Forage systems effect on forage-fed beef production

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Keywords: Greenhouse gases, methane, nitrous oxide, profitability, steers, sustainability.

Introduction

Locally produced forage-finished beef offers high value while enhancing economic, environmental, and social sustainability. It enhances environmental quality and the natural resource base, and makes good use of resources both on and off-farm. On the farm, it makes the most of the ability of cattle to convert grass to meat in a low-input system, making efficient use of solar energy, improving soil nutrient cycling, conserving soil and water, and limiting reliance on non-renewable resources (DeRamus 2004). Although the major causes of increased greenhouse gas emissions are due to population growth and industrialization, agriculture contributes to carbon dioxide (CO₂) emissions through its use of fossil fuels during cultivation, and indirectly through energy-intensive inputs such as fertilizers. Since grassland agriculture is also a significant contributor of methane (CH₄) and nitrous oxide N₂O, there is now increasing pressure to curb emissions from livestock production

Methods

In three consecutive years, 54 fall born steers were assigned to one of three forage systems (S1, S2, and S3) immediately after weaning through to slaughter at an age of 17 to 19 months. Each treatment was replicated three times and had the same stocking rate (1.01 ha/head). Systems 1 and 2 had 3 paddocks (Paddocks A, B, and C comprising 45, 35, and 20% of the area, respectively) and System 3 with 5 paddocks (Paddocks A, B, C, D, and E comprising 20, 20, 45, 7.5, and 7.5% of the area, respectively). The 3 system treatments were: S1 = Paddock A: BG; Paddock B: dallisgrass + berseem, red, and white clovers; Paddock C: RG+rye+ berseem, red, and white clovers; Paddock D: forage soybean (Glycine max)/RG (for summer and winter, respectively); Paddock E: sorghum-sudan hybrid/RG (for summer and winter, respectively).

All steers were weighed on a monthly basis. Fresh water and mineral-mix supplement were available at all times. From May to October, shade was provided in all pastures where animals were grazing using portable shades. Carcass data were collected at slaughter. All data were analyzed using Proc GLM with pasture as the experimental unit, treatment and year as main effects. Total soil C storage in different plant systems was determined by soil C contents at the initial and final stage of the project. To obtain soil C content, soil core samples were taken up to 1 m depth from each forage system. The core was sectioned into 10 cm subsamples and each section analyzed for total C using a combustion C/N analyzer.

By integrating accumulation of total organic carbon (TOC), total C storage was determined. In addition, C gas emission was determined. In doing so, close chambers were set up at selected forage systems to monitor the CO₂ and CH₄ emissions. Gas samples were collected monthly and analyzed for CO₂ and CH₄ using gas chromatography. Flux of these emissions was determined based on area and volume of chamber sampler and gas concentration measured. Besides CO₂ and CH₄, N₂O was also determined.

To conduct the economic analysis of the experiment conducted, detailed records were kept for the years of the experiment for each of the pastures. Twenty-seven cost and returns estimates were developed on the basis of 3 treatments × 3 replicates × 3 years. Differences in fixed costs, variable costs, returns, and net returns among the treatments were determined using a mixed model with fixed treatments, and year as a fixed repeated measure effect. The Kenward-Roger Degrees of Freedom method was used. Soil carbon emission data and soil samples were collected and analyzed. Net global warming potential (GWP) in kg of CO₂ equivalent for each treatment was determined similar to that conducted by Liebig et al. (2010), which included nitrogen (N)
fertilizer production and application (NPA), \( \text{CH}_4 \) emission from enteric fermentation (EF), change in soil organic carbon (\( \Delta \text{SOC} \)), the atmospheric \( \text{CH}_4 \) flux, and the \( \text{N}_2\text{O} \) flux. Since the experiment was run for only three years, change in soil carbon was barely noticeable. Therefore, \( \text{CO}_2 \) flux was used instead of change in soil carbon for the GWP calculation. Carbon prices that would entice farmers to switch management practices (treatments) were determined.

**Results and discussion**

During summer, steers gained an average of 0.21 kg a day and during the hay feeding, as expected, even less. Steers were weaned in May with 8-9 months of age; hence, they were growing animals with very high requirements (energy, protein). Bermudagrass fell short of providing the nutrients required by this class of cattle. Concentrations (%DM) of CP (8.3%) and NDF (65%) were low and high, respectively. Average daily gains during winter (average of 1.6 kg) were explained by: (1) compensatory gain effect; and (2) cattle were 1 year old and older, hence requirements for protein and energy was decreased. Steers were finished at similar weights (522 ± 18 kg) across systems. Hot carcass weights, marbling scores, fat thickness, and ribeye area did not differ between treatments. Dalligrass+ clovers pastures yielded the greatest \( \text{CO}_2 \) (3,000 mg \( \text{CO}_2\)-C/d/m\(^2\)) and \( \text{CH}_4\)-C (1.7 mg/d/m\(^2\)) emissions whereas bermudagrass exhibited the highest \( \text{N}_2\text{O}\)-N emissions (2.5 mg/d/m\(^2\)).

Results of the economic analysis indicated that steer income did not differ among the treatments. Fertilizer expense for S1 was greater than for S2 and S3. This was due to higher use of N-fixing legumes in S2 and S3, which substituted for commercial N fertilizer. Seed and diesel cost differed among the systems with the lowest in S1 and highest in S3. Net profits per steer were US$678, US$597 and US$367 for S1, S2, and S3, respectively, with the net profits of S1 and S2 being significantly greater than for S3.

GWP per year for each system was determined. Results showed that S3 produced the lowest GWP per animal (16,000 kg \( \text{CO}_2 \) equivalent) and S1 produced the highest (21,000 kg \( \text{CO}_2 \) equivalent). Due to the higher use of N fertilizer, \( \text{CO}_2 \) produced through NPA, \( \text{CH}_4 \) flux, and \( \text{NO}_2 \) flux was highest in S1, which contributed to the highest GWP relative to the other pasture systems.

**Conclusions**

Year-round forage systems may not have a definite impact on performance of beef cattle. Inputs and labor are major variables affecting systems profitability. Due to the short term of this project (3 years), we did not observe any statistically significant difference in soil C contents between these pasture systems, which suggests the difficulty in interpreting the soil C storage as influenced by these specific systems.

**Acknowledgements**

We are extremely thankful to Southern SARE (Sustainable Agriculture Research and Education) for funding the Project “Maximizing profitability, sustainability, and carbon sequestration of no-till forage systems for finishing beef cattle in the Gulf Coast region”; Number: LS09-221.

**References**
