Herbage responses and performance of mature horses grazing warm-season perennial grass-legume mixed pastures

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Keywords: bahiagrass, botanical composition, herbage mass, horse body weight, rhizoma peanut

Abstract. Legume-grass mixtures may be a useful alternative to nitrogen-fertilized grass monocultures, but pasture and animal responses have not been assessed for pastures grazed by horses in Florida. This 2-yr study compared pasture and horse responses of continuously stocked, mixed pastures of rhizoma peanut (RP, *Arachis glabrata* Benth) and bahiagrass (BG, *Paspalum notatum* Flüggé) receiving 30 kg nitrogen (N)/ha (RP-BG) compared with BG pastures fertilized with 120 kg/N ha (BG-N) or with no N (BG-No N). Herbage mass was similar among treatments in 2020 and for most evaluation days in 2019. In 2019, stocking rate (AU/ha) was greater in BG-N (3.9) than in RP-BG (3.7) and BG-No N (3.1). In 2020, BG-No N (2.6) had the lesser stocking rate compared with BG-N (2.9) and RP-BG (2.9), with RP-BG not differing from BG-N. Herbage crude protein (CP) and digestible energy were similar across treatments in 2020, but they were greater for BG-N and RP-BG than BG-No N at some evaluation days in 2019. Except for CP, treatment did not affect nutrient digestibility by horses. Digestibility of CP was greatest for RP-BG in the late season. In the RP-BG treatment, proportion of RP in the pasture (~29%) was not affected by sampling date, and RP comprised 18.4% of the diet. Nonetheless, no differences were observed among treatments for body weight and condition score. The results indicate that intercropping legumes into warm-season perennial pastures can improve some measures of nutritive value and maintain horses' body condition with similar stocking rate as N-fertilized bahiagrass pastures, while contributing to development of sustainable grazing systems for horses with reduced off-farm nitrogen inputs.

Introduction

Providing horses with pasture access benefits their health and welfare. However, C_4 grass pastures used for grazing by horses may require N fertilizer inputs to increase production and nutritional value. Incorporating a forage legume into these grasslands may be a sustainable alternative that reduces the need for nitrogen fertilizer while maintaining pasture productivity and increasing forage nutritive value (Jaramillo et al., 2021). Although most warm-season legumes persist poorly when planted with C_4 grasses (Muir et al., 2011), rhizoma peanut (*Arachis glabrata* Benth.) has spread and persisted for decades in grazed warm-season pastures when grazed by cattle (Mullenix et al., 2014). Cattle performance and forage nutritive value were enhanced in rhizoma peanut-bahiagrass systems compared with N-fertilized bahiagrass monocultures (Jaramillo et al., 2021). To our knowledge, no study has yet investigated herbage and animal responses on warm-season, grass-legume mixed pastures grazed by horses. We hypothesized that incorporating rhizoma peanut into warm-season grass pastures grazed by mature horses would offset inputs of N fertilizer and maintain forage production, increase forage nutritive value, and maintain animal body weight and condition. Therefore, the objective of this study was to compare forage nutritive value and production and horse performance responses on continuously stocked rhizoma peanut-bahiagrass pastures compared with bahiagrass monocultures at two levels of N fertilization.

Methods and Study Site

A two-year grazing experiment was conducted at the University of Florida, Beef Research Unit, located in Gainesville, FL. Treatments consisted of well-established 'Argentine' bahiagrass (BG) monoculture fertilized with N at 120 kg N/ha (BG-N), bahiagrass monoculture with no N applied (BG-No N), and

bahiagrass intercropped with 'Florigraze' rhizoma peanut (RP) and fertilized with N at 30 kg N/ha (RP-BG). Experimental units measured 1 ha and were continuously stocked for 84 days each year, from July to October 2019 and 2020, by two mature horses each. Herbage allowance was adjusted every 14 days as recommended by Sollenberger et al. (2005), which averaged 1.9±0.43 kg DM kg/BW. Horses had free access to loose mineral and water. Treatments were replicated two times in a randomized complete block design. All measurements were taken every 14 days, except for intake of dry matter (DM), crude protein (CP) and digestible energy (DE), digestibility of DM and CP, and estimation of the proportion of rhizoma peanut in the daily intake, which were measured every 28 days. Stocking rate (SR) was calculated by dividing the total body weight by 450 kg to obtain the number of animal units that was subsequently divided by the grazed pasture area in ha. Herbage mass (HM, kg DM/ha) was measured using the double sampling technique (Haydock and Shaw 1975). Botanical composition (BC, %) was also determined using a double-sampling technique (Ortega-S et al. 1992) and is reported as proportion of bahiagrass, rhizoma peanut, and weed. Forage nutrient composition was measured by collecting hand-plucked samples in ten locations within each experimental unit and samples were shipped to the Equi Analytical laboratory for chemical analysis. Horse body weight was measured using a livestock platform scale, while body condition score was determined using the Henneke scale (Henneke et al. 1983). Intake and digestibility of dry matter and nutrients were measured every 28 days using the dual marker system (Winsco et al. 2013) with titanium dioxide used as the external indigestible marker and indigestible neutral detergent fiber used as the internal indigestible marker. The proportion of rhizoma peanut in the diet was estimated using the $\delta^{13}C$ from fecal and forage samples (Jones et al. 1979).

Results and Discussion

Stocking Rate and Herbage Mass

Stocking rate (AU/ha) was affected by a year × treatment × evaluation day effect (P=0.03, SEM=0.34). Stocking rate for BG-N (3.9 in 2019 and 2.9 in 2020) was greater than BG-No N (3.1 in 2019 and 2.6 in 2020) in both years, and RP-BG (2.9 in 2020) was greater than BG-No N in 2020. The SR responses indicate that non-fertilized bahiagrass pastures require greater pasture area to maintain mature horses in the warm season compared to fertilizing or intercropping bahiagrass with rhizoma peanut. There was a year × treatment × evaluation day interaction for HM (P=0.02, SEM=150). Fertilized bahiagrass had greater HM than BG-No N and RP-BG on d 28 in 2019, while no differences were observed among treatments on other days. There was no difference among treatments in 2020. Mean HM (kg DM/ha) for the two years was greatest (P=0.01; SEM=120) for BG-N (2,660) and RP-BG (2,480), and least for BG-No N (2,280). The lack of difference in HM among treatments across time agrees with data for continuously stocked cattle reported by Jaramillo et al. (2021).

Botanical Composition and Nutrient Composition

The percentage of bahiagrass in botanical composition was affected by treatment (P=0.01, SEM=3.5). Fertilized bahiagrass had the greatest, and RP-BG had the least percentage of bahiagrass, with BG-No N being intermediate between them. There was a treatment × evaluation day (P=0.02, SEM=5.67) effect on the percentage of weeds in the botanical composition. Unfertilized bahiagrass had greater weed percentage than RP-BG and BG-N late in the season. Weed percent increased from the early to the late season in BG-No N, while in RP-BG and BG-N it remained constant throughout the grazing season. The percentage of RP in RP-BG was not affected by time (P=0.24, SEM=7.0), averaging 29% and remaining consistent in both years. The consistent proportion of RP in RP-BG is consistent with the ability of RP to persist in the grass mixture (Castillo et al. 2013). The similar weed proportion between BG-N and RP-BG, combined with similar HM across time in both years, reinforces that the incorporation of RP into bahiagrass may be used as a strategy to maintain HM in warm-season pastures and suppress weeds (Sanderson et al. 2013). A year × treatment × evaluation day interaction (P=0.01, SEM=0.045) was

observed for DE. In 2019, BG-N resulted in DE greater than BG-No N, with RP-BG not differing from the other pastures on day 42. No differences were observed in 2020. The DE levels found in this study (~1.86 Mcal/kg DM) are within the range reported for warm-season forages for horses (NRC, 2007). There was a year × treatment × evaluation day interaction for CP (P=0.01, SEM=8.2). In 2019, differences in CP were only observed on day 0, with BG-N and RP-BG (16%) having greater CP than BG-No N (10%). Except for days 14 and 84, CP was similar among treatments in 2020. On day 14, BG-N and RP-BG had greater CP than BG-No N (14.6 vs. 9.2%). Later in the season, RP-BG was able to sustain greater CP (14.7%) than both BG-N (11.2%) and BG-No N (8.7%).

Daily intake and digestibility of nutritional components and proportion of RP in the diet

Intake and digestibility of the nutritional components are reported in Table 1. Incorporating rhizoma peanut into bahiagrass with less N fertilizer resulted in lesser estimated DM intake as %BW than BG-No N but similar to BG-N. Consequently, estimated intake of DE was greater for BG-No N than for RP-BG. Even with differences in daily DM intake, daily intake of CP did not differ among treatments, averaging 2.5 kg CP/d. The estimated pasture DM intake reported in this study is substantially greater than the voluntary DM intake of 2 to 2.5 %BW typically required for horses fed all-forage diets (NRC, 2007). However, Longland et al. (2011) reported similar results (3.7 to 4.9 %BW) using pony mares grazing grass-legume mixed pastures. Overall, horses grazing BG-No N required 41% more DM intake than RP-BG to maintain body parameters. We recognize that methodological limitations associated with marker feeding could have played a role in the remarkably high intake for horses grazing BG-No N. No difference was observed for digestibility of DM and CP. There was a treatment x evaluation day interaction (P=0.04, SEM=3.25) effect on CP digestibility. Intercropping RP resulted in greater CP digestibility in the late season than monoculture bahiagrass (54.9 vs 41.7%).

Table 1. Intake and digestibility of nutritional components of monoculture bahiagrass pastures that were fertilized, unfertilized, or mixed with rhizoma peanut and continuously stocked by horses.

Item	Treatment*			*P*-value	SEM
	RP-BG	BG-N	BG-No N		
	Intake				
Dry matter, %BW	3.22[b]	3.69[ab]	5.03[a]	0.04	0.49
Digestible energy, Mcal/d	38.8[b]	38.8[ab]	55.2[a]	0.02	7.00
Crude protein, kg	2.15	2.38	2.93	0.10	0.031
	Digestibility, %				
Dry matter	54.6	49.5	50.2	0.30	5.56
Crude protein	58.7	52.7	47.3	0.13	3.91

*RP-BG = bahiagrass intercropped with rhizoma peanut and fertilized with 30 kg N/ha; BG-N = bahiagrass as monoculture and fertilized with 120 kg N/ha; and BG-No N = bahiagrass as monoculture with no N applied

The estimated proportion of RP in the diet was affected by evaluation day (Fig 1). Proportion of RP was similar between d 28 and 56, and greatest on d 84 (Fig 1). There was no difference in the selection index across time, which averaged 0.68 (Fig 1). The selection index under 1.0 suggests horses had preference for BG over RP throughout the grazing season. Forage preference in horses is influenced by prior exposure to a forage species. The increase in the proportion of RP in the diet observed in this study suggests that horses may have avoided RP early in the grazing due to lack of previous exposure, or it is possible that the canopy structure changed later in the season resulting in greater preference for RP.

Horse Performance

Body weight (538 ± 18 kg) did not differ among treatments, evaluation days, or years (P>0.05). Similarly, horse body condition score did not differ (P=0.08) among treatments, averaging 5.9. In combination with similar nutrient composition and HM, these findings confirm that all treatments provided adequate nutrition to maintain the horses' body weight and condition score throughout the grazing season.

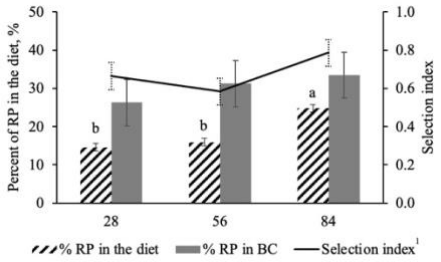

Figure 1. Evaluation day effect (*P*=0.03, SEM=1.3) on percent of rhizoma peanut (RP) in the diet of horses, percent of RP in herbage botanical composition (*P* = 0.24; SEM = 7), and selection index (*P*=0.30; SEM=0.2) of mature horses continuously stocked in bahiagrass pasture mixed with rhizoma peanut. [ab]Means without a common letter differ (*P*<0.05) across time. [1]Selection index, percent of rhizoma peanut in the diet divided by percent of rhizoma peanut in pasture botanical composition

Conclusions

The results of this study support our hypothesis that incorporating rhizoma peanut into warm-season pastures grazed by horses can offset N fertilization of bahiagrass and maintain forage production and horse body weight. Non-fertilized bahiagrass pastures require greater pasture area to maintain horse body condition compared to fertilizing or intercropping bahiagrass pastures with rhizoma peanut. The incorporation of rhizoma peanut into warm-season pastures can maintain digestibility of protein longer in the grazing season than fertilized or non-fertilized monoculture bahiagrass. Overall, incorporating rhizoma peanut into warm-season grass pastures increases sustainability of management practices in horse operations by decreasing off-farm N inputs.

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