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Timing of cultural and chemical methods to remove perennial ryegrass overseeded in bermudagrass

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Abstract

Bermudagrass (*Cynodon dactylon* L.) is a warm-season grass that is often overseeded with cool-season perennial ryegrass (*Lolium perenne* L.) in the fall to provide green cover. Overseeded bermudagrass is desirable from late fall to early spring; however, turfgrass managers face challenges removing it in the spring and summer months. A 2-year field study was conducted in northeast Mississippi to determine the most effective timing for removing perennial ryegrass and to compare removal methods for improving the bermudagrass transition. The plots were overseeded with perennial ryegrass in mid-October of 2017 and 2018. Four removal timings of perennial ryegrass were performed from mid-March to late May–early June. Five removal methods were evaluated, including fraise mowing at two depths (0.3 inches and 0.6 inches), weekly scalping to a height of 1 inches, two rimsulfuron applications applied 3 weeks apart, and one glyphosate application. The plots were assessed for turfgrass quality, perennial ryegrass cover, and overall green cover. In 2018 and 2019, 0.6-inch fraise mowing resulted in the greatest perennial ryegrass removal within 1 week after treatment (WAT) compared with chemical removal treatments and weekly scalping; however, it also resulted in reduced green cover from 0 to 2 WAT compared with rimsulfuron application and the untreated control. March treatments generally resulted in higher perennial ryegrass cover at 8 WAT, whereas April, May, and June treatments resulted in <50% perennial ryegrass cover. Overall, the most effective timings for perennial ryegrass removal by chemical and cultural methods in northeast Mississippi were late spring and early summer. Effective methods that prevented long-term delays in bermudagrass recovery depended on the timing of perennial ryegrass removal.

Abbreviations: AUTQC, area under the turfgrass quality curve; TQ, turfgrass quality; WAT, weeks after treatment.

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Plain Language Summary

Bermudagrass is a popular warm-season grass in temperate climates; however, it becomes dormant (brown) during winter. For year-round green cover, turfgrass managers often overseed with perennial ryegrass, a cool-season grass. While this is beneficial in winter and early spring, removing perennial ryegrass can be problematic for bermudagrass when the plant breaks dormancy. This field study evaluated five removal methods—fraise mowing at two depths, weekly scalping, and applying rimsulfuron or glyphosate—along with four removal timings in Mississippi. This study found that fraise mowing immediately removed ryegrass, but bermudagrass was slow to recover with earlier removal timings; rimsulfuron applications provided a smooth transition at later timings; and early glyphosate application was effective for ryegrass removal, but late application damaged the bermudagrass. Turfgrass managers can use these results to determine the perennial ryegrass removal method and timing best suited for their needs.

1 | INTRODUCTION

Winter overseeding is the process of seeding cool-season grass(es) into an established warm-season sward prior to winter dormancy of the warm-season species (Kopec & Umeda, 2015). Perennial ryegrass (*Lolium perenne* L.) is a common cool-season grass used for overseeding bermudagrass (*Cynodon dactylon* L.) because of its relatively fast establishment, widely available seed, and seasonal dark green color (Kopec & Umeda, 2015). Although there are many benefits to using perennial ryegrass for overseeding, improved cultivars of perennial ryegrass exhibit increased heat and drought tolerance, as well as disease resistance, presenting challenges during the spring to summer transition for bermudagrass (Horgan & Yelverton, 2001). These cultivars are beneficial for regions above the transition zone where perennial ryegrass may be desired year-round; however, in the transition zone, perennial ryegrass is desirable only during the cooler months (Green et al., 2004). The presence of actively growing perennial ryegrass presents challenges as temperatures rise and bermudagrass begins to transition out of dormancy. Competition between perennial ryegrass and bermudagrass for sunlight and water reduces stand uniformity and bermudagrass recovery due to differences in growth rates between the species (Peppers et al., 2021). Yelverton (2005) reported that bermudagrass needs at least 100 perennial ryegrass-free days in North Carolina to minimize susceptibility to cold temperature damage the following winter.

Chemical applications of acetolactate synthase-inhibiting sulfonylurea herbicides or the 5-enolpyruvylshikimate 3-phosphate synthase inhibitor glyphosate are sometimes used to remove perennial ryegrass and transition to bermudagrass. These herbicides are effective when applied correctly

at bermudagrass green-up (Hutto et al., 2008). However, applying glyphosate after bermudagrass begins to emerge from dormancy may injure the desired turfgrass (Horgan & Yelverton, 2001). Chemical applications of sulfonylurea herbicides are used for a smoother transition by slowly killing perennial ryegrass with minimal injury to bermudagrass. The timing of these applications is crucial to minimize periods of brown turf. If applied too early, the perennial ryegrass will be terminated before the bermudagrass actively recovers from dormancy; however, if applied too late, the bermudagrass may not have the sufficient perennial ryegrass-free period needed for healthy turfgrass (Serensits et al., 2011; Yelverton, 2005). Thus, timing profoundly affects the success of the perennial ryegrass transition. Achieving optimal timing can be challenging because it varies with different environmental conditions and weather patterns from year to year (Hutto et al., 2008). Gerlenter and Stowell (2003) suggested that sulfonylurea herbicides should not be applied until bermudagrass has recovered at least 70% in California. The optimum air temperature for bermudagrass shoot growth ranges from 81 to 104°F, while the optimum soil temperature for root growth may be 75 to 84°F (Beard, 1973; McCurdy et al., 2020; Youngner, 1961).

In addition to chemical removal strategies, various cultural practices can be used to remove perennial ryegrass. Their implementation may depend on several factors, including labor, budget, and machinery availability. Scalping increases bermudagrass and soil exposure to sunlight by removing and stressing the perennial ryegrass without requiring more specialized machinery (Gerlenter & Stowell, 2003). Fraise mowing is a contemporary cultural practice with various uses and may be effective for removing overseeded perennial ryegrass (Dickson et al., 2022), as well as other annual and

perennial weeds (Brosnan et al., 2020; Richardson et al., 2021). Fraise mowers use a set of tines or blades aligned vertically on a rotating shaft parallel to the soil surface that can be raised or lowered to a depth of up to 2 inches. In addition to removing perennial ryegrass, fraise mowing can remove thatch and other organic matter, leaving only bermudagrass stolons and rhizomes for recovery (Hansen & Christians, 2015). While this approach can be beneficial, more aggressive fraise mowing requires longer recovery times, especially if performed too early or too late, when optimal bermudagrass growth cannot be achieved.

Information comparing chemical and cultural perennial ryegrass removal strategies across various removal timings remains limited. Dickson et al. (2022) evaluated fraise mowing and chemical applications for spring transition at a single removal time. Fraise mowing may effectively remove perennial ryegrass, and timing likely directly affects bermudagrass recovery. Research was conducted to compare fraise mowing, repeated scalping, and chemical applications of rimsulfuron or glyphosate for perennial ryegrass removal and to determine how treatment timing affects bermudagrass recovery.

2 | MATERIALS AND METHODS

This study was conducted at the Mississippi State University R.R. Foil Plant Science Research Center near Starkville, MS, from October 2017 to July 2019. The study area consisted of mature 'Tifway' hybrid bermudagrass [*Cynodon dactylon* (L.) Pers. $\times$ *C. transvaalensis* Burt Davy] established on a Marietta fine sandy loam (fine-loamy, siliceous, active, Fluvaquentic Eutrupept) with a pH of 6.2. The experimental design was a split plot within a randomized complete block, with timing as the main plot and mechanical surface cultivation as subplots. The treatments were replicated four times, with subplots (4 ft $\times$ 10 ft) randomized within each main plot (24 ft $\times$ 10 ft).

Two adjacent study areas were overseeded with a Lescro 80 LB rotary spreader on October 17, 2017, and October 15, 2018. Experimental areas were overseeded at 435 lb pure live seed ac^{-1} with 'Ph.D.' perennial ryegrass blend (DLF Seeds), which comprised 32.91% 'Gator 3,' 32.87% 'Banfield,' and 32.68% 'Aspire' perennial ryegrass cultivars by weight in 2017 and 33.10% 'Thrive,' 33.07% 'Karma,' and 32.82% 'Bandalore' perennial ryegrass cultivars by weight in 2018. The plots were irrigated in the fall to promote perennial ryegrass establishment and, as needed, during the following spring and summer to prevent drought stress. For both experiments, plots were fertilized every 2 weeks with urea (46% N, 0% P_2O_5 , 0% K_2O) at a rate of 22 lb N ac^{-1} , beginning 7 days after seeding until June 1, with no fertilizer applied between December 1 and March 1. Grass was mowed weekly using a Craftsman 4.5-hp rotary lawn mower at a height of 2 inches (2 ft width).

The removal treatments were performed on four dates $\sim$ 3 weeks apart each year: March 15, April 5, April 30, and June 4 in 2018; and March 19, April 9, April 30, and May 21 in 2019. Within each removal time, the six subplot removal methods included an untreated control, fraise mowing at depths of 0.3 inches or 0.6 inches below the mineral soil surface, two rimsulfuron applications at a rate of 0.016 lb a.i. ac^{-1} (25 DF, Rimsulfuron 25 DF; Quali-Pro) with a nonionic surfactant at 0.25% v/v (Preference; Winfield Solutions) 3 weeks apart, glyphosate application at a rate of 1.0 lb a.i. ac^{-1} (Glyphosate Plus; Quali-Pro), and weekly scalping to 1 inch above the mineral soil surface (eight total scalping events per removal timing). A Redexim Charter House Turf Stripper 1200 (Redexim Turf Products; 3.9 ft width) was used for fraise mowing, and an Exmark 52 Lazer Z X-Series Zero-Turn Mower (Exmark Mfg. Co.; 4.3 ft width) was used for scalping. Herbicides were applied using a handheld CO_2 -pressurized boom sprayer calibrated to deliver 40-gal ac^{-1} with XR TeeJet 11002VS nozzles (TeeJet; Spraying Systems Co.) and allowed to dry on the surface without immediate post-application irrigation or precipitation.

Assessments were conducted six times over 0 to 8 weeks after treatment (WAT). The visual percentage of perennial ryegrass cover was assessed on a 0%–100% scale, where 0% indicates no perennial ryegrass cover, and 100% indicates complete perennial ryegrass cover. The percent green cover was evaluated using digital image analysis (Karcher & Richardson, 2013). Images were taken inside a 20 inches $\times$ 20 inches light box containing four 100 W equivalent natural daylight compact fluorescent light bulbs (Sylvania). Images were captured with a Canon PowerShot G12 10MP digital camera, white-balanced using the following settings: f/2.8 aperture, 1/25-s shutter speed, 100 ISO, and 2736 $\times$ 2736-pixel resolution. The percent green cover was determined using the Turf Analyzer software program, with hue, saturation, and brightness ranges of 66–140, 10–100, and 0–100, respectively (Karcher et al., 2017).

Visual turfgrass quality (TQ) was assessed on a 1–9 scale, where 1 indicates dead or dormant grass with a straw brown color, and 9 indicates uniform, dense, dark green turfgrass (Morris & Shearman, 1998). The area under the turfgrass quality curve (AUTQC) from 0 to 8 WAT was calculated using the following formula:

$$\text{AUTQC} = \sum [(y_i + y_{i+1}) / 2] (t_{i+1} - t_i)$$

where $i + 1, 2, 3, \dots, n - 1$, y_i is the measurement, and t_i is the time at the i th rating (Shaner & Finney, 1977).

All data were subjected to ANOVA (version 9.4, SAS Institute Inc.), with means separated using Fisher's protected LSD ($\alpha = 0.05$) in PROC GLIMMIX. Significant year $\times$ method and timing interactions were observed for all response variables; therefore, data were analyzed separately by year.

TABLE 1 ANOVA for visual percent perennial ryegrass cover and percent green coverage overall using digital image analysis (Karcher & Richardson, 2013) as influenced by perennial ryegrass removal method and timing in 2018 and 2019.

Response variable	Main effect	0 WAT	1 WAT	2 WAT	3 WAT	5 WAT	8 WAT
2018							
Percent ryegrass cover ^a	Method	801.7***	148.3***	19.6***	21.3***	11.7***	10.1***
	Timing	13.3***	121.6***	82.9***	105.9***	46.3***	101.0***
	Method × timing	7.4***	12.9***	7.2***	6.2***	6.1***	6.9***
Percent green cover ^b	Method	575.5***	159.3***	36.8***	35.1***	44.2***	16.8***
	Timing	NS	19.6***	16.2***	15.5***	11.1***	5.2**
	Method × timing	NS	5.8***	5.3***	5.6***	9.7***	4.7***
2019							
Percent ryegrass cover	Method	632.1***	107.1***	58.9***	51.1***	23.1***	12.6***
	Timing	14.5***	67.3***	118.4***	65.4***	44.0***	16.3***
	Method × timing	5.6***	7.4***	6.3***	6.2***	5.9***	2.0*
Percent green cover	Method	835.7***	158.0***	48.4***	63.0***	55.1***	5.6**
	Timing	NS	59.1***	55.6***	34.4***	38.5***	50.3***
	Method × timing	8.8***	10.9***	8.0***	5.7***	7.4***	2.0*

Note: *F*-Value is shown for each evaluation.

Abbreviation: WAT, weeks after treatment.

^aPercent ryegrass was assessed visually on a 0%–100% scale (0% = no ryegrass coverage, and 100% = complete ryegrass coverage).

^bPercent green coverage overall using digital image analysis.

*Significant at the .05 probability level. **Significant at the .01 probability level. ***Significant at the .001 probability level. NS, nonsignificant at the .05 probability level.

3 | RESULTS

3.1 | Effect of removal method and timing on visual percent perennial ryegrass cover

The timing and removal interactions were significant within each week; therefore, perennial ryegrass cover data are presented for the interaction × evaluation week across removal timings for both 2018 and 2019 (Table 1).

3.1.1 | 2018

Fraise mowing at 0.6 inches was the only treatment resulting in the lowest perennial ryegrass cover across all removal timings at 0 WAT (Figure 1A–D). By 3 WAT, both March fraise mowing treatments increased perennial ryegrass cover from 3% to 45% and 79% when fraise mowed at 0.3 inches and 0.6 inches, respectively; all other March treatments had >51% perennial ryegrass cover. While March allowed for an increase in perennial ryegrass after 0.3-inch and 0.6-inch fraise mowing, plots 0.6-inch fraise mowed in April, and May had <9% perennial ryegrass cover at 3 WAT. All treatments—including the untreated control—were similarly effective at 3 WAT when performed in June (<20% perennial ryegrass cover). Among 0.6-inch fraise mowing timings, March was the only timing in which the perennial ryegrass had an increase of

>15% by 8 WAT. At the March timing, perennial ryegrass that was either scalped weekly or treated with rimsulfuron resulted in the lowest perennial ryegrass cover, at 8 WAT (10% and 25%, respectively). Weekly scalping in March, April, and May reduced perennial ryegrass cover more than 0.3-inch fraise mowing, at 8 WAT (10%, March; 1%, April; 0%, May). Timing at which weekly scalping began did not provide differences in perennial ryegrass cover at 8 WAT. All plots treated in June had 0% perennial ryegrass cover at 8 WAT.

3.1.2 | 2019

Fraise mowing at 0.3 inches in May and June, and at 0.6 inches at all timings, reduced ryegrass cover to <10% at 0 WAT (Figure 1E–H). Weekly scalping also reduced perennial ryegrass cover at 0 WAT (21%–56% ryegrass) compared with the untreated control (>90% ryegrass). Increases in perennial ryegrass cover among the fraise mowed treatments were greatest in April at the 0.3 inches depth, with an increase of 50% between 0 and 5 WAT. Fraise mowing at 0.6 inches in March resulted in similar perennial ryegrass cover as 0.6-inch fraise mowing, glyphosate application, or rimsulfuron applications in May and June at 3 WAT. Rimsulfuron applications in March and April required 5 WAT to reduce perennial ryegrass cover to <30%, whereas applications in May and June required only 2 WAT to achieve the same level of perennial ryegrass

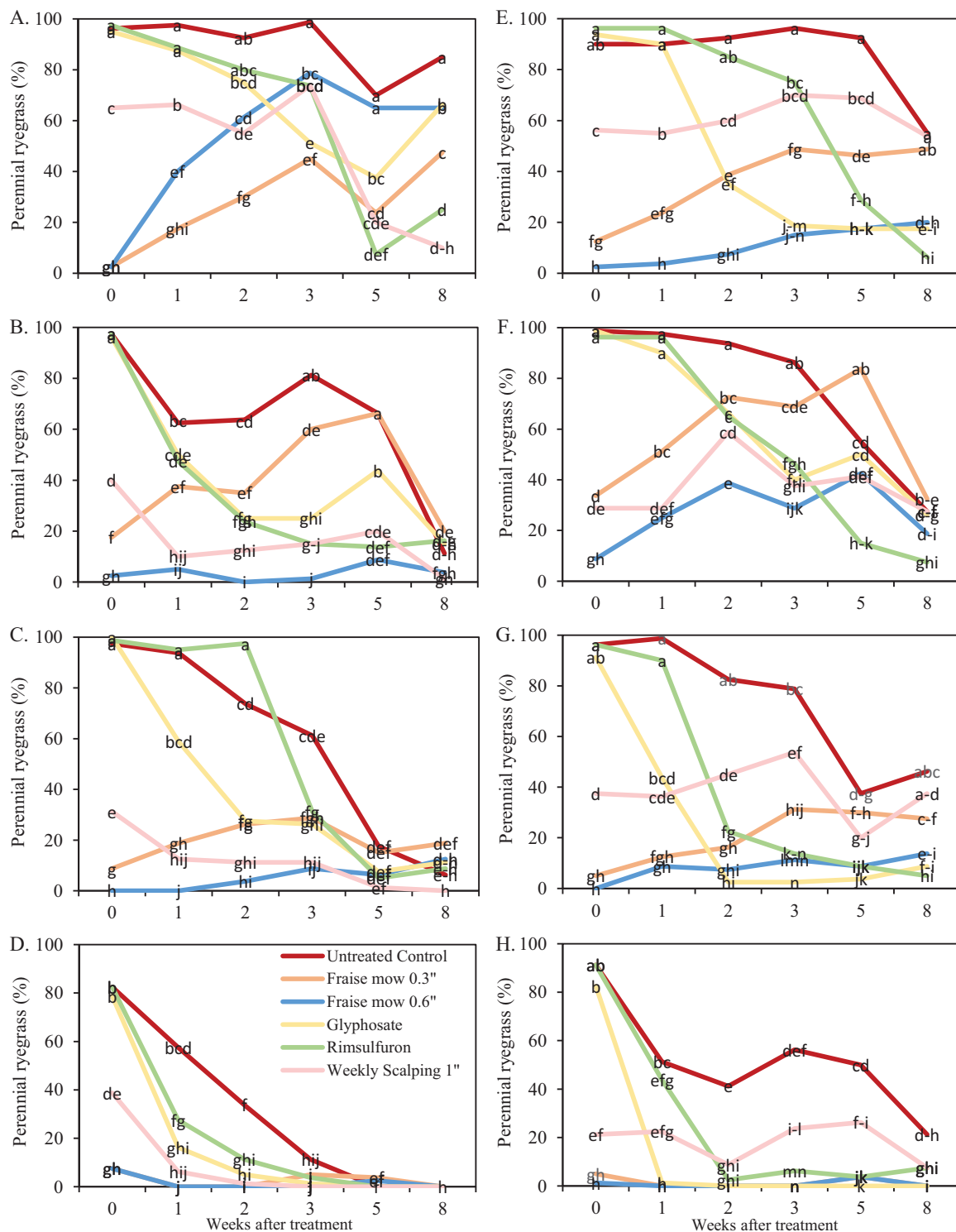


FIGURE 1 Visual percent perennial ryegrass as affected by removal method and timing [(A) March 2018, (B) April 2018, (C) May 2018, (D) June 2018, (E) March 2019, (F) April 2019, (G) May 2019, and (H) June 2019] on overseeded bermudagrass. Means with the same letter within a week across removal timings are not different according to Fisher's protected LSD test ($p < .05$).

cover. At 5 WAT, 0.6-inch fraise mowing in March, May, and June timings resulted in lower perennial ryegrass cover than plots 0.6 inches fraise mowed in April. Additionally, June was the only timing where fraise mowing at both depths reduced perennial ryegrass cover more than the untreated control, at 8 WAT. While rimsulfuron reduced perennial ryegrass cover more than the untreated control, 0.3-inch fraise mowing, and weekly scalping in March (6% vs. 49%–55% ryegrass), perennial ryegrass cover at 8 WAT was similar to 0.6-inch fraise mowing (20%) and glyphosate application (18%). No differences were observed among the timings of rimsulfuron applications at 8 WAT, with all timings having <8% ryegrass cover. At 8 WAT, perennial ryegrass cover in the untreated control was similar to that seen with weekly scalping and 0.3-inch fraise mowing in March, April, and May, but not in June.

3.2 | Effect of removal method and timing on percent green cover

The timing and removal interactions were significant within each week; therefore, percent green cover data are presented for the interaction $\times$ evaluation week across removal timings for both 2018 and 2019 (Table 1).

3.2.1 | 2018

The 0.3-inches and 0.6-inch fraise mowing reduced percent green cover to <1% at 0 WAT across all timings compared with the untreated control, rimsulfuron applications, and glyphosate application, which each had ~80%–90% green cover (Figure 2A–D). At 1 WAT, fraise mowing at both depths resulted in the lowest percent green cover in March, April, and May. Fraise mowing at either depth in May and June achieved 75% green cover and did not differ from the untreated control at 3 WAT. Glyphosate application in April, May, and June resulted in <25% green cover at 3 WAT, 2 WAT, and 1 WAT, respectively, while the application in March reached only 32% green cover at 3 WAT. At 5 WAT, the lowest percent green cover was observed with rimsulfuron applications in March (17%) and April (33%), and with glyphosate application in June (29%) compared with all other treatments and timings. By 8 WAT, fraise mowing at either depth resulted in one of the highest percentages of green cover among all removal strategies and timings. At 8 WAT, percent green cover for glyphosate treatment was similar to that of the untreated control for all timings; however, percent green cover in June was lower (72%) than at all other glyphosate timings (>88%).

3.2.2 | 2019

Fraise mowing at both heights reduced green cover to <2% on the day of treatment except in April (Figure 2E–H). Reductions in percent green cover due to glyphosate application began 1 WAT in May (56%) and June (9%), compared with the untreated control at the same timings (93% vs. 74%, respectively). By 3 WAT, the lowest percent green cover was observed for glyphosate application in March, May, and June. Fraise mowing at 0.3 inches did not reduce percent green cover compared with the untreated control at 3 WAT for any treatment timing. Treatment timing did not affect plots that were 0.6-inch fraise mowed at 3 WAT. At 5 WAT, results from 0.6-inch fraise mowing in April and June were similar to those of the untreated control at the same timing and exhibited a higher percent green cover than 0.6-inch fraise mowing in March and May. Two rimsulfuron applications in June produced a higher percent green cover at 5 WAT than any other rimsulfuron timing. Glyphosate application and weekly scalping in April had the lowest percent green cover at 8 WAT (74% and 67%, respectively) than glyphosate application and weekly scalping at any other timing (>95% and >83%, respectively).

3.3 | Effect of removal method and timing on turf quality

The perennial ryegrass removal method $\times$ timing interaction was significant for AUTQC in both study years (data not shown).

3.3.1 | 2018

Overseeded bermudagrass treated with two rimsulfuron applications in May resulted in a greater AUTQC compared with rimsulfuron applications at any other time (Figure 3A). No differences in AUTQC were observed among 0.3-inch fraise mowing plots from April to June. Among all removal timings, weekly scalping showed no difference in AUTQC. The AUTQC of 0.6-inch fraise mowing in April was lower than for all other removal timings.

3.3.2 | 2019

Glyphosate applied in April resulted in a greater AUTQC than applications at any other time point. Compared with 0.6-inch fraise mowing, rimsulfuron application yielded a greater AUTQC value at all timings. However, no differences

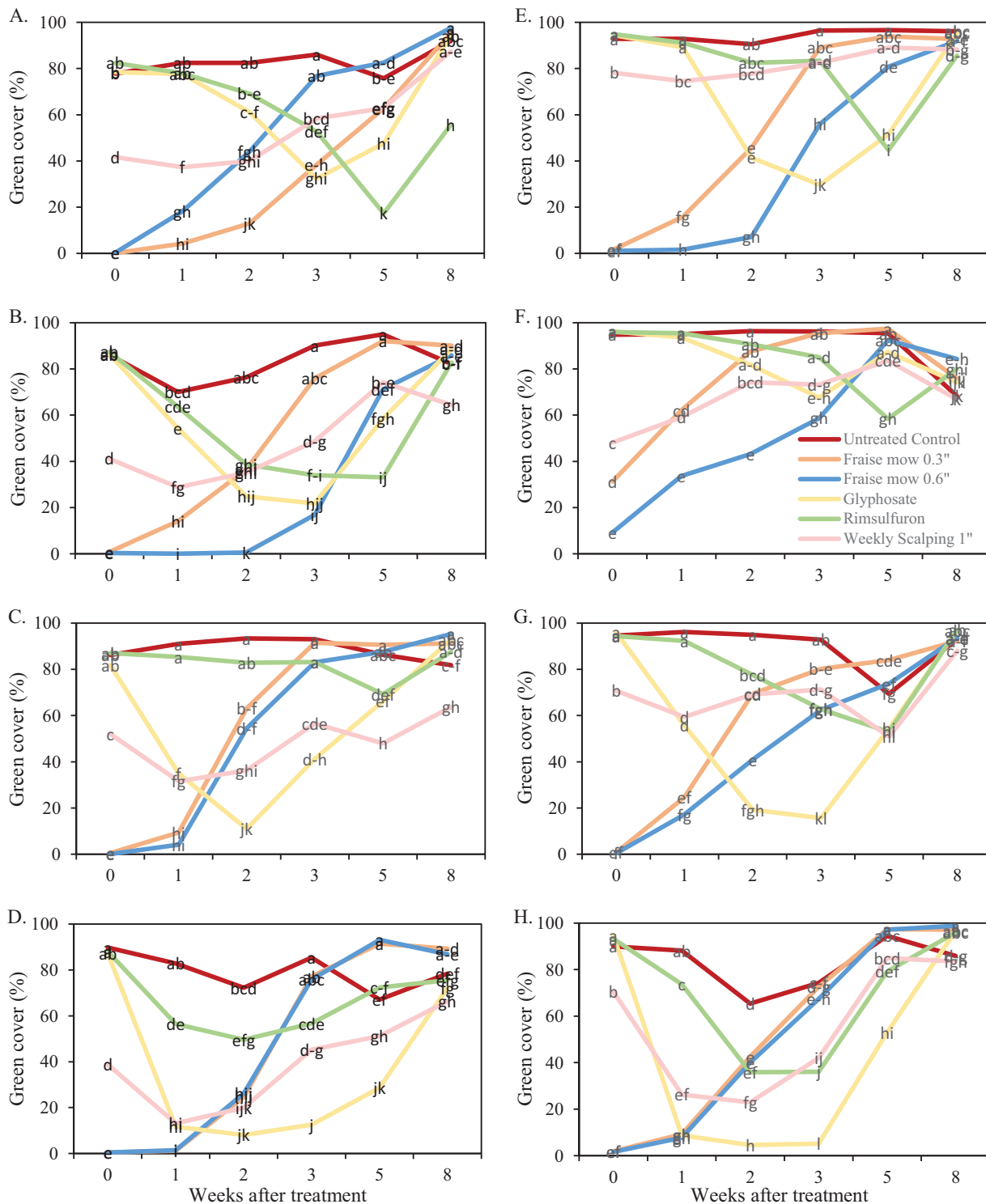


FIGURE 2 Percent green cover as affected by removal method and timing [(A) March 2018, (B) April 2018, (C) May 2018, (D) June 2018, (E) March 2019, (F) April 2019, (G) May 2019, and (H) June 2019] on overseeded bermudagrass. Digital images were taken from each plot every 7 days (Karcher & Richardson, 2013) and analyzed using the Turf Analyzer software program to determine percent green coverage (Karcher et al., 2017). Means with the same letter within a week across removal timings are not different according to Fisher's protected LSD test ($p < .05$).

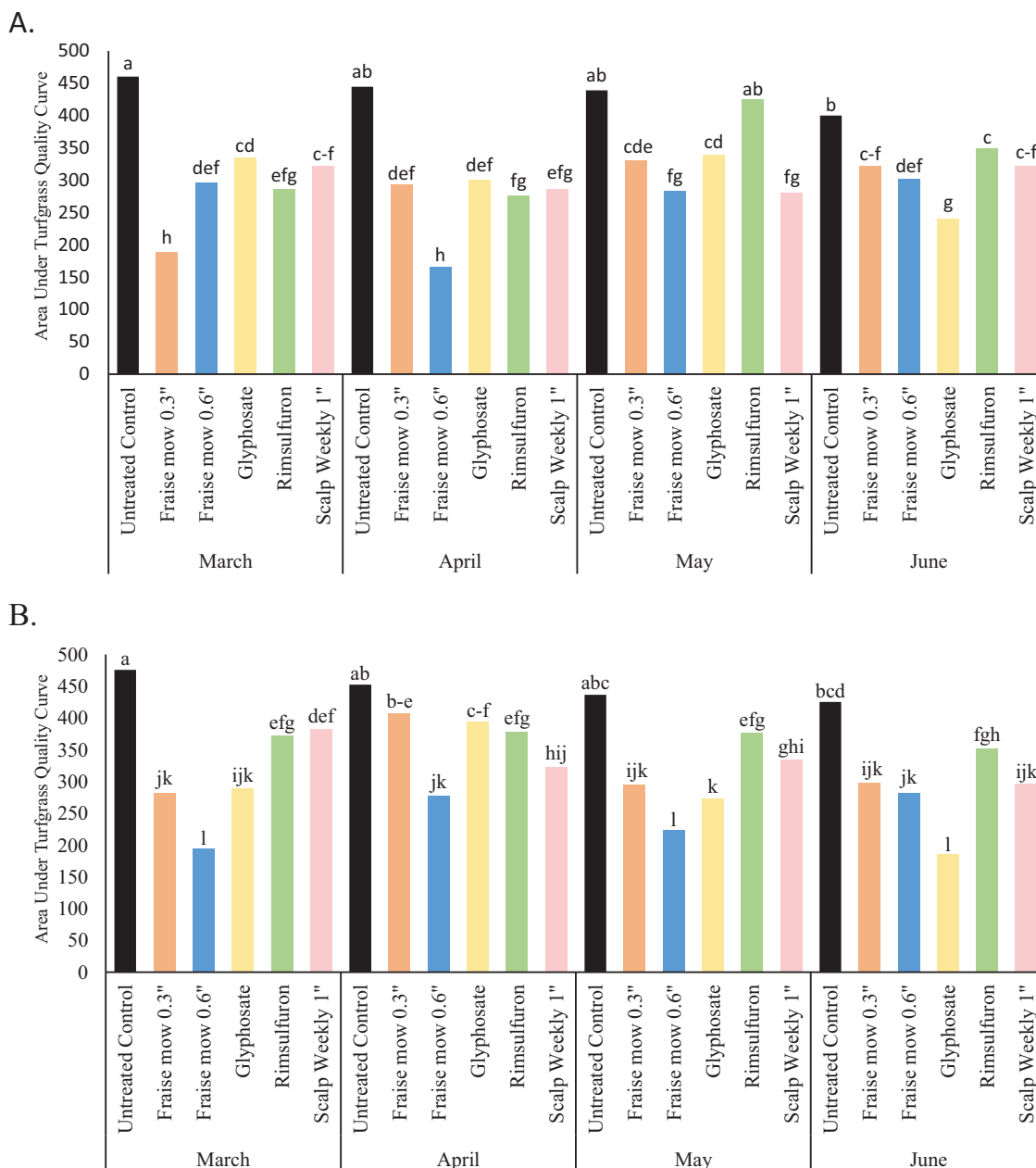


FIGURE 3 Area under the turfgrass quality curve (AUTQC) as affected by the perennial ryegrass removal method and timing in 2018 and 2019. Columns with the same letter within a study year are not significantly different according to Fisher's protected LSD test ($p < .05$). (A) AUTQC of cultivation methods in 2018 ($p < .0001$), (B) AUTQC of timings in 2019 ($p < .0001$).

in AUTQC were observed across removal timings for rimsulfuron treatments. Compared with all other timings, 0.3-inch fraise mowing resulted in the highest AUTQC in April. The AUTQC of glyphosate applied in June was lower than that of glyphosate applied at any other time point in either year.

4 | DISCUSSION AND CONCLUSION

The removal of perennial ryegrass from overseeded bermudagrass is essential for maintaining a healthy stand of turfgrass

year-round. Effective perennial ryegrass removal in this 2-year field study varied depending on study year, ryegrass removal timing, and removal method. The differing results by year are likely due to higher rainfall in 2019 than in 2018. From mid-March through July 2018, there was 13.8 inches of rain, whereas during the same period in 2019, there was 41.5 inches (NWS, 2025). However, the average temperature was consistent from March to July in both years, with 2018 averaging 70.9°F and 2019 averaging 70.2°F (NWS, 2025).

Among removal methods, 0.6-inch fraise mowing provided quicker perennial ryegrass removal than 0.3-inch fraise

mowing. At all times in 2018 and 2019—except in June 2019—0.3-inch fraise mowing consistently resulted in higher perennial ryegrass cover at 3 and 5 WAT than did 0.6-inch fraise mowing. However, by 8 WAT in both years, no significant difference in perennial ryegrass cover was observed with fraise mowing in May and June at either depth. This finding is attributable to the amount of perennial ryegrass removed, which reduces competition for bermudagrass recovery. While the 0.6-inch fraise mowing depth removed more ryegrass, the 0.3-inch depth increased AUTQC in the April and May removal timing in 2018, as well as in the March, April, and May removal timings in 2019 due to increased delays in bermudagrass recovery after fraise mowing. Fraise mowing at deeper depths too early could lead to extended periods of bare soil due to minimal bermudagrass growth, particularly during growing years with cooler weather. Fraise mowing in April, in moist soil, pressed the perennial ryegrass into the soil rather than removing it completely. This compaction allowed for greater perennial ryegrass recovery and increased competition for bermudagrass, particularly in 2019. This effect could be due to the type of tines used on the Redexim Turf Stripper 1200 (J-blades), which are more L-shaped, as opposed to the various-shaped tines on other fraise mowers that cut into the soil more aggressively. When recovery time is delayed by earlier timings, the canopy remains open longer, giving weeds more time to develop and compete with bermudagrass for sunlight, water, and space (Yelverton, 2005).

Although only in 2018, weekly scalping in March, April, and May resulted in a significantly lower percent perennial ryegrass cover at 8 WAT than did 0.3-inch fraise mowing. This suggests that scalping could be a cost-effective and practical option to accelerate perennial ryegrass removal, especially for courses with limited financial and labor resources. Application of rimsulfuron consistently yielded the lowest percent perennial ryegrass cover at 5 WAT at all removal times; however, when applied in March and April, it also resulted in the lowest percent green cover at 5 WAT. This finding directly correlates with the fraise mowing results, where the bermudagrass was not growing as quickly, resulting in an in-between period lacking green cover. In both years, April was the only treatment timing that yielded a difference in perennial ryegrass cover between rimsulfuron and glyphosate treatments at 5 WAT. Rimsulfuron applications did not demonstrate a higher AUTQC than weekly scalping at the March timing in either 2018 or 2019. Glyphosate application in June is too late and not a viable option due to the rapid and dramatic decrease in green cover at 1 WAT than application at any other timing in either 2018 or 2019. Applying glyphosate in June damaged actively growing bermudagrass and prolonged its recovery time. However, when glyphosate was applied in April, the decrease in green cover was less dramatic and more gradual, allowing for a smoother transition. Applying rimsulfuron in

May or June resulted in a more gradual transition from perennial ryegrass to bermudagrass and minimized the loss of green color.

While Dickson et al. (2022) also reported that nonchemical transitions, such as 0.6-inch fraise mowing, can be as effective as chemical applications for perennial ryegrass removal, their study did not consider timing and was conducted only once, in mid-May, in Tennessee. Fraise mowing and chemical applications performed earlier in the season caused a period of less desirable color (Dickson et al., 2022; Umeda & Towers, 2004). However, similar to our results, both studies found that fraise mowing at greater depths in May led to greater removal of perennial ryegrass and healthier recovery of bermudagrass (Dickson et al., 2022; McCauley et al., 2019). Carpenter et al. (2023) found October 15 was the best time to overseed bermudagrass with perennial ryegrass in northeast Mississippi. Therefore, if a turf manager wants to overseed in the upcoming fall, all ryegrass competition must be removed by July 8 to allow the 100 days needed for healthy bermudagrass growth (Yelverton, 2005).

Depending on when the turf is needed for use and whether the turf manager prefers a chemical or nonchemical strategy, there are options for perennial ryegrass removal and bermudagrass transition in Northeast Mississippi. It is vital to remove all perennial ryegrass each year to prevent the development of patchy perennial ryegrass that remains and competes with actively growing bermudagrass throughout the season. Starting weekly scalping to 1 inch in April could be a viable option for turf managers looking for a cost-effective or nonchemical perennial ryegrass removal method, though results may vary from year to year. While 0.3-inch fraise mowing quickly removed perennial ryegrass it allowed for more recovery when performed in April and May. Whereas 0.6-inch fraise mowing was consistently both quick and effective at complete perennial ryegrass removal in both May and June. Rimsulfuron is a good chemical option for perennial ryegrass removal and can be applied as early as April for a smooth transition and effective removal if the turf is needed throughout the summer. If the turf is not needed until fall, as on some athletic fields, removing the stressed perennial ryegrass in June using any of the treatment methods will be effective, provided bermudagrass growing conditions improve. Based on this study's results, both chemical and cultural practices are effective options for perennial ryegrass removal in bermudagrass.

AUTHOR CONTRIBUTIONS

Matthew C. Carpenter: Data curation; formal analysis; investigation; methodology; writing—original draft. **Jada S. Powlen:** Data curation; formal analysis; writing—review and editing. **James D. McCurdy:** Methodology; resources; writing—review and editing. **Barry R. Stewart:** Funding acquisition; methodology; project administration; supervision; writing—review and editing.

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CONFLICT OF INTEREST STATEMENT

There are no conflicts of interest to declare.

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