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Use of grazing management to mitigate greenhouse gas emissions while increasing soil organic matter and water-holding capacity of cool season pastures in southern Iowa

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LEOPOLD CENTER
FOR SUSTAINABLE AGRICULTURE

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Abstract:

Grasslands play a major role in maintaining the stability and resiliency of ecosystems. This project explored the role that grazing system management could play to influence carbon sequestration and methane oxidation.

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Budget:
$49,618 for year one
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$48,043 for year three

ECOLOGY

Q Can grazing management be used to manipulate soil carbon sequestration (SOC) and cow enteric methane emissions to reduce net greenhouse gas emissions?

A Over three years, the particular stocking system used did not affect SOC sequestration in cool season grass pastures that were established for at least 22 years. In contrast, cow enteric methane emissions could be reduced by limiting daily forage allowance to less than three percent of bodyweight. But, to utilize this strategy without adversely affecting calf production, cattle must be bred and/or selected for improved feed efficiency.

Background

Some grazing consultants have observed that because of increased root growth and trampling of unconsumed forage into the soil, high density-short duration grazing systems (such as mob grazing) could increase carbon sequestration in the soil as soil organic carbon (SOC). However, no replicated experiments had been conducted to support this hypothesis.

Furthermore, because pasture forage becomes mature during the long delay prior to initial grazing and the long recovery periods after each grazing period, high density-short duration grazing systems seem likely to increase methane production per unit of forage dry matter consumed. Therefore, a project was conducted to quantify the effects of grazing management on various elements of soil structure, plant growth and diversity, and CH_4 emissions.

Objectives for the project were to:

- Quantify the effects of grazing management on the enteric CH_4 emissions, SOC accumulation, soil compaction and plant community biodiversity from grasslands in southern Iowa; and
- Assess the relationships between the enteric CH_4 emissions and SOC sequestration with the botanical and chemical composition of the vegetation and physical characteristics of the soil in southern Iowa grasslands.

Approach and methods

Six 10-acre, cool-season pastures at Iowa State's McNay Research Farm near Chariton were grazed by eight fall-calving cows from mid-May through mid-October 2012, 2013, and 2014. One of these three stocking treatments was used in each:

- continuous stocking,
- rotational stocking, or
- strip-stocking.

Cows wearing methane collection devices.

Both the rotationally and strip-stocked pastures were divided into 10 paddocks and grazed by eight fall-calving mature Angus cows. In rotationally stocked pastures, there were three to four rotations annually with 4.4+1.89 d grazing events and 34.0+9.46 d recovery periods per paddock. In strip-stocked pastures, there were one to two rotations annually with 9.7 + 5.16 d grazing events and 91.8 + 25.97 d recovery periods per paddock.

Results and discussion

The stocking system used did not affect forage botanical composition or total forage mass or composition across the three years. However, live forage in the upper half of the plant canopy in rotationally stocked pastures had higher concentrations of *in vitro* digestible dry matter (IVDMD) and crude protein and lower concentrations of neutral detergent fiber (NDF) than strip-stocked pastures simultaneous to methane measurements in June and August. In spite of these differences in forage composition, cows in strip-stocked pastures emitted less methane daily than cows in the continuously or rotationally stocked pastures, likely because of lower feed intake. When forage allowances were increased to three percent of bodyweight, cows in both the rotationally and strip-stocked pastures in August, the stocking system did not affect daily methane emissions. Rotational stocking decreased SOC accumulation near the water trough, but increased SOC accumulation at distances of 150 feet or greater from the water trough. In contrast, strip-stocking increased SOC accumulation near the water trough, but decreased SOC accumulation at distances of 150 feet or greater from the water trough. As a result, over the short time period of three years, the stocking system did not affect SOC accumulation across the pastures.

However, strip-stocked pastures had lower soil bulk densities in the upper three inches of soil and lower penetration resistance measurements to a depth of four inches at distances than continuously or strip-stocked pastures at distances of 200 feet or greater from the water trough. This reduced soil compaction in the strip-stocked pastures could contribute to greater root growth and water infiltration. In conclusion, over three years, a stocking system of cool season pastures at a moderate stocking rate does not influence SOC accumulation in long-established cool season grass pastures. But limiting forage intake by controlling forage allowance in a high density-short duration stocking system such as strip or mob-stocking can reduce daily methane emissions.

Conclusions

Grazing practices that reduce forage maturity will increase IVDMD concentration and reduce NDF concentration of forage selected by grazing animals, thereby reducing the amount of CH_4 emitted per unit of DM consumed. However, as the effects of DM intake on total daily CH_4 emissions supersede the effects of forage composition, management practices that limit forage intake will limit total daily CH_4 emissions per animal. To utilize this strategy without adversely affecting animal production, cows will need to be capable of improved feed efficiency. The delayed grazing and long recovery periods associated with strip-stocking result in the accumulation of mature forage. Strip or rotational stocking will alter distribution of SOC within a pasture. However, over a short time period, total accumulation of SOC across a long established pasture is not affected by different stocking systems with equivalent stocking rates.

Methane collection measurement.

In contrast, strip-stocking will reduce soil compaction in pastures which may improve water infiltration rates.

Impact of results

It has generally been believed that reducing forage quality will increase CH_4 emissions by ruminant animals. While this belief is correct for the amount of CH_4 emitted per unit of DM consumed, the amount of DM consumed has a much larger effect on the total daily emissions of CH_4 by cows. Strip-stocking in which the daily live forage allowance was limited to two percent of the cows' body weights reduced daily CH_4 emissions by 24 to 26 percent in comparison to cows that were rotationally stocked with a live forage allowance at four percent of the cows' body weights. Unfortunately, reductions in feed intake also are associated with reduced productivity, as lower body weights and body condition scores were observed in the strip-stocked cows. Therefore, CH_4 emissions may be reduced by limiting feed intake, but also require high forage nutritional quality and grazing cattle with genotypes for improved feed efficiency to maintain animal productivity.

Results of this project showed no effects of three very different stocking systems on total SOC accumulation in established cool season grass pastures over three grazing seasons. While grazing at low to moderate intensities does increase SOC, the type of stocking system had little effect on SOC in pastures over short time periods.

To provide definitive answers regarding the effects of grazing management on carbon sequestration and other ecological services, the Leopold Center and the ISU College of Agriculture and Life Sciences should develop an integrated effort to create a long-term Ecological Research Center at the McNay Research Farm to evaluate the effects on grazing management on ecological services from grasslands.

Education and outreach

Publications

Refereed journal papers

Russell, J.R. and J.J. Bisinger. 2015. Forages and Pastures Symposium: "Improving soil health and productivity on marginal lands using managed grazing of livestock." *J. Anim. Sci.* 93:2626-2640.

Abstracts

Russell, J.R., J.J. Bisinger, and W.J. Powers. 2016. "Stocking management effects on forage composition, cow methane emissions, and soil properties of cool season pastures." *J. Anim. Sci.* 94:159.

Russell, J.R. and J.J. Bisinger. 2014. "Improving soil health and productivity on marginal lands using managed grazing of livestock." *J. Anim. Sci.* 92 (E-Supplement 2):155.

Non-refereed invited papers

Russell, J.R. 2015. "Implications of grazing management on soil health and environmental quality." Proceedings of the annual meeting of the Arkansas Forage and Grassland Council. Nov. 4-5. Conway, Arkansas.

Extension publications

Russell, J.R., J. Bisinger, and W.J. Powers. "Grazing system effects on enteric methane emissions from cows in southern Iowa pastures." R3092. 2016 Animal Industry Report. Iowa State University, Ames.

Russell, J.R. and J.J. Bisinger. "Grazing systems effects on soil compaction in southern Iowa pastures." R2987. 2015 Animal Industry Report. Iowa State University, Ames.

Workshop and Field Day Presentations

- Grazing management effects on greenhouse gases (update), McNay Research Farm Field Day, September 2012, Chariton, IA
- Grazing management effects on greenhouse gases. Iowa Grazing Conference Preview. Iowa Beef Cattlemens' Association. June 24, 2013. Ames, IA
- Grazing management effects on greenhouse gases. McNay Research Farm Field Day. July 16, 2013. Chariton, IA
- Future of Iowa's Grasslands. Animal Science Think Tank. September 30, 2013. Ames, IA
- Future of Iowa's Grasslands. Iowa State University Beef Nutrition Showcase. October 2, 2013. Ames, IA
- Grazing management effects on greenhouse gases. Iowa State University Beef Nutrition Showcase. October 2, 2013. Ames, IA
- Mob grazing as a tool for grassland management. Missouri Forage and Grassland Council/Grazing Lands Conservation Initiative, November 5, 2013. Osage Beach, MO
- Mob grazing as a tool for grassland management. University of Missouri Extension In-service Training, February 12, 2013, Columbia, MO
- Improving soil health and productivity on marginal lands using managed grazing of livestock. ASAS-ADSA Joint Annual Meeting, July 22, 2014, Kansas City, MO
- Grazing management and the environment. Iowa State University Beef Nutrition Showcase, October 1, 2015, Ames, IA
- Implication of grazing management on soil health and environmental quality. Annual meeting of the Arkansas Forage and Grassland Council, November 5, 2015, Conway, AR

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