Seasonal Variations of the In Vitro Dry-Matter Digestibility of Three Sandhill Grasses[1]

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Highlight

Investigation of the seasonal variation of in vitro dry-matter digestibility of forage of three range grasses was completed. The in vitro dry-matter digestibility declined in all grasses with advance in maturity. Crude protein content declined with advance in maturity and was more highly correlated with dry-matter digestibility than was lignin. Predicted digestibility based on Van Soest's summative equations seemed unrealistically high for forage collections made in late season. No consistent or significant variations in cell-wall constituents or acid-detergent fiber were measured.

The chemical composition of range forage plants has been studied by numerous investigators. These studies have resulted in many publications relating to the proportionate amount of nitrogen, crude fiber, nitrogen-free extract, carotene and of one or more of the mineral components of the forage (Clark and Tisdale, 1945; Cook, Stoddart and Harris, 1956; McCall, 1932; Watkins and Repp, 1964; Beath and Hamilton, 1952).

The real value of a range plant in providing nutriments for livestock lies in two factors—(1) the amount of the forage that an animal will consume on a free-choice basis and (2) the amount of digestible dry matter the animal receives per unit of consumption. Variations in palatability have been documented for various forage plants (U.S. Forest Service, 1953; Forbes and Garrigus, 1950; Davis, 1925). Variations in livestock preference are largely responsible for the classification of range plants into groups according to grazing response as increasers or decreasers. Newell (1968) showed inter- and intra-specific variations in crude protein content and crude fat content of sand bluestem, big bluestem, and switchgrass. He theorized that the variations in crude fat may be closely related to preference patterns of grazing livestock. Hathaway et al. (1945) characterized carotene content of native Nebraska grasses. They reported that sand bluestem of sandhill origin had a higher carotene content than other of the warm-season grasses of eastern Nebraska. Cook and Harris (1968) present extensive data relative to interspecific variations in range forage of the Intermountain Region and the changes that occur with advance in season. They reported also that the nutritional value of a diet reflected animal preference for certain classes of livestock. Hoehne (1966) demonstrated patterns in livestock preference for cattle grazing native ranges in western Nebraska.

Sand bluestem (*Andropogon hallii* Hack.), little bluestem (*Andropogon scoparius* Mich X.), and prairie sandreed (*Calamovilfa longifolia* (Hook.) Scribn.) are three grasses exhibiting variation in apparent livestock preference. These grasses are the major forage resource of certain sandhill ranges and are of concern in programs of revegetating abandoned farmland and depleted rangeland. The study was designed to determine seasonal variations in the nutritive content of these grasses and to determine regression equations for predicting nutritive value of forages.

Procedures

Little bluestem, sand bluestem, and prairie sandreed were established in four replicated plots at the Ft. Robinson Beef Cattle Research Station, Crawford, Nebraska. The stands were obtained by transplanting clonal material from natural grasslands in the vicinity.

Vegetation was collected at various intervals from initiation of growth in the spring of 1963 until one month after killing frost in the fall. New plants were selected for each collection. The material was dried at 63 C in a forced-air oven for 48 hours. The dried material was ground and stored in Mason jars. This material was subjected to laboratory analysis which included determinations for (1) nitrogen content, (2) cell-wall constituents, (3) acid-detergent fiber, (4) acid-detergent lignin, and (5) in vitro dry-matter digestion.

Acid-detergent fiber, cell-wall constituents, and lignin were determined through the use of laboratory techniques outlined by Van Soest (1963) and Van Soest and Wine (1967). Predicted digestibility was calculated from the summative equations of Van Soest et al. (1966). In vitro dry-matter digestibility was obtained through a procedure outlined by Tilley and Terry (1963). Inoculum was obtained from a rumen-fistulated steer on a grass-hay diet. Nitrogen determinations were made in duplicate by the Kjeldahl procedure (Ass. Official Agr. Chem., 1960).

Results and Discussion

Crude Protein Content

Advance in season greatly influenced the crude protein content of all three forages (Fig. 1 and Table 1). The decline in protein content among grasses with advanced maturity was highly significant ($P < .01$). The crude protein content of sand bluestem was higher than that of the other grasses. This superiority of protein content over the other two grasses was maintained at each collection throughout the growing season although the magnitude of difference decreased with maturity. The protein content of little bluestem was the lowest of the three grasses from early July until

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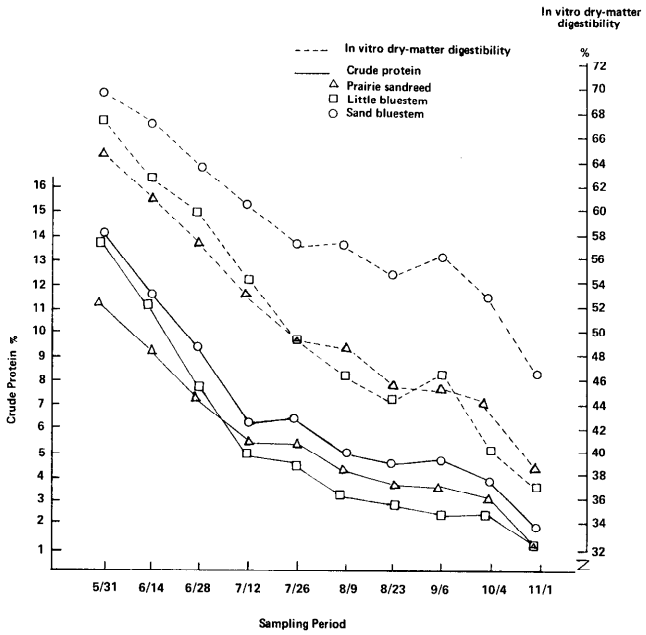

FIG. 1. Variation in the in vitro dry-matter digestibility and crude protein content of forage from 3 range grasses sampled over an extended period.

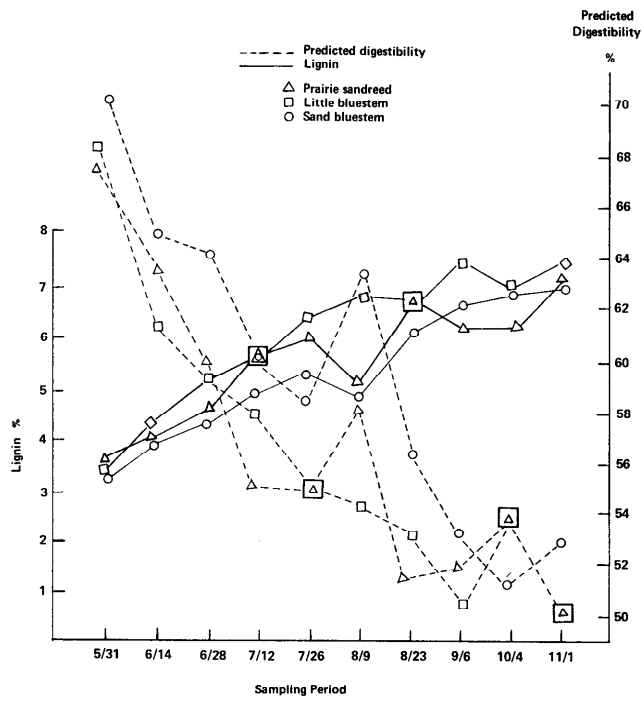

FIG. 2. Variation in predicted digestibility and lignin content of forage from 3 range grasses over an extended period of sampling.

frost when levels of crude protein became similar for all grasses.

Of significance is the rather high correlation (.84) between protein content and in vitro dry-matter digestibility as determined by the artificial rumen (Table 2). This was similar to a correlation coefficient given for the relationship between protein and apparent organic matter digestibility by Forbes and Garrigus (1950). If a consistent relationship between these factors can be established it will be possible to predict the digestibility of range grasses through their crude protein content.

Lignin, Cell-Wall Constituents, and Acid-Detergent Fiber

Lignin content increased significantly with advance in season (Table 1). There were no differences among grasses in this trend to higher levels of lignin in the mature forage (Fig. 2). Hoehne (1966) measured significant negative correlation between lignin content and voluntary intake of range forage. Forbes and Garrigus (1950) reported lignin content of forage was the best measure of its organic matter digestibility. Although the negative relationship was established (Table 2) lignin was not significantly correlated with either in vitro dry-matter digestibility or predicted digestibility. Lignin appears to be of little use as a predictive index for digestibility of range grasses (Table 2).

The percentage of cell-wall constituents seemed to be inconsistently variable with advance in season (Fig. 3). There were no statistically significant patterns to the variations within a particular grass over the sampling period, although differences

Table 1. Mean squares from the analysis of variance for various components of forage of three grasses harvested at various dates in the growing season.

Component	Among dates	Among grasses	Error
Crude protein	81.19 **	13.59 **	0.555
Dry-matter digestibility	504.6 **	539.6 **	39.97
Lignin	8.822**	0.646	1.006
Cell-wall constituents	105.7	349.28 *	89.14
Acid-detergent fiber	65.32	41.26	30.88
Predicted digestibility	290.2 *	155.0	42.82

* Significance at the .05 level.
** Significance at the .01 level.

Table 2. Correlation coefficients and regression equations for selected constituents of range forage.

Constituents	Correlation coefficients	Regression equation	Std. error of reg. coef.
X_1 Y_1	.84	$\hat{Y}_1 = 37.6 + 2.59\ X$	.217
X_1 Y_2	.70	$\hat{Y}_2 = 46.4 + 1.78\ X$	.239
X_2 Y_1	−.31	$\hat{Y}_1 = 66.1 - 2.43\ X$	.952
X_2 Y_2	−.12	$\hat{Y}_2 = 61.1 - .789\ X$	.824

X_1 = crude protein content of forage
X_2 = lignin content of forage
Y_1 = in vitro dry-matter digestibility
Y_2 = predicted dry-matter digestibility

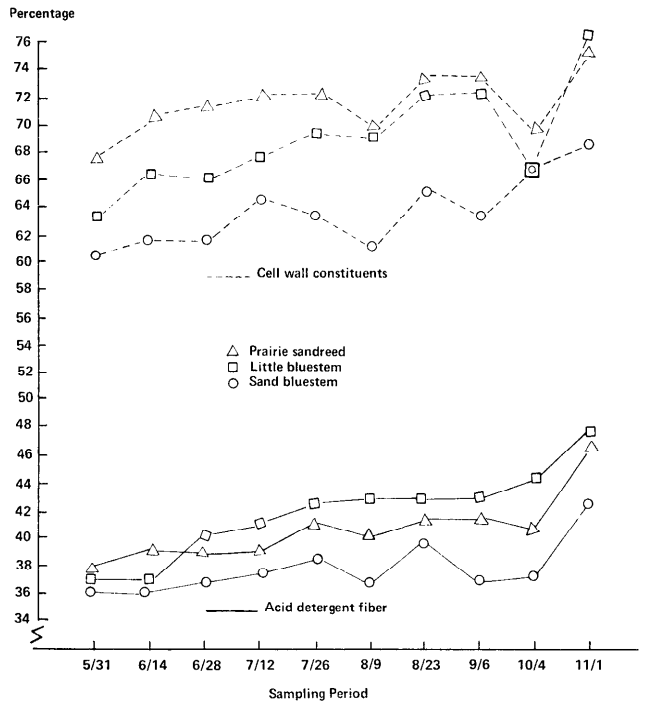

FIG. 3. Trends in the cell-wall constituents and acid-detergent fiber content of forage from 3 range grasses over an extended period of sampling.

among the three grasses were significant ($P < .05$, Table 1). Van Soest (1966) showed a significant relationship between cell-wall constituents and voluntary intake. The consistently lower content of cell-wall constituents demonstrated for sand bluestem (Fig. 3) could, in part, be responsible for the preference exhibited by livestock for this grass.

No significant trends in acid-detergent fiber were measured among the grasses or among sampling dates for a particular grass. Since this fraction represents the lignin plus cellulose portion of the cell-wall constituents it is less closely related to estimates of digestibility than lignin alone.

In Vitro and Predicted Dry-Matter Digestibilities

Estimates of dry-matter digestibility as measured by the artificial rumen or as predicted by Van Soest's (1966) summative equation showed highly significant differences among dates and species (Table 1). Sand bluestem had the highest dry-matter digestibility of any grass with both systems of estimation. Prairie sandreed was intermediate in this respect with little bluestem apparently the least digestible of the three grasses. These trends were consistent for each collection date.

The predicted estimates of digestibility for these grasses did not decline as much in the late sampling dates as did the in vitro determinations of dry-matter digestibility (Figs. 1 and 2). Van Soest (1968) verified the role of silica in digestibility of grasses and indicated that his summative equation had to be corrected to account for this. Unfortunately silica determinations were not made on the forage of these grasses, so such a correction was not possible.

Conclusion

It can be concluded from this study that concentration of crude protein in sand bluestem, little bluestem and prairie sandreed declined with increasing maturity of the forage. The crude protein content of the three grasses exhibited a positive and highly significant correlation with their in vitro dry-matter digestibility.

In vitro dry-matter digestion of the forage of these grasses indicated that sand bluestem was more digestible at all collection dates than little bluestem or prairie sandreed. All three grasses declined in dry-matter digestibility with advance in maturity.

Predicted digestibility using Van Soest's summative equation was less accurate at late stages of maturity. It was theorized this may have been the result of increased silica content. Crude protein was more closely correlated with digestibility than lignin. Although trends existed, no significant of consistent changes in cell-wall constituents or acid-detergent fiber were measured over the sampling period.

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