Utilizing Annual Forages in a Single and Dual Cropping System for Late-Fall and Early Winter Grazing: Impacts on Forage Production and Quality, Cow Performance, Soil Health, and Economics

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2010 Cocktail Mix in November (3700 lbs/ac production)

INTRODUCTION

As feed grain, fuel costs and hay expenses for beef cattle production rise, extending the grazing season by utilizing annual forage crops has been considered (McCartney et al. 2008). In some cases, extending the grazing season can benefit producers by lowering production costs of beef cattle operations (D'Souza et al. 1990, Adams et al. 1994, McCartney et al. 2009). In the northern Great Plains, grazing rangeland and pastureland into the fall and early winter is not always an option, especially if forage quantity and quality is limited due to environmental conditions. Annual forages planted in late summer provide a late-fall, early winter grazing option to complement grazing rangeland. Annual plants seeded later in the growing season can provide high quality forage (Neville et al. 2008) that can enhance and maintain body condition scores among cows, plus supply soil benefits (Koch et al. 2002). Annual forages can serve as cover crops and have the potential to grow quickly in poor conditions, providing immediate residual cover and organic matter to the soil surface and sub-surface, thereby improving soil aggregation, while capturing nutrients from deep in the soil profile and depositing them in the upper profile for subsequent crop use (Fageria et al. 2005). Grazing annual forages late in the year can provide high nutritional feed, large quantities of forage and supply long-term physical, chemical and biological soil benefits.

MATERIALS AND METHODS

This study was conducted at the Central Grasslands Research and Extension Center (CGREC) located in south-central North Dakota, approximately nine miles northwest of Streeter, North Dakota. A one-crop system (annual forage crop) was tested in 2007 using a randomized complete block design with three replicates. Annual forage type was treatment and native range was the control. In 2008, 2009 and 2010, a one-crop system (annual forage crop) and a dual-crop system (cereal hay crop/annual forage crop) were used in a split-plot randomized complete block design with three replicates. A chemical burn-down (spray) application was applied as a response variable on 75 percent of the cereal hay crop system in 2009 and 2010 to compare a sprayed *vs*. unsprayed response. The dual-crop system (cereal crop/annual forage crop), often referred to as a cover crop program, has the potential to be more cost-efficient opposed to the one-crop system. All animal care and handling procedures were approved by the NDSU Institutional Animal Care and Use Committee prior to the initiation of the study.

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 forage treatments from 16-October to 27-November, 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 turnip, 3) cocktail mix consisting of purple-top turnip, forage radish, cowpea, soybean, sunflower and foxtail millet, and 4) standing native range (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 forage treatments from 15-October to 26-November, 2008. Body weight and BCS were collected in the same manner as 2007. Treatments were: 1) foxtail millet, 2) pasja turnip, 3) cocktail mix consisting of pasja turnip, forage radish, sorghum-Sudangrass hybrid, sunflower, triticale and red clover, and 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 forage treatments 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 turnip, 3) cocktail mix consisting of pasja turnip, forage radish, sorghum-Sudangrass hybrid, sunflower, forage barley and hairy vetch and 4) standing native range.

***2010 season*:** One hundred fifty-nine mature, pregnant Angus-Simmental cross beef cows were stratified by initial BW (1287 ± 145 lbs) and initial BCS (5.25 ± 0.18) and assigned randomly to graze one of four forage treatments from 19-October to 6-December, 2010. Body weight and BCS were collected in the same manner as 2007. Treatments were: 1) foxtail millet, 2) pasja turnip, 3) cocktail mix consisting of pasja turnip, forage radish, sorghum-Sudangrass hybrid, sunflower, forage oat and forage soybean and 4) standing native range.

Stocking Rate and Carrying Capacity

Carrying capacities were determined based on available forage production prior to the cow turn-out date and an estimated utilization. We estimated carrying capacity using a harvest efficiency of 70% of the foxtail millet, 90% of turnip foliage, 80% of the cocktail mix, and for the native range treatment, 25% of the grasses and 15% of the forbs. In 2010, we increased the harvest efficiency of native range grasses to 35% to provide a more realistic use pattern of grazing non-lactating cows on rangelands. Stocking rates were determined by taking the available forage and dividing by dry matter intake per day (DMI/d), then dividing by 60 days (planned grazing days) to predict number of cows/pasture (pasture represents a replicate within a treatment). The DMI/d was 32 lb/d in 2007 and 2008, 35 lb/d in 2009, and 38 lb/d in 2010 for all treatments except foxtail millet, which was reduced to 32 lb/d in 2010 to attempt to reduce waste. For example, a cocktail mix pasture which produces 4000 lb of forage/ac yields 3200 lb of available forage/ac (4000 lb x 80% harvest efficiency); at 38 lb of DMI/d and a 60 d grazing season, stocking rate would be 1.4 cows/ac. The DMI/d was increased every year because cattle intake was higher than the nutrient requirement recommended in the Beef Cattle Handbook (NRC 1996). Intake was higher than expected, probably due to the high level of palatability provided by the forage types.

Forage establishment

2007 season**:** Seeding of annual forage treatments 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 cocktail mix was seeded with a seed mixture containing 20, 15, 4, 1, 1 and 0.5 lb/ac for soybean, cowpea, foxtail millet, sunflower, radish and turnip, 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**:** One-half of each paddock was dedicated for an annual forage crop (single crop system) and the other half planted to an annual hay crop followed by the seeding of the annual forage crop (duel crop system/cover crop). Two varieties of forage barley (Stockford and Hayes) were tested on the annual hay crop half. 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, ten 0.25-m^2 plots were clipped from each variety in each paddock. Total dry-matter (DM) forage production as well as nutrient analysis was obtained from these samples. Seeding of annual forage treatments for grazing occurred on 27-July for both the single and dual cropping systems. Seeding rate for foxtail millet and pasja turnip was 20 and 3 lb/ac, respectively. The cocktail mix was seeded with a seed mixture containing 15, 4, 1.5, 1, 1 and 1 lbs/ac of triticale, sorghum, red clover, sunflower, radish and pasja turnip, respectively. No fertilizer was applied 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: The design in 2009 was similar to 2008. Forage barley and oats were tested on the forage crop portion, which was removed as a hay crop prior to seeding of the annual forage crop. 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, ten 0.25-m^2 plots were clipped for each species in each paddock. Total forage production (DM) as well as nutrient analysis was obtained from these samples. Following removal of the hay crop, 75 % of this area was sprayed with 1 qt/ac glyphosate (Roundup) plus 2 oz/ac dicamba (Banvel) to kill all live plants and minimize regrowth by the hay crop. Seeding of foxtail millet on the single cropping system portion occurred on 2-July while other annual forages in the single and dual cropping system portions were seeded on 22-July. Seeding rates for foxtail millet and turnip (purple-top and pasja) were 20 and 3 lb/ac, respectively. The cocktail mix 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 done 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).

2010 season: The design in 2010 was similar to 2008 and 2009. A hulless oat was seeded on the forage crop portion, which was removed as a hay crop prior to seeding of the annual forage crop. Oat was seeded at 50 lbs/ac 20-April with 60 lbs/ac urea (46%) broadcasted following the seeding date. The oat crop was swathed 8-July at the soft dough stage and baled 12-July. Prior to swathing, ten 0.25-m^2 quadrats were clipped in each paddock for oat production (DM) and subsequent nutrient analysis. Following removal of the hay crop, 75 % of this area was sprayed with 1 qt/ac glyphosate (Roundup) plus 3 oz/ac dicamba (Banvel) and 0.5 pt/ac 2,4-D to kill all live plants and minimize regrowth by the hay crop. Additionally, a herbicide application was applied on the single crop system on 2-June and 10-June on the oat crop of the dual crop system for broadleaf weed control. One qt glyphosate, 3 oz dicamba and 0.5 pt 2,4-D was used per acre on the single crop system; whereas, 1.33 pt of WideMatch was used per acre on the standing oat crop. Cool soil temperatures during oat germination and delayed fertilizer application due to wet conditions may have been responsible for poor oat production. Foxtail millet was seeded on 23-July, while both turnip and cocktail mix were seeded 29-July. Seeding rate for foxtail millet was 20 lbs/ac and 3.3 lbs/ac for turnip. Cocktail mix seeding rate was 1.5, 4.0, 14.0, 1.0, 0.7 and 3.0 lbs/ac for sunflower, sorghum-Sudangrass hybrid, oat, radish, pasja turnip and forage soybean, respectively. Soil nutrient results revealed low soil nitrogen levels, thus we applied 140 lbs/ac urea (46% N) at the time of the annual forage treatment seeding. This fertilizer cost will be split evenly between the 2010 and 2011 annual forage crops. Rainfall events were above average at 3.91, 2.21, 6.44, 1.84, 4.86 and 0.51 inches/month for May, June, July, August, September and October, respectively. Rainfall events totaled six inches above average; whereas in 2009, rainfall events were one inch less than average (NDAWN, 2010).

Forage Sampling

Clipping for standing crop (potential forage production) was conducted approximately seven to ten days prior to grazing. Forage production was estimated by clipping five 0.25-m^2 quadrats per pasture. Forage production/nutritional samples were collected at the initiation of the grazing period and then bi-weekly throughout the grazing period. All forage samples were analyzed for crude protein, acid and neutral detergent fiber, calcium, phosphorus, and *in vitro* organic matter and dry-matter disappearance.

Soil Sampling

Soil samples were collected during June of 2009 and 2010 in each of the nine single/dual crop system pastures and in each of the three native range paddocks. Separate samples were collected from the single and dual crop systems. Sample points were selected by stratifying for similar soil series' across all treatments and replicates using soil maps from Web Soil Survey (USDA, NRCS 2009). Physical, chemical and biological measurements of the soil included bulk density, macronutrients, pH, hydraulic conductivity, total organic carbon and microbial biomass. Aggregate stability sampling was conducted in early August with six samples taken per system and collected at a depth of six inches.

Economic analysis

An economic analysis was conducted for all treatments. Input costs and grazing costs were calculated in dollars per acre ($/ac) and dollars per head per day ($/hd/d), respectively. Average non-irrigated cropland cash rent values and average non-irrigated pastureland cash rent values for Kidder County, North Dakota were used for each year (National Agriculture Statistics Service, 2010). Additionally, 2007 North Dakota average custom rates for fertilizer application, no-till seeding, and herbicide application were used to represent input costs for all years of the study (North Dakota Agricultural Statistics, 2009). Cost to graze one cow per day was figured by multiplying total input costs by amount of acres available per head in each system (single, dual, dual with spray) and divided by number of days grazed.

RESULTS AND DISCUSSION

Forage Production and Quality

Annual forage crop production for 2007 through 2010 is found in Table 1. On average, clipping for peak biomass production was completed around 80 days following the seeding of the annual forage treatments. No fertilizer was applied for the annual forage crops used for grazing in 2008 and 2009; whereas, 50 lbs/ac of fertilizer [25 lbs urea (46% N) and 25 lbs of 11:52]was applied in 2007, and 140 lbs/ac of urea (46 % N) was applied in 2010. The dual cropping system without a burn-down spray was detrimental to the production of an annual forage crop (cover crop) for grazing. On average, production of a second forage crop following the harvest of an annual hay crop (dual crop system) was reduced by 92, 86 and 92 % compared to the single forage crop (single crop system) in 2008, 2009 and 2010; respectively. When we sprayed the hay crop with glyphosate to burn-down the oat re-growth and kill any invading weeds, production of the second forage crop within the dual cropping system was reduced by 60 and 21 % compared to the single forage crop (single crop system) in 2009 and 2010; respectively. Moisture is critical to obtain a productive second crop in a dual cropping system. June – September precipitation started out below average in 2009, creating poor conditions for growth of a second crop. However, June – September precipitation was well above average in 2010, providing excellent growing condition for a second crop.

Foxtail millet was the highest producing annual forage crop using a single cropping system in 2007, 2009 and 2010, followed by the turnip in 2007 and cocktail in 2009 and 2010 (Table 1). The turnip treatment was the highest producing annual forage crop using a single cropping system in 2008; however, lowest in 2009 and 2010, likely due to low soil fertility. Of the three treatments, it is most critical for the turnip treatment to receive additional nitrogen fertilizer to maintain good forage production.

Table 1. Forage production[1] in lbs/ac (DM basis) on the annual forage and native range treatments at CGREC from 2007 through 2010.

Treatment and Year	Single Cropping System	Dual Cropping System	Dual Cropping System with Herbicide	Native Range
2007				
Millet	5199	-	-	-
Turnip[2]	2718	-	-	-
Cocktail	1893	-	-	-
Native Range	-	-	-	2709
2008				
Millet	3103	540	-	-
Turnip[2]	4099	83	-	-
Cocktail	2822	191	-	-
Native Range	-	-	-	2504
2009				
Millet	2763	291	858	-
Turnip[2]	811	162	625	-
Cocktail	2275	356	841	-
Native Range	-	-	-	3500
2010				
Millet	4589	470	2913	-
Turnip[2]	3577	237	2903	-
Cocktail	3757	298	3570	-
Native Range	-	-	-	3140

[1] Production was sampled in the first week of October prior to grazing in 2007 through 2010.
[2] Turnip production reflects foliage only.

Cow Performance

Beef cow performance for 2007 through 2010 is given in Table 2. We compared initial (pre-trial) body weight, initial body condition score (BCS), final (post-trial) body weight (BW), final BCS and average daily gain (ADG) among years and treatments. No differences (P>0.05) in final BW, final BCS and ADG were found among treatments in 2007 and 2008. Final body weight (P=0.02) and final BCS (P=0.04) were affected by treatment in 2009 (Table 2). All four treatments showed an increased final BW and final BCS. There was no difference (P=0.19) in ADG among treatments in 2009. The ADG for all treatments combined was 3.22±0.53 lbs. On average, cattle performance was poorest on the foxtail millet while only the cocktail and native range providing increased final BW, final BCS and ADG in both years. In 2010, final body weight, final BCS and ADG (P=0.0017, P=0.0037, P=0.0019, respectively) were affected by treatment. Both the turnip and foxtail millet treatments showed declining final body weight, final BCS and ADG in 2010, unlike the previous three years of this trial. Cow performance for final BW, final BCS and ADG increased in both cocktail and native range treatments in 2010.

Table 2. Beef cow performance grazing annual forage treatments and native range at the Central Grasslands Research Center near Streeter, ND in 2007 - 2010.

	Millet	Turnip	Cocktail	Native Range	SE	P-value
2007						
Initial BW, lbs	1185^{a}	1170^{b}	1178^{a}	1170^{b}	2.23	< 0.01
Initial BCS	5.30	5.22	5.27	5.38	0.04	0.15
Final BW, lbs	1255	1266	1261	1258	9.59	0.85
Final BCS	5.57	5.48	5.63	5.47	0.06	0.31
ADG, lbs	1.66	2.27	1.96	2.08	0.21	0.29
2008						
Initial BW, lbs	1260	1263	1260	1262	4.39	0.95
Initial BCS	5.30	5.25	5.30	5.26	0.07	0.93
Final BW, lbs	1330	1350	1333	1356	11.14	0.33
Final BCS	5.37	5.48	5.47	5.37	0.08	0.66
ADG, lbs	1.61	2.02	1.71	2.19	0.24	0.36
2009						
Initial BW, lbs	1160	1167	1172	1159	8.68	0.68
Initial BCS	5.10	5.19	5.16	5.17	0.06	0.71
Final BW, lbs	1290^{b}	1355^{a}	1331^{ab}	1299^{b}	12.91	0.02
Final BCS	5.37^{b}	5.72^{a}	5.56^{ab}	5.38^{b}	0.08	0.04
ADG, lbs	2.70	3.92	3.31	2.94	0.37	0.19
2010						
Initial BW, lbs	1286	1285	1287	1289	1.86	0.46
Initial BCS	5.18	5.22	5.32	5.29	0.06	0.39
Final BW, lbs	1194^{c}	1252^{b}	1306^{a}	1323^{a}	15.97	0.0017
Final BCS	4.89^{b}	4.97^{b}	5.36^{a}	5.61^{a}	0.10	0.0037
ADG, lbs	-1.88^{c}	-0.66^{b}	0.38^{ab}	0.70^{a}	0.32	0.0019

^{abc} Values in a row with same letter are not different at P> 0.05.

Soil Health

Soil bulk density and soil organic carbon (SOC) for 2009 and 2010 are given in Table 3. Soil bulk density was reduced (P<0.01) on all annual forage treatments at a depth of 0 – 1.2 inches, and on the turnip and cocktail treatment at a depth of 2 – 3.2 inches from 2009 to 2010. Mean soil bulk density at a depth of 0 – 1.2 inches declined (P<0.01) on the foxtail millet from 2009 to 2010; however, it did not change (P>0.05) at the depth of 2 – 3.2 inches. On the native range treatment, soil bulk density did not change (P>0.05) at either soil depth. Soil bulk density was not different (P>0.05) among annual forage treatments, with all treatments lower than the native range treatment. Soil organic carbon was greater on native range compared to all annual forage treatments (Table 3). With the exception of the cocktail treatment, SOC did not change from 2009 to 2010. The SOC on the cocktail treatment increased (P<0.01) by 34 percent from 2009 to 2010.

Table 3. Soil bulk density (Db) and soil organic carbon (SOC) on the annual forage and native range treatments at CGREC near Streeter, ND in 2009 and 2010.

	Treatment					**P-value**	
	Millet	Turnip	Cocktail	Native Range	SE	Year	Treatment
Mean Db (0-1.2 in depth)	1.25[x]	1.18[x]	1.24[x]	0.80[y]	0.057	-	<0.01
2009	1.36[a]	1.27[a]	1.35[a]	0.85[a]	0.072	-	-
2010	1.15[b]	1.10[b]	1.14[b]	0.74 [a]	0.072	<0.01	-
Mean Db (2-3.2 in depth)	1.36[x]	1.35[x]	1.37[x]	1.05[y]	0.047	-	<0.01
2009	1.40[a]	1.41[a]	1.44[a]	1.07[a]	0.055	-	-
2010	1.33[a]	1.30[b]	1.30[b]	1.03[a]	0.055	<0.01	-
SOC	2.74[x]	2.65[x]	2.52[x]	4.34[y]	0.29	-	<0.01
2009	2.74[a]	2.51[a]	2.15[a]	4.09[a]	0.36	-	-
2010	2.75[a]	2.79[a]	2.89[b]	4.59[a]	0.36	<0.03	-

[xy] Indicates difference between treatments (p<0.05)
[ab] Indicates difference between years within treatment (p<0.05)
Unit for Db is g/cm^3, while SOC is given in percent found in soil

Economics

Both the foxtail millet ($0.98/hd/d) and cocktail ($1.05/hd/d) treatments using a single cropping system had similar daily costs per head compared to the native range ($1.01/hd/d) treatment in 2009 (Table 4). The turnip treatment using a single cropping system cost $2.04/hd/d, twice the cost of the native range treatment and 66 % higher than the cost of custom dry-lot feeding ($1.34/hd/d) in 2009. None of the dual cropping system treatments were cost efficient at late-season grazing compared to the native range treatment or custom dry-lot feeding, costing approximately $6 to $9/hd/d. Both foxtail millet and cocktail treatments using a single cropping system were cost effective compared to custom dry lot feeding (NASS, 2007) at 27 and 22 % lower, respectively. When using a burn-down herbicide treatment to kill the oat crop re-growth (dual cropping system with herbicide), stocking rate was increased 150 to 275 percent compared to the dual cropping system without herbicide, depending on treatment. Thus, grazing costs were also reduced by 139 to 232 percent, depending on treatment. However, using a dual cropping system with herbicide was not cost efficient compared to grazing late-season native range or custom dry-lot feeding in 2009.

Only the foxtail millet ($0.72/hd/d) treatment using a single cropping system had lower daily costs per head to the native range ($0.82/hd/d) treatment in 2010 (Table 5). The cost to graze a cow on the foxtail millet treatment using a dual cropping system with herbicide was higher ($1.27/hd/d) than native range, but lower than custom dry-lot feeding ($1.34/hd/d) in 2010. Interestingly, the cocktail treatment using a dual cropping system with herbicide ($0.85/hd/d) had similar costs to the native range treatment; however, it was higher using the single cropping system ($1.13/hd/d). The cost to graze a cow on turnip ($1.13/hd/d) and cocktail ($1.13/hd/d) treatments using a single cropping system were higher than grazing native range, but lower than the cost of custom dry-lot feeding ($1.34/hd/d) in 2010. None of the dual cropping system treatments without herbicide were cost efficient at late-season grazing compared to the native range treatment or custom dry-lot feeding, costing approximately $0.12 to $0.30/hd/d.

Table 4. Input costs ($/ac), returns ($/ac) and grazing costs ($/hd/d) by treatment at CGREC in 2009.										
	Single Cropping System			Dual Cropping System			Dual Cropping System with Herbicide			Native Range
Item	Millet	Turnip	Cocktail	Millet	Turnip	Cocktail	Millet	Turnip	Cocktail	
Costs, $/ac										
Cereal crop seed	-	-	-	6.00	6.00	6.00	6.00	6.00	6.00	-
No-till seeding with application*	-	-	-	12.73	12.73	12.73	12.73	12.73	12.73	-
Fertilizer (April)[1]	-	-	-	10.25	10.25	10.25	10.25	10.25	10.25	-
Swath/baling*	-	-	-	14.86	14.86	14.86	14.86	14.86	14.86	-
Herbicide (July)[2]	-	-	-	-	-	-	4.50	4.50	4.50	-
Herbicide application	-	-	-	-	-	-	4.83	4.83	4.83	-
Land rent[3]	30.40	30.40	30.40	30.40	30.40	30.40	30.40	30.40	30.40	16.50
Annual forage seed	8.80	7.31	12.60	8.80	7.31	12.60	8.80	7.31	12.60	-
No-till seeding with application*	12.14	12.14	12.14	12.14	12.14	12.14	12.14	12.14	12.14	-
Other[4]	-	3.60	-	-	3.60	-	-	3.60	-	-
Returns, $/ac										
Cereal crop hay (oat)[5]	-	-	-	55.10	67.59	68.70	55.10	67.59	68.70	-
Adjusted Costs, $/ac	51.34	53.45	55.14	40.08	29.70	30.28	49.41	39.03	39.61	16.50
Stock density, hd/ac	1.31	0.65	1.08	0.14	0.08	0.16	0.41	0.30	0.40	0.38
Grazing cost, $/hd/d[6]	0.98	2.04	1.05	6.13	8.95	7.63	2.56	3.26	2.30	1.01

[1] 50 lbs/ac urea nitrogen (46% N)
[2] Herbicide burn-down spray (Cereal crop: 1 qt glyphosate, 3 oz Banvel, 0.5 pt 2,4-D)
[3] Non-irrigated cropland and non-irrigated pasture average rental rates for Kidder County, ND (NASS, 2010)
[4] Oat straw bale supplement to prevent digestive upset (2 bales at $18.00/bale)
[5] Result of cereal crop grown prior to annual forage (premature oat hay: $35.00/1500 lb bale)
[6] (Adjusted costs) x (acre/animal) / (# of days grazed) *North Dakota custom rate values (NASS, 2007)

Table 5. Input costs ($/ac), returns ($/ac) and grazing costs ($/hd/d) by treatment at CGREC near Streeter, ND in 2010.

	Single Cropping System			Dual Cropping System			Dual Cropping System with Herbicide			Native Range
Item	Millet	Turnip	Cocktail	Millet	Turnip	Cocktail	Millet	Turnip	Cocktail	
Costs, $/ac										
Cereal crop seed	-	-	-	6.25	6.25	6.25	6.25	6.25	6.25	-
No-till seeding with application*	-	-	-	12.73	12.73	12.73	12.73	12.73	12.73	-
Fertilizer (April)[1]	-	-	-	12.30	12.30	12.30	12.30	12.30	12.30	-
Swath/baling*	-	-	-	14.86	14.86	14.86	14.86	14.86	14.86	-
Herbicide (June)[2]	4.50	4.50	4.50	9.50	9.50	9.50	9.50	9.50	9.50	-
Herbicide application*	4.83	4.83	4.83	4.83	4.83	4.83	4.83	4.83	4.83	-
Herbicide (July)[3]	4.50	4.50	4.50	-	-	-	4.50	4.50	4.50	-
Herbicide application	4.83	4.83	4.83	-	-	-	4.83	4.83	4.83	-
Land rent[4]	30.30	30.30	30.30	30.30	30.30	30.30	30.30	30.30	30.30	17.00
Annual forage seed	7.00	6.26	11.23	7.00	6.26	11.23	7.00	6.26	11.23	-
No-till seeding with application*	12.73	12.73	12.73	12.73	12.73	12.73	12.73	12.73	12.73	-
Fertilizer (July)[5]	14.35	14.35	14.35	14.35	14.35	14.35	14.35	14.35	14.35	-
Other[6]	-	1.80	-	-	1.80	-	-	1.80	-	-
Returns, $/ac										
Cereal crop hay (oat)[7]	-	-	-	40.28	30.21	74.89	40.28	30.21	74.89	-
Adjusted Costs, $/ac	83.04	84.10	87.37	84.57	95.70	54.30	93.90	105.03	63.63	17.00
Stock density, hd/ac	1.95	1.57	1.65	0.24	0.07	0.13	0.88	1.27	1.57	0.43
Grazing cost, $/hd/d[8]	0.72	1.13	1.13	29.58	17.09	12.07	1.27	1.72	0.85	0.82

[1] 60 lbs/ac urea nitrogen (46% N) [2] Spray for weed control (Non-crop: 1 qt glyphosate, 3 oz Banvel, 0.5 pt 2,4-D) (Cereal crop: 1.3 pt WideMatch)
[3] Herbicide burn-down spray (Non-crop and cereal crop: 1 qt glyphosate, 3 oz Banvel, 0.5 pt 2,4-D)
[4] Non-irrigated cropland and non-irrigated pasture average rental rates for Kidder County, ND (NASS, 2010)
[5]140 lbs/ac urea nitrogen (46% N) (total cost: $28.70, divided over two years at $14.35/ac for 2010 & 2011)
[6] Oat straw bale supplement to prevent digestive upset (1 bale at $18.00)
[7] Result of cereal crop grown prior to annual forage (premature oat hay: $35.00/1500 lb bale)
[8] (Adjusted costs) x (acre/animal) / (# of days grazed) *North Dakota custom rate values (NASS, 2007)

IMPLICATIONS

The foxtail millet treatment using a single cropping system was the only treatment with lower costs to late-season grazing as compared to grazing native range in 2009 and 2010. However, livestock performance was lowest on the foxtail millet treatments for both years. The cocktail treatment using a single cropping system had similar or slightly higher costs to graze a cow compared to native range in both years, and was the only treatment using a dual cropping system with herbicide to match the cost of grazing native range in 2010 (an above-average precipitation year). Unlike the foxtail millet treatment, the livestock performance on the cocktail treatment was positive for both years. The turnip treatment was the poorest annual forage in the study for cost to graze a cow and for forage production; however, it was superior for livestock performance in 2009 and poor in 2010. The native range treatment was a cost-effective treatment for late-season grazing non-lactating, gestation cows while providing a sufficient quality diet that resulted in positive livestock performance in both years. A dual cropping system without a burn-down herbicide treatment is not recommended, as forage production was poor and not cost effective. A burn-down herbicide treatment is required for the second crop to germinate and grow, and if moisture is good, forage production and grazing costs will be slightly lower to higher than a single cropping system. If moisture is limited following harvest of the first crop, the second crop, even with a burn-down herbicide, will be poor-producing and costly. Soil bulk density decreased and soil organic carbon increased similarly on all annual cropping systems in 2010. However, no differences were found between the annual and dual cropping systems.

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