COMPOSITION OF PASTURE GRASS AS INFLUENCED BY SOIL TYPE AND FERTILIZER TREATMENT

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COMPOSITION OF PASTURE GRASS AS INFLUENCED BY SOIL TYPE AND FERTILIZER TREATMENT

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COMPOSITION OF PASTURE GRASS AS INFLUENCED BY SOIL TYPE AND FERTILIZER TREATMENT

Introduction

Pasture fertilization experiments in America have dealt mainly with total yields of herbage. There seems to be a decided lack of information regarding the composition and nutritional value of pasture herbage as influenced by the kind of soil and soil conditions and by fertilization. Inasmuch as the feeding value of pasturage, as well as yield, is of great interest to the progressive animal husbandman and is deserving of thoughtful consideration in any intelligent pasture management program, this investigation was conducted with the object of collecting such data.

Scope of Investigation

This paper reports some differences in the chemical composition of native pasture herbage during May and June of 1930, due to soil type and analysis of fertilizer applied as a top dressing.

Review of Literature

I. Water Content of Herbage

Greenhill (8)[1] showed that green herbage from intensively fertilized plots contained a markedly lower percentage dry matter (that is, a greater percentage water) than herbage from unfertilized plots. Archibald and Nelson (1) obtained similar findings.

Enlow and Coleman (5) made monthly applications of nitrogen, together with plenty of water from overhead irrigation, to Bahia and centipede grasses. When only one cutting was taken during the season the water-dry matter ratio was greatly increased with both grasses. At the same time the yields were increased ten to fourteen times those of the untreated plots, undoubtedly due largely to the fact

[1]Reference to literature cited.

that the untreated plots received no water except rain. When frequent clippings were made, the water-dry matter ratio was increased in Bahia grass and decreased in centipede grass; that is, the ratio was not always increased by nitrogen treatments when several cuttings were taken.

McCool and Cook (9) in greenhouse studies on small grains applied fertilizers when the plants were about six inches high and determined their water content at various periods during the next four weeks. From their data it is apparent that urea and sodium nitrate applied to oats, and ammonium phosphate and sodium nitrate applied to barley increased the water-dry matter ratio somewhat. With wheat, the water-dry matter ratio was much smaller than with barley or oats, and the differences due to fertilizer treatment were apparently too small to be significant.

Crist (3) in garden studies on mineral soils with lettuce, spinach, radish and beets, found that application of fertilizers increased the water-dry matter ratio in the tops; roots of radish and beets were investigated also, and it was found that in these also the water-dry matter ratio was increased by the fertilizers. Sodium nitrate and potassium chloride were more effective in increasing the water-dry matter ratio than was acid phosphate.

When lettuce was grown in muck-sand mixtures in the greenhouse, PK[1] fertilizers increased the water-dry matter ratio. Liming to fractions of the lime requirement which, as determined by the Jones method, was 51,480 pounds CaO per acre caused a depression of the water-dry matter ratio below that of the untreated lettuce. PK fertilizers applied with lime treatments up to 100 per cent of the lime requirement maintained an increased water-dry matter ratio over that of the untreated lettuce;

[1] For convenience, the letters N, P, and K will be used for nitrogen, phosphate, and potash fertilizers, respectively.

greater lime application, to 125 and 150 per cent of the lime requirement, when applied with PK fertilizers, caused the water-dry matter ratio to decrease below that of the untreated lettuce. These large applications of lime seemed to offset the effect of the fertilizers.

II. Crude Protein

Barnes (2) showed that topdressing pasture with phosphates and lime increased the crude protein production per acre five or six times. This great increase was evidently due very largely to the increased proportion of clovers in the herbage. Percentage crude protein in the dry herbage was not changed more than one or two per cent, in case the untreated herbage contained about twenty per cent.

Gardner et al (6) showed that nitrogen applications increased the percentage of protein and also total protein per acre all during the pasture season. His results show that nitrogen increased the percentage protein in the dry matter of clovers, weeds and grass. There was generally a marked difference in the protein percentage of the three groups of the herbage--clovers were highest, weeds intermediate, and grasses lowest.

Enlow and Coleman (5) in Florida with Bahia, carpet and centipede grasses maintained a higher percentage of nitrogen in the dry grass and a greater total nitrogen content per acre yield by monthly applications of nitrogen with plenty of water for optimum growth supplied from overhead irrigation.

III. Phosphorus and Calcium

Increases in phosphorus percentages in pasturage were observed by Roloff (10) in 1869 following applications of bonemeal, and by Pasturel (10) in 1911 following applications of slag and lime. Bonnetal and Touchard (10) in 1903 by application of phosphate fertilizers increased the percentage of phosphorus.

Richardson (10) in 1924 in his comprehensive pasture experiments in Australia observed great increases in the percentages of calcium and phosphorus from fertilization with superphosphate and lime. Lime and superphosphate applied together resulted in slightly smaller calcium and phosphorus percentages than where superphosphate was applied alone. However, the total yield of herbage, and consequent total weight of calcium and phosphorus in the herbage per acre, was considerably greater where the two treatments were applied.

Richardson doubled the percentage phosphorus in grasses, clovers, trefoils and weeds by manuring with phosphates. The per cent increase was about the same for all these groups of the herbage.

Godden (7,10) in 1926 showed that effects of mineral fertilizers on increasing the mineral content of pasture herbage is most marked on poor soils. Lime and superphosphate application on rich cultivated soil did not produce an increase in phosphorus percentage and produced a very much smaller increase in calcium percentage than similar applications on poor moorland soil. Godden states "There are two factors concerned in this correlation between soil and herbage. A rich soil favors the spread of those species which are naturally rich in minerals, and also tends to enrich the individual plant whatever its species."

Barnes (2) found that fertilization with superphosphate and lime on five soils did not always increase the calcium and phosphorus percentages. On only three soils was the phosphorus percentage increased, and on four the calcium percentage was increased. On the other soils, decreases were observed.

Cruickshank, (4) reporting seasonal variations in untreated pasture herbage, states that the calcium-phosphorus ratio is quite variable.

Description of Experimental Fields

Experimental plots were located on three soil types. The accompanying table gives the main soil characteristics, fertilization and liming rates, size of plots, and other miscellaneous information about the projects.

Field Name	Weberville	Oakley	Riggs
Soil Type	Fox sandy loam	Napanee silt loam	Miami loam
Drainage	good	poor	good
Water holding capacity	low	high	high
Topography	gentle regular slope	level	irregular slope
Acidity of surface soil	strongly acid	medium acid	medium acid
Stones	none	very stony	none
Rate Fertilization	500 lbs.	500 lbs.	300 lbs.
Rate Limestone	4000 lbs (1930)	none	5000 lbs. (1928)
Size of Plot: area fertilized	2x8 rods	2x8 rods	0.01 acre
Area harvested	1 square rod	1 square rod	0.01 acre
Year project started	1930	1930	1928
Previous pasturing system	sheep--heavily pastured	cows--heavily pastured	cows--lightly pastured-clipped 1928, 1929
Weeds	few	few	many

At Weberville the plots were laid out in a single row with the long dimension of each plot bounding the adjacent plot. The south end of all the plots sloped gently toward a creek about 75 yards distant.

At Oakley the plots were laid out similarly to those at Weberville, except the plots were arranged in two parallel rows of five plots each. The topography was level.

The plots at Riggs consist of two parallel series of 22 plots each. One series received 5000 pounds limestone per acre in 1928. The general slope of the land is from the limed series to the unlimed series. The

slope is somewhat irregular in places, especially in the unlimed series. The lower third or fourth of the unlimed plots is low lying bottom soil and is noticeably moister in a dry period than is the soil higher on the slope.

Botanical Composition of the Herbage

Grass from the plots, except in the case of some of the plots on Miami loam at Riggs which were especially high in weeds, constituted eighty per cent or more of the total air dry herbage, and was mainly Kentucky bluegrass. On the Napanee silt loam at Oakley there was considerable timothy, particularly on the fertilized plots; also, on the Miami loam soil, a grass resembling timothy was present in considerable amount.

On the Miami loam plots at Riggs there were several varieties of weeds, with silver cinquefoil, sheep sorrel, dandelion, plantain and red clover occurring most abundantly.

On the Fox sandy loam plots at Weberville there was considerable sheep sorrel in the herbage, and also some plantain and a very few plants of silver cinquefoil, as well as some other weeds.

On the Napanee silt loam at Oakley, there were so very few weeds that no observations on them were made.

Fertilizers and Lime

Mixed commercial fertilizers were applied at Weberville and Oakley; hence the ingredients used are not known. The fertilizers for the Riggs project were mixed in the laboratory; and the carriers used were Chilean nitrate of soda, 20 per cent superphosphate, and 50 per cent potassium chloride. Limestone was used as the source of lime.

The fertilizers and limestone were applied by hand. The limestone was applied at Riggs in the spring of 1928, and the fertilizers

were applied annually in the springs of 1928, 1929 and during the last week of March in 1930. The fertilizers and limestone were applied at Weberville and Oakley during the first half of April in 1930.

Experimental Methods

I. Management of the Projects During the Season.

The Riggs and Weberville projects were fenced so that no stock could get on those portions of the plots which were cut for yields. At Oakley, however, cows were turned out into the field May 11, before the fence was erected and two days before the first cutting was taken. The cows had obviously eaten heavily from the fertilized plots, but apparently had hardly touched the untreated herbage. Since the pasture was grazed for about two weeks longer before the fence was erected, one cutting less was taken than would otherwise have been necessary. The effects of grazing at Oakley make comparisons of yields from the fertilized plots at least for the first cutting, meaningless, but probably do not alter appreciably the chemical analyses.

II. Sampling in the Field.

The herbage was cut with a hand lawn mower, fitted with an attached carrier in which the cutting was collected. In some cases it was necessary to cut the weeds with a scythe. This procedure was most necessary at the first cutting at Riggs. The entire cutting was dumped on a canvas six by six feet square and weighed with a spring scale. It was then mixed by hand, and spread out as thinly as the size of the canvas permitted. Five or six small handfuls, totalling enough for a 100-gram sample, were collected from various portions of the pile. These were placed in a small paper bag and weighed on a small two-pan balance, which was protected from the wind to avoid inaccuracy in weighing.

III. Preparation of Samples for Analysis.

The samples were allowed to air dry in a well ventilated laboratory, with the tops of the bags open and with the herbage well loosened. After thirty days dry weights were taken. The grasses were then separated by hand and weighed separately. All other herbage was considered as weeds, and was estimated by difference between the weight of total herbage and that of the grasses. Clovers were not estimated since there were none at Weberville or Oakley, and only a few scattering red clover plants on some of the plots at Riggs. The air dry grass was ground fine in a Wiley grinder and uniformly mixed before samples were taken for chemical analyses.

IV. Chemical Methods.

Water in the air dry grass was determined by overnight heating at 105° C. Nitrogen was determined by the Gunning method and crude protein calculated by multiplying nitrogen by 6.25. Ash was determined by overnight ignition in the electric furnace at barely dull red heat. Calcium and phosphorus in the ash were determined--the former by the O. A. A. C. 1925 tentative method for plant material and the latter by the volumetric molybdate method.

V. Basis of Reporting Analyses.

Water content is reported on the basis of the total oven dry herbage. Crude protein, calcium, and phosphorus are reported on the basis of oven dry grass.

EXPERIMENTAL

PART I--WATER AND DRY MATTER CONTENT OF HERBAGE

The estimation of the water content of the herbage involved two separate determinations--air dry weight of the total herbage and oven dry weight of the grass portion only. The water content of the air dry weeds was assumed to be approximately the same as that of the air dry grass, and the water content of the entire air dry herbage was calculated from determinations on the air dry grass only. This assumption would seem to introduce no large error for two reasons:First, the lowest proportion grass-weeds in the air dry herbage for the season at Weberville was 5.5-1; at Oakley, 6.4-1; at Riggs, 1.07-1. The Riggs plots were very weedy as compared with the other fields. This was especially true of the plots receiving 10-6-4 fertilizer, which were located on a portion of the field which was naturally very weedy. The next lowest grass-weeds plot at Riggs was 2.04-1, and the highest was 6.75-1. Thus, weeds constituted a relatively small proportion of the herbage except at Riggs. Second, from 95 to 98 per cent of the total water content of the green herbage was lost by air drying for thirty days. For any particular cutting this percentage of water lost from the herbage of the untreated or treated plots by air drying seldom varied more than 1 per cent and in no case was the variation as much as 2 per cent. Thus, only about 5 per cent of the water of the green herbage remained after air drying; and only this 5 per cent is concerned in the assumption that air dry grass and air dry weeds contain approximately the same percentage of water.

I. The Effect of Soil Type on the Total Water-Dry Matter Ratio and Dry Yields of Herbage for May and June Cuttings.

Tables 1, 2, and 3 give the total water and dry matter content of

Table 1.

Weberville: Fox Sandy Loam

Water and dry matter content of herbage at time of cutting; totals for two cuttings, May 27 and June 25.

Fertilizer Treatment	Plot No.	Lbs. per Acre		Per cent water in green herbage	Water-dry herbage ratio
		Oven dry herbage	Water in green herbage		
None	7	291	653	69.2	2.24
None	4	339	797	70.2	2.35
0-10-0	1	345	823	70.5	2.39
L-0-10-0	2	304	672	68.8	2.21
L-0-10-10	3	526	1330	71.7	2.53
5-10-5	9	561	1359	70.7	2.42
L-5-10-5	8	479	1185	71.2	2.47
L-10-10-5	6	801	2095	72.4	2.62
L-5-10-10	5	833	2383	74.1	2.86

Table 2

Oakley: Napanee Silt Loam

Water and dry matter content of herbage at time of cutting; totals for two cuttings, May 13 and June 27.

Fertilizer Treatment	Plot No.	Lbs. per Acre		Per cent water in green herbage	Water-dry herbage ratio
		Oven dry herbage	Water in green herbage		
None	1	216	552	71.9	2.56
None	5	231	601	72.2	2.60
None	8	329	887	73.0	2.70
0-10-0	2	212	588	73.5	2.77
0-10-0	10	283	821	74.4	2.90
0-10-10	3	220	676	75.4	3.07
5-10-5	9	264	856	76.4	3.24
5-10-5	6	298	982	76.8	3.30
10-10-5	7	257	879	77.4	3.42
5-10-10	4	280	1000	78.2	3.57

Table 3.

Riggs: Miami Loam

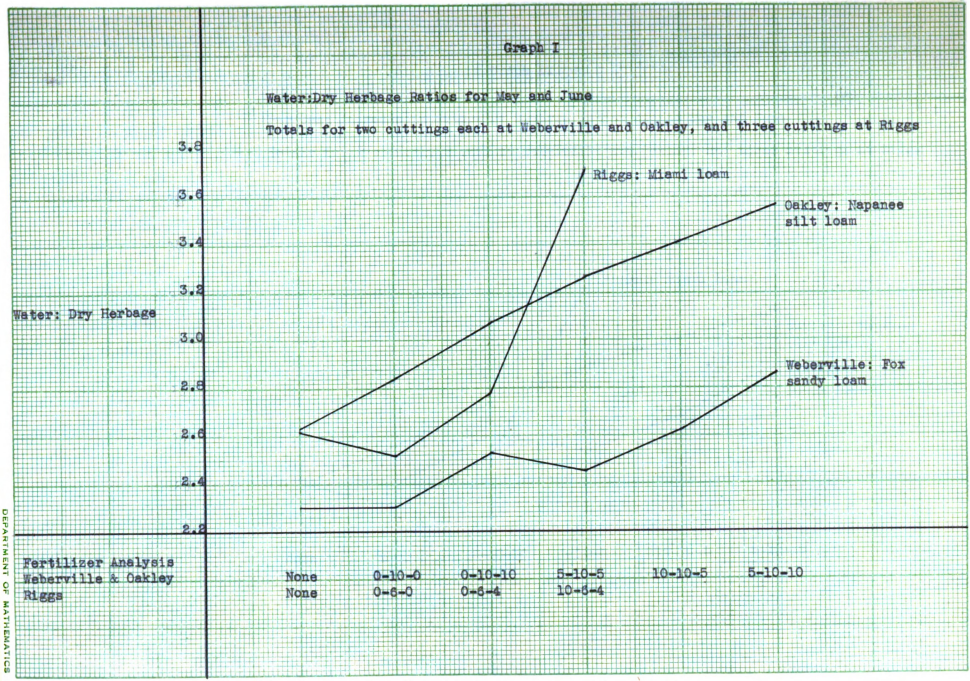
Water and dry matter content of herbage at time of cutting; totals for three cuttings, May 21, June 10, and July 2.

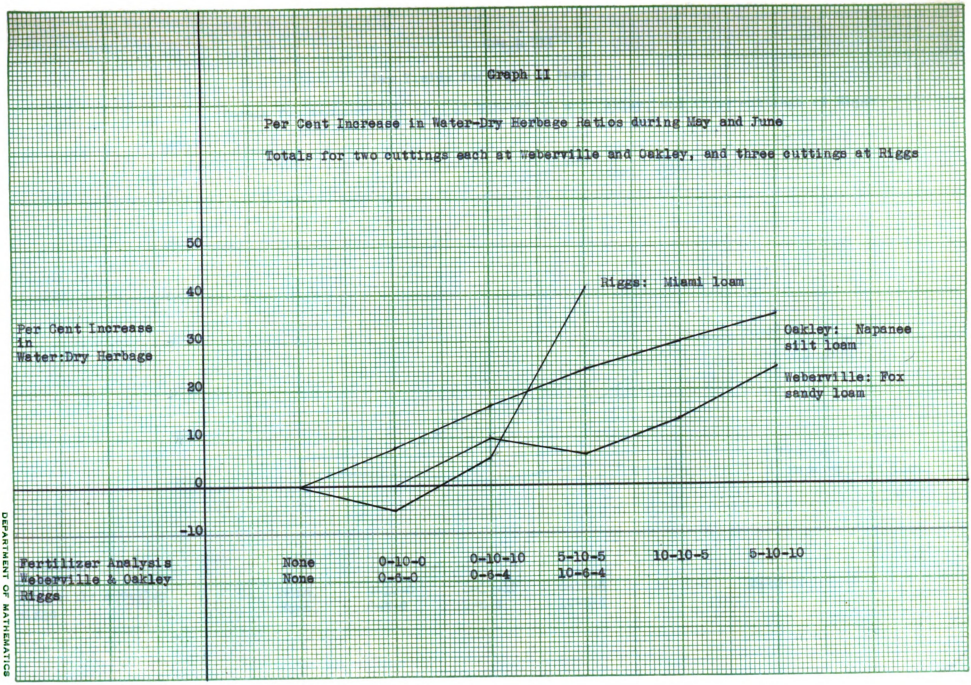
Fertilizer Treatment	Plot No.	Lbs. per Acre		Per cent water in green herbage	Water-dry herbage ratio
		Oven dry herbage	Water in green herbage		
None	116	1118	3132	73.7	2.80
0-6-0	118	958	2572	72.8	2.68
0-6-4	115	1609	4677	74.5	2.91
10-6-4	106	1628	6292	79.4	3.86
L	216	1031	2509	70.9	2.43
L+0-6-0	218	1120	2660	70.4	2.38
L+0-6-4	215	1248	3262	72.3	2.61
L+10-6-4	206	1519	5391	78.0	3.55

Graph I

Water:Dry Herbage Ratios for May and June

Totals for two cuttings each at Weberville and Oakley, and three cuttings at Riggs

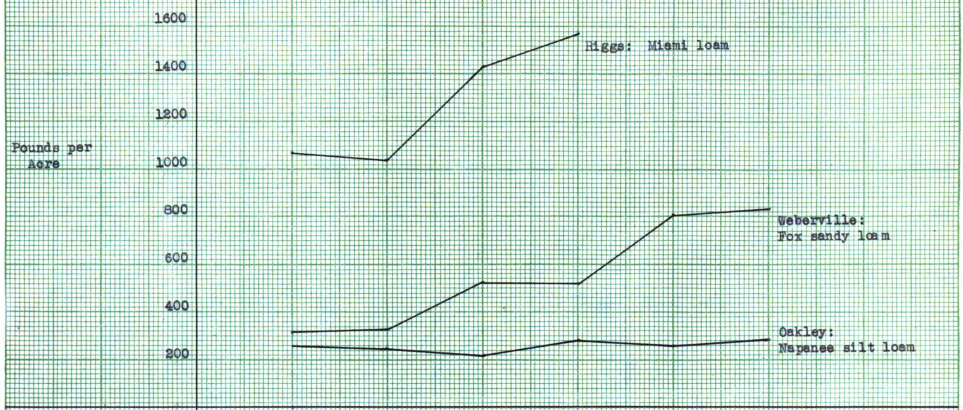


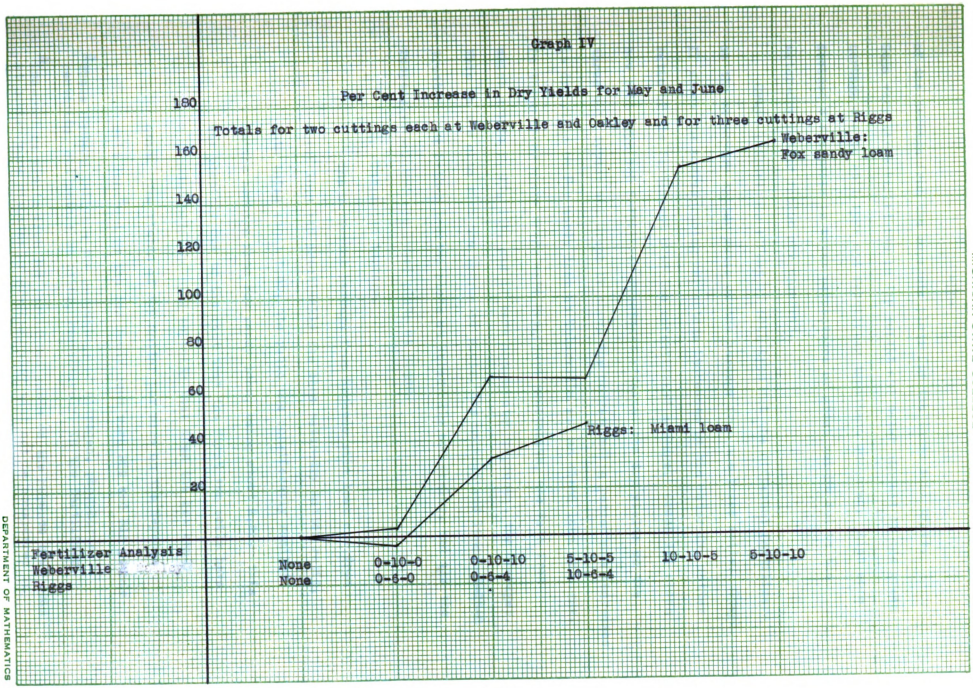

Graph II
Per Cent Increase in Water-Dry Herbage Ratios during May and June
Totals for two cuttings each at Weberville and Oakley, and three cuttings at Riggs
Per Cent Increase in Water:Dry Herbage
50
40
30
20
10
0
-10
Riggs: Miami loam
Oakley: Napanee silt loam
Weberville: Fox sandy loam
Fertilizer Analysis
Weberville & Oakley
Riggs
None
None
0-10-0
0-5-0
0-10-10
0-6-4
5-10-5
10-6-4
10-10-5
5-10-10

Graph III

Dry Yields for May and June

Totals for two cuttings each at Webervile and Oakley, and three cuttings at Riggs




Graph IV
Per Cent Increase in Dry Yields for May and June
Totals for two cuttings each at Weberville and Oakley and for three cuttings at Riggs
180
160
140
120
100
80
60
40
20
Weberville:
Fox sandy loam
Riggs: Miami loam
Fertilizer Analysis
Weberville
Riggs
None
None
0-10-0
0-6-0
0-10-10
0-6-4
5-10-5
10-6-4
10-10-5
5-10-10

of the herbage from the separate plots for the three soil types. Some very large variations in dry weight and water content of the green herbage due to soil type and fertilizer treatment occurred. Also some decided differences in water percentages of green weight and in the water-dry matter ratios are apparent.

Graph I shows the effect of soil type and the different fertilizers on the water-dry matter ratio of the herbage from the three soils. Graph II shows the corresponding percentage increases in the water-dry matter ratio of the fertilized over the unfertilized herbage. Graph III shows how soil type and fertilizer treatment affected the dry yields on the three soil types; and Graph IV shows the corresponding percentage increases in dry yield on Fox sandy loam at Weberville and on Miami loam at Riggs. In those cases where there were duplicate treatments, the data from which graphs I, II, III, and IV were constructed represent the averages. This is the case with the untreated plots, the unlimed and limed--0-10-0 treated, the 5-10-5 treated plots at Weberville and Oakley, and all the respective unlimed and limed plots at Riggs.

A. Untreated Herbage.

The untreated herbage from Napanee silt loam and from Miami loam had practically the same water-dry matter ratio, both being about 2.60; the ratio was considerably smaller in the herbage from Fox sandy loam, being about 2.25. This was possibly due to the fact that the first two soils have a greater water holding capacity than does the Fox sandy loam. The yields of dry matter per acre on the Napanee silt loam[2] and on the Fox sandy loam were 259 and 315 pounds

[1] These numbers indicate the percentage of nitrogen, phosphorus, pentoxide, and potassium oxide, respectively, in the fertilizer.

[2] Inasmuch as yields from the fertilized plots on the Napanee silt loam at Oakley were vitiated by grazing, they will not be considered in further discussion.

per acre, respectively. On the Miami loam the dry yields of the untreated plots were more than three times as great, being more than 1000 pounds per acre. The relatively low yields on the Napanee silt loam and on the Fox sandy loam were likely due largely to poor drainage on the former soil type and to low nutrient supply on the latter.

B. Fertilized Herbage.

1. Phosphate Treatment.

Of all the fertilizer treatments, phosphate was the only one which did not consistantly increase the water-dry matter ratio. Phosphate fertilizer increased the water-dry matter ratio at Oakley, decreased it at Riggs, and did not alter it at Weberville.

Phosphate treatment appeared not to cause any Marked variation in the dry yields.

2. PK Treatment.

PK treatment increased the water-dry matter ratio of the herbage from all three soil types. The greatest percentage of increase occurred on Napanee silt loam, next on Fox sandy loam, and least on Miami loam. It is interesting to note that although the water-dry matter ratio of the PK treated herbage was greater on Miami loam than on Fox sandy loam, the percentage of increase in water-dry matter ratio was greater on Fox sandy loam.

PK fertilizers increased dry yields on Fox sandy loam and on Miami loam by 67 per cent and 33 per cent respectively. The actual pounds per acre increase, or the increased growth attributable to the fertilizer

treatment, was somewhat the greater on the Miami loam.

3. NPK Treatments.

a. At Riggs.

At Riggs the great increase in the water-dry matter ratio caused by the 10-6-4 fertilizer was outstanding. Although the dry yields produced by the 10-6-4 treated plot were not much in excess of the dry yield of the 0-6-4 plot, the water-dry matter ratio or succulence was far greater on the 10-6-4. Thus, though N when applied in combination with PK on Miami loam sod at Riggs does increase dry yield considerably, its main effect would seem to be exerted in increasing the water-dry matter ratio, or succulence, over that of the PK treated herbage.

b. At Weberville and Oakley.

The three complete fertilizers on Napanee silt loam and on Fox sandy loam caused large increases and large percentages of increase in the water-dry matter ratios of the herbage. Both increases were far greater at Oakley on the Napanee silt loam than at Weberville on Fox sandy loam. The water-dry matter ratios on the Napanee silt loam and on the Fox sandy loam for the 5-10-5 treated herbage are 3.27 and 2.45 respectively; for the 10-10-5 treated herbage, 3.42 and 2.62, respectively; and for the 5-10-10 treated herbage, 3.56 and 2.86, respectively. The corresponding percentage increases in the water-dry matter ratios at Oakley and Weberville for the 5-10-5 treated herbage were 24 per

cent and 6.5 per cent, respectively; for the 10-10-5 treated herbage, 30 per cent and 14 per cent, respectively; and for the 5-10-10 treated herbage, 36 per cent and 24 per cent, respectively. On the Fox sandy loam at Weberville, the 0-10-10 treated herbage was considerably more succulent than the 5-10-5 treated, from which it appears that, in combination with a constant application of P, K may be more effective in increasing the water-dry matter ratio than N. This would be somewhat contrary to the findings at Riggs. At the same time it should be noted, however, that the dry yields resulting from 0-10-10 and 5-10-5 were almost exactly the same.

At Weberville, 0-10-0 treatment did not alter dry yields appreciably; 0-10-10 and 5-10-5 increased dry yields by 67 per cent and 65 per cent, respectively; 10-10-5 and 5-10-10 increased dry yields by 154 per cent and 164 per cent, respectively.

C. Limed Herbage and Water-Dry Matter Ratio.

1. Lime Treatment.

Lime on Miami loam at Riggs, where limestone had been applied two years before the 1930 season, appeared to depress the water-dry matter ratio considerably, from 2.80 to 2.43. This apparent depression may be due to a soil difference between the unlimed and limed plots, as will be discussed on the following page. There was no separate lime treatment on Fox sandy loam at Weberville; where lime was applied, it was applied in conjunction with a fertilizer treatment. No lime was applied to any of the plots on Napanee silt loam at Oakley.

2. LP Treatment

On Miami loam, at Riggs, LP treatment decreased the water-dry matter ratio of the herbage to 2.38, which is considerably less than that of the untreated herbage and slightly less than that of the limed herbage. At Weberville, on Fox sandy loam, which was limed in 1930 about the same time the fertilizer was applied, LP decreased the water-dry matter ratio slightly below that of the untreated herbage.

3. LNPK Treatment

On Miami loam at Riggs, lime with 10-6-4 decreased the water-dry matter ratio somewhat from that of the 10-6-4 without lime, to 3.55 from 3.86. On Fox sandy loam at Weberville, lime with 5-10-5 appeared to increase the water-dry matter ratio slightly over the corresponding 5-10-5 without lime. However, this apparent increase is probably too small to be significant.

4. Discussion of Liming and the Water-Dry Matter Ratio of the Herbage on Miami Loam at Riggs.

The apparent considerable decrease in the water-dry matter ratio of the herbage due to liming on Miami loam at Riggs may be due at least partly to soil differences. Analysis of the data of Table 3 shows that the limed plots, irrespective of whether unfertilized or fertilized, were lower in the water-dry matter ratio by an almost constant value of .30. The lime treatment might, of course, exert this constant depression on the water-dry matter ratio regardless of the fertilizer elements with which it was associated in the soil solution. However, it seems more reasonable that

this constant difference should be due to a soil difference.

If there is really an appreciable soil difference between the limed and unlimed plots at Riggs, as is suspected, any comparison between limed and unlimed plots there would likely be misleading.

5. Liming and Dry Yields.

On Fox sandy loam, lime applied in addition to 0-10-0 or 5-10-5 significantly decreased dry yields per acre below those resulting from the respective fertilizer applications alone. The same decrease of dry yield following lime application occurs on Miami loam at Riggs, with the exception of the LP treatment, which appeared to increase the dry yield over the corresponding unlimed plot. The lime plot at Riggs produced a smaller yield of dry matter than did the corresponding unlimed plot. Inasmuch as liming depressed both the dry yield and the water-dry matter ratio, however, any influence of the suspected variation in soil between the unlimed and limed plots would be exerted on dry yields as well as on the water-dry matter ratio. It would appear, however, that lime treatment depressed dry yield, both on Fox sandy loam at Weberville and on Miami loam at Riggs.

II. The Effect of Soil Type on the Water-Dry Matter Ratios for the Separate Cuttings during May and June.

Graph V shows the effects of soil type and fertilizer treatment on the water-dry matter ratios of the herbage at the separate cuttings during May and June[1].

A. Untreated Herbage.

The water-dry matter ratio of the untreated herbage decreased at the second cutting on Napanee silt loam at Oakley and on Miami loam at Riggs from the value at the first cutting. On Fox sandy loam at Weberville, it increased slightly at the later cutting.

B. Fertilized Herbage.

1. Phosphate Treatment.

On the Napanee silt loam the water-dry matter ratio of the herbage was smaller at the second cutting than at the first. However, the increase in the water-dry matter ratio due to phosphate treatment was about the same at the two cuttings.

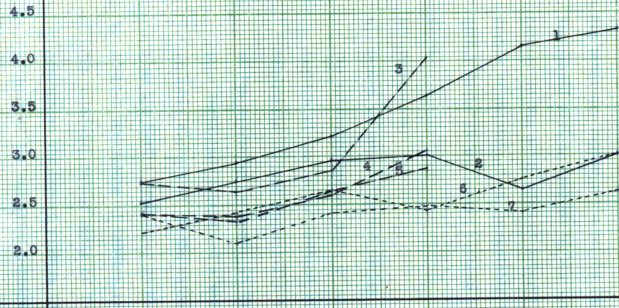
On Fox sandy loam, phosphate treatment increased the water-dry matter ratio of the herbage at the first cutting, but decreased it by an almost equal amount at the second cutting.

On Miami loam, phosphate treatment seemed to cause a slight depression in the water-dry matter ratio at all cuttings.

[1] The data from which this graph was constructed represent the averages in the case of the limed and unlimed 0-10-0 and 5-10-5 treated plots at Weberville and Oakley, and in the case of all the respective unlimed and limed plots at Riggs.

Graph V

Water: Dry Matter Ratios at the Separate Cuttings during May and June



Fertilizer Analysis
Weberville & Oakley
Riggs

None	0-10-0	0-10-10	5-10-5	10-10-5	5-10-10
None	0-6-0	0-6-4	10-6-4		

——— (1-May 13 Oakley, Nepenee silt loam
(2-June 27
– – – (3-May 31 Riggs, Miami loam
(4-June 10
(5-July 2
- - - - - - (6-May 27 Weberville, Fox sandy loam
(7-June 25

2. PK Treatments.

The water-dry matter ratio of the PK and NPK fertilized herbage in every case was lower at the second cutting, except with 5-10-5 on Fox sandy loam; but in no case did it decrease below the corresponding untreated herbage.

The water-dry matter ratio of the PK treated herbage at the second cutting dropped to the level of the untreated herbage on Fox sandy loam at Weberville. On the other fields PK maintained an appreciably higher water-dry matter ratio at the second cutting than did the untreated plots.

3. NPK Treatments.

a. 5-10-5 at Weberville and Oakley and 10-6-4 at Riggs.

The water-dry matter ratio of the 5-10-5 treated herbage at the second cutting on Fox sandy loam at Weberville dropped practically to the level of that of the untreated herbage. On the Napanee silt loam this fertilizer maintained a water-dry matter ratio somewhat above that of the untreated herbage, as did also the 10-6-4 fertilizer on Miami loam at Riggs.

b. 10-10-5 Treatments at Weberville and Oakley.

The water-dry matter ratio of the 10-10-5 treated herbage at the second cutting dropped to the level of that of the untreated herbage on Fox sandy loam at Weberville, and was maintained at only .15 above that of the untreated herbage on Napanee silt loam at Oakley.

c. 5-10-10 Treatments at Weberville and Oakley.

On both Fox sandy loam at Weberville and on Napanee

silt loam at Oakley this fertilizer maintained an appreciably higher water-dry matter ratio at the second cutting than did the 10-10-5.

The decrease in the water-dry matter ratio from the first to the second cutting where these 25 unit fertilizers were used was very marked, being far greater at Oakley than at Weberville. The fertilizer seemed to exert a more marked effect on the water-dry matter ratio during the first period of growth.

III. Conclusions regarding the Dry Yields and the Water-Dry Herbage Ratio.

A. The total dry yields from the untreated plots during May and June were only 250-300 pounds per acre on the Napanee silt loam at Oakley and the Fox sandy loam at Weberville, but were more than 1000 pounds per acre on the Miami loam at Riggs. Possible reasons for the relatively small yields on the Napanee silt loam and Fox sandy loam are suggested. The total water-dry matter ratio of the untreated herbage was considerably greater on the relatively finer textured soils at Oakley and Riggs than on the sandy loam at Weberville. Some appreciable variations in the water-dry matter ratio between the first and second cuttings were observed. Decreases occurred on Napanee silt loam and on Miami loam, but an increase was observed on the Fox sandy loam.

B. Liming on Miami loam at Riggs and on Fox sandy loam at Weberville seemed to have a depressing effect on growth as measured by yield of dry matter.

Liming does not appear to alter the water-dry matter ratio greatly. The small constant increase in the ratio at Riggs attributable to lime, whether lime was applied alone or

with fertilizers, may be due largely to a suspected soil variation between the unlimed and limed plots.

C. PK and NPK fertilizers on Miami loam at Riggs and on Fox sandy loam at Weberville caused large increases in dry yields, whereas P treatment caused practically no variation.
PK and NPK fertilizers caused large increases in the water-dry matter ratio. This ratio appeared to increase in the herbage from the three soils with every increase in the number of fertilizer units applied. N seemed to be especially effective in increasing the water-dry matter ratio on Miami loam at Riggs. On the other two fields, particularly on Fox sandy loam at Weberville, on the contrary, it is indicated that K seemed more effective in this regard than did N.
The water-dry matter ratios of the fertilized herbage, particularly where 10-10-5, 5-10-10, or 10-6-4 were applied, were very high at the first cutting, but dropped greatly at the sedond cutting.

D. PK and NPK fertilizers caused greater percentage increases in dry yield on the relatively less fertile Fox sandy loam soil at Weberville than on Miami loam at Riggs. The increased production of dry matter per acre, attributable to the PK treatment, however, was somewhat the greater on the Miami loam at Riggs, being more than twice as great with 10-6-4 at Riggs as with 5-10-5 at Weberville. Increases in dry yield attributable to 10-10-5 and 5-10-10 on the Fox sandy loam, however, were quite comparable with those produced by 10-6-4 on Miami loam, being about 500 pounds per acre increase in dry yield in each case.

PART II--THE EFFECT OF SOIL TYPE ON THE PERCENTAGE CRUDE PROTEIN IN THE OVEN DRY GRASS AT THE SEPARATE CUTTINGS DURING MAY AND JUNE, AND THE TOTAL CRUDE PROTEIN PRODUCTION PER ACRE.

I. Percentage and Total Yields of Crude Protein.

Table 4 shows the crude protein percentages in the oven dry grass at the separate cuttings from the three soils. Table 5 gives the total production of crude protein during May and June. It is observed that the general effect of the PK and NPK fertilizers was to increase the crude protein percentages of grass somewhat, but in no case more than about 3 per cent in 15 per cent, or from 15 to 18 per cent; and to greatly increase the total crude protein production, even doubling or trebling it in some cases.

The untreated grass from any one of the fields did not vary in crude protein percentage as much as 0.5 per cent between cuttings.[1] The PK and NPK treated herbage in some cases varied as much at the different cuttings as did the differently fertilized grass at one cutting.

Since other plants as well as the grasses used a portion of the applied fertilizers and inasmuch as the proportion of weeds-grass was especially high and differed considerably between plots on Miami loam at Riggs, it is obvious that the crude protein yield in the grass portion of the herbage only is not an accurate measure of the effect of the different fertilizers on crude protein production on this field. It was thought that a fairer comparison of the fertilizer effects would be obtained by calculating the crude protein production per acre on the basis of the total herbage. Such a calculation would involve the assumption that the weeds of the herbage contained the same percentage crude protein as did the grasses. Godden (7) however, observed that weeds really are slightly higher in protein than grasses. Thus, calculation of the crude

[1] On the Oakley field, which was grazed, this variation was much greater than 0.5 per cent.

Table 4.

Crude Protein Content of Oven Dry Grass

Percentage crude protein in unfertilized and differently fertilized grass, grown on three soil types.

Fertilizer Treatment: Weberville and Oakley	Weberville: Fox sandy loam		Oakley: Napanee silt loam		Riggs: Miami loam			Fertilizer Treatment: Riggs
	May 27	June 25	May 13	June 27	May 21	June 10	July 2	
None	13.0	13.3	20.2	14.9	15.3	15.6	15.7	None
None	13.3	13.3	19.0	20.8	14.3#	14.5#	15.3#	None
None			18.4	20.1				
0-10-0	13.4	13.0	18.0	13.4	15.0	15.1	15.0	0-6-0
0-10-0	12.7#	13.0#	17.2	21.4	14.3#	15.4#	14.9#	0-6-0
0-10-10	14.6#	13.9#	16.1	13.7	15.1	17.4	16.4	0-6-4
					14.9#	16.2#	15.4#	0-6-4
5-10-5	13.6	13.6	17.4	21.0	15.7	17.6	16.1	10-6-4
5-10-5	13.7#	13.7#	19.0	23.4	17.1#	17.9#	16.5#	10-6-4
10-10-5	15.9#	13.1#	20.4	20.0				
5-10-10	15.8#	14.3#	17.9	13.4				

Limed

Table 5.

Crude Protein Content of Oven Dry Grass

Pounds per acre crude protein produced in unfertilized and differently fertilized grass (and in total herbage at Riggs), grown on three soil types.

Fertilizer Treatment: Weberville and Oakley	Weberville: Fox sandy loam	Oakley: Napanee silt loam	Riggs: Miami loam		Fertilizer Treatment: Riggs.
			In Grass	In Herbage*	
None	34	32	140	172	None
None	38	40	123#	150#	None
None		59			
0-10-0	41	28	118	144	0-6-0
0-10-0	36#	51	144#	164#	0-6-0
0-10-10	66#	28	180	251	0-6-4
			131#	190#	0-6-4
5-10-5	64	47	142	262	10-6-4
5-10-5	57#	60	154#	260#	10-6-4
10-10-5	114#	51			
5-10-10	116#	38			

Limed

* The determination was made on the grass only. This column was calculated from the percentage crude protein in the grass, assuming grass and herbage contained equal percentages crude protein.

protein yield on the basis of the total herbage would likely involve a small error; and if Godden's observation holds for the Riggs field, calculation of crude protein production from percentage crude protein in the grass and pounds per acre of total herbage would make crude protein yield appear slightly less than it actually was and also relatively less for those plots which were exceptionally high in weeds. At any rate, crude protein production calculated on this basis affords an approximate comparison of the relative effects of the different fertilizer treatments.

The crude protein content of the grass at Oakley was so very irregular both in percentage and in total production, evidently due to grazing, it seems unwise to attempt any correlation with the fertilizer treatments. Hence, in subsequent discussion of protein content the effects of fertilizer treatment at only the Weberville and Riggs fields will be considered.

A. Untreated Grass.

The crude protein percentages in the untreated grass from the three soils seemed to be maintained for both cuts at distinctly different levels. That on Napanee silt loam at Oakley was highest, being almost 20 per cent; that on Miami loam at Riggs, about 15 per cent; and that on Fox sandy loam at Weberville, about 13 per cent.

The total production was far greater on Miami loam at Riggs, since the dry matter yield on this field was about three times that at the other two fields.

B. Limed Grass.

Lime with 0-10-0 or 5-10-5 on Fox sandy loam seemed to slightly depress crude protein yield in the grass, but the percentages did not vary appreciably.

On Miami loam at Riggs, lime alone or with PK appeared to decrease crude protein yield; lime with P, increased it; lime with NPK did not affect crude protein yield.

C. Fertilized Grass.

1. Phosphate Treatment.

Phosphate treatment on Fox sandy loam at Weberville and on Miami loam at Riggs did not appear to vary the crude protein percentage as much as one per cent in any case.

The crude protein production was apparently increased slightly at Weberville and decreased somewhat at Riggs by phosphate treatment.

2. PK Treatment.

0-10-10 fertilizer on Fox sandy loam at Weberville increased the crude protein percentage in the grass somewhat, increasing it by more than one per cent at the first cutting. The total yield of crude protein was nearly doubled.

The crude protein percentage in the grass from Miami loam at Riggs was increased at the second and third cuttings, but was not appreciably changed at the first cutting. The total yield of crude protein was much larger, than that of the untreated plots.

3. NPK Treatment.

The 10-6-4 fertilizer on Miami loam caused small increases in the percentages of crude protein at the first and third cuttings, but raised the percentage from 15.6 to 17.6 at the second cutting. The total production of crude protein, if comparison is made on

the basis of the total herbage, was practically the same as that produced on the PK treated plot.

On Fox sandy loam, 5-10-5 treatment caused a very slight increase in crude protein percentage, but nearly doubled the yield of crude protein. The crude protein yield was practically the same for the 5-10-5 and 0-10-10.

The 10-10-5 and 5-10-10 treatments increased the crude protein percentages by almost 3 per cent, or from 13.3 to almost 16.0 per cent, at the first cutting on Fox sandy loam at Weberville; at the second cutting, the crude protein percentage of the 10-10-5 treated grass dropped to the level of that of the untreated grass, but that of the 5-10-10 treated was maintained at one per cent higher than the untreated. The crude protein yields, where these fertilizers were applied, were almost identical, being about 115 pounds per acre, and were about three times as great as those of the untreated plots.

II. Conclusions Regarding Crude Protein.

A. Crude protein percentage was not appreciably changed by phosphate fertilizer, but was elevated by from 1 to 3 per cent by 10-6-4 fertilizer on Miami loam at Riggs or by 10-10-5 and 5-10-10 on Fox sandy loam at Weberville. PK treatments also tended to raise the crude protein percentage slightly.

B. Crude Protein Yield at Weberville on Fox sandy loam was nearly doubled by 0-10-10 or 5-10-5 and was more than trebled by 10-10-5 or 5-10-10 treatment. The increased

production attributable to these 25 unit fertilizers was about 80 pounds crude protein per acre. Phosphate fertilizer alone caused only a small variation in yield of crude protein.

C. The crude protein yield on Miami loam at Riggs was perhaps somewhat depressed by phosphate fertilizer alone. The crude protein yield was greatly increased, however, by 0-6-4 and 10-6-4, the increase being 80-90 pounds crude protein per acre. This increase is practically the same as that attributable to the 25 unit fertilizers on Fox sandy loam at Weberville.

PART III--THE CALCIUM AND PHOSPHORUS CONTENT OF THE GRASS.

I. Percentage of Phosphorus in the Grass.

A. Untreated Grass.

Table 6 shows that the percentage of phosphorus was distinctly different in the untreated grass grown on the three soil types. That on Fox sandy loam at Weberville was highest, being about 0.36 at the first cutting and 0.50 at the second cutting; that on Miami loam at Riggs was intermediate and almost constant for the three cuttings at about 0.29 per cent; while that on Napanee silt loam at Oakley was lowest at about 0.20 or even less. The largest variation between cuttings occurred at Weberville. There the phosphorus percentages were much higher at the second cutting than at the first cutting.

B. Lime Treatment.

On Fox sandy loam, lime with 0-10-0 or 5-10-5 fertilizer did not appear to change the phosphorus percentage appreciably.

On Miami loam at Riggs, lime alone seemed to depress the phosphorus percentage slightly; lime with P, PK, or NPK did not cause any considerable alteration.

C. Fertilized Grass.

1. General Effects of the Fertilizers.

All phosphate containing fertilizers on Napanee silt loam increased the percentage of phosphorus greatly, and the increase caused by the different fertilizers was about the same. On Fox sandy

Table 6.

Phosphorus Content of Oven Dry Grass

Percentage phosphorus in unfertilized and differently fertilized grass, grown on three soil types.

Fertilizer Treatment: Weberville and Oakley	Weberville: Fox sandy loam		Oakley: Napanee silt loam		Riggs: Miami loam			Fertilizer Treatment: Riggs.
	May 27	June 25	May 13	June 27	May 21	June 10	July 2	
None	.351	.500	.158	.188	.294	.286	.302	None
None	.371	.499	.189	.201	.253#	.250#	.271#	None
None			.195	.208				
0-10-0	.369	.478	.419	.331	.309	.303	.300	0-6-0
0-10-0	.360#	.503#	.340	.296	.302#	.285#	.304#	0-6-0
0-10-10	.341#	.442#	.370	.322	.356	.375	.355	0-6-4
					.320#	.376#	.361#	0-6-4
5-10-5	.350	.414	.366	.315	.357	.323	.298	10-6-4
5-10-5	.360#	.435#	.376	.288	.339#	.336#	.340#	10-6-4
10-10-5	.370#	.419#	.389	.302				
5-10-10	.385#	.421#	.413	.331				

Limed

loam and on Miami loam, phosphate treatment alone did not alter the phosphorus percentage of the grass. However, PK and NPK treatments caused considerable changes, in some cases increasing the phosphorus percentage and in other cases decreasing it.

2. Effects of the Fertilizers at Weberville.

On Fox sandy loam at Weberville at the first cutting none of the fertilizers caused any appreciable variation in the percentage of phosphorus. At the second cutting, however, although the percentage of phosphorus in the phosphate treated grass was not changed, that of the PK and NPK treated grass was decreased from 0.50 to 0.44 or even to 0.42 per cent. All the grass, however, unfertilized as well as the fertilized, increased in phosphorus percentage at the later cutting.

3. Effects of the Fertilizers on Miami Loam at Riggs.

Phosphate treatment did not increase the phosphorus percentage in the grass on Miami loam. Both PK and NPK fertilizers, however, usually increased the phosphorus percentage from about 0.30 to about 0.35 per cent.

P and PK treated grass was not appreciably changed in phosphorus percentage at the different cuttings. NPK treated grass decreased somewhat at each successive cutting, and at the last cutting on July 2 was the same as the untreated grass.

4. Effects of the Fertilizers on Napanee Silt Loam at Oakley.

All the fertilizers caused large increases in the phosphorus percentages of the grass on the Napanee silt loam, almost doubling the phosphorus percentage at the first cutting and increasing it by more than half at the second cutting. There were only small differences in the increased phosphorus percentages caused by the different fertilizers, however. These increases brought the phosphorus percentages in the Napanee silt loam grass to about the same level as that on Fox sandy loam at Weberville and on Miami loam at Riggs.

II. Percentage of Calcium in the Grass.

A. Untreated Grass.

The calcium percentage in the untreated grass, as shown in Table 7, varied between 0.41 and 0.58 for the three fields during May and June. The untreated grass on Napanee silt loam had a somewhat higher percentage calcium at the first cutting than did either the Fox sandy loam or Miami loam grass. The Fox sandy loam grass at the last cutting, however, was higher in percentage of calcium than either the grass from Napanee silt loam or from Miami loam, which were about the same.

The calcium percentages of the Oakley and Riggs grass increased considerably at the last cutting, while that at Oakley hardly changed appreciably.

B. Lime Treatment.

Table 7.

Calcium Content of Oven Dry Grass

Percentage calcium in unfertilized and differently fertilized grass, grown on three soil types.

Fertilizer Treatment: Weberville and Oakley	Weberville: Fox sandy loam		Oakley: Napanee silt loam		Riggs: Miami loam			Fertilizer Treatment: Riggs
	May 27	June 25	May 13	June 27	May 21	June 10	July 2	
None	.451	.647	.576	.564	.413	.409	.585	None
None	.420	.642	.575	.511	.345#	.328#	.473#	None
None			.492	.528				
0-10-0	.453	.695	.771	.532	.382	.597	.499	0-6-0
0-10-0	.427#	.713#	.605	.607	.377#	.350#	.447#	0-6-0
0-10-10	.549#	.629#	.684	.563	.395	.436	.588	0-6-4
					.368#	.473#	.526#	0-6-4
5-10-5	.474	.645	.622	.510	.437	.377	.399	10-6-4
5-10-5	.476#	.652#	.716	.529	.465#	.414#	.476#	10-6-4
10-10-5	.524#	.601#	.682	.564				
5-10-10	.508#	.634#	.683	.546				

#Limed

At Weberville, on Fox sandy loam, grass to which lime was applied together with 0-10-0 or 5-10-5 was not appreciably different in calcium percentage from that to which the respective fertilizer alone was applied. On Miami loam at Riggs, however, lime treatment alone or with PK fertilizers, in every case except the PK treated grass at the second cutting, seemed to decrease the calcium percentage of the grass; at the same time, the NPK treatment appeared to increase the calcium percentage.

C. Fertilizer Treatments.

1. Effects of the Fertilizers on Fox Sandy Loam at Weberville.

On Fox sandy loam at the first cutting, phosphate treatment did not alter the calcium percentage appreciably, while the 0-10-10 and all the complete fertilizers increased it. At the second cutting, however, the only one of the fertilizers which caused an appreciable change in the calcium percentage was the phosphate treatment, and this increased it.

2. Effects of the Fertilizers on Napanee Silt Loam at Oakley.

On Napanee silt loam at the first cutting, all the fertilizer treatments increased the calcium percentage of the grass; but at the second cutting, no similar increase over the untreated grass due to fertilizer treatment was evident.

3. Effects of the Fertilizers at Riggs.

On Miami loam at Riggs, none of the fertilizers

consistently altered the calcium percentage at the different cuttings. At the first cutting there was no considerable alteration in the calcium percentage of grass due to fertilization. At the second cutting, however, phosphate treatment increased the calcium percentage by almost half, or from 0.409 to 0.597, while the PK and NPK fertilizers caused slight variations. At the third cutting the phosphate treated grass had approximately the same calcium percentage as did the untreated grass, while the PK treated grass was considerably higher and the NPK treated considerably lower in calcium percentage.

III. The Total Calcium-Phosphorus Ratio in the Grass during May and June.

A. Untreated Grass.

Table 8[1] shows that the total Calcium-phosphorus ratios in the grass from the three fields differed very markedly. The calcium-phosphorus ratio of the Napanee silt loam grass was the highest, being 2.82; that of the Miami loam grass was 1.43, or approximately half that of the Napanee silt loam grass; while that of the Fox sandy loam grass was 1.25, or even slightly less than that of the grass from Miami loam.

B. Fertilizer Treatments.

1. General Effects of the Fertilizers.

The most marked effect of the fertilizers on the calcium-phosphorus ratio occurred on Napanee silt loam at Oakley. The ratio on this field was decreased from 2.82 to about 1.7 or 1.8. On Miami loam at Riggs also

[1] The data in this table represent the averages in the case of the unlimed and limed 0-10-0 and 5-10-5 treated plots at Weberville and Oakley, and in the case of all the respective unlimed and limed plots at Riggs.

Table 8.

Calcium-Phosphorus Ratio in the Oven Dry Grass during May and June. Totals for two cuttings each at Weberville and Oakley, and three cuttings at Riggs.

Fertilizer Treatment: Weberville and Oakley	Calcium-Phosphorus Ratio			Fertilizer Treatment: Riggs.
	Weberville: Fox sandy loam	Oakley: Napanee silt loam	Riggs: Miami loam	
None	1.25	2.82	1.43	None
0-10-0	1.31	1.83	1.38	0-6-0
0-10-10	1.52	1.79	1.20	0-6-4
5-10-5	1.41	1.76	1.29	10-6-4
10-10-5	1.42	1.80		
5-10-10	1.39	1.65		

all the fertilizers depressed the calcium-phosphorus ratio. On Fox sandy loam at Weberville, where the calcium-phosphorus ratio was lowest of the three fields, fertilizers increased the ratio somewhat.

2. Effects of the Fertilizers on Napanee Silt Loam at Oakley.

All the fertilizers, whether P, PK, or NPK, decreased the calcium-phosphorus ratio greatly on Napanee silt loam and there seemed to be no considerable difference in the decreases caused by the different fertilizers. The calcium-phosphorus ratio, however, still remained a good deal higher than that at the other fields. It should be recalled that the different fertilizers on Napanee silt loam caused large, and approximately equal increases in the percentage of phosphorus, but also caused comparatively smaller increases in the percentage of calcium. It seems evident from these responses to phosphate fertilizer as evidenced by the increase in the percentage of phosphorus and the decrease in the calcium-phosphorus ratio, that the Napanee silt loam at Oakley is deficient in phosphorus.

3. Effect of the Fertilizers on Miami Loam at Riggs.

On Miami loam the fertilizers caused much smaller decreases in the calcium-phosphorus ratio than on Napanee silt loam. P treatment decreased the ratio from 1.43 to 1.38, while NPK treatment decreased it to 1.29 and PK treatment to the lowest ratio of 1.20.

4. Effect of the Fertilizers on Fox Sandy Loam at Weberville.

On Fox sandy loam, contrary to the findings on

Napanee silt loam and on Miami loam, the fertilizers increased the calcium-phosphorus ratio in the grass somewhat. The 0-10-0 caused the smallest increase, while 0-10-10 caused the largest.

IV. Conclusions regarding the Calcium and Phosphorus Content of the Grass.

A. The percentage of phosphorus in the unfertilized grass from the three fields was lowest on Napanee silt loam at Oakley, intermediate on Miami loam at Riggs, and highest on Fox sandy loam at Weberville.

B. On Napanee silt loam all phosphate containing fertilizers caused very large increases in the phosphorus percentage, almost doubling it at the first cutting, while the calcium percentage was usually increased somewhat. There was also a marked decrease in the calcium-phosphorus ratio.

C. On Fox sandy loam and on Miami loam, phosphate treatment did not appreciably alter the phosphorus percentage of the grass. PK and NPK fertilizers, however, caused some considerable variations, tending to increase the phosphorus percentage on Miami loam and to decrease it on Fox sandy loam.

D. On Fox sandy loam and on Miami loam, fertilizer treatments tended to increase the percentage of calcium in the grass.

E. On Miami loam, all the fertilizers caused slight decreases in the calcium-phosphorus ratio, while on Fox sandy loam corresponding small increases occurred.

Summary

Cuttings of unfertilized and differently fertilized pasture herbage from Fox sandy loam, Miami loam, and Napanee silt loam during May and June of 1930 were analyzed for water, dry matter, crude protein, calcium, and phosphorus content. Water and dry matter were determined on the total herbage. Crude protein, calcium and phosphorus were determined on the oven dry grass.

I. Dry Yields.

The dry yields of untreated herbage were more than 1000 pounds per acre on Miami loam, and only 250-300 pounds per acre on Napanee silt loam and Fox sandy loam.

Phosphate fertilizer did not appreciably alter dry yields on Miami loam or on Fox sandy loam. PK and NPK fertilizers caused large increases in the dry yields. The percentage increases in dry yields over the untreated plots were with all fertilizers considerably the greater on the Fox sandy loam. The actual increase in yield attributable to the 10-10-5 or the 5-10-10 on Fox sandy loam, however, is comparable to that caused by the 10-6-4 fertilizer on Miami loam. The increase from the 5-10-5 treatment on Fox sandy loam is, however, much less than that produced by the two 25 unit fertilizers on that soil.

II. The Water-Dry Matter Ratio, or Succulence.

The water-dry matter ratio was greater in herbage grown on Miami loam and on Napanee silt loam than in that grown on Fox sandy loam. Phosphate fertilizer did not alter the water-dry matter ratio of the herbage on Fox sandy loam, but increased it somewhat on Napanee silt loam and decreased it slightly on Miami loam. PK

and NPK fertilizers, however, caused large increases in the water-dry matter ratio. On Miami loam, N, in combination with PK, seemed to be especially effective in increasing succulence. On Fox sandy loam and Napanee silt loam, somewhat to the contrary, K seemed to be slightly more effective in this regard than did N.

III. Crude Protein.

The percentage crude protein in the grass from the three soil types was distinctly different, that from Napanee silt loam being about 20 per cent, from Miami loam about 15 per cent, and that from Fox sandy loam about 13 per cent.

PK and NPK fertilizers elevated the crude protein percentages somewhat, but not by more than by 3 per cent.

Phosphate fertilizers did not appreciably alter crude protein yield in the grass. The 0-10-10 or 5-10-5 treatment on Fox sandy loam doubled crude protein yield, while 10-10-5 or 5-10-10 treatment more than trebled it. These increases in crude protein production followed closely the increases in dry yield. The 0-6-4 or 10-6-4 treatments caused large, and approximately equal, increases in the crude protein production. The increase was 80-90 pounds per acre, and is comparable to the increases attributable to the 25 unit fertilizers on Fox sandy loam.

IV. Calcium and Phosphorus and the Calcium-Phosphorus Ratio.

In the untreated grass from Napanee silt loam, the percentage of phosphorus was lower and the percentage of calcium was higher than in the grass from the other two soil types. Also the calcium-phosphorus ratio was highest in the grass from this soil.

All phosphate containing fertilizers greatly increased the phosphorus percentage and also greatly decreased the calcium-phosphorus ratio in the grass on Napanee silt loam. P, PK, or NPK fertilizers seemed to be equally effective in these regards.

The phosphorus percentage and the calcium-phosphorus ratio at Weberville and Riggs were not appreciably altered by phosphate treatment, and were altered to a much less extent by PK and NPK fertilizers on these fields than they were altered by similar fertilizer treatments on Napanee silt loam.

On Miami loam, all the fertilizers slightly decreased the calcium-phosphorus ratio, while on Fox sandy loam all the fertilizers slightly increased the ratio.

On Miami loam and Fox sandy loam fertilizers tend to increase the calcium percentage in the grass.

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