., a closely related species, at 60 DAA in corn with preemergence-applied acetochlor + atrazine. Buhler (1991) reported 91% to 97% control of giant foxtail at 60 DAA with preemergence applied atrazine + metolachlor in chisel-plow or no-till corn.

Limited herbicide options for controlling annual grass weeds in pearl millet production is a significant constraint in developing effective chemical-based weed control strategies (Dowler and Wright 1995; Mishra 2015). The lack of preemergence or postemergence herbicides labeled for use on pearl millet is one of the major concerns for producers. Widespread evolution of herbicide-resistant weed biotypes across various regions further exacerbates the problem of weed control in pearl millet (Heap 2025). In addition, information on the performance of various preemergence herbicides for crop safety and weed control in pearl millet is lacking. Therefore, we initiated field studies to evaluate the effectiveness of different preemergence herbicides (labeled for use with sorghum) for crop safety and weed control in advanced pearl millet hybrids developed at Kansas State University. The main objectives for this study were to 1) assess the phytotoxicity of various preemergence herbicides on pearl millet hybrids, 2) evaluate the effectiveness of preemergence herbicides for weed control in pearl millet, and 3) determine the impacts of phytotoxicity and weed control on pearl millet grain yield.

Material and Methods

Pearl Millet Hybrids

The advanced pearl millet parental lines initially developed at Kansas State University Agricultural Research Center in Hays (KSU-ARCH) were used to develop pearl millet hybrids in the summer of 2022 and 2023 (Ramalingam et al. 2024; Serba et al. 2017). Three hybrids (Hyb1, ARCH-32A/ARCH-21R; Hyb2, ARCH-37A/ARCH-49R; and Hyb3, ARCH-41A/ARCH-70R) developed by the millet breeding program at KSU-ARCH were used in this study.

Field Experiment

Field studies were conducted in summer 2023 and 2024 at the KSU-ARCH. The soil type at the study site (38.86201°N, 99.33461°W) is Roxbury silt loam, moderately deep, well-drained with a silt loam texture, pH 7.6, and 2.1% organic matter. Information on various preemergence herbicides, their rates, and manufacturers is summarized in Table 1. A nontreated weedy check was included to enable the determination of the effects of preemergence herbicides and weed competition on the growth and yield of pearl millet hybrids. Mean monthly air temperatures and total monthly precipitation during the study periods are summarized in Table 2 and were recorded from the KSU Mesonet weather station (https://mesonet.kstate.edu). The study sites were historically under a conventionally tilled sorghum-fallow rotation for >5 y and had a uniform infestation of Palmer amaranth and green foxtail. Each year, the study site was tilled, and a fine seedbed was prepared before the pearl millet hybrids were planted. Each hybrid was planted at a density of 172,149 seeds ha^{-1} in rows spaced 76 cm apart on June 16th in both years. All selected preemergence herbicides were applied immediately after pearl millet hybrids had been planted using a CO_2-operated backpack sprayer equipped with flat-fan 110015XR nozzles (TeeJet Technologies, Glendale Heights, IL). The sprayer was calibrated to deliver a spray solution at a rate of 140 L ha^{-1}, maintaining a consistent pressure of 276 kPa. The amount and timing of precipitation relative to preemergence herbicide applications differed in both years (Table 2). Precipitation of 1 to 2 cm is generally required for soil-applied herbicides to become more readily available to germinating and emerging weed seedlings (Parker 1966). In the 2023 growing season preemergence herbicides were applied immediately after pearl millet was planted, and 2.5 cm of rain fell on the same day. A supplemental irrigation of 2.5 cm was applied using a sprinkler irrigation system on June 17, 2024. Total monthly precipitation ranged from 17 to 95 mm in 2023 and 6 to 111 mm in 2024 during the experimental periods (Table 2). Mean monthly air temperature ranged from 14 to 26 C in 2023 and 17 to 26 C in 2024 during the experimental periods (Table 2). Treatments were laid out in a split-plot (each hybrid as a main plot and preemergence herbicide as a subplot), randomized complete block design with three replications (each plot was 1.5 m wide and 3 m long). All standard agronomic practices for pearl millet production, including time of planting, seeding rate, and nutrient and pest management were followed as recommended by an agronomist at KSU (Perumal et al. 2024).

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Table 2. Monthly average air temperature and monthly total precipitation at Kansas State University Agricultural Research Center during the 2023 and 2024 growing seasons.

Month	Average temperature			Total precipitation		
	2023	2024	30-yr average	2023	2024	30-yr average
	——C——			——mm——		
May	19	18	17	79	45	83
June	23	26	23	88	111	72
July	26	25	26	50	76	100
August	26	23	25	95	107	77
September	22	17	20	17	22	52
October	14	17	13	19	6	40

Data Collection

Pearl millet stand counts were determined in each plot at 7 and 14 DAA of preemergence herbicides by counting the number of plants per meter of row. Percent visible injury on a scale of 0% to 100% (where 0% = no injury and 100% = complete death) was assessed at 7, 14, 28, and 56 DAA. Injury was observed as stand loss, plant stunting, leaf chlorosis, bleaching, and necrosis of leaves. Similarly, visual control ratings of Palmer amaranth and green foxtails were collected at 7, 14, 28, and 56 DAA. Individual densities of Palmer amaranth and green foxtail were also recorded at 28 and 56 DAA in a 1-m^2 quadrat placed in the center of each plot. Plants of each pearl millet hybrid were manually harvested from a 1-m row from the middle two rows of each plot at maturity. Harvested plants were dried in an oven at 65 C for 7 d, and grain heads were threshed using a millet thresher (BT-14 Single Plant Belt Thresher; ALMACO, Nevada, IA) and weighed to estimate the grain yield (in kilograms per hectare; kg ha^{-1}) of each pearl millet hybrid.

Statistical Analyses

Due to nonsignificant year-by-treatment interaction ($P = 0.472$), all data were pooled across both years. Pooled data were checked for ANOVA assumptions using the UNIVARIATE and MIXED procedures with SAS software (v.9.4; SAS Institute Inc., Cary, NC). Data on percent visible injury, weed control, and weed density were log-transformed to improve the normality of the residuals and homogeneity of variance; however, back-transformed data were presented with mean separation based on the transformed data. Pooled data were subjected to ANOVA using the GLIMMIX procedure with SAS software to test the significance of the fixed effects. The fixed effects in ANOVA were preemergence herbicides, pearl millet hybrids, and their interactions. Replications and all interactions involving replication were considered random effects. Means were separated using Fisher's protected LSD test at $\alpha = 0.05$.

Results and Discussion

Percent Visible Injury

A significant interaction ($P = 0.0215$) between pearl millet hybrids and tested preemergence herbicides was observed for percent of visible injury (Table 3). Averaged across both years, atrazine or mesotrione applied preemergence either alone or in combination produced the least injury (3% or less) to the three hybrids at 28 and 56 DAA (Table 3). However, visible injury to pearl millet at 28 DAA ranged from 50% to 96% with acetochlor + atrazine applied preemergence. Furthermore, visible injury ranging from 33% to 92% was observed at 56 DAA with acetochlor + atrazine applied preemergence. Data on pearl millet treated with acetochlor alone or in combination with atrazine applied preemergence is lacking. However, Geier et al. (2009) reported sorghum stand reduction and stunting of 23% to 54% with acetochlor. Among all tested herbicides, *S*-metolachlor applied alone or in combination with atrazine or atrazine + mesotrione applied preemergence was highly injurious (90% to 97%) to all three hybrids (Table 3). Chloroacetanilide herbicides, including acetochlor and *S*-metolachlor, are known to cause significant phototoxicity and reduce yields of proso millet (*Panicum miliaceum* L.) (Jia et al. 2022). Dowler and Wright (1995) reported 95% to 100% injury to pearl millet with metolachlor applied preemergence in Florida and Georgia. Furthermore, Courrier et al. (2010) reported a significant reduction in plant density and yield of grain and forage pearl millet with *S*-metolachlor/benoxacor applied preemergence in Canada. Results from that study indicate that preemergence applied *S*-metolachlor alone or *S*-metolachlor containing herbicide premixes are injurious to pearl millet (Courrier et al., 2010).

Weed Control and Density

Palmer Amaranth Control. In general, all preemergence herbicides tested were effective in controlling Palmer amaranth in both growing seasons. Averaged among hybrids, mesotrione applied preemergence provided 97% control of Palmer amaranth throughout the growing season, a percentage that did not differ from that of atrazine + mesotrione (Table 4). These results are consistent with those reported by Kohrt and Sprague (2017) that preemergence-applied atrazine + mesotrione resulted in 97% control of atrazine-resistant Palmer amaranth at 45 d after corn planting in Michigan. In the current study, atrazine alone applied preemergence resulted in ≥91% control of Palmer amaranth at 56 DAA (Table 4). Hay et al. (2019) reported only 72% control of atrazine-resistant Palmer amaranth at 60 DAA after atrazine was applied alone preemergence. It is important to note that the atrazine rate tested in the current study was 2,260 g ha^{-1}, compared with 1,680 g ha^{-1} used in tests by Hay et al. (2019). These results are consistent with those reported by Starkey (2015) that >90% control of Palmer amaranth was observed at 60 DAA with an application of mesotrione.

Green Foxtail Control. Consistent with the results for Palmer amaranth, most of the tested preemergence herbicides also effectively controlled green foxtail in both growing seasons. For instance, atrazine applied preemergence alone or combined with mesotrione provided 97% to 100% control of green foxtail (Table 4). Furthermore, atrazine applied preemergence either alone or in combination with *S*-metolachlor or *S*-metolachlor + mesotrione resulted in 93% to 95% control of green foxtail. These results are consistent with those reported by Buhler (1991) that 91% to 97% control of giant foxtail was observed at 60 DAA with preemergence-applied atrazine + metolachlor in chisel-plow or no-till corn. Results from the current study are contrary to those reported by Currie and Geier (2016) that only 75% to 83% control of green foxtail was observed at 71 DAA with acetochlor + atrazine and *S*-metolachlor + atrazine + mesotrione applied preemergence to grain sorghum.

Weed Density

Palmer Amaranth Density. Consistent with observations of percent control, all tested preemergence herbicides produced a significant

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Table 3. Percent visible injury to three pearl millet hybrids treated with various preemergence herbicides evaluated at 14, 28, and 56 d after application averaged across the 2023 and 2024 growing seasons.[a,b]

		14 DAA			28 DAA			56 DAA		
Herbicide	Rate	Hyb1	Hyb2	Hyb3	Hyb1	Hyb2	Hyb3	Hyb1	Hyb2	Hyb3
	ai ha^{-1}	%								
Atrazine	2,240	3 bA	4 cA	2 cA	2 bA	3 cA	3 cA	1 bA	2 cA	1 cA
S-metolachlor	1,740	93 aA	90 aA	95 aA	95 aA	97 aA	97 aA	97 aA	97 aA	97 aA
Mesotrione	210	2 bA	2 cA	3 cA	3 bA	2 cA	2 cA	2 bA	2 cA	2 cA
Atrazine + *S*-metolachlor	17,37 + 1,345	97 aA	93 aA	97 aA	97 aA	97 aA	98 aA	97 aA	98 aA	98 aA
Atrazine + mesotrione	672 + 105	2 bA	3 cA	2 cA	4 bA	4 cA	3 cA	1 bA	1 cA	1 cA
Acetochlor + atrazine	1,512 + 751	96 aA	72 bB	63 bC	96 aA	67 bB	50 bC	92 aA	43 bB	33 bB
Atrazine + *S*-metolachlor + Mesotrione	524 + 1,395 + 140	93 aA	97 aA	93 aA	97 aA	96 aA	97 aA	98 aA	98 aA	97 aA
S-metolachlor + mesotrione	1,872 + 185	93 aA	90 aA	91 aA	98 aA	97 aA	97 aA	98 aA	98 aA	98 aA

[a]Abbreviations: DAA, days after application; Hyb1, pearl millet hybrid ARCH-32A/ARCH-21R; Hyb2, pearl millet hybrid ARCH-37A/ARCH-49R; Hyb3, pearl millet hybrid ARCH-41A/ARCH-70R.
[b]Means following lowercase letters within each column indicate no statistical difference according to Fisher's protected LSD test (α = 0.05); however, means following uppercase letters within each row indicate no statistical difference according to Fisher's protected LSD test (α = 0.05).

Table 4. Percent visual control of Palmer amaranth and green foxtail at 14, 28, and 56 d after application of preemergence herbicides during the 2023 and 2024 growing seasons.[a–c]

		Palmer amaranth			Green foxtail		
Herbicide	Rate	14 DAA	28 DAA	56 DAA	14 DAA	28 DAA	56 DAA
	g ae or ai ha^{-1}	% control					
Atrazine	2,240	97 b	92 b	91 b	99 a	98 ab	97 b
S-metolachlor	1,740	92 c	87 c	86 c	96 b	93 c	93 d
Mesotrione	210	99 a	98 a	97 a	100 a	100 a	98 ab
Atrazine + *S*-metolachlor	1,737 + 1,345	98 ab	95 ab	91 b	96 b	95 b	93 d
Atrazine + mesotrione	672 + 105	99 a	96 ab	95 ab	100 a	100 a	98 ab
Acetochlor + atrazine	1,512 + 751	99 a	99 a	99 a	100 a	99 a	100 a
Atrazine + *S*-metolachlor + mesotrione	524 + 1,395 + 140	98 ab	92 b	92 b	100 a	98 ab	97 b
S-metolachlor + mesotrione	1,872 + 185	97 b	93 b	92 b	95 b	96 b	95 c

[a]Abbreviation: DAA, days after application.
[b]Visual ratings are averaged across three pearl millet hybrids.
[c]Means following lowercase letters within each column indicate no statistical difference according to Fisher's protected LSD test (α = 0.05).

reduction in Palmer amaranth density compared with the nontreated weedy check. For instance, when observed at 28 DAA, Palmer amaranth density was just 1 to 2 plants m^{-2} compared with 14 plants m^{-2} in the nontreated weedy check after mesotrione and atrazine + mesotrione had been applied preemergence (Table 5). Similarly, atrazine was equally effective, in that Palmer amaranth density was reduced to 5 plants m^{-2} compared with the nontreated weedy check when observed at 28 DAA (Table 5). When assessed at 56 DAA, compared with the nontreated weedy check (15 plants m^{-2}) the lowest Palmer amaranth density (1 plant m^{-2}) was observed following mesotrione applied preemergence, which wasn't much different from an application of atrazine + mesotrione, for which density was 3 plants m^{-2}. Furthermore, Palmer amaranth density at 56 d after atrazine had been applied was 5 plants m^{-2} (Table 5). Those results are consistent with those reported by Hay et al. (2019) that in a double-cropped sorghum study, a significant reduction in atrazine-resistant Palmer amaranth density (1.45 plants m^{-2}) occurred when atrazine was applied preemergence compared with the nontreated weedy check, which had 10.9 plants m^{-2}.

Green Foxtail Density. Consistent with visual observations of control, green foxtail density at 28 and 56 DAA was significantly reduced with all preemergence herbicides compared with the nontreated weedy check. For instance, mesotrione, atrazine + mesotrione, and atrazine + *S*-metolachlor + mesotrione applied preemergence provided complete control of green foxtail density at 28 DAA. Compared with the nontreated weedy check at 56 DAA when 10 plants m^{-2} were observed, green foxtail density was just 2 plants m^{-2} after preemergence applications of atrazine or mesotrione alone, and atrazine + mesotrione (Table 5).

Grain Yield

Grain yields among all three pearl millet hybrids were consistent with pearl millet injury and weed control responses to the preemergence herbicides. Season-long weed interference in the nontreated check resulted in grain yields of 3,420 to 3,650 kg ha^{-1} among the three hybrids. The highest grain yield among the hybrids (5,250 to 5,870 kg ha^{-1}) was measured after the atrazine + mesotrione preemergence treatment (Table 6). Grain yields from all three hybrids ranged from 4,370 to 4,690 kg ha^{-1} after atrazine was applied preemergence, and 5,050 to 5,250 kg ha^{-1} after mesotrione alone was applied preemergence (Table 6). Grain yield (1,530 to 3,830 kg ha^{-1}) was variable among the three tested hybrids. Consistent with visible observations of injury, Hybrid grain yields were significantly reduced (110 to 300 kg ha^{-1}) after all preemergence treatments containing *S*-metolachlor (Table 6).

Practical Implications

This study provides key insights into the tolerance of pearl millet hybrids to various preemergence herbicides (labeled for use in grain sorghum production) and their effectiveness on weed

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Table 5. Palmer amaranth and green foxtail density at 28 and 56 d after application of preemergence herbicides averaged across three pearl millet hybrids during the 2023 and 2024 growing seasons.[a,b]

	Rate	Palmer amaranth	Green foxtail	Palmer amaranth	Green foxtail
		28 DAA		56 DAA	
	g ha^{-1}	plants m^{-2}			
Atrazine	2,240	5 bc	1 c	5 b	2 cd
S-metolachlor	1,740	7 b	3 b	4 bc	3 c
Mesotrione	210	1 e	0 cd	1 e	2 cd
Atrazine + *S*-metolachlor	1,737 + 1,345	5 bc	2 bc	4 bc	3 c
Atrazine + mesotrione	672 + 105	2 e	0 cd	3 cd	2 cd
Acetochlor + atrazine	1,512 + 751	1 e	1 c	3 cd	0 d
Atrazine + *S*-metolachlor + mesotrione	524 + 1395 + 140	3 de	0 cd	3 cd	1 d
S-metolachlor + mesotrione	1,872 + 185	4 cd	4 b	2 de	5 b
Nontreated	–	14 a	7 a	15 a	10 a

[a]Abbreviation: DAA, days after application.
[b]Means following lowercase letters within each column indicate no statistical difference according to Fisher's protected LSD test ($\alpha = 0.05$).

Table 6. Grain yield of pearl millet hybrids under various preemergence herbicides averaged across the 2023 and 2024 growing seasons.[a,b]

Herbicide	Rate	Hyb1	Hyb2	Hyb3
	g ae or ai ha^{-1}	kg ha^{-1}		
Atrazine	2,240	4,370 bA	4,480 bA	4,690 cA
S-metolachlor	1,740	190 eA	110 dA	120 eA
Mesotrione	210	5,050 aA	5,250 aA	5,150 bA
Atrazine + *S*-metolachlor	1,737 + 1,345	170 eA	150 dA	180 eA
Atrazine + mesotrione	672 + 105	5,250 aB	5,670 aA	5,870 aA
Acetochlor + atrazine	1,512 + 751	1,530 dB	3,210 cA	3,830 dA
Atrazine + *S*-metolachlor + mesotrione	524 + 1,395 + 140	170 eA	300 dA	160 eA
S-metolachlor + mesotrione	1,872 + 185	1,200 eA	150 dA	150 eA
Nontreated	–	3,570 cA	3,420 cA	3,650 dA

[a]Abbreviations: Hyb1, ARCH-32A/ARCH-21R pearl millet hybrid; Hyb2, ARCH-37A/ARCH-49R pearl millet hybrid; Hyb3, ARCH-41A/ARCH-70R pearl millet hybrid.
[b]Means following lowercase letters within each hybrid indicate no statistical difference according to Fisher's protected LSD test ($\alpha = 0.05$), whereas means following uppercase letters within each herbicide treatment indicate no statistical difference according to Fisher's protected LSD test ($\alpha = 0.05$).

control. Results identified that atrazine or mesotrione applied preemergence either alone or in combination were safest on all three hybrids and provided excellent control (>95%) of Palmer amaranth and green foxtail throughout the growing season. In contrast, *S*-metolachlor applied preemergence either alone or in combination with atrazine, mesotrione, or atrazine + mesotrione produced significant injury (93% to 97%) to all three pearl millet hybrids. The preemergence herbicides tested in this study are currently not labeled for use on pearl millet and information gained from this study may help in furthering the registration of these preemergence herbicides for use in pearl millet production. A variable injury response of pearl millet hybrids to acetochlor + atrazine applied preemergence further suggests that hybrid selection may play a crucial role in herbicide tolerance. These results provide effective preemergence herbicide options for pearl millet; however, effective postemergence herbicide options for crop safety and weed control in pearl millet crops are further warranted. In this context, Tugoo et al. (2025) have recently reported a reduced sensitivity to postemergence applied nicosulfuron and imazamox in advanced pearl millet parental lines. These advanced lines may be useful in developing elite pearl millet hybrids that are resistant to herbicides that inhibit acetolactate synthase, which can further allow postemergence applications of imazamox and nicosulfuron for in-season grass weed control.

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