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INTEGRATING SILVOPASTURES INTO CURRENT FORAGE-LIVESTOCK SYSTEMS

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Abstract: Prior research has demonstrated that grazing forage within tree stands can be a viable production practice. Most studies to date have compared whole systems of silvopasture practice to systems where livestock have no access to silvopastures. A more likely scenario is that a portion of the farm would be converted to silvopasture practice and the rest of pasture acreage remain under traditional management. Our objective was to determine the impact of introducing silvopasture as part of an integrated forage-livestock system. This experiment had two treatments. In one treatment, cow-calf pairs grazed traditional "open" pastures and in the other they were grazed in a system where approximately 25% of the land area was under silvopasture practice. The silvopastures included a 10 to 12 year old pine-walnut plantation and a 6-year old mixed hardwood plantation. Angus crossed fall-calving cows and their calves rotationally grazed a mixture of tall fescue, alfalfa and red clover in a year-round systems trial. Cow body condition and weights were collected at breeding, at weaning, and in mid-summer. Calf weights were measured at birth and at weaning. Cows in the integrated silvopasture system lost approximately 10% less weight over winter, and were 12% less likely to experience calving difficulty. In addition, calves in the integrated silvopasture system were 25 kg/hd heavier at weaning compared to their counterparts in the traditional system. By integrating silvopasture practice into traditional pasture systems, cow-calf producers could lower winter feeding costs, decrease calving problems and produce heavier calves.

Keywords: Cow-calf production, beef, pasture systems

INTRODUCTION

More than 20% (20.2 million head) of the beef cattle in the USA are raised in the lower Midwest (USDA, 2009). This region, which includes Missouri, Kentucky, Tennessee, Kansas, Arkansas, and Oklahoma use more than 62.9 million acres of private grasslands and engage more than 312,000 farm families in its beef operations (Vesterby and Krupa, 2001). Despite the enormity of this industry, most beef operations in the lower Midwest are unprofitable. The average beef producer has a net operating margin of -\$23.75 head^{-1} year^{-1} (Short, 2001).

Planned forestry might provide better economic returns than pastures in the lower Midwest. Economic analyses conducted by Kurtz et al. (1984), Dwyer et al. (1990), Campbell et al. (1991), and Kurtz (2000) have demonstrated that well-planned forestry systems can provide an above-average long-term return on investment. Even though the conversion of pastures to planned forestry systems could have long-term economic benefits for producers, many landowners feel that it is economically difficult for them to make the change. This is because

most landowners need some income from their land during the 10 to 60+ years necessary to sell marketable forest products.
One feasible way to introduce forestry to producers in the lower Midwest is through silvopasture, one of the five recognized agroforestry practices. Typically in silvopasture practice, perennial grasses and/or grass-legume mixes are planted between rows of trees for livestock pasture (Clason and Sharrow, 2000). The trees not only provide a long-term investment, but also provide the animals shade in the summer and a windbreak in the winter (Clason and Sharrow, 2000). In turn, the forage base provides feed for beef cattle which ultimately provides livestock sales for short-term income.

Prior research has demonstrated that grazing forage within tree stands can be a viable production practice (Pearson and Whitaker, 1974; Clason and Sharrow, 2000; Kallenbach et al., 2006). Most research to date has compared a single or series of silvopasture practices to systems where livestock have no access to silvopastures. However, at the farm level, it is unlikely that current livestock producers would convert their entire pasture acreage to silvopasture practice. Rather, a more likely scenario is that a portion of the farm would be converted to silvopasture practice and much of the rest of pasture acreage used as it has been in the past. Little research, where silvopasture practice has been integrated into a larger grazing system has been conducted. Our objective was to determine the impact of introducing silvopasture as part of an integrated whole-farm forage-livestock system.

MATERIALS AND METHODS

Experimental site

This study was conducted at the Horticulture and Agroforestry Research Center near New Franklin, MO, USA (latitude 39° 01' N, longitude 92° 44' W). The soil type at this location is a Menfro silt loam (Fine-silty, mixed, superactive, mesic Typic Hapludalfs). Average annual precipitation is 943 mm and the mean annual temperature is 12.3°C.

Treatments

This experiment had two treatments: i) cow-calf pairs that were maintained in a traditional "open" pasture system and ii) cow-calf pairs that had access to silvopastures at strategic times in winter, early spring, during heat stress periods in summer and at calving. The animals with access to silvopastures spent approximately 25% of the year in pastures with trees. For the purposes of this manuscript the treatments will be referred to as the "traditional" and "integrated" treatments hereafter. In the integrated treatment, the silvopastures included a 10 to 12-year old pine-walnut plantation and a 6-year old mixed hardwood plantation. Each treatment was replicated three times. The pasture species used for both treatments were a mixture of tall fescue (*Lolium arundinaceum* (Schreb.) S.J. Darbyshire = *Schedonorus phoenix* (Scop.) Holub), alfalfa (*Medicago sativa* L.) and red clover (*Trifolium pretense*, L.) established in 2001. All treatments were fertilized with 84 kg ha^{-1} of N as ammonium nitrate in mid-August each year to stimulate fall growth. Fertilization rates for P, K, secondary and microelements were based on the results of soil analysis from the University of Missouri Soil Testing Laboratory. The experiment was conducted from September 2005 through September 2007 (2 years).

Animals and Grazing Management

The animals used in this project were Angus crossed fall-calving cows and their calves. The average calving date was 10 September each year and calves remained on cows until weaning in June. After weaning calves were sold. Water and salt blocks were provided to animals throughout the duration of the experiment.

Each of the six (2 treatments x 3 replications) grazing units was 4.8 ha, divided into 8 equally (± 0.05 ha) sized paddocks. In the integrated treatment there were 1.2 ha (two paddocks) of silvopasture and 3.6 ha (six paddocks) of open pasture. The paddocks were rotationally stocked, except during winter when hay was fed. Six cow-calf pairs were stocked in each 4.8 ha unit for a total of 36 cow-calf pairs (6 cow-calf pairs x 2 treatments x 3 replications). Except when hay was fed in winter, animals remained in their respective pasture areas during the entire 2-year experiment. During the grazing season, animals were moved to a new paddock within each unit every 3 to 7 days based on forage availability and expected forage growth. Paddocks were stocked to remove forage down to an 8- to 10-cm stubble height, before moving to the next paddock. In spring, when forage growth rates exceeded the ability of animals to graze it in a timely manner, excess forage was harvested and stored as round bale silage, and then fed back to animals in winter.

Forage Mass Determinations

Forage mass was determined weekly from each paddock by taking 50 rising plate meter readings (Earle and McGowan, 1979). The rising plate meter was calibrated every 3 to 4 weeks during the experiment by clipping six strips, from the most recently grazed and next-to-be-grazed paddock within each unit. The strips were cut to a 1-cm stubble height using a flail-type harvester. The forage mass values from the harvested strips were used in a multiple regression equation to estimate forage mass on a weekly basis using rising plate meter values (R^2=0.87).

Performance Measurement Indices

Cow body condition (nine-point scale) and weights were collected at breeding, at weaning, and in mid-summer. Cows were palpated annually and conception rates calculated. Calf weights were measured at birth and at weaning. Cumulative forage production was calculated for each paddock using the following formula:

Cumulative forage production = (Pre-grazing forage mass at T1) + (Pre-grazing forage mass at T2 – post-grazing forage mass at T1) + (Pre -grazing forage mass at T3 – post-grazing forage mass at T2) + ······+ (Pre grazing forage mass at Tn – post grazing forage mass at Tn–1). In this formula T = time sample was collected and n = the number of times a paddock was sampled.

Experimental Design

Each treatment was replicated three times in a randomized complete block design (three traditional units and three integrated units) in a split-split plot arrangement. In this analysis, treatments were considered main plots, years as sub-plots, and sampling dates as sub-sub-plots

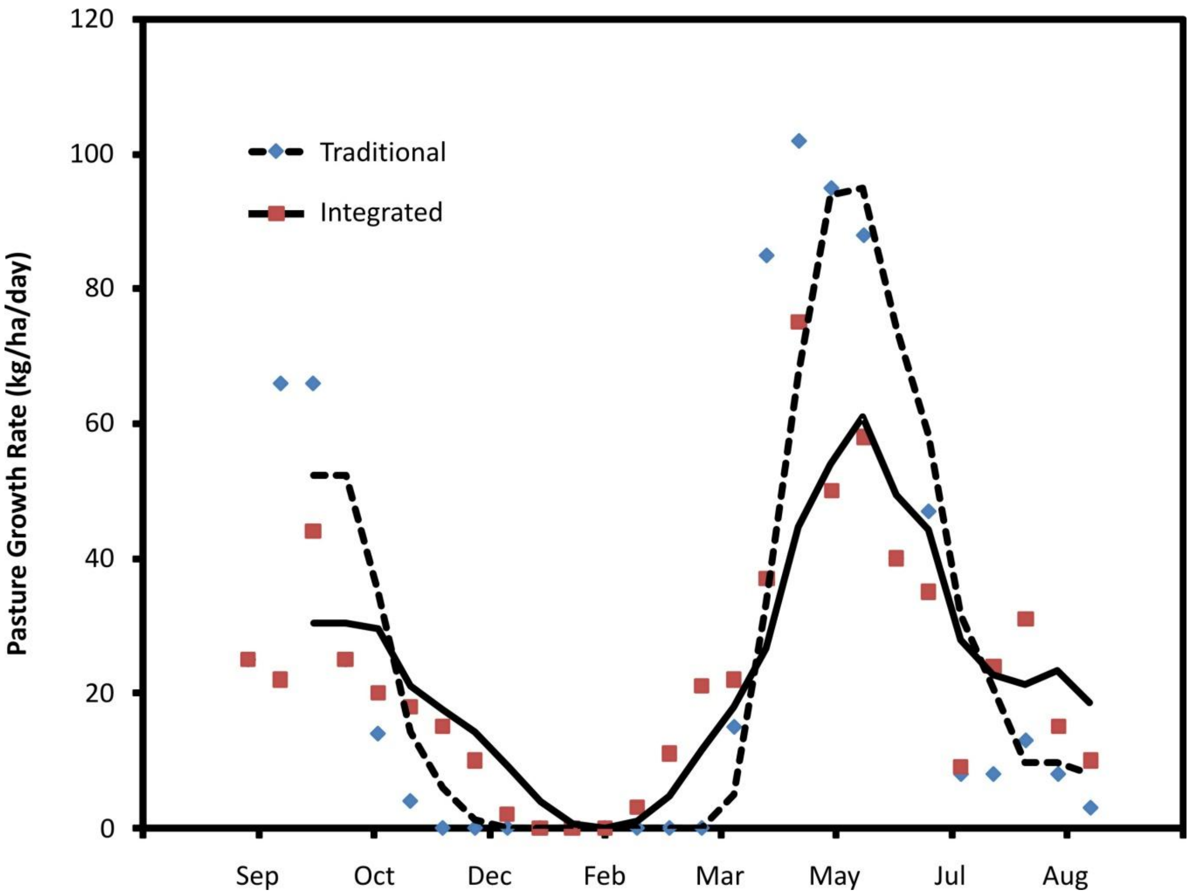
(Steel and Torrie, 1980). Sampling dates were analyzed as repeated measures. Analysis of variance was conducted on treatments, years, and sampling dates (forage measurements only), and all possible interactions using the model outlined by Steel and Torrie (1980). Main effects and all interactions were considered significant when $P<0.05$.

RESULTS AND DISCUSSION

Cumulative Forage Production

Cumulative forage production did not have an interaction between years, so data were pooled over both years. Cumulative forage production on an annual basis was greater ($P=0.02$) for the traditional treatment at 9,625 kg/ha compared to only 8,409 kg/ha for the integrated treatment. If we stopped there, however, we would only have a portion of the story. Most of the extra forage produced by the traditional treatment was in spring, when forage in both systems was in excess of what the animals could reasonably consume by grazing alone (Fig. 1). Thus, the amount of silage that had to be made in the traditional treatment was nearly twice that required by the integrated treatment (data not shown). Additionally, forage growth began earlier in the spring and continued longer in the summer and late autumn in the integrated treatment. Most of this extended growth for the integrated treatment was produced in the silvopasture portion. This would have real benefits to cow-calf producers because it would allow more days of direct harvesting by grazing animals and reduce the need to make and feed stored forage.

Fig. 1. Pasture growth rates in the traditional and integrated pasture systems at the Horticulture and Agroforestry Research Center near New Franklin, MO. Data are averaged over two years. Trend lines are the 3-week moving average.



Several researchers have reported that cumulative forage production in silvopastures is often lower when compared to open pastures, especially as trees develop a dense canopy (Pearson and Whitaker, 1974; Clary, 1979; Sibbald et al., 1991; Silva-Pando et al., 2002). Similar to our findings, Silva-Pando et al. (2002) reported that the variation in seasonal forage production was greater from open pastures than from silvopastures in Spain. They concluded that the presence of trees in a pasture provided a microclimate that produced fewer fluctuations in light transmission, air temperatures and photosynthetically active radiation. Although we did not take these environmental measurements in our study, it is probable that the trees provided some insulation from the cold temperatures in spring and autumn. In addition, Frost and McDougald (1989) found that shade in silvopastures can reduce evapotranspiration from herbage and thus allow forage plants to avoid drought stress. So during the summer of both years, it is possible that forage in the integrated treatment was able to avoid short-term drought stress better than forage traditional treatment and this led to a greater rate of forage accumulation during this period.

Animal Performance

Cow body weight loss over winter, calving difficulty, and calf weaning weight did not show an interaction between treatments and years, and thus the data were pooled over both years. Cows in silvopastures lost approximately 10% less weight over winter, reducing the need for supplementation by about 12% (Table 1). Additionally, cows that gave birth in the integrated treatment were 12% less likely to experience calving difficulty. McArthur (1991) suggested that the trees in silvopastures can protect animals from wind and extremes in temperatures. This likely provided cows a more comfortable environment and reduced the need for them to use metabolic energy to maintain body temperatures during cold weather in winter and reduced animal stress in summer.

At weaning, calves in the integrated treatment weighed 295 kg which was 25 kg more (P<0.01) than calves in the traditional treatment. This additional weight is likely a result of less stress on cows during stressful periods and additional forage produced in early spring. In all, the additional calf weight would be worth approximately $50/head on an annual basis.

Table 1. Performance of cow-calf pairs in a traditional "open" pasture system compared to those in an integrated system where both open and silvopastures were used.

Treatment	Cow body weight loss in winter	Calving difficulty	Calf weaning weight
	(kg)	%	(kg)
Traditional	105	15	270
Integrated	93	3	295
P value	0.02	0.04	<0.01

CONCLUSIONS

1. Cumulative forage production in the integrated system was about 13% less than in a traditionally managed system. However, the growth patterns in the integrated system required less forage to be harvested during the spring and less forage to be fed in mid-summer and winter.
2. Cow-calf pairs in the integrated system lost approximately 10% less weight over winter, had less stress at calving time and weaned heavier calves compared to those in the traditional system. These are tangible benefits that cattle producers could use to improve farm income in the short-term.

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