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Mechanical renovation of bermudagrass for interseeding tall fescue

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ABSTRACT

Perennial year-round grazing systems require both warm- and cool-season grass components that establish readily and persist in the warm, humid climate of the southeastern USA. The ideal conditions for tall fescue (*Festuca arundinacea* Schreb.) establishment in bermudagrass [*Cynodon dactylon* L. (Pers.] pastures have not been extensively investigated. Previous attempts to establish tall fescue in bermudagrass pasture at our location have produced variable results. Manipulation of surface residue and surface soil conditions may improve tall fescue establishment, although it may be at the expense of bermudagrass stand. There should be an optimum disturbance level that favors a balanced mixed-stand of bermudagrass-tall fescue. A strip-plot, block design consisting of 10 treatments replicated 4 times in 675 m^2 plots was conducted to determine (1) whether surface disturbance of 'Coastal' bermudagrass pasture would improve interseeded tall fescue establishment, (2) which surface disturbance would lead to improved tall fescue establishment, and (3) how surface disturbance would alter botanical composition with time. Treatments were a factorial arrangement of (a) burning surface residue prior to interseeding or not and (b) level of mechanical disturbance of surface soil, including no disturbance with broadcast seeding, no disturbance with drill seeding, chisel plow with drill seeding, disking with broadcast seeding, and disking with drill seeding. We report the results of botanical composition during the first year following tall fescue interseeding sampled at 3-month intervals.

Keywords: Botanical composition; Broadcast seeding; Chisel plow; Direct drilling; Disk tillage; No tillage

INTRODUCTION

Interseeding of tall fescue into established bermudagrass sod has the potential to increase forage and animal productivity and increase the length of the grazing season in the southeastern USA (Fribourg and Overton, 1979; McLaren et al., 1983; Wilkinson et al., 1968). The ideal conditions for tall fescue establishment in bermudagrass pastures have not been extensively investigated, but different options have been suggested (Wolf et al., 1996). Previous attempts to establish tall fescue in bermudagrass pasture have produced variable results. One of our research team's experience suggested that allowing bermudagrass to develop an upright morphology (low grazing pressure) with late-season haying of forage prior to seeding of tall fescue was more successful in obtaining a mixed-stand pasture than continuous high grazing pressure, which produced a more matted, horizontal morphology of bermudagrass and promoted winter annual weed development. This suggested that above-ground forage or residue played a role in establishment of tall fescue. In addition, we had attempted to interseed tall fescue into the bermudagrass pasture where this experiment was conducted for three consecutive years without success. Precipitation during winter/spring had been below normal during this time. Surface soil compaction may limit tall fescue seed placement for good germination and may alter the competitive forces for successful tall fescue establishment with other forages present. Manipulation of surface residue and surface soil conditions may improve tall fescue establishment, although it may be at the expense of bermudagrass stand. There should be an optimum disturbance level that favors a balanced mixed-stand of bermudagrass-tall fescue.

The objective of this study was to determine (1) whether surface disturbance of 'Coastal' bermudagrass pasture will improve interseeded tall fescue stand establishment, (2) which surface disturbance will lead to improved tall fescue establishment, and (3) how surface disturbance could alter stand composition with time.

METHODS

The experimental site was a 7-ha upland field located near Farmington GA USA (33E 22' N, 83E 24' W). 'Coastal' bermudagrass was established by sprigging in 1991. This pasture served as the reserve area when cattle were removed from an adjacent experimental grazing study. Angus steers grazed the area intermittently from 1994 to 2001. If needed, hay was harvested to remove excessive growth.

In the autumns of 1998, 1999, and 2000, tall fescue was directly drilled into the bermudagrass sod with little success each time. In the autumn of 2001, four blocks measuring 60 x 112.5 m each were established. One half of each block was control burned on 26 November 2001 to remove excess above-ground forage and surface litter. Perpendicular to the two surface treatments, five mechanical disturbance treatments were assigned in strips. A total of 40 plots measuring 675 m^2 each were established. The five mechanical disturbance treatments were (1) none with broadcast seeding, (2) none with drill seeding, (3) disk tillage with broadcast seeding, (4) disk tillage with drill seeding, and (5) chisel-plow tillage with drill seeding. Tillage operations were a single pass on 27 November 2001 with disturbance to approximately 10 cm with disk tillage and 15 cm with chisel-plow tillage. 'Georgia-5' tall fescue was either broadcasted with a spin-type spreader or drilled in 18-cm-wide rows with a no-till double-disk opener at 3.4 $g \cdot m^{-2}$ on 28 November 2001. Broadcasted seed was incorporated with a drag harrow.

Botanical composition of forage was evaluated from 10 randomly selected 0.25-m^2 areas within each plot beginning in January 2002 and repeated thereafter every three months. Composition was divided into tall fescue, bermudagrass, winter annual grass [primarily ryegrass (*Lolium annuum* L.)], broadleaves [primarily henbit deadnettle (*Lamium amplexicaule* L.)and common chickweed (*Stellaria media* (L.) Vill.)], and bare soil. The same experienced technician made all estimates on a visual basis, with the lowest unit of discrimination being 5%.

Forage quantity was estimated on 15-16 April 2003 by harvesting a 10 m^2 area within each plot to a height of -4 cm with a vacuum mower. Total wet weight was determined in the field and a 400- to 800-g subsample was weighed in the field and following drying at 70 EC for several days.

Multiple observations within a plot were averaged prior to statistical evaluation using a general linear model (SAS Institute Inc., 1990). The experiment was analyzed as a strip-plot, block design with four replications. Sources of variation within each sampling date were blocks (4), surface treatment (2), mechanical disturbance (5), and surface treatment x mechanical disturbance (10). Orthogonal contrasts were developed to test the following: (i) broadcast *vs* drill seeding, (ii) no tillage with broadcast seeding *vs* disk tillage with broadcast seeding, (iii) no tillage with drill seeding *vs* disk/chisel tillage with drill seeding, and (iv) disk tillage with drill seeding *vs* chisel-plow tillage with drill seeding. Effects were considered significant at *p* # 0.1.

RESULTS

Visual assessment of botanical composition is not an estimate of plant population, but rather an assessment of relative above-ground presence of plant species. The seasonal variation in bermudagrass is an example of this relative presence of above-ground forage composition (Fig. 1). Plant population of bermudagrass did not likely decline from January 2002 to April 2002, but the proliferation of cool-season species (e.g., tall fescue, annual grass, and broadleaves) during this period led to the large decline in above-ground presence of bermudagrass.

Surface treatment (i.e., burning or not) had large immediate impacts on botanical composition, but these effects moderated with time (Fig. 2). Burning reduced bermudagrass composition at the end of 1 month and increased the bare soil composition such that equal percentages of land area were occupied by each. Unburned plots had initially twice as much bermudagrass as bare soil. This physical consequence of burning was limited to the first sampling event. At the end of 4 and 10 months, tall fescue composition was slightly improved and bermudagrass composition was slightly reduced with burning. In general when averaged across disturbance/seeding treatments, burning the surface residue and removing above-ground forage completely prior to interseeding did give a slight advantage for the establishment of tall fescue.

When bermudagrass was disked in November 2001, the method of seeding tall fescue significantly affected both tall fescue and bermudagrass composition (Fig. 3). Broadcast seeding of tall fescue led to 37% tall fescue compared with 30% with drilling at the end of 4 months. Tall fescue composition was 63% with broadcast seeding and 53% with drilling at the end of 7 months. However, after 10 months from seeding there were no longer differences between broadcast seeding and drilling. At the end of 10 months, broadcast seeding of tall fescue led to 55% bermudagrass composition compared with 43% bermudagrass when tall fescue was drilled.

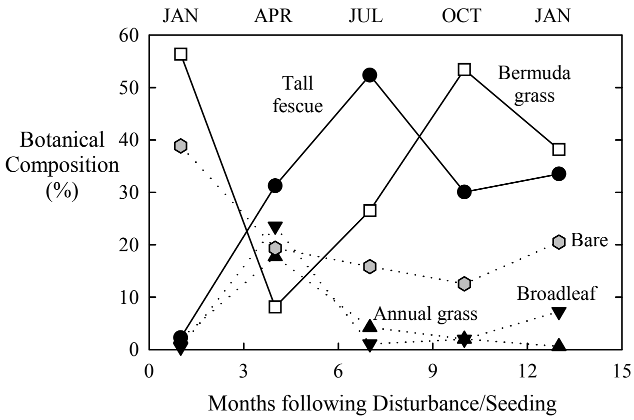

Figure 1. Seasonal changes in botanical composition averaged across surface/disturbance/seeding treatments. LSD value (*p* # 0.1) for tall fescue was 18%, for bermudagrass was 18%, for annual grass was 5%, for broadleaf was 9%, and for bare soil was 16%.

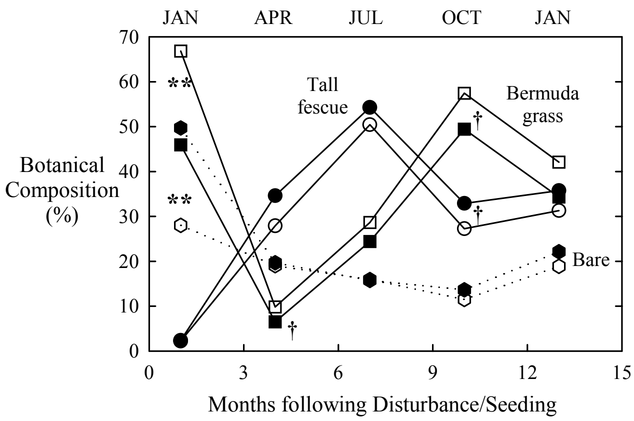

Figure 2. Seasonal changes in tall fescue, bermudagrass, and bare soil composition averaged across disturbance/seeding treatments as affected by surface treatment (open symbols are unburned and closed symbols are burned prior to seeding). † and ** between surface treatment means indicate significance at *p* # 0.1 and *p* # 0.01, respectively.

Botanical composition under the two extreme treatments primarily affected bermudagrass and bare soil components (Fig. 4). The highly disturbed treatment of burned-chisel plow-drill seeding greatly increased the bare soil component at the expense of the bermudagrass component. This effect was greatest at the end of 1 month (difference of 78%), but a consistent difference of 18 to 24% was maintained thereafter. Interestingly, extreme treatments did not significantly affect tall fescue composition within sampling events. However averaged across sampling events, tall fescue composition was significantly higher with burned-chisel plow-drill seeding (30%) than with unburned-no tillage-broadcast seeding (26%).

The standing stock of fresh forage was little affected by surface treatment, tillage disturbance, and seeding method at the end of 16 months following treatment (Table 1). The only significant difference that occurred was that unburned-disk-drill produced lower fresh forage mass than either burned-no tillage-drilled, burned-disk-broadcast, or unburned-chisel plow-drill.

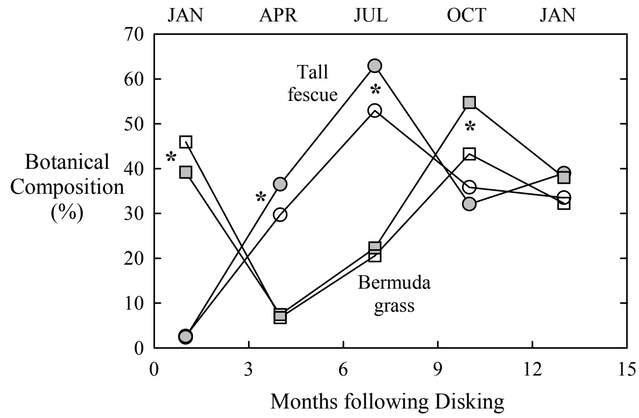

Figure 3. Seasonal changes in tall fescue and bermudagrass composition averaged across surface treatments as affected by seeding with disk-tillage disturbance (open symbols are drill and closed symbols are broadcast seeding). * between seeding means indicate significance at *p* # 0.05.

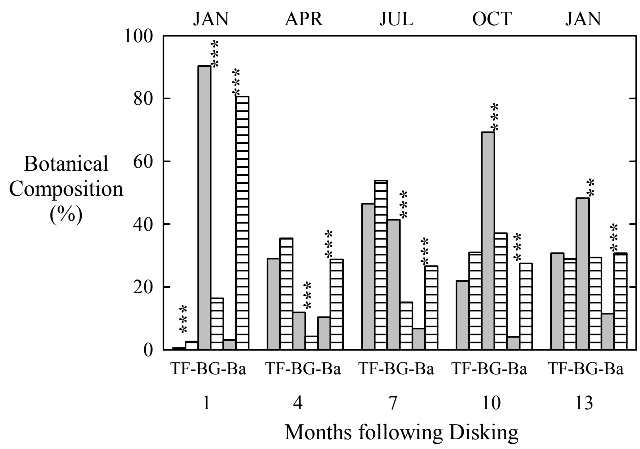

Figure 4. Seasonal changes in tall fescue, bermudagrass, and bare soil composition in the two extreme treatments (gray-filled bars are least disturbed without burning, no disturbance, and broadcast seeding white-hatched bars are most disturbed through burning, chisel-plow tillage, and drill seeding). TF is tall fescue, BG is bermudagrass, and Ba is bare soil. ** and *** between treatment means indicate significance at *p* # 0.01 and *p* # 0.001, respectively.

DISCUSSION

Tall fescue became relatively well established, irrespective of treatments. This was unexpected, based on previous attempts to establish tall fescue at this site. Although there were some differences in tall fescue establishment, the differences were either relatively small or not consistent throughout the evaluation period. Depending upon the equipment and environmental concerns of a producer, any of the various establishment procedures could be recommended for establishing tall fescue under conditions similar to those of our study. However to reduce the risks of stand failure, loss of seed-cost investment, and opportunities to graze, drilling of tall fescue seed into burned bermudagrass stubble would appear to be the most advantageous renovation strategy under a wider range of environmental conditions. More work is needed to validate this tenet, despite these results suggest otherwise.

Burning of remaining bermudagrass forage at the end of the growing season, at which time plants had naturally senesced due to cold temperatures, appeared to be an effective means of getting faster and consistently better tall fescue establishment (Fig. 2). The reasons for this response are several. The blackened soil-surface condition likely increases soil temperature so that the relatively weak tall fescue seedling has greater opportunity to emerge and become established. Also, the removal of surface residue might alleviate the presence of inhibitory substances from senescent forage and allow greater contact of seeds with soil. Although the amount of bermudagrass production area that might potentially be burned in order to establish a cool-season grass would not be extensive, precautions should be taken to avoid uncontrolled burning that might cause off-site damage and concerns over the prominent impact on local air quality. Once tall fescue is established in a mixed stand of forage, its strong competitiveness and persistence should limit the frequency for reestablishment to a decade or more, given sustainable defoliation and fertilization strategies that allow both warm- and cool-season grasses to reach their potential.

Soil disturbance of an established bermudagrass sod with either disk or chisel-plow tillage did not have an enormously large effect on bermudagrass composition, except initially. The lack of a reduction in bermudagrass composition with tillage is due its stoloniferous and rhizomatous nature, which allows bermudagrass to rapidly reestablish from both stolons and rhizomes relocated by the tillage operation. Except on very steep uplands, tillage for renovation of a bermudagrass sod would also not be expected to greatly increase soil erosion. Even with nearly half of the visual bermudagrass composition removed immediately after disk or chisel-plow tillage, revegetation occurred rapidly and may ultimately increase the productivity of the forage stand similar to that of an aerator, sometimes used to stimulate forage and increase water infiltration.

One possibility for previous failures to establish tall fescue into living bermudagrass sod may have been due to inadequate depth penetration of seed into soil. However, the adequate establishment of tall fescue when bermudagrass was not burned, surface soil was not disturbed with tillage, and seed was broadcasted, suggests that this may not have been a major problem.

Quantity and timing of rainfall following sowing of tall fescue may have been part of the reason for failures in establishing interseeded tall fescue into bermudagrass prior to this study. The winter period from December to March in northern Georgia is typically wet and cool without great moisture stress. However, the winters of 1998/99 and 1999/00

Table 1. Quantity of fresh forage ($g \cdot m^{-2}$) harvested from plots on 15-16 April 2003 as affected by surface treatment, disturbance regime, and seeding methods.

	Surface treatment	
Disturbance/seeding	Burned	Unburned
Chisel-plow/drill	747	890
Disk/drill	835	615
Disk/broadcast	911	868
None/drill	968	836
None/broadcast	856	863
LSD (p # 0.1)	272	

Table 2. Cumulative rainfall (mm) and average temperature (EC) conditions prior to and during experimental setup recorded at a weather station 12 km to the north of the study site and 50-year mean values from a weather station 25 km to the north of the study site (from Georgia Automated Environmental Monitoring Network, http://www.griffin.peachnet.edu/cgi-bin/GAEMN.pl?site=GAWU).

	Temperature		Rainfall	
	Min	Max	Total	Dev
50-year means				
OCT-NOV	7.8	20.3	173	
DEC-JAN	1.1	13.2	244	
FEB-MAR	3.5	16.3	246	
APR-SEP	16.9	28.8	612	
OCT-NOV 1998	9.6	22.9	117	-56
DEC-JAN 1999	3.3	14.9	206	-38
FEB-MAR 1999	2.9	16.5	146	-100
APR-SEP 1999	16.6	29.3	585	-27
OCT-NOV 1999	8.7	21.5	145	-28
DEC-JAN 2000	1.0	12.7	182	-62
FEB-MAR 2000	4.6	18.8	132	-114
APR-SEP 2000	16.1	29.2	446	-166
OCT-NOV 2000	7.2	20.6	127	-46
DEC-JAN 2001	-1.5	9.8	177	-67
FEB-MAR 2001	4.0	16.1	307	+61
APR-SEP 2001	16.4	28.4	604	-8
OCT-NOV 2001	6.0	22.6	26	-147
DEC-JAN 2002	2.6	15.0	157	-87
FEB-MAR 2002	3.1	16.6	229	-17
APR-SEP 2002	17.2	29.3	435	-177
OCT-NOV 2002	8.8	19.5	237	+64
DEC-JAN 2003	0.1	11.3	200	-44
FEB-MAR 2003	4.9	16.2	288	+42

received 64-72% of 50-year average precipitation with slightly above-average temperature (Table 2). The winter of 2000/01 received normal precipitation, but was 1.4 EC below normal in temperature, mainly due to a very cold December immediately following emergence. The winter of 2001/02, in which we initiated this study, received only 79% of average precipitation and was 0.8 EC above average in temperature. The summer period from April to September immediately following treatment implementation was one of the driest on record for the region.

CONCLUSIONS

In general, surface disturbance either through removing surface residue with burning or through mechanically loosening surface soil with tillage did not dramatically improve tall fescue establishment. However, there was a minor improvement in tall fescue establishment with burning than without burning (averaged across other treatments and sampling events, tall fescue was 32% of botanical composition with burning and 28% without burning). Mechanical disturbance of surface soil prior to interseeding tall fescue also had a positive, but minor effect on tall fescue establishment (averaged across other treatments and sampling events, tall fescue was 33% of botanical composition with disking and 27% with no mechanical disturbance; with drill seeding only, tall fescue was 30% with chisel-plow and 26% with no mechanical disturbance). Surprisingly, whether tall fescue was interseeded by drilling or broadcasting had little overall effect on tall fescue establishment. At the end of 13 months following interseeding treatments (January 2003), bermudagrass composition was greatest (43-48%) when surface soil remained undisturbed (without tillage) and tall fescue seed was broadcasted. The same treatments that maximized bermudagrass composition minimized the percentage of area that was bare soil. Available forage harvested at the end of 16 months following interseeding treatment (April 2003) was little affected by most treatments, although significantly greater (57%) fresh forage was harvested from the burned, no-tillage, drill seeded treatment than from the unburned, disk-tillage, drill seeded treatment. Additional data will be collected on forage composition and forage mass during the remainder of 2003.

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