

EFFECTS OF CERTAIN FERTILIZER AND LIME TREATMENTS  
ON YIELD, CHEMICAL COMPOSITION, AND VEGETATIVE  
POPULATION OF A PASTURE AND ON CERTAIN  
PROPERTIES OF COEBURN SILT LOAM

By

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Effects of Certain Fertilizer and Lime Treatments  
on Yield, Chemical Composition, and Vegetative  
Population of a Pasture and on Certain  
Properties of Coeburn Silt Loam

INTRODUCTION

Fertilizer and lime investigations to determine their effect upon crops and soils have been carried out at many experiment stations. The correlation of the yield, the type and the chemical composition of vegetation and changes taking place in chemical properties of soil will contribute to a better understanding of soil fertility problems.

Since 1940 the Virginia Agricultural Experiment Station, in cooperation with the Tennessee Valley Authority has conducted a pasture experiment on Coeburn Silt Loam in Wise County, Virginia. Several different fertilizer treatments, with and without lime, were used to evaluate their effect upon pasture vegetation.

The purpose of this study is to determine the extent and nature of the effects of certain fertilizers and lime treatments on pasture vegetation and on the soil.

The experiment was conducted on Coeburn Silt Loam, a soil derived from interbedded shale and arkosic sandstone. This soil is well drained, occurs on rolling to hilly relief, is low in inherent fertility and is fairly well adapted to agricultural uses.

## MATERIALS USED AND METHODS OF PROCEDURE

### Description of Plots

This experiment was laid out in a native pasture with no additional seedings being made. The plots (see Figure 1) receiving different fertilizer treatments are one tenth of an acre in size. One half of each plot was limed in 1940 and in 1944 at the rate of one ton of ground limestone per acre. Each sub-plot is one twentieth of an acre in size. The fertilizer was broadcast annually at the rate of 300 pounds per acre.

### Herbage and Chemical Studies

Yields were determined by clipping the herbage from an area protected from grazing by a 4 by 4 foot wire enclosed pen. After each clipping, the pens were moved to a new location on the plot, from which excess growth, if any, was removed so that only growth made from the time of placement of pen would be measured in the next clipping.

The clipped herbage was dried in a steam heated oven and weighed. These samples were then ground in a Wiley mill and stored in pint ice cream cartons.

Determinations of protein, phosphorus and calcium were made on the samples to study the effect of fertilization and liming on the chemical composition of the herbage. The analysis were made

Figure 1. - Layout of Field Experiment in Wise County, Virginia.

|         | Limed | Fertilizer*   | No Lime |
|---------|-------|---------------|---------|
| Plot 16 |       | 0-12-0 (3)    |         |
| 1       |       | 4-12-4 (1)    |         |
| 2       |       | 4-12-4 (2)    |         |
| 3       |       | 4-12-4 (3)    |         |
| 4       |       | 0-12-4        |         |
| 5       |       | 4-0-4         |         |
| 6       |       | 4-12-0        |         |
| 7       |       | 4-36-4        |         |
| 8       |       | 4-12-12       |         |
| 9       |       | No Fertilizer |         |
| 10      |       | 4-36-0        |         |
| 11      |       | 4-0-12        |         |
| 12      |       | 2-6-2         |         |
| 13      |       | 8-24-8        |         |
| 14      |       | 12-36-12      |         |
| 15      |       | 0-12-0 (2)    |         |

\* Annual application of 300 pounds per acre.

- (1) Superphosphate
- (2) Triple superphosphate
- (3) Calcium metaphosphate



according to the methods prescribed by the Association of Official Agricultural Chemists (2)<sup>1</sup>. Moisture determinations were made and results calculated on oven dry basis. The chemical analysis were made in duplicate of clippings taken in May and August of 1945.

#### Plant Population Studies

The plant population was determined by use of a one foot square grid. This grid is divided into 25 squares (each representing 4 percent of the total area) by small crosswires. An estimation of the percentage of area occupied by the various types of plants was determined by dropping the grid on the sod at random and counting the plant population found in the squares. Three such counts were made and averaged for each sub-plot. Plant population counts were divided into four groups: (1) desirable grasses, (2) undesirable grasses, (3) legumes and (4) weeds. Another division was made for bare space. A more detailed description of these divisions are given by O'Brien and Obenshain (19). Plant population analysis were made on Spring and Fall clippings for 1941 through 1945.

#### Soil Sampling

Composite soil samples were taken from each sub-plot in February 1946. These samples, comprising approximately twenty-five samplings, were taken with a soil auger to a depth of two inches and prepared for analysis according to the method outlined by Robinson (22).

<sup>1</sup> Numbers in parenthesis refer to literature cited.

The prepared samples were stored in quart ice cream cartons.

Method of Soil Analysis

Total nitrogen was determined according to the method prescribed by the Association of Official Agricultural Chemists (2). Organic matter was determined by a modification of the Schollenberger method (26) as outlined by Thomas (31). Exchangeable hydrogen, calcium, magnesium, potassium and total base exchange was determined by the method outlined by Peech, et al (24). All determinations were made in duplicate and data reported as averages. Where close agreement was not found between the two determinations, the analysis was repeated.

## RESULTS

### Herbage Yield

The pasture experiment on which this study is based is located on a soil of very low inherent fertility. At the beginning of the experiment the sod was extremely poor, about 40 percent of the area being bare of any growth and the remainder being occupied mostly by broom-sedge, poverty grass and weeds. There is still a low percentage of desirable grasses in this pasture.

1941 The yields in 1941 (Table 1) were extremely low as compared with the yields of other years. This was probably the result of the low rainfall during the growing season. The May rainfall was 3 inches below that of a 5 year average. According to O'Brien and Obenshain (19) the May rainfall profoundly effects the amount of growth during the entire season. The highest yield on the limed treatment was from plot 2, the unlimed treatment plot 14. The lowest yield on the limed and unlimed plots were from no fertilizer and 4-0-4 respectively.

1942 There was a decided increase in yields in 1942 (Table 1) over 1941 due to a more favorable growing season. The highest yields from the limed plots were from fertilizer treatments, 4-12-4 (2), 4-12-4 (1) and 8-24-8. Highest yields on unlimed plots were from 12-36-12, 4-36-0 and 8-24-8 treatments. The average unlimed yields were about equal the limed yields due to a higher percentage of weeds after the unfavorable 1941 growing season.

Table 1 - The Effect of Different Fertilizers With and Without Lime on the Yields of Pasture Herbage.

Yields expressed as air dry material in pounds per acre.

| Fertilizer : | 1941    |       | 1942    |       | 1943    |       | 1944    |       | 1945    |       | Average  |          |
|--------------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|----------|----------|
| Treatment :  | Unlimed | Limed | Unlimed | Limed | Unlimed | Limed | Unlimed | Limed | Unlimed | Limed | Unlimed* | Limed*   |
| 4-12-4 (1)   | 461     | 1225  | 2496    | 3672  | 4238    | 5254  | 1885    | 2723  | 4301    | 4895  | 2676(20) | 3554(6)  |
| 4-12-4 (2)   | 515     | 1652  | 2190    | 3743  | 4573    | 4626  | 2063    | 2349  | 2749    | 5390  | 2418(21) | 3552(7)  |
| 4-12-4 (3)   | 551     | 1395  | 2389    | 2502  | 3683    | 4783  | 1745    | 2724  | 3016    | 4911  | 2276(23) | 3263(8)  |
| 0-12-4       | 248     | 526   | 2077    | 2175  | 2985    | 4373  | 1831    | 2727  | 2771    | 4791  | 1982(28) | 2918(16) |
| 4-0-4        | 697     | 505   | 2032    | 2135  | 2510    | 3651  | 1378    | 2013  | 1606    | 3294  | 1644(31) | 2379(22) |
| 4-12-0       | 1171    | 1271  | 2012    | 3199  | 3136    | 4278  | 1772    | 2380  | 2047    | 4459  | 2027(27) | 3117(10) |
| 4-36-4       | 641     | 1083  | 2148    | 2780  | 4487    | 5715  | 2361    | 3336  | 4503    | 5956  | 2827(18) | 3773(4)  |
| 4-12-12      | 412     | 941   | 2173    | 2708  | 5260    | 6890  | 3737    | 3666  | 3773    | 5496  | 3071(12) | 3940(2)  |
| No Fert.     | 232     | 730   | 1514    | 1221  | 2819    | 3591  | 1106    | 2069  | 1693    | 3637  | 1473(32) | 2249(24) |
| 4-36-0       | 1194    | 987   | 3800    | 2663  | 4166    | 5392  | 2541    | 4056  | 3400    | 5856  | 3020(13) | 3791(3)  |
| 4-0-12       | 482     | 1201  | 2221    | 2815  | 2482    | 4276  | 1657    | 2549  | 3316    | 4176  | 2032(26) | 3003(15) |
| 2-6-2        | 470     | 1540  | 1772    | 1788  | 3539    | 4348  | 1466    | 2795  | 2399    | 3789  | 1929(30) | 2852(17) |
| 8-24-8       | 1040    | 887   | 3281    | 3331  | 4600    | 5490  | 2519    | 3577  | 3964    | 5396  | 3080(11) | 3736(5)  |
| 12-36-12     | 1542    | 1611  | 4114    | 3095  | 4448    | 6155  | 2469    | 5142  | 3207    | 5458  | 3155(9)  | 4292(1)  |
| 0-12-0 (2)   | 743     | 1117  | 1851    | 1543  | 3771    | 3806  | 1354    | 2187  | 1986    | 4780  | 1941(29) | 2686(19) |
| 0-12-0 (3)   | 306     | 1030  | 1892    | 2207  | 3688    | 3892  | 1676    | 2744  | 3392    | 5189  | 2191(25) | 3012(14) |

\* Relative placings

- (1) Superphosphate
- (2) Triple superphosphate
- (3) Calcium metaphosphate

1943 The 1943 yield results (Table 1) show the average limed treatment produced 951 pounds of air dry herbage more than the unlimed per acre. The highest yields from the limed plots were from 4-12-12, 12-36-12, and 4-36-4. The highest yield on unlimed plots was from 4-12-12, 8-24-8 and 4-12-4 (2).

1944 In 1944 the highest yields (Table 1) from the limed plots were from 12-36-12, 4-36-0 and 4-12-12; from unlimed plots 4-12-12, 4-36-0 and 8-24-8. The limed plots produced 1000 pounds per acre more herbage than the unlimed plots.

1945 In 1945 treatments 4-36-4, 4-36-0 and 12-36-12 with lime produced the highest yields. The unlimed highest yields were from 4-36-4, 4-12-4 (1) and 8-24-8.

As seen from table 2 the highest 3 yields for each year with lime and without lime for 5 years was with fertilizers carrying at least 4 units of nitrogen and 12 units of phosphoric acid (one exception). The units of potassium varied. One of the three lowest yields for each year with and without lime for the 5 year period was from the no fertilizer plots. This indicates the need of nitrogen and phosphates in establishing a pasture on this soil.

Table 2. - Highest and Lowest Yearly Yields from Different Fertilizer Treatments.

|                   | Highest limed                      | Highest unlimed                 | Lowest limed                    | Lowest unlimed                   |
|-------------------|------------------------------------|---------------------------------|---------------------------------|----------------------------------|
| 1941              | 4-12-4 (2)<br>12-36-12<br>2-6-2    | 12-36-12<br>4-36-0<br>4-12-0    | 4-0-4<br>0-12-4<br>No Fert.     | No Fert.<br>0-12-4<br>0-12-0 (3) |
| 1942              | 4-12-4 (2)<br>4-12-4 (1)<br>8-24-8 | 12-36-12<br>4-36-0<br>8-24-8    | No Fert.<br>0-12-0 (2)<br>2-6-2 | No Fert.<br>2-6-2<br>0-12-0 (2)  |
| 1943              | 4-12-12<br>12-36-12<br>4-36-4      | 4-12-12<br>8-24-8<br>4-12-4 (2) | No Fert.<br>4-0-4<br>0-12-0 (3) | 4-0-12<br>4-0-4<br>No Fert.      |
| 1944              | 12-36-12<br>4-36-0<br>4-12-12      | 4-12-12<br>4-36-0<br>8-24-8     | 4-0-4<br>No Fert.<br>0-12-0 (2) | No Fert.<br>0-12-0 (2)<br>4-0-4  |
| 1945              | 4-36-4<br>4-36-0<br>12-36-12       | 4-36-4<br>4-12-4 (1)<br>8-24-8  | 4-0-4<br>No Fert.<br>2-6-2      | 4-0-4<br>No Fert.<br>0-12-0 (2)  |
| 5 Year<br>Average | 12-36-12<br>4-12-12<br>4-36-0      | 12-36-12<br>8-24-8<br>4-12-12   | No Fert.<br>4-0-4<br>0-12-0 (2) | No. Fert.<br>4-0-4<br>2-6-2      |

- (1) Superphosphate
- (2) Triple superphosphate
- (3) Calcium metaphosphate

On the 5 year average the highest yields with lime were obtained from 12-36-12, 4-12-12 and 4-36-0. On the unlimed plots the highest yields were from 12-36-12, 8-24-8, and 4-12-4. In all cases the yield from limed plots exceeded that of the unlimed plots. The average limed and fertilized plot out-yielded the average unlimed and

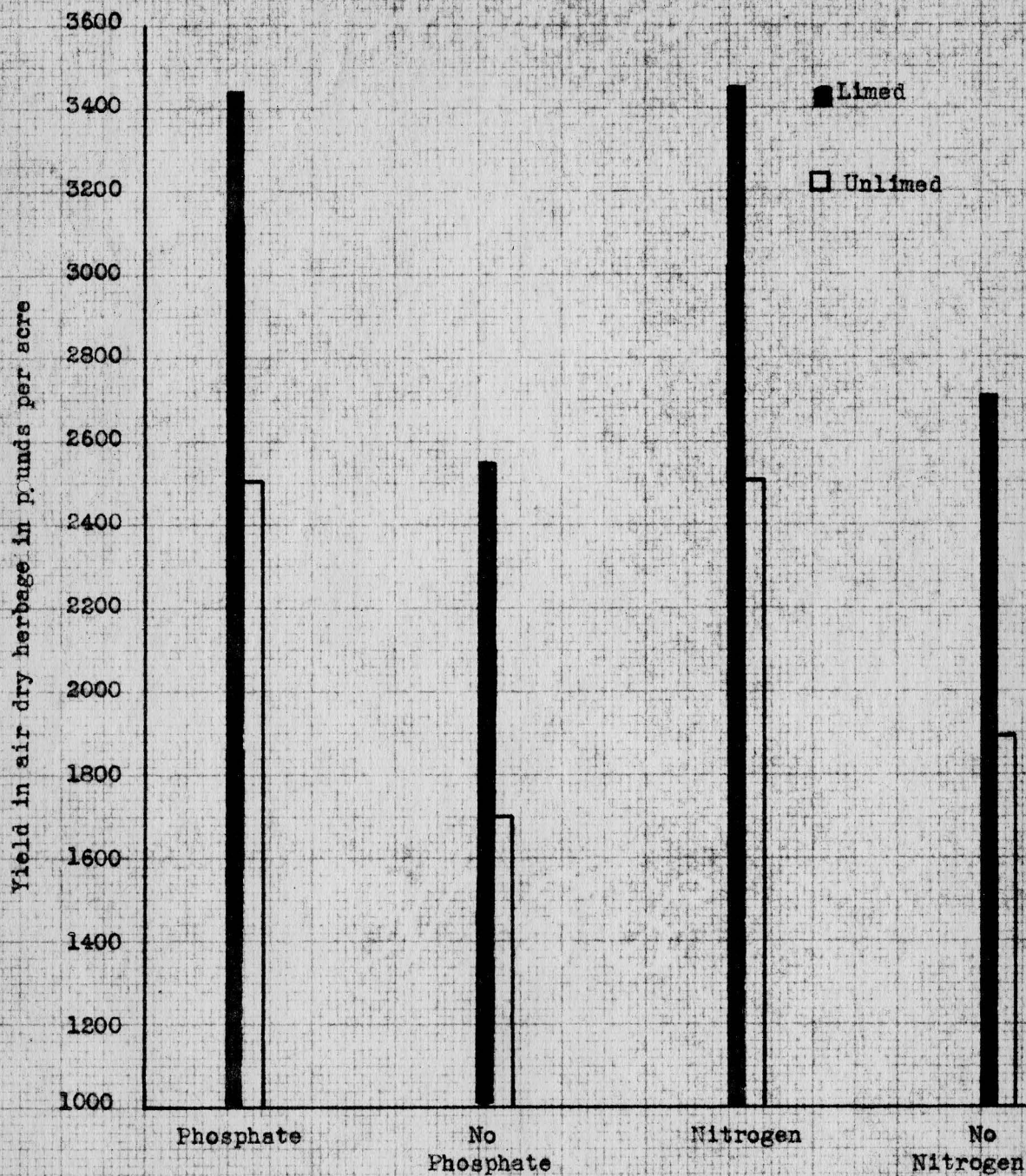
fertilized plot by over 800 pounds air dry herbage per acre. On the plots receiving no fertilizer, the limed averaged 775 pounds air dry herbage more than the unlimed. Schaller, et al (28) in a pasture experiment in West Virginia found that lime and superphosphate gave profitable increases in pasture yields.

Figure 2 shows the effect of phosphate and nitrogen fertilizer on the 5 year average yield. In all cases the phosphate and nitrogen fertilizers gave higher yields than the no nitrogen and no phosphate fertilizers. The limed nitrogen and phosphate plots gave higher yields than unlimed nitrogen and phosphate plots. Sprague, et al (29) found that nitrogen fertilizer increased pasture yields. O'Brien and Obenshain (19) got increased yields in pasture where phosphate fertilizer was used. Natfel (18) found that lime increased crop yields.

#### Plant Population

In 1941 the limed plots (Table 3) averaged 26 percent bare space, 1 percent desirable grasses, 34 percent undesirable grasses, 14 percent clovers and 25 percent weeds. In 1945 the limed plots (Table 7) averaged 7 percent bare space, 15 percent desirable grasses, 34 percent undesirable grasses, 30 percent clover and 14 percent weeds. As seen by this comparison there was an appreciable decrease in percentage of bare space and weeds which was replaced by desirable grasses and clovers. The same results were obtained from the check plot receiving lime and no fertilizer.

Figure 2. Effects of phosphate and nitrogen fertilizer on average yields



The unlimed plots in 1941 (Table 3) showed an average of 33 percent bare space, 1 percent desirable grasses, 28 percent undesirable grasses, 4 percent clovers and 34 percent weeds. In 1945 (Table 7) these plots contained an average of 12 percent bare space, 6 percent desirable grasses, 35 percent undesirable grasses, 10 percent clovers and 37 percent weeds. During the five year period there was a decrease in percentage bare space and an increase in desirable grasses, undesirable grasses, clovers and weeds. As seen by Figure 3 the efficiency of the fertilizer was not as great as when used with lime. The most outstanding change in the vegetative population of this pasture, due to fertilizer and lime treatments, is the decrease in percentage of weeds and bare space. Robinson and Pierre (23) found that lime and fertilizer increased the percentage of desirable plants while weeds and bare space decreased.

The improvement in this pasture which has received lime and fertilizer is more apparent from observation (see Figures 4, 5, and 6) than is evident from the yield and vegetative composition comparisons. Figure 4 shows a marked difference between the lime and no lime plots. Figure 5 is of the 4-0-4 unlimed plot. It is noted that this plot is predominantly weeds, particularly hawkweed. Figure 6 shows the plant population of the 4-12-4 limed plot. Lime and phosphate have changed the vegetative composition of this plot from weeds to principally white dutch clover.

Figure 3. Vegetative composition of herbage in 1941 and 1945

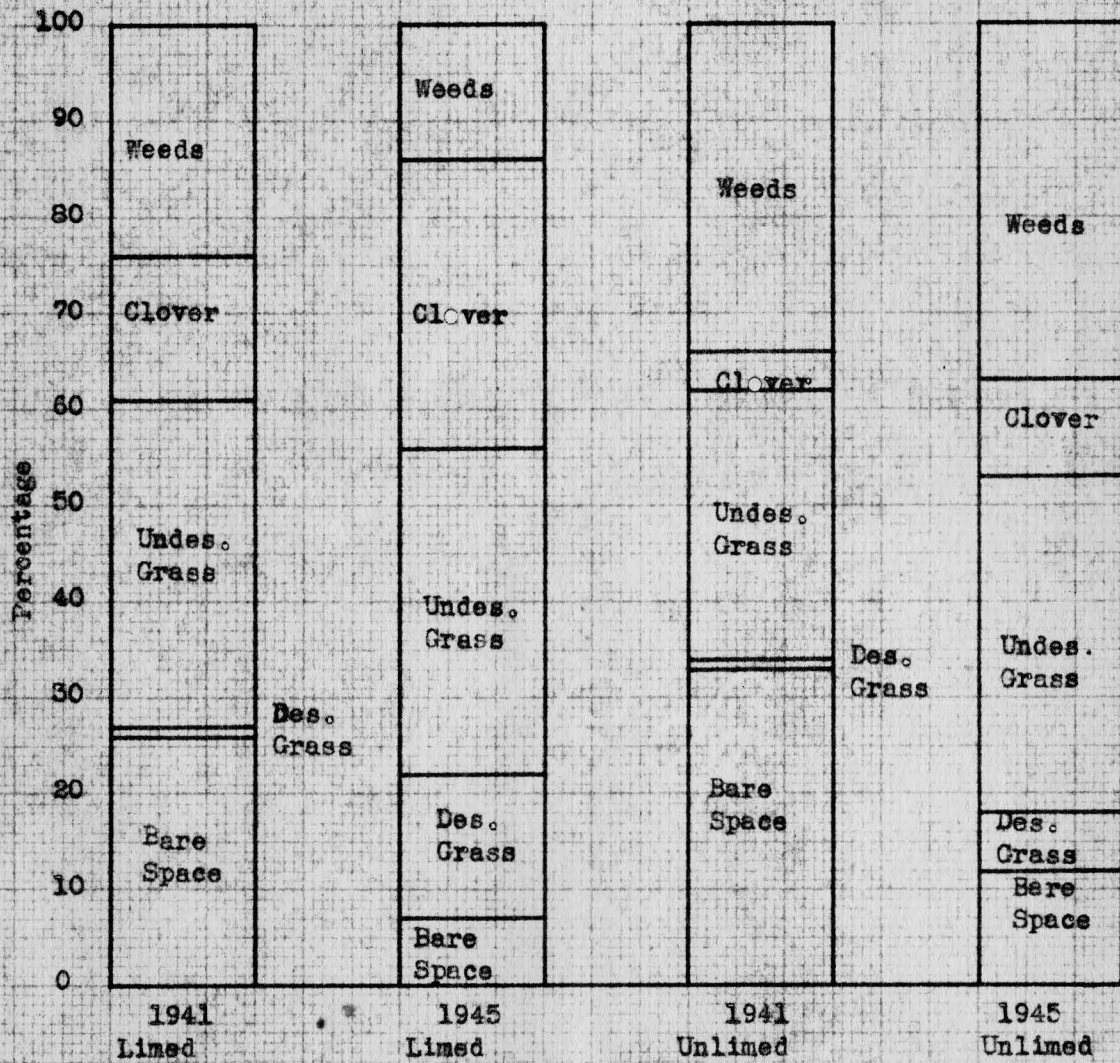




Figure 4. - Line Between Limed and Unlimed Plots.

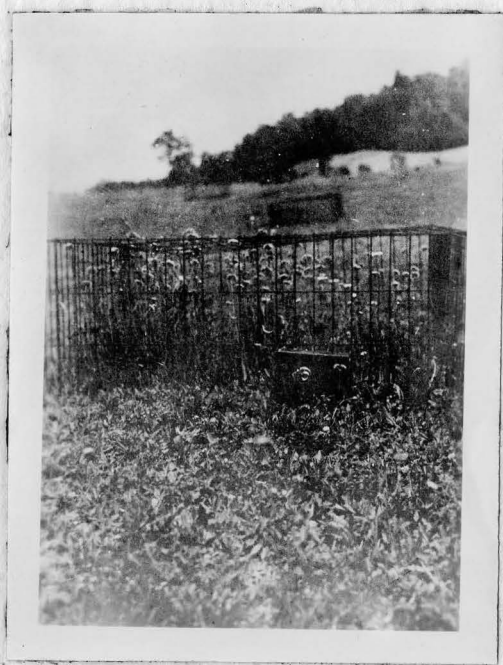


Figure 5. - 4-0-4 Unlimed Plot.



Figure 6. - 4-12-4 Limed Plot.

Table 3.- 1941 Percentage of Different Types of Herbage and Bare Space.

| Fertilizer Treatment* | <u>LIMED</u>                  |            |              |        |       | <u>LIMED</u>                |            |              |        |       |
|-----------------------|-------------------------------|------------|--------------|--------|-------|-----------------------------|------------|--------------|--------|-------|
|                       | Spring Clipping Percentage of |            |              |        |       | Fall Clipping Percentage of |            |              |        |       |
|                       | Bare Space                    | Des. Grass | Undes. Grass | Clover | Weeds | Bare Space                  | Des. Grass | Undes. Grass | Clover | Weeds |
| 4-12-4 (1)            | 31                            | 1          | 12           | 34     | 22    | 17                          | 1          | 63           | 3      | 16    |
| 4-12-4 (2)            | 37                            | 1          | 18           | 19     | 25    | 21                          | 1          | 51           | 7      | 20    |
| 4-12-4 (3)            | 39                            | 1          | 16           | 12     | 32    | 19                          | 1          | 52           | 8      | 20    |
| 0-12-4                | 37                            | 1          | 19           | 16     | 27    | 18                          | 1          | 54           | 7      | 20    |
| 4-0-4                 | 42                            | 1          | 18           | 6      | 33    | 21                          | 1          | 40           | 8      | 30    |
| 4-12-0                | 31                            | 1          | 20           | 19     | 29    | 18                          | 1          | 50           | 9      | 22    |
| 4-36-4                | 32                            | 1          | 15           | 26     | 26    | 16                          | 1          | 50           | 15     | 18    |
| 4-12-12               | 33                            | 1          | 12           | 29     | 25    | 15                          | 1          | 53           | 11     | 20    |
| No Fert.              | 39                            | 1          | 13           | 7      | 40    | 19                          | 0          | 47           | 7      | 27    |
| 4-36-0                | 32                            | 1          | 11           | 25     | 31    | 17                          | 1          | 54           | 10     | 18    |
| 4-0-12                | 33                            | 1          | 16           | 13     | 37    | 19                          | 1          | 52           | 4      | 24    |
| 2-6-2                 | 36                            | 1          | 21           | 12     | 30    | 20                          | 1          | 45           | 7      | 27    |
| 8-24-8                | 35                            | 1          | 15           | 19     | 30    | 17                          | 1          | 55           | 6      | 21    |
| 12-36-12              | 33                            | 1          | 18           | 16     | 32    | 19                          | 3          | 53           | 7      | 18    |
| 0-12-0 (2)            | 34                            | 1          | 18           | 16     | 31    | 20                          | 1          | 45           | 7      | 27    |
| 0-12-0 (3)            | 33                            | 1          | 6            | 36     | 24    | 17                          | 1          | 57           | 7      | 18    |

UNLIMED

|            |    |   |    |   |    |    |   |    |   |    |
|------------|----|---|----|---|----|----|---|----|---|----|
| 4-12-4 (1) | 42 | 2 | 11 | 4 | 41 | 25 | 1 | 47 | 3 | 24 |
| 4-12-4 (2) | 43 | 1 | 18 | 2 | 41 | 25 | 1 | 47 | 3 | 24 |
| 4-12-4 (3) | 47 | 1 | 17 | 2 | 33 | 27 | 1 | 41 | 4 | 27 |
| 0-12-4     | 48 | 1 | 20 | 2 | 29 | 26 | 1 | 38 | 7 | 28 |
| 4-0-4      | 40 | 1 | 23 | 2 | 34 | 27 | 1 | 36 | 2 | 34 |
| 4-12-0     | 42 | 1 | 21 | 4 | 32 | 27 | 1 | 33 | 3 | 36 |
| 4-36-4     | 39 | 1 | 12 | 7 | 41 | 24 | 1 | 38 | 3 | 34 |
| 4-12-12    | 46 | 1 | 13 | 4 | 36 | 24 | 1 | 40 | 2 | 33 |
| No Fert.   | 46 | 1 | 15 | 1 | 37 | 27 | 0 | 29 | 1 | 43 |
| 4-36-0     | 42 | 1 | 14 | 2 | 41 | 22 | 1 | 49 | 3 | 25 |
| 4-0-12     | 44 | 1 | 12 | 2 | 41 | 22 | 1 | 46 | 3 | 28 |
| 2-6-2      | 44 | 1 | 14 | 2 | 39 | 22 | 1 | 49 | 3 | 25 |
| 8-24-8     | 41 | 1 | 13 | 4 | 41 | 21 | 1 | 52 | 4 | 22 |
| 12-36-12   | 41 | 1 | 17 | 8 | 33 | 21 | 1 | 46 | 4 | 28 |
| 0-12-0 (2) | 41 | 1 | 18 | 4 | 36 | 22 | 1 | 38 | 3 | 36 |
| 0-12-0 (3) | 43 | 1 | 13 | 7 | 33 | 25 | 1 | 42 | 4 | 28 |

\* Applied annually at the rate of 300 pounds per acre.

- (1) Superphosphate
- (2) Triple superphosphate
- (3) Calcium metaphosphate

Table 4. - 1942 Percentage of Different Types of Herbage and Bare Space.

| Fertilizer Treatment* | <u>LIMED</u>    |            |              |        |       | <u>LIMED</u>  |            |              |        |       |
|-----------------------|-----------------|------------|--------------|--------|-------|---------------|------------|--------------|--------|-------|
|                       | Spring Clipping |            |              |        |       | Fall Clipping |            |              |        |       |
|                       | Bare Space      | Des. Grass | Undes. Grass | Clover | Weeds | Bare Space    | Des. Grass | Undes. Grass | Clover | Weeds |
| 4-12-4 (1)            | 33              | 4          | 12           | 14     | 37    | 6             | 2          | 17           | 65     | 10    |
| 4-12-4 (2)            | 33              | 3          | 13           | 11     | 40    | 10            | 2          | 20           | 56     | 12    |
| 4-12-4 (3)            | 37              | 2          | 12           | 10     | 39    | 10            | 1          | 20           | 57     | 12    |
| 0-12-4                | 36              | 2          | 15           | 12     | 35    | 8             | 1          | 22           | 58     | 11    |
| 4-0-4                 | 36              | 1          | 14           | 6      | 43    | 12            | 0          | 27           | 47     | 14    |
| 4-12-0                | 30              | 1          | 15           | 11     | 43    | 9             | 1          | 18           | 59     | 13    |
| 4-36-4                | 31              | 1          | 12           | 14     | 42    | 8             | 2          | 15           | 63     | 12    |
| 4-12-12               | 33              | 1          | 10           | 13     | 43    | 7             | 2          | 13           | 67     | 11    |
| No Fert.              | 42              | 0          | 10           | 2      | 49    | 16            | 0          | 23           | 40     | 21    |
| 4-36-0                | 33              | 1          | 13           | 8      | 45    | 11            | 1          | 14           | 60     | 14    |
| 4-0-12                | 36              | 0          | 13           | 1      | 50    | 14            | 0          | 23           | 46     | 17    |
| 2-6-2                 | 35              | 1          | 21           | 6      | 37    | 15            | 0          | 22           | 48     | 15    |
| 8-24-8                | 27              | 4          | 16           | 7      | 46    | 12            | 6          | 17           | 52     | 13    |
| 12-36-12              | 25              | 11         | 11           | 13     | 40    | 11            | 9          | 15           | 53     | 12    |
| 0-12-0 (2)            | 30              | 2          | 13           | 5      | 50    | 13            | 1          | 17           | 52     | 16    |
| 0-12-0 (3)            | 34              | 6          | 12           | 13     | 35    | 9             | 4          | 21           | 55     | 11    |

| <u>UNLIMED</u> |    |   |    |   |    |    |   |    |    |    |
|----------------|----|---|----|---|----|----|---|----|----|----|
| 4-12-4 (1)     | 37 | 1 | 13 | 1 | 48 | 30 | 1 | 38 | 9  | 32 |
| 4-12-4 (2)     | 40 | 1 | 14 | 1 | 44 | 22 | 1 | 39 | 7  | 31 |
| 4-12-4 (3)     | 39 | 1 | 18 | 1 | 41 | 23 | 1 | 40 | 6  | 30 |
| 0-12-4         | 42 | 1 | 19 | 1 | 37 | 22 | 0 | 37 | 7  | 34 |
| 4-0-4          | 37 | 0 | 21 | 1 | 41 | 23 | 0 | 39 | 3  | 35 |
| 4-12-0         | 35 | 1 | 15 | 3 | 46 | 22 | 0 | 34 | 8  | 36 |
| 4-36-4         | 35 | 1 | 11 | 5 | 48 | 20 | 1 | 35 | 12 | 32 |
| 4-12-12        | 36 | 1 | 9  | 2 | 52 | 19 | 1 | 35 | 10 | 35 |
| No Fert.       | 43 | 0 | 11 | 0 | 46 | 22 | 0 | 34 | 5  | 39 |
| 4-36-0         | 35 | 1 | 12 | 3 | 49 | 14 | 1 | 41 | 16 | 28 |
| 4-0-12         | 37 | 0 | 13 | 0 | 50 | 15 | 0 | 45 | 7  | 33 |
| 2-6-2          | 34 | 1 | 14 | 2 | 49 | 15 | 1 | 39 | 12 | 33 |
| 8-24-8         | 26 | 4 | 15 | 5 | 50 | 16 | 1 | 37 | 23 | 23 |
| 12-36-12       | 27 | 4 | 12 | 6 | 51 | 15 | 1 | 38 | 23 | 22 |
| 0-12-0 (2)     | 32 | 1 | 18 | 2 | 47 | 17 | 0 | 35 | 24 | 24 |
| 0-12-0 (3)     | 40 | 1 | 15 | 1 | 43 | 20 | 0 | 42 | 8  | 30 |

\* Applied annually at the rate of 300 pounds per acre.

- (1) Superphosphate
- (2) Triple Superphosphate
- (3) Calcium Metaphosphate

Table 5. - 1943 Percentage of Different Types of Herbage and Bare Space.

| Fertilizer Treatment* | <u>LIMED</u>                  |            |              |        |       | <u>LIMED</u>                |            |              |        |       |
|-----------------------|-------------------------------|------------|--------------|--------|-------|-----------------------------|------------|--------------|--------|-------|
|                       | Spring Clipping Percentage of |            |              |        |       | Fall Clipping Percentage of |            |              |        |       |
|                       | Bare Space                    | Des. Grass | Undes. Grass | Clover | Weeds | Bare Space                  | Des. Grass | Undes. Grass | Clover | Weeds |
| 4-12-4 (1)            | 12                            | 8          | 6            | 65     | 9     | 12                          | 11         | 54           | 17     | 6     |
| 4-12-4 (2)            | 14                            | 7          | 5            | 65     | 9     | 13                          | 9          | 55           | 15     | 8     |
| 4-12-4 (3)            | 17                            | 4          | 9            | 59     | 11    | 13                          | 7          | 59           | 13     | 8     |
| 0-12-4                | 16                            | 5          | 9            | 61     | 9     | 12                          | 5          | 62           | 14     | 7     |
| 4-0-4                 | 20                            | 4          | 13           | 47     | 16    | 15                          | 1          | 63           | 10     | 11    |
| 4-12-0                | 13                            | 5          | 7            | 64     | 11    | 14                          | 6          | 53           | 17     | 10    |
| 4-36-4                | 11                            | 6          | 5            | 69     | 9     | 11                          | 5          | 60           | 17     | 7     |
| 4-12-12               | 11                            | 7          | 4            | 68     | 10    | 12                          | 8          | 51           | 20     | 9     |
| No Fert.              | 20                            | 3          | 13           | 36     | 28    | 16                          | 2          | 56           | 10     | 16    |
| 4-36-0                | 13                            | 7          | 6            | 64     | 10    | 14                          | 7          | 50           | 20     | 9     |
| 4-0-12                | 17                            | 3          | 12           | 45     | 23    | 13                          | 1          | 59           | 14     | 13    |
| 2-6-2                 | 14                            | 5          | 11           | 55     | 15    | 14                          | 4          | 58           | 12     | 12    |
| 8-24-8                | 10                            | 8          | 5            | 69     | 8     | 13                          | 7          | 59           | 13     | 8     |
| 12-36-12              | 10                            | 13         | 4            | 65     | 8     | 13                          | 13         | 52           | 12     | 10    |
| 0-12-0 (2)            | 12                            | 6          | 7            | 62     | 13    | 14                          | 7          | 54           | 14     | 11    |
| 0-12-0 (3)            | 12                            | 8          | 9            | 61     | 10    | 11                          | 8          | 56           | 19     | 6     |

| <u>UNLIMED</u> |    |    |    |    |    |    |   |    |    |    |
|----------------|----|----|----|----|----|----|---|----|----|----|
| 4-12-4 (1)     | 17 | 9  | 20 | 31 | 23 | 21 | 2 | 52 | 11 | 14 |
| 4-12-4 (2)     | 22 | 9  | 21 | 18 | 30 | 18 | 1 | 49 | 12 | 20 |
| 4-12-4 (3)     | 25 | 6  | 20 | 17 | 32 | 21 | 1 | 45 | 12 | 21 |
| 0-12-4         | 26 | 3  | 26 | 16 | 29 | 18 | 1 | 47 | 13 | 21 |
| 4-0-4          | 32 | 2  | 19 | 8  | 39 | 24 | 1 | 39 | 5  | 31 |
| 4-12-0         | 27 | 5  | 19 | 12 | 37 | 22 | 1 | 48 | 5  | 23 |
| 4-36-4         | 19 | 7  | 21 | 27 | 26 | 17 | 2 | 49 | 10 | 22 |
| 4-12-12        | 23 | 8  | 16 | 25 | 28 | 19 | 2 | 52 | 9  | 18 |
| No Fert.       | 33 | 2  | 13 | 7  | 45 | 23 | 1 | 41 | 5  | 30 |
| 4-36-0         | 22 | 5  | 16 | 31 | 26 | 16 | 2 | 53 | 15 | 14 |
| 4-0-12         | 27 | 5  | 17 | 12 | 39 | 19 | 0 | 51 | 8  | 22 |
| 2-6-2          | 25 | 2  | 20 | 18 | 35 | 13 | 2 | 61 | 8  | 16 |
| 8-24-8         | 21 | 10 | 15 | 26 | 28 | 15 | 6 | 56 | 10 | 13 |
| 12-36-12       | 20 | 11 | 17 | 27 | 25 | 14 | 3 | 56 | 13 | 14 |
| 0-12-0 (2)     | 28 | 4  | 16 | 15 | 37 | 14 | 1 | 51 | 10 | 24 |
| 0-12-0 (3)     | 18 | 1  | 26 | 25 | 30 | 17 | 1 | 54 | 12 | 16 |

\* Applied annually at the rate of 300 pounds per acre.

- (1) Superphosphate
- (2) Triple superphosphate
- (3) Calcium metaphosphate

Table 6. - 1944 Percentage of Different Types of Herbage and Bare Space.

| Fertilizer<br>Treatment* | <u>LIMED</u>                     |               |                 |        |       | <u>LIMED</u>                   |               |                 |        |       |
|--------------------------|----------------------------------|---------------|-----------------|--------|-------|--------------------------------|---------------|-----------------|--------|-------|
|                          | Spring Clipping<br>Percentage of |               |                 |        |       | Fall Clipping<br>Percentage of |               |                 |        |       |
|                          | Bare<br>Space                    | Des.<br>Grass | Undes.<br>Grass | Clover | Weeds | Bare<br>Space                  | Des.<br>Grass | Undes.<br>Grass | Clover | Weeds |
| 4-12-4 (1)               | 19                               | 24            | 6               | 22     | 29    | 9                              | 16            | 35              | 30     | 10    |
| 4-12-4 (2)               | 20                               | 21            | 4               | 18     | 37    | 10                             | 16            | 37              | 28     | 9     |
| 4-12-4 (3)               | 21                               | 18            | 4               | 16     | 41    | 11                             | 13            | 40              | 23     | 13    |
| 0-12-4                   | 29                               | 14            | 8               | 15     | 34    | 11                             | 12            | 45              | 22     | 10    |
| 4-0-4                    | 29                               | 10            | 9               | 5      | 47    | 11                             | 8             | 51              | 16     | 14    |
| 4-12-0                   | 21                               | 15            | 7               | 14     | 43    | 11                             | 11            | 36              | 30     | 12    |
| 4-36-4                   | 22                               | 15            | 5               | 13     | 45    | 8                              | 13            | 39              | 31     | 9     |
| 4-12-12                  | 18                               | 22            | 3               | 25     | 32    | 8                              | 15            | 28              | 42     | 7     |
| No Fert.                 | 37                               | 7             | 7               | 6      | 43    | 13                             | 6             | 48              | 17     | 16    |
| 4-36-0                   | 22                               | 14            | 5               | 23     | 36    | 10                             | 13            | 40              | 28     | 9     |
| 4-0-12                   | 29                               | 7             | 9               | 9      | 46    | 9                              | 7             | 47              | 25     | 12    |
| 2-6-2                    | 26                               | 8             | 9               | 15     | 42    | 11                             | 8             | 46              | 23     | 12    |
| 8-24-8                   | 22                               | 17            | 5               | 12     | 44    | 8                              | 19            | 39              | 23     | 11    |
| 12-36-12                 | 17                               | 30            | 3               | 9      | 41    | 8                              | 26            | 32              | 25     | 9     |
| 0-12-0 (2)               | 27                               | 13            | 5               | 10     | 45    | 11                             | 16            | 37              | 22     | 14    |
| 0-12-0 (3)               | 16                               | 19            | 4               | 22     | 39    | 12                             | 11            | 41              | 28     | 8     |

| <u>UNLIMED</u> |    |    |    |   |    |    |   |    |    |    |
|----------------|----|----|----|---|----|----|---|----|----|----|
| 4-12-4 (1)     | 34 | 14 | 8  | 4 | 40 | 12 | 9 | 32 | 11 | 36 |
| 4-12-4 (2)     | 33 | 9  | 10 | 3 | 45 | 14 | 6 | 27 | 9  | 44 |
| 4-12-4 (3)     | 38 | 8  | 10 | 3 | 41 | 15 | 5 | 25 | 9  | 46 |
| 0-12-4         | 41 | 5  | 13 | 3 | 38 | 14 | 3 | 26 | 8  | 49 |
| 4-0-4          | 41 | 4  | 12 | 2 | 41 | 17 | 1 | 24 | 5  | 53 |
| 4-12-0         | 38 | 6  | 11 | 3 | 42 | 15 | 2 | 32 | 5  | 46 |
| 4-36-4         | 34 | 8  | 10 | 5 | 43 | 10 | 5 | 37 | 9  | 39 |
| 4-12-12        | 34 | 6  | 10 | 3 | 47 | 13 | 6 | 38 | 10 | 33 |
| No Fert.       | 44 | 2  | 13 | 2 | 39 | 14 | 2 | 36 | 6  | 42 |
| 4-36-0         | 32 | 5  | 12 | 6 | 45 | 13 | 5 | 40 | 9  | 33 |
| 4-0-12         | 40 | 3  | 10 | 2 | 45 | 16 | 2 | 38 | 4  | 40 |
| 2-6-2          | 36 | 5  | 12 | 3 | 44 | 12 | 4 | 45 | 8  | 31 |
| 8-24-8         | 30 | 10 | 8  | 4 | 48 | 12 | 9 | 46 | 11 | 22 |
| 12-36-12       | 23 | 11 | 8  | 6 | 52 | 12 | 7 | 48 | 9  | 24 |
| 0-12-0 (2)     | 39 | 2  | 12 | 3 | 44 | 14 | 4 | 50 | 6  | 26 |
| 0-12-0 (3)     | 40 | 4  | 12 | 3 | 41 | 12 | 5 | 34 | 10 | 39 |

\* Applied annually at the rate of 300 pounds per acre.

- (1) Superphosphate
- (2) Triple superphosphate
- (3) Calcium metaphosphate

Table 7. - 1945 Percentage of Different Types of Herbage and Bare Space.

| Fertilizer Treatment* | <u>LIMED</u>    |            |              |        |       | <u>LIMED</u>  |            |              |        |       |
|-----------------------|-----------------|------------|--------------|--------|-------|---------------|------------|--------------|--------|-------|
|                       | Spring Clipping |            |              |        |       | Fall Clipping |            |              |        |       |
|                       | Bare Space      | Des. Grass | Undes. Grass | Clover | Weeds | Bare Space    | Des. Grass | Undes. Grass | Clover | Weeds |
| 4-12-4 (1)            | 5               | 13         | 28           | 39     | 15    | 6             | 19         | 31           | 32     | 12    |
| 4-12-4 (2)            | 5               | 13         | 30           | 38     | 14    | 4             | 19         | 31           | 35     | 11    |
| 4-12-4 (3)            | 8               | 7          | 36           | 31     | 18    | 7             | 16         | 33           | 35     | 9     |
| 0-12-4                | 7               | 9          | 40           | 29     | 15    | 9             | 11         | 44           | 23     | 13    |
| 4-0-4                 | 10              | 5          | 45           | 20     | 20    | 10            | 11         | 44           | 19     | 16    |
| 4-12-0                | 11              | 9          | 32           | 33     | 15    | 7             | 19         | 32           | 27     | 15    |
| 4-36-4                | 5               | 9          | 35           | 36     | 15    | 9             | 17         | 36           | 25     | 13    |
| 4-12-12               | 5               | 11         | 25           | 47     | 12    | 7             | 22         | 23           | 37     | 11    |
| No Fert.              | 6               | 4          | 45           | 24     | 21    | 8             | 16         | 40           | 21     | 15    |
| 4-36-0                | 5               | 11         | 35           | 35     | 14    | 7             | 23         | 32           | 27     | 11    |
| 4-0-12                | 4               | 7          | 39           | 32     | 18    | 8             | 13         | 41           | 23     | 15    |
| 2-6-2                 | 5               | 5          | 42           | 29     | 19    | 7             | 19         | 39           | 23     | 12    |
| 8-24-8                | 7               | 16         | 33           | 29     | 15    | 7             | 21         | 36           | 25     | 11    |
| 12-36-12              | 8               | 22         | 29           | 29     | 12    | 6             | 27         | 30           | 28     | 9     |
| 0-12-0 (2)            | 6               | 13         | 33           | 29     | 19    | 7             | 21         | 32           | 28     | 12    |
| 0-12-0 (3)            | 7               | 9          | 35           | 37     | 12    | 7             | 19         | 33           | 30     | 11    |

| <u>UNLIMED</u> |    |    |    |    |    |    |    |    |    |    |
|----------------|----|----|----|----|----|----|----|----|----|----|
| 4-12-4 (1)     | 8  | 9  | 33 | 11 | 39 | 9  | 12 | 29 | 15 | 35 |
| 4-12-4 (2)     | 8  | 6  | 25 | 12 | 49 | 12 | 9  | 27 | 13 | 39 |
| 4-12-4 (3)     | 18 | 5  | 26 | 9  | 42 | 17 | 9  | 27 | 8  | 39 |
| 0-12-4         | 10 | 5  | 26 | 9  | 50 | 14 | 5  | 23 | 11 | 47 |
| 4-0-4          | 14 | 2  | 24 | 5  | 55 | 19 | 4  | 21 | 7  | 49 |
| 4-12-0         | 14 | 3  | 27 | 7  | 49 | 14 | 5  | 29 | 8  | 44 |
| 4-36-4         | 8  | 6  | 35 | 11 | 40 | 11 | 7  | 38 | 7  | 37 |
| 4-12-12        | 10 | 7  | 38 | 12 | 33 | 14 | 8  | 39 | 12 | 27 |
| No Fert.       | 8  | 5  | 34 | 8  | 45 | 14 | 4  | 35 | 11 | 36 |
| 4-36-0         | 9  | 6  | 37 | 11 | 37 | 13 | 7  | 37 | 11 | 32 |
| 4-0-12         | 13 | 3  | 37 | 5  | 42 | 12 | 4  | 40 | 5  | 39 |
| 2-6-2          | 9  | 5  | 43 | 9  | 34 | 15 | 5  | 40 | 8  | 32 |
| 8-24-8         | 8  | 11 | 41 | 11 | 29 | 13 | 11 | 40 | 12 | 24 |
| 12-36-12       | 9  | 8  | 45 | 10 | 28 | 10 | 9  | 47 | 11 | 23 |
| 0-12-0 (2)     | 11 | 4  | 47 | 7  | 31 | 14 | 9  | 47 | 5  | 25 |
| 0-12-0 (3)     | 9  | 7  | 35 | 9  | 40 | 14 | 5  | 36 | 8  | 37 |

\* Applied annually at the rate of 300 pounds per acre.

- (1) Superphosphate
- (2) Triple superphosphate
- (3) Calcium metaphosphate

Chemical Composition of Herbage

The effects of lime and fertilization on the chemical composition of pasture plants has been studied by numerous investigators. Beaumont (5) and Brown (7) revealed that applications of complete fertilizers to pasture caused increased percentages of nitrogen, phosphorus and calcium in pasture herbage. McClendon and Mayton (13) in Alabama and Schaller, et al (28) in West Virginia reported increase in yield and mineral content of pasture plants from application of lime and fertilizer. Robinson and Pierre (23) on a pasture experiment in West Virginia found an increase in the protein, phosphorus and calcium content of pasture grasses from lime and complete fertilizer application. Beeson (6) in a review and compilation on mineral composition of crops shows that liming the soil may have various effects upon the chemical composition of plants. Fudge and Fraps (9) found that the percentage of protein, phosphoric acid and lime in grasses are related to the total nitrogen, active phosphoric acid and active lime of the soils but there are other factors which effect the composition of the grasses, and the effect of these other factors at times may be greater than the effect of the composition of the soil.



### Protein

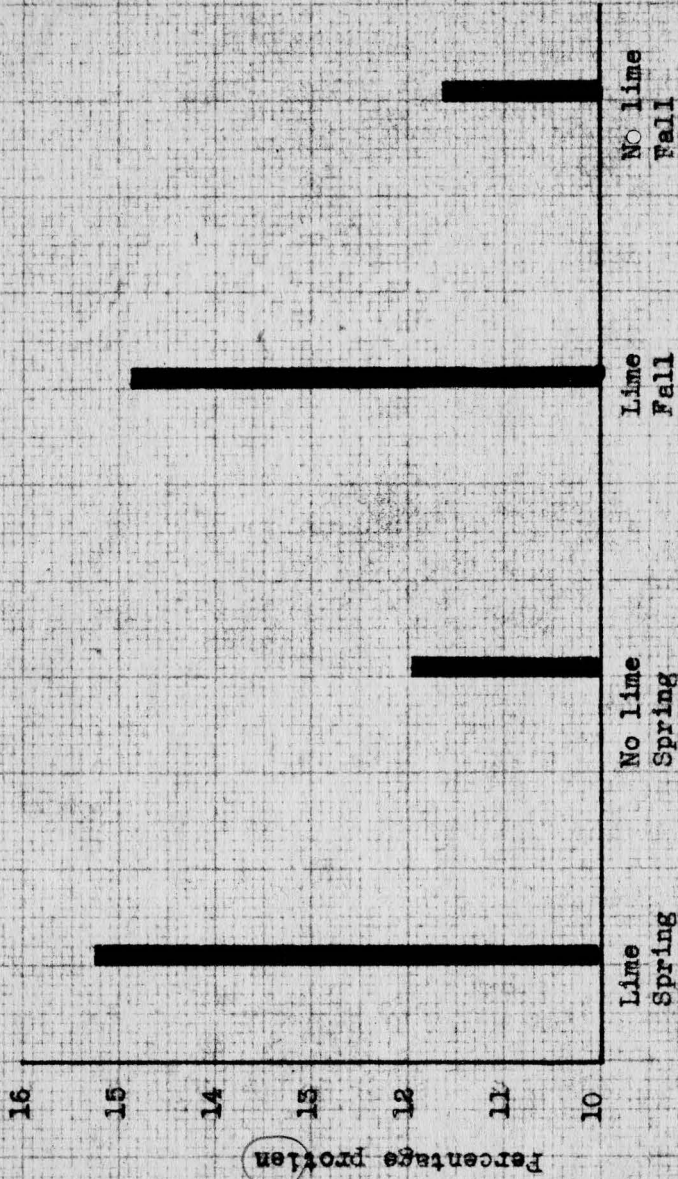
There was a higher percentage of protein\* in the herbage on the limed than on the unlimed plots as shown in Figure 7. The average of the limed plots was 37 percent higher in protein than in the unlimed plots. The protein was slightly higher in the spring than in the fall herbage.

In Figure 8 is shown the relationship of protein in herbage where nitrogen and no nitrogen fertilizer was used. The nitrogen fertilizers give higher percentages of protein in herbage. This is in agreement with Aldous (1), Gardner (10), and Mortimer, et al (17) who reported a higher percentage of protein in pastures receiving nitrogen fertilizers.

As seen in Figure 9, phosphate fertilizers increased the percentage of protein in herbage. Wilkins and Vinall (32) found that both protein and phosphorus content of grasses increased from the use of phosphate fertilizer.

\* In this study the nitrogen content of the herbage is expressed as percentage protein.

Figure 7. Average percentage of protein from limed and unlimed plots



Percentage protein

Figure 8. Effects of nitrogen fertilizer on protein in herbage

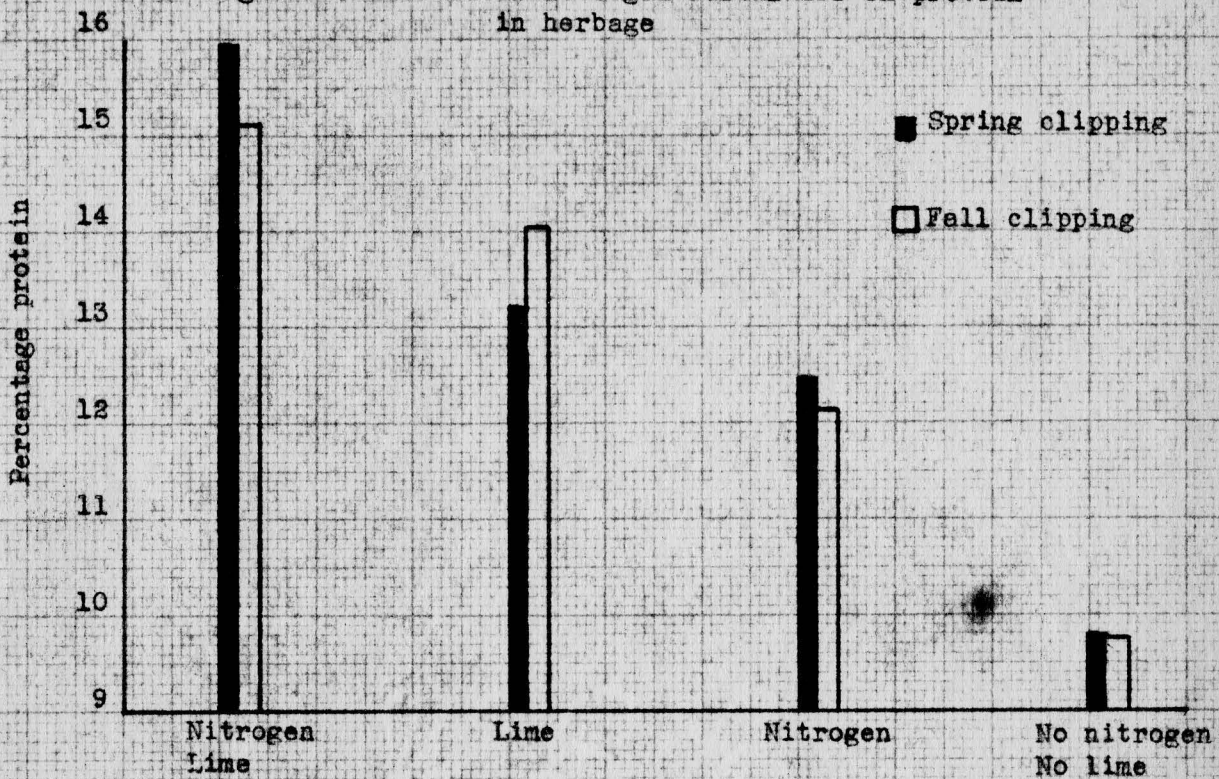
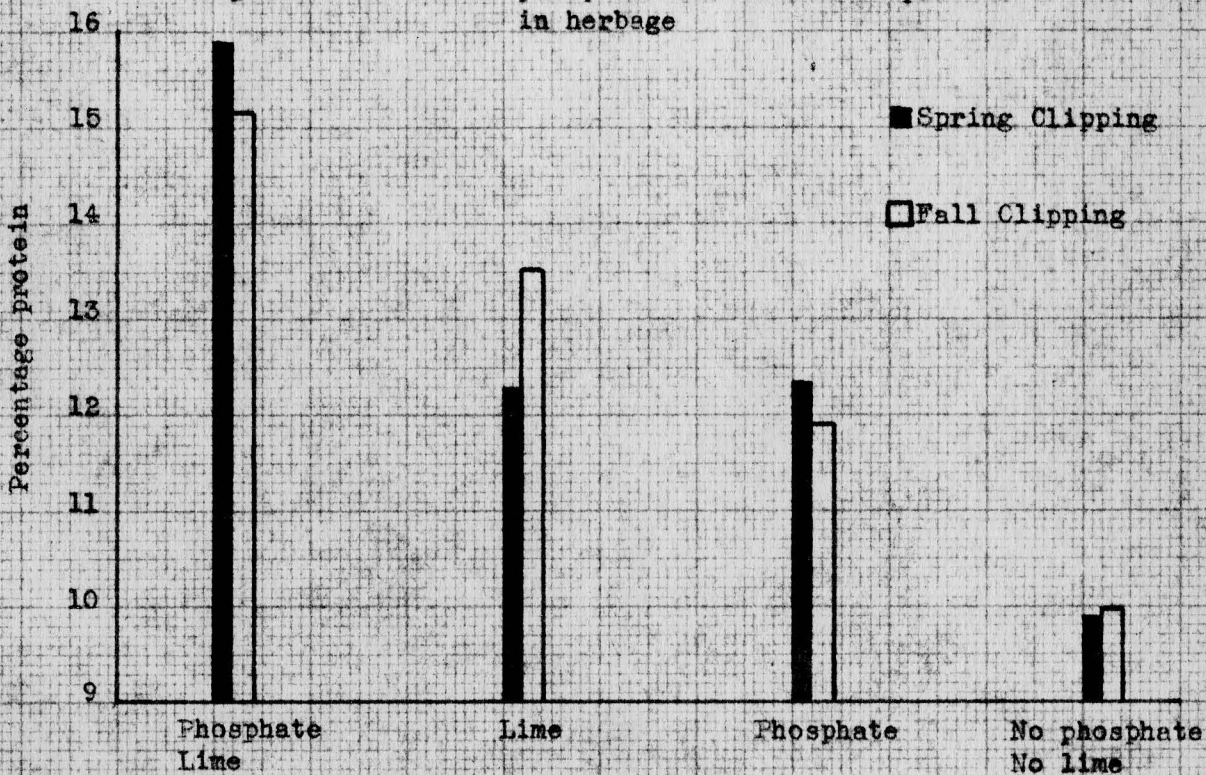


Figure 9. Effect of phosphate fertilizer on protein in herbage



### Phosphoric Acid

There was a higher average percentage phosphoric acid\* from the limed than from the unlimed plots (Figure 10). The phosphoric acid content was higher in the herbage on the limed plots in the fall than in the spring. The highest phosphoric acid content in the spring was from the limed 4-36-4 plot and in the fall from the limed 4-36-4 plot. The lowest phosphoric acid content in the spring and fall was from the no fertilizer plot.

In Figure 11 is shown that phosphate fertilizer increased phosphoric acid content in herbage. Brown (7), and Robinson and Pierre (23) reported increase in phosphorus content of grasses where phosphate fertilizer was applied. Wilkins and Vinall (32) found that both protein and phosphorus content of pastures increased with the use of phosphate fertilizer.

Plots 7 and 10, receiving 36 units of phosphate fertilizer plus lime, contain nearly twice as much phosphoric acid in herbage as limed plots receiving no phosphate fertilizer.

\* In this study the phosphorus content of the herbage is expressed as percentage phosphoric acid ( $P_2O_5$ ).

Figure 10. Percentage of phosphoric acid in herbage from limed and unlimed plots

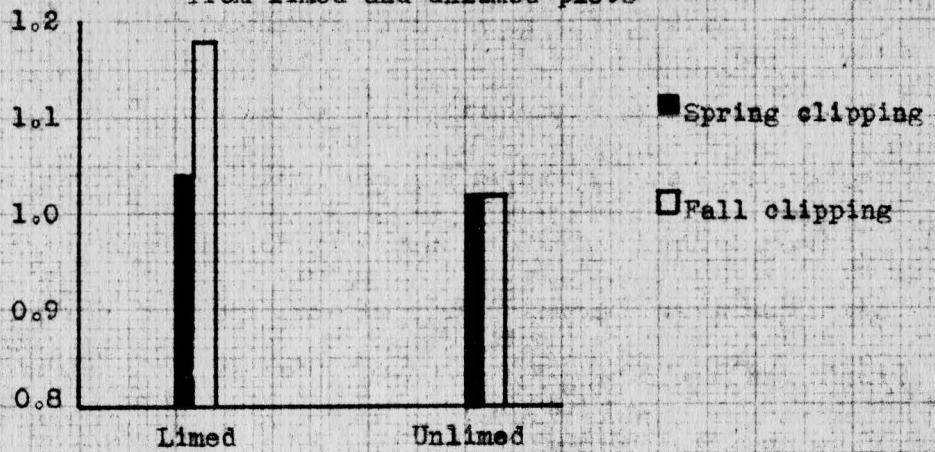
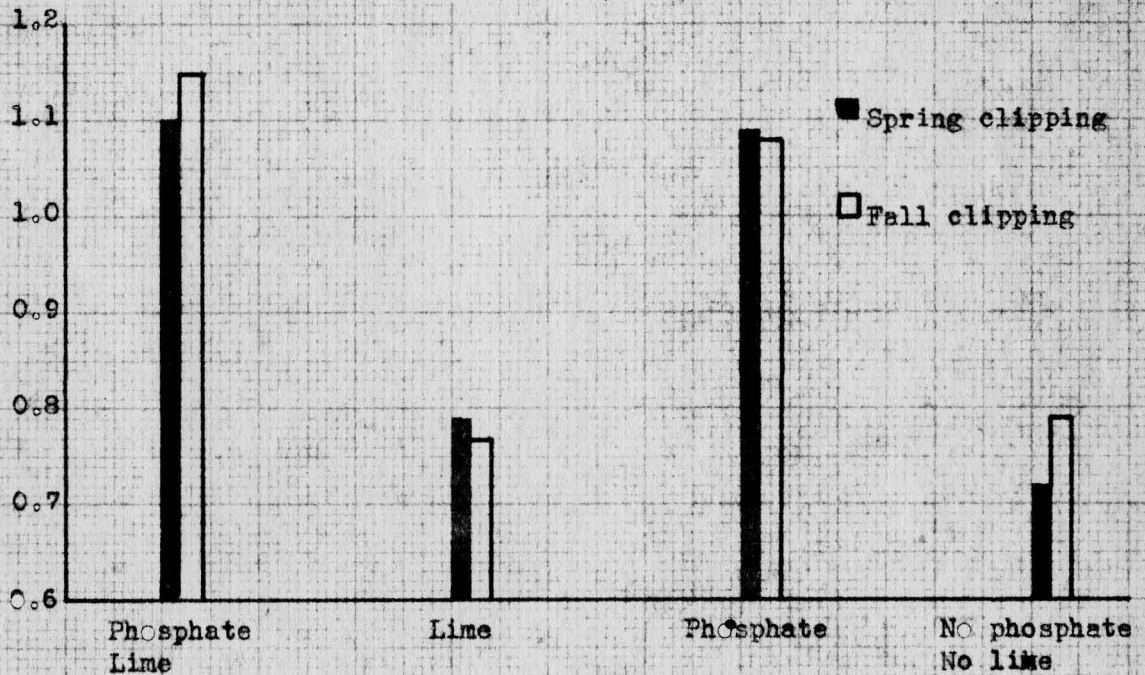


Figure 11. Effect of phosphate fertilizer on phosphoric acid content of herbage



### Calcium Oxide

The calcium oxide\* content of the herbage was higher on the plots receiving lime than on the unlimed plots (Figure 12). The herbage clipped in spring contained a higher average calcium oxide content than that clipped in the fall. Haltz (12) found the calcium content of herbage was influenced by calcium content of the soil.

In Figure 14 is shown that nitrogen fertilizers increase the calcium oxide content of herbage except in the fall clipping on the unlimed plots and the difference there is very small. The herbage from the plots receiving nitrogen fertilizer and lime contained 22 percent more calcium oxide in the spring than in the fall.

The calcium oxide content of herbage in relation to the phosphate fertilizers used is shown in Figure 13. Where phosphate fertilizer was used the calcium oxide was higher in the spring than in the fall clippings and where no phosphate fertilizer was used the reverse was true.

\* In this study the calcium content of the herbage is expressed as percentage calcium oxide.

Figure 12. Averaged percentage calcium oxide from limed and unlimed plots

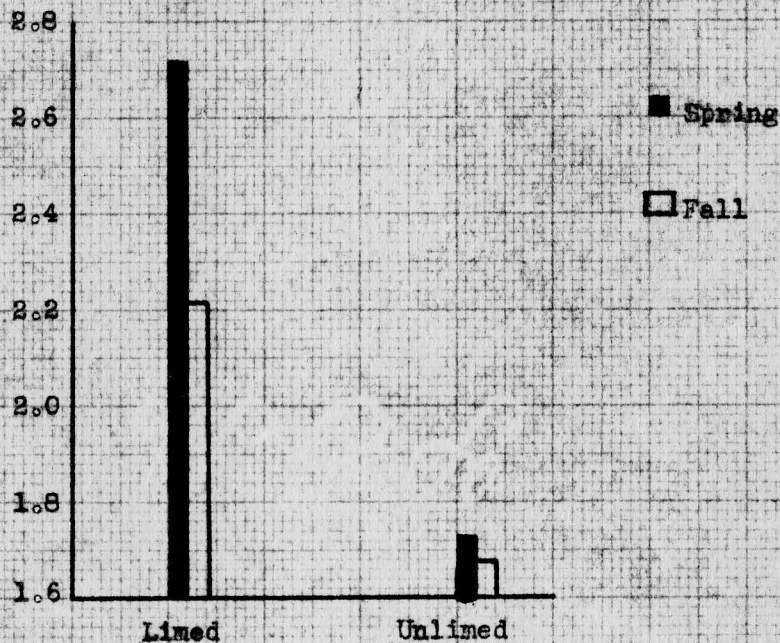


Figure 13. Effect of phosphate fertilizer on calcium oxide content of herbage

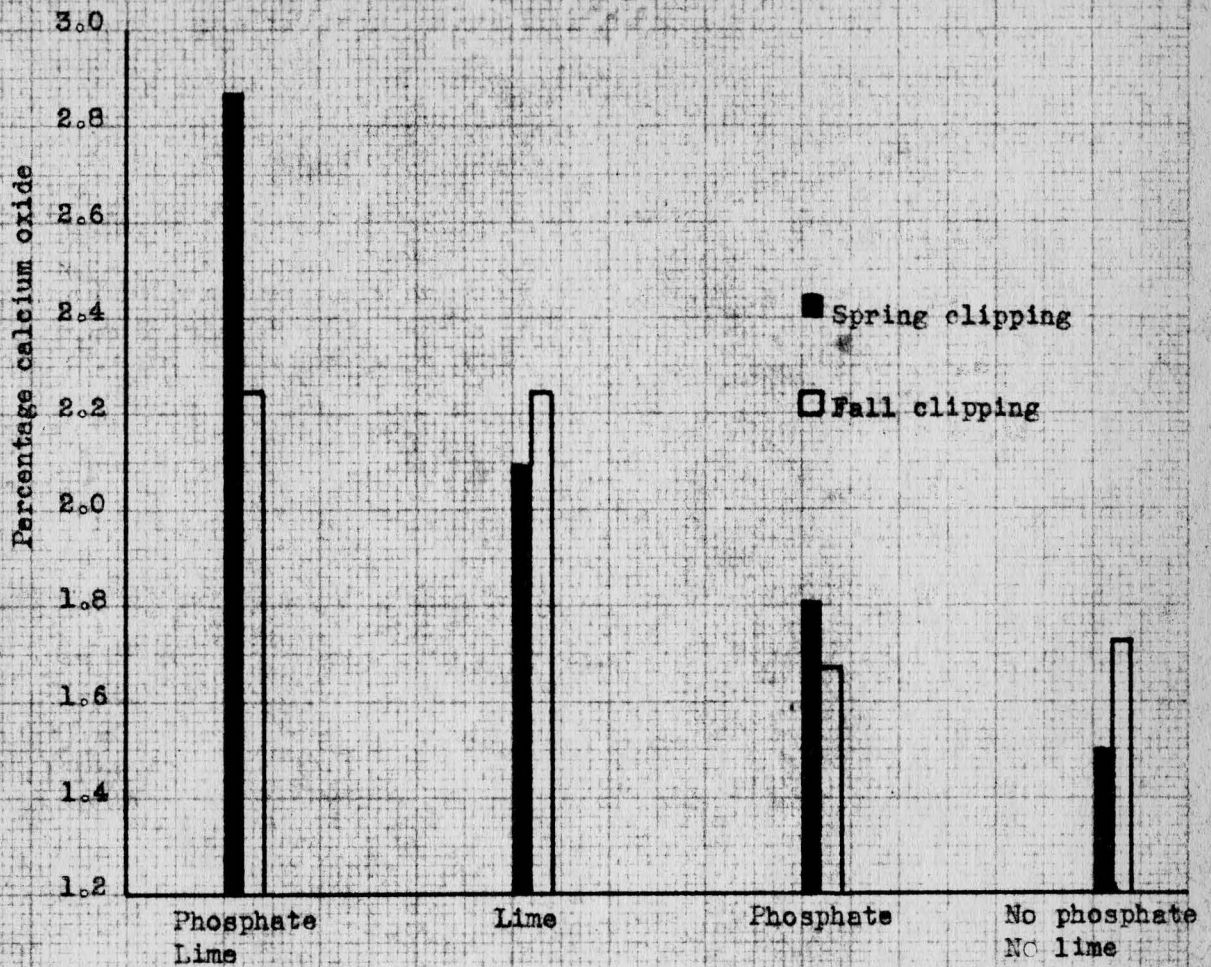
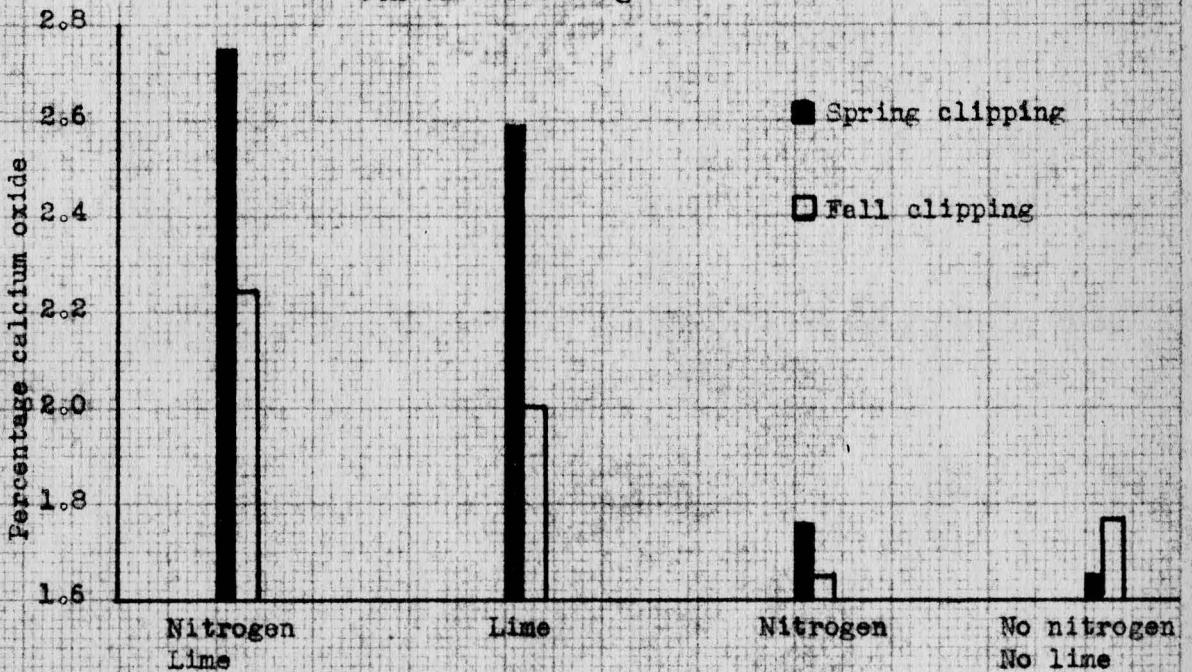


Figure 14. Effect of nitrogen fertilizer on calcium oxide content of herbage



### SOIL ANALYSIS

The properties of this soil at the beginning of the experiment are not known. It is assumed however that this soil is fairly uniform and the check plot will give an indication of the soil properties at the beginning of the experiment. The plots that have been fertilized present differences which are the results of the fertilization and liming treatments during the five year period.

The comparisons of soil analysis were made between the averages of different fertilizer treatments, such as lime versus no lime, nitrogen versus no nitrogen and phosphorus versus no phosphorus.

Tables 9 and 10 show the results of the analysis of the soil.

#### Effect of Fertilizer and Lime on Organic Matter Accumulation

In Figure 15 is shown the effect of fertilizer and lime on organic matter accumulation. The lime and fertilizers gave the highest organic matter accumulation and the limed no fertilizer plot higher than the average of the fertilizer no lime plots. In every case the organic matter was higher in plots receiving lime than those receiving no lime.

The pH of the check plots receiving no fertilizer were slightly higher than the average pH for the fertilized plots. A comparison of tables 1 and 9 indicates the highest yielding plots contain the higher percentage of organic matter. Strasser, et al (30), Slater and Green (25) and Bear and Salter (4) found a relationship between organic matter content and total dry matter produced.

Table 9. - The Effect of Different Fertilizer and Lime Treatments on Organic Matter, Total Nitrogen and pH of the Soil.

| Fertilizer Treatment* | Percent Organic Matter |         | Percent Total Nitrogen |         | pH    |         |
|-----------------------|------------------------|---------|------------------------|---------|-------|---------|
|                       | Limed                  | Unlimed | Limed                  | Unlimed | Limed | Unlimed |
| 4-12-4 (1)            | 2.98                   | 2.88    | 2.49                   | 1.78    | 6.01  | 4.87    |
| 4-12-4 (2)            | 2.80                   | 2.60    | 2.30                   | 1.40    | 5.99  | 4.76    |
| 4-12-4 (3)            | 2.87                   | 1.80    | 2.23                   | 1.35    | 5.85  | 4.68    |
| 0-12-4                | 2.38                   | 1.88    | 1.86                   | 1.72    | 5.90  | 4.69    |
| 4-0-4                 | 2.35                   | 2.00    | 1.93                   | 1.68    | 5.98  | 4.62    |
| 4-12-0                | 2.98                   | 1.70    | 2.30                   | 1.70    | 6.01  | 4.64    |
| 4-36-4                | 2.78                   | 2.35    | 2.22                   | 1.98    | 6.01  | 4.78    |
| 4-12-12               | 3.25                   | 2.25    | 2.86                   | 2.02    | 6.12  | 4.92    |
| No Fert.              | 2.48                   | 1.85    | 2.60                   | 2.01    | 6.09  | 4.89    |
| 4-36-0                | 2.65                   | 2.40    | 2.59                   | 2.02    | 6.01  | 4.91    |
| 4-0-12                | 2.90                   | 2.18    | 2.32                   | 1.79    | 5.99  | 4.91    |
| 2-6-2                 | 3.40                   | 2.15    | 2.49                   | 2.12    | 6.08  | 4.91    |
| 8-24-8                | 3.30                   | 1.80    | 2.39                   | 1.62    | 6.02  | 4.81    |
| 12-36-12              | 2.80                   | 1.78    | 1.62                   | 1.60    | 5.89  | 4.81    |
| 0-12-0 (2)            | 2.73                   | 1.30    | 1.99                   | 1.33    | 6.17  | 4.87    |
| 0-12-0 (3)            | 3.43                   | 2.43    | 2.54                   | 1.73    | 6.21  | 4.87    |

\* Applied annually at the rate of 300 pounds per acre.

- (1) Superphosphate
- (2) Triple superphosphate
- (3) Calcium metaphosphate

Table 10. - The Effect of Different Fertilizer and Lime Treatments on Cation Exchange Properties and pH of the Soil.

| Fertilizer Treatment* | Calcium<br>m.e. <sup>1</sup> |      | Magnesium<br>m.e. |      | Potassium<br>m.e. |      | Hydrogen<br>m.e. |      | Total<br>m.e. |       | Percent.<br>Base<br>Saturation |      | Cation Ex-<br>change Ca-<br>pacity m.e. |       | pH   |      |
|-----------------------|------------------------------|------|-------------------|------|-------------------|------|------------------|------|---------------|-------|--------------------------------|------|---|-------|------|------|
|                       | L                            | Unl. | L                 | Unl. | L                 | Unl. | L                | Unl. | L             | Unl.  | L                              | Unl. | L                                       | Unl.  | L    | Unl. |
| 4-12-4 (1)            | 10.37                        | 3.76 | .163              | .111 | .027              | .027 | 8.4              | 12.2 | 18.96         | 16.10 | 56.2                           | 24.2 | 13.63                                   | 13.27 | 6.01 | 4.87 |
| 4-12-4 (2)            | 9.74                         | 2.52 | .182              | .099 | .031              | .027 | 7.1              | 12.7 | 17.05         | 15.35 | 58.4                           | 17.2 | 13.67                                   | 12.22 | 5.99 | 4.76 |
| 4-12-4 (3)            | 8.76                         | 2.80 | .164              | .073 | .040              | .028 | 8.5              | 14.0 | 17.46         | 17.56 | 51.3                           | 16.5 | 14.33                                   | 13.49 | 5.85 | 4.68 |
| 0-12-4                | 7.61                         | 2.21 | .153              | .072 | .020              | .038 | 7.1              | 12.5 | 14.89         | 14.82 | 49.0                           | 15.7 | 13.55                                   | 13.05 | 5.90 | 4.69 |
| 4-0-4                 | 9.43                         | 2.17 | .179              | .099 | .035              | .048 | 6.0              | 12.5 | 15.64         | 14.82 | 61.7                           | 15.6 | 12.96                                   | 13.29 | 5.98 | 4.62 |
| 4-12-0                | 9.33                         | 2.33 | .182              | .109 | .017              | .038 | 7.5              | 12.6 | 17.03         | 15.08 | 56.0                           | 16.4 | 13.92                                   | 13.33 | 6.01 | 4.64 |
| 4-36-4                | 9.62                         | 3.46 | .173              | .093 | .031              | .028 | 6.8              | 12.6 | 16.62         | 16.18 | 59.1                           | 22.1 | 13.72                                   | 14.33 | 6.01 | 4.78 |
| 4-12-12               | 11.01                        | 3.56 | .188              | .115 | .039              | .035 | 8.9              | 12.3 | 20.14         | 16.11 | 55.8                           | 23.6 | 13.82                                   | 14.15 | 6.12 | 4.92 |
| No Fert.              | 11.46                        | 2.99 | .137              | .081 | .046              | .030 | 7.4              | 14.0 | 19.04         | 17.10 | 61.2                           | 16.3 | 13.38                                   | 13.94 | 6.09 | 4.89 |
| 4-36-0                | 10.56                        | 3.81 | .137              | .103 | .027              | .031 | 9.8              | 13.3 | 20.52         | 17.24 | 52.3                           | 22.9 | 13.98                                   | 14.77 | 6.01 | 4.91 |
| 4-0-12                | 8.90                         | 2.93 | .179              | .061 | .054              | .051 | 9.3              | 13.0 | 18.43         | 15.99 | 50.0                           | 19.0 | 13.51                                   | 12.74 | 5.99 | 4.91 |
| 2-6-2                 | 9.64                         | 3.40 | .138              | .061 | .029              | .036 | 8.1              | 14.1 | 17.91         | 17.60 | 54.8                           | 19.9 | 12.02                                   | 13.97 | 6.08 | 4.91 |
| 8-24-8                | 10.09                        | 2.82 | .181              | .090 | .028              | .027 | 8.1              | 12.7 | 18.40         | 15.64 | 56.0                           | 18.8 | 13.79                                   | 13.93 | 6.02 | 4.81 |
| 12-36-12              | 7.10                         | 3.07 | .181              | .070 | .043              | .033 | 7.9              | 13.0 | 15.22         | 16.17 | 48.1                           | 19.6 | 13.56                                   | 12.40 | 5.89 | 4.81 |
| 0-12-0 (2)            | 9.13                         | 2.58 | .154              | .069 | .016              | .021 | 6.8              | 12.7 | 16.10         | 15.37 | 57.8                           | 17.4 | 13.93                                   | 12.88 | 6.17 | 4.87 |
| 0-12-0 (3)            | 11.16                        | 3.03 | .223              | .095 | .023              | .026 | 6.3              | 13.0 | 17.71         | 16.15 | 64.4                           | 19.5 | 12.54                                   | 13.33 | 6.21 | 4.87 |

\* Applied annually at the rate of 300 pounds per acre.

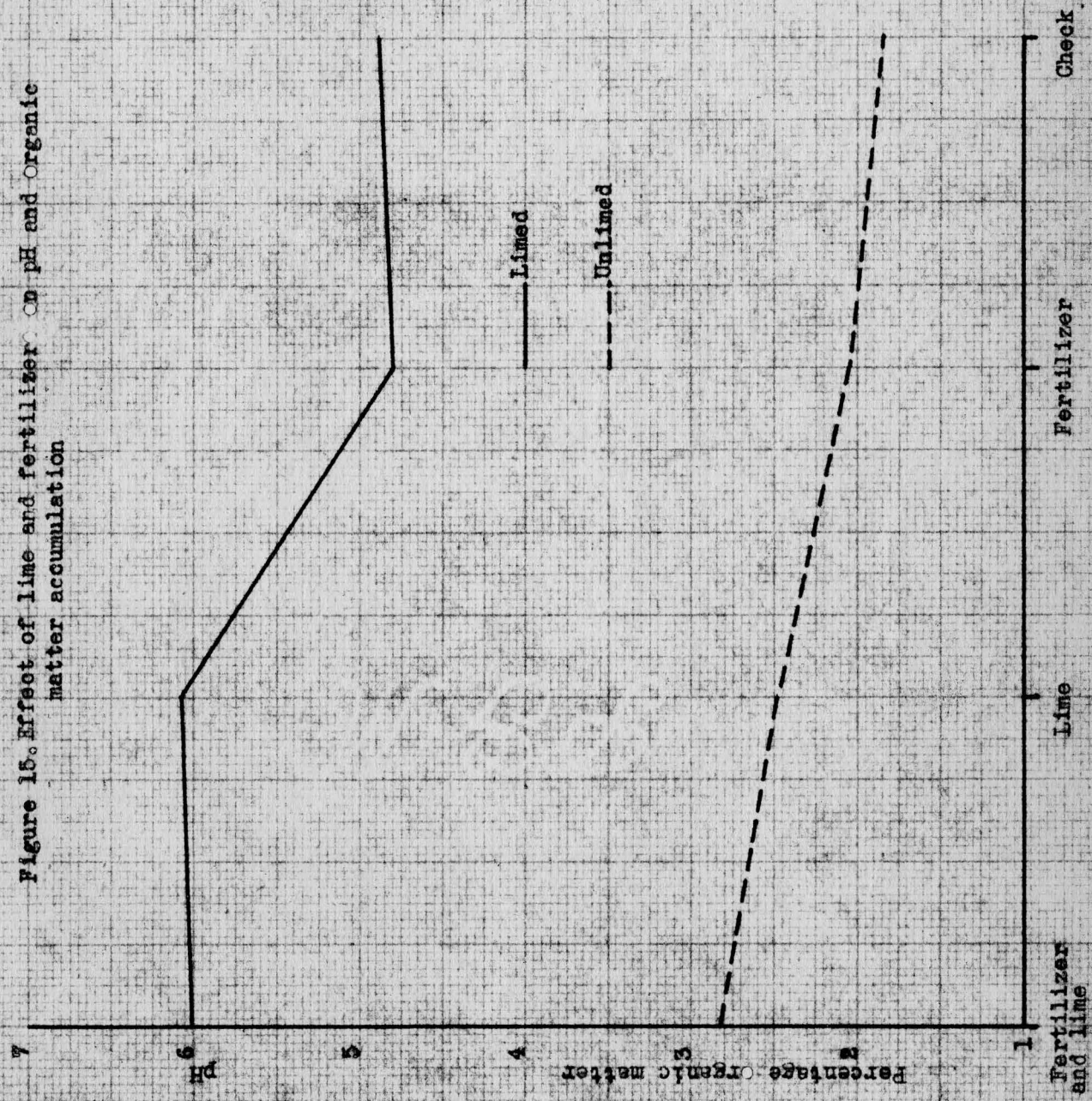
- (1) Superphosphate
- (2) Triple superphosphate
- (3) Calcium metaphosphate

<sup>1</sup> Milliequivalent per 100 grams soil.

L - Limed  
Unl. - Unlimed

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Figure 15. Effect of lime and fertilizer on pH and Organic matter accumulation



Effects of Fertilizer and Lime Treatments on the  
Total Nitrogen Content

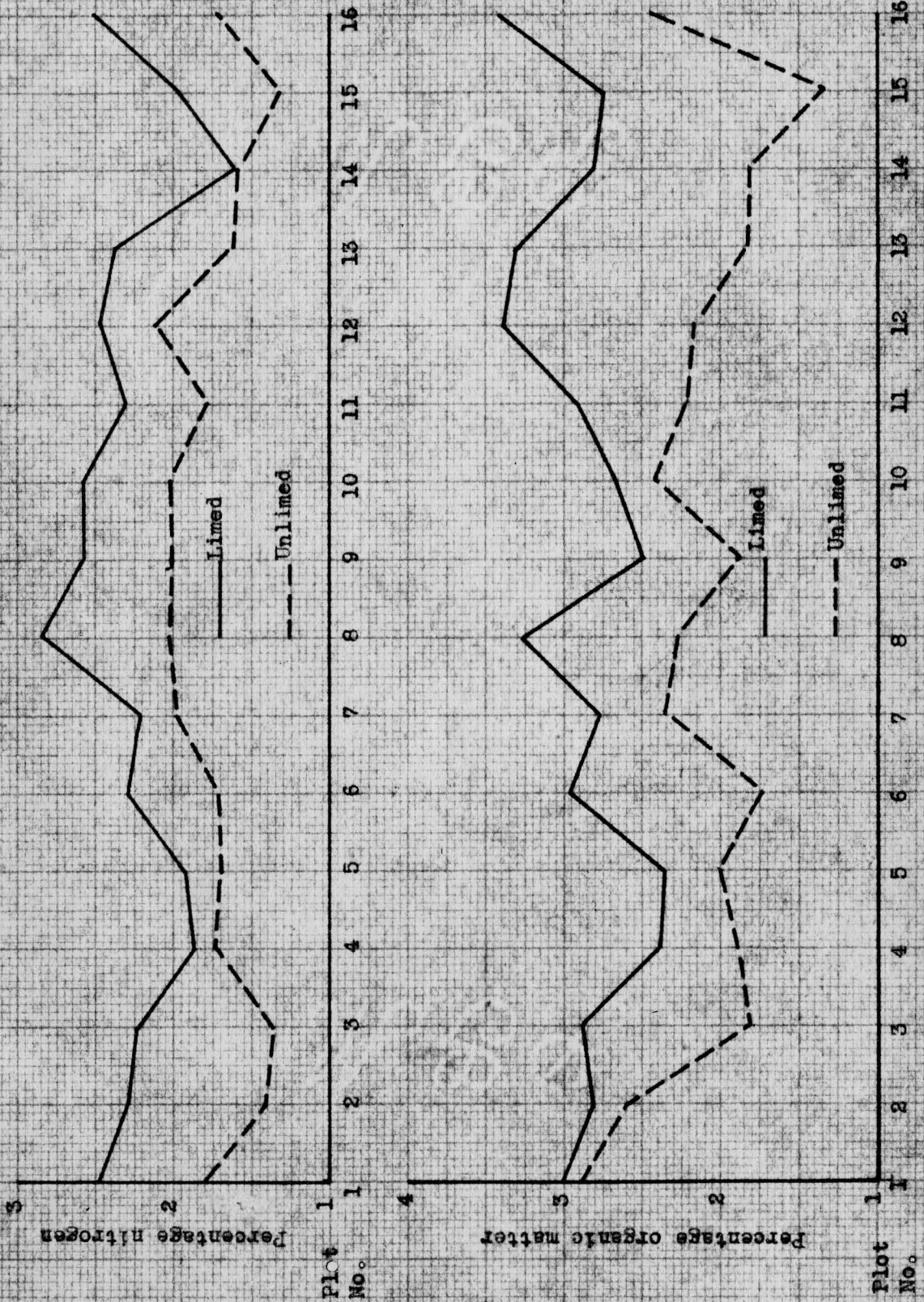
In Table 9 and Figure 16 it is indicated that the percentage of total nitrogen is rather closely related to percentage organic matter. There was a higher average percentage of nitrogen in herbage from limed plots than the plots receiving no lime. In every case the limed portions of the plots contained more soil organic matter than the unlimed portions.

The higher yielding plots contain a higher percentage of nitrogen in the soil. Bear and Salter (4) and Salter and Green (25) found a relationship between size of crop grown and both organic matter and nitrogen accumulation.

Effects of Fertilizer and Lime Treatments on the  
Base Exchange Properties of the Soil

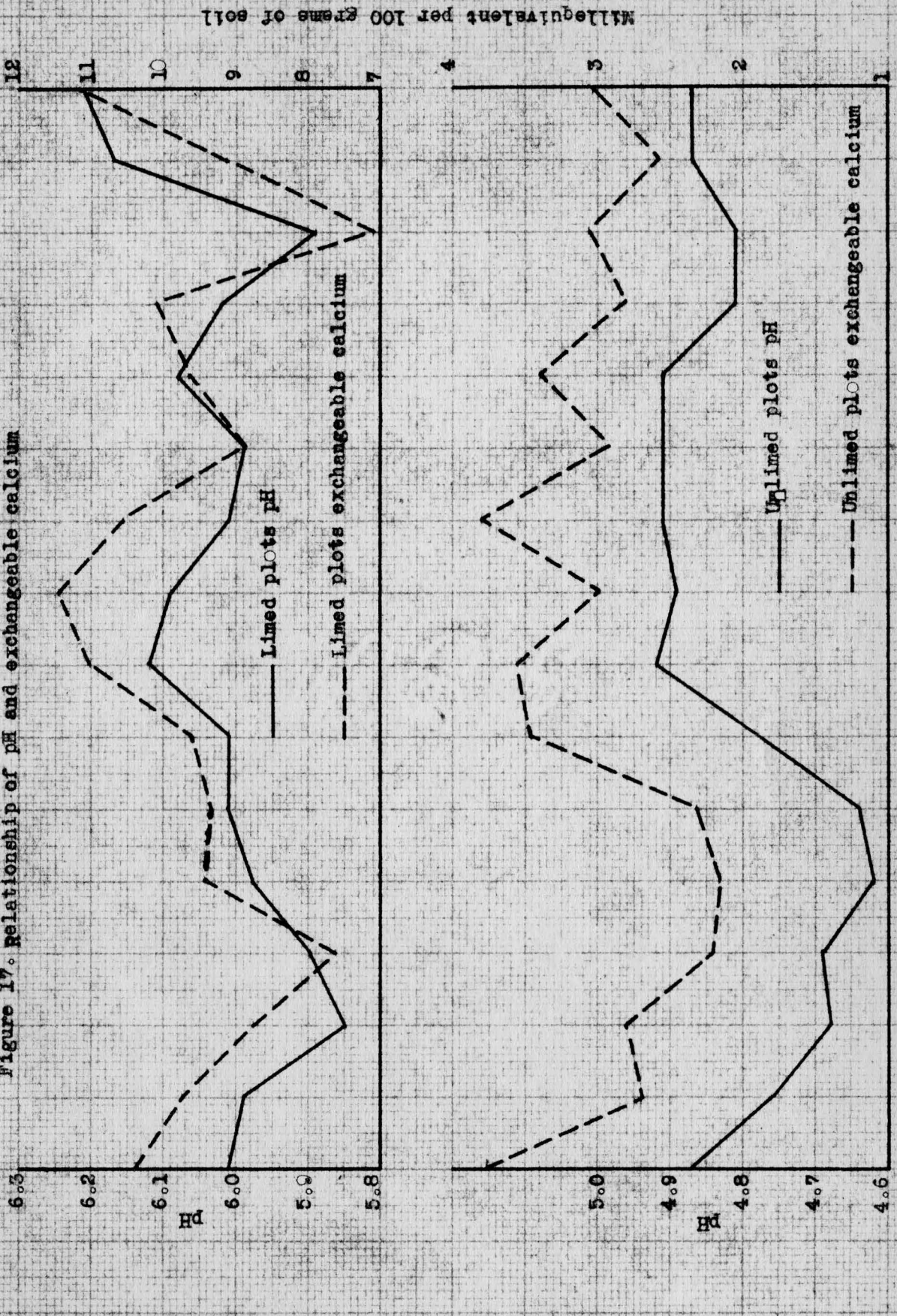
In Table 10 is shown that the application of lime has increased the average exchangeable calcium. Merkle (15), Schollenberger and Dreibelbis (27), Ravikovitch (20) indicate similar results. There was a definite relationship between the pH of the soil and the exchangeable calcium as seen in Figure 17. Green (11) found that exchangeable calcium followed very closely the reaction of the soil. There was no apparent relationship between fertilizer treatment and the amount of exchangeable calcium in the soil.

Figure 16. Percentage of nitrogen and organic matter in the soil



Treatment received by each plot given in Figure 1.

Figure 17. Relationship of pH and exchangeable calcium



Millicivalent per 100 grams of soil

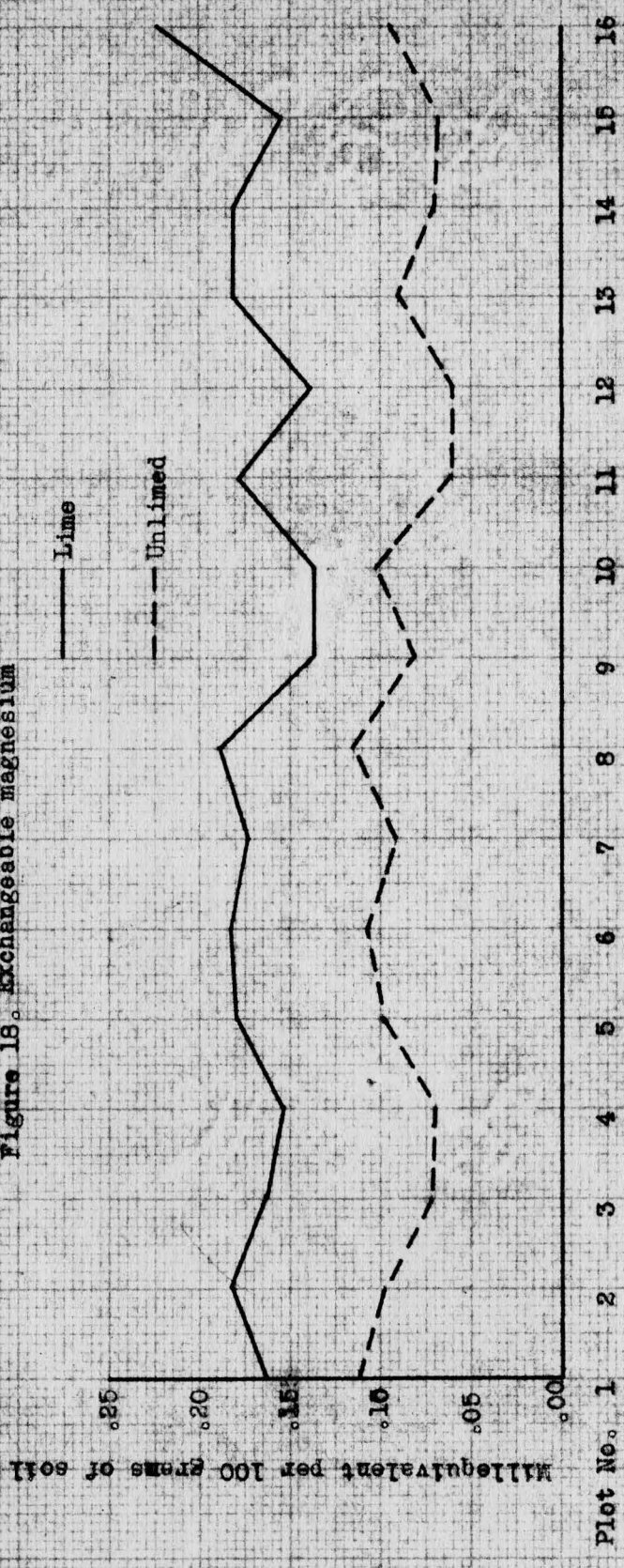
Treatment received by each plot given in Figure 1.

The average value of exchangeable magnesium for all limed plots is 102 percent larger than the corresponding value for the unlimed plots (Figure 18). This is probably due partially to the fact that dolomitic limestone was used on limed plots. Merkle (15) found that dolomitic limestone applications resulted in an increase in exchangeable magnesium in the soil. There was no effect of the different fertilizer treatments upon the exchangeable magnesium.

The results of exchangeable potassium determinations on limed and unlimed plots are given in Table 10 and Figure 19. Plots 11 and 14 show relatively high exchangeable potassium. These two plots received 12 units of  $K_2O$  per acre per year. Plots 6, 15, and 16 receiving no potassium in fertilizer treatment were relatively low in exchangeable potassium. Rich and Obenshain (21) found a notable increase in exchangeable potassium where potash fertilizer was used. Schollenberger and Dreibelbis (27) found that exchangeable potassium was little influenced by fertilizers not containing potassium.

From Table 10 and Figure 20 it can be seen that in every case the unlimed portion of the plots were higher in exchangeable hydrogen. The average exchangeable hydrogen is 67 percent higher on unlimed plots than on limed plots. Schollenberger and Dreibelbis (27), Wilson (33), and Merkle (15) found that the application of lime reduced the amount of exchangeable hydrogen.

Figure 18. Exchangeable magnesium



Treatment received by each plot given in Figure 1.

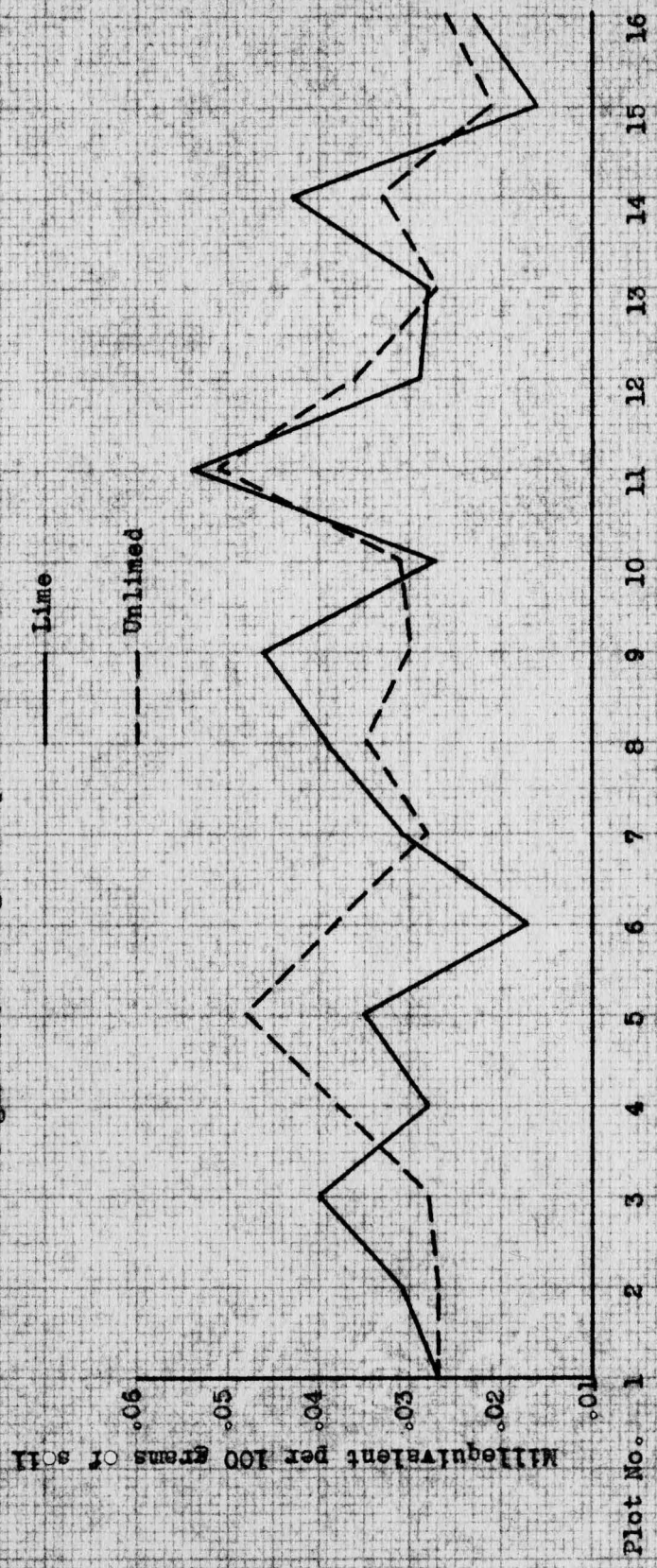
Plot No. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

Milliequivalent per 100 grams of soil

Lime

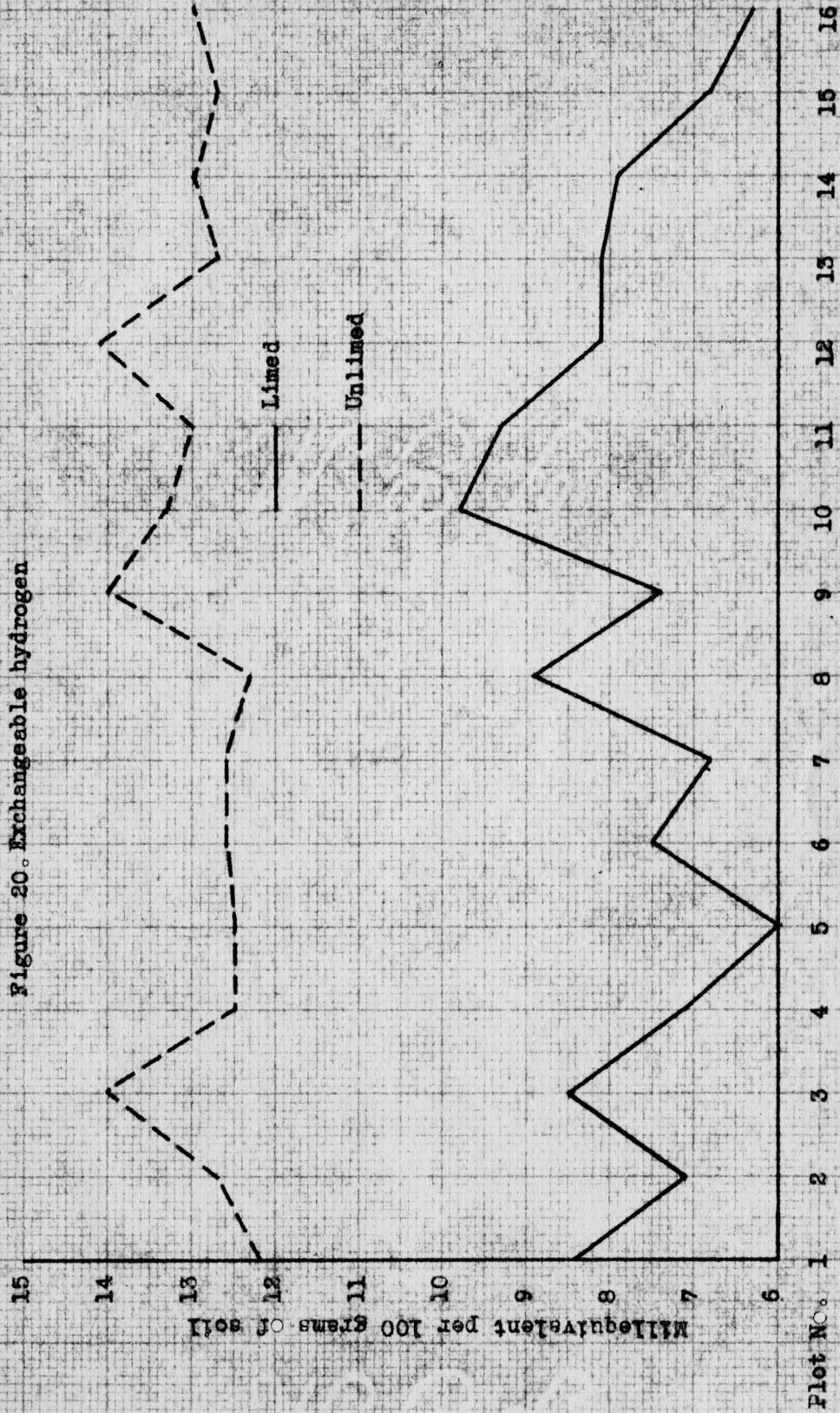
Unlimed

Figure 19. Exchangeable potassium



Treatment received by each plot given in Figure 1.

Figure 20. Exchangeable hydrogen



Treatment received by each plot given in Figure 1.

As shown in Figure 15 the application of lime increased the pH value. In Table 10 is shown that the degree of base saturation is lower on plots receiving no lime.

There is no apparent relationship between the different fertilizer treatments and the exchangeable hydrogen. Bayer (3) found that fertilizer treatments did not materially effect the hydrogen ion concentration.

The average cation exchange capacity was higher on the limed than on the unlimed plots. This is in close agreement with the literature cited. Schollenberger and Dreibelbis (27), Merkle (15), Strasser, et al (30) and Metzger (16) found that the application of lime increased cation exchange capacity.

There was only a very small amount of variation in the cation exchange capacity for the different fertilizer treatments

Effects of Fertilizer and Lime on pH, Percentage Base Saturation and Sum of Individual Bases

Table 10 and Figure 15 show that the pH of the limed plots was higher than the pH of the unlimed plots. In all cases but two (plots 3 and 14) the sum of the individual bases was higher on limed plots than on unlimed plots. Schollenberger and Dreibelbis (27) found that total bases were higher from limed than on unlimed plots. It is noted in Table 10 and on Figures 21 and 22 that the cation exchange capacity

Figure 21. Sum of individual bases

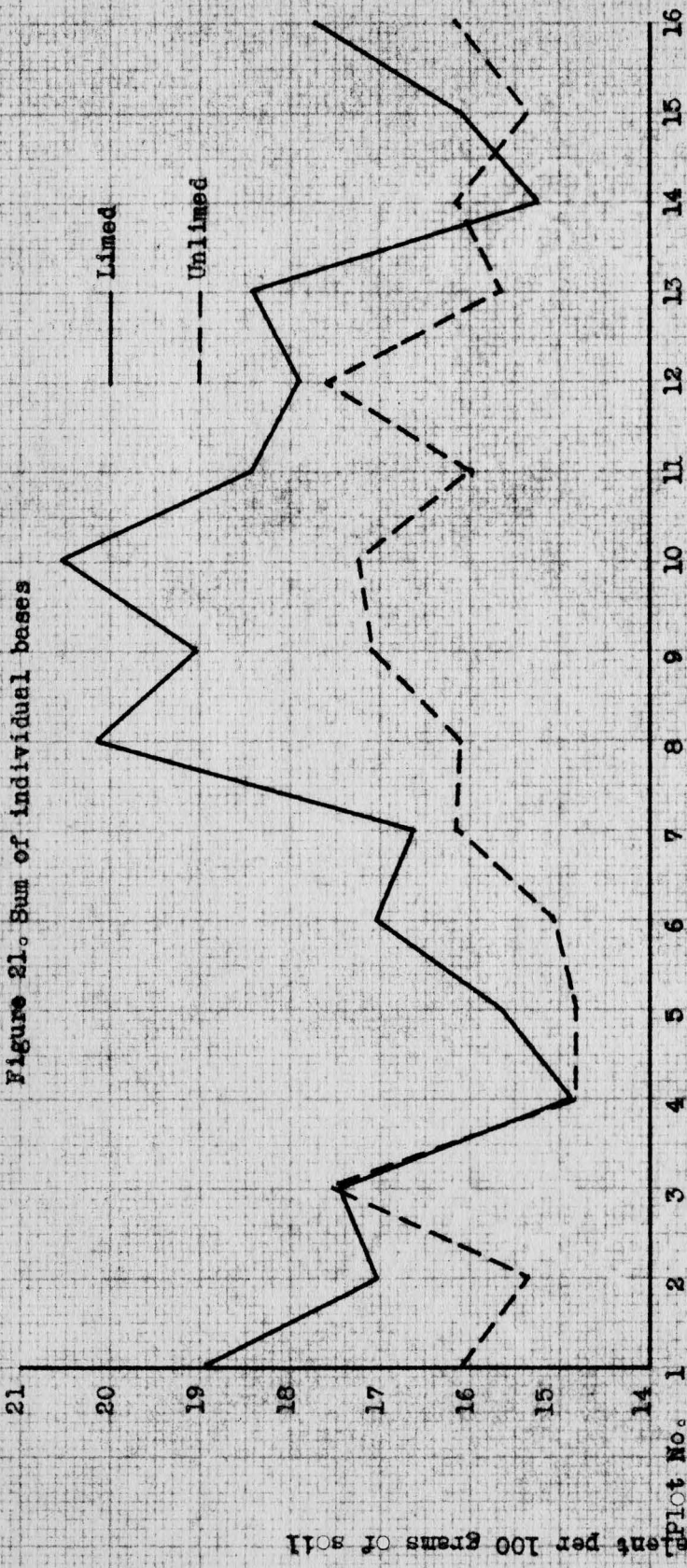
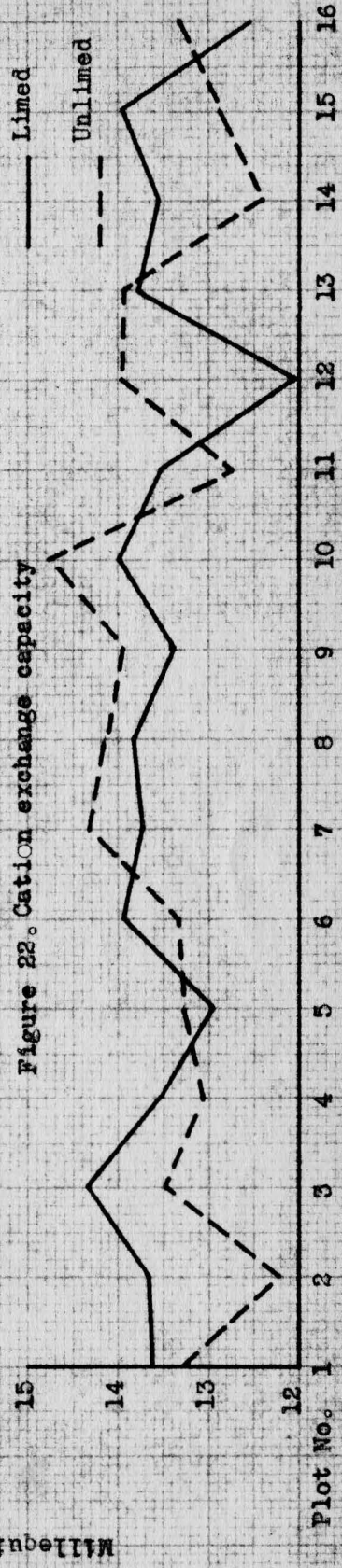


Figure 22. Cation exchange capacity

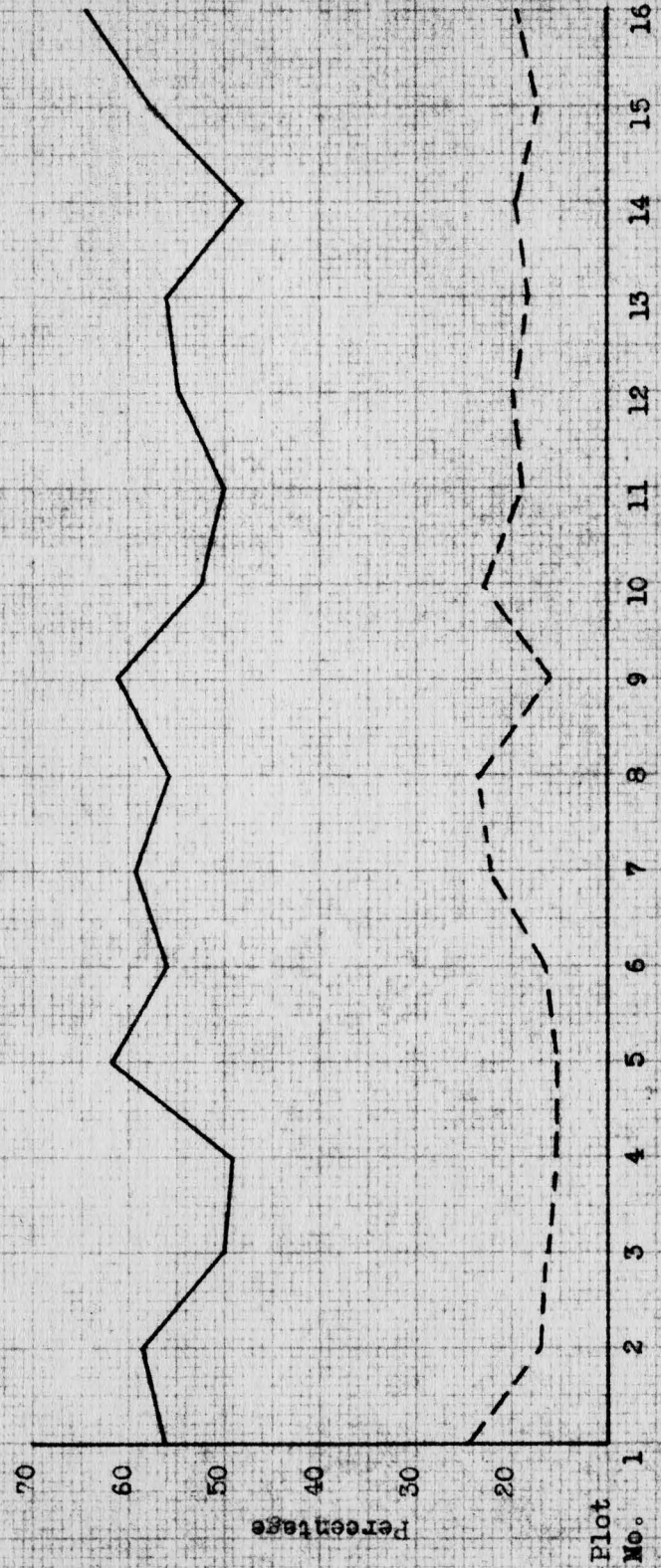


Treatment received by each plot given in Figure 1.

Millicent per 100 grams of soil

Figure 23. Percentage base saturation

— Limed  
- - - Unlimed



Treatment received by each plot given in Figure 1.

is lower than the sum of the individual bases. This is probably due to the method used for analysis of cation exchange capacity. Mehlich (14) found that ammonium acetate method gave lower values for cation exchange capacity on colloids of the organic and 1:1 lattice type. In Figure 23 is shown the percentage of base saturation, which is much higher on plots receiving lime. Green (11) found a definite increase in degree of base saturation as pH values increase.

There is no apparent relationship between percentage of base saturation and the different fertilizer treatments.

SUMMARY AND CONCLUSIONS

A study of the effects of certain fertilizers and lime treatments on yield, chemical composition and vegetative population of a pasture and on certain properties of Coeburn silt loam was carried out. The yield and vegetative analysis were made for a five year period. The chemical composition of herbage analysis for a one year period (1945). Individual soil analysis were made on the 32 sub-plots on samples secured in February 1946. As a result of this investigation, the following conclusions are presented:

1. Lime, nitrogen and phosphate fertilizers increase pasture yields.
2. Lime decreased the amount of bare space and weeds and increased the amount of clover and grasses in pasture.
3. Lime, nitrogen and phosphate fertilizers increased the amount of protein in herbage.
4. Lime and phosphate fertilizers increased the amount of phosphorus in herbage.
5. Lime and fertilizer increased organic matter and nitrogen content of the soil.
6. Lime increased calcium content of herbage, pH and exchangeable calcium of the soil.
7. Lime increased the cation exchange capacity of the soil and decreased exchangeable hydrogen.

8. Dolomitic limestone increased exchangeable magnesium in the soil.

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