Effect of Nitrogen Rate and Clipping Frequency upon Lignin Content and Digestibility of Coastal Bermuda Grass

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This study was conducted to ascertain the effect of nitrogen fertilizer and clipping frequency upon the lignin content and digestibility of Coastal Bermuda grass when fed to lambs. When the grass was fertilized with 100 pounds or less of nitrogen per acre, clipping frequency did not affect lignin content; at higher nitrogen rates, lignin increased with age of the grass. Grass fertilized with 600 pounds of nitrogen per acre increased from 9.45 to 12.05% lignin with an age increase from 2 to 8 weeks. Total digestible nutrient values of 69.64, 67.81, 67.23, 67.24, and 59.07% were obtained from 1- to 2-, 3-, 4-, 6-, and 8-week-old grass, respectively, fed to lambs. Not more than 6 weeks should elapse between cuttings if top-quality Coastal Bermuda hay is desired.

COASTAL BERMUDA GRASS, a vegetatively propagated F_1 hybrid, is now grown on well over 1,500,000 acres throughout the southeastern United States. Owing to its desirable agronomic qualities such as unusual productivity, dependability, efficiency in fertilizer and water use, drought tolerance, and disease resistance, the acreage planted to this grass is increasing rapidly. Although much time and money have been spent evaluating the pasture, hay, and silage produced from Coastal Bermuda (*1*), many questions concerning its feeding value are still unanswered. One of these questions—"How does fertilization and management affect the quality of Coastal Bermuda forage?"—motivated the study reported here.

Forage quality (palatability, nutrient content, and digestibility) decreases as the age of the plant increases. Stage of maturity, as evidenced by seed-head development, furnishes a convenient index for adjudging the quality of such forages as orchard grass and timothy. As Coastal Bermuda may produce few, if any, heads during the entire growing season, this criterion for quality determination cannot be used. Most timothy hay cut at any specified stage of development will be fairly constant in protein content. Six-week-old Coastal Bermuda grass, however, may range from 7 to 15% protein, depending upon the quantity of nitrogen applied.

In an effort to ascertain the effect of nitrogen level and clipping frequency (age of the grass) upon the yield and quality of Coastal Bermuda grass, the following experiment was begun. The effect of these treatments upon yield, protein content, and numerous morphological characters has been reported (*5*). Therefore, only the effect of these variables upon the lignin content and digestibility of the grass is dealt with here.

Materials and Methods

A 5-year-old sod of Coastal Bermuda grass growing on a Tifton sandy loam was chosen for these investigations. The test area contained very few weeds and no other grasses or legumes. Consequently, the forage used in all investigations reported here was practically pure Coastal Bermuda grass. The treatments consisted of annual rates of 0, 100, 300, 600, and 900 pounds of nitrogen per acre and clipping intervals of 2, 3, 4, 6, and 8 weeks arranged in all possible combinations. In addition, one set of plots receiving 600 pounds of nitrogen per acre annually was clipped at weekly

Table I. Seasonal Variations in Lignin Content of Coastal Bermuda Grass as Influenced by Nitrogen Level and Clipping Frequency

1953 Clipping Date	Lignin Content When Grass Fertilized and Clipped at Weekly Intervals as Follows: 100 Pounds N/Acre			300 Pounds N/Acre			600 Pounds N/Acre			900 Pounds N/Acre			Weather during Previous 2 Weeks	
	2 weeks	4 weeks	8 weeks	2 weeks	4 weeks	8 weeks	2 weeks	4 weeks	8 weeks	2 weeks	4 weeks	8 weeks	Rainfall, inches	Mean temp.
May 4	11.2	...	...	9.6	...	...	9.1	...	...	10.0	...	...	0.60	68
18	10.6	10.4	...	8.6	10.4	...	8.5	10.6	...	8.5	9.4	...	1.24	73
June 1	9.7	...	...	9.5	...	...	9.4	...	...	9.4	...	...	1.02	79
15	10.3	9.9	10.5	9.8	10.1	10.3	9.5	10.6	11.7	8.4	10.6	12.5	2.41	79
Av.	10.4	10.1	10.5	9.4	10.2	10.3	9.1	10.6	11.7	9.1	10.0	12.5	...	..
June 29	9.6	...	...	9.7	...	...	9.9	...	...	9.4	...	...	2.05	81
July 13	9.3	9.6	...	9.8	10.1	...	9.1	10.1	...	8.4	10.3	...	2.08	81
27	9.0	...	...	8.5	...	...	8.3	...	...	8.1	...	...	5.31	79
Aug. 10	9.2	10.1	10.1	9.7	11.4	10.3	9.9	10.5	12.4	8.6	10.6	11.9	2.77	82
Av.	9.3	9.8	10.1	9.4	10.7	10.3	9.3	10.3	12.4	8.6	10.4	11.9	...	..
Aug. 24	11.0	...	...	10.5	...	...	10.2	...	...	9.5	...	...	2.73	78
Sept. 7	10.2	9.6	...	10.6	10.2	...	9.4	9.7	...	9.2	9.5	...	5.72	77
21	11.8	...	...	11.0	...	...	10.3	...	...	10.1	...	...	0.83	75
Oct. 5	11.0	10.1	10.2	9.9	10.6	11.3	9.5	9.9	12.1	9.8	9.6	10.9	6.47	72
Av.	11.0	9.8	10.2	10.5	10.4	11.3	9.8	9.8	12.1	9.6	9.5	10.9	...	..
5% LSD	0.58	NS	0.32	0.58	0.75	0.32	0.58	0.75	0.32	0.58	0.75	0.32	...	..

Table II. Effect of Nitrogen Rate and Clipping Frequency on Lignin Content of Coastal Bermuda Grass during a 24-Week Period, Summer, 1953

Clipping Intervals, Weeks	*Nitrogen Per Acre, Lb.* 0	100	300	600	900	*Av.*
	% Lignin Content					
2	10.95	10.25	9.80	9.45	9.15	9.92
3	10.95	10.20	9.50	9.65	9.45	9.95
4	9.65	10.00	10.45	10.30	10.00	10.08
6	9.95	9.60	11.25	11.20	11.45	10.69
8	10.65	10.25	10.70	12.05	11.80	11.09
Av.	10.43	10.06	10.34	10.53	10.37	10.35

5% LSD for clipping-frequency and nitrogen-level averages is 0.15 and for clipping frequency × nitrogen interaction is 0.34.

Table III. Effect of Clipping Frequency upon Digestibility of Coastal Bermuda Grass[a] Hay Fed to Lambs

Clipping Intervals, Weeks	*Digestion Coefficients, %* Dry matter	Protein	Fat	Fiber	NFE	TDN
	Coastal Bermuda Grass Hay					
1 to 2	70.91	79.36	64.23	72.56	67.46	69.64
3	70.38	78.03	65.45	70.75	64.54	67.81
4	65.69	76.45	64.39	68.06	63.87	67.23
6	66.49	70.99	64.19	66.00	67.57	67.24
8	59.14	63.38	55.19	58.94	60.56	59.07
	Annual Lespedeza Hay					
	61.91	57.08	45.69	59.22	67.93	62.51

[a] Bermuda grass fed represented all forage produced on plots fertilized with 600 pounds of nitrogen per acre plus adequate phosphorus and potassium during a 24-week period in the summer of 1954. The 1- to 2-week forage was one third 1-week-old and two thirds 2-week-old grass. Annual lespedeza hay was included in this digestion trial as a standard check.

intervals. These 26 treatments were replicated five times in a randomized block design. Plots 6 × 20 feet in size were used in the study. The experiment was continued for a 24-week period each year in order to terminate all clipping treatments on the same date. The nitrogen source—ammonium nitrate—mixed with superphosphate and muriate of potash to make a 2 to 1 to 1 ratio of nitrogen, phosphorus pentoxide, and potassium oxide was applied half in early spring and half after the 12-week clipping date. The 24-week clipping period was begun April 20, 1953, and April 12, 1954.

Representative samples were collected and oven-dried from each clipping of each treatment from two of the five replications in both years. These samples collected in 1953 were ground and analyzed for lignin content using the method of Davis and Miller (*2*). These data are summarized in Tables I and II.

Forage for the digestion trial with lambs was collected as follows: Only plots receiving 600 pounds of nitrogen per acre were sampled because lower fertilization rates would not have produced sufficient forage for the test. All forage from the five plots of each clipping treatment were dried in a greenhouse and were stored until the end of the 1954 season. These were then combined so that one lot contained all 8-week-old hay, another all 6-week-old hay, and another all 4-week-old hay—cut during the 24 week test period in 1954. As there was only one third enough week-old hay and two thirds enough 2-week-old hay for a digestion trial, these two lots were combined in a 1 to 2 ratio to make the youngest lot studied. All grass was cut to within 2 inches of the ground and very few heads had developed even in the 8-week-old grass. Good quality annual lespedeza hay was fed as a check in this investigation.

The digestibility data presented in Table III were obtained as follows: The hays used in the digestion trial were individually ground through a 3/8-inch hammer-mill screen and stored in closed containers until used. During the course of the feeding test, small samples of the individual hays were taken to form the samples for analysis. Six yearling Hampshire × native crossbreed wethers weighing 115 to 120 pounds were fed in two 3 × 3 Latin squares. Lambs of each 3 × 3 Latin square were fed an equal amount of hay per period with the lowest-consuming lamb limiting the intake of the other two. Daily consumption was approximately 1.5 pounds (about a full maintenance ration), with the 6- and 8-week-cut hays being the most unpalatable, as determined by consumption. Hays were fed in boxes designed to reduce waste to a minimum. A simple mineral mixture and water were kept before lambs at all times. Chemical analyses of these hays are presented in Table IV.

Total fecal collections were made by use of a canvas collection bag and harness. Lambs had a 10-day preliminary feeding period with 5-day collection and 8-day change-over periods. Total fecal material was dried in a forced–hot-air oven and ground, mixed, and sampled for analysis.

Results

The influence of season upon the lignin content of Coastal Bermuda grass is shown in Table I. A study of the 2-week clipping data reveals that lignin content was usually lower during the middle of the summer, when temperatures and growth rates were higher. There is also evidence, particularly after July 1, to indicate that high rainfall resulted in lower lignin. These relationships between lignin content of the grass and weather did not hold, however, when the grass was cut at 4- and 8-week periods. This lack of consistency in the data and the rather small seasonal differences in lignin content of the grass suggest that season may exert comparatively little influence upon the lignin content of Coastal Bermuda. If lignin content were considered an index of digestibility (*3*), Coastal Bermuda forage of equal age and fertilization

Table IV. Effect of Clipping Frequency upon Chemical Composition of Coastal Bermuda Grass Hay[a] Fed to Lambs

Clipping Intervals, Weeks	*Average Composition, %* Dry matter	Crude protein	Fat	Crude fiber	NFE	Ash
	Coastal Bermuda Grass Hay					
1 to 2	93.90	20.63	3.11	22.22	42.11	5.83
3	93.90	17.63	2.90	25.00	43.32	5.05
4	93.90	16.25	2.67	25.21	45.62	4.15
6	93.70	11.81	2.30	25.75	50.79	3.05
8	93.70	9.94	1.85	27.00	50.93	3.98
	Annual Lespedeza Hay					
	93.50	10.56	3.03	27.90	47.83	4.18

[a] Above analyses (conducted according to standard AOAC methods) of Bermuda hay fed to lambs in the digestibility trial summarized in Table III represent all forage produced on plots fertilized with 600 pounds of nitrogen per acre plus adequate phosphorus and potassium during a 24-week period in the summer of 1954. The 1- to 2-week forage was one third 1-week-old and two thirds 2-week-old grass. Annual lespedeza hay was included in this digestion trial as a standard check.

would be similar in digestibility, regardless of the season of the year in which it was produced.

There has been considerable research to prove that the digestibility of western range grasses decreases with advance in season. Patton and Giesker (*4*) reported an increase of lignin in Montana grasses from 5% in May to 18% in September. They sampled the entire season's growth, however, making the grass cut in September 4 months older than that cut in May. Striking changes in physiological development of the plants also occurred during their test period. Grass cut in May, for example, was described as "snow disappearance to flower stalks first in evidence," whereas that cut in September had "seedheads shattered." Thus, it is believed that seasonal differences in digestibility and lignin content previously observed have been largely the result of differences in age and stage of development on the grass rather than a result of seasonal changes in temperature and rainfall.

The data in Table II show an interesting and highly significant interaction between clipping frequency and nitrogen level as they affect the lignin content of Coastal Bermuda grass. When the grass was clipped at 2-week intervals, increasing rates of nitrogen decreased the lignin content of the forage harvested, but at 6- and 8-week intervals, lignin tended to increase with increasing increments of nitrogen. When fertilized with 100 pounds or less of nitrogen per acre, 8-week-old grass contained no more lignin than 2- and 3-week-old grass. When fertilized at the heavier rates, the lignin content of the grass increased noticeably with its age.

A partial explanation for these results may be found in the effect of these treatments upon the leafiness of the forage harvested (*5*). As Coastal Bermuda stems contain more lignin than the leaves (12.88 *vs.* 10.88% in 8-week-old grass), any treatment that would increase the stem percentage might also be expected to increase the lignin content. When the grass was clipped at 2-week intervals, leaf percentages did not change—ranging from 84.1 to 85.4% with nitrogen increases from 0 to 900 pounds per acre. Leaf percentages decreased from 64.8 to 49.1 with increased rates of nitrogen when the grass was cut at 8-week intervals. With no nitrogen, leaf percentages dropped from 84.1 to 64.8% with increasing age; whereas they dropped from 85.4 to 49.1% with age when fertilized with 900 pounds of nitrogen per acre. As changes in leaf percentage did not always result in lignin changes, other factors, as yet unknown, influenced the lignin development in this study.

The data presented in Table III show that the digestibility of the Coastal Bermuda cut in 1954 generally decreases as the length of the clipping period or age of the grass increased. The big drop in digestibility occurred, however, between the 6- and 8-week-old hay, suggesting that no more than 6 weeks should elapse between cuttings where high quality hay is sought. The close negative correlation between the crude-fiber content of the hay (Table IV) and its total digestible nutrients (TDN) content is interesting. Although lignin analyses of the forage collected in 1954 were not made, they would probably have been similar to those obtained in 1953. As the forage fed the lambs in this digestion trial received 600 pounds of nitrogen per acre in 1954, the lignin analyses in Table II for forage receiving 600 pounds of nitrogen per acre should be applicable. These data show a linear increase in lignin content from 9.45% for 2-week-old grass to 12.05% for 8-week-old grass. With the exception of the 8-week-old grass, the Coastal Bermuda forage exceeded the annual lespedeza check in digestibility. A full ration (rather than the maintenance ration fed) might have decreased the digestion coefficients slightly, but it should not have altered the relative performance of the hays studied.

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Literature Cited

(1) Burton, G. W., *Georgia Agr. Expt. Stas., Bull.*, No. 2 (September 1954).
(2) Davis, R. E., Miller, C. O., *Ind. Eng. Chem., Anal. Ed.* **11**, 651–2 (1939).
(3) Forbes, R. M., Garrigus, W. T., *J. Animal Sci.* **9**, 531 (1950).
(4) Patton, A. R., Giesker, L., *Ibid.*, **1**, 22 (1942).
(5) Prine, G. M., Burton, G. W., *Argon. J.* **48**, 296–301 (1956).

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AMINO ACIDS IN FOODS

Cystine, Tyrosine, and Essential Amino Acid Content of Selected Foods of Plant and Animal Origin

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In recent years, emphasis has been placed on the evaluation of protein quality, rather than the total quantity of protein in foods. This is indeed a timely approach, as utilization of the amino acids, which are constituents of protein, is dependent on all of the essential amino acids being present simultaneously and in proper proportions. More information on the amino acid composition of foods commonly consumed is necessary to evaluate these foods as sources of protein in the diet. This approach is also of value in practical nutrition education programs, where it may be possible to recommend foods, individually, which may be low in specific amino acids, but which supplement each other when eaten at the same time. Thus, knowing the amino acid composition of ordinary foods in the diet, the nutritionist may be able to raise the level of health and well being through assisting the population in specific areas to achieve a good state of protein nutrition without altering the basic dietary pattern.

This work represents the second in a series of determinations of the moisture, ash, total nitrogen, and amino acid contents of selected foods, including grain, meat, milk, and vegetable products. Foods reported in the first investigation (*3*) were commonly consumed in the southeastern section of the United States. Those reported herein are generally consumed throughout the country. Determinations of 10 essential and two other important amino acids, cystine and tyrosine, are reported for 20 foods.

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