EFFECTS OF HEIGHTS OF CLIPPING AND NITROGEN FERTILIZATION ON FORAGE YIELD AND CHEMICAL COMPOSITION OF BERMUDA GRASS, *CYNODON DACTYLON*, (L.) PERS. AND BUFFALO GRASS, *BUCHLOE DACTYLOIDES*, (NUTT.) ENGELM

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INTRODUCTION

More experimental data are needed concerning the beneficial effects of nitrogen fertilization upon the seasonal variation in chemical composition, yield, and stand of bermuda grass and buffalo grass, before any definite conclusions can be drawn or fertilizer recommendations can be made. Knowledge of the effects of various clipping heights upon these grasses should be of great benefit to all persons interested in turf management.

Farmers and stockmen are interested in the variations in chemical composition of these grasses in order to derive maximum benefit from the forage, both green and cured, in the feeding of their livestock. Turfmen and all lawn growers are interested in the influence of nitrogen fertilization upon stand and appearance of the turf. They are also interested in the increased amount of clipping caused by the addition of nitrogen.

Elting and others (7)[1] state that the dry matter of grasses increased from about 20% in the spring to approximately 70% in the fall. The protein content varied inversely with the dry matter. They further state that upon nitrogen fertilization an increase in yield resulted which necessitated an increased amount of clipping. Nitrogen fertilization not only increased the yield, but imparted a dark green color to the forage.

It was reported by Sprague and Duval (19) that a light green turf was undesirable. The general appearance of the turf was greatly improved by a deep green color.

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[1] Figures in parenthesis refer to "Literature Cited", p. 18.

In March, 1948, a three year experiment was designed to study the effects of nitrogen fertilization and various clipping heights upon the appearance, yield, and chemical composition of bermuda grass, Cynodon dactylon, (L.) Pers. and buffalo grass, Buchloe dactyloides, (Nutt.) Engelm. These are Oklahoma's two most important pasture and turf grasses.

REVIEW OF LITERATURE

Harrison (11) reports that nitrogen fertilization increased the vegetative growth of grass thereby widening the ratio between roots and stems. This fertilization increased stem growth, but not root development. Root development was retarded by low clipping. It was found by Willard and Ries (22) that permanence and root growth of a lawn was greatly increased if a large amount of superphosphate (20 to 25 pounds per 1,000 square feet) was well mixed with the top three to four inches of soil. This should be followed with 15 to 20 pounds of 4-12-4 fertilizer. They also state that 5 to 10 pounds of 4-12-4 fertilizer per 1,000 square feet should be applied in September and 5 to 10 pounds of 10-6-4 the following spring. The lawn should not be mowed closer than 1.5 inches.

Golf courses must be kept in an actively growing state throughout the entire growing season if they are to withstand the close mowing and excessive wear, according to Morgan et al.(15). Hence, fertilizers should be applied in frequent small applications. The grass should be mowed to a height of 1.5 inches with the clippings left on the ground. Bell and DeFrance (1) found that a 10-6-4- fertilizer was the most satisfactory for turf. Twenty per cent nitrogen gave excellent color, vigor, and density, but the turf became too spongy for putting. Fertilizer with 5% nitrogen gave the finest textured grass, but it was susceptible to clover and weed infestation. Medium amounts of phosphorus aided the beneficial effects of the nitrogen, but large amounts of it encouraged weed infestation and retarded root development. It is reported by Carroll (3) that grass treated with 5 pounds of Ammonium Sulfate per 1,000 square feet was less resistant to drouthy conditions and extremes of heat and cold than was

untreated grass.

Very comprehensive recommendations for turf fertilization are presented by Sprague (18). Both the type of fertilizer and the rates of application are presented as determined by soil fertility and time of application. For best results he recommends that one-third of the nitrogen in such fertilizers be supplied from slowly available organic forms such as tankage, castor pomace, soybean meal, or something similar. Two important precautions should be observed in applying fertilizer to turf: (1) the fertilizer must be evenly distributed to produce uniform results and (2) the fertilizer should be spread only when the grass leaves are completely dry to avoid burning the foliage.

In New Jersey, Sprague and Evual (19) found that the height at which turf should be mowed depended upon two factors: namely, the use to be made of the turf, and the ability of the grass to withstand close mowing. For lawns and golf fairways the grass should not be mowed closer than three-fourths of an inch and mowed twice weekly. In outlining maintenance standards for green keepers, it was found that golf course tees should be mowed one-half to three-fourths of an inch high to allow the ball to stand clear of the uncut grass (20).

Newell and Keim (16) state that in Nebraska, a relatively high percentage of protein may be maintained in buffalo grass by frequent mowing. Buffalo grass mowed one inch high ten times over a season had an average crude protein content of 11.7%, but when cut only 4 times the crude protein content was 9.3%. Clipping increased the protein content 2.4%. The chemical composition of buffalo grass was not greatly affected by reasonable clipping. From May 6, to September 15, the crude protein content decreased from 13.3% to 8.4% and the calcium and phosphorus contents

decreased slightly. This drop in constituents was apparently due to maturity, not clipping (13).

McMillen and Williams (14) in Oklahoma, report that the composition of buffalo grass was largely determined by maturity. Rainfall influenced the chemical composition only through its effect upon maturity. The rapid drop in moisture, protein, and phosphorus content of buffalo grass throughout the season was due to approaching maturity.

Daniels (4) reports that in Oklahoma, buffalo grass was very high in calcium, phosphorus, and nitrogen when compared with other grasses, but in comparison with legumes, this grass was very low in mineral content. When grown on fertile soil there was a tendency for the grass to be higher in calcium and phosphorus. Nitrogen and phosphorus content was highest in May, and decreased toward the end of the growing season. On an average, the calcium content increased from May to June, and then decreased slowly toward August.

During periods of low rainfall the dry matter of bermuda grass increased with the lower green yields. The percent of protein was highest in the spring and decreased toward fall and maturity with the more frequently clipped grass containing the higher percentage of protein (7). Fraps and Fudge (9) found that bermuda grass had a higher protein content than any other principal species of grass in eastern Texas. Bermuda grass was also lower in crude fiber than most.

In Oklahoma, bermuda grass cut every week throughout the growing season had a three-year average protein content of 14.19% and ash content of 7.73%, according to Francis and Baird (10).

Brown and Hollowell (2) report that little response was obtained from the fertilization of bermuda grass. Small gains in phosphorus content

resulted from phosphate fertilization and a slight increase in calcium from liming. The increase in protein due to nitrogen fertilization was usually gone within one month. The use of nitrogen fertilizer regardless of carrier, resulted in a slightly greater phosphorus content, but appreciably reduced the calcium content of the grass.

Grass should be fertilized with nitrogen throughout the growing season. The plan of fertilization will not greatly increase forage yields, but summer applications of nitrogen aid in maintaining uniformity (17). Nitrogen recovery in the foliage was increased on an average of 21% due to nitrogen fertilization.

Truog and others (21) report that the application of nitrogen as early in the spring as was possible made it possible to graze the pasture from a week to 10 days longer. The pasturage was more palatable and richer in protein. Ammonium Nitrate should be applied at the rate of 125 to 175 pounds per acre. The protein content of grasses mowed frequently was found by Enlow and Coleman (8) to average much higher than when the grasses were mowed only at the end of the growing season. The protein content of a grass in a grazed-condition was raised and maintained at a somewhat higher level than ordinary by frequent light applications of nitrogen fertilizer. Rainfall rather than available nitrogen was the limiting factor in forage production as the ratio between total nitrogen content and pounds of forage produced was flexible.

Daniels and Harper (5) report that in Oklahoma the study of a single plant food element in the soil will not give an accurate estimate of the amount of that element which will be found in the plant. The effect of soil moisture conditions during the growing season was a very important factor in increasing or retarding the intake of calcium and phosphorus

from the soil. During periods of high rainfall the calcium content of plants decreased and the phosphorus content increased (6).

It was reported in Horticulture (12) that the best time to renovate the lawn or turf was spring. The lawn or turf should be rolled to repack any plants shoved up during the freezing and thawing processes. As the turf shows signs of increased activity it should be treated with a complete fertilizer, high in nitrogen. A combination of organic fertilizers is considered best. A fertilizer with the ratio of 10-5-5 was satisfactory if applied at the rate of 5 to 10 pounds per 1,000 square feet or higher if the soil was poor.

METHODS AND MATERIALS

To determine the influence of nitrogen fertilization and the effects of various heights of clipping upon bermuda grass and buffalo grass, four rates of nitrogen, 0, 50, 100, and 150 pounds per acre, were applied in all combinations with three heights of clipping, 5/8 inch, 1 inch, and 2 inches, using two replications.

The bermuda grass plots were located on the Oklahoma Agriculture Experiment Station Agronomy Farm -- series 3400. Twenty-four plots, 9 by 16 feet were laid off with no alleys between plots or replications. The dead foliage was burned on March 16, 1948. The various rates of nitrogen, in the form of Ammonium Nitrate, were applied March 24, 1948.

The buffalo grass plots were located three miles east of Stillwater, Oklahoma, on the college-leased Thomas farm. Twenty-four 8 by 25 feet plots were laid off with no alleys between plots. There was, however, an alley between the replications. The various rates of Ammonium Nitrate were applied April 8, 1948, just prior to a heavy rain.

The plots were clipped with a powered lawn mower as often as yields were obtainable at the respective heights. The lawn mower was equipped with a basket to catch the clippings from each plot. After each clipping a composite 500-gram sample of the green forage was taken from each plot and dried to determine the moisture percentage of the forage. The oven dried samples were combined according to treatment and date of clipping and were used as a basis for conducting the chemical analyses.

The chemical analyses were conducted in the soils laboratory at Oklahoma A. and M. College. Determinations were made for the percentages of ash, nitrogen, protein, calcium, and phosphorus. The methods used in these tests were outlined by Dr. H. J. Harper.[2]

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[2] Mimeographed manual for use in the Soils Laboratory, Oklahoma A. and M. College, p. 43-45, 51-52, 54, 65-66. 1948.

RESULTS AND DISCUSSIONS

Climatic Condition

The climatic conditions at Stillwater, Oklahoma, are characterized by moderate rainfall (35 inches annually), which is somewhat erratic in distribution, and usually by moderate winters with occasional severe freezes. The meterorological data for the period January, 1948, to December, 1948, are presented in Table 1. The rainfall was slightly above normal during February and March. April and May were characterized by a slightly drouthy period, with June, July, and August, having an excessive amount of rainfall. The temperature throughout the months of January, February, and March, was from two to five degrees below normal for that period with an excessive amount of snow and a minus five degrees on March 12. The temperature for the summer months was approximately normal with the first killing frost occurring on October 18.

Appearance of the Turf

The application of ammonium nitrate greatly enhanced the appearance of the bermuda grass and the buffalo grass. The fertilized bermuda grass took on a dark green color with the color deepening with the increased amounts of fertilizer added. The normal color of buffalo grass is a grayish-green, but the addition of nitrogen imparted a desirable dark green color to the foliage. The increase in color intensity was noticeable until the last of June, after which there were no color differences in the treated plots and check plots of either bermuda grass or buffalo grass.

The plots clipped at 1 inch produced the smoothest turf and had the most pleasing appearance. The grass that had been clipped at 2 inches looked rough and slightly unkept when compared to the other plots. Where

Table 1.-- Meteorological data for the period January, 1948 to December, 1948. Stillwater, Oklahoma.

Month	Temperature						Precipitation - Inches								
							Rainfall				Snowfall		No. of Days		
	Mean	Departure From Nor.	Highest	Date	Lowest	Date	Total	Departure From Nor.	Greatest Day	Date	Total	Date	.01 Inch Or More	.25 Inch Or More	1 Inch Or More
January	32.6	-4.3	69	8	3	28	0.45	-0.68	.40	1	4.5		2	-	-
February	37.6	-2.2	76	17	12	9	1.83	0.56	.80	5	10.0		10	-	-
March	45.3	-4.9	81	20	-5	12	4.15	1.96	1.36	1	14.5		8	-	-
April	66.4	6.9	90	6	33	1	2.61	-1.2	2.2	25	0		5	-	-
May	68.1	0.2	92	22	41	7	2.65	-2.12	1.1	10	0		9	4	1
June	77.3	0.4	100	19	57	2	7.84	3.75	1.85	23	0		14	6	4
July	79.9	-1.5	96	28	62	31	4.83	2.15	1.15	8	0		13	6	2
August	78.7	-2.6	100	21	58	5	3.55	0.32	0.85	8	0		14	4	-
September	74.3	0.80	99	7	47	27	0.61	-2.91	0.6	24	0		2	1	-
October	61.0	-0.8	90	14	28	18	0.41	-2.75	0.16	21	0		4	-	-
November	48.0	-1.2	82	1	22	29	2.48	0.25	1.70	28	T	19	4	2	1

the ground was rough and uneven, the reel set to clip at five-eighths inch dug into the sod leaving bare patches in the turf. Not only do bare patches detract from the appearance of the turf, but they interfere with the play of the ball on golf course fairways and greens.

Yields of Forage

The application of ammonium nitrate increased the yields of bermuda grass (Table 2) and buffalo grass (Table 3). With the exception of the bermuda grass plots clipped at 5/8 inch, the yields increased proportionately with the amount of nitrogen added. Of the low clipped plots, those treated with 100 pounds of nitrogen produced the greatest yield, 2,067 pounds per acre, while the yield of the plots fertilized with 50 pounds of nitrogen fell below that of the check plots, 1,537 and 1,564 pounds, respectively.

Considering all rates of fertilization combined, the amounts of forage produced by the bermuda grass plots decreased with the increased clipping heights. The plots clipped at 5/8 inch produced the greatest yield, 1,800 pounds per acre, followed by 1,451 and 1,295 pounds produced by the plots clipped at 1 and 2 inches, respectively. However, due to an excessive amount of weeds in the low-clipped plots, the forage produced was of poor appearance and quality until the clipping on July 21, which contained only a trace of weeds.

Buffalo grass yields also decreased with the increased clipping heights. The plots clipped at 5/8 inch, 1 inch, and 2 inches produced 649, 454, and 221 pounds per acre, respectively. The yields at all clipping heights increased with the increased amounts of nitrogen applied. The last 3 clippings of the high clipped, highly fertilized buffalo grass plots were exceedingly weedy. The predominating weeds were the wild

Table 2. The average chemical composition of bermuda grass as affected by nitrogen fertilization and clipping at Stillwater, Oklahoma. 1948.

Nitrogen Treatment lbs./A	Green Wt. lbs./A	Percentage Ash	N.	Prot.	Ca.	P.
Low clipped (five-eighths inch)						
0	1,564	8.40	2.39	14.93	0.47	0.20
50	1,537	7.35	2.42	15.13	0.48	0.19
100	2,067	8.08	2.23	13.96	0.45	0.20
150	2,032	8.44	2.36	14.77	0.46	0.20
Average	1,800	8.19	2.35	14.69	0.46	0.19
Medium clipped (one inch)						
0	1,098	8.03	2.28	14.25	0.46	0.18
50	1,309	8.33	2.24	14.02	0.46	0.19
100	1,655	8.54	2.38	14.92	0.49	0.19
150	1,742	8.44	2.44	14.65	0.47	0.19
Average	1,451	8.34	2.34	14.60	0.47	0.19
High clipped (two inches)						
0	992	7.77	2.09	12.88	0.45	0.20
50	1,140	8.03	1.98	12.36	0.46	0.20
100	1,422	8.11	2.18	13.65	0.47	0.20
150	1,482	8.21	2.25	14.04	0.48	0.21
Average	1,295	8.03	2.13	13.31	0.47	0.20
Grand Average	1,503	8.19	2.27	14.20	0.47	0.20

Table 3. The average chemical composition of buffalo grass as affected by nitrogen fertilization and clipping at Stillwater, Oklahoma. 1948.

Nitrogen Treatment lbs./A	Green Wt. lbs./A	Percentage Ash	N.	Prot.	Ca.	P.
	Low clipped (five-eighths inch)					
0	429	6.69	1.79	11.22	0.43	0.14
50	566	6.86	1.96	12.25	0.48	0.15
100	748	7.18	2.08	13.01	0.45	0.14
150	852	6.88	2.24	14.00	0.42	0.13
Average	649	6.90	2.02	12.63	0.45	0.14
	Medium clipped (one inch)					
0	277	6.80	1.95	12.19	0.50	0.15
50	425	6.54	1.87	11.80	0.45	0.14
100	492	6.36	2.01	12.56	0.54	0.14
150	622	6.44	2.30	14.39	0.51	0.14
Average	454	6.54	2.03	12.70	0.50	0.14
	High clipped (two inches)					
0	119	7.09	1.93	12.07	0.62	0.15
50	214	6.81	2.08	13.01	0.49	0.14
100	240	6.48	2.01	12.58	0.57	0.13
150	311	6.70	1.78	11.91	0.58	0.14
Average	221	6.77	1.95	12.19	0.57	0.14
Grand Average	441	6.74	2.00	12.50	0.51	0.14

Paspalams.

Due to adaptation and growth habit, the bermuda grass produced over 3 times as much forage as the buffalo grass.

Chemical Composition of the Forage

Bermuda grass--It will be noted in Table 2 that, in general, the protein content of bermuda grass was slightly increased by the addition of nitrogen. The bermuda grass clipped at 5/8 inch did not follow this trend in that the protein content of the check plot, 14.93%, was exceeded only by the 15.13% of the plots fertilized with 50 pounds of nitrogen. This discrepancy is probably due to the excessive amount of weeds found in the plots until the latter part of July. The greatest variation in protein content, 13.96% to 15.13%, was found in these weedy plots, however, the average protein content of the low-clipped plots, 14.69%, exceeded the average protein contents, 14.60% and 13.31%, of the grasses clipped at 1 inch and 2 inches respectively. Combining all treatments the bermuda grass had an average protein content of 14.20%.

Apparently, the ash content was not affected by the various clipping heights. There was variation due to nitrogen fertilization, but no definite trend was established with the possible exception of the grass clipped at 2 inches. In this treatment there was a definite increase in ash content with the increased amounts of nitrogen fertilization. The average ash content of all treatments was 9.19%.

The calcium and phosphorus contents were not greatly affected by clipping or nitrogen fertilization. The calcium content remained within the range of 0.47 $\pm$ 0.02% throughout the growing season. There was a range of 0.19% to 0.21% in the phosphorus content with the mean being

0.20%. As could be expected, slight negative correlation occured between these two constituents.

Buffalo grass--The protein content of buffalo grass was appreciably increased by the addition of nitrogenous fertilizer (table 3). The grass clipped at 2 inches and fertilized with 150 pounds of nitrogen did not show this increase due, very likely, to the fact that the last three clippings contained a high percentage of weedy growth which lowered the nitrogen content. Combining fertilizer treatment, the grass clipped at 2 inches contained a much lower protein content, 12.19%, than either the low-clipped or medium-clipped grass, 12.63% and 12.70%, respectively. The variations due to nitrogen fertilization were approximately the same in all clipping heights with no one height exhibiting excessive amounts of variation.

Different clipping heights seemed to have very little effect upon the ash content of buffalo grass. The grass showed rather wide variations in ash content between the different rates of nitrogen, but no correlation was exhibited.

The calcium content was extremely variable, ranging from 0.42% to 0.62%. The application of nitrogen did not apparently affect the percentage. Little differences were found in the phosphorus contents of all treatments. The content was found to be in the range of 0.13% to 0.15%. The average of all treatments was 0.14%.

As based upon these determinations, the bermuda grass contained a higher nutrient content than buffalo grass. The complete chemical analyses of these grasses are presented in the appendix (tables 4 and 5).

SUMMARY AND CONCLUSIONS

In March, 1948, a three-year experiment was set up at Stillwater, Oklahoma, in order to study the effects of nitrogen fertilization and various clipping heights upon the appearance, yield, and chemical composition of bermuda grass and buffalo grass. As the data presented in this paper only represent the results obtained the first year, no definite conclusions can be drawn; however, the one year's data show the following:

1. Nitrogen fertilization created a desirable dark green color in the forage of bermuda grass and buffalo grass.
2. The 1 inch mowing height appeared to be the best height to maintain, a smooth, well kept appearance of the turf.
3. The bermuda grass outyielded the buffalo grass on both fertilized and unfertilized plots.
4. The addition of nitrogen increased the yields and, with some notable exceptions, the protein content of the grasses grown in pure stands.
5. The calcium and phosphorus contents of the grasses were not appreciably affected by nitrogen fertilization or clipping height.
6. A slight negative correlation was exhibited between the calcium and phosphorus contents of the bermuda grass.
7. The nitrogen content of the forage was lowered by infestation of weeds.

LITERATURE CITED

1. Bell, R. S. and DeFrance, J. A.
   Influence of fertilizers on the accumulation of roots from closely clipped bent grasses and on the quality of the turf.
   Soil Sci., 58:17-24. 1944.

2. Brown, B. A. and Howllowell, E. A.
   The chemical composition of some pasture and hay plants as affected by soild and fertilizers.
   Soil Sci. Soc. Amer. Proc., 5:131-39. 1940.

3. Carroll, J. C.
   Effects of drouth, temperature, and nitrogen on turf grasses.
   Plant Physio., 18:19-36. 1943.

4. Daniels, H. A.
   A study of certain factors which affect the calcium, phosphorus, and nitrogen content of prairie soils.
   Proc. Okla. Acad. Sci., 12:42-45. 1932.

5. _____ and Harper, H. J.
   The relation between total calcium and phosphorus in mature prairie grass and available plant food in the soil.
   Jour. Amer. Soc. Agron., 26:986-992. 1934.

6. _____ and _____.
   The relation between effective rainfall and total calcium and phosphorus in alfalfa and prairie hay.
   Jour. Amer. Soc. Agron., 27:644-652. 1935.

7. Elting, E. C., LaMaster, J. P., and Mitchell, J. H.
   Permanent pasture studies. S. C. Agr. Exp. Sta. Bul. 308:25-28. 1937.

8. Enlow, C. R. and Coleman, J. M.
   Increasing protein content of grasses by frequent light applications of nitrogen fertilizers.
   Jour. Amer. Soc. Agron., 21:845-853. 1929.

9. Fraps, G. S. and Fudge, J. F.
   Chemical composition of forage grasses of the East Texas Timber Country. Tex. Agr. Exp. Sta. Bul. 528:14-17. 1940.

10. Francis, C. K. and Baird, R. O.
    A study of bermuda grass. Okla. Agr. Exp. Sta. Bul. 90:10-15. 1910.

11. Harrison, C. M.
Effects of cutting and fertilizer application on grass development. Plant Physio., 6:669-684. 1931.

12. Horticulture, 25:136-137. 1947.
Time to fix the lawn. Clark, W. H. (Editor).

13. Langham, Wright, McMillen, W. N., and Walker, Lamar.
A comparison of carotene, protein, calcium, and phosphorus content of buffalo grass and blue gramma grass.
Jour. Amer. Soc. Agron., 35:35-41. 1943.

14. McMillen, W. N. and Williams, Quenton.
Range and pasture studies and grazing recommendations for the southern great plains.
Panhandle A. and M. Exp. Sta. Bul. 67. 1944.

15. Morgan, M. F., Stoddard, E. M., and Johnson, J. P.
Turf management. Conn. Agr. Exp. Sta. Cir. 139:14-20. 1940.

16. Newell, L. C. and Keim, F. D.
Effects of mowing frequency on the yield and protein content of several grasses grown in pure stands.
Nebr. Agr. Exp. Sta. Res. Bul. 150:27-31. 1947.

17. Robinson, R. R. and Pierre, W. H.
The effects of nitrogen fertilization on permanent pastures on season distribution of yields and on nitrogen recovery in the herbage. Jour. Amer. Soc. Agron., 34:747-761. 1942.

18. Sprague, H. B.
Better Lawns, Double-Day Doran and Co., Inc. New York. pages 45-47. 1945.

19. _____ and Evual, E. G.
Experiments with turf grasses in New Jersey.
N. J. Agri. Exp. Sta. Bul. 497:23-30. 1930.

20. Timely Turf Topics. 1. 1947.
Standards of maintenence suggested for best playing conditions.
U.S.G.A. Greens Section, Beltsville, Md.

21. Truog, Emil, Chapman, C. J., and Graul, E. S.
Ammonium Nitrate For Pastures. Com. Fert., 68:13-14. 1944.

22. Willard, C. J. and Ries, V. H.
Your lawn. Ohio Agr. Ext. Bul. 271:1-8. 1946.

APPENDIX

Table 4. Chemical composition of bermuda grass as affected by nitrogen fertilization and various heights and dates of clipping at Stillwater, Oklahoma. 1948.

N. Treatment lbs./A	Date Clipped	Green Yield lbs./A	Percentage Moist.	Ash	N.	Prot.	Ca.	P.
			Low clipped (five-eighths inch)					
0	5-12	2,269	69.60	6.70	3.07	19.18	0.76	0.09
	6-2	2,798	77.90	5.90	2.68	16.75	0.50	0.20
	6-17	1,543	71.20	8.10	1.68	10.50	0.50	0.20
	6-28	1,377	68.50	8.20	2.25	14.06	0.36	0.19
	7-13	1,739	67.20	8.50	2.58	16.12	0.40	0.22
	7-21	1,271	71.50	8.90	2.51	15.69	0.42	0.23
	7-31	1,316	71.00	9.00	1.77	11.06	0.55	0.23
	8-13	1,210	70.50	8.45	2.42	15.13	0.41	0.17
	8-21	1,119	70.70	10.90	2.77	17.31	0.41	0.20
	9-3	998	67.60	9.40	2.16	13.50	0.43	0.23
50	5-12	2,133	73.00	7.20	2.98	18.62	0.71	0.08
	6-2	3,554	66.40	5.90	2.83	17.68	0.54	0.19
	6-17	1,830	72.00	7.90	1.97	12.31	0.57	0.19
	6-28	1,346	67.90	7.70	2.55	15.94	0.38	0.18
	7-13	1,467	66.80	8.00	2.45	15.31	0.46	0.21
	7-21	1,301	71.40	7.90	2.34	14.63	0.35	0.23
	7-31	1,089	69.00	7.80	2.04	12.75	0.54	0.22
	8-13	1,074	71.00	7.90	2.23	13.94	0.41	0.16
	8-21	877	69.70	9.60	2.66	16.62	0.40	0.19
	9-3	696	66.60	8.60	2.17	13.56	0.42	0.22
100	5-12	4,659	76.60	6.75	2.55	15.93	0.68	0.12
	6-2	4,728	76.30	5.00	2.33	14.56	0.55	0.19
	6-17	1,432	72.10	7.90	1.90	11.88	0.49	0.20
	6-28	1,561	69.90	9.00	2.38	14.88	0.38	0.21
	7-13	1,996	69.30	8.21	2.53	15.81	0.40	0.21
	7-21	1,649	71.30	8.40	2.44	15.25	0.35	0.20
	7-31	1,225	69.70	7.80	1.65	10.31	0.52	0.23
	8-13	1,361	72.60	8.10	2.20	13.75	0.40	0.18
	8-21	1,119	70.90	11.00	2.60	16.25	0.34	0.19
	9-3	892	67.30	9.60	1.76	11.00	0.40	0.24
150	5-12	3,010	72.90	7.05	2.76	17.25	0.83	0.10
	6-2	5,974	76.00	9.80	2.67	16.70	0.56	0.21
	6-17	2,057	73.30	8.20	2.07	12.94	0.55	0.20
	6-28	1,528	63.50	8.50	2.37	14.81	0.36	0.20
	7-13	2,072	69.10	7.90	2.51	15.69	0.41	0.23
	7-21	1,271	71.90	8.50	2.55	15.94	0.40	0.23
	7-31	1,150	68.60	7.90	1.69	10.56	0.54	0.22
	8-13	1,271	71.40	7.70	2.26	14.13	0.35	0.17
	8-21	1,134	70.30	9.30	2.59	16.19	0.39	0.17
	9-3	862	67.70	9.50	2.17	13.56	0.37	0.22

Table 4. (cont.)

N Treatment lbs./A	Date Clipped	Green Yield lbs./A	Percentage Moist.	Ash	N.	Prot.	Ca.	P.
			Medium clipped (1 inch)					
0	5-12	212	63.02	7.03	3.09	19.31	0.72	0.08
	6-2	1,700	68.90	9.00	2.33	14.56	0.60	0.20
	6-17	1,346	71.90	7.00	1.68	10.50	0.45	0.20
	6-28	1,119	69.40	7.90	2.20	13.75	0.36	0.17
	7-13	1,513	68.20	6.92	2.68	16.75	0.34	0.20
	7-21	1,361	70.30	8.30	2.56	16.00	0.35	0.21
	7-31	953	69.10	7.10	1.66	10.38	0.48	0.21
	8-13	1,240	71.30	8.10	2.24	14.00	0.46	0.16
	8-21	802	69.70	9.90	2.70	16.88	0.40	0.20
	9-3	726	67.20	9.05	1.66	10.38	0.41	0.21
50	5-12	454	67.40	7.95	2.39	14.93	0.67	0.08
	6-2	3,137	75.40	9.80	2.44	15.25	0.37	0.17
	6-17	1,528	72.20	7.30	1.76	11.00	0.48	0.21
	6-28	1,331	69.20	7.90	2.28	14.25	0.36	0.17
	7-13	1,634	68.80	7.70	2.37	14.81	0.39	0.20
	7-21	1,119	71.10	8.30	2.47	15.44	0.37	0.24
	7-31	943	69.60	7.80	1.65	10.31	0.52	0.22
	8-13	1,195	72.00	7.90	2.30	14.38	0.39	0.17
	8-21	983	70.00	9.90	2.53	15.81	0.43	0.22
	9-3	756	67.30	8.70	2.25	14.06	0.40	0.24
100	5-12	1,286	67.80	7.50	2.55	15.93	0.80	0.07
	6-2	4,538	76.30	10.20	2.61	16.31	0.53	0.21
	6-17	1,906	74.50	7.90	1.92	12.00	0.54	0.20
	6-28	1,437	70.70	8.40	2.55	15.94	0.40	0.17
	7-13	1,169	65.40	7.90	2.45	15.31	0.41	0.21
	7-21	1,422	70.10	8.10	2.73	17.06	0.43	0.23
	7-31	1,059	69.50	8.50	1.84	11.50	0.54	0.23
	8-13	1,301	71.30	8.40	2.48	15.50	0.46	0.18
	8-21	968	69.90	9.60	2.67	16.69	0.40	0.21
	9-3	938	68.00	9.90	2.08	13.00	0.44	0.23
150	5-12	1,513	66.80	7.80	2.59	16.10	0.66	0.06
	6-2	4,008	74.10	9.60	2.43	15.19	0.46	0.21
	6-17	2,042	73.60	7.60	2.05	12.81	0.52	0.21
	6-28	1,300	63.60	8.10	2.45	15.31	0.40	0.17
	7-13	1,815	67.80	7.80	2.58	16.12	0.40	0.22
	7-21	1,437	70.40	8.60	2.68	16.75	0.43	0.22
	7-31	1,240	69.40	8.40	1.80	11.25	0.53	0.22
	8-13	1,422	71.00	8.00	2.46	15.38	0.44	0.17
	8-21	1,134	69.90	9.30	2.77	17.31	0.38	0.21
	9-3	1,013	66.50	9.20	1.65	10.31	0.45	0.23

Table 4. (cont.)

N Treatment lbs./A	Date Clipped	Green Yield lbs./A	Moist	Ash	Percentage N.	Prot.	Ca.	P.
			High clipped (2 inches)					
0	6-2	1,180	73.78	8.60	2.73	13.31	0.73	0.19
	6-17	847	68.90	6.60	1.49	9.31	0.43	0.18
	6-28	892	69.50	7.30	2.18	13.63	0.38	0.16
	7-13	1,316	67.60	7.20	2.63	16.44	0.42	0.20
	7-21	1,376	69.90	7.80	2.28	14.25	0.40	0.22
	7-31	1,029	68.60	7.60	1.45	9.06	0.52	0.22
	8-13	711	73.10	7.70	2.25	14.06	0.43	0.17
	8-21	908	68.00	9.00	2.46	15.38	0.38	0.20
	9-3	666	66.20	8.20	1.67	10.44	0.39	0.20
50	6-2	1,815	73.30	8.60	2.38	14.87	0.79	0.22
	6-17	1,301	70.90	6.70	1.25	7.80	0.44	0.19
	6-28	983	62.10	8.00	2.31	14.44	0.37	0.18
	7-13	1,331	66.00	7.30	2.12	13.25	0.39	0.22
	7-21	1,346	69.30	7.90	2.35	14.69	0.40	0.22
	7-31	1,165	67.90	7.90	1.27	7.94	0.53	0.20
	8-13	847	72.90	8.40	2.18	13.63	0.45	0.16
	8-21	787	67.90	9.50	2.28	14.25	0.38	0.17
	9-3	696	66.00	8.00	1.66	10.38	0.42	0.22
100	6-2	3,176	70.20	9.40	2.63	16.44	0.79	0.22
	6-17	1,392	70.60	6.70	1.85	11.56	0.50	0.19
	6-28	1,044	63.20	8.10	2.49	15.56	0.40	0.18
	7-13	1,709	67.60	7.60	2.23	13.94	0.39	0.20
	7-21	1,331	70.00	8.00	2.11	13.19	0.42	0.22
	7-31	1,240	67.80	8.10	1.37	8.56	0.53	0.21
	8-13	1,210	72.60	7.90	2.33	14.56	0.41	0.17
	8-21	847	68.70	9.20	2.50	15.63	0.41	0.19
	9-3	847	67.10	8.00	2.14	13.38	0.38	0.23
150	6-2	3,252	72.36	9.40	2.43	15.19	0.81	0.20
	6-17	1,420	71.40	7.00	2.08	13.00	0.56	0.21
	6-28	1,322	67.20	8.60	2.53	15.81	0.40	0.15
	7-13	1,785	67.80	7.50	2.54	15.88	0.35	0.20
	7-21	1,543	70.00	8.30	2.56	16.00	0.42	0.22
	7-31	1,089	68.00	8.30	1.72	10.75	0.56	0.32
	8-13	1,286	72.60	7.50	2.16	13.50	0.44	0.15
	8-21	998	68.60	8.70	2.44	15.25	0.38	0.19
	9-3	832	65.00	8.60	1.76	11.00	0.42	0.23

Table 5. Chemical composition of buffalo grass as affected by nitrogen fertilization and various clipping heights and dates of clipping at Stillwater, Oklahoma. 1948.

N Treatment lbs./A	Date Clipped	Green Yield lbs./A	Percentage Moist.	Ash	N.	Prot.	Ca.	P.
			Low clipped (five-eighths inch)					
0	5-21	632	64.20					
	6-15	283	57.30	5.10	1.71	10.69	0.52	0.10
	6-30	436	53.50	6.00	1.70	10.62	0.51	0.16
	7-15	218	64.70	6.60	1.75	10.94	0.42	0.17
	7-22	915	58.80	7.20	1.82	11.38	0.36	0.16
	8-2	327	57.60	7.10	1.82	11.38	0.43	0.12
	8-17	348	62.60	7.50	2.02	12.63	0.34	0.10
	8-25	272	54.60	7.30	1.74	10.88	0.40	0.19
50	5-21	1,133	66.70	7.00	1.62	10.13	0.85	0.17
	6-15	348	59.70	7.20	1.90	11.88	0.56	0.12
	6-30	534	56.70	7.00	2.72	17.00	0.40	0.16
	7-15	534	62.70	7.00	1.77	11.06	0.46	0.18
	7-22	1,002	61.40	6.90	1.87	11.69	0.33	0.16
	8-2	305	38.70	6.60	2.03	12.69	0.46	0.12
	8-17	414	66.40	6.30	2.10	13.13	0.41	0.11
	8-25	261	58.70	6.90	1.66	10.38	0.41	0.17
100	5-21	1,634	67.50	6.70	2.40	15.00	0.70	0.16
	6-15	468	53.40	6.80	2.07	12.94	0.63	0.09
	6-30	751	60.30	9.00	2.54	15.88	0.39	0.14
	7-15	534	64.20	7.00	1.71	10.69	0.37	0.17
	7-22	1,209	64.00	7.20	2.01	12.56	0.35	0.15
	8-2	436	58.30	6.70	2.02	12.63	0.42	0.12
	8-17	610	65.80	6.50	2.31	14.44	0.39	0.10
	8-25	348	59.40	7.50	1.59	9.94	0.39	0.18
150	5-21	1,470	69.80	6.90	2.48	15.50	0.67	0.16
	6-15	599	54.30	7.40	2.02	12.63	0.47	0.10
	6-30	947	61.90	6.00	2.69	17.00	0.35	0.13
	7-15	653	66.70	6.20	1.96	12.25	0.35	0.16
	7-22	1,340	64.60	6.90	2.10	13.13	0.36	0.14
	8-2	490	59.40	6.40	2.18	13.63	0.40	0.12
	8-17	871	68.30	6.70	2.42	15.13	0.37	0.09
	8-25	446	61.30	7.00	2.04	12.75	0.40	0.16

Table 5. (cont.)

N Treatment lbs./A	Date Clipped	Green Yield lbs./A	Percentage Moist.	Ash	N.	Prot.	Ca.	P.
			Medium clipped (1 inch)					
0	5-21	457	62.90	7.50	1.71	10.69	0.84	0.16
	6-15	172	65.70	5.00	1.49	9.31	0.79	0.16
	6-30	98	53.10	7.00	2.16	13.50	0.46	0.16
	7-15	249	64.20	7.20	1.67	10.44	0.42	0.16
	7-22	555	59.10	6.80	1.73	11.81	0.35	0.16
	8-2	240	57.30	6.90	1.87	11.69	0.38	0.13
	8-17	261	62.80	6.60	2.91	18.19	0.38	0.09
	8-25	185	57.20	7.40	2.04	12.75	0.40	0.16
50	5-21	806	65.00	6.70	2.07	13.94	0.83	0.17
	6-15	250	51.40	6.40	1.64	10.25	0.60	0.12
	6-30	272	57.50	6.00	2.36	14.75	0.40	0.15
	7-15	479	62.20	6.40	1.54	9.63	0.37	0.16
	7-22	697	59.50	6.70	1.87	11.69	0.32	0.16
	8-2	249	57.60	6.80	1.81	11.31	0.44	0.11
	8-17	338	64.30	6.50	2.04	12.75	0.42	0.10
	8-25	261	56.90	6.80	1.66	10.38	0.43	0.11
100	5-21	915	68.20	6.30	2.08	13.00	0.89	0.16
	6-15	266	51.10	5.06	1.96	12.25	0.63	0.10
	6-30	348	59.50	7.30	2.48	15.50	0.74	0.15
	7-15	566	62.10	5.90	1.87	11.69	0.40	0.16
	7-22	795	59.80	6.70	1.89	11.81	0.39	0.14
	8-2	338	55.20	6.50	1.98	12.38	0.46	0.10
	8-17	403	63.90	6.40	2.16	13.50	0.38	0.11
	8-25	305	58.70	6.70	1.66	10.38	0.41	0.17
150	5-21	1,056	66.20	6.80	2.39	14.94	0.82	0.16
	6-15	348	51.10	6.30	2.58	16.12	0.43	0.17
	6-30	545	63.40	6.60	2.75	17.19	0.89	0.12
	7-15	832	62.50	6.50	2.01	12.56	0.37	0.16
	7-22	849	62.60	6.40	2.19	13.69	0.36	0.15
	8-2	370	59.70	6.10	2.16	13.50	0.44	0.11
	8-17	566	66.80	6.60	2.38	14.88	0.39	0.09
	8-25	359	60.30	6.70	1.96	12.25	0.40	0.17

Table 5. (cont.)

N Treatment lbs./A	Date Clipped	Green Yield lbs./A	Moist.	Ash	Percentage N.	Prot.	Ca.	P.
			High clipped (2 inches)					
0	5-21	54	58.37	8.30	1.78	11.13	0.95	0.20
	6-15	87	65.25	5.40	1.66	10.38	0.94	0.18
	6-30	22	60.23	7.80	2.40	15.00	0.54	0.13
	7-15	78	63.47	6.90	1.70	10.63	0.48	0.18
	7-22	316	59.60	7.00	1.74	10.88	0.53	0.15
	8-2	131	55.60	7.30	1.61	10.08	0.53	0.12
	8-17	155	61.00	6.70	2.94	18.44	0.46	0.11
	8-25	107	57.75	7.30	1.60	10.00	0.51	0.19
50	5-21	111	64.70	6.70	2.40	15.00	0.70	0.16
	6-15	170	66.00	6.40	2.07	12.94	0.91	0.09
	6-30	57	64.30	6.50	2.54	15.88	0.39	0.14
	7-15	224	69.93	7.00	1.71	10.69	0.37	0.17
	7-22	512	63.90	7.20	2.01	12.56	0.35	0.15
	8-2	198	60.84	6.70	2.02	12.63	0.42	0.12
	8-17	272	67.20	6.50	2.31	14.44	0.39	0.10
	8-25	170	62.04	7.50	1.59	9.94	0.39	0.18
100	5-21	163	64.34	7.00	2.41	15.06	1.02	0.18
	6-15	209	58.71	8.00	1.79	11.19	1.00	0.12
	6-30	72	59.48	5.00	2.52	15.75	0.62	0.12
	7-15	283	64.10	6.10	1.73	10.81	0.38	0.13
	7-22	534	59.80	6.40	1.88	11.75	0.35	0.13
	8-2	220	54.51	6.40	1.88	11.75	0.43	0.10
	8-17	253	63.46	6.00	2.20	13.75	0.39	0.09
	8-25	185	58.81	6.90	1.69	10.56	0.39	0.16
150	5-21	194	59.97	7.40	1.79	11.19	0.94	0.18
	6-15	272	63.40	5.70	2.30	14.37	0.99	0.12
	6-30	96	64.18	7.00	2.16	13.50	0.46	0.16
	7-15	436	68.20	6.90	1.72	10.75	0.39	0.15
	7-22	545	63.50	6.70	1.74	10.88	0.38	0.13
	8-2	261	51.75	6.40	1.95	12.19	0.51	0.10
	8-17	425	68.40	6.40	2.02	12.63	0.43	0.09
	8-25	257	62.24	7.10	1.56	9.75	0.51	0.15

TYPED BY: FLORENE E. ADAMS