Stocking System Effects on Soil and Forage Characteristics, and Performance of Fall-Calving Cows Grazing Tall Fescue Pastures (A Progress Report)

A.S. Leaflet R2585

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Summary and Implications

Fall-calving Angus cows grazed tall fescue pastures by three stocking systems to determine their effects on forage yield, quality, and species composition; soil carbon content, bulk density, and water infiltration; and cow and calf performance. In May 2010, two blocks of three 10-acre tall fescue pastures were each subdivided into ten 1-acre paddocks. Sixty cows (mean bodyweight 1291 lb and body condition score (BCS) 4.84 on a 9-point scale) were randomly allotted to the six pastures. One of three stocking systems was randomly assigned to one of the pastures within each block: rotational (RS), strip (SS), or mob (MS) stocking. Grazing of pastures in the RS, SS, and MS treatments was initiated on May 14, 14, and 26 respectively, and continued until September 30. Cows in RS pastures were moved to a new paddock daily for the first 21 days. Cows in the RS pastures after the first 21 days, and cows in the SS and MS treatments throughout the grazing season, were provided live forage DM at an allowance of 4% BW/day except from August 1 through mid September, when allocation was increased to 5% BW/day to account for the increased demands of lactation. Residency time or strip size was determined by measuring forage DM with a falling plate meter (8.8 lb/yd^2) before and after cows were rotated into a new paddock. Cows in RS pastures were moved to a new paddock when 50% of the live forage DM was consumed. Paddocks in SS pastures were subdivided into strips providing the assigned daily forage allowance and cows were given access to a new strip daily with no backfence installed. Paddocks in the MS pastures were subdivided into strips to provide 25% of the assigned daily forage allowance and cows were moved into new strips with a backfence installed four times daily. Mineral and water were provided ad libitum. Cow BW did not differ between treatments in any month. Cow BCS was lower for cows in the SS pastures than RS or MS pastures at the initiation of grazing in May. BCS of cows in RS pastures were greater ($P < 0.05$) than SS or MS pastures in August. The proportion of calved cows, live births, and calves alive at the termination of grazing, and the calf birth weight and average daily gain (ADG) did not differ between treatments. Average pasture sward height was lower ($P < 0.05$) in RS than SS and MS pastures in June, but did not differ in other months. Grazing efficiency, as measured with the falling plate meter, was lower ($P < 0.05$) in RS than SS or MS pastures in May, but did not differ in other months. Water infiltration rates into the soil and soil moisture content measured in May, July, and October did not differ between blocks or treatments. Ongoing analysis will allow more complete comparisons in the future.

Introduction

Beef producers have shown interest in mob stocking, which utilizes stockpiling of pastures in the spring before grazing at extremely high stocking densities with frequent rotations of the cows, and allows extended rest periods. The practice is attributed with ecological benefits such as increased soil carbon and organic matter, greater forage production, introduction of legumes, and greater pasture utilization by cattle. However, there is insufficient scientific evidence to confirm these claims. Rotational stocking has been shown to increase forage production and legume content by incorporating rest periods for the grazed forage and reducing grass competition. The extended rest periods associated with mob stocking may enhance root nutrient stores. Increasing cattle concentration may amplify the animals' effects on the ecosystem, such as nutrient deposition through manure and urine, and physical changes through hoof action. Greater concentration of manure may improve soil organic matter. Treading incorporates plant biomass into the soil, which may increase soil organic matter content, but may also potentially increase soil compaction.

Grazing selectivity may be reduced and forage utilization may be increased by limiting the forage available to cattle through mob stocking. Cattle productivity per area of land may be increased with greater stocking density which may provide an opportunity for increased profitability. However, mob-stocked cattle are forced to eat less nutrient-dense plants, as they are given less opportunity for selectivity, and because stockpiled forage declines in quality as it matures. As a result, individual animal performance may suffer. Stockpiling in the spring in order to mob-graze may also increase the amount of time stored feeds must be provided in the winter and spring at least until the system has been established over several years. Furthermore, mob-stocking requires increased labor for fence construction, water resource management, and cattle movement. Some of the benefits of mob-stocking may be attained with less labor by strip-stocking.

Therefore, a project is being conducted to evaluate the effects of rotation, strip, and mob-stocking on the soil bulk density and water infiltration; forage mass and botanical and nutritional composition, and the grazing selectivity and production of fall-calving cows grazing tall fescue pastures.

Materials and Methods

In the spring of 2010, soil was sampled from two blocks of cool-season grass pastures at the Iowa State University Beef Nutrition Farm near Ames and tested for pH, soil test phosphorus, and potassium at the Iowa State University Soil and Plant Analysis Laboratory. As the minimum values found for pH, Bray-1 phosphorus, and potassium were 6.95, 35 ppm, and 128 ppm potassium, no additional fertilizer was applied

The two blocks of three 10-acre pastures were divided into ten 1-acre paddocks. Pastures consisted primarily of tall fescue (*Festuca arudinacea* Schreb.) and reed canarygrass (*Phalaris arudinacea*) which had been grazed and/or harvested as hay since 2001. Pastures had been frost-seeded with red clover (*Trifolium pratense*) in each spring from 2001 through 2004. But as the pastures were sprayed for thistles with herbicide (Grazon; Dow Agrosciences LLC; Indianapolis, IN) in 2009, few legumes remained in the pasture. Therefore, pastures were broadcast-seeded with red clover at 10 lb/acre in March, 2010.

On May 14, one pasture in each block was randomly assigned to one of three stocking systems: rotational (RS) strip (SS), or mob (MS) stocking from May 14 through September 30. Sixty multiparous fall-calving Angus cows (mean body weight 1291 lb and body condition score (BCS) 4.84 on a 9-point scale), in mid-gestation, were blocked by weight and ten cows were randomly allotted to each pasture. Cows in the RS pastures were moved to a new paddock daily for 21 days to utilize the rapid growth of forage and moderate overall yield. Simultaneously, cows in the SS pastures began grazing by strip-stocking at a forage sward height of 7.1 inches. Cows in the MS pastures were placed in the first paddock and fed tall fescue hay as large round bales until May 26 when forage sward height of the remaining paddocks was 11.8 inches which was needed to attain a minimal stocking density of 250,000 lb/acre and supply the daily forage allowance. After June 3, May 14, and May 26 for the RS, SS, and MS treatments, respectively, cattle movement was controlled to maintain a daily live forage dry matter allowance of 4% of cow body weight per day, as estimated with a falling plate meter (8.8 lb/yd^2). Cows in RS pastures had access to an entire 1-acre paddock, until sward height had been reduced by 50% of the initial value. Paddocks in SS pastures were subdivided with electrified fence into strips that provided daily live forage dry matter allowance of 4% BW with no back fence and cows provided access to a new strip once daily. Paddocks in the MS pastures were similarly subdivided into strips providing live forage dry matter at 1% BW; cows were moved to a new strip four times daily. Forage allowances were increased to 5% BW/day from August 1 through mid-September to account for the additional nutrient requirements of lactation, and increased by 10% when one ruminally-fistulated steer was transiently grazed on pasture with the cows to determine grazing selectivity in June, July, and August. Water and salt were provided to cows at an *ad libitum* level. A mineral mixture (Framework 365 Mineral; Kent Feeds, Inc; Muscatine, IA; Table 1) was provided at an *ad libitum* level until June 20 after which the mineral mixture was limit-fed once per week to prevent overconsumption.

Cows were weighed at the initiation and termination of grazing after being fed grass hay in large round bales at an ad libitum level for five days to equalize gut fill. Cow body weights and BCS were also measured monthly during the grazing season. Cows were observed to ensure that average BCS did not fall below 5.0 on a 9-point scale. Calves were weighed at birth and at the termination of grazing.

Sward heights were measured with a falling plate meter before and after cattle rotated into a new paddock. Grazing efficiency for each paddock was calculated as the difference between initial and final sward heights, divided by the initial height. Forage samples were collected from three randomly selected sites per paddock each month. All forage contained within a sampling square (2.7 ft^2) was hand-clipped to 1-inch stubble height. Samples are being hand-sorted into dead forage, live grass, live legumes, and live weeds, and dried at 65°C (140°F) for 48 hours to determine dry matter concentration and the botanical composition of the pasture. Dead and total live fractions will be ground separately for future nutrient analysis (*in vitro* digestibility and % CP).

Soil was sampled with a 2.95 by 1.93 inch core-sampler in May, July, and October at three sites per paddock for determination of bulk density and carbon content. Simultaneously, an additional soil sample was collected with a 0.875 by 6 inch core-sampler at an adjacent site for determination of the bulk density from 3 to 6 inches Samples were dried at 100°C for four days to determine percent dry matter.

To measure water infiltration rates of the pasture soils, forage was removed from two randomly selected sites per paddock in May, July, and October. Double-ring infiltrometers with a 6 inch inner ring diameter were pushed into the soil and filled with water to a 2-inch ponding depth. The central ring of the infiltrometer was refilled and the time and volume of added water recorded every time water level fell one inch, after 30 minutes from initiation of the measurements, and at termination at 90 minutes. Infiltration rates were calculated in/min as the mean of the last three measurements if three or more additions of water were recorded during the last 60 minutes of measurements. Otherwise, infiltration rates were calculated from the total amount of water that infiltrated the soil during the last 60 minutes of measurements. Simultaneous to measurement of water infiltration, soil was sampled to a depth of six inches adjacent to each site and dried at 100ºC for four days for determination of antecedent soil moisture content.

Grazing selectivity was analyzed on two consecutive days per pasture in June, July, and August. One ruminally-fistulated steer was randomly assigned to each pasture and allowed to acclimate for at least 5 days. In the morning of each sampling day, the rumen of each steer was evacuated before it was allowed to graze for two hours. After grazing, rumen extrusa samples were collected, sub-sampled, and freeze-dried for future nutrient analysis. Simultaneous to collection of rumen extrusa, forage samples were collected by hand-clipping of a 2.7 ft^2 square at two sites within the paddocks or strips being grazed by the steers. Forage samples were oven-dried at 65°C (140°F) for 48 hours to determine dry matter concentration. Forage samples will be ground and analyzed in the future. A grazing selectivity index for each nutrient will be calculated as the ratio of the concentration of the nutrient in the rumen extrusa divided by its concentration in the hand-clipped forage sample.

Data analysis was done by the PROC MIXED procedure of SAS, with pastures serving as the experimental units. Models included treatment and block. All values reported are least-squares means.

Results and Discussion

Although stocking rate was equal across treatments, stocking densities (lb liveweight/acre) were consistently greater for MS than for SS or RS pastures. Similarly, SS pastures tended to have greater stocking densities than RS pastures in June ($P < 0.07$) and August ($P < 0.07$).

Mean cow body weights did not differ between treatments within any month (Table 2). Although cows were blocked by weight prior to allotment to treatments, condition scores of SS cows were lower than RS or MS cows at the initiation of grazing in May ($P = 0.05$). Condition scores of RS cows were greater ($P = 0.02$) than SS or MS cows in August and tended ($P = 0.09$) to be greater than SS cows in September. These differences are likely caused by differences in calving times. Cows in one RS pasture had not started calving prior to condition scoring in August, while all other pastures had.

The proportion of cows that calved, live births, calves alive at the termination of grazing, and calf birth weight and average daily gain (Table 3) did not differ between treatments.

Average forage sward heights (Table 4) were lower ($P < 0.01$) for RS than SS or MS pastures in June In May, cattle in RS pastures were rotated daily for 21 days before initiating the standard rotation scheme to control forage maturity. This management likely contributed to reduced sward heights, compared to the stockpiled heights of the SG and MG pastures.

Grazing efficiency (Table 5) was lower ($P < 0.02$) in RS pastures than SS or MS pastures in May. At this time, RS cattle were rotated daily (reducing utilization), while SS were limited to strips providing live forage dry matter at 4% of BW and MS cattle were kept in a single paddock to allow stockpiling. Grazing efficiency did not differ between stocking systems in June through September. This result is not surprising as the forage allowance from each paddock, as estimated with a falling plate meter, was equal across treatments.

The duration of grazing on each paddock was less for RS pastures than for SS or MS pastures ($P < 0.01$, Table 6). Again, this is due to the rapid rotation of RS cattle in May. However, the average rest period for paddocks between grazing events did not differ.

Water infiltration rates did not differ between treatments (Table 7). Weather may explain month-to-month difference in infiltration rates. Rainfall in June and July was 12.27 and 4.79 inches, which is 7.51 and 0.12 inches above the 30-year average. Meanwhile, precipitation in October was 1.50 inches, which is 1.14 inches lower than the 30-year average. Thus, the antecedent soil moisture concentrations in July were greater than May and October. Furthermore, although randomly allotted within pasture blocks without large variations in soil type or elevation, MS pastures were on higher ground than RS or SS pastures and were less affected by rain or flooding, leading to higher soil DM values. Water ponding after heavy August rains was most prominent in RS and SS pastures, possibly contributing to tendencies for reduced soil dry matter and soil water infiltration rate in the grazing season.

Conclusions

This project and the associated data are still being analyzed. Furthermore, this year functioned primarily to establish baseline environmental data which will enable comparisons and observations of changes over time when combined with future years. From the information analyzed thus far, the different stocking systems did not show consistent differences in cow weights and condition scores, successful calvings, and calf growth. Forage heights were lower for RS than MS or SS pastures in June, due to early rapid rotation of cattle in May, which caused the grazing efficiency of RS cattle to be lower in May. Water infiltration rates and soil moisture did not differ between treatments. It is likely that heavy August rains followed by dry weather in September had a much greater influence on forage production and soil characteristics than did treatment.

Table 1. Composition of trace mineral supplied to cows.

Kent Framework 365 Mineral			
Ca, min	15.3%	Cu, min	1450 ppm
Ca, max	18.3%	Mg, min	4950 ppm
P, min	8.0%	Se, min	26.4 ppm
NaCl, min	13.5%	Zn, min	4750 ppm
NaCl, max	16.2%	Vit A, min	380,000 IU/lb
Mg, min	1.0%	Vit D3, min	100,000 IU/lb
K, min	0.15%	Vit E, min	375 IU/lb

Table 2. Effects of stocking systems on the mean cow body weight, condition score, and stocking density.

	Measurement and stocking system								
	Body weight, lb			Body condition score[a]			Stocking Density, lb/acre		
	RS[b]	SS	MS	RS	SS	MS	RS	SS	MS
May	1289.00	1266.20	1317.40	4.935[c]	4.715[d]	4.885[c]	12,890[c]	61,713[c]	395,336[d]
June	1401.90	1381.00	1435.70	5.285	5.115	4.980	14,019[c]	104,895[c]	386,512[d]
July	1435.90	1391.90	1420.70	5.450	5.330	5.335	14,359[c]	79,246[c]	339,043[d]
August	1444.50	1412.00	1430.30	5.920[c]	5.515[d]	5.515[d]	14,609[c]	48,060[c]	190,236[d]
September	1394.30	1360.90	1410.30	5.835	5.550	5.600	15,054[c]	30,822[c]	133,695[d]
October	1424.25	1379.30	1434.90	5.685	5.200	5.405			

[a]9-point scale
[b]RS=Rotational stocking, SS=Strip-stocking, MS=Mob-stocking
[c,d]Within a row, means without a common superscript differ, $P<0.05$

Table 3. Effects of stocking system on the proportion of cows calving, calves born alive and alive at grazing termination, and calf birth weight and average daily gain.

	Measurement and stocking system.[a,b]				
	Calving percentage, %	Live births[c], %	Total live calves[d]	Birth weight, lb	Average daily gain, lb/d
RS	100	95	9.5	72.8750	2.4720
SS	100	90	8.0	74.2302	2.3697
MS	90	95	9.0	72.8889	2.4337

[a]RS = Rotational stocking, SS = Strip-stocking, MS = Mob-stocking
[b]No significant differences, $P > 0.10$
[c]Calves alive 24 h after birth, % of total births
[d]Calves alive and in the herd at termination of grazing

Table 4. Effects of stocking system on mean forage sward height.

	Sward height, in.				
	May	June	July	August	September
RS[a]	8.96	9.88[b]	10.08	8.05	5.14
SS	9.09	13.9[c]	10.77	7.89	4.51
MS	11.75	13.48[c]	12.44	8.41	5.47

[a]RS = Rotational stocking, SS=Strip-stocking, MS=Mob-stocking
[b,c]within a column, means without a common superscript differ, ($P<0.05$)

Table 5. Effects of stocking system on grazing efficiency.

	% forage removed				
	May	June	July	August	September
RS[a]	13.275[b]	45.610	59.170	55.935	51.785
SS	42.290[c]	64.445	55.400	51.320	39.900
MS	62.375[c]	55.315	58.920	51.220	41.970

[a]RS = Rotational stocking, SS=Strip-stocking, MS=Mob-stocking
[b,c]Within a column, means without a common superscript differ, $P<0.05$

Table 6. Effects of stocking system on the duration of grazing and rest periods.

Treatment	Grazing duration, days[b]	Rest period, days[c]
RS[a]	2.70[d]	27.23
SS	3.72[e]	33.25
MS	3.82[e]	31.25

[a]RS = Rotational stocking, SS = Strip-stocking, MS = Mob-stocking

[b]Average number of days that cows were present in a given paddock

[c]Average number of days between grazing events

[d,e]Within a column, means without a common superscript differ ($P < 0.05$)

Table 7. Effects of stocking system on soil water infiltration and dry matter content.

	Measurement and stocking system[ab]					
	Water infiltration, in/min			Soil dry matter, %		
	RS	SS	MS	RS	SS	MS
May	0.14	0.11	0.16	83.20	84.30	85.47
July	0.14	0.13	0.21	78.57	77.66	79.67
October	0.07	0.08	0.10	82.48	80.58	83.19

[a]RS = Rotational stocking, SS=Strip-stocking, MS=Mob-stocking
[b]No significant treatment differences, $P > 0.10$

Acknowledgments

The authors would like to thank the crew of the ISU Beef Nutrition Unit for their help and assistance, and to the undergraduate crew who helped over the summer and through the fall. This project is funded, in part, by the Leopold Center for Sustainable Agriculture.