GRAZING ANNUAL FORAGES: IMPACTS ON ANIMAL PERFORMANCE, FORAGE PRODUCTION, SOIL HEALTH, AND ECONOMICS

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Summary: The objective of this research was to determine the effect of annual forage type on beef cow performance, forage production, soil health, and economics under grazing conditions during late fall and early winter in North Dakota. Forage treatment included: 1) foxtail millet, 2) turnips, 3) a forage mix (café), and 4) standing native range. The café treatment consisted of: turnip, forage radish, cowpeas, soybeans, foxtail millet, and sunflower in 2007; turnip, forage radish, sorghum, triticale, sunflower, and red clover in 2008; and turnip, forage radish, sorghum, forage barley, sunflower, and hairy vetch in 2009. Cattle grazed for 42 days in 2007 and 2008, and 48 days in 2009. A spring cereal (forage barley or oats) was planted prior to cover crop in a double cropping system in 2008 and 2009. Fallow, cover crop following a spring cereal, and cover crop following a spring cereal with burn-down with glyphosate (Roundup – Monsanto) were examined for impacts on forage production. Soil physical and chemical properties were determined by treatment in 2009 to create baseline for current and future studies. Various sampling techniques were used to determine physical, chemical, and biological properties of the soil. Forage production of cereal hay crop (forage barley or oats) averaged 4370 and 3115 pounds per acre (DM basis) for 2008 and 2009, respectively. Forage production of cover crops is presented in Table 2. Cattle, in terms of average daily gain and body condition score, performed equally across all treatments. Cost of grazing was $0.75, $0.83, $1.81 and $1.18 per head per day for foxtail millet, turnips, café, and native range, respectively in 2007. Cost of grazing was $1.03, $0.59, $1.10, and $1.24 per head per day for foxtail millet, turnips, café, and native range, respectively in 2008.

Introduction

Many livestock producers try to extend the grazing season with the assumption that extending grazing reduces feed costs (D'Souza et al., 1990; Adams et al., 1994). Allowing cattle to graze stockpiled perennial forages decreased the amount of hay needed to maintain body condition (Hitz and Russell, 1998). Grazing annual forages is another such way to not only graze livestock longer into the fall or early winter, but also provide potentially higher quality forages. Brassicas, such as turnips, are one example of annual forage that can be grazed effectively by sheep (Koch et al., 2002) or cows. A warm-season annual, foxtail millet previously has been evaluated as a standing, bale-fed or swath-grazed forage (Munson et al., 1999) for wintering beef cows. More recently, forage mixtures often including warm-season annual grasses, legumes and Brassicas have received more interest, not only because of benefits to cattle performance, but also possibly improving soil health. Desirable attributes of plant mixtures including legume species and non-legume species include: ability to break soil pest cycles, rapid establishment under less than ideal conditions, sufficient dry matter or soil cover production, ability to fix atmospheric N and to reduce leaching of NO_3, erosion control, deep root penetration that facilitates nutrient uptake from lower soil depths, production of organic matter with a low C:N residue ratio, and absence of allelopathic or phytoxic effects on subsequent crops (Fageria et al., 2005). Therefore the objective of this research was to determine the effect of annual forage type on beef cow performance, forage production, soil health, and economics under grazing conditions during the late fall and early winter in North Dakota.

Materials and Methods

This study was conducted at the Central Grasslands Research and Extension Center (CGREC) located in south central North Dakota, approximately 9 miles NW of Streeter, ND. All animal care and handling procedures were approved by the NDSU Institutional Animal Care and Use Committee prior to the initiation of the study.

Cows grazing turnips.

Animal grazing

2007 season: One-hundred fifty-nine mature, pregnant Angus- Simmental cross beef cows were stratified by initial body weight (BW) (1176 ± 93.27 lbs) and initial body condition score (BCS) (5.29 ± 0.41) and assigned randomly to graze one of four treatment forages from 16-October to 27-Novermber, 2007. At the beginning and end of the trial two day BW and BCS (Wagner et al., 1988) were collected. Treatments were: 1) foxtail millet; 2) purple-top turnips; 3) a forage mix (**café**) consisting of purple-top turnip, forage radish, cowpea, soybean, sunflower, and foxtail millet; or 4) standing native range (which was the control). The most prevalent species on native range were Kentucky bluegrass (*Poa pratensis*), western wheatgrass (*Pascopyrum smithii*), green needlegrass (*Nassella viridula*), needle and thread (*Hesperostipa comata*), sunsedge (*Carex inops*), and heath aster (*Symphyotrichum ericoides*).

2008 season: One-hundred fourteen mature, pregnant Angus- Simmental cross beef cows were stratified by initial BW (1260 ± 80.6 lbs) and initial BCS (5.27 ± 0.31) and assigned randomly to graze one of four treatment forages from 15-October to 26-Novermber, 2008. Body weight and BCS were collected in the same manner as 2007. Treatments were: 1) foxtail millet; 2) pasja turnip; 3) a forage mix (café) consisting of pasja turnip, forage radish, sorghum sudangrass hybrid, sunflower, triticale, and red clover; or 4) standing native range.

2009 season: Eighty-one mature, pregnant Angus- Simmental cross beef cows were stratified by initial BW (1160 ± 103 lbs) and initial BCS (5.15 ± 0.26) and assigned randomly to graze one of four treatment forages from 20-October to 7-December, 2009. Body weight and BCS were collected in the same manner as 2007.

Treatments were: 1) foxtail millet; 2) purple-top and pasja turnips; 3) a forage mix (**café**) consisting of pasja turnip, forage radish, sorghum sudangrass hybrid, sunflower, forage barley, and hairy vetch; or 4) standing native range.

Stocking Rate: Stocking rates were determined based on forage production and estimated utilization. We estimated carrying capacity using a harvest efficiency of 80% all forages in the café, 70% of the foxtail millet, 25% of the grasses and 15% of the forbs in the native range, and 90% of turnip foliage and 30% of turnip bulbs in the turnip paddocks. The harvest efficiency for native range was based on the take-half leave-half theory of range management.

Forage establishment

2007 season: Seeding of annual forages occurred on July 13 with 25 lb/ac urea (46% N) and 25 lb/ac 11:52 (11% N, 52% P) broadcasted at time of seeding. Seeding rates for foxtail millet and purple-top turnip were 20 and 3.5 pounds per acre (lb/ac), respectively. The cafeteria treatment (café) was seeded with a seed mixture containing 20, 15, 4, 1, 1 and 0.5 lb/ac for soybeans, cowpeas, foxtail millet, sunflowers, radishes and turnips, respectively. Rainfall events totaled 2.99, 3.95, 2.02 and 1.5 inches/month for July, August, September and October, respectively (NDAWN, 2009).

2008 season: In 2008, one-half of each paddock remained fallow while the other half planted to forage barley that would be removed as a hay crop prior to seeding of the annual forage crops. Two varieties of barley (Stockford and Hayes) were tested, each representing one-fourth of the total paddock. Barley was seeded (100 lb/ac) 3-May with 50 lb/ac urea broadcasted at time of seeding, swathed 11-July at the soft dough stage, and baled in mid July. Prior to harvest, 10 - 0.25 m^2 plots were clipped from each variety in each paddock. Total dry-matter (DM) forage production as well as nutrient analysis subsequently was obtained from these samples.

Seeding of annual forages for grazing occurred on 27-July. Seeding rates for foxtail millet and pasja turnip were 20 and 3 lb/ac, respectively. The cafeteria treatment (café) was seeded with a seed mixture containing 15, 4, 1.5, 1, 1 and 1 lbs/ac of triticale, sorghum, red clover, sunflowers, radishes and pasja turnips, respectively. No fertilization was used in 2008. Rainfall events totaled 0.13, 5.01, 2.91, 2.44, 2.87 and 3.22 inches/month for May, June, July, August, September and October, respectively (NDAWN, 2009).

2009 season: In 2009, one-forth of each paddock was planted to either forage barley or oats, which was removed as a hay crop prior to seeding of the annual forage crops. Barley was seeded at 100 lb/ac and oats 64 lb/ac 4-May with 50 lb/ac urea broadcasted at time of seeding, swathed 10-July at the soft dough stage, and baled in mid July. Prior to harvest, 10 - 0.25 m^2 plots were clipped for each species in each paddock. Total dry matter (DM) forage production as well as nutrient analysis subsequently was obtained from these samples. After removal of hay crop, one half of the area planted to the forage barley and oats was sprayed with 1 quart/acre glyphosate (Roundup) plus 2 ounce/acre dicamba (Banvel) to kill the live plants and minimize regrowth.

Seeding of foxtail millet on fallow occurred on 2-July while other annual forages for grazing were seeded on 22-July. Seeding rates for foxtail millet and turnips (purple-top and pasja) were 20 and 3 lb/ac, respectively. The cafeteria treatment (café) was seeded with a seed mixture containing 15, 2, 4, 1.5, 1, 1 lbs/ac of forage barley, hairy vetch, sorghum sudangrass hybrid, sunflower, forage radish, and pasja turnip, respectively. No fertilization was used in 2009. Rainfall events totaled 0.8, 2.14, 2.04, 2.44, 1.8, and 3.44 inches/month for May, June, July, August, September and October, respectively (NDAWN, 2009).

Forage Sampling
Forage sampling for production data was conducted approximately seven to 10 days prior to grazing. Forage production was estimated by clipping five 0.25m^2 plots in each pasture. Turnip plots were sorted by tops and bulbs. Café plots were sorted by species contained within the mixture. Native range was sorted by grasses and forbs, while foxtail millet clipped by entire sward. Grab samples for forage production nutritional qualities were collected at the initiation of and then bi-weekly throughout the grazing period. In the case of split pastures (fallow vs. forage crop) or (fallow vs. forage crop without herbicide burn-down vs. forage barley with herbicide burn-down) five 0.25m^2 plots were clipped on each sub-plot. All forage samples were analyzed for crude protein, acid and neutral detergent fiber, calcium, phosphorus, and *in vitro* organic mater and dry-matter disappearance.

Soil Sampling
Soil sampling was conducted during June on each of the nine fallow/crop pastures and in each of the three native pastures. Sampling within the fallow/crop pastures was conducted on both fallow and crop sections of each pasture replicate. Sample points were selection by stratifying for same soil series across all treatments and replicates using soil maps from Web Soil Survey (USDA, NRCS 2009). Physical, chemical, and biological analysis of the soil included bulk density, macronutrients, pH, hydraulic conductivity, total organic carbon and microbial biomass.

Three samples were collected per replicate and tested for water infiltration; whereas six samples per site were used to evaluate the remaining soil characteristics. Core samples were removed to a depth of 24 inches at increments of six inches. The topography at each site was considered and represented equally across all treatments. Aggregate stability sampling was conducted in early August with six samples per site collected at a depth of six inches each.

Economic analysis
Rental and custom rates were used to calculate the cost of forage establishment for an economic comparison. The land rental rates used were $14.90 and $16.50/acre for nonirrigated pasture, as well as $27.10 and $30.40/acre for nonirrigated cropland in 2007 and 2008, respectively (NASS, 2008). Custom rates for tillage, drilling and fertilizer application were determined from NASS (2007).

Statistical Analysis
Cow performance data was analyzed as a completely random design using GLM procedures of SAS (SAS Inst. Inc., Cary, NC). The experimental unit was paddock and treatment was forage type. Statistical analysis was conducted for differences in initial BW, initial BCS, final BW, final BCS, ADG, and BCS change.

Results and Discussion

No differences in animal performance (BW and BCS) were found in either 2007 or 2008. As such, the focus of this paper is on the forage production and economics. The variable and fixed costs that will serve as our basis for comparison are outlined in Table 1. Seed costs increased from 2007 to 2008; however, fertilizer costs were eliminated in 2008. For example, foxtail millet seed increased in cost by 30 percent and turnip seed increased by 138 percent compared to prices for similar seed in 2007. The cost of the café mixture seed decreased from 2007 to 2008. This was due to differences in species included in the mix (elimination of soybeans and cowpeas and inclusion of sorghum-sudangrass hybrid, red clover and triticale in 2008). The reason for the change in café mixture composition was based on forage production and cost of seed.

Table 1. Input costs ($/ac) and grazing cost ($/hd/day) for grazing various annual grazing systems in 2007 and 2008.

	2007				2008			
Item	Café	Millet	Turnips	Native Range	Café	Millet	Turnips	Native Range
***Variable costs,* $/ac**								
Seed	16.77	9.60	3.15	-	15.10	12.48	7.50	-
Other[1]	-	-	5.40	-	-	-	4.40	-
***Fixed costs,* $/ac**								
Land Rent	27.10	27.10	27.10	14.90	30.40	30.40	30.40	16.50
Farming[2]	13.38	13.38	13.38	-	13.38	13.38	13.38	-
***Total cost,* $/ac**	57.25	50.08	49.03	14.90	58.88	56.25	55.68	16.50
Stocking rate, hd/ac	0.8	1.7	1.5	0.3	1.2	1.2	2.0	0.3
Grazing cost, $/hd/d[3]	1.81	0.75	0.83	1.18	1.10	1.03	0.59	1.24

[1] Cost of oat straw provided to prevent digestive upset.
[2] Farming = Field cultivation, drilling, and fertilizer application (Custom Rate for West-Central ND; NASS, 2007).
[3] Grazing cost = (Total cost ($/ac) multiplied by acres/animal) divided by number of days grazed.

Forage production for foxtail millet decreased from 2007 to 2008, likely due to the later seeding date in 2008. Differences in forage production of the turnip treatment are mostly related to the variety of turnip planted. In 2007, purple-top turnips were planted and the resulting biomass contained mainly turnip bulbs. However, in 2008, Pasja turnips were planted. Pasja turnips have substantially smaller bulbs and produce more foliage, making them better suited for grazing applications. Forage production of cover crops is presented in Table 2.

Table 2. Average production (lbs/acre; DM basis) of forage in various annual grazing systems in 2007, 2008, and 2009.

	Forage Production (lb/ac)[1]		
Item	2007	2008	2009
Café	1,893	2,822	2,275
Millet	5,058	3,103	2,763
Turnips[2]	1,956	4,099	811
Native Range	2,709	2,504	3,500

[1] Based on clipping data from early October.
[2] Total production of foliage only.

Grazing costs on a $/head/day basis show that turnips were consistently the least expensive forage tested

in this research, averaging 71 cents/head/day during the two years. However, foxtail millet shows promise if adequate forage production can be obtained, as in the case of 2007, when our grazing cost was 75 cents/head/day. Changing the forage composition of the café treatment helped lower grazing costs, but further increases in forage production are needed to make this option viable for cattle owners. The lower stocking rate (0.3 head/acre) required for proper management makes grazing native range in the late fall and early winter more expensive compared with grazing annuals such as turnips or foxtail millet.

The use of forage barley in a double-cropping system had mixed results. The hay produced was good quality (10.7 percent crude protein) and production adequate (4,370 lbs/ac; DM basis; Table 3). The calculated net income was $50.47 and $33.04/acre for Hayes and Stockford varieties, respectively, based on a $60/ton value for the forage barley. However, barley regrowth did impact our annual cover crops. Regrowth of forage barley dramatically decreased the production of our winter annual forages compared with the areas that were left unplanted. In the future herbicides will be sprayed to kill any barley regrowth in an effort to mitigating these effects. If successful, the double cropping system may become the preferred management system from an economical point of view.

Table 3. Input cost, net income, forage production and quality of two varieties of forage barley in 2008.

	Variety	
	Hayes	Stockford
Input Costs		
Seed cost, $/lb	$0.27	$0.38
Land rent, $/ac	$30.40	$30.40
Drilling, $/ac	$7.95	$7.95
Swathing, $/ac	$7.97	$7.97
Baling, $/bale	$6.57	$6.57
Total cost, $/ac	$94.34	$104.03
Net income, $/ac[2]	$50.47	$33.04
Forage production, lb/ac DM	4,490	4250
Nutrient analysis, %		
CP	10.8	10.7
NDF	60.1	59.2
ADF	32.3	32.0
IVDMD	76.2	76.4
Ca	0.4	0.5
P	0.3	0.3

[1] Rental and custom rates obtained from (NASS, 2007 and NASS, 2008)
[2] Net income = (As Fed Forage production (ton/ac) * $60/ton) – Total Costs ($/ac) of inputs

Implications

Given that both foxtail millet and turnips produced more forage than café and that there were no statistical differences observed in cow performance, producers could benefit from increased stocking rates when utilizing these annual forage crops in their livestock production systems. Annual forage mixes, such as the café treatment, show promising results when considering beef cow performance; however, work is needed to decrease the cost of planting these mixtures to make application more economical.

Planting a cover crop following a spring cereal crop for hay is economically risky. When July, August and September precipitation is 8 inches or less and soil type has poor water holding capacity as seen in shallow-to-gravel, gravel and sandy soils, poor germination and forage production may occur.

Present Progress

At the time of publication, grazing of livestock was still on-going thus animal performance, forage quality, and economic data was not completed for 2009. Additionally, lab analysis had not been completed on the soil samples or forage barley and oats for hay. Results of this project in 2009 will be available at a later date.

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