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Nomenclature:
Palmer amaranth, *Amaranthus palmeri* (S.) Wats; Austrian winterpea, *Pisum sativum* L.; cereal rye, *Secale cereale* L.; corn, *Zea mays* L.; cotton, *Gossypium hirsutum* L.; hairy vetch, *Vicia villosa* Roth; rice, *Oryza sativa* L.; soybean, *Glycine max* (L.) Merr.; winter wheat, *Triticum aestivum* L.

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Impact of cover crops on furrow-irrigated rice and Palmer amaranth (*Amaranthus palmeri*) emergence

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Abstract

As mid-southern U.S. rice producers continue to adopt furrow-irrigated rice production practices, supplementary management efforts will be vital in combating Palmer amaranth due to the extended germination period provided by the lack of a continual flood. Previous research has revealed the ability of cover crops to suppress Palmer amaranth emergence in corn, cotton, and soybean production systems; however, research on cover crop weed control efficacy in rice production is scarce. Therefore, trials were initiated in Arkansas in 2022 and 2023 to evaluate the effect of cover crops across five site-years on rice emergence, groundcover, grain yield, and total Palmer amaranth emergence. The cover crops evaluated were cereal rye, winter wheat, Austrian winterpea, and hairy vetch. Cover crop biomass accumulation varied by site-year, ranging from 430 to 3,440 kg ha^{-1}, with cereal rye generally being the most consistent producer of high-quantity biomass across site-years. Rice growth and development were generally unaffected by cover crop establishment; however, all cover crops reduced rice emergence by up to 30% in one site-year. Rice groundcover was reduced by 13% from cereal rye in one site-year 2 wk before heading but cover crops did not affect rough rice grain yield in any of the site-years. Palmer amaranth emergence was reduced by 19% and 35% with cereal rye relative to the absence of a cover crop when rice was planted in April in Marianna, and May in Fayetteville, respectively. In most trials, Palmer amaranth emergence was not reduced by a cereal cover crop. In most instances, legume cover crops resulted in less Palmer amaranth emergence than without a cover crop. Based on these results, legume cover crops appear to provide some suppression of Palmer amaranth emergence in furrow-irrigated rice while having a minimal effect on rice establishment and yield.

Introduction

In 2022, furrow-irrigated rice accounted for 18% of rice hectares in Arkansas (Hardke et al. 2022). The implementation of furrow irrigation involves drill-seeding rice on raised beds similar to methods used in corn, soybean, and cotton production in the mid-southern United States (Chlapecka et al. 2021; Norsworthy et al. 2011b). Unlike flood-irrigated rice, which is typically flooded after it reaches the V5 growth stage, furrow-irrigated rice involves administering water through the furrows via polyethylene pipe and using gravity to move it away from the higher end of the field (Bagavathiannan et al. 2011; Counce et al. 2000). Although producing furrow-irrigated rice can be advantageous over a flooded rice system, grain yields in a flooded rice system generally exceed those of furrow-irrigated rice (Vories et al. 2002). With effectively managed furrow-irrigated rice, growers can decrease labor and input costs depending on soil texture, topography, and other climatic barriers by using up to 23% less water relative to a delayed-flood system (Chlapecka et al. 2021; Massey et al. 2022).

The water management practices associated with different rice production systems can also significantly influence the weed spectrum present in a field (Kraehmer et al. 2016). In a delayed-flood system, terrestrial weed emergence typically occurs before flooding due to the anaerobic conditions acting as a weed suppression mechanism. Still, the intrinsic nature of furrow-irrigated rice enables weed emergence throughout most of the growing season due to a consistently wet environment (Bagavathiannan et al. 2011). In flooded rice, barnyardgrass [*Echinochloa crus-galli* (L.) P. Beauv.], sedges (*Cyperus* spp.), and weedy rice (*Oyrza sativa* L.) are among the most problematic weed species (Butts et al. 2022). However, furrow-irrigated rice creates a favorable environment for traditional upland crop weeds, such as Palmer amaranth, to flourish throughout the growing season (Beesinger et al. 2022; Norsworthy et al. 2011b).

Rice, like many other agronomic crops, can be a host for numerous broadleaf and grass species. In 2020, survey respondents indicated that Palmer amaranth was the second and fifth most troublesome weed species in furrow- and flood-irrigated rice, respectively, with barnyardgrass holding the top position in both systems (Butts et al. 2022). The increased adoption of furrow irrigation enhances potential problems with Palmer amaranth due to the extended emergence period the system provides (Norsworthy et al. 2008). While information is scarce on the effect of Palmer amaranth on rice yields, the competitive nature of the weed has been reported in cotton and soybean production in the mid-southern United States because it ranks among the most troublesome weeds in both crops (Klingaman and Oliver 1994; Van Wychen 2022). With an increasing number of hectares being used for furrow-irrigated rice and the innate combative character of Palmer amaranth, a dire demand exists for methods to control the weed in rice production.

Herbicides typically serve as the foundation of a weed control program due to their ease of application and general effectiveness against problematic weeds (Norsworthy et al. 2012; Priess et al. 2022). Unfortunately, Palmer amaranth has evolved resistance to many herbicide sites of action that are typically applied to rice, meaning a creative weed management program that includes multiple control methods is vital for successful weed control (Norsworthy et al. 2008, 2016). Chemical, cultural, biological, and physical control practices are key factors in an integrated weed management program, which supports the suggested zero-tolerance threshold associated with Palmer amaranth management (Norsworthy et al. 2014; UC IPM 2020). Broadening weed control practices is important because repeated herbicide use poses the potential to become less effective due to the increasing incidences of herbicide-resistant Palmer amaranth (Norsworthy et al. 2012). Additionally, even under favorable conditions and timely applications, herbicides rarely provide complete weed control (Bagavathiannan and Norsworthy 2012). Weed control options in furrow-irrigated rice, outside the scope of herbicide chemistries, need to be identified to reduce the risk of herbicide resistance in troublesome weed species.

One way to diversify a weed management program is through the use of cover crops. Implementing cultural control methods such as planting cover crops helps to minimize reliance on herbicides and shift the focal point to reducing weed emergence from the soil seedbank (Shekhawat et al. 2020). Winter-annual cover crop usage was initially targeted for improving soil health and preventing surface runoff; however, potential weed control benefits from cover crops have been demonstrated in recent years (Krutz et al. 2009; Norsworthy et al. 2011a; Price et al. 2012). In cotton and soybean production systems, cover crops can assist in reducing Palmer amaranth emergence (DeVore et al. 2012; Palhano et al. 2018).

In Arkansas, cereal rye and winter wheat can reduce Palmer amaranth emergence by up to 83% and 78%, respectively, compared to treatments that omit the use of cover crops (Palhano et al. 2018). The chemical and physical characteristics of cover crop residues reduce weed seed germination (Liebl et al. 1992; Moore et al. 1994). Furthermore, some types of cereal rye can lower Palmer amaranth germination and development through the innate ability to produce allelopathic chemicals such as 2,4-dihydroxy-1,4(2H)-benzoxazine-3-1 and 2,3-benzoxazolinone, during residue decomposition (Burgos and Talbert 2000; Webster et al. 2013). Legume cover crops such as crimson clover (*Trifolium incarnatum* L.) and hairy vetch can also reduce weed emergence through the production of allelopathic compounds (Fisk et al. 2001; White et al. 1989). While cover crop usage in rice production is novel, the cultural practice could prove beneficial in providing early-season suppression of Palmer amaranth, potentially eliminating preemergence herbicide applications and reducing input costs. Therefore, the objective of this study was to determine the best cover crop for suppression of Palmer amaranth while having the least effect on rice.

Materials and Methods

Influence of Cover Crops on Palmer Amaranth Suppression and Rice Development

Field experiments were initiated at the Lon Mann Cotton Research Station in Marianna, AR (34.72567°N, 90.73498°W), in 2022, and the Milo J. Shult Research and Extension Center in Fayetteville, AR (36.09344°N, 94.17449°W), in 2022 and 2023. One trial for a given experiment focused on cover crop biomass, rice stand establishment, rice groundcover, and rough rice grain yield assessments while being kept free of all weeds. An identical, adjacent trial with the same experimental setup focused on the suppression of Palmer amaranth emergence. In the fall, before each rice growing season, the ground was tilled and hipped into 96-cm spaced and 91-cm spaced beds in Marianna and Fayetteville, respectively. The soil at the Marianna location was a Convent silt loam (course-silty, mixed, superactive, nonacid, thermic Fluvaquentic Endoaquepts) consisting of 9% sand, 80% silt, 11% clay, and 1.8% organic matter with a pH of 6.5. In Fayetteville, the soil was a Leaf silt loam (fine, mixed, active, thermic Typic Albaquults) consisting of 18% sand, 69% silt, 13% clay, and 1.6% organic matter, with a pH of 6.6. The experiments were conducted as a randomized complete block design with five monoculture cover crop treatments, each replicated four times.

In the fall, plots were drill-seeded with cover crops on a 19-cm spacing, which included cereal rye, wheat, Austrian winterpea, and hairy vetch. A control plot with no cover crop planted was included for comparison. Cereal rye, wheat, Austrian winterpea, and hairy vetch were sown at 67, 67, 50, and 17 kg ha^{-1}, respectively (Roberts 2021). At all rice plantings, a hybrid, long-grain rice cultivar 'RT 7321FP" (RiceTec Inc., Alvin, TX) was planted at 36 seeds m^{-1} of row at a 1-cm depth with 19 cm between rows. In 2022, rice was planted in separate experiments on April 22 and May 3 in Fayetteville, and an additional site in Marianna on April 27. In 2023, rice was planted on April 15 and May 3 in separate experiments in Fayetteville. In total, this experiment consisted of five site-years (Table 1). Plot dimensions were 3.9 m wide (four beds) by 5.2 m long in Marianna, and 3.7 m wide (four beds) by 5.2 m long in Fayetteville. A 0.9-m alley was placed between blocks. All herbicides, including over-sprays, were applied using a CO_2-pressurized backpack sprayer calibrated to deliver 140 L ha^{-1} at 276 kPa using four AIXR 110015 nozzles (TeeJet Technologies, Glendale Heights, IL) at 4.8 km h^{-1}. The soil for each trial was amended for fertility before planting based on soil test values

Table 1. List of dates for cover crop planting and termination and rice planting for each site-year.[a]

Year	Location	Cover crop planting	Cover crop termination	Rice planting
2022	Fayetteville	October 14, 2021	March 28	April 22
2022	Fayetteville	October 14, 2021	April 26	May 13
2022	Marianna	October 20, 2021	April 4	April 27
2023	Fayetteville	November 3, 2022	April 3	April 15
2023	Fayetteville	November 3, 2022	April 14	May 3

[a]Calendar year that the cover crop was terminated and rice was planted.

provided by the Marianna Soil Test Laboratory. Nitrogen, as urea (460 g N kg^{-1}), was applied at 135 kg N ha^{-1} in three separate applications at 2-wk intervals beginning at the V5 stage of rice.

Two weeks before each rice planting and at planting, each trial received an application of glyphosate at 1,260 g ae ha^{-1} for cover crop termination. Clomazone at 336 g ai ha^{-1} was broadcast-applied to all experiments on the day of rice planting for residual control of annual grasses. Aboveground cover crop biomass was collected from two 0.5-m^2 quadrats within the center two rows of each plot before planting rice. All harvested aboveground biomass was placed in an oven at 66 C for 2 wk, dried to constant mass, and then weighed. Seven days after rice emergence, rice plants in two 1-m sections of row were counted in each plot. Singular images (in red-green-blue) of the experiment were captured at 40 m above the crop canopy by an unmanned aerial system (DJI Mavic 2; DJI Technology Co., Nanshan, Shenzhen, China) 2 wk before heading and used to determine rice groundcover based on green pixel counts using Field Analyzer (Green Research Services, Fayetteville, AR).

An earlier greenhouse experiment confirmed that propanil and thiobencarb do not affect Palmer amaranth emergence (personal observations). Hence, propanil (STAM; UPL, King of Prussia, PA) was applied approximately three times during the 5 wk following rice emergence in the experiment in which Palmer amaranth density was quantified. After rice planting, two 1-m^2 quadrats were established in each plot, allowing Palmer amaranth plants to be counted weekly and removed 5 wk after rice emergence. The yield assessment portion of the experiment relied on applications of fenoxaprop-p-ethyl (Ricestar® HT; Gowan Co., Yuma, AZ) and florpyrauxifen-benzyl (Loyant®; Corteva Agriscience, Indianapolis, IN), as well as hand-weeding, to keep the experimental area weed-free throughout the growing season. After the rice reached maturity, the center two rows of each four-row plot were harvested using an 8-XP plot combine (Kincaid, Haven, KS) with a header width of 1.8 m. The yields collected from each plot were adjusted to 12% moisture.

Data Analysis

Data were analyzed using JMP Pro software (v. 17.0; SAS Institute Inc, Cary, NC). Data were assessed for normality using Shapiro-Wilk tests and equal variance by testing the residuals in the distribution platform with JMP software. Data that did not satisfy normal distribution and equal variance assumptions were analyzed using the GLIMMIX procedure in JMP. After the residuals failed to violate the Shapiro-Wilk and Levene tests, cover crop biomass, rice stand, ground coverage, and yield were analyzed using a Gaussian or normal distribution, whereas Palmer amaranth count data assumed a Poisson distribution (Gbur et al. 2012). All data were subjected to ANOVA to evaluate the main effect of cover crop, and means were separated using Fisher's protected LSD at value of $\alpha = 0.05$. Normally distributed data were analyzed within JMP Pro using the fit-model platform, and Palmer amaranth count data were analyzed using the generalized linear mixed model add-in with a Poisson distribution (Gbur et al. 2012). Site was analyzed separately due to differences in weed density between the experimental locations.

Results and Discussion

Cover Crop Biomass

Cover crop biomass differed by cover crop treatment in two of the five site-years, and dry biomass ranged from 430 to 3,440 kg ha^{-1} across all studies (Table 2), which is similar to the range of biomass that Wiggins et al. (2017) observed with similar cover crop treatments. In 2022, cereal rye produced 2,680 kg ha^{-1} of biomass, which was greater than that of Austrian winterpea and hairy vetch at 430 and 1,310 kg ha^{-1}, respectively, at Marianna. Similarly, in 2023, biomass accumulation of Austrian winterpea (1,080 kg ha^{-1}) and hairy vetch (1,070 kg ha^{-1}) was less than that of cereal rye (1,560 kg ha^{-1}) at Fayetteville of rice planted in April. Previous literature has shown that cereal cover crops, including cereal rye and winter wheat, produce greater aboveground biomass relative to legume cover crops such as hairy vetch, Austrian winterpea, and crimson clover (Daniel et al. 2019; Schulz et al. 2013).

Cereal rye produced more biomass than any other cover crop at the Marianna location in 2022, and in all other site-years, no cover crop produced more biomass than cereal rye (Table 2), creating a favorable environment for suppression of Palmer amaranth (Norsworthy et al. 2011a). These results are similar to findings reported by Wiggins et al. (2017), who also determined that cereal rye provided the greatest quantity of biomass. However, the extreme variability associated with cover crop biomass accumulation has been documented over several years and soil textures, indicating that the weed control efficacy is potentially less consistent in the absence of herbicides (Norsworthy et al. 2011a; Palhano et al. 2018). In three out of the five trials conducted, no differences in biomass production were observed among cover crops. In general, cover crop biomass was highly variable among trials, which could be attributed to the timing of cover crop planting, differences in heat unit accumulation in the spring, and cumulative precipitation (Grint et al. 2022; Mirsky et al. 2011; Wilson et al. 2013). As a result, cover crop biomass production and subsequent efficacy in this region should be further evaluated, considering the growth and development can be dependent upon location (Schomberg et al. 2006).

Rice Density

In four of the five site-years for the experiment, the main effect of cover crop did not influence rice establishment 7 d after emergence relative to the no cover crop treatment ($P > 0.05$) (Table 2), indicating that rice emergence is generally uninterrupted by the cover crops that were evaluated. Although in one trial, rice stand was reduced by 25%, 22%, 30%, and 22% relative to the no-cover-crop treatment with cereal rye, wheat, Austrian winterpea, and hairy vetch, respectively. Previous literature has documented that cover crops with high biomass have the potential to negatively affect planting, subsequently affecting crop uniformity and crop development (Kornecki et al. 2009; Schulz et al. 2013). In general, the cover crops evaluated in this study had minimal effect on rice emergence and establishment.

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Table 2. Influence of cover crop within five site-years on cover crop aboveground biomass, rice density, relative rice groundcover, relative grain yield, and Palmer amaranth density.[a]

Cover crop	Marianna April 2022	Fayetteville April 2022	Fayetteville May 2022	Fayetteville April 2023	Fayetteville May 2023
			Biomass kg ha^{-1}		
Cereal rye	2,680 a	1,580	3,440	1,560 a	2,790
Wheat	1,160 b	1,480	2,040	1,430 ab	2,690
Austrian winterpea	430 b	1,420	2,890	1,080 b	1,770
Hairy vetch	1,310 b	780	2,980	1,070 b	1,570
P-value	0.0025	0.1546	0.1839	0.0332	0.0593
			Rice density no. m^{-1} row		
None	23	36 a	23	19	21
Cereal rye	23	27 b	21	17	19
Wheat	23	28 b	19	20	19
Austrian winterpea	20	25 b	19	16	25
Hairy vetch	22	28 b	15	19	25
P-value	0.6900	0.0296	0.3025	0.6440	0.1130
			Relative groundcover % of no cover crop		
Cereal rye	102	98	93	87 b	96
Wheat	102	96	95	100 a	98
Austrian winterpea	101	100	100	97 a	99
Hairy vetch	101	103	101	99 a	98
P-value	0.9587	0.4317	0.1008	0.02310	0.1090
			Relative grain yield % of no cover crop		
Cereal rye	100	96	92	97	89
Wheat	103	103	95	95	97
Austrian winterpea	97	117	99	118	93
Hairy vetch	93	114	102	114	95
P-value	0.6475	0.1217	0.5481	0.0613	0.7590
			Total Palmer amaranth emerged no. m^{-2}		
None	52 a	18 c	42 bc	2.5 ab	17 a
Cereal rye	42 b	27 b	34 c	2.2 a	11 bc
Wheat	52 a	19 c	38 c	1.6 a	15 ab
Austrian winterpea	36 b	37 a	57 a	1.6 ab	3 d
Hairy vetch	55 a	30 ab	52 ab	1.0 b	10 c
P-value	0.0020	0.0002	0.0007	0.0311	0.0002

[a]Means within a column and assessment followed by the same letter are not different according to Fisher's protected LSD ($\alpha = 0.05$).

Relative Rice Groundcover

The main effect of cover crop did not influence rice groundcover in four of five trials for the experiment, with rice groundcover ranging from 93% to 102% at those sites relative to the no-cover-crop treatment ($P > 0.05$) (Table 2). However, rice groundcover was reduced following cereal rye by up to 13% relative to the no-cover-crop treatment in Fayetteville in 2023, when rice was planted in April. Wheat, with similar biomass production, did not reduce rice groundcover within the trial, suggesting other factors could have influenced the lack of soil coverage observed in the cereal rye treatments. The ability of cereal rye to release allelochemicals such as benzoxazinones is known to reduce crop growth and development; therefore, rice groundcover could be influenced by the production of these phytotoxic compounds (Martinez-Feria et al. 2016). Additionally, controlled experiments in a laboratory once determined that allelochemicals were more harmful to small-seeded plant species (Liebman and Sunberg 2006). Cereal rye can also efficiently sequester nutrients within the soil, potentially affecting crop maturity through increased competition for soil minerals (Krueger et al. 2011). However, in most instances, rice development and canopy closure were unaffected by cover crop biomass production.

Relative Rice Grain Yield

The biomass produced by cover crops did not influence rough rice grain yield across all trials for the experiment ($P > 0.05$) (Table 2). One of the benefits of using a legume cover crop is the ability to fixate atmospheric nitrogen during plant decomposition, which then becomes available to the crop (Reddy 2001). To our knowledge, no peer-reviewed data have been published on the influence of cover crops on furrow-irrigated rice yields; however, a preliminary study produced by Henry and Clark (2023) showed no statistical yield differences with the use of a cover crop blend consisting of annual rye (*Lolium perenne* L.), cowpea (*Vigna unguiculata* L.), crimson clover, and Daikon radish (*Raphanus sativus* L.) compared to a no-cover-crop treatment in a furrow-irrigated rice system. In all cases, rice maturity was not disrupted by the established cover crops.

Palmer Amaranth Density

Across all trials of the experiment, Palmer amaranth emergence varied by cover crop treatment (Table 2). On average, Palmer amaranth emergence was greater in trials conducted in 2022 (197 m^{-2}) than in 2023 (32 m^{-2}). In 2022, at the Marianna site, cereal rye and Austrian winterpea were the only cover crops to significantly reduce Palmer amaranth emergence, minimizing total emergence by 19% and 31% compared with the nontreated control, respectively. Oppositely, Palmer amaranth densities were comparable or greater among each cover crop treatment compared with those of the no-cover-crop treatment, with total weed emergence being greatest in both legume cover crop treatments at Fayetteville in 2022. Wiggins et al. (2016) also found that Palmer amaranth densities were comparable in several evaluated monoculture cover crops, including cereal rye, crimson clover, hairy vetch, and winter wheat. Additionally, Norsworthy et al. (2010) reported that hairy vetch and Austrian winterpea provided minimal benefit in suppressing Palmer amaranth in cotton production in the mid-southern United States.

In 2023, at the April rice planting, Palmer amaranth emergence was not reduced by any of the cover crops compared with the no-cover-crop treatment. However, weed pressure at this location was extremely low compared to other sites, considering the nontreated control totaled 2.5 plants m^2, on average, by the end of the evaluation period. Within the same year, at the May rice planting, a 35%, 82%, and 41% reduction in Palmer amaranth emergence was provided by cereal rye, Austrian winterpea, and hairy vetch, respectively. Considering soil disturbance can influence weed germination and emergence (Chauhan et al. 2006), Palmer amaranth emergence in furrow-irrigated rice will likely be enhanced due to increased soil and cover crop residue disturbance from the narrow and more frequent row spacing in contrast to the typical planting methods used in corn, cotton, and soybean production.

Palmer amaranth densities were generally higher for cereal cover crops than legume cover crops. Legume cover crops innately possess lower carbon-to-nitrogen (C:N) ratios than cereal cover crops, allowing for less persistence on the soil surface; hence, Palmer amaranth suppression could be influenced by the increased decomposition rate of cover crop residues (Berg and McClaugherty 2003; Clark 2012; Pittman et al. 2020; Touchton et al. 1984). Likewise, research has revealed that some *Amaranthus* species are extremely responsive to soil inorganic nitrogen, consequently increasing the competitive ability of the weed with the crop (Blackshaw et al. 2003; Blackshaw and Brandt 2008). Based on the Palmer amaranth data collected, cereal cover crops provide little to no benefit from a weed control standpoint in furrow-irrigated rice.

Practical Implications

Cover crops have proven to be an effective weed control tactic when targeting problematic weeds, including Palmer amaranth, in many cropping systems across the United States (Brennan and Smith 2005; Burgos and Talbert 2000; Collins et al. 2007; Fisk et al. 2001; Palhano et al. 2018; Reddy 2001). Only one research series publication has evaluated the effect of cover crops in a furrow-irrigated rice system, which constitutes approximately 18% of Arkansas rice hectares (Hardke et al. 2022; Henry and Clark 2023). Although results differed among trials, the experiments conducted in 2022 and 2023 show some potential for cover crops to be used in furrow-irrigated rice to manage Palmer amaranth.

In most cases but not all, the cover crops evaluated in this study did not reduce rice emergence, groundcover, or grain yield. However, high biomass production from cover crops can affect crop emergence, as demonstrated here (Table 2) and in research conducted by Schulz et al. (2013). Cereal rye appears to exhibit some ability to reduce Palmer amaranth emergence through increased biomass production, suppressing the weed by 19% to 35% in three of five trials. Additionally, legume cover crops generally decreased total Palmer amaranth emergence, with weed emergence being lowest for legume cover crops in three of the five site-years for the experiment.

Cover crop biomass accumulation and Palmer amaranth suppression from cover crops varied by site-year, suggesting that more research is needed in the rice-growing regions to ensure greater confidence before adopting as a stand-alone weed control method in furrow-irrigated rice production. Additionally, bed width is a key component in both weed and crop development due to its potential effects on irrigation and soil moisture content (Reed et al. 2024); hence, future cover crop research may also include determining the optimal bed width for increased Palmer amaranth suppression. Furthermore, some cover crop studies found added weed control when combining preemergence and postemergence herbicides with cover crops (Reddy 2001; Reeves et al. 2005; Wiggins et al. 2015). Thus, it may be advantageous to replicate these experiments in conjunction with a standard rice herbicide program to determine whether the addition of herbicides would result in enhanced Palmer amaranth suppression compared to the observations noted here.

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

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