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Stockpiled tall fescue and livestock performance in an early stage midwest silvopasture system

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Abstract Using stockpiled forage can substantially reduce livestock feed costs over the winter. However, little is known about utilizing stockpiled forage in an early-stage silvopasture system. This study was conducted to determine if silvopasture production practices utilizing stockpiled forage influence stocker steer performance. The treatments were: (1) stockpiled forage in a non-forested pasture (OPEN) and (2) stockpiled forage in a silvopasture (TREE). Grazing began early December and ended in late February in each of 2 years. Each treatment was replicated three times in a completely randomized design. Forage nutritive value, production, and steer average daily gain (ADG) for the OPEN and TREE treatments were not significantly different as long as the areas occupied by trees was excluded from analyses. When the area occupied by trees was included, the OPEN treatment produced more ($P < 0.01$) forage than the TREE treatment, with the OPEN producing 3510 kg ha^{-1} and the TREE producing 2812 kg ha^{-1}. Average daily gain ($P = 0.21$) was 0.41 kg for the steers in the OPEN treatment and 0.37 kg for steers in the TREE treatment. Gain per ha was significantly different ($P < 0.01$); the OPEN treatment produced 193 kg of animal gain and the TREE treatment produced 125 kg of animal gain. Exclusion of the area under the tree row from the analysis changed the total gain per ha for the TREE treatment to 148 kg, but was still less ($P = 0.01$) than the OPEN treatment.

Keywords Cattle · Afforestation · Silvopasture · Stockpiled tall fescue · Winter forages

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Introduction

Prior to European settlement, much of eastern United States (including Missouri) loosely resembled a modern-day park with large trees interspersed throughout a grassy landscape (Bromley 1935; O'Brien and Wood 1998). As settlement occurred, trees were harvested for lumber, fuel, railroad ties, and other wood products. The harvest of trees created large areas conducive to the production of cereal grains and beef. In large part, these acreages are now in permanent pasture. Recently however, many landowners in the Midwestern USA have expressed the desire to allow some of this land to revert back to resemble pre-European settlement (Garrett and Buck 1997).

Instead of allowing natural succession of oftentimes undesirable species to occur, landowners should select trees (or other woody species) based on adaptation and preference, and plant the trees systematically throughout the landscape (Hüttl and Ende 1997; Garrett and McGraw 2000). It is not a requisite cattle be removed from the system. Rather, it is generally necessary for cattle to remain within the system to be economically viable. The system of intentionally interspersing woody species throughout a grazingland with livestock is silvopasture (Gold et al. 2000).

Silvopasture systems have been studied, but not extensively for stockpiled tall fescue intended for winter grazing. Stockpiling tall fescue for winter grazing in traditional open pasture systems has recently increased in usage since the practice has been shown to decrease winter feed costs substantially (Bishop-Hurley and Kallenbach 2001). However, similar economical advantages may not be imparted to a system if forage and animal response are influenced heavily by the presence of woody species interspersed throughout the landscape. Information regarding late summer forage and winter animal production within a partially forested system needs to be made available to landowners before consideration of these practices.

Kurtz (2000) and Gold et al. (2000) purport greater stability and economic return from grazinglands when under a silvopasture system compared to a traditional grazing system. They attribute this to the diversity of components salable at various intervals over time; the return on the timber investment being several years after establishment of trees. Although several years are necessary to realize economic returns on timber, the ecological influence of immature trees in a silvopasture system has been shown to be more immediate (Feldhake, 2001; Kallenbach et al. 2006).

This study was conducted to determine how an immature silvopasture system compares to a traditional open pasture system in the amount and quality of stockpiled tall fescue ([*Lolium arundinaceum* (Schreb.) Darbysh. = (*Schedonorus arundinaceus* (Schreb.) Dumort.)]) available for winter grazing by stocker steers. Our objective was to compare forage production, nutritive value, and animal response between the two systems. The results are intended to be used for economic projections regarding potential afforestation efforts of interested landowners. We hypothesized total forage production and animal weight gain per ha would be equivalent for the TREE system compared to the OPEN system.

Materials and methods

Experimental site

This study was conducted on an 8-ha set of pastures at the Horticulture and Agroforestry Research Center near New Franklin, MO, USA (latitude 39°01′ N, longitude 92°44′ W). The soil at this location was a Menfro silt loam (Fine-silty, mixed, superactive, mesic Typic Hapludalf). Half the study area (three, 1.3-ha pastures) was planted to include trees 4 years prior to the initiation of the study (1998). The tree species planted were red oak (*Quercus rubra* L.), black walnut (*Juglans nigra* L.), pecan (*Carya illinoinensis* [Wangenh.] K. Koch), and honey locust (*Gleditsia triacanthos* L.). The trees were Root Production Method (Forrest Keeling Nursery, MO) seedlings grown in 11.4 l containers and were approximately 12 months of age when transplanted into the pasture. Tree species were uniformly alternated within a row at the 3-m planting increments, and each row was 12 m apart. Around each tree row, a single strand of electrified polywire was placed 1 m away from the base of the trees on each side to prevent livestock from damaging the trees. The vegetation within the fenced tree rows was chemically suppressed with glyphosate twice each year to aid in tree growth (Roth and Mitchell 1982). Botanical composition (based on visual estimation) of forage species within the pastures was approximately 70% tall fescue, 20% orchardgrass and 10% other species. A tiller test of the tall fescue showed that 48% of tillers were infected with the endophytic fungus, *Neotyphodium coenophialum* [(Morgan-Jones and W. Gams) Glenn, Bacon, and Hanlin]. The subsequent determination of ergovaline [using the procedure described by Hill et al. (1993)] indicated that the concentrations were too low to cause detrimental effects to grazing livestock.

Treatments

The treatments were; (1) tall fescue stockpiled in an open pasture (OPEN) and (2) tall fescue stockpiled in a silvopasture (TREE). Each treatment was replicated three times in a completely randomized design. Each treatment utilized three, 1.3-ha pastures (2 treatments × 3 reps = 6 pastures).

Management of pastures for stockpiling

All pastures were mowed early August each year to a height of 10 cm. After mowing, 80 kg ha^{-1} of N as ammonium nitrate was applied to stimulate fall growth. Lime applications as well as P and K fertilization rates for were based on the results of soil analysis from the University of Missouri Soil Testing Laboratory (Brown and Rodriguez 1983). Forage was allowed to accumulate until grazing began in December.

Grazing management

All steers (Angus cross) were placed on a common pasture near the study site on 3 December (±1 day) for 7 days to allow acclimation to stockpiled forage. Steers were collectively penned on 11 December (±1 day) and fasted for 16 (±1) h then weighed. After measuring initial body weight, steers were stratified by weight and randomly assigned to treatments. At the start of the experiment, steers weighed an average of 218 (±27) kg. Six steers were assigned to the OPEN treatment, and five steers to the TREE treatment. Grazing started 12 December 2002 (Year 1) and 11 December 2003 (Year 2). Animals were weighed every 21 (±1) days thereafter with fasted weights taken once again at the conclusion of the study. Pastures were strip grazed with a new strip supplied every 3 days. Forage was allocated at 3.6% of body weight per day. No back fence was used to exclude steers from returning to previously grazed areas. Grazing continued until the forage supply was exhausted. This allowed 55 days of grazing in Year 1 and 63 days in Year 2.

Forage mass determinations

Forage mass was determined by clipping ten, 0.8-m × 4.6-m strips from unallocated (pre-grazing) forage available for grazing and ten additional strips from the entire previously grazed area (post-grazing). The strips were cut to a 5-cm stubble height using a flail-type harvester. Pastures were sampled at the onset of the experiment, every 21 days (±1 day) during the experiment and on the final day of grazing. A subsample (300-g [±50 g] fresh mass) from both pre- and post-grazing strips in each pasture were weighed fresh and again after drying for 96 h in a forced air oven at 50°C to determine dry matter. After drying, subsamples were ground in a cyclone mill (UDY Corp., Ft. Collins, CO) to pass a 1-mm screen. These samples were used in forage nutritive value analyses.

Forage nutritive value

Crude protein (CP), neutral detergent fiber (NDF), NDF digestibility (NDFD), and ash, concentrations were determined from the harvested dried sub-samples. Crude protein was determined by measuring total N concentration using a Leco® model N analyzer. NDF for samples was determined using the methods described by Vogel et al. (1999). Samples analyzed for NDFD were digested 48-h in vitro, and then washed with NDF solution (Spanghero et al. 2003). The rumen fluid used for the digestion was collected from a cannulated cow fed a forage-based diet.

Statistical analyses

The model was a completely randomized design (Steel and Torrie 1980) with five or six steers in each of three replications of each treatment. The experiment was repeated for 2 years. Main effects were forage system (TREE or OPEN) and year. Year was considered a random variable. Pasture was considered the experimental unit, which for measures of animal performance was a group of five or six steers in each replication. Statistical analysis software (SAS Inst. Inc., Cary, NC) was used to test main effects. PROC MIXED was used to compare ADG, total animal gain per ha, total forage per ha produced and forage nutritive value. Gain per ha and total forage produced per ha were analyzed in two different ways. The first way was with the area under the trees included as part of the experimental unit (pasture) and the second way did not include this area for these measures (TREE EX). Repeated measures procedures assuming first-order autoregressive correlation were used to test effects of treatments for the amount of forage produced.

Results and discussion

Animal response

There was no difference in steer ADG ($P = 0.21$) between the two treatments (Table 1). Average daily gain for steers in the OPEN treatment was 0.41 and 0.37 kg for steers in the TREE treatment. There was a difference between total gain per ha ($P < 0.01$). Total gain per ha for steers in the OPEN treatment was 193 kg, while the steers in the TREE treatment gained 125 kg (with the area of the tree row included) and 148 kg (with tree row excluded from the calculation). The reason for total gain per ha difference was due to the area required to stock the steers through the study and allow for equivalent amount of forage offered. Total area used to stock steers in the OPEN was less than ($P < 0.01$) the area required for the TREE treatment (Table 1). Even with the areas occupied by tree rows excluded from the analysis, more area was required ($P = 0.02$) for each steer in the TREE treatment (Table 1).

Forage response

Forage nutritive value was the same for both treatments (Table 2). Other reports show equal or improved quality of forages grown under shade (Lin et al. 2001). Generally the increase in nutritive value comes from the increase in CP, as the effect of shade on cell wall components is generally small and inconsistent (Norton et al. 1991; Lin et al. 2001). Since forage DM production was not influenced (Table 2) in the alleyways, it was expected CP would not differ. Crude protein tends to accumulate as shade reduces the amount of non-structural carbohydrate available for new tissue synthesis. In this experiment, trees were immature and completed leaf abscission approximately 60 days into the stockpiling phase. Thus, in the silvopasture practice we used, shade was likely a small factor during the growing period.

Pre-grazing forage-on-offer declined in both treatments approximately 500 kg ha^{-1} between first and last sampling dates (data not shown). If the entire area was included (silvopasture with tree rows included) then forage available for grazing was 21% lower ($P < 0.01$) for TREE than for OPEN (Table 2). This was a direct reflection of the loss of available grazing area from the tree rows. If the area from the 2-m wide tree row was excluded, then forage available for grazing was equivalent ($P = 0.31$) between the treatments. Thus, forage growth in the TREE was neither negatively nor positively impacted by the trees. However, if electric fencing is used to protect tree row from livestock damage, then the space the tree rows occupy obviously limits forage available for grazing. Using tree species that are less venerable to competition from forage (such as pines) and/or using tree protection methodologies that do not require excluding as much of the pasture area, potentially offer a way to maintain forage production when converting lands from pastures to silvopastures.

Kallenbach et al. (2006) found pastures of cereal rye (*Secale cereale* L.) and annual ryegrass (*Lolium multiflorum* Lam.) in silvopasture yielded approximately 20% less compared to open pastures. Norton

Table 1 Average daily gain and gain per ha of beef steers grazing stockpiled tall fescue in a silvopasture and an open pasture without trees

	Treatment			Contrast[d], *P* value	
	OPEN[a]	TREE[b]	TREE EX[c]	OPEN vs. TREE	OPEN vs. TREE EX
ADG, kg	0.41	0.37	–	0.21	–
SEM[e]	0.05	0.03	–		
Gain/ha, kg	193	125	148	<0.01	0.01
SEM	21.2	7.5	9.1		
Area used, ha/hd	0.13	0.17	0.14	<0.01	0.02
SEM	0.005	0.005	0.005		

Data pooled over 2 years (2002–2003 and 2003–2004). The weight of the steers when grazing started was 218 (±27) kg

[a] OPEN = Strip grazed stockpiled tall fescue with no trees

[b] TREES = Strip grazed stockpiled tall fescue with trees, entire area included in analysis

[c] TREE EX = Strip grazed stockpiled tall fescue with trees, area around tree line excluded from analysis

[d] Contrast between treatments for ADG for both years

[e] SEM values are for the item found directly above it

Table 2 Forage yield, crude protein, neutral detergent fiber, neutral detergent fiber digestibility (NDFD), ash, and forage utilization of stockpiled tall fescue in OPEN and silvopastures (TREE) at the Horticulture and Agroforestry Research Center near New Franklin, MO

	Treatment			Contrast[d], *P* value	
	OPEN[a]	TREE[b]	TREE EX[c]	OPEN vs. TREE	OPEN vs. TREE EX
Forage Yield, kg/ha	3510	2812	3269	<0.01	0.31
SEM[e]	164	139	162		
Forage Utilization, %	60	54	–	0.24	–
SEM	1.8	4.6			
Crude Protein, g/kg	101	104	–	0.30	–
SEM	2.8	2.1			
NDF, g/kg	607	602	–	0.68	–
SEM	9.6	7.3			
NDFD, g/kg	821	810	–	0.33	–
SEM	11.5	8.3			
Ash, g/kg	129	133	–	0.42	–
SEM	4.3	5.8			

Data pooled over 2 years (2002–2003 and 2003–2004)

[a] OPEN = Strip grazed stockpiled tall fescue with no trees

[b] TREES = Strip grazed stockpiled tall fescue with trees, entire area included in analysis

[c] TREE EX = Strip grazed stockpiled tall fescue with trees, area around tree line excluded from analysis

[d] Contrast between treatments for ADG for both years

[e] SEM values are for the item found directly above it

et al. (1991) also reported a decrease in DM production under shade for all species tested except for bahiagrass (*Paspalum notatum* Flueggé). The maturity level of the deciduous trees in this study influenced forage production little. However, animal gain per ha was lower due to the loss of area available for forage production.

The decrease in forage and animal production over the winter for an immature silvopasture system may be regained the following summer, especially if management is intensive. As the popularity of intensive grazing management increases, shade will be needed during the summer months in every paddock to avoid heat stress (Cartwright 1955) and maximize animal weight gains. McDaniel and Roark (1956) reported a 57% increase in calf ADG through the summer months when abundant natural shade was available as compared to no shade. Cattle grazing endophyte infected tall fescue may particularly need shade during the summer months (Schmidt and Osborn 1993; Paterson et al. 1995). The additional weight gain of cattle during the summer months with shade may outweigh the loss of forage production during the fall stockpile phase, especially if tree rows are spaced optimally. McGraw et al. (2008) found alfalfa yield was not reduced when tree rows were spaced 24.4 m apart. Burner and Brauer (2003) also reported forage DM production decreased as the alleyway between tree rows narrowed. Optimal tree spacing and row dimensions need to be determined to mitigate losses of stockpiled forage and animal performance in an immature silvopasture system, but this study indicates that the only loss in production can be attributed to the areas chemically suppressed and fenced to exclude cattle.

Implications

Landowners wishing to restore their land to resemble pre-European times should carefully examine the short-term economic impacts of removing land from forage production. The decrease in a short-term salable product was 35% over the winter. This decrease in production over several years would need to be recovered by the long-term salable product of timber. If the long term increase in timber sales approach the short term loss of forage production, and the true desire is afforestation, the relatively small loss in production found in this study is immaterial, especially if management is focused on recovery of animal gains the following summer. For maximal animal weight gain and wellbeing, intensive management requires abundant natural shade that is not available in open systems. Animal responses to the shade during the summer may mitigate winter revenue losses.

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