The Stage of Maturity and Its Effect upon the Chemical Composition of Four Native Range Species

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Highlight: *Prairie range forage plants can provide needed energy and protein for grazing ruminants, particularly in an era of grass fattened animals. Nutritive value and, therefore, animal performance, are directly related to stage of plant maturity at the time of cutting or grazing. The effect of maturity of four native species in this study was accompanied by a decline in in vitro dry matter digestibility and protein content, and by an increase in fibrous fractions and lignin. Laboratory analyses of prairie species showed seasonal chemical and digestibility changes similar to those of cultivated grasses. A significant date-by-class interaction suggests that cool-season species did not respond differently to maturity changes than did the warm-season species. The neutral sugars found in hemicellulose were xylose, arabinose, glucose, and galactose. Xylose was the predominant structural sugar in all species studied. It would appear that laboratory analysis could serve to estimate nutritive value of various prairie grasses.*

Chemical composition and in vitro dry matter digestibility of range plants vary greatly in relation to maturity and seasonal climatic conditions. Early research (Hopper and Nesbitt, 1930) found that protein decreased with advancing maturity in grasses. An advantage of warm-season grasses over cool-season grasses was faster regrowth following early-fall precipitation (Rogers and Box, 1967; Rauzi et al., 1969). Since prairie range species grow in areas of poor soil, limited rainfall and short growing seasons, it is an advantage to maintain desirable mixed range species to obtain maximum utilization of pastures.

Research on the nutritive value of prairie species has been limited and relied primarily upon proximate analyses. Difficulty in isolating plant hemicellulose without destruction has delayed plant carbohydrate research.

The study presented in this paper discusses the carbohydrate fractions of four range species. Kamstra (1973) discussed the nutrient and digestive potential of important range species at the Cottonwood Range Field Station in southwestern South Dakota. This paper presents information on important cool- and warm-season species in northwestern South Dakota at the Antelope Range Field Station. Annual rainfall at this station averages 33.0 cm, which is one of the lowest precipitation zones in the state. Soils are chestnut with fine sand incorporated in the surface horizon. Tentative classification of the soils are Aridie Argiborall fine-loamy, mixed. Information obtained should aid in estimation of the potential feeding value of mixed range species for grazing ruminants.

Materials and Methods

Triplicate samples of two warm-season species, blue grama (*Bouteloua gracilis*) and prairie sandreed (*Calamovilfa longifolia*), and two cool-season species, needle-andthread (*Stipa comata*) and threadleaf sedge (*Carex filifolia*), were collected

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Table 1. Phenological stage of maturity of each prairie grass species at each sampling date.

	Sampling dates				
Species	June 17	June 28	July 17	August 16	September 13
Needleandthread	Vegetative	Early flowering	Seed ripe	Shattered	Some regrowth
Threadleaf sedge	Early vegetative	Vegetative	Seed ripe	Shattered	Dormant
Blue grama	Early vegetative	Vegetative	Developing seed stalks	Some seedstalks	Several seedstalks
Prairie sandreed	Early vegetative	Vegetative	Developing seed	Seed ripe	Shattering

Table 2. Fibrous fractions (%) and protein composition (%) of prairie grass species.

						Acid detergent	
Species		Protein	Holocellulose	Hemicellulose	Cellulose	Fiber	Lignin
Blue grama	June 17	12.1	69.3	38.1	29.1	32.5	3.2
	June 28	10.7	73.2	39.0	30.9	36.5	3.5
	July 17	8.8	68.4	38.7	30.6	36.3	3.6
	Aug. 16	6.7	72.1	40.7	30.0	37.0	3.5
	Sept. 13	4.5	75.8	40.8	32.8	41.0	4.8
Prairie sandreed	June 17	11.1	65.4	34.4	36.0	37.7	3.1
	June 28	9.0	71.0	36.7	37.8	41.5	4.2
	July 17	6.2	73.2	42.9	39.5	43.2	3.8
	Aug. 16	4.8	74.0	43.5	40.4	44.6	4.3
	Sept. 13	3.0	73.8	43.5	38.5	43.9	4.4
Needleandthread	June 17	9.2	65.6	41.3	30.0	32.9	4.0
	June 28	7.5	69.2	43.0	32.8	36.3	4.9
	July 17	6.0	69.1	44.5	33.2	38.8	6.9
	Aug. 16	4.6	73.1	44.0	35.2	42.8	6.5
	Sept. 13	4.9	73.1	40.1	36.3	43.2	6.4
Threadleaf sedge	June 17	11.4	58.3	38.9	24.4	29.4	3.2
	June 28	9.6	55.9	39.8	24.4	29.3	3.2
	July 17	7.8	57.4	35.4	25.4	31.7	4.0
	Aug. 16	6.0	61.0	37.6	27.6	35.6	3.8
	Sept. 13	4.3	69.2	41.2	31.8	41.9	4.8

throughout the growing season. The growth stage at each cutting date for each of the species is given in Table 1. The samples were hand-clipped 5 cm above ground level in pastures in good range condition. These pastures were deferred from winter grazing the previous year. The samples were air dried, then further oven dried at 90°C for 24 hours before they were ground using a Wiley mill with a 40-mesh screen.

Holocellulose was prepared by the method of Whistler et al. (1948), using a .3-gram sample of forage. The hemicellulose separation from holocellulose and its subsequent acid hydrolysis to free sugars followed the procedure outlined by Myrhe and Smith (1960). Partition chromatography of the sugars followed the aniline phthlate procedure developed by Partridge (1948). Relative amounts of each sugar were measured on the chromatograph using an Ohotovolt Densitometer (Model 425). Cellulose was determined by the method of Crampton and Maynard (1938). Acid detergent fiber (ADF) and acid detergent lignin (ADL) analyses followed procedures described by Van Soest (1963). Crude protein was determined by Ass. Offic. Agr. Chem. (1965) procedures. Digestion was estimated with the in vitro dry matter (IVDMD) technique of Tilley and Terry (1963). Data were analyzed by least squares procedures. Differences between means were tested by Lonnett's procedure (Steele and Torrie, 1960).

Results

Fibrous Fractions and Lignification

Increased holocellulose levels were noted with advances in maturity (Table 2). Threadleaf sedge displayed the most pronounced overall increase from 58.3 to 69.3% holocellulose. However, blue grama contained the highest percentage of holocellulose when compared to other species in the collection period. Hemicellulose changed less than other fibrous fractions. All species were found to have different hemicellulose patterns, with highly significant species-by-date interaction for all fibrous fractions (Tables 3 and 5). This indicates that each species followed individual growth characteristics during the growing season.

ADF vaues were similar to cellulose, but at later collection dates the inclusion of more lignin increased the ADF fraction. ADF has been shown to be an excellent indicator of forage value (Van Soest, 1963). It is a pure lignocellulose and is a better indicator of nutritive value than is cellulose or crude fiber because the ADF fraction includes both cellulose and lignin. Needleandthread and prairie sandreed contained more ADF and cellulose than did blue grama and threadleaf sedge. Oh et al. (1966) found a high correlation between ADF and digestibility within a forage species. This study also found that range species low in fiber were more digestible.

Table 3. Analyses of variance for holocellulose and hemicellulose of grasses.

Source	d.f.	Holocellulose (Mean squares)	Hemicellulose (Mean squares)
Rep	2	4.20	2.55
Species	2	1082.80**	59.44**
RxS	4	5.24	4.04
Date	4	217.63**	19.88**
RxD	8	3.66	1.83
SxD	8	43.88**	31.32**
RxSxD	16	2.49	2.65

$^{**}P < .01$.

Table 4. Comparative (%) neutral sugar components for four prairie grass species on various cutting dates.

Grass species	Collection date	Components of hemicellulose hydrolzate			
		Xylose	Arabinose	Galactose	Glucose
Needleandthread	June 17	12.6	18.6	30.0	38.8
	June 28	11.8	18.9	31.1	38.1
	July 17	10.6	20.3	31.0	38.0
	Aug. 16	12.4	19.9	30.7	37.0
	Sept. 13	13.6	19.0	29.4	38.0
Threadleaf sedge	June 17	19.8	13.7	30.0	36.6
	June 28	20.0	15.4	30.8	33.8
	July 17	21.1	11.0	31.8	36.0
	Aug. 16	19.0	13.1	30.6	37.3
	Sept. 13	17.7	11.6	33.3	37.4
Blue grama	June 17	12.8	24.8	27.7	34.8
	June 28	17.6	20.7	28.6	33.0
	July 17	17.1	14.6	29.5	38.9
	Aug. 16	17.2	21.6	29.6	31.6
	Sept. 13	14.2	13.8	31.6	40.4
Prairie sandreed	June 17	13.8	24.2	26.8	35.2
	June 28	11.9	25.2	29.8	33.1
	July 17	10.9	23.2	31.2	34.7
	Aug. 16	10.9	22.4	30.8	35.9
	Sept. 13	11.3	20.9	29.2	38.6

ADL increased in all species from June through to September. Needleandthread was the most lignified, probably because it is genetically a more lignified species. It matured in mid-June and after the awned seed head developed remained semi-dormant.

Crude Protein and In Vitro Dry Matter Digestibility

All species significantly declined ($P<.01$) in crude protein from June through September, reaching levels of 5% or less by September 13. Blue grama had the highest crude protein mean of 8.6% when compared to the other species. The sharp decline in crude protein content is a typical characteristic occurrence of maturation. There was some late summer regrowth of needleandthread but it did little to increase protein content.

Prediction of animal performance was made by using IVDMD technique with a 48-hour digestion period. A continual decline in digestibility occurred in all species until the end of the collection period (Fig. 1). The increased ADF values were associated with low dry matter digestibility. Blue grama and threadleaf sedge were more digestible than were the other two species. Little new growth or improvement in dry matter digestibility occurred in late summer because of low rainfall in August and September.

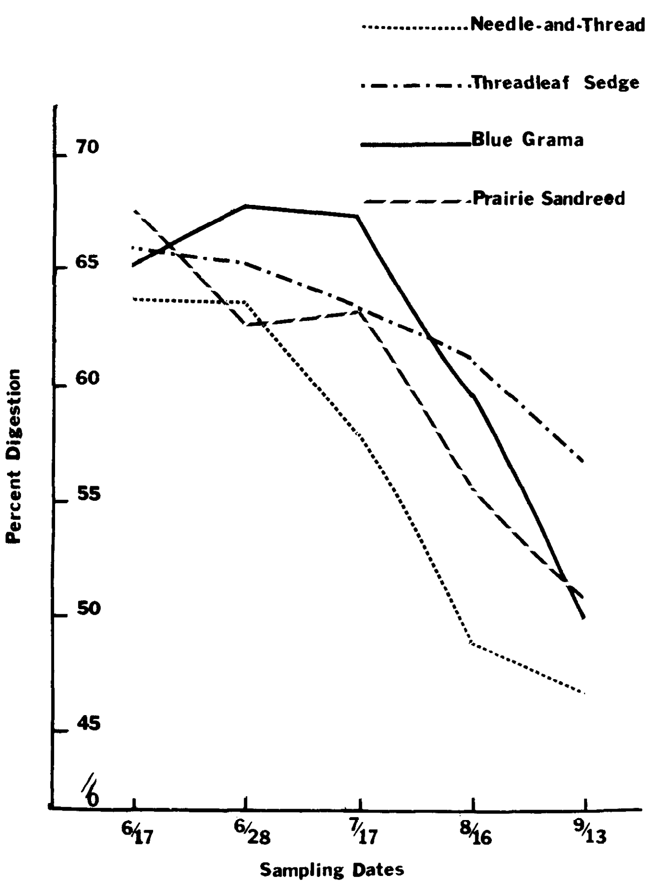

Fig. 1. *Relation of grass species and sample date to in vitro dry matter digestibility.*

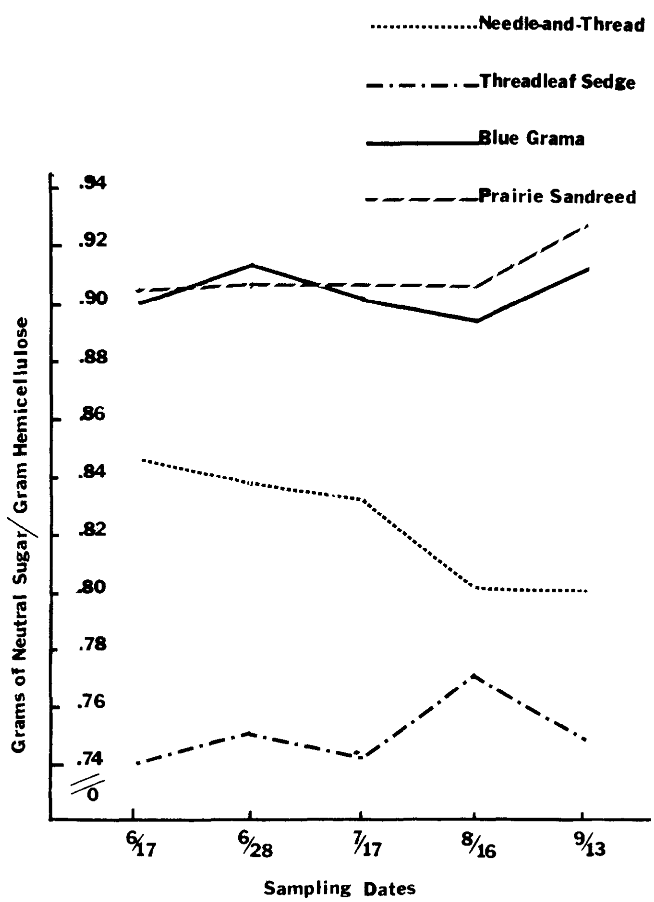

Fig. 2. *Relation of grass species and sample date to neutral sugar content of hemicellulose.*

Table 5. Analyses of variance for acid detergent fiber, acid detergent lignin, cellulose, crude protein, and in vitro digestibility of grasses.

Source	d.f.	Acid detergent fiber (Mean squares)	Acid detergent lignin (Mean squares)	Cellulose (Mean squares)	Crude protein (Mean squares)	In vitro digestibility (Mean squares)
Rep.	2	.54	0.1	1.72	2.31	3.72
Species	3	381.07**	13.06**	731.81**	28.01**	229.30**
RxS	6	1.30	0.16	0.71	1.63	4.08
Date	4	335.65**	10.49**	85.94**	178.86**	757.55**
RxD	8	0.71	0.03	0.85	0.67	6.58
SxD	12	36.31**	1.67**	12.60**	3.15**	37.92**
RxSxD	24	0.62	0.20	0.53	0.29	6.59

**$P < .01$.

Neutral Sugars

The neutral sugars in all species were xylose, arabinose, galactose, and glucose (Table 4). Xylose was the primary structural sugar present. Arabinose and galactose levels appeared to be inversely related to xylose content. However, the galactose content throughout the collection period remained essentially unchanged in each species.

All species varied only slightly in neutral sugar content during the entire collection (Fig. 2). Although no attempt was made to isolate individual uronic acids, they did appear more frequently in the cool-season species. This corresponded to reduced recovery of neutral sugars in the cool-season species after acid hydrolysis.

Discussion

Chemical analyses showed an inverse relationship between digestibility and lignification. Highly lignified species had lower in vitro dry matter digestibility values. In the natural biome situation, the grazing animal selects the more palatable species such as blue grama if adequate range conditions are maintained. As suggested by a previous study in southwestern South Dakota (Kamstra, 1973), prairie species are individualistic. This was shown by significant species-by-date interaction for all parameters tested (Tables 3 and 5). At the same time, certain basic structural similarities exist among all species, such as the neutral sugars in the hemicellulose fraction. During early seasonal growth and the stage of inflorescence, the concentration of neutral sugar components fluctuated according to the need of the plant. The sugars linked together as polysaccharide units may serve as structural functions for metabolic plant needs or be available as reserve carbohydrates. Additional studies to demonstrate the importance of the structural sugars may eventually provide predictable estimates of the potential nutritive value of range species. In general, a composite of analysis for nutritive components should be the most useful in determining the potential utilization of range grasses for energy and growth by ruminants. Specific nutrients which contribute to palatability and animal intake are beyond the scope of this study.

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