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Nutrient Composition, Productivity, and Growth of Selected Warm-season Grasses:

Preliminary Report

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Introduction

Warm-season grasses are planted in North Dakota for mid to late summer pastures, hay land, wildlife habitat, roadside right-of-ways, and set aside acres. However, warm-season plantings are somewhat atypical in North Dakota due to dominating cool-season species. New varieties/cultivars of warm and cool-season grasses have been established and released by plant materials centers around the country. Grasses of the same species can take on different growth forms due to their point of origin. These ecotypical species, or cultivars, have great potential for adding more diversity to a producer's forage supply. Whatever a producer desires from a grass species, evaluation of cultivars can have great importance to decision-making.

Meeting the nutritional requirements of domestic livestock is the key to optimizing performance on and off pasture. Crude protein (CP) content, acid detergent fiber (ADF), and total digestible nutrients (TDN) comprise the majority of values needed to develop feed requirements for domestic livestock (Nutrient Requirements of Beef Cattle 1996). It is generally accepted that as grasses mature, they decline in nutritional quality. Knowledge of the nutritional concentrations of these warm-season grasses can be used by livestock producers to obtain optimum performance through best-use management and timely supplementation during the grazing season when nutritional requirements are deficient.

Many ranchers in the northern Great Plains have an overabundance of cool-season forage and would benefit from a complementary system involving high quality warm-season grasses in July and August (Tober and Chamrad 1992, Conard and Clanton 1963, Krueger and Green 1976). Likewise, many cost cutting measures are focused on the mechanical side of ranching, when more attention should be

directed towards cutting feed costs (Ricketts 1994). To best suit these needs, nutritional content of the grasses, production potential, and best use based on plant maturity and production are needed to address these concerns. With the advent of such knowledge and the potential to improve cattle performance on a regional basis, a need has developed to determine the nutrient content and production potential of selected warm-season grasses in the Northern Great Plains region.

The primary objectives of this study are to 1) determine and compare the nutrient content by date and phenological growth stage of 16 selected warm-season grasses, 2) determine and compare herbage production levels of these selected 16 warm-season grasses, and 3) develop management recommendations on proper use of these grasses.

Study Area

Two locations were selected for this study, one near Hettinger, ND and a second near Pierre, SD. The Hettinger site is located on private land approximately 3 kilometers south of Hettinger, ND. It lies on the Verbar-Flasher-Parshall soil association, with a sandy loam soil texture (Ulmer and Conta 1987). The Pierre site is located north of Ft. Pierre, SD, on land managed by the U.S. Army Corps of Engineers. Soil on the Pierre site is a Promise clay with nearly level slope, a high shrink-swell potential, and restrictive root growth (Bismarck PMC, 1992).

The climatic condition in both sites is a continental climate characterized by continuous air movement and large annual, daily, and day-to-day temperature changes. Relative humidity is low and precipitation tends to be irregular in time and cover (Jensen 1972). Average annual precipitation in the Hettinger and Pierre study sites is approximately 40.6 cm. Most precipitation occurs during the growing season. Seventy-seven percent of the annual precipitation falls during the summer months, with 50 percent falling during May, June, and July (Bavendick 1952). On average for the year, the temperature is 44 to 48 degrees F with a 130 to 160 day freeze-free period.

Temperatures were normal to above normal during the field season during the summer of 1999. From mid to late July, extreme temperatures occurred throughout much of the country, with temperatures reaching 100+ degrees F in the Pierre area for consecutive days. Precipitation was variable throughout the summer at both locations. The Pierre area received above average precipitation for the year (23 in or 46.6 cm) while the Hettinger area was relatively dry receiving 80 percent of its normal precipitation. The 2000 study year was similar to 1999 with warm temperatures and normal to below normal precipitation.

Grasses Studied

Sixteen grasses were selected to be analyzed for nutrient and forage production in 1999 and 2000. A total of eight grass species were tested encompassing 16 cultivars (Table 1).

Table 1. List of grass species and cultivar of each warm-season grass tested near Hettinger, ND, and

Pierre, SD 1999.

Grass Species	Common Name	Cultivar	Origin
Andropogon gerardii	Big bluestem	Bison	ND
Andropogon gerardii	Big bluestem	Sunnyview	SD
Andropogon hallii	Sand bluestem	Garden*	NE
Andropogon hallii	Sand bluestem	Goldstrike*	NE
Bouteloua curtipendula	Sideoats grama	Butte	NE
Bouteloua curtipendula	Sideoats grama	Pierre	SD
Bouteloua gracillis	Blue grama	Bad River*	SD
Bouteloua gracillis	Blue grama	Willis*	ND
Calamovilfa longifolia	Prairie sandreed	Goshen	WY
Calamovilfa longifolia	Prairie sandreed	ND-95	ND
Panicum virgatum	Switchgrass	Dacotah	ND
Panicum virgatum	Switchgrass	Forestburg	SD
Schizachyrium scoparium	Little bluestem	Badlands*	SD, ND
Schizachyrium scoparium	Little bluestem	Camper	NE
Sorghastrum nutans	Indiangrass	Holt	NE
Sorghastrum nutans	Indiangrass	Tomahawk	SD, ND

* Grass cultivar was not sampled at Pierre, SD site.

Methods and Materials

Nutritional quality and herbage production were determined from ungrazed, non-mowed warm-season grass clippings. An array of 16 warm-season grass cultivars were seeded in 2m by 8m plots at the Hettinger site on 20 May 1997. An array of 33 warm-season cultivars were seeded in 3.5m by 15m plots at the Pierre site on 20-21 May 1986; however, only 11 of these 33 cultivars were analyzed in this study. Seeding rate varied with species but followed recommended seeding rates as specified in the North Dakota Natural Resource Conservation Service Technical Guide. Species with no specified seeding rates were planted at 20-25 seeds/0.1m^2. Three replicated arrays were developed and each grass cultivar randomly seeded in each array to create a randomized complete block design (RCBD).

This nutritional quality and forage production trial began in June 1999. Six sample collection dates were selected at three-week intervals beginning in June and ending in October of 1999. In 2000, seven collections dates were selected at three-week intervals beginning in May and ending in October. Samples from both locations were collected from each plot using a 0.5 m2 frame placed in its designated quadrant as randomly selected for each clipping period. Grasses were clipped to 1 cm stubble with plant tissue placed into a paper bag for future preparation. Clipping date and phenological growth stage was recorded for all grass cultivars at each clipping period. Forage production was determined for the Pierre, SD and nutritional quality determined for both sites in 1999. Each of the grass cultivars were analyzed for crude protein (CP), in vitro dry matter digestibility (IVDMD), acid detergent

fiber (ADF), neutral detergent fiber (NDF), phosphorus (P), calcium (Ca), copper (Cu), zinc (Zn), magnesium (Mg), sodium (Na), iron (Fe), potassium (K), and manganese (Mn).

All samples were oven dried at 60 degrees Celsius, measured for production, ground through a 1 mm screen in a Wiley mill, and analyzed for dry matter, ash, minerals, CP, IVDMD, ADF, and NDF at the North Dakota State University, Animal and Range Sciences nutritional laboratory. Dry matter, ash, minerals, and ADF were determined following standardized procedures (AOAC 1990), NDF using procedures described by Robertson and Van Soest (1982), CP using the Kjeldahl Auto System II (AOAC 1990), and IVDMD using methods outlined by Tilley and Terry (1963).

Data was analyzed to determine differences at the 0.05 percentile ($P<0.05$) between time periods and grass species and cultivars. Analysis comparing differences in nutrient quality and herbage production between time periods will be conducted using one-way analysis of variances as performed using Statistical Procedures for Social Sciences (1999). When significant differences occurred, means were separated using Tukey's Honesty Significant Difference (Steel and Torrie 1980).

Results and Discussion

Production

Most varieties reached peak herbage productivity by early August, with some exceptions occurring in July or September. Species or cultivars that matured earliest included blue grama, sideoats grama, and 'Dacotah' switchgrass. Sand bluestem, little bluestem, and 'Sunnyview' big bluestem were species or cultivars that tended to mature later. In addition, cultivars of a northern origin can be expected to mature earlier than southern varieties; therefore, one might expect southern cultivars to produce more herbage. However, this is highly dependent on site characteristics such as soil and microclimatic influence. The north-south origin difference among selected cultivars ranges from North Dakota to Nebraska (Table 1). One of the main limiting factors to production in the northern Great Plains is the soil moisture deficit common in late August and September (Rogler and Haas 1947).

The highest producing grasses at Pierre were 'Forestburg' and 'Dacotah' switchgrass, with cumulative production (peak production plus regrowth) 4,065 and 3,320 pounds per acre respectively (Table 2). Overall productivity did not differ between the two study locations ($P=0.756$). However, there was a variety by location interaction effect ($P<0.05$). Sideoats grama varieties had different levels ($P<0.05$) of production based on location. At Hettinger, 'Butte' and 'Pierre' sideoats grama achieved peak production levels of nearly 3000 pounds per acre; however, the Pierre location had levels closer 200 pounds per acre (Tables 3 and 4). Varieties of big bluestem, Indiangrass, and prairie sandreed produced more herbage at the Pierre location, where stands of Indiangrass were poor to nonexistent at the Hettinger site. Consequently, it must be stressed that soil type and characteristics such as water holding capacity be determined prior to seeding a grass species or cultivar. Shorter grasses like sideoats grama and blue grama produce more in upland sandy sites similar to the Hettinger location; whereas, taller species prefer low to midland sites similar to the Pierre location.

A significant year effect was detected for the Pierre location. ‘Forestburg’, ‘Bison’, ‘Sunnyview’, ‘Goshen’, and ‘Holt’ were cultivars that produced more herbage (P<0.05) in 2000 than 1999. Other cultivars showed no difference (P>0.05) between 1999 and 2000. Sideoats grama cultivars were the only grasses that had a reduction (P<0.05) in 2000. Although production was not evaluated at Hettinger in 1999, it is the belief of the investigators that production in 1999 was similar to that in 2000.

Table 2. Production levels at each date (dry lbs/acre) among 11 select warm-season grasses at Pierre, SD in 1999.

Species (Variety)	6/23	7/13	8/5	8/24	9/15	10/6
Big bluestem (Bison)	1158	2198	2420	1343	1940	1381
Big bluestem (Sunnyview)	874	2103	2192	1446	1691	862
Sideoats grama (Butte)	116	228	353	340	378	257
Sideoats grama (Pierre)	270	485	615	329	775	462
Prairie sandreed (Goshen)	626	1234	1306	1034	1168	1125
Prairie sandreed (ND-95)	1200	1813	2834	1419	1458	1437
Switchgrass (Dacotah)	1877	2716	2548	2421	3193	2084
Switchgrass (Forestburg)	851	1855	2997	1939	3002	1798
Little bluestem (Camper)	394	1157	1915	932	1989	1114
Indiangrass (Holt)	270	915	1909	717	1405	702
Indiangrass (Tomahawk)	302	1389	2065	791	1278	953

Table 3. Production levels at each date (dry lbs/acre) among 11 select warm-season grasses at Pierre, SD in 2000.

Species (Variety)	5/30	6/20	7/10	8/2	8/23	9/12	10/3
Big bluestem (Bison)	1311	2466	3495	3906	3060	2444	2341
Big bluestem (Sunnyview)	1104	2665	3842	3805	4590	4292	3472
Sideoats grama (Butte)	53	114	139	137	253	218	202
Sideoats grama (Pierre)	150	218	227	413	240	244	249
Prairie sandreed (Goshen)	845	1489	1683	1961	2176	2753	2270
Prairie sandreed (ND-95)	1007	1468	2318	3145	2791	2136	2392
Switchgrass (Dacotah)	1252	2179	3107	3164	2644	2925	2845
Switchgrass (Forestburg)	941	2156	3666	5360	4757	4196	3655
Little bluestem (Camper)	364	1044	1430	2622	1731	1682	1806
Indiangrass (Holt)	490	1607	1734	2105	2269	1947	1871
Indiangrass (Tomahawk)	409	1104	1334	1223	1279	1451	1735

Table 4. Production levels at each date (dry lbs/acre) among 14 select warm-season grasses at Hettinger, ND in 2000.

Species (Variety)	5/31	6/20	7/11	8/1	8/22	9/13	10/3
Big bluestem (Bison)	936	2322	2728	3175	1728	1512	987
Big bluestem (Sunnyview)	580	658	1444	2788	1556	2382	1535
Sideoats grama (Butte)	1116	2373	2699	3934	2517	2810	2453
Sideoats grama (Pierre)	1016	2143	2293	3372	2177	2983	2484
Prairie sandreed (Goshen)	169	1072	812	1066	894	1365	1185
Prairie sandreed (ND-95)	294	734	1110	1006	1456	1854	1030
Switchgrass (Dacotah)	683	2534	3362	3611	4140	3513	3111
Switchgrass (Forestburg)	614	1491	4208	5464	3794	4267	3856
Little bluestem (Camper)	162	605	934	701	2119	1356	1279
Little bluestem (Badlands)	160	446	710	925	900	858	1050
Blue grama (Willis)	640	1171	1191	2350	1897	2648	1754
Blue grama (Bad River)	770	928	1307	2722	2622	2071	1677
Sand bluestem (Garden)	216	1149	1380	2178	2260	3353	1874
Sand bluestem (Goldstrike)	228	693	1483	2579	1680	2447	2177

Nutritional Quality

Crude Protein:

Sixteen warm-season grass varieties were analyzed for nutritional quality in 1999 and 2000. To optimize livestock performance, ranchers would like the nutrient content of the grass to remain at or above the minimum requirements of the livestock throughout the grazing season or in harvested feeds for hay. These goals can be achieved if knowledge of nutrient content is determined and correlated with the production parameters.

All grass cultivars showed a decline in crude protein (CP) content from June to October 1999 (Table 5). Initially, no differences ($P>0.05$) were found between varieties. As cultivars matured, they began to exhibit larger differences in percent CP. Species that maintained a higher percentage of CP included blue grama and prairie sandreed cultivars. Cultivars of switchgrass and big bluestem declined to the lowest levels among the species. Sideoats grama tended to have higher CP at Pierre than Hettinger.

The phenological stage contrast between cultivars of the same species indicated nutritional differences. ‘Sunnyview’ big bluestem maintained a vegetative state longer than ‘Bison’ throughout the study and tested slightly higher CP levels. All grass species initially met the minimum nutrient requirements of a 1200 lb lactating cow, but dropped below requirements by mid-summer.

Overall, varieties at the Pierre location had a lower level of crude protein ($p<0.05$) when compared to Hettinger; however, there were no variety by site interactions ($p=0.206$). All varieties exhibited similar trends regardless of location. Due to a large amount of standing litter, the grass at the Pierre site had some obvious interference that may have contributed in reducing quality in 1999.

When reviewing the nutritional quality results of these warm-season grasses, quality can only be assessed for hay quality and not actual grazing quality for pasture. Livestock can selectively graze for higher quality than shown in this data; however, hay quality will be accurate as shown since clipping was conducted similar to a haying operation. Comparison among grass species can be conducted and selection for grazing or haying use since all grass species were collected and analyzed the same.

Table 5. 1999 Crude protein (%) content by date for selected warm-season grasses in Hettinger, ND and Pierre, SD.

Species (Variety)	6/21	7/12	8/4	8/23	9/14	10/5
Hettinger, North Dakota						
Big bluestem (Bison)	13.27	9.97	7.79	6.59	5.90	3.41
Big bluestem (Sunnyview)	14.95	10.36	7.55	9.05	7.88	5.41
Sand bluestem (Garden)	14.07	10.81	8.09	8.24	7.32	5.82
Sand bluestem (Goldstrike)	14.59	10.87	8.54	8.55	7.63	6.05
Blue grama (Bad River)	15.49	12.07	8.92	9.34	8.75	6.89
Blue grama (Willis)	15.99	12.51	9.22	9.94	9.12	7.46
Sideoats grama (Butte)	14.85	11.18	8.68	7.73	6.30	4.84
Sideoats grama (Pierre)	15.12	10.97	7.78	7.48	6.57	4.75
Prairie sandreed (Goshen)	13.53	10.80	7.99	7.92	8.74	7.48
Prairie sandreed (ND-95)	14.90	11.56	9.44	9.02	9.77	8.07
Switchgrass (Dacotah)	15.89	10.49	7.05	6.71	5.61	4.24
Switchgrass (Forestburg)	15.88	11.42	7.84	7.77	6.88	3.92
Little bluestem (Badlands)	13.73	10.75	6.50	5.60	6.56	5.24
Little bluestem (Camper)	14.18	10.60	7.95	8.20	6.89	6.67
Indiangrass (Holt)	13.46	10.35	8.18	7.89	7.14	6.21
Indiangrass (Tomahawk)	14.27	9.84	7.14	5.81	5.05	4.22
Pierre, South Dakota						
Big bluestem (Bison)	9.58	5.95	5.24	3.85	3.64	3.38
Big bluestem (Sunnyview)	9.82	6.23	5.41	4.34	4.58	3.76
Sideoats grama (Butte)	12.09	8.83	7.48	6.42	7.41	7.25
Sideoats grama (Pierre)	11.06	9.02	6.75	5.51	6.45	5.87
Prairie sandreed (Goshen)	10.28	7.78	6.53	5.56	6.60	5.99
Prairie sandreed (ND-95)	10.46	7.72	6.07	4.96	6.23	5.50
Switchgrass (Dacotah)	8.31	5.17	4.17	2.83	3.27	2.29
Switchgrass (Forestburg)	11.16	6.74	4.95	4.20	3.47	2.95
Little bluestem (Camper)	8.94	6.25	.5.22	4.41	4.43	4.25
Indiangrass (Holt)	11.05	6.42	5.58	4.88	5.13	5.03
Indiangrass (Tomahawk)	11.10	7.18	5.99	4.67	5.08	3.34

In Vitro Dry Matter Digestibility:

The in vitro dry matter digestibility (IVDMD), like crude protein, declined with advancing maturity of the grasses (Table 6). The cultivars at Hettinger had a higher digestibility than Pierre throughout the entire 1999 season ($p<0.05$); however, there was not a variety by location interaction ($p=0.274$) suggesting similar trends in cultivars. Big bluestem, sideoats grama, sand bluestem, and indiangrass cultivars tended to be highest in digestibility throughout the season, regardless of location. Fibrous grasses like prairie sandreed and 'Badlands' little bluestem were relatively low among the cultivars. Switchgrass exhibited some variability by location with extremely low late season values at Pierre compared to Hettinger.

Table 6. In Vitro Dry Matter Digestibility (%) by date for 16 select warm-season grasses near Hettinger, ND and Pierre, SD 1999.

Hettinger, North Dakota	**Date**					
Species (Variety)	**6/21**	**7/12**	**8/4**	**8/23**	**9/14**	**10/5**
Big bluestem (Bison)	72.25	71.70	57.21	55.33	48.81	46.30
Big bluestem (Sunnyview)	77.72	71.70	60.07	64.38	55.45	55.44
Sand bluestem (Garden)	74.00	70.53	59.59	61.05	52.32	51.88
Sand bluestem (Goldstrike)	73.68	71.15	61.79	58.24	51.60	52.51
Blue grama (Bad River)	74.55	72.18	56.86	51.88	47.90	45.46
Blue grama (Willis)	73.20	69.88	56.14	48.14	49.31	44.85
Sideoats grama (Butte)	71.26	68.38	59.21	54.79	48.72	50.15
Sideoats grama (Pierre)	71.99	69.37	56.64	49.93	47.44	47.04
Prairie sandreed (Goshen)	72.03	69.89	58.31	46.28	44.63	41.27
Prairie sandreed (ND-95)	72.95	70.59	58.83	49.81	43.42	41.80
Switchgrass (Dacotah	75.84	68.61	53.85	50.79	46.34	49.26
Switchgrass (Forestburg)	76.28	73.10	54.84	49.80	47.44	49.26
Little bluestem (Badlands)	72.17	69.59	53.18	41.90	37.98	38.49
Little bluestem (Camper)	72.58	66.36	54.52	49.44	40.28	45.54
Indiangrass (Holt)	77.83	72.84	61.42	59.06	52.18	52.86
Indiangrass (Tomahawk)	79.76	72.63	59.69	51.47	44.45	47.50
Pierre, South Dakota						
Big bluestem (Bison)	64.42	53.98	50.17	47.57	35.63	41.17
Big bluestem (Sunnyview)	65.12	54.46	49.89	51.15	41.66	45.59

Sideoats grama (Butte)	60.24	59.14	50.55	51.16	42.13	46.43
Sideoats grama (Pierre)	61.73	59.65	49.26	47.80	42.11	43.01
Prairie sandreed (Goshen)	59.12	55.74	45.44	42.94	36.57	36.69
Prairie sandreed (ND-95)	62.27	56.16	46.27	44.61	38.46	38.44
Switchgrass (Dacotah)	59.82	42.52	38.67	32.99	31.65	30.87
Switchgrass (Forestburg)	67.79	46.54	38.61	34.39	31.11	33.45
Little bluestem (Camper)	58.38	49.94	43.78	46.22	35.28	44.31
Indiangrass (Holt)	67.70	58.21	52.30	49.23	40.98	47.00
Indiangrass (Tomahawk)	67.64	61.01	51.34	47.97	41.73	44.08

Summary

Herbage production and nutrient content differed between warm-season grasses and between cultivars for some species. Production differences were most likely due to soil characteristics and climate. Peak yields were generally obtained in early August for each year regardless of location. Grasses such as prairie sandreed and blue grama were able to maintain relatively high levels of crude protein throughout the growing season; however, prairie sandreed tested low in digestibility and high in fiber. Grasses that produced the most biomass (i.e. switchgrass) typically had lower levels of crude protein but variable levels of digestibility and fiber. Phenological development differences between cultivars of big bluestem indicate the effect of morphology on nutritional characteristics. Least matured plants were highest in nutritional quality. Great potential exists for many of these grasses as a forage source in mid summer when cool-season grasses are less productive.

A full report will be published at a later date showing results of all minerals and statistical analysis for production, crude protein, IVDMD, ADF, and NDF among all grass species and cultivars.

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