Journal of
RANGE MANAGEMENT
Volume 19, Number 2
March, 1966

Effect of Stage of Maturity, Method of Storage, and Storage Time on Nutritive Value of Sandhills Upland Hay[1]

C. L. STREETER, D. F. BURZLAFF, D. C. CLANTON, AND L. R. RITTENHOUSE
Graduate Student, Associate Professor of Agronomy, Associate Professor of Animal Science and Graduate Student; University of Nebraska, respectively.

Highlight

Forage yield was influenced more by differences in year and date of cutting than was nutritive value as measured by metabolizable energy and nitrogen retention. Chemical analysis showed relatively little difference in nutritive value between windrowed, bunched and baled hay, whereas standing forage had lower nutritive value than any of the harvested forages.

Common haying practices on upland meadows in the Nebraska Sandhills consist of mowing and either round baling, windrowing with a dump rake or bunching the forage with a dropper attached to the cutter bar. Regardless of the method of storage, the hay is left at the site and cattle are turned to the hay during the winter and/or spring. Most studies relative to the effect of storage on the nutritive value of hay have been limited to areas of the United States where the forage consists of tame species of grasses and legumes, e.g. Archibald et al. (1951). It it doubtful if results from such investigations are applicable to native range forage. Moxon et al. (1951) showed a decrease in crude protein content from about 8% to less than 3% in standing native grasses from July 13 to December 7. The crude protein content of windrowed hay remained constant during this storage period. Other workers have shown that early cut native hay contained more protein and had a higher feed value than late cut hay (Baker et al. 1951, Briggs et al. 1948, Embry, et al. 1956, and Moxon et al. 1951).

The purpose of this investigation was to study the effect that date of cutting, method of storage and storage time had upon nutritive value of Sandhills upland hay.

Procedure

The experimental plots were located on a sands range site at the Reed Hamilton Ranch 9 miles north of Thedford, Nebraska. The following methods of storage were imposed upon the early (July 13) and late (August 27) cutting dates: (1) round baling with a rotobaler, (2) windrowing with a dump rake, (3) bunching with a basket attached to the cutter bar of a tractor-mounted mower, and (4) standing forage. The four methods of storage were replicated three times within each of the two cutting-date plots and were randomized within each replication. The forage was sampled immediately after each cutting and monthly thereafter until the end of the storage period in late January.

Yield data were collected in 1962 and 1963 previous to haying the plots by clipping areas 3.3 by 100 ft with a hand mower which left a 1 to 2 inch stubble. The botanical composition and ground cover (Table 1) were obtained with a point-quadrat frame as described by Burzlaff (1962).

Two criteria were used to measure the nutritive value of the forages: (1) determination of the digestible and metabolizable nutrients of the early and late cut round baled hay and (2) determination of the change in chemical composition as influenced by cutting date, method of storage and storage time.

Eight steer calves randomly assigned to two groups of four were used in the metabolism trials. Different calves were used in each year of the study. A 12-day preliminary feeding period was followed by a 7-day collection period. One group was fed early-cut, round-baled hay and the other late-cut, round-baled hay. The steers were placed in metabolism crates and fed 8 lb of

Table 1. Botanical composition and ground cover percentages of early cut plots—1963.

Ground Cover	
Vegetation Cover	67.2
Litter Cover	31.0
Bare Ground	1.8
Botanical Composition	
Grass & grass-like[1]	
Calamovilfa longifolia	25.6
Stipa comata	25.4
Bouteloua gracilis	21.1
Andropogon hallii	5.1
Panicum scribnerianum	3.8
Sporobolus cryptandrus	3.0
Carex heliophila & Cyperus schweinitzii	3.6
Major forbs & shrubs	
Aster ericoides	2.7
Rosa arkansana	1.7
Amorpha canescens	1.2
Solidago missouriensis	0.7
Other species	6.3

[1] Major grass and grass-like species.

[1] *Contribution of the Nebraska Agricultural Experiment Station. Published with the approval of the Director as Paper No. 1777 Journal Series, Nebraska Agricultural Experiment Station.*

chopped hay per day in addition to water and iodized salt which were available ad lib. Dietary, fecal and urine samples were collected during the course of the trial. Daily samples were combined to form one sample for each animal. The amounts of digestible and metabolizable energy, digestible nitrogen and nitrogen retention were calculated from concentration of nitrogen and gross energy in the hay, feces and urine.

The chemical analyses were made on the samples of hay from the two cutting dates and four storage methods which had been taken at monthly intervals during the storage period. These analyses included determinations of lignin (Crampton and Maynard, 1938) and carotene (A.O.A.C., 1960) content of samples collected in 1962 and nitrogen, phosphorus and calcium content of samples collected in 1962 and 1963 (A.O.A.C., 1960).

The least-squares analysis of variance was used to statistically analyze the data because of the unequal numbers between the early and late cutting dates. Least-squares adjusted means were calculated for the cutting date-storage time and method of storage-storage time interactions. The figures presented here were derived from graphic "best-fit" curves through these two-way interaction means.

Results and Discussion

Forage Production. — The significantly ($P < .01$) greater yield (Table 2) in 1962 was probably due to 9.0 inches more precipitation falling prior to the time of early cutting in 1962 as compared to 1963. Apparently, the plants continued to grow from mid-July until late-August, producing the greater yield ($P < .01$) at the later cutting date.

In 1962, 406 lb/acre more of dry matter were harvested from the late than from the early cutting. In 1963 the difference was only 102 lb in favor of the late cutting. This significant ($P < .10$) interaction between years and cutting dates could be a result of 9.1 inches of precipitation that fell between the early and late cutting dates in 1962 as compared to 4.8 inches in 1963.

Metabolism Study.—Digestible and metabolizable energy and digestible nitrogen and nitrogen retention values for the round baled hay cut in 1962 and 1963 are shown in Table 2. The animals fed the 1962 hay retained more nitrogen ($P < .10$) than those fed the 1963 hay but there was no difference in the metabolizable energy content of the hay. The early cut hay contained more ($P < .10$) metabolizable energy than the late cut hay, but there was no difference in nitrogen retention. The cutting date by year interaction was not significant for either metabolizable energy or nitrogen retention.

It would appear that forage yield was influenced more by differences in precipitation than was nutritive value. Some of the yearly difference in nitrogen retention could have been due to the use of different animals each year for the metabolism study.

Chemical Analysis. — The chemical composition of hay cut at the two dates in 1962 and 1963 cannot be directly compared to the metabolism study, as the former involved all methods of storage and all storage times while the latter only involved the round baled hay which had been stored in the field for a short period of time.

Year. Higher ($P < .01$) nitrogen, phosphorus and calcium levels but lower forage yields were recorded in 1963 than in 1962. The inverse relationship between nutrient concentration and forage yield was attributed to the greater precipitation which fell in 1962 as compared to 1963.

Cutting Date. All hay cut in mid-July had a significantly ($P < .01$) higher nitrogen and phosphorus content than the hay cut in the latter part of August, with no difference in the calcium content (Table 3). These results would indicate that the plants translocated some nitrogen and phophorus but not calcium from the shoots to other parts of the plant during the period from July to August. At no time did the calcium level fall below the level recommended by the National Research Council (1958) as necessary for wintering 800 lb cattle to gain 0.7 lb/day. Similar results were found by Moxon et al. (1951) in South Dakota and Baker et al. (1951) in Nebraska.

Table 2. Average production and nutritive value of round-baled hay as determined by digestion and metabolism trials.

	Cutting date			
	1962		1963	
Item	July 13	Aug. 27	July 13	Aug. 27
Forage production, lb/acre	1176	1582	959	1061
Apparent metabolizable energy, megcal.kg.[1]	1.54	1.12	1.32	1.20
Apparent digestible energy, megcal./kg.	1.81	1.38	1.71	1.72
Lignin, % of D. M.	16.2	17.8	—	—
Apparent nitrogen retention, g./kg.	−0.44	−1.44	−2.04	−1.58
Apparent digestible nitrogen, g.kg.	3.67	1.61	5.12	6.02
Nitrogen, % of D. M.	1.08	0.79	1.30	1.32
Dry matter, %	92.0	92.3	89.6	89.7

[1]Digestion and metabolism values are based on the amount of dry matter (D.M.) offered to the animal.

Table 3. Least squares adjusted means for main effects.

Item	Nitrogen	Phosphorus	Calcium	Lignin	Carotene
	— — — —	— — — Percent	— — —	— — —	mg. lb.
Years					
1962	0.95	0.10	0.34	17.3	6.7
1963	1.13	0.12	0.68	—	—
Cutting Dates					
Early	1.14	0.13	0.52	17.0	5.2
Late	0.94	0.09	0.50	17.3	8.2
Methods					
Standing forage	0.77	0.09	0.46	17.2	7.4
Windrowed hay	1.12	0.11	0.51	17.1	5.2
Bunched hay	1.16	0.12	0.53	17.5	4.9
Baled hay	1.10	0.12	0.54	16.8	9.2

Little difference in lignin content was found between the late-cut and early-cut hay in 1962 when averaged over all methods of storage (Table 3). The higher lignin content of the late-cut round-baled hay was, however, associated with the lower metabolizable energy content of that hay (Table 2). This relationship has been proposed by other workers. For example, Armstrong et al. (1964), using calorimetry studies, found metabolizable energy to be related to the percentage of lignin in artificially dried grass. Patton and Gieseker (1942) in Montana and Stanley and Hodgson (1938) in Arizona found that lignin content of range forages increased as the growing season advanced.

The overall average carotene content of the late cut hay was higher than that of the early cut hay (Table 3). The greater percentages of carotene in early cut hay found by Briggs et al. (1948) in Oklahoma and Whitman et al. (1951) in North Dakota are not in disagreement with the results presented here, as their comparisons involved the carotene content immediately after cutting and not an average value throughout a long period of storage.

Method of Storage. Evaluating the different methods of storage was complicated by the presence of standing forage as a method of storage. The change in chemical composition in the standing forage was considerably different from that of the hay during storage. Many of the significant interactions and main effects of methods of storage are a result of the inclusion of standing forage in the study. There was little difference in the chemical composition of the various hays. The advantage of the greater nutritive value of the hay over the standing forage might be of no economic saving when the cost of haying is considered.

There appeared to be no significant difference in the nitrogen and phosphorus content (Table 3) of the three hays, whereas the standing forage was considerably lower in both constituents. Similar results were found by Moxon et al. (1951) in a comparison of standing forage and windrowed hay. Such things as palatability and availability of the forage during snow cover could favor the use of the baled hay over the windrows or bunches.

There was no significant effect ($P > .10$) of method of storage on the calcium content of the forages (Table 3). There was a significant ($P < .05$) effect of method of storage on the lignin content of the forage.

Storage Time. Storage time had little effect on the nitrogen, phosphorus and calcium content of the hay. The percent lignin increased ($P < .01$) from the time of cutting until November, after which time it did not change appreciably. Carotene content decreased ($P < .01$) in a pattern similar to the increase in lignin. The influence of storage time on nutritive value is apparent only for a few months after harvesting and not of importance in the winter feeding period.

Cutting Date and Method of Storage. The significant interaction between cutting date and method of storage in the case of nitrogen and phophorus content (Fig. 1) appeared to result from the inclusion of the standing forage as there were no important differences in the responses of the hays stored by the three other methods. The standing forage should not have been included in the cutting date by method of storage interaction as the late cutting date was simply a replicate of the early cutting date with the July sampling time missing. There was no significant ($P > .10$) interaction between methods of storage and time of cutting with respect to lignin or calcium. Only the round-baled hay had a significantly greater ($P < .01$) caro-

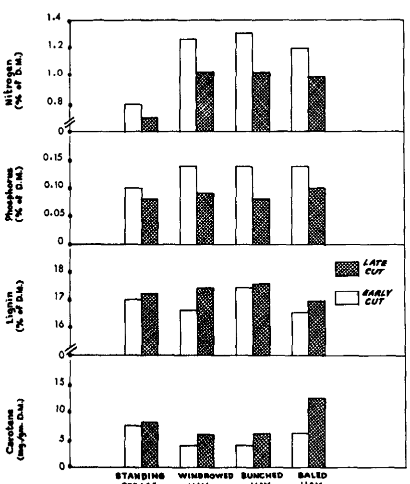

Fig. 1. The effect of the interaction of cutting date and method of storage on nitrogen, phosphorus, lignin and carotene content.

tene content when cut late as compared to early.

Cutting Date by Storage Time. The cutting date by storage time interaction was difficult to interpret because the earlier cut hay was in storage a month longer at the same chronological date than the late-cut hay. If equal periods of storage were compared, however, there would have been a confounding of storage time with the climatic conditions to which the hay was exposed. The former method of comparison was chosen, therefore, as the better alternative.

Early-cut hay lost phosphorus more rapidly ($P < .01$) than late-cut hay during the period from August to October, after which time it stabilized (Fig. 2). There was no significant cutting date-storage time interaction with respect to nitrogen or lignin. The significantly greater ($P < .01$) carotene content of the late-cut hay as compared to the early-cut hay at any given date was a result of the longer exposure of early-cut hay to weathering. Little difference in carotene content between the hays cut at different dates occurred after October. At this time, the carotene content of both cuttings of hay was near the recommended levels of the National Research Council (1958).

Method of Storage and Storage Time. Little change in the nitrogen and phosphorus levels of the hay occurred during storage, however, the standing forage showed a steady decrease in nitrogen and phosphorus from July through January (Fig. 3).

There was no method of storage-storage time interaction with respect to lignin. No difference in the calcium content during storage time was noted among the various methods of storage.

The standing forage maintained a higher composition of carotene than did any of the hay until about mid-September. After this time, the baled hay retained the highest level, and the

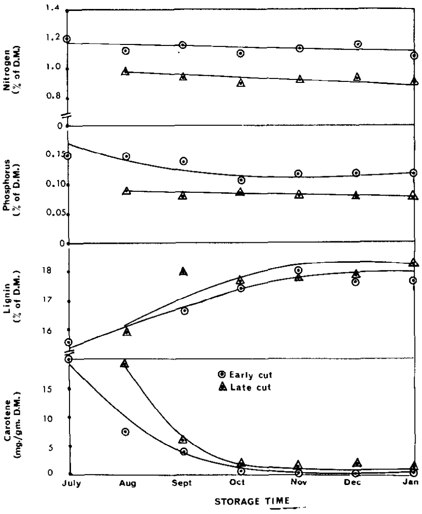

Fig. 2. The effect of the interaction of cutting date and storage time on the nitrogen, phosphorus, lignin and carotene content.

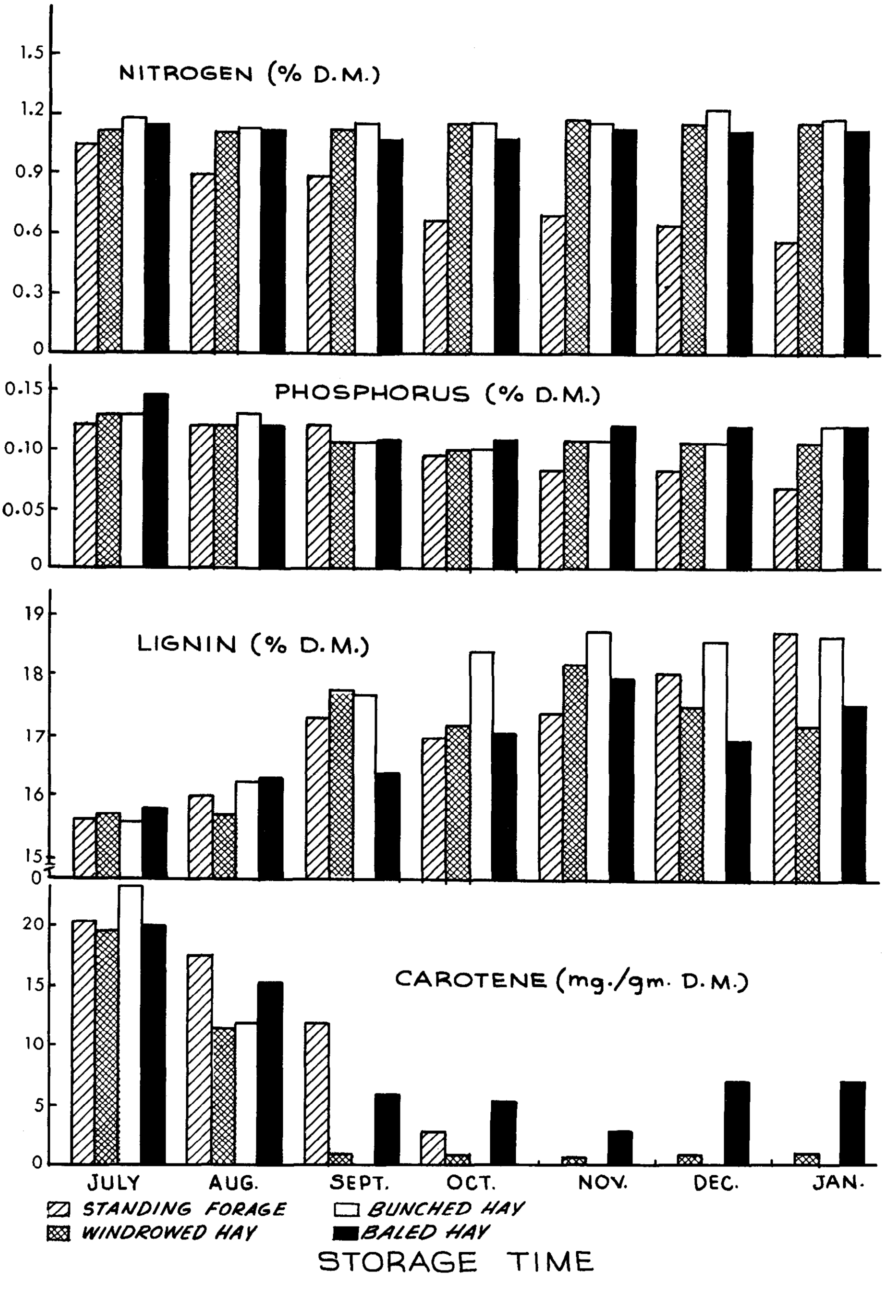

Fig. 3. The effect of the interaction of method of storage and storage time on the nitrogen, phosphorus, lignin and carotene content.

carotene content of the hay stored in all other methods was almost immeasurable. The carotene content of range grasses can be best preserved for the winter feeding period by baling the forage. The importance of this finding is somewhat lessened by the fact that carotene (Vitamin A) deficiencies have been shown to be rare with range livestock and occur only in cases of prolonged drought (Savage and Heller, 1947). Moxon et al. (1951) also found the carotene content of standing forage to decrease more rapidly than when the forage was cut and stored in windrows.

Summary

The purpose of this investigation was to study the effect of date of cutting, method of storage and storage time on the nutritive value of native Sandhills upland hay. The forage was cut at two dates, mid-July and late-August, in 1962 and 1963. The methods of storage included windrowed, bunched and round-baled hay and standing forage. A metabolism trial was conducted each year to determine the quantity of digestible nitrogen and energy, metabolizable energy and nitrogen balance of the early- and late-cut, round-baled hay. Forage samples from each method-cutting date subclass were also obtained monthly from the time of harvest until late January. The samples were analyzed for lignin, nitrogen, calcium, phophorus and carotene in 1962 and for nitrogen, calcium and phosphorus in 1963.

The greater precipitation that fell in 1962 as compared to 1963 caused a greater production of forage per acre in 1962. In both years more forage was harvested in late-August than in mid-July. Forage yield was influenced more by differences in precipitation and date of cutting than was nutritive value as measured by metabolizable energy and nitrogen retention. Chemical analysis showed relatively little difference in nutritive value between the windrowed, bunched and baled hay. Standing forage had considerably lower nutritive value than any of the harvested forages. The influence of storage time on nutritive value was only important for a few months after harvesting and of little significance in the winter hay feeding period.

LITERATURE CITED

A.O.A.C. 1960. Official Methods of Analysis (9th Ed.). Association of Official Agricultural Chemists. Washington D. C.

Archibald, J. G., J. Bart, M. L. Blaisdell, and A. F. Spelman. 1951. Quality in roughage. I. Factors which influence hay composition and quality. J. Dairy Sci. 34:656-668.

Armstrong, D. G., K. L. Blaxter, and R. Waite. 1964. The evaluation of artificially dried grass as a source of energy for sheep. III. The prediction of nutritive value from chemical and biological measurements. J. Agr. Sci. 62:417-424.

Baker, M. L., E. C. Conard, V. H. Arthaud, and L. C. Newell. 1951. Effect of time of cutting on yield and feeding value of prairie hay. Nebr. Agr. Exp. Sta. Bull. 403. 19 p.

Briggs, H. M., W. D. Gallup, and A. E. Darlow. 1948. Yield and feeding value of prairie hay cut at different stages of maturity. Okla. Exp. Sta. Bull. B-320. 15 p.

Burzlaff, D. F. 1962. A soil and vegetation inventory and analysis of three Nebraska Sandhills range sites. Nebr. Agr. Exp. Sta. Res. Bull. 206. 33 p.

Crampton, E. W., and L. A. Maynard. 1938. The relation of cellulose and lignin content to the nutritive value of animal feeds. J. Nutr. 15: 383-395.

Embry, L. B., G. F. Gastler, and O. E. Olson. 1956. Feeding value of early-, medium-, and late-cut prairie hay. S. Dak. Agr. Exp. Sta. Bull. 457. 30 p.

Moxon, A. L., G. F. Gastler, G. E. Staples, and R. M. Jordan. 1951. Grass hay at its best; As shown by chemical analysis and feeding value. S. Dak. Agr. Exp. Sta. Bull. 405. 24 p.

N.R.C. 1958. Nutrient Requirements of Farm Animals, No. 4. Nutrient Requirements of Beef Cattle. National Research Council, Washington, D. C.

Patton, A. R., and Leonard Gieseker. 1942. Seasonal changes in the lignin and cellulose content of some Montana grasses. J. Anim. Sci. 1:22-26.

Savage D. A., and V. G. Heller. 1947. Nutritional qualities of range forage plants in relation to grazing with beef cattle on the southern plains experimental range. U.S. Dep. of Agr. Tech. Bull. 943. 61 p.

Stanley, E. B., and C. W. Hodgson. 1938. Seasonal changes in the chemical composition of some Arizona range grasses. Ariz. Agr. Exp. Sta. Tech. Bull. 73. 451-466.

Whitman, W. C., D. W. Bolin, E. W. Klosterman, H. J. Klosterman, K. D. Ford, Leroy Moomaw, D. G. Hoag, and M. L. Buchanan. 1951. Carotene, protein and phosphorus in range and tame grasses of western North Dakota. N. Dak. Agr. Exp. Sta. Bull. 370. 55 p.