Seasonal Changes in Quality of Some Important Range Grasses

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Highlight: *Holocellulose, hemicellulose, and in vitro fiber digestibility were significantly different between cool and warm season grasses. A significant class x date interaction for protein and lignin suggested that each forage could be expected to follow a different growth pattern during the growing season. Sugars (xylose, arabinose, galactose, and glucose) were found as hemicellulose components in all grasses at all cutting dates. Xylose was the most prominent structural sugar in all grasses studied. In vitro dry matter digestibility could be most easily adapted to routine studies of forages, but cannot be expected to define the contributions of individual parameters making up plant dry matter.*

The nutritive differences among grasses at various sampling dates suggest the value of a mixture of desirable grasses. This would assure grazing animals continued nutrition throughout the grazing period.

A critical examination of the nutritive potential of native grasses should assist in decisions relative to any planned changes in range ecosystems. Such alterations might stem from continued economic pressures to elevate the productivity of rangeland by fertilization, interseeding with introduced species, or replacement by various crops.

Studies of the energy-containing components of plants has long been neglected because investigation of these complex components is difficult. The main difficulty was the failure to isolate discrete carbohydrate fractions free from lignin encrustation. Isolation of relatively lignin-free holocellulose, which contains the major portion of plant carbohydrates, has aided plant carbohydrate research (Schmidt et al., 1931; Wise et al., 1946; Ely and Moore, 1955a; Kamstra and Thurston, 1965). This study is a consideration of in vitro dry matter digestibility, crude protein, and holocellulose carbohydrate components of selected prairie grasses during a growing season. Species selected are important in the mixed prairie of western South Dakota.

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Methods

Two replicates of western wheatgrass (*Agropyron smithii*) and green needlegrass (*Stipa viridula*), cool season species, and blue grama (*Bouteloua gracilis*) and little bluestem (*Andropogon scoparius*), warm season species, were collected June 11, June 22, July 11, and August 11. An additional collection of warm season grasses was made September 28. The phenology of the various grasses at each cutting date is indicated in Table 1. Samples were hand-clipped approximately 5 cm above ground level from pastures in good range condition deferred for winter grazing. All samples were air-dried at 65° C, ground to 40 mesh, and stored at −20° C.

The sampling areas were located at the Cottonwood Range Field Station 120 kilometers east of Rapid City. This area has average annual rainfall of 38.35 cm. The total annual rainfall for 1967 was 12.7 cm above normal with the greatest precipitation occurring in June followed by near drought conditions in July and August. Soils are formed mainly from Pierre shale. Although the sampling area included clayey, shallow, and overflow soil groups, sampling sites were located in the clayey soil groups. The soil was weakly developed in the sampling sites for blue grama and little bluestem but would be classed as thin clayey.

Carbohydrates were studied by initial preparation of the holocellulose fraction (Whistler et al., 1948) with further separation and identification of the neutral sugar components of hemicellulose (Myrhe and Smith, 1960). Cellulose was prepared as an isolate from holocellulose from a separate plant sample (Crampton and Maynard, 1938), as well as by the detergent method of Van Soest (1963) to obtain a fiber fraction. Crude protein was determined on all samples by the A.O.A.C. method (1960). In vitro dry matter digestions (IVDMD) by the Tilley and Terry (1963) procedure was used to estimate animal utilization.

Table 1. Phenology of prairie grasses at each sampling date.

Grass species	Stage of maturity				
	June 11	June 22	July 11	August 11	September 28
Western wheatgrass	Vegetative	Early flowering	Full flowering	Shattered	
Green needlegrass	Late vegetative	Full flowering	Seed ripe	Shattered	
Blue grama	Early vegetative	Vegetative	Vegetative	Some seedstalks	Several seedstalks
Little bluestem	Early vegetative	Vegetative	Vegetative	Late boot	Seed ripe

Results and Discussion

Fibrous Fractions and Lignification

Fibrous fractions of plants usually increase with maturity (Kamstra et al., 1968). This trend was apparent with all grasses except blue grama, which made little growth until late season rains in August and September. Detergent cellulose analysis showed that little bluestem was the most fibrous (51%) and western wheatgrass the least (38%) by the end of the growing season (Fig. 1). Similar patterns were indicated by cellulose isolated by the Crampton and Maynard method (1938) and by cellulose isolated from the holocellulose fraction. Hemicellulose, on the other hand, increased during June and decreased or remained stable during July and August. Western wheatgrass and green needlegrass had the highest hemicellulose values throughout the season and had very similar amounts at each collection date. The high hemicellulose content of these grasses should contribute to better animal utilization, since hemicellulose was shown to be of much higher digestibility than the cellulose component of the holocellulose fraction (Kamstra and Thurston, 1965).

Lignification in all species increased continually throughout the growing season. As the lignin content of a forage increases, digestibility invariably decreases, although the most highly lignified forage is not always the least digestible (Kamstra et al., 1958) since so many factors contribute to digestibility. All factors considered, however, lignin is one of the more important single plant components that determine the digestibility of plant fibers. Green needlegrass and little bluestem were the most highly lignified at the end of the growing season, while blue grama and western wheatgrass had the lowest lignin content. Cool and warm season grasses lignify in a manner somewhat unique to their group, that is, lignification patterns are similar for species within each group. A significant ($P<0.05$) class x date interaction suggests that the grasses did not lignify similarly with date.

Crude Protein and In Vitro Digestibility

Crude protein content of all species decreased significantly with maturity (Fig. 2). A significant ($P<0.05$) class x date interaction was also shown for crude protein. The wide variation in protein content of blue grama at different collection dates would contribute to this interaction.

The 48-hour in vitro digestibility of dry matter and cellulose were used to predict animal utilization. Significant differences ($P<0.05$ and $P<0.01$, respectively) in dry matter and cellulose digestibility existed between cool and warm season grasses. The digestibility of the cellulose portion of the cool season grasses remained at a higher level than that of warm season grasses throughout sample collection period. Digestibility of warm season grasses increased following a 4.4 cm rainfall about 2 weeks prior to the September 28 collection (Fig. 3).

Neutral Sugar Components of Hemicellulose

The neutral sugar components of hemicellulose were xylose, arabinose, galactose, and glucose in order of decreasing concentration. This was observed for all grasses collected at all dates (Table 2). Although not included in this study, it was interesting to note that the rhizomes of western wheatgrass had much higher levels xylose with lesser amounts of galactose

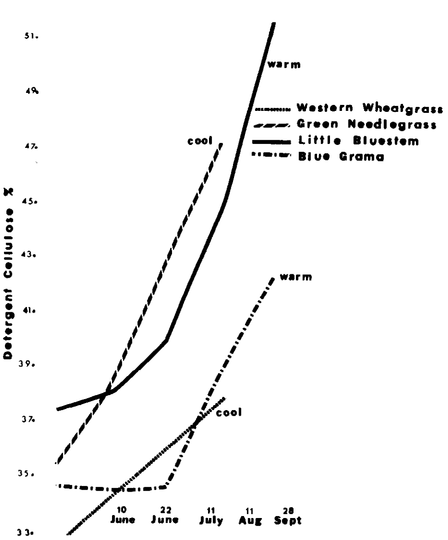

Fig. 1. *Relation of grass species and sample date to cellulose content.*

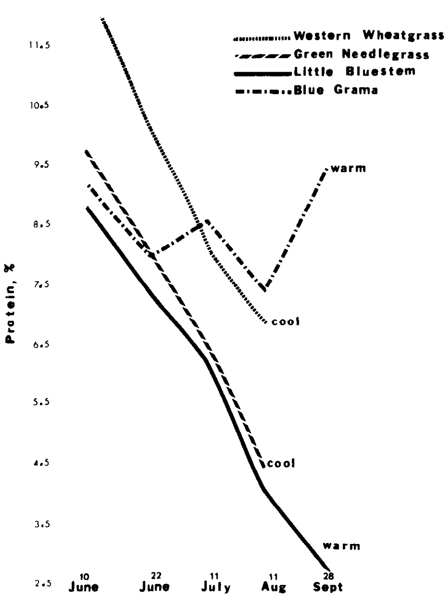

Fig. 2. *Relation of grass species and sample date to protein content.*

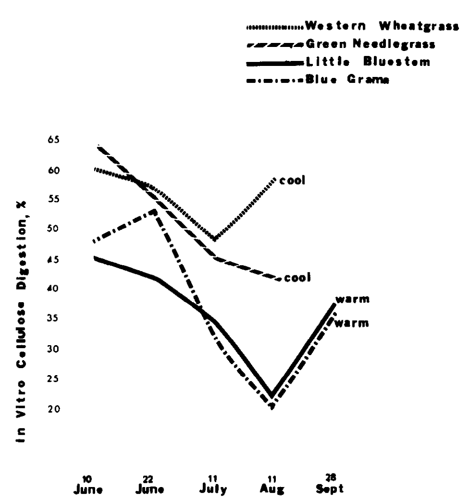

Fig. 3. *Relation of grass species and sample date to in vitro cellulose digestibility.*

Table 2. Comparative neutral sugar components of prairie grasses at various cutting dates.

Grass species	Collection date	Percent of hemicellulose hydrolzate			
		Xylose	Arabinose	Galactose	Glucose
Western wheatgrass	June 10	31.8	30.4	22.0	15.8
	June 22	32.8	31.0	20.9	15.2
	July 11	39.3	33.1	17.0	10.7
	Aug. 11	41.4	32.4	14.7	11.5
Green needlegrass	June 10	33.5	32.1	21.7	12.7
	June 22	33.9	31.9	21.9	12.4
	July 11	32.1	30.6	21.4	15.9
	Aug. 11	37.0	29.6	20.3	13.1
Little bluestem	June 10	32.5	31.3	25.8	10.4
	June 22	30.1	28.7	27.8	13.4
	July 11	33.2	28.9	24.7	13.2
	Aug. 11	35.6	34.5	22.6	7.4
	Sept. 28	38.7	31.9	19.1	10.2
Blue grama	June 10	29.1	28.4	24.5	18.0
	June 22	32.0	29.2	24.1	14.8
	July 11	34.9	27.4	21.1	16.6
	Aug. 11	30.4	29.2	23.1	17.3
	Sept. 28	30.8	28.5	22.9	17.7

and glucose. The high comparative levels of xylose and arabinose suggest that these sugars are the major structural units of hemicellulose (Myhre and Smith, 1960, and Kamstra et al., 1968). The same hemicellulose components were found in subtropical grasses (Kamstra et al., 1966) and with a different series of cool and warm season grasses collected at the Antelope Range Field Station (Cogswell, 1971). The relationship of the relative concentration of any one neutral sugar component of hemicellulose to forage quality has not been established. As noted previously, the total amount of hemicellulose, however, appears to enhance digestibility (Kamstra et al., 1965).

It would be difficult to envision a selection of cultivated grasses which would provide the flexibility to withstand extreme weather variations and grazing pressures offered by mixed prairie grasses. As this study indicates, each grass has its own seasonal growth characteristics that can vary its nutritional value as maturation proceeds. Direct comparison of quality components between cultivated and range grasses at equivalent maturity stages cannot be made accurately since the usual definitions do not consistently apply to range grasses. Many range grasses, for example, produce seed only during favorable years. This is especially true of grasses such as western wheatgrass, which does not depend on seed for reproduction. It would appear that introduced grasses should be selected on noncomparative basis to serve a specific need such as increase forage production or to provide additional nutritional benefits. The rapid decrease in protein and increase in lignification of cool and warm season grasses as the growing season progresses are accepted negative quality indices to animal utilization of forage. As more intense management becomes possible for large prairie acreages, this problem should receive consideration. Introduction of legume forages could alleviate protein shortages, which are chronic to late season grazing. Fertilization practices could be used as a tool to promote growth of desired range species for grazing during selected periods of the growing season. Grazing or clipping of forages have been shown to increase digestibility (Kamstra et al., 1966, and Kamstra et al., 1968) and with proper management could provide better utilization. Above all, however, a thorough understanding of nutritional qualities of the various range grass species should precede altering competition among range grasses as it now exists.

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