Yearling Beef Cattle Grazing Diverse Summer Annual Swards

Mercier, K. M.*, Teutsch, C. D.*, Smith, S. R.†, Burdine, K. H.†, Vanzant, E. S.†, Ritchey, E. L.*
*University of Kentucky Research and Education Center; †University of Kentucky

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Abstract. Utilizing summer annuals is often regarded as "a breakeven proposition at best" due to high establishment costs. This study investigated using botanical diversity to increase forage yield or animal performance to improve the economic feasibility of grazing summer annual forages in western Kentucky, USA. Sorghum-sudangrass (*Sorghum bicolor x S. bicolor* spp. *drummondii*)-based treatments included a monoculture, a three-species mixture (two grasses, one legume), and a 12-species mixture (five grasses, four legumes, two brassicas, and one forb). Angus-cross yearling beef calves (329, 366, and 297 kg in 2017, 2018, and 2019, respectively) grazed summer annuals in 2017-2019 for an average of 40 days each year without supplementation. Pastures were stocked when forage was approximately 1 m tall and calves were removed when forage was 2-2.5 m tall (seedheads present). In all years, forage dry matter yield was not different between treatments ($p > 0.85$) and both mixtures were dominated by sorghum-sudangrass. In 2017 ($p < 0.03$) and 2019 ($p < 0.03$), calves grazing the 12-species mixture had lower average daily gains (ADG) than the monoculture and 3-species mixture, while there was no difference in 2018 ($p > 0.3$). Average daily gains were suboptimal for stocker calves in all years (0.75, 0.01, 0.54 kg day^{-1} in 2017, 2018, and 2019). The extremely low ADG in 2018 was likely a result of stocking pastures late in the season when grasses were at physiological maturity. Additional species increased seed cost but did not contribute significantly to forage production and did not result in increased animal production. Unless greater forage yield or livestock gains are attained, planting mixtures may not provide any economic benefit. However, adjusting seeding rates to favor less dominant species may provide a more accurate representation of species diversity manipulation effects on forage and livestock production.

Introduction

Summer annual forage systems have been dubbed "a breakeven proposition at best" (Ball *et al.* 2007) due to high annual establishment costs as compared to one establishment cost that is depreciated over multiple years in perennial pastures (Ball and Prevatt, 2009). Past work has determined that summer annual systems are not an economical enterprise when compared to perennial forage systems (Allison *et al.* 2021; Tracy *et al.* 2010).

Multi-species forage mixtures often demonstrate transgressive overyielding (resource partitioning) where mixtures of species utilize resources more efficiently than monocultures due to differing morphologies and physiologies (Tofinga *et al.* 1993). This phenomenon has been observed in many annual grass-legume intercropping systems (Bybee-Finley *et al.* 2016; Emuh, 2007; Ram and Meena, 2014; Zhang *et al.* 2011). Livestock grazing diverse pastures (especially with a strong legume presence) also have the potential to perform better than their counterparts grazing a less diverse pasture (Totty *et al.* 2013). Therefore, this study evaluated forage and animal performance of stocker calves grazing summer annual forage mixtures of varying species complexities.

Methods

This study took place in the summers of 2017-2019 at the University of Kentucky Research and Education Center in western Kentucky, USA on Crider silt loam soil. Forage treatments included 1) a sorghum-sudangrass (*Sorghum bicolor x S. bicolor* spp. *drummondii*) monoculture, 2) a three-species mixture of sorghum-sudangrass, pearl millet (*Pennisetum glaucum*), and soybean (*Glycine max*), and 3) a 12-species mixture (three-species mixture plus sudangrass (*Sorghum bicolor* ssp. *drummondii*), crabgrass (50:50 blend of *Digitaria sanguinalis* and *D. ciliaris*), corn (*Zea mays*), cowpea (*Vigna unguiculate*), sunn hemp (*Crotalaria juncea*), Korean lespedeza (*Kummerowia stipulacea*), sunflower (*Helianthus annuus*), forage rape (*Brassica napus*), and Daikon radish (*Raphanus sativus*); Table 1). Seed costs for treatments were as follows: sorghum-sudangrass monoculture, \$195 ha^{-1}, three-species mixture, \$212 ha^{-1}, and 12-species mixture, \$249 ha^{-1}. Three replications of treatments were arranged in a randomized complete block.

Table 1. Species, cultivars, and seeding rates of forage treatments.

Mixture	Cultivar	Seeding Rate (kg ha^{-1})

Monoculture		
Sorghum-sudangrass	AS6402	56
Three-Species Mixture		
Sorghum-sudangrass	AS6402	28
Pearl Millet	Wonderleaf	6
Soybean	Big Fellow (2017); Large Lad (2018-2019)	28
	Total	62
12-Species Mixture		
Sorghum-sudangrass	AS6402	11
Sudangrass	AS9301 (2017); AS9302 (2018-2019)	4.5
Pearl millet	Wonderleaf	4.5
Crabgrass	50:50 blend of Red River and Quick-N-Big	1
Corn	AgriGold 115 day	11
Soybean	Big Fellow (2017); Large Lad (2018-2019)	11
Cowpea	Iron Clay (2017); Red Ripper (2018, 2019)	11
Korean lespedeza	VNS (2017 and 2019); Legend (2018)	4.5
Sunflower	Peredovic (2017, 2019); VNS (2018)	2
Forage rape	Barsica (2017, 2018); T-Raptor (2019)	1
Daikon radish	Nitro (2017); SF Select (2018); Badger (2019)	2
Sunn hemp	VNS	2
	Total	65.5

Site preparation included spraying with a non-selective herbicide and fertilizing with P and K according to soil test results. Nitrogen was applied at 67 or 34 kg N ha^{-1}, with the lower rate applied to both mixtures that contained N-fixing legumes. Forages were no-till drilled into each pasture (experimental unit) on June 12, 2017, July 3, 2018, and June 11, 2019.

Pastures were stocked when forage was approximately 1 m tall and calves were removed when forage ran out (at last grazing event forage was 2-2.5 m tall with seedheads present). Angus-cross yearling beef calves (mix of heifers and steers; 329, 366, and 297 kg in 2017, 2018, and 2019, respectively) grazed summer annuals in for an average of 40 days each year without supplementation. In 2017 and 2018 calves strip grazed, while in 2019 calves rotationally grazed. In 2019, calves were given access to half of a pasture and were rotated to the other half. Hay was fed while the first half was regrowing. Calves grazed the regrowth on the first half and were then removed because the second half did not regrow enough to sustain grazing. In 2018 stocking was unintentionally delayed until late in the season when forages were already at physiological maturity.

Statistical analysis was conducted using the Generalized Linear Model procedure in SAS 9.4 (SAS Institute, Cary, NC, USA). Treatment x year interactions occurred; therefore, response variables are presented for each year.

Results and Discussion

Forage Mass and Botanical Composition

At the end of each grazing season in each year, no differences in forage mass occurred between the monoculture, three-species mixture, and 12-species mixture, even though the monoculture was fertilized with slightly more N than the mixtures (2017: 13.5 Mg ha-^{1}, $p > 0.24$; 2018: 15.9 Mg ha-^{1}, $p > 0.33$; 6.3 Mg ha-^{1}, $p > 0.96$.

Each year, sorghum-sudangrass and sudangrass (12-species mixture only) comprised a minimum of 93, 73, and 64% of the monoculture, three-species mixture, and 12-species mixture, respectively. Legumes and forbs in both mixtures comprised less than 10% of forage mass in each year leading to quite low functional diversity in mixtures. Summer annual grasses likely established quicker than other species, leading to competitive dominance as was also shown by Bybee-Finley *et al.* (2016). Dickson and Busby (2009) stated that to improve plant species diversity, grass seeding rates should be reduced to improve resource acquisition of other more slowly developing species. Although their research focused on native prairie restoration, the principle applies to summer annual pastures.

Animal Performance

In 2017, calves grazing the monoculture and three-species mixture had higher average daily gain (ADG) than calves grazing the 12-species mixture (0.79 vs. 0.66 kg day^{-1}; $p < 0.03$; Fig. 1). In 2018, no differences in ADG were detected among treatments ($p > 0.3$), however, calves only gained an average of 0.01 kg day^{-1}. In 2019, calves grazing the monoculture and three-species mixtures again had higher ADG than calves grazing the 12-species mixture (0.59 vs. 0.43 kg day^{-1}, $p < 0.03$). In contrast to these results, cattle grazing brown mid-rib sorghum-sudangrass have been reported to gain in excess of 0.95 kg day^{-1} (Banta *et al.* 2002; Harmon *et al.* 2020; McCuistion, *et al.* 2011)

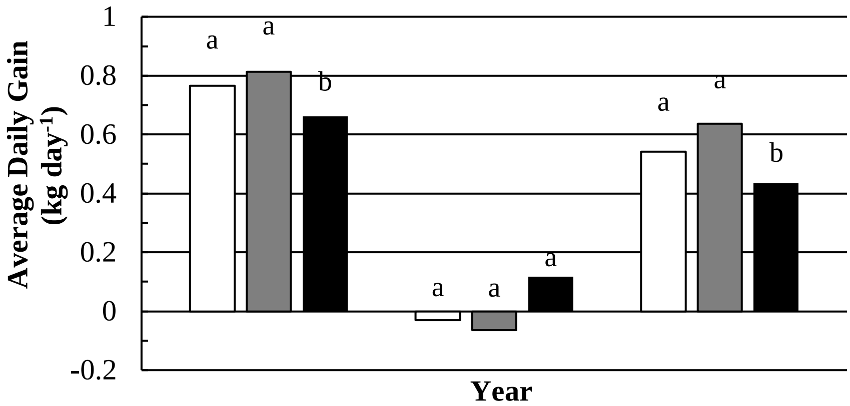

Figure 1. Average daily gain for stocker calves grazing sorghum-sudangrass based pastures (monoculture, white bar; three-species mixture, grey bar; 12-species mixture, black bar). Treatments within a year with common letters do not differ (Fisher's protected least significant difference; α = 0.1).

Several factors may have contributed to poor livestock gains in 2018, including the advanced maturity of forages leading to poorer forage nutritive characteristics (Nelson and Moser, 1994), heavier calves, warmer temperatures/heat stress (O'Brien *et al.* 2010), and limited visibility due to tall forages. Cattle are affected more by visual as opposed to auditory cues (Uetake and Kudo, 1994), and like other prey animals, they prefer areas with greater visibility to aid in predator avoidance (Riginos and Grace, 2008). Calves in the current study were observed to be flightier in 2018 than in 2017 and 2019 (K. Mercier, personal observation). This additional agitation may have adversely influenced animal performance (Petherick *et al.* 2009).

According to the University of Kentucky's Beef Ration Formulator, in 2017, protein supplied by forages should have allowed for an ADG near 0.9 kg day^{-1}. This implies that cattle diets were energy limited, as average ADG was only 0.75 kg day^{-1}. In 2018, protein and TDN were far below suggested values for growing steers to gain a target of 0.68 kg day^{-1}. Fiber concentrations were also high (40% ADF, 64% NDF, 3.6-4.5% lignin), which likely decreased intake and digestibility (Jung and Allen, 1995). These, and previously discussed factors, most likely contributed to the poor ADG observed in 2018. In 2019, although the Ration Formulator indicated that protein and energy were relatively balanced, the lower concentrations of these components likely limited growth.

Conclusions and/or Implications

The objective of this study was to determine the effects of grazing stockers on summer annual swards of increasing botanical diversity. Increasing botanical diversity did not improve cattle performance, making the increased seed cost of mixtures difficult to justify. If diversity is a priority, producers should reduce grass seeding rates and utilize legume and/or forb species that are more competitive in mixtures.

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