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Comparison of mechanical removal of perennial ryegrass overseeding out of bermudagrass to chemical transitions

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Abstract

In the fall, bermudagrass athletic fields are overseeded with perennial ryegrass [*Lolium perenne* L.] to provide a uniform playing surface to slowed or dormant bermudagrass. Chemical techniques have been utilized for quick and efficient spring transition of perennial ryegrass. Fraise mowing has been identified as a tool that can aid in ryegrass transition in the spring. These studies were to determine the effectiveness of spring transition comparing mechanical removal of perennial ryegrass overseeding to traditional techniques on 'Riviera' bermudagrass [C*ynodon dactylon* (L.) Pers.]. In 2017, field studies were conducted at the University of Tennessee Center for Athletic Field Safety (Knoxville, TN) and the Oklahoma State University Turfgrass Research Center (Stillwater, OK). The seven treatments for the study were: fraise mow at 6.4 mm from the grass surface, fraise mow at 12.7 mm from the grass surface, fraise mow at 19.1 mm from the grass surface, spray application of trifloxysulfuron at the 27.8 g ha^{-1} with non-ionic surfactant at 0.25% v/v, spray application of foramsulfuron at the 28.9 g ha^{-1}, scalping (19.1 mm) with a rotatory mower, and an untreated control. Treatments were initiated on 11 May 2017 in Stillwater, OK USA and 17 May 2017 in Knoxville, TN USA. Plots were monitored for six weeks following treatment application. Fraise mowing at 12.7 mm was identified as the optimum depth for perennial ryegrass transitioning in this study compared to chemical transitions. This study found that the fraise mowing at 12.7 mm removed more perennial ryegrass and maintained percent green turfgrass cover throughout the study. However, if time of use for the turfgrass area is not a primary concern then depths greater than 12.7 mm are effective at perennial ryegrass removal but delay spring green-up.

1 | INTRODUCTION

In the transition zone, many sports seasons last through the period of growth for warm-season grasses. Due to time of year, athletic fields are overseeded to provide actively growing grass throughout the colder months. Traditionally, bermudagrass athletic fields are overseeded with perennial ryegrass (*Lolium perenne*) to provide a uniform playing surface to slowed or dormant bermudagrass (Mazur & Wagner, 1987). Perennial ryegrass is selected for overseeding due its quick germination, and acceptable turf quality (Horgan &

Abbreviations: DIA, digital image analysis.

Yelverton, 2001). Many athletic fields are seeded at higher rates than home lawns, making transitioning difficult in the spring (Haselbauer et al., 2012). The longer overseeding persists into the summer, the shorter the window of growth for the warm-season grass, negatively impacting the turfgrass quality (Kopec, Gilbert, Marcum, Pessarakli, & Jensen, 2001, Richardson, 2004).

Warm-season grass athletic fields need assistance in transitioning for optimal quality (Askew, Willis, Ricker, LaBranche, & Ervin, 2006). Common techniques for transitions include chemical herbicide applications along with a variety of mechanical techniques (verticutting, aerification, scalping, etc.) (Kopec et al., 2001). Some studies have shown a lack of effectiveness in mechanical techniques due to aggressiveness that delays spring green-up (Kopec et al., 2001; Mazur & Wagner, 1987). Scalping and verticutting are cultural practices that are effective for ryegrass transition (Horgan & Yelverton, 2001). Additionally, some mechanical transition techniques can take longer for ryegrass to transition out. Chemical controls have been shown to be an effective tool for rapid and effective transition of ryegrass out of bermudagrass (Bruneau, Peacock, Cooper, & Erickson, 2004). Due to its rapid results and success in transition of ryegrass, chemical controls remain a popular option.

Fraise mowers are a cultural tool that remove desired amounts of material from a turf surface. Fraise mowers have blades aligned vertically on a rotating horizontal shaft to remove material from a surface up to 5.0 cm from the subsurface (Hansen & Christians, 2015). Munshaw, Dickson, Cropper, and Sorochan (2017) found that fraise mowing was an adequate tool for thinning the turf for overseeding establishment in *Cynodon dactylon*. In addition, McCauley, Pinnix, and Miller (2019) found that fraise mowing at 12.7 and 19.1 mm depths was an effective tool for spring transition of ryegrass overseeding out of bermudagrass. However, no research was found comparing spring transition of ryegrass with a fraise mower to chemical transitions. The possibility for fraise mowing to remove ryegrass for a quick transition in the spring as effectively as a chemical control, with additional benefits, is valuable. The objective of this study was to determine the effectiveness of new mechanical removal techniques of perennial ryegrass overseed in spring transition in *C. dactylon* compared to chemical and traditional scalping techniques.

2 | MATERIALS AND METHODS

In 2017, field studies were conducted at the University of Tennessee Center for Athletic Field Safety (Knoxville, TN, USA) and the Oklahoma State University Turfgrass Research Center (Stillwater, OK, USA). These studies were to determine the effectiveness of spring transition comparing mechanical removal of perennial ryegrass overseeding to traditional techniques on 'Riviera' bermudagrass [*Cynodon dactylon* (L.) Pers.]. Plots at the Tennessee location were established on a Sequatchie silt loam soil (fine-loamy, siliceous, semiactive, thermic Humic Hapludult) with a 6.2 soil pH. The Oklahoma location plots established on a Norge Loam (Fine-silty, mixed, active, thermic Udic Paleustolls) with a soil pH of 7.0. Root zones and bermudagrass variety were selected due to their common use on athletic fields in Knoxville and Stillwater.

Granular urea (46 N–0 P_2O_5–0 K_2O) was at a rate of N 48.8 kg ha^{-1}, 1 May 2017 and 1 June 2017, at both locations of the study. Knoxville plots were mown at 3.8 cm using a triplex reel mower (TriKing 1900D; Jacobsen, Charlotte, NC, USA), while Stillwater plots were mown at 3.8 cm using a triplex reel mower (2653B Precision Cut, John Deere, Moline, IL, USA). Clippings were returned to the surface while mowing. Irrigation was applied as needed to prevent drought stress. Perennial ryegrass was established on 16 Oct. 2016 at a rate of 488.2 kg ha^{-1} with 'PhD' blend perennial ryegrass of Aspire, Thrive (DLF Pickseed, Halsey, OR, USA) and Hancock (Hancock Seed Company, Dade City, FL, USA). Seeding rates were based on overseeding practices of collegiate fields within each state (Tennessee and Oklahoma). Overseeding was broadcast on the surface and dragged in using a coco mat (Southern Athletic Fields, Columbia, TN, USA). Both plots were given 24.4 kg ha^{-1} of N in the form of (17–17–17) at establishment of ryegrass in the fall.

The seven treatments for the study were: fraise mow at 6.4 mm from the grass surface, fraise mow at 12.7 mm from the grass surface, fraise mow at 19.1 mm from the grass surface, spray application of trifloxysulfuron at the 27.8 g ha^{-1} (Monument 75WG, Syngenta, Basel, CH) with non-ionic surfactant at 0.25% v/v (Activator 90, Loveland Products Inc., Greeley, CO, USA), spray application of foramsulfuron at the 28.9 g ha^{-1} (Revolver, Bayer Environmental Sciences, Research Triangle Park, NC, USA), scalping (19.1 mm) with a rotary mower, and an untreated control. Herbicides were applied with a piston pump backpack sprayer (Solo 425, Solo, Inc. Newport News, VA, USA) equipped with a single flat fan nozzle (XR 8004 VS, TeeJet Technologies, Tifton, GA, USA) using 7.6 L of water. Backpack sprayer were calibrated by collecting water output of the sprayer nozzle for a 1-min period and time for the applicator to walk six meters with the sprayer, with each test being completed five times then averaged. After the averages of the amount collected and the distance walked were determined, the application rate per area was calculated. Fraise mowing applications were applied with a Koro fraise mower (Field Top Maker 2000, Campey Turf Care, Cheshire, UK), while scalping treatments were applied with a rotary mower (HRX217VYA, Honda, Tokyo, JP). Treatments were initiated on 11 May 2017 in Stillwater and 17 May 2017 in Knoxville. Treatments were applied once at each location and recovery was monitored for six weeks following treatment applications at both locations. Plots were monitored for six

TABLE 1 Repeated measures analysis of variance (ANOVA) of 'Riviera'; bermudagrass (*Cynodon dactylon*) for green cover and grid counts among spring perennial ryegrass ryegrass (*Lolium perenne*) transitioning treatments and rating dates in Knoxville, TN and Stillwater, OK in spring of 2017

Effect	DF[a]	Green Cover[b]	Bermudagrass Grid Count[c]	Bare Ground Grid Count	Ryegrass Grid Count
Treatment (T)	6	d	d	d	d
Date (D)	5	d	d	d	d
T × D	30	d	d	d	d
Location (L)	1	NS***	NS	NS	NS
L × D	5	NS	NS	NS	NS
L × T	6	NS	NS	NS	NS
L × T × D	30	NS	NS	NS	NS

[a]DF, degrees of freedom.
[b]Green Cover was determined using digital image analysis for green cover.
[c]Collected using three feet by three feet grid with 100 interceptions points.
[d]NS, not significant at P = .05 probability level.
***Significant at the .001 probability level.

TABLE 2 Changes in percent green turfgrass cover for seven different transition treatments over six weeks in the spring in Knoxville, TN and Stillwater, OK. Treatments included control (Trt 1), fraise mow at 6.4 mm (Trt 2), 12.7 mm (Trt 3) and 19.1 mm (Trt 4) depths in addition to scalping at 19.1 mm (Trt 5), chemical applications of trifloxysulfuron (Trt 6) and foramsulfuron (Trt 7). Fisher's least significant difference (LSD) was used to separate means at α = .05. Standard error bars are presented as a means of statistical comparison

WAT[a]	Trt 1	Trt 2	Trt 3	Trt 4	Trt 5	Trt 6[b]	Trt 7[c]	SE[d]
1	97	90	64	12	90	70	70	2.5
2	96	91	66	24	90	68	73	2.5
3	96	92	68	40	91	66	76	2.5
4	95	92	70	47	91	68	79	2.5
5	93	91	75	51	91	72	82	2.5
6	91	91	79	60	90	76	84	2.5

[a]WAT, weeks after treatment.
[b]Spray application of trifloxysulfuron at the 27.8 g ha^{-1} (Monument 75WG, Syngenta, Basel, CH) with non-ionic surfactant at 0.25% v/v (Activator 90, Loveland Products Inc., Greeley, CO, USA).
[c]Spray application of foramsulfuron at the 28.9 g ha^{-1} (Revolver, Bayer Environmental Sciences, Research Triangle Park, NC, USA).
[d]SE, standard error.

weeks following treatment application. Plot sizes were 1.5 m by 1.5 m with each treatment being replicated three times.

Digital image analysis was used to quantify green cover and quality immediately after and for six weeks following treatment initiation according to the methods of Richardson, Karcher, and Purcell (2001). Grid counts for bermudagrass, ryegrass, and bare ground were completed biweekly following treatment initiation according to the methods of Brosnan and Breeden (2013) using a 1 m by 1 m grid. One grid count was collected in each plot per data collection event due to the size of the grid used. A randomized complete block design with three replications was utilized for all treatments. Plot randomization was completed in Excel (Microsoft, Redmond, WA, USA).

A repeated measures analysis of variance was conducted in SAS (v.9.3; SAS Institute Inc., Cary, NC, USA) for all variables (Table 1). No significant location differences were detected; therefore, results were pooled and analyzed. Fisher's least significant difference (LSD) was used to separate means at α = .05. Changes in green cover and bermudagrass grid count were analyzed using regression analyses in GraphPad Prism 8 (GraphPad Software, San Diego, CA, USA) with linear models best fitting data. Model parameter estimates were calculated in GraphPad Prism 8.

3 | RESULTS AND DISCUSSION

Foramsulfuron and fraise mowing at 12.7 mm followed a statistically similar trend in recovery over time in percent green cover (Table 2). On every date, both chemical and fraise mowing at 12.7 mm treatments never varied more than 10% green

TABLE 3 Changes in perennial ryegrass (*Lolium perenne*) grid counts for seven different treatments over six weeks in the spring in Knoxville, TN and Stillwater, OK. Treatments included control (Trt 1), fraise mow at 6.4 mm (Trt 2), 12.7 mm (Trt 3) and 19.1 mm (Trt 4) depths in addition to scalping at 19.1 mm (Trt 5), chemical applications of trifloxysulfuron (Trt 6) and foramsulfuron (Trt 7). Fisher's least significant difference (LSD) was used to separate means at α = .05. Standard error bars are presented as a means of statistical comparison

WAT[a]	Trt 1	Trt 2	Trt 3	Trt 4	Trt 5	Trt 6[b]	Trt 7[c]	SE[d]
1	73	39	34	20	50	68	65	4.2
2	62	36	31	19	44	44	35	4.2
3	40	32	27	14	43	32	32	4.2
4	40	27	26	14	35	31	29	4.2
5	32	21	8	6	31	27	18	4.2
6	25	21	6	4	26	27	12	4.2

[a]WAT, weeks after treatment.

[b]Spray application of trifloxysulfuron at the 27.8 g ha^{-1} (Monument 75WG, Syngenta, Basel, CH) with non-ionic surfactant at 0.25% v/v (Activator 90, Loveland Products Inc., Greeley, CO, USA).

[c]Spray application of foramsulfuron at the 28.9 g ha^{-1} (Revolver, Bayer Environmental Sciences, Research Triangle Park, NC, USA).

[d]SE, standard error.

cover from each other (Table 2). However, perennial ryegrass grid counts indicated that fraise mowing at all depths reduced ryegrass to less than 40% of the ryegrass contained in the untreated control plots one week after treatment initiation (Table 3). Weeks five and six showed the 12.7 and 19.1 mm fraise mowing treatments had the greatest amount of perennial ryegrass removal (Table 3). These findings for fraise mowing at 12.7 and 19.1 mm correlate that with findings of McCauley et al. (2019), that fraise mowing at a minimum depth of 12.7 mm is effective at perennial ryegrass removal. The lack of difference in percent green cover and low amount of perennial ryegrass grid counts suggests fraise mowing at depth 12.7 mm or greater is as effective if not more at ryegrass removal compared to the chemical treatments.

The 19.1 mm fraise mowing plots reduced green cover to less than 52% until six weeks after treatment application and took the longest to green-up. The 19.1 mm fraise mow is aggressive and delayed spring green-up, following the trend of previous research on mechanical transition (Kopec et al., 2001; Mazur & Wagner, 1987). Ryegrass grid counts showed that fraise mowing at 19.1 mm removed the greatest amount of ryegrass for up to six weeks after treatment application (Table 3). These findings correlate with McCauley et al. (2019) that fraise mowing greater than 12.7 mm depths were effective at perennial ryegrass removal. However, fraise mowing to a depth greater than 12.7 mm is not recommended if play is desirable within six weeks of the fraise mowing event. If play or use of the turfgrass is not a concern, the deeper fraise mowing depth removed the more thatch and could add additional benefits seen by previous studies (Miller, Earlywine, & Fresenburg, 2017; Munshaw et al., 2017).

Minimal loss in percent green cover was noticed in the scalping, 6.4 mm fraise mow, and the control plots (Tables 2 and 4). However, grid counts showed that scalping and fraise mowing at 6.4 mm were statistically the same as the control in number of ryegrass plants from three weeks after treatment initiation until the end of the study (Table 3). Also, by week five, the control had statistically the same amount of perennial ryegrass through the end of the study as scalping, fraise at 6.4 mm, and trifloxysulfuron. These results also indicated that if a fast transition is not needed, in Tennessee and Oklahoma, perennial ryegrass will begin to decline due to environmental factors (Table 3). Knoxville, TN has an average high temperature of 25 ˚C in May and 29 ˚C in June, while Stillwater, OK has an average high temperature of 26.7 ˚C in May and 32 ˚C in June (National Oceanic and Atmospheric Administration, Asheville, NC, USA). During this study in 2017, the average high temperature in Knoxville was below average in May (24 ˚C) but was above average in June (30 ˚C), while Stillwater had a cooler than average in May (25.9 ˚C) and slightly warmer than average June (33.3 ˚C) of 2017. Previous studies have found that trifloxysulfuron and foramsulfuron can have lower efficacy in perennial ryegrass removal from bermudagrass under adverse environmental conditions such as cooler soil temperatures (Willis et al., 2007; Willis, 2008). The efficacy of both chemical applications would have been expected to improve had application been delayed to June, but a delay in fraise mowing would have potentially limited the ability of the bermudagrass to recover before the next playing season. While soil temperature and other environmental conditions were beyond the scope of this study, these potential differences in efficacy could have impacted the effectiveness of the chemical controls.

One limitation of this study was that this study only went six weeks after treatment initiation, complete ryegrass removal that lasted beyond the end of the six weeks was collected in this study. Previous studies have found that poor transition can occur due to leaf shading or plant competition that persists into the summer from the overseeded grass (Horgan &

TABLE 4 Changes in bermudagrass (*Cynodon dactylon*) amount for seven different treatments over six weeks in the spring in Knoxville, TN and Stillwater, OK. Treatments included control (Trt 1), fraise mow at 6.4 mm (Trt 2), 12.7 mm (Trt 3) and 19.1 mm (Trt 4) depths in addition to scalping at 19.1 mm (Trt 5), chemical applications of trifloxysulfuron (Trt 6) and foramsulfuron (Trt 7). Fisher's least significant difference (LSD) was used to separate means at α = .05. Standard error bars are presented as a means of statistical comparison

WAT[a]	Trt 1	Trt 2	Trt 3	Trt 4	Trt 5	Trt 6[b]	Trt 7[c]	SE[d]
1	25	35	41	15	50	32	35	4.2
2	37	58	53	49	56	58	59	4.2
3	60	66	63	68	65	67	64	4.2
4	60	67	64	79	56	68	71	4.2
5	68	73	71	85	64	74	71	4.2
6	75	78	74	86	74	77	74	4.2

[a]WAT, weeks after treatment.

[b]Spray application of trifloxysulfuron at the 27.8 g ha^{-1} (Monument 75WG, Syngenta, Basel, CH) with non-ionic surfactant at 0.25% v/v (Activator 90, Loveland Products Inc., Greeley, CO, USA).

[c]Spray application of foramsulfuron at the 28.9 g ha^{-1} (Revolver, Bayer Environmental Sciences, Research Triangle Park, NC, USA).

[d]SE, standard error.

Yelverton, 2001; Kopec et al., 2001). These findings would suggest that scalping and fraise mowing at 6.4 mm did not significantly reduce the ryegrass due to treatment effects from the control. The lack of impact of the scalping treatment could be that greater depth was needed. Previous research has found scalping to be effective in transition but did delay spring green up (Kopec et al., 2001; Mazur & Wagner, 1987).

Bare ground was only observed in grid counts in some 12.7 mm and all 19.1 mm in fraise mow plots (data not shown). Other plots contained some yellowing but no bare ground due to bermudagrass growth. In the six-week recovery period, the 19.1 mm fraise mow treatments went from 73% bare ground to 13%. The 12.7 mm fraise mow was below 10% bare ground by three weeks after treatment application (data not shown). Previous studies found similar results that mechanical transitions can be effective but can delay green-up due to the aggressiveness of the cultural practice (Kopec et al., 2001; Mazur & Wagner, 1987).

The objective of the study is answered in that fraise mowing at 12.7 mm or greater is as effective as chemical transitions in perennial ryegrass removal. Depths of at least 12.7 mm are needed in fraise mowing to be effective, but beyond that depth are not recommended for spring transition due to slower spring green-up. However, the 19.1 mm fraise mow treatment showed the amount of tissue removed overall indicated this might be too aggressive for an in season use of an area of turfgrass. This study is the first to find that fraise mowing at 12.7 mm mechanical transition behaves similarly to a chemical transition without the delay in spring green-up in bermudagrass.

While this study identifies the potential for fraise mowing use in ryegrass transitioning, there are some limitations. This study only investigates one type of fraise mower; however, there are several different brands of mowers available. Also, investigating how annual fraise mowing would impact the playing surface throughout the year is warranted. There are additional benefits of fraise mowing (thatch removal, decreased disease pressure, etc.) that were beyond the scope of this study but have been found to be beneficial for bermudagrass in previous publications (Miller et al., 2017; Munshaw et al., 2017). The additional benefits of fraise mowing make non-chemical transition of ryegrass an attractive option, compared to chemical transition alone. While there are more potential benefits of fraise mowing, the reduced cost of herbicides and ease of application makes chemical transition the most used option. If further benefits are observed and plant health is improved beyond what has been previously established, annual fraise mowing could become a way to remove ryegrass while reducing thatch at the same time saving time and money.

4 | CONCLUSION

Non-chemical transitioning of ryegrass can be just as effective as chemical transitions without the spring green-up delay. However, selecting the correct fraise mow depth is critical for an effective transition. Fraise mowing at 12.7 mm was identified as the optimum depth for perennial ryegrass transitioning in this study compared to chemical transitions. However, if time of use for the turfgrass area is not a primary concern then depths greater than 12.7 mm are effective at perennial ryegrass removal but may delay spring green-up. Fraise mowers are a tool that should be considered when transitioning ryegrass due to its reduced chemical use and the extra potential benefits of fraise mowing. Future research is still needed to find the impact of fraise mowing over multiple years. Turf managers can use fraise mowers as an acceptable transition method for overseeded areas in the future without delaying spring green-up.

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