EFFECTS OF SOIL TYPE AND SOIL TREATMENTS ON THE CHEMICAL COMPOSITION OF ALFALFA PLANTS

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Title

Effects of Soil Type and Soil Treatments on the Chemical Composition of Alfalfa Plants.

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INTRODUCTION

Plants absorb their mineral nutrients from the soil; hence analysis of the plant should give some idea regarding the supply of available mineral nutrient elements in the soil. Climatic conditions, due to their effect on growth, cause changes in the mineral composition of plants. Similarly, variations in soil types may markedly affect the absorption and utilization of plant nutrients.

Investigations show that certain soils are deficient in available nitrogen, phosphorus, and calcium and these deficiencies are reflected in some cases in the plants grown on them. Forage crops generally have a low calcium and phosphorus content when grown on soils inadequately supplied with these elements.

In some of the western states and in other parts of the United States, especially in the dairy sections, certain diseases in dairy cattle are associated with mineral deficiencies, especially phosphorus in the roughage fed to these animals. As these cattle diseases have been observed in Michigan, information concerning the calcium and phosphorus content of alfalfa hay grown in this state on different soils and with various fertilizer treatments was desired in order to determine under what soil conditions mineral deficiencies in alfalfa hay would be found. Accordingly, this research was undertaken to study the effect of limestone and phosphate and potash fertilizers on the nitrogen, calcium and phosphorus content of alfalfa grown on the following soil types: Isabella sandy loam, Brookston loam, Brookston silt loam, Brookston clay loam, Gilford loam, Montcalm sandy and Miami silt loams.

REVIEW OF LITERATURE

A great amount of work has been done on the quality of crops as affected by fertilizer treatments and soil conditions. In this paper the author cites only those articles found in the literature which deal directly with this work, however, 283 papers were reviewed.

Mather (8) in studying the effects of fertilizers upon the forms and amount of phosphorus in hays, found that the phosphate treatments increased the total phosphorus content of timothy and alsike hays as much as 62 per cent compared to that from the unfertilized plots; and alfalfa from the fertilized plats showed an increase of 34 per cent as compared to that from the unfertilized plat.

Fonder (4) reports studies on the influence of soil type on the calcium and magnesium content of alfalfa stems grown on different soil types and analyzed at different stages of growth to show that there was a noticeable and consistent variation in the calcium content of the alfalfa grown on the different soil types throughout the growth period, the calcium content increasing with maturity of the plant. The calcium content was considerably higher in the leaves than in the stems. Soil texture influences the calcium content, it being highest in plants grown on medium textured soils as compared with very light or heavy soils.

Holtz (6) in studying the effect of the calcium and phosphorus content of western Washington soils upon the calcium and phosphorus content of oats and clover hay found the calcium content of oats and red clover to be largely influenced by the calcium content of the soil. The phosphorus content of oats and red clover are materially affected by the soil phosphorus content, but the two crops are not affected alike; the phosphorus content of oats follows more closely the total phosphorus content of the soil, while that of red clover follows the available phosphorus content of the soil more closely.

Sewell and Latshaw (18) in studying the effects of lime, phosphate and potash on soil reaction and the composition of alfalfa, found that applications of superphosphate alone did not increase the phosphorus content of the alfalfa, but the lime plus superphosphate treatments increased the phosphorus content of alfalfa. The potassium content of the alfalfa was very markedly affected by applications of lime, it decreasing in proportion to the rate of liming.

McCool and Weldon (9) investigating the effect of soil type and fertilization on the composition of expressed sap of plants, found that red clover grown on muck soil in pots, gave a good response to both phosphate and potash treatments, the amount of each element in the juice being roughly proportional to the amounts of phosphate and potash fertilizers applied.

Studies by the chemistry department of the Montana State College (10) on fertilizers and forage plants, show that phosphate fertilizer treatments, in all cases increased the phosphorus content of alfalfa hay as compared to that from the no treatment plats, 65 per cent in the first cutting, 43 in the second and 32 in the third.

Nygard (12) investigated the phosphorus deficiencies in the soils of Montana and found that the phosphorus content of alfalfa growing on soils deficient in phosphorus was materially increased by an application of available phosphorus to those soils. In some cases the phosphorus content of alfalfa was increased as much as 46 per cent by the application of treble superphosphate to the soil.

Ames and Boltz (2) in their investigations on the nitrogen and mineral constituents of the alfalfa plant, found the phosphorus supply of the soil, as increased by the addition of superphosphate, to be reflected by the phosphorus content of the alfalfa, which followed the same order as the yeilds obtained. Phosphate alone treatments produced larger increases in the phosphorus content of alfalfa than did the nitrogen plus phosphate treatments. Additions of calcium and magnesium to the soil in the forms of lime increased the calcium and magnesium content of the alfalfa, but decreased the yeild. The percentages of nitrogen, phosphorus, potassium and calcium were higher in the first cutting of alfalfa, where the yields were larger, than in the second cutting.

Eckles and co-workers (3) found in their studies with the mineral deficiencies in cattle rations, that the phosphorus and calcium content of alfalfa and other hays was increased with ordinary phosphate applications to the soil.

Sewell and co-workers (17) found in their investigations on the effect of phosphate and lime applications on soil reaction and the growth of alfalfa, that the calcium content of alfalfa increased with increasing applications of lime up to 2,000 pounds of hydrated lime per acre. Applications of lime produced a decrease in the potassium content of the alfalfa up to 8,000 pounds of hydrated lime per acre, above that rate, the potassium content of the alfalfa increased. Lime applications decreased the nitrogen content of the alfalfa. Phosphate treatments depressed the per cent of nitrogen, calcium, phosphorus, and potash contained in the plants in proportion to the amount of phosphate applied to the soil.

Reimer and Tartar (14) investigated the use of sulfur as a fertilizer for alfalfa in souther Oregon and found that alfalfa grown on sulfur treated soils had a higher nitrogen content than that grown on soils not receiveing sulfur treatments.

Sotola (15) found that alfalfa hay cut in the one-half bloom stage contained more calcium than plants cut at the one-fourth or three-fourth bloom stage. The calcium content of alfalfa decreased with the number of cuttings, it was higher in the first cutting than it was in the second and it in turn contained a higher calcium content than alfalfa cut the third time.

Salmon and co-workers (16) have shown that the time of cutting greatly influences the quantity of leaves retained by alfalfa harvested for hay. There was a consistent decrease in the proportion of leaves as cutting was delayed. When alfalfa was cut in the bud stage 53.4 per cent of the crop consisted of leaves as compared with 51.1, 48.4 and 41.6 per cent for the tenth-bloom, full-bloom and seed-stages respectively.

Neidig, and co-workers (11) have shown that sulfur in all forms applied to the soil produced increases in the total nitrogen removed by the alfalfa grown on those soils. The nitrogen and sulfur content of alfalfa grown on phosphate treated soils was increased in all cases.

Graber and co-workers (5) have reported work showing that with increasing the number of cuttings, the nitrogen content of alfalfa roots rapidly decreases. Plant roots from plats not cut at all contained the highest per cent total dry weight, total sugars and total nitrogen.

Pittman (13) presents data which show quite conclusively that, under Utah conditions, on a calcareous soil that is high in total but low in available phosphorus wherever the use of manure or phosphate fertilizer on alfalfa gave an increase in the yeild of the hay it also produced a marked increase in the phosphorus content.

Alway (1) has shown on muck soils that fertilizer treatments in most cases increased the phosphorus content of alfalfa and clover hay, whether referred to the dry matter or the ash. Also that the phosphorus content was not affected by applications of potash, but was greatly increased by both phosphate and manure applications. Potash alone increased the yeild of hays but lowered the phosphorus content of the crop.

EXPERIMENTAL

The investigation was carried on under both field conditions and in the greenhouse. For the field studies use was made of the experimental plats in soil fertility conducted by the Department of Soils of the Michigan State College in different sections of the State. The fertilizer was applied in some cases to established stands of alfalfa as a topdressing while in other instances the fertilizer and lime were applied and worked into the soil before seeding the alfalfa. One or two cuttings only were obtained from some fields before the farmer plowed down the alfalfa in order to continue his system of crop rotation. In other cases several cuttings of alfalfa were taken.

The pot experiments in the greenhouse were conducted in order that the effect of soil treatments on the composition of the alfalfa growing on it might be measured under more controlled conditions than pertain in the field.

Another phase of the problem was the comparison of the composition of alfalfa samples taken from field plats by the random method with the composition of samples taken according to a systematic method of sampling.

Method of Eield Sampling

The random sampling method was used to collect samples of alfalfa for chemical analysis. The entire plat was carefully observed for variations in the plant growth and uniformity of stand, and samples were then taken from two places decided upon by two persons as representative of plant growth on the plat. An area of one half square rod was cut in each location selected and several handfuls of green plants were taken from each area and put together to make a standard sample from each plat. Care was exercised not to lose any of the plant leaves.

All samples were placed in paper containers, labeled, and taken to the drying room to cure. Each sample was cured in a large laboratory for 6 weeks from date taken.

Alfalfa samples taken in 1930 and 1931 were carefully separated into stems and leaves before analyzing. The weight of the stems and leaves was obtained.

The moisture content, total nitrogen, calcium oxide and phosphorus pentoxide content of the alfalfa plants was determined according to the methods outlined in the second edition of the Official and Tentative Methods of Analysis of the Association of Official Agricultual Chemists. All analyses were made in duplicate and all results are reported on the oven dry basis.

Under the name of each soil type on which studies were conducted a description of the soil is given followed by the presentation and discussion of the experimental data obtained.

ISABELLA SANDY LOAM

This soil type is widely distributed in the central or west-central portions of the lower peninsula of Michigan and is one of the major soil types used for general agriculture, especially for potatoes. Where under cultivation the surface seven inches of soil is light-brown to grayish-brown in color, grading into a pale yellowish, loose, sandy material extending to depths of about two to three feet. Just under this horizon is the heavier subsoil which is a reddish brown in color and consists of moderately compact but friable, sandy clay or a gritty clay which is generally acid to a depth of 36 to 40 inches. The topography ranges from level to rolling or steeply sloping. Drainage is rapid because of the porosity of the soil, in fact in dry seasons the low moisture retaining power of the soil results in depressed crop yields. This soil is easy to cultivate because of the light texture and granular structure of the surface soil. This soil type is generally low in organic matter content and medium in fertility; it is acid in reaction, requiring about three tons of limestone to correct the acidity sufficiently for the successful growing of alfalfa. Crop response is particularly good in case of alfalfa to applications of phosphate and potash fertilizers alone or combined.

In view of these facts it was considered advisable to determine the effects of additions of limestone, phosphate and potash fertilizers to this soil on the composition of alfalfa grown on it.

The limestone was applied in early June after the land had been plowed and worked down, and was worked thoroughly into the soil by harrowing. The phosphate and potash fertilizers were applied about five inches deep in the soil the last week in July by means of a grain drill. Due to the deficiency of moisture at this season the seeding of alfalfa was delayed to the first week in August, 1929. A good stand of alfalfa was obtained which produced better than an average crop. The effects of the various soil treatments on the composition of the alfalfa grown are shown by the data in tables: 1, 2, 3, 4 and 5.

Table 1 contains the analytical data obtained from samples of the alfalfa taken from the various plats at the early bud stage of growth.

The results show that the weight of the leaves always exceeded the weight of the stems. Individual soil treatments had but little effect on the ratio of leaves to stems. The average results, however, show that the addition of limestone-alone and of limestone plus phosphate resulted in a somewhat greater proportion of leaves to stems, and the addition of limestone plus potash and of limestone plus potash and phosphate reduced the ratio of leaves to stems compared to that found in alfalfa grown on untreated soil.

Additions of limestone without fertilizer increased slightly the moisture content of the stems over that of the leaves, and also the moisture content of both stems and leaves over that of alfalfa grown on the plat receiving no treatment. There was no consistent difference in the moisture content of leaves and stems of alfalfa grown on plats receiving other treatments. Additions of limestone plus phosphate gave alfalfa of the lowest water content, and limestone plus phosphate and potash gave alfalfa with the highest water content in both stems and leaves, on the basis of the average results obtained for the various group treatments.

The nitrogen determinations show clearly that the nitrogen content of

Table 1.- Effect of increasing limestone applications with superphosphate and muriate of potash to Isabella sandy loam soil on the partial composition of alfalfa cut in the bud stage in 1930. Results in percent on oven dry basis.

Plat No.	Soil treatment	Ratio leaves to stems	Percent Water S.[1]	Percent Water L.[2]	Percent N S.	Percent N L.	Percent CaO S.	Percent CaO L.	Percent P_2O_5 S.	Percent P_2O_5 L.
1	No treatment	1.46	10.2	9.5	1.43	2.81	2.03	4.75	0.74	0.82
2	552 lbs. L. S.*	1.36	11.1	10.0	1.54	2.81	1.83	4.86	0.76	0.82
3	2000 lbs. L. S.	1.46	10.8	10.0	1.72	3.08	1.83	4.30	0.68	0.79
4	6000 lbs. L. S.	1.72	12.4	10.6	1.86	3.47	2.03	5.16	0.60	0.84
5	12500 lbs. L. S.	1.43	11.8	10.9	2.22	4.04	1.99	5.28	0.69	0.86
		390 lbs. 20 per cent superphosphate plus limestone as indicated								
6	No limestone	1.43	11.2	10.4	1.56	2.68	2.03	5.22	0.74	0.79
7	552 lbs. L. S.	1.35	9.8	10.2	1.55	2.84	1.97	5.09	0.72	0.78
8	2000 lbs. L. S.	1.44	9.8	9.3	1.53	2.92	2.04	4.65	0.74	0.83
9	6000 lbs. L. S.	1.43	9.4	9.3	1.86	3.26	1.93	4.71	0.70	0.83
10	12500 lbs. L. S.	1.48	10.9	10.1	2.17	3.82	1.76	5.49	0.60	0.73
		186 lbs. muriate of potash plus limestone as indicated								
11	No limestone	1.43	9.9	11.8	1.59	2.45	1.65	3.81	0.57	0.61
12	552 lbs. L. S.	1.20	9.9	10.8	1.69	2.81	1.81	4.14	0.53	0.71
13	2000 lbs. L. S.	1.30	10.0	12.7	1.89	3.60	1.39	3.40	0.60	0.61
14	6000 lbs. L. S.	1.17	10.4	9.5	1.70	2.55	1.65	4.29	0.64	0.60
15	12500 lbs. L. S.	1.54	10.7	9.9	2.14	3.94	1.23	3.47	0.50	0.67
		234 lbs. of 20 per cent superphosphate and 94 lbs. of muriate of potash, or 390 lbs. of 0-12-12 fertilizer plus limestone as indicated								
16	No limestone	1.25	13.2	11.3	1.55	2.84	1.72	3.61	0.80	0.85
17	552 lbs. L. S.	1.31	13.9	11.8	1.69	3.99	1.64	3.77	0.72	0.81
18	2000 lbs. L. S.	1.54	13.2	12.3	2.07	4.14	1.57	3.62	0.64	0.88
19	6000 lbs. L. S.	1.38	12.4	12.8	1.61	3.16	1.71	4.41	0.64	0.78
20	12500 lbs. L. S.	1.19	12.8	13.0	1.91	3.51	1.63	4.78	0.55	0.66
		Averages								
	No limestone	1.39	11.1	10.8	1.53	2.69	1.86	4.35	0.71	0.77
	L. S. alone	1.49	11.5	10.4	1.84	3.35	1.92	3.90	0.68	0.83
	L. S. + phos.	1.42	9.9	9.7	1.78	3.21	1.92	4.99	0.69	0.79
	L. S. + potash	1.30	10.7	10.8	1.86	3.23	1.52	3.83	0.57	0.65
	L. S. + phos. and potash	1.35	13.1	12.5	1.82	3.70	1.64	4.14	0.64	0.78

* - Limestone
1 - Stems
2 - Leaves

the leaves was consistently higher than that of the stems. In the case of the limestone-alone treatments, the nitrogen content of alfalfa stems and leaves gradually increased with the increasing quantities of limestone applied. The same was true of the alfalfa fertilized with limestone plus phosphate, with the exception of the stems of that from plats 7 and 8; and of the alfalfa receiving limestone plus potash excepting the leaves from plat 14. Greater irregularities were found, however, in the nitrogen content of the stems and leaves of the alfalfa grown on the plats receiving the limestone plus phosphate and potash treatments. With the exception of the alfalfa from plats 2, 7 and 8, there was a marked increase in nitrogen content of both stems and leaves over that found in alfalfa from plats receiving fertilizer without limestone. Although some exceptions were apparent in the case of individual treatments, on the basis of the averages all of the treatments increased the nitrogen content of alfalfa stems and leaves. The nitrogen content of the stems, however, varied little with the different treatments. The limestone plus phosphate and potash treatments considerably increased the nitrogen of the alfalfa leaves over that from the other treatments.

Considering the results for calcium, greater differences were found between stems and leaves than for the other constituents determined. The calcium content of the leaves was found to be two or three times higher than that of the stems. With the exception of those from plats 9 and 15, the two largest applications of limestone increased the calcium content of the leaves over that of leaves from the no treatment and no limestone treatment plats.

On the basis of the averages the plats receiving limestone-alone and limestone plus phosphate, produced alfalfa with a higher calcium content in the stems than alfalfa from the no limestone treatment plat. Any treatment including potash resulted in a noticeable decrease in the calcium content of alfalfa stems. The limestone plus phosphate treatment increased the calcium content of alfalfa leaves, while the other treatments depressed it.

The phosphorus content of both the stems and leaves of alfalfa grown on plats receiving superphosphate-alone was less than that of alfalfa grown on plats treated with both superphosphate and potash without limestone and from plats receiving no treatment. Potash-alone greatly depressed the phosphorus content of both the stems and leaves, although phosphate and potash combined increased the phosphorus content of both the stems and leaves compared to that of alfalfa from plats receiving no treatment.

As shown by the average results, all of the treatments depressed the phosphorus content of alfalfa stems as compared with those from the no limestone treatments. Limestone-alone increased the phosphorus content of alfalfa leaves, and limestone plus potash had a depressing effect in this respect. Potash when used with limestone markedly depressed the phosphorus content of both stems and leaves of alfalfa.

Table 2 contains the analytical data obtained from samples of alfalfa taken from the various plats at the one half-bloom stage of growth for the first cutting of hay.

Studying first the character of the alfalfa with respect to proportions of leaves to stems, it was found that all treatments increased the ratio of leaves to stems with the exception of that grown on plats 10 and 14. The average results show an increased ratio of leaves to stems for all treatments.

Table 2.- Effect of increasing limestone applications with superphosphate and muriate of potash to Isabella sandy loam soil on the partial composition of alfalfa, first cutting for hay, one half-bloom stage, 1930

Plat No.	Soil treatment	Ratio leaves to stems	Percent Water S.[1]	L.[2]	Percent N S.	L.	Percent CaO S.	L.	Percent P_2O_5 S.	L.
1	No treatment	0.94	8.3	10.3	1.35	2.26	2.57	7.11	0.97	0.90
2	552 lbs. L. S.*	0.95	8.9	10.6	1.49	2.95	2.07	6.29	0.66	0.85
3	2000 lbs. L. S.	0.95	8.9	10.7	1.54	2.87	2.19	6.77	0.79	1.03
4	6000 lbs. L. S.	0.99	8.6	11.1	1.79	3.34	1.92	5.78	0.83	1.03
5	12500 lbs. L. S.	1.21	9.6	11.5	1.96	3.50	2.04	6.11	0.59	0.88
	390 lbs. 20 per cent superphosphate plus limestone as indicated									
6	No limestone	0.88	9.1	10.1	1.16	2.32	2.43	6.61	0.93	1.00
7	552 lbs. L. S.	1.09	9.2	10.0	1.63	3.12	2.09	6.37	0.63	0.88
8	2000 lbs. L.,S.	0.93	9.4	9.6	1.47	3.18	1.88	6.54	0.88	1.00
9	6000 lbs. L. S.	1.07	10.0	10.9	1.84	3.56	1.94	5.92	0.59	0.88
10	12500 lbs. L. S.	0.81	8.4	10.3	1.55	3.03	1.81	5.59	0.62	0.84
	186 lbs. muriate of potash plus limestone as indicated									
11	No limestone	0.83	9.5	10.9	1.18	2.35	2.12	5.51	0.96	1.01
12	552 lbs. L. S.	0.88	9.4	10.3	1.58	2.90	2.05	5.37	0.67	0.79
13	2000 lbs. L. S.	1.01	10.0	10.4	1.75	3.22	1.67	4.20	0.63	0.74
14	6000 lbs. L. S.	0.83	9.0	10.4	1.54	3.23	1.58	4.06	0.53	0.72
15	12500 lbs. L. S.	1.12	9.1	10.2	1.71	3.37	1.71	4.64	0.36	0.59
	234 lbs. 20 per cent superphosphate and 94 lbs. muriate of potash, or 390 lbs. 0-12-12 fertilizer plus limestone as indicated									
16	No limestone	0.90	9.6	10.5	1.55	2.39	2.24	6.09	0.92	1.00
17	552 lbs. L. S.	1.05	9.2	10.5	1.27	3.27	1.98	5.68	0.48	0.74
18	2000 lbs. L. S.	0.93	9.0	11.5	1.31	2.78	1.93	5.65	0.68	0.80
19	6000 lbs. L. S.	1.06	9.4	11.1	1.57	3.37	1.74	4.83	0.62	0.76
20	12500 lbs. L. S.	1.01	9.6	12.1	1.60	3.34	1.91	5.26	0.49	0.69
	Averages									
	No limestone	0.89	9.1	10.4	1.31	2.33	2.34	6.33	0.95	0.98
	L. S. Alone	1.03	8.9	10.9	1.69	3.15	2.06	6.24	0.72	0.95
	L. S. + phos.	0.97	9.3	10.2	1.62	3.22	1.93	6.11	0.68	0.90
	L. S. + potash	0.96	9.4	10.3	1.64	3.18	1.75	4.57	0.55	0.71
	L. S. + phos. and potash	1.01	9.3	11.3	1.44	3.19	1.89	5.36	0.57	0.75

* - Limestone
1 - Stems
2 - Leaves

Limestone-alone treatment gave the largest increase in the ratio of alfalfa leaves to stems and limestone plus phosphate and potash treatment produced the next largest increase.

In this stage of growth the water content of the leaves was higher than that of the stems. Although no consistent differences were obtained with the individual treatments in the water content of either the stems or leaves, the average results show that limestone plus phosphate and potash application increased the water content in case of the leaves.

The nitrogen determinations show clearly that the nitrogen content of the leaves was consistently higher than that of the stems. In case of the limestone-alone treatment, the nitrogen content of the stems gradually increased with increasing quantities of limestone applied, and the same was true in case of the leaves with the exception of those from plat 3. Greater irregularities were found, however, in the nitrogen content of both stems and leaves from all other treatments. All of the limestone treatments increased the nitrogen content of the leaves over that of leaves from the no treatment and no limestone treatment plats. Applications of phosphate and potash alone depressed the nitrogen content in case of the stems; but combined, increased that of the stems over the nitrogen content of the stems grown on the plat which received no treatment. On the basis of the average results, all of the limestone treatments increased the nitrogen content of both stems and leaves.

Greater differences were found between the calcium content of stems and leaves than for the other elements determined. The calcium content of the leaves was found to be two to three times higher than that of the stems.

Applications of phosphate and potash alone or in combination depressed the calcium content of both the stems and leaves over that of those grown on the plat without treatment. Potash-alone having the greatest depressing effect in both the stems and leaves. Limestone plus phosphate, limestone plus potash, and limestone plus phosphate and potash treatments in all cases depressed the calcium content of both the stems and leaves compared to the calcium content of those grown on the no treatment and no limestone plats. The average results show that limestone treatments, in all cases depressed the calcium content of both the stems and leaves of alfalfa, limestone plus potash, however, exerted the greatest effect in this respect of all treatments applied.

The phosphorus content of the leaves was higher than that of the stems in all the samples except in those from soil receiving no treatment. Phosphate and potash applied alone or in combination increased the phosphorus content of alfalfa leaves over that of those grown on the no treatment plat. All of the limestone treatments depressed the phosphorus content of alfalfa stems compared to that of those grown on the no treatment and no limestone treatment plats. Increasing quantities of limestone plus potash treatments gradually depressed the phosphorus content of both the stems and leaves of alfalfa. The average results show that in all cases limestone treatments depressed the phosphorus content of both alfalfa stems and leaves; here again, the limestone plus potash treatment exerted the greatest depressing effect on the phosphorus content of the alfalfa stems and leaves.

Table 3 contains the analytical data obtained from samples of alfalfa taken from the various plats at the one half-bloom stage of growth for the second cutting of hay.

The weight of alfalfa leaves always exceeded that of the stems. Applications of limestone-alome markedly increased the ratio of leaves to stems as compared to that of plants from the no treatment plat. Treatments of limestone plus potash, and limestone plus phosphate and potash increased the ratio of leaves to stems over that found in plants grown on plats receiving no limestone. Plat 10 which received the largest application of limestone plus phosphate and potash greatly increased the ratio of alfalfa leaves to stems as compared to that of plants grown on the no limestone treatment plat. It was found on the basis of the average results, that all limestone treatments increased the ratio of leaves to stems over that of plants grown without limestone, the most marked effect resulting from treatments of limestone plus phosphate.

The water content of both alfalfa stems and leaves varied but little with the different soil treatments.

The nitrogen content of the leaves was nearly double that of the stems for all soil treatments. Alfalfa from plats receiving fertilizer plus limestone or limestone-alone contained more nitrogen in both stems and leaves than alfalfa from plats receiving fertilizer without limestone and plats receiving no treatment, with the exception of the stems of alfalfa from plats 17 and 18. Treatments of phosphate and potash-alone or in combination, increased the nitrogen content of the stems as compared with that of the stems from the plat without treatment. The average results show that the nitrogen content of both the stems and leaves of alfalfa was increased by all limestone treatments over that of the stems and leaves of alfalfa grown on the plats without limestone.

Table 3.- Effect of increasing limestone applications with superphosphate and muriate of potash to Isabella sandy loam soil on the partial composition of alfalfa, second cutting for hay, one half-bloom stage, 1930

Plat No.	Soil treatment	Ratio leaves to stems	Percent Water S.	Percent Water L.	Percent N S.	Percent N L.	Percent CaO S.	Percent CaO L.	Percent P_2O_5 S.	Percent P_2O_5 L.
1	No treatment	1.21	11.2	11.1	1.72	3.25	2.14	4.44	0.91	0.94
2	552 lbs. L. S.*	1.67	11.5	11.4	1.95	3.93	1.89	3.98	0.71	0.77
3	2000 lbs. L. S.	1.51	11.6	12.9	1.87	3.68	2.02	4.26	0.68	0.79
4	6000 lbs. L. S.	1.59	12.4	12.5	2.06	4.00	2.09	4.36	0.67	0.75
5	12500 lbs. L. S.	1.66	12.1	12.8	2.03	4.06	2.13	4.38	0.66	0.69
390 lbs. 20 per cent superphosphate plus limestone as indicated										
6	No limestone	1.73	9.6	12.2	1.76	3.65	2.03	4.00	0.92	1.09
7	552 lbs. L. S.	1.68	10.4	12.0	2.06	3.88	2.37	4.90	0.72	0.83
8	2000 lbs. L. S.	1.61	10.8	10.5	2.32	4.14	2.21	3.93	0.68	0.81
9	6000 lbs. L. S.	1.71	11.0	11.5	2.06	4.02	2.32	3.85	0.73	0.75
10	12500 lbs. L. S.	2.03	11.0	11.0	2.06	4.08	2.06	6.66	0.53	0.70
186 lbs. muriate of potash plus limestone as indicated										
11	No limestone	1.15	9.7	11.5	1.77	2.94	2.12	4.87	0.94	1.09
12	552 lbs. L. S.	1.47	10.8	12.0	1.87	3.81	1.86	3.77	0.65	0.76
13	2000 lbs. L. S.	1.39	11.0	12.1	1.96	3.50	2.14	4.41	0.65	0.71
14	6000 lbs. L. S.	1.81	11.2	12.8	2.16	4.01	1.67	3.65	0.70	0.79
15	12500 lbs. L. S.	1.77	11.4	11.9	2.15	4.11	2.24	4.02	0.53	0.68
234 lbs. 20 per cent superphosphate and 94 lbs. muriate of potash, or 390 lbs. 0-12-12 fertilizer plus limestone as indicated										
16	No limestone	1.38	11.4	11.3	1.98	3.30	2.25	4.42	0.88	0.95
17	552 lbs. L. S.	1.56	11.4	11.9	1.97	3.88	2.18	4.20	0.67	0.75
18	2000 lbs. L. S.	1.56	11.5	11.0	1.87	3.53	2.15	4.30	0.57	0.64
19	6000 lbs. L. S.	1.69	12.0	10.9	2.10	3.94	2.05	4.12	0.63	0.76
20	12500 lbs. L. S.	1.54	10.9	11.6	2.13	3.69	2.18	4.84	0.51	0.66
Averages										
	No limestone	1.28	10.5	11.5	1.81	3.29	2.14	4.43	0.91	1.02
	L. S. Alone	1.61	11.9	12.2	1.98	3.92	2.03	4.25	0.68	0.75
	L. S. + phos.	1.76	10.8	11.3	2.13	4.03	2.24	4.84	0.67	0.77
	L. S. + potash	1.61	11.1	12.2	2.04	3.86	1.98	3.96	0.63	0.74
	L. S. + phos. and potash	1.59	11.5	11.4	2.02	3.76	2.14	4.37	0.59	0.70

* - Limestone
1 - Stems
2 - Leaves

Wherever potash occurred in any treatment, it depressed the nitrogen content of both the stems and leaves of alfalfa slightly as compared to that of alfalfa grown on plats receiving the limestone plus phosphate treatments.

Greater differences were found between the calcium content of stems and leaves of alfalfa than for the other elements determined, the calcium content of the leaves being nearly double that of the stems in all cases. All treatments depressed the calcium content of alfalfa stems and leaves as compared to that of plants grown on the plats which received no treatment and no limestone, except in the case of plats 7, 10 and 20. Alfalfa grown on these plats exhibited a marked increase in the calcium content of the stems and leaves. The average results show that the limestone-alone and limestone plus potash treatment depressed the calcium content of both the stems and leaves of alfalfa below that of alfalfa grown without limestone, the limestone plus potash treatment exhibiting the greatest depressing effect. Both the stems and leaves of alfalfa grown on the limestone plus phosphate treatment plats showed an increase in the calcium content as compared to that produced on plats not receiving limestone.

In all cases limestone applications very markedly depressed the phosphorus content of the stems and leaves of alfalfa. The phosphorus content of leaves, however, was higher than that of the stems. Applications of phosphate and potash alone markedly increased the phosphorus content of the leaves as compared to that of leaves grown on the plat without treatment. On the basis of the average results all limestone treatments depressed the phosphorus content in both the stems and leaves of alfalfa compared to that from the no limestone treatment plats; the limestone plus phosphate and potash treatment exerted the greatest depressing effect.

Table 4 contains the analytical data obtained from samples of the alfalfa taken from the various plats as the first cutting for hay at the one-half bloom stage in 1931.

It is seen that the weight of stems greatly exceeded that of the leaves in all cases. Additions of superphosphate and potash-alone, or in combination depressed the ratio of leaves to stems as compared to that for alfalfa produced on the no treatment plat.

The water content of the leaves was higher than that of the stems in all cases. No consistent difference in the water content of the stems and leaves was obtained with the various soil treatments.

All soil treatments increased the nitrogen content of both the stems and leaves over that of alfalfa grown on the no limestone and no treatment plats, with the exception of the stems from plats 7 and 13, and the leaves from plats 7 and 18. The average results show that all limestone treatments increased the nitrogen content of both alfalfa stems and leaves.

The calcium determinations, show that all limestone treatments depressed the calcium content of the stems as compared to that of stems grown on the no treatment plat and no limestone treatment plats, with the exception of alfalfa from plats 13, 17 and 18. In all cases the limestone treatments markedly increased the calcium content of alfalfa leaves as compared to that of those grown on the no limestone treatment plats and the plat without treatment, with the exception of the leaves from plat 12. Average results show that all limestone treatments depressed the calcium content of alfalfa stems, but increased that of the leaves.

Table 4.- Effect of increasing limestone applications with superphosphate and muriate of potash to Isabella sandy loam soil on the partial composition of alfalfa, first cutting for hay, one half-bloom stage, 1931

Plat No.	Soil treatment	Ratio leaves to stems	Percent Water		Percent N		Percent CaO		Percent P_2O_5	
			S.[1]	L.[2]	S.	L.	S.	L.	S.	L.
1	No treatment	0.81	5.7	6.8	1.55	3.41	1.79	3.65	0.72	1.00
2	552 lbs. L. S.*	0.64	5.7	7.2	1.81	3.91	1.50	4.34	0.35	0.74
3	2000 lbs. L. S.	0.69	5.8	7.5	1.62	3.71	1.48	4.27	0.66	0.81
4	6000 lbs. L. S.	0.67	6.6	8.6	1.69	4.05	1.61	4.90	0.40	0.84
5	12500 lbs. L. S.	0.57	6.5	8.2	1.74	4.00	1.59	4.16	0.41	0.85
	390 lbs. 20 per cent superphosphate plus limestone as indicated									
6	No limestone	0.65	6.5	8.2	1.57	3.75	1.73	2.35	0.50	0.84
7	552 lbs. L. S.	0.64	6.2	8.4	1.50	3.54	1.58	4.62	0.45	0.78
8	2000 lbs. L. S.	0.64	6.1	8.2	1.66	3.85	1.45	4.59	0.51	0.80
9	6000 lbs. L. S.	0.89	6.5	8.4	1.90	4.15	1.70	4.49	0.51	0.86
10	12500 lbs. L. S.	0.64	6.6	8.6	1.87	3.97	1.51	4.71	0.49	0.85
	186 lbs. muriate of potash plus limestone as indicated									
11	No limestone	0.72	6.4	7.8	1.49	3.24	1.53	3.46	0.75	1.02
12	552 lbs. L. S.	0.56	6.1	7.6	1.64	4.03	1.44	3.46	0.36	0.74
13	2000 lbs. L. S.	0.55	6.2	7.9	1.42	3.51	1.53	3.77	0.34	0.73
14	6000 lbs. L. S.	0.55	6.2	7.9	1.53	3.89	1.23	3.96	0.37	0.77
15	12500 lbs. L. S.	0.59	6.1	8.1	1.82	3.83	1.29	4.35	0.39	0.72
	234 lbs. 20 per cent superphosphate and 94 lbs. muriate of potash, or 390 lbs. of 0-12-12 fertilizer plus limestone as indicated									
16	No limestone	0.63	6.5	7.8	1.41	3.75	1.37	3.27	0.55	0.99
17	552 lbs. L. S.	0.76	6.8	8.2	1.58	3.87	1.52	4.03	0.37	0.77
18	2000 lbs. L. S.	0.68	6.6	8.3	1.59	3.66	1.37	4.40	0.35	0.69
19	6000 lbs. L. S.	0.52	6.5	8.3	1.59	4.00	1.19	4.33	0.40	0.77
20	12500 lbs. L. S.	0.61	6.5	8.0	1.76	4.06	1.24	3.62	0.42	0.77
	Averages									
	No limestone	0.70	6.3	7.6	1.51	3.54	1.61	3.18	0.63	0.99
	L. S. Alone	0.64	6.2	7.9	1.72	3.92	1.55	4.43	0.46	0.81
	L. S. + phos.	0.70	6.3	8.4	1.73	3.88	1.56	4.60	0.49	0.82
	L. S. + potash	0.56	6.2	7.9	1.60	3.82	1.37	3.89	0.37	0.74
	L. S. + phos. and potash	0.64	6.6	8.2	1.63	3.89	1.33	4.09	0.39	0.75

* - Limestone
1 - Stems
2 - Leaves

The phosphorus content of both the stems and leaves of alfalfa was very markedly depressed by the limestone, limestone plus potash, and limestone plus phosphate and potash treatments. However, the average results show that limestone treatments in all cases depressed the phosphorus content of both the stems and leaves; limestone plus potash having the greatest effect.

The results from the analysis of samples of the alfalfa taken from the various plats at the second cutting for hay in the one half-bloom stage in 1931 are presented in Table 5.

The weight of the leaves exceeded that of the stems in all cases, although soil treatments appeared to have little influences upon the ratio of leaves to stems.

The data on the water content of the stems and leaves were inconsistent, the leaves, however, contained a higher water content than the stems in all cases.

For all limestone treatments, the nitrogen content of both the stems and leaves was higher than that of leaves and stems grown on the no treatment plats and plats not receiving limestone. The nitrogen content of the leaves was nearly double that of the stems. Treatments of phosphate and potash alone or in combination, increased the nitrogen content of both the stems and leaves as compared to that of alfalfa on the plat without treatment. The average results show that all soil treatments increased the nitrogen content of both the stems and leaves of alfalfa.

In all cases the calcium content of the leaves was double that of the stems. On the basis of the average results all treatments depressed the calcium content of the stems. The calcium content of the leaves, however, exhibited an increase with all limestone treatments except for the largest

Table 5.- Effect of increasing limestone applications with superphosphate and muriate of potash to Isabella sandy loam soil on the partial composition of alfalfa, second cutting for hay, one half-bloom stage, 1931

Plat No.	Soil treatment	Ratio Leaves to stems	Percent Water S.	Percent Water L.	Percent N S.	Percent N L.	Percent CaO S.	Percent CaO L.	Percent P_2O_5 S.	Percent P_2O_5 L.
1	No treatment	1.53	8.2	9.9	1.71	3.29	1.77	3.56	0.54	0.59
2	552 lbs. L. S.*	1.87	8.6	10.1	1.95	3.78	1.79	3.69	0.36	0.59
3	2000 lbs. L. S.	1.24	8.0	10.2	2.01	4.11	1.59	4.07	0.37	0.60
4	6000 lbs. L. S.	1.60	8.0	10.5	2.38	4.22	1.55	3.69	0.39	0.59
5	12500 lbs. L. S.	1.36	10.5	13.8	1.95	4.03	1.52	4.08	0.37	0.62
	390 lbs. 20 per cent superphosphate plus limestone as indicated									
6	No limestone	1.34	9.7	11.7	1.80	3.88	1.52	3.59	0.42	0.64
7	552 lbs. L. S.	1.61	9.8	11.9	2.20	4.17	1.79	4.08	0.49	0.65
8	2000 lbs. L. S.	1.25	10.6	12.5	2.07	4.37	1.49	4.15	0.43	0.64
9	6000 lbs. L. S.	1.25	10.4	13.8	2.05	4.05	1.67	4.27	0.40	0.60
10	12500 lbs. L. S.	1.14	11.0	14.0	2.09	4.35	1.44	3.79	0.49	0.72
	186 lbs. muriate of potash plus limestone as indicated									
11	No limestone	1.54	9.9	11.2	1.98	3.70	1.66	3.33	0.64	0.70
12	552 lbs. L. S.	1.55	9.3	11.0	2.02	3.98	1.78	3.63	0.42	0.61
13	2000 lbs. L. S.	1.22	9.3	11.2	2.09	4.01	1.51	3.89	0.39	0.59
14	6000 lbs. L. S.	1.74	9.9	12.7	2.06	4.19	1.33	3.28	0.43	0.54
15	12500 lbs. L. S.	1.46	8.9	11.5	2.10	4.11	1.41	3.33	0.42	0.63
	234 lbs. of 20 per cent superphosphate and 94 lbs. of muriate of potash, or 390 lbs. of 0-12-12 fertilizer plus limestone as indicated									
16	No limestone	1.66	7.8	8.7	1.81	3.35	1.93	3.53	0.50	0.57
17	552 lbs. L. S.	1.65	8.9	8.9	1.84	3.90	1.57	3.57	0.39	0.57
18	2000 lbs. L. S.	1.55	7.6	9.3	2.00	4.02	1.16	2.77	0.38	0.57
19	6000 lbs. L. S.	1.48	7.9	10.1	2.06	3.88	1.52	3.27	0.40	0.61
20	12500 lbs. L. S.	1.26	9.4	10.0	2.15	4.16	1.32	2.80	0.39	0.61
	Averages									
	No limestone	1.52	8.9	10.4	1.83	3.56	1.72	3.50	0.53	0.63
	L. S. Alone	1.52	8.8	11.2	2.07	4.04	1.61	3.88	0.37	0.60
	L. S. + phos.	1.31	10.5	13.1	2.10	4.24	1.60	4.07	0.45	0.65
	L. S. + potash	1.49	9.4	11.6	2.07	4.07	1.51	3.53	0.42	0.59
	L. S. + phos. and potash	1.49	8.5	9.6	2.01	3.99	1.39	3.10	0.39	0.59

* - Limestone
1 - Stems
2 - Leaves

limestone treatments.

The phosphorus content of the leaves was higher than that of the stems. Limestone-alone depressed the phosphorus content of alfalfa stems over that of those from the no treatment plat. Limestone plus potash treatment depressed the phosphorus content of both the stems and leaves of alfalfa as compared to that of plants grown on the no treatment plat. Average results show that the phosphorus content of the stems was depressed with all limestone treatments, as was the phosphorus content of the leaves with one exception.

In comparing all the alfalfa cuttings made on Isabella sandy loam soil, it was found that, the first cuttings exhibited a much lower ratio of leaves to stems than the second cuttings at the one half-bloom stage of growth. Also, the weight of stems exceeded that of the leaves in the first cuttings, which was just the opposite of the condition for the second cuttings.

The water content of both the stems and leaves was higher in the second than in the first cuttings.

In both the stems and leaves the nitrogen content was higher in the second than the first cuttings.

The calcium content of the stems was higher in the second than the first cuttings, but in case of the leaves the opposite was true.

Phosphorus content of both the stems and leaves was higher in the first than the second cuttings. The phosphorus content of both the stems and leaves of the first and second cuttings, however, was lower in the second year.

Summarizing the main points that were borne out by the data, it can be said that all soil treatments increased the nitrogen content of both the stems and leaves in all cases, and all limestone treatments depressed the phosphorus content of both the stems and leaves.

BROOKSTON SILT LOAM

The topsoil of Brookston silt loam consists of dark-gray, friable silt loam from 8 to 12 inches deep, underlain by light gray silty clay loam mottled with rust brown and yellow. The subsoil is heavy, mottled yellow, rust-brown, and bluish-gray clay. The substratum is of heavy, calcarious till, which is coarse and granular when dry. The surface is nearly flat. Drainage is naturally deficient and where the subsoil is especially heavy the movement of water is exceedingly slow. Tiling is necessary for adequate drainage. This soil must be managed carefully when wet, but under suitable moisture conditions it readily works into a good seed bed. Although Brookston silt loam is a fertile soil the yields of most crops grown on it are increased by applications of phosphate fertilizer. Alfalfa and root crops are also usually benefited by the inclusion of some potash in the fertilizer. The soil is sufficiently sweet to allow the growing of alfalfa without the use of limestone.

On field one the alfalfa was seeded with oats in the spring of 1929 and the fertilizer was applied broadcast on the surface of the soil after the second cutting in the season of 1930, without harrowing to work the fertilizer into the soil. The alfalfa on field two was several years old. The fertilizer was applied as a topdressing after the second cutting in the season of 1930. Samples were taken from both fields in 1931.

In Table 6 are the analytical data for the samples of the first and second cuttings of alfalfa taken in the one half-bloom stage.

The weight of stems exceeded that of the leaves in all cases in the first cuttings, but the opposite was true for the secohd cuttings. In field two, all fertilizer treatments slightly increased the ratio of leaves to stems over that for alfalfa from the no treatment plats in the first cutting, but depressed it in the second cutting.

Table 6.- Effect of various fertilizer applications to Brookston silt loam soil on the partial composition of alfalfa, cut in the one-half bloom stage, 1931.

Plot No.		Ratio leaves to stems	Percent Water		Percent N.		Percent CaO		Percent P_2O_5	
			S.	L.	S.	L.	S.	L.	S.	L.
	First cutting, Field 1									
1	No treatment	0.59	8.2	10.9	1.70	3.88	1.51	6.49	0.30	0.57
2	250 lbs. 0-20-20	0.63	7.9	10.0	1.91	3.96	1.52	5.61	0.41	0.57
3	500 lbs. 0-20-20	0.59	9.8	10.0	2.20	4.02	1.42	5.64	0.50	0.55
4	500 lbs. 0-0-20	0.51	7.5	10.1	1.84	3.94	1.47	5.50	0.30	0.52
5	500 lbs. 0-20-0	0.55	7.2	9.9	2.16	4.00	1.30	5.30	0.57	0.67
	Second cutting, Field 1									
1	No treatment	1.26	11.0	11.2	1.86	3.46	1.95	4.32	0.40	0.42
2	250 lbs. 0-20-20	1.28	11.6	12.3	1.87	3.88	1.99	5.12	0.41	0.51
3	500 lbs. 0-20-20	1.27	11.5	12.0	1.86	3.84	1.90	4.86	0.57	0.56
4	500 lbs. 0-0-20	1.29	11.1	11.4	1.88	4.05	1.98	4.95	0.39	0.53
5	500 lbs. 0-20-0	1.26	11.3	10.6	1.86	3.99	1.99	4.97	0.59	0.60
	First cutting, Field 2									
6	No treatment	0.64	8.2	10.2	2.08	3.89	1.57	5.15	0.37	0.57
7	300 lbs. 0-16-0	0.83	8.7	10.3	2.14	3.94	1.47	4.42	0.38	0.56
8	300 lbs. 0-16-8	0.75	8.1	10.1	2.07	4.18	1.61	5.63	0.38	0.62
	Second cutting, Field 2									
6	No treatment	1.39	7.7	10.4	1.96	4.07	1.99	4.98	0.37	0.58
7	300 lbs. 0-16-0	1.19	7.7	9.8	1.89	4.15	1.80	4.39	0.30	0.49
8	300 lbs. 0-16-8	1.30	7.7	10.2	2.19	4.11	1.85	5.03	0.33	0.53

The water content of the leaves was higher than that of the stems in the first cutting from both fields, and in the second cutting from field two, but not from field one.

The nitrogen content of both the stems and leaves in the first cutting from the fertilized plats on field one was higher than that from the no treatment plats. The same was true for the leaves in the second cuttings. On field two, all fertilizer treatments increased the nitrogen content of the leaves over that of leaves from the no treatment plats in both the first and second cuttings.

All fertilizer treatments depressed the calcium content of alfalfa stems and leaves in the first cutting from field one with the exception of those from plat 2, but the opposite was true in the second cutting with the exception of the stems from plat 3. Applications of phosphate in both cuttings depressed the calcium content of alfalfa stems and leaves on field two.

The phosphorus content of the leaves was higher than that of the stems in both the first and second cuttings from field two, but only in the first cutting from field one. All fertilizer treatments increase the phosphorus content of alfalfa leaves on field one. This result was not true for the stems except those from plats 3 and 5 in the second cutting. On field two all fertilizer treatments depressed the phosphorus content of both stems and leaves of alfalfa in the second cutting, but this was not true in the first cutting.

BROOKSTON CLAY LOAM

Brookston clay loam has a surface soil ranging from 5 to 8 inches in thickness, which consists of very dark-gray or dark brownish gray friable silty clay loam. Plowed fields when dry appear gray or dark brown. The subsoil is bluish-gray or dull-gray, heavy, plastic, fairly granular clay, mottled yellow and rust brown, and containing black concretions in places. Below a depth ranging from 25 to 30 inches the material becomes more splotched with yellow, without much change in texture. Generally the soil reaction is alkaline.

The surface is nearly level and drainage is poor. The principal need for the improvement of Brookston clay loam is adequate drainage. In some places, drainage has been improved artificailly by open ditches or tile drains or both. Well drained land is in a high state of cultivation.

Care is required to work the land when in the proper moisture condition, as it clods if worked when wet and on drying, cracks open in the surface soil.

The alfalfa grown on this soil was seeded in wheat in the spring of 1929 and topdressed after the first cutting for hay in the season of 1930. Samples taken for analytical work were obtained in 1931.

The data in table 7 show that with one exception the ratio of alfalfa leaves to stems was depressed by all fertilizer treatments. The weight of leaves exceeded that of stems in all cases.

Alfalfa leaves contained a higher moisture content than did the stems.

Applications of phosphate alone, increased the nitrogen content of alfalfa stems but not that of the leaves except those from plat 3. Treatments that contained potash exerted a depressing effect upon the nitrogen content of both alfalfa stems and leaves compared to that of alfalfa from the plat without treatment.

Fertilizer treatments depressed the calcium content of alfalfa stems from plats 3, 4, and 5, and of leaves from plats 2, 3, and 5, but increased that of the stems from plat 2 and that of the leaves from plat 4 as compared to the calcium content of plants from the plat receiving no fertilizer. The calcium content of alfalfa leaves was more than twice that of the stems in all cases.

Table 7.- Effect of various fertilizer applications to Brookston clay loam soil on the partial composition of alfalfa, cut in the one-half bloom stage, second cutting for hay, 1931.

Plot No.	Soil treatment	Ratio leaves to stems	Percent Water		Percent N		Percent CaO		Percent P_2O_5	
			S.	L.	S.	L.	S.	L.	S.	L.
1	No treatment	1.75	7.1	8.4	2.26	4.47	1.83	4.90	0.30	0.58
2	300 lbs. 0-20-0	1.84	7.3	8.3	2.47	4.45	1.90	4.75	0.47	0.65
3	500 lbs. 0-20-0	1.35	6.7	8.1	2.41	4.66	1.68	4.28	0.46	0.70
4	300 lbs. 0-20-20	1.56	8.0	10.9	2.18	4.37	1.79	5.12	0.33	0.66
5	500 lbs. 0-20-20	1.28	7.7	10.6	2.21	3.43	1.61	4.74	0.40	0.63

Alfalfa leaves contained a higher phosphorus content than did the stems in all cases. All fertilizer treatments increased the phosphorus content of both stems and leaves of alfalfa over that found in plants from the no treatment plats.

BROOKSTON LOAM

The more noticeable characteristics of Brookston loam are the very dark color of the surface soil and the nearly flat or depressed position of the areas. This soil type is widely distributed in the eastern side of Michigan, extending from the Saginaw bay and thumb region down to the Ohio state line.

The surface soil to a depth ranging from 6 to 12 inches is dark-gray or very dark gray loam which is sufficiently high in organic matter to import a granular structure to the plow soil. Owing to the high content of organic matter, the moisture content is more stable and affords growing plants a more equable moisture supply than do soils of a low organic matter content.

The subsoil is heavy textured, consisting principally of clay and silt. The physical characteristics of the subsoil material cause it to be retentive of moisture. The color is dominantly gray, but many splotches of yellow and brown are characteristic. The Brookston soils are typically underlain by a substratum of gray clayey material, though patches of light-textured materials occur.

Natural drainage is very poor, but much of the land has been tile drained, though not everywhere thoroughly.

The surface soil in some places gives a slightly acid reaction, but in some places it is as much as moderately acid according to the Soiltex test. At a depth varying from 18 to 24 inches the subsoil is neutral or alkaline in reaction and at a greater depth an abundance of limy materials occur.

The field was prepared after corn for the seeding of wheat; but before seeding the wheat, the fertilizers for both the wheat and alfalfa were drilled about four inches into the soil. In the spring of 1930, alfalfa was seeded in the wheat and a very excellent stand was obtained.

Table 8 contains the analytical data for the samples of alfalfa taken from the plats receiving various soil treatments.

Table 8.- Effect of various fertilizer applications to Brookston loam soil on the partial composition of alfalfa, cut in the one-half bloom stage for hay in 1931.

Plot No.	Soil treatment	Ratio leaves to stems	Percent Water S.	Percent Water L.	Percent N S.	Percent N L.	Percent CaO S.	Percent CaO L.	Percent P2O5 S.	Percent P2O5 L.
				First cutting						
1	No treatment	0.66	6.2	7.4	1.59	4.20	1.69	4.45	0.23	0.55
2	500 lbs. 0-16-0	0.64	6.3	7.7	1.78	4.28	1.75	5.04	0.37	0.64
3	500 lbs. 0-16-20	0.52	6.4	7.5	1.76	3.61	1.50	4.48	0.32	0.61
				Second cutting						
1	No treatment	1.03	6.3	7.6	1.86	4.01	2.22	5.30	0.35	0.50
2	500 lbs. 0-16-0	1.32	7.1	8.5	2.15	4.11	2.25	5.43	0.39	0.50
3	500 lbs. 0-16-20	1.76	7.3	7.9	2.19	4.13	2.28	4.85	0.37	0.50

Fertilization increased the ratio of alfalfa leaves to stems very markedly in the second cutting but slightly decreased it in the first cutting. The weight of leaves exceeded that of the stems in the second cutting, but the opposite was true in the first cutting.

The water content of the leaves was higher than that of the stems in both of the cuttings.

All fertilizer treatments increased the nitrogen content of the stems in both cuttings. The same was true for the leaves with one exception.

The phosphate treatment increased the calcium content of stems and leaves from both cuttings as compared to that of alfalfa produced on the no treatment plat.

Fertilizer treatments increased the phosphorus content of both the stems and leaves of alfalfa from the first cutting, but not from the second.

MIAMI SILT LOAM

This soil type is widely distributed in the central portion of the lower half of the lower peninsula of Michigan. The Miami silt loam surface soil is a light-brown or grayish-brown, friable, silt loam, to a depth of 7 to 12 inches, underlain by yellow-brown silt to silty clay loam. The lower subsoil, at about 18 to 24 inches, is a yellow-brown clay loam to clay, in places mottled with gray and rusty brown. Calcareous material is usually found in the substratum, which is a heavy till extending to considerable depths. Varying quantities of gravel appear on the surface and through out the soil profile. It has an undulating to gently rolling topography well suited to farming. Natural drainage is fair, but the soil at times holds an excess of moisture, owing to the impervious nature of the subsoil.

Miami silt loam is of medium fertility with a rather low content of organic matter. The commonly grown grain crops respond favorably to applications of complete fertilizer high in phosphoric acid. Root crops and alfalfa are benefited by applications of fertilizer containing moderate percentages of potash and a high percentage of phosphoric acid. Some nitrogen is also usually advisable in the fertilizer for roots.

In the late spring of 1929, corn stubbles were plowed down and a good seed bed for alfalfa prepared. The fertilizer was placed on the soil surface with a broadcasting machine and worked well into the soil during the seed bed preparation. A good stand of alfalfa was obtained, the yeilds being considerably influenced by fertilizer treatments. Samples of the second cutting only were taken for analysis. The data are presented in Table 9.

The results show that phosphate alone and phosphate plus potash treatments very markedly depressed the ratio of alfalfa leaves to stems as compared to the ratio for plants from the no treatment plat. The weight of alfalfa leaves greatly exceeded that of the stems in all cases.

Table 9.- Effect of various fertilizer applications to Miami silt loam soil on the partial composition of alfalfa, cut in the one-half bloom stage, second cutting for hay, 1930.

Plat No.	Soil treatment	Ratio leaves to stems	Percent Water		Percent N		Percent CaO		Percent P_2O_5	
			S.	L.	S.	L.	S.	L.	S.	L.
1	No treatment	2.05	11.9	10.9	1.98	3.97	2.08	5.32	0.28	0.46
2	300 lbs. 0-16-0	1.48	10.9	13.7	2.02	4.15	2.01	5.41	0.29	0.50
3	300 lbs. 0-16-8	1.61	11.9	13.5	2.11	4.21	1.86	3.38	0.34	0.53

All fertilizer treatments increased the nitrogen content of alfalfa stems and leaves over that of plants from the no treatment plats.

The treatment that contained potash markedly depressed the calcium content of alfalfa stems and leaves compared to that of alfalfa which received no treatment.

Alfalfa leaves contained a higher phosphorus content than that of the stems in all cases. The phosphate plus potash treatment increased the phosphorus content of both alfalfa stems and leaves over that of plants from the untreated soil. Phosphate applications alone increased it only in case of the leaves.

GILFORD LOAM

The general appearance of Gilford loam is not unlike that of Brookston loam. It occupies nearly flat or slightly depressed positions in the same regions with Brookston soils and is high in organic matter content. The surface soil is nearly neutral and the lower part of the subsoil and the substrata are highly calcareous. This soil differs from Brookston loam in the textural composition of the subsoil and substratum. Gilford loam is developed on the wettest part of the plains and, like most soils of the sandy plains, the subsoil is composed of a mixture of sand, gravel, and clay, resting on a sand and gravel substratum. This substratum provides a natural underpass for drainage water, which does not exist under Brookston loam.

This soil is fairly productive, being medium in organic matter content. Fertilizers high in phosphoric acid are beneficial to most crops grown.

The soil from which the samples of alfalfa for analysis were taken had been in alfalfa for several years. Fertilizer was applied as a topdressingby means of the fertilizer attachment on the grain drill and it was not worked into the soil.

The data presented in Table 10 show that treatments of phosphate alone and of phosphate plus potash depressed the ratio of alfalfa leaves to stems compared to that for plants from unfertilized soil.

Taking the nitrogen content of stems and leaves of alfalfa from unfertilized soil as a basis, the phosphate treatment increased the nitrogen content of both stems and leaves; while the phosphate plus potash treatment depressed it in both the stems and leaves.

All fertilizer treatments lowered the calcium content of alfalfa stems and leaves, the treatment that contained potash having the greatest depressing effect.

The phosphorus content of alfalfa leaves was higher than that of the

Table 10.- Effect of various fertilizer applications to Gilford loam soil on the partial composition of alfalfa, cut in the one-half bloom stage, first cutting for hay, 1931.

Plot No.	Soil treatment	Ratio leaves to stems	Percent Water		Percent N		Percent CaO		Percent P_2O_5	
			S.	L.	S.	L.	S.	L.	S.	L.
1	No treatment	1.26	8.4	11.0	2.05	3.57	2.28	7.56	0.26	0.38
2	300 lbs. 0-16-0	0.97	8.3	10.8	2.15	3.78	2.11	7.43	0.38	0.58
3	300 lbs. 0-16-8	0.93	8.0	11.2	1.99	3.64	1.78	7.00	0.38	0.59

stems. Both fertilizer treatments increased the phosphorus content of alfalfa stems and leaves compared to the phosphorus content of plants from the no treatment plat.

In comparing all alfalfa cuttings made on the heavier soil types which did not receive limestone treatments, it was found that plants grown on the Brookston silt loam soil, showed increase in the nitrogen, calcium and phosphorus content of the stems and leaves for all fertilizer treatments. The phosphate treatment produced the greatest increase in the phosphorus content of the plants grown on this soil.

Fertilizer treatments on the Brookston clay loam soil increased the nitrogen and phosphorus content of alfalfa grown on it.

On the Brookston loam soil all fertilizer treatments increased the phosphorus content of alfalfa stems and leaves with the first cutting, and in most instances increased the nitrogen and calcium content of the plants.

Fertilizer treatments on the Miami silt loam soil produced increases in the nitrogen and phosphorus content of alfalfa stems and leaves.

Plants grown on the Gilford loam soil showed increases in their phosphorus content with all fertilizer treatments.

Table 11.- Average results for all alfalfa cuttings made on the several soil types as indicated.

Soil Type	Percent N		Percent CaO		Percent P_2O_5	
	S.	L.	S.	L.	S.	L.
Brookston Silt Loam	1.96	3.96	1.71	5.14	0.41	0.55
Brookston Clay Loam	2.31	4.02	1.76	4.76	0.39	0.65
Brookston Loam	1.89	4.06	1.94	4.93	0.32	0.55
Miami Silt Loam	2.04	4.11	1.92	4.70	0.30	0.49
Gilford Loam	2.06	3.63	2.06	7.33	0.34	0.52
Isabella Sandy Loam	1.79	3.56	1.78	4.31	0.59	0.77

The averages for cuttings of alfalfa made on any soil type as presented in Table 11, show that the heavier soils produced plants with a higher nitrogen content in the stems and leaves than plants grown on the lighter soil types. Plants from the medium soil types, the Gilford loam, are markedly higher in calcium content in both the stems and leaves than that of plants from either the heavier or lighter soil types.

Alfalfa grown on the lighter soil, the Isabella sandy loam, showed a decidedly higher phosphorus content in both the stems and leaves over that of plants from either the medium or heavier soil types.

GREENHOUSE EXPERIMENTS

The inconsistencies in the results obtained from analysis of samples of alfalfa taken from field plats receiving different soil treatments raised the question as to whether or not the composition of alfalfa grown in pot cultures in the greenhouse under controlled conditions would vary more directly with soil treatment.

The Montcalm sandy loam soil was used in the greenhouse pot test. Montcalm sandy loam soil is fairly widely distributed in the central part of the lower peninsula of Michigan. The topsoil is a grayish-brown loamy sand, or a yellowish-brown soil about 7 to 8 inches thick. This layer is underlain by a horizon of grayish or light brownish gray, slightly cemented loamy sand, 3 to 4 inches thick. The subsoil, which ranges from 10 to 18 inches in thickness is reddish-brown somewhat plastic gritty clay. As a rule this soil is only slightly acid in reaction.

Generally the soil is gently undulating or moderately rolling. Drainage is good. This soil is moderately supplied with organic matter and fairly productive, responding well to fertilizer treatments. A large part of this soil is farmed to corn, wheat, clovers and potatoes.

The samples of soil taken for greenhouse pot test came from a no treatment plat in the experimental field on King's farm near Greenville. Acidity test on it showed a requirement of two tons of limestone per acre to bring the reaction to a point near neutrality. The soil was well mixed and 12 kilograms placed in each of the 54 two gallon glazed jars. Fertilizer treatments as indicated in Table 11 were thoroughly mixed through the soil while dry. Sufficient water to bring the moisture content to 20 per cent, which determinations showed to be about optimum, was added and each jar of moist soil weighed. Water to bring the jars up to weight was added once each week the first few weeks, and later twice a week.

All treatments were in duplicate except treatments 4, 5, 11, 12, 18, and 19, which were in sets of four. Plants were thinned to 10 per pot and good growth was obtained, but there were no marked physical differences in growth that could be photographed. All cuttings were made in the one half-bloom stage of growth for partial analysis, with particular attention being paid to the phosphorus content. The total green weight of alfalfa from each pot treatment was not obtained.

In series 1 plants grown on pot tests receiving per acre application of 100 pounds muriate of potash, and 800 to 1200 pounds of 20 per cent superphosphate and 2 tons of calcium limestone show a decrease in water content compared to those from the pots treated with limestone and potash.

There were no marked increases or decreases in the nitrogen content of alfalfa plants in any of the series for the first and second cuttings. The nitrogen content of the third and fourth cuttings was lower than that of the first and second, in all series. There were, however, no changes in the nitrogen content of the alfalfa for the various treatments, and the series averaged about the same total nitrogen content in each set of cuttings.

In series 1 alfalfa plants showed an increase in phosphorus content on treatments 3 and 7, which received 400 and 4,800 pounds of superphosphate per acre respectively as compared to that of those grown on the no treatment pots. Series 2 and 3 show that soil treatments increased the phosphorus content of alfalfa plants only when superphosphate was applied at the rate of 4,800 pounds per acre. There were no differences in the average phosphorus contents for each of the three series in the first and second cuttings. The third and fourth cuttings, show that the phosphorus content of alfalfa plants grown in pots receiving superphosphate at the rate of 2,400 and 4,800 pounds per acre was increased compared to that of plants grown in the no treatment tests in series one. Treatments 12, 13, and 14, which received superphosphate at the rate of 1,200, 2,400 and 4,800 pounds per acre respectively in series two and test 20 and 21 in series three, which received superphosphate at the rate of 2,400 and 4,800 pounds per acre produced increases in the phosphorus content of alfalfa plants as compared to that of plants from the no treatment test. In the third and fourth cuttings the alfalfa plants contained a higher phosphorus content than the plants of the first and second cuttings.

When the averages of the phosphorus content of the alfalfa receiving the high calcium limestone and those receiving the high magnesium limestone

Table 12.- Effect of two tons of limestone plus increasing amounts of 20 per cent superphosphate applied to Montcalm sandy loam soil on the phosphorus and nitrogen content of alfalfa grown in the greenhouse in 1932.

Series I. High calcium limestone plus 100 lbs. muriate of potash and Phosphate as indicated

Pot No.	Soil treatment	1st and 2nd cutting Percent Water	Percent N	Percent P_2O_5	3rd and 4th cutting Percent Water	Percent N	Percent P_2O_5
1	No treatment	11.25	4.25	0.98	7.59	3.55	1.06
2	200 lbs. S. P.	12.81	4.23	1.00	7.51	3.31	1.04
3	400 lbs. S. P.	14.75	4.24	1.05	7.21	3.34	1.03
4	800 lbs. S. P.	9.39	4.26	0.94	7.23	3.51	0.99
5	1200 lbs. S. P.	9.82	4.19	0.98	7.59	3.51	1.03
6	2400 lbs. S. P.	10.18	4.22	0.97	8.11	3.48	1.15
7	4800 lbs. S. P.	10.52	4.22	1.13	8.56	3.51	1.35
	Average	11.25	4.23	1.01	7.69	3.46	1.09
	Series II. High calcium limestone plus phosphate as indicated						
8	No treatment	8.45	4.31	0.99	8.54	3.55	1.13
9	200 lbs. S. P.	9.43	4.26	0.96	8.58	3.45	1.13
10	400 lbs. S. P.	9.97	4.28	0.98	8.17	3.35	1.07
11	800 lbs. S. P.	7.29	4.26	0.93	9.95	3.64	1.11
12	1200 lbs. S. P.	8.24	4.27	0.99	9.85	3.65	1.20
13	2400 lbs. S. P.	7.33	4.16	1.01	8.94	3.65	1.28
14	4800 lbs. S. P.	7.89	4.17	1.05	8.76	3.50	1.55
	Average	8.37	4.24	0.99	8.97	3.54	1.21
	Series III. High magnesium limestone plus phosphate as indicated						
15	No treatment	9.29	4.27	0.99	9.64	3.58	1.20
16	200 lbs. S. P.	9.66	4.41	0.96	9.35	3.52	1.10
17	400 lbs. S. P.	10.08	4.29	0.97	9.39	3.56	1.23
18	800 lbs. S. P.	7.49	4.23	0.97	8.89	3.49	1.15
19	1200 lbs. S. P.	7.72	4.33	0.93	9.09	3.56	1.08
20	2400 lbs. S. P.	8.07	4.34	1.03	9.13	3.63	1.27
21	4800 lbs. S. P.	8.24	4.19	1.20	8.94	3.63	1.74
	Average	8.58	4.29	1.01	9.20	3.57	1.25

are compared, it is evident, that the magnesium added to the soil in the form of magnesium limestone did not make the phosphorus more available in accord with the results of Kellog (7) who found that magnesium oxide added to some North Dakota soils enhanced phosphate availability in such soils. Truog (19) attributes this effect to a better calcium-magnesium soil balance, in which event the plants are not forced to excess feeding on calcium in order to obtain phosphorus.

SYSTEMATIC SAMPLING RESULTS

In 1932 a comparative study was made of the random method of sampling previously described with a systematic method of taking samples of alfalfa from field plats for chemical analysis. The plat was divided lengthwise into four strips of equal width for the systematic sampling. From each strip three square-yard areas were harvested, the areas being equi-distant from each other and from the sides of the strips. The areas were staggered in respect to the distance from the end of the plat. The method of sampling is diagramed on page 41.

Sets of samples were taken from the Brookston clay loam soil on the Guyer farm near Frankenmuth, the Isabella sandy loam soil on the Higbee farm near Stanwood, the Mancelona gravelly sandy loam soil on the Department of Soils' farm at Mancelona, and the Fox sandy loam soil near Cassopolis, on the Cass County farm and the Hansen farm. The Isabella sandy loam soil and Brookston clay loam has previously been described in this paper.

The surface soil from cultivated fields of Mancelona gravelly sandy loam is brownish gray and varies in thickness from 5 to 10 inches. The plow soil is commonly somewhat gravelly and in some places cobble stones are abundant. The horizon below the plow layer is brown and gravelly varying in thickness from 6 to 20 inches, is cemented in places and contains an appreciable quantity of clay. It grades into a material that is coarser, less coherent, and more gravelly. The substratum consists of pervious sand with gravel and cobble stones. However the horizon above the substratum is sufficiently compact and colloidal to impede the downward movement of water and to retain moisture, so that the soil, notwithstanding its coarse, pervious substratum, is not so draughty as similar sandy soils.

Though commonly acid in places, the soil may give an alkaline reaction. Generally the land is nearly level, except for occasional pot holes or shallow depressions. Natural drainage is good. This soil type is perhaps the most productive soil on the dry sandy plains and a large percentage of it is under cultivation.

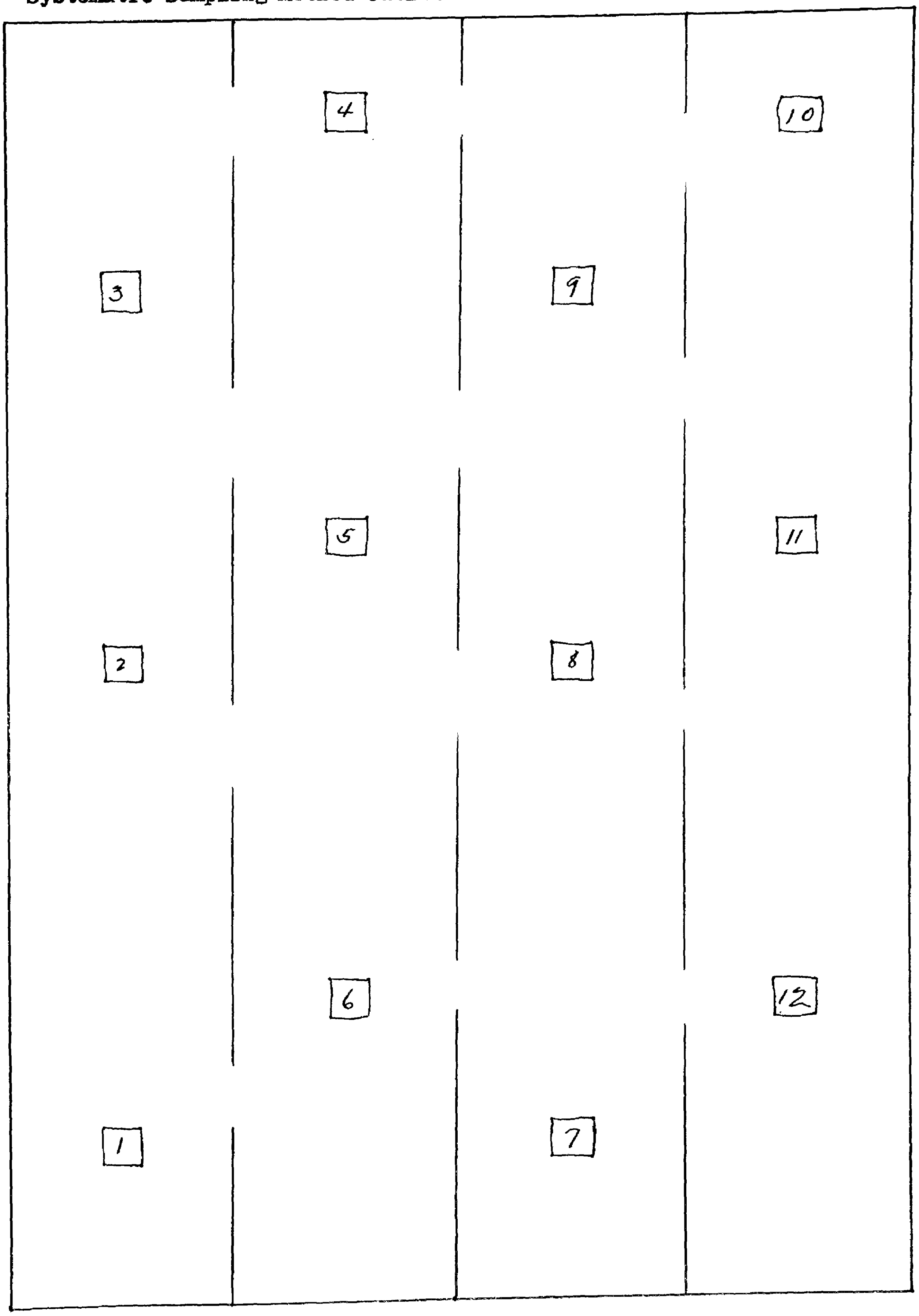
The soil is low in organic matter content and fertility. All crops grown on this soil type respond to applications of fertilizer. Potatoes and alfalfa require a fertilizer higher in potash content.

The surface soil of the Fox sandy loam in cultivated fields is a brown to grayish-brown sandy loam, 7 to 12 inches deep, underlain by a lighter colored layer of loamy sand, usually yellowish brown in color, and grading at about 18 to 24 inches into reddish-brown loam to gravelly clay. The substratum, consisting of coarse sandy and gravelly material, is moderately calcareous.

Generally the surface is flat to gently undulating or slightly sloping. Drainage of the type as a whole is very good, both in the surface soil and subsoil: Probably excessive drainage is a detriment to these soils.

Fox sandy loam is only moderately fertile and is low in organic matter content. Though the surface soil to a depth ranging from 20 to 30 inches is acid, lime becomes more plentiful in the lower part of the subsoil, and

Systematic Sampling Method Outline



it is abundant in the gravelly substratum which in most places is less than 36 to 48 inches beneath the surface.

Liming is beneficial to most crops, especially good response to liming on this soil is shown by alfalfa and sweet clover. Crops respond to fertilizers that carry a fairly high phosphorus and potash content, however, alfalfa responds to a high potash and lower phosphorus content fertilizer.

The analytical data obtained from the samples are presented in Table 13. Since only two samples were taken at random it is impossible to treat the data statistically. It appears, however, from a consideration of the averages of the percents of the elements determined in the plants from each soil type that there is little difference in favor of either method of field sampling. It may, therefore, be concluded that the data collected during the main potion of the investigation represent the average composition of the alfalfa on the plats studies as accurately as though a large number of samples had been taken according to a systematic pattern. The data from the systematic samples do show a considerable variation in composition of alfalfa from different portions of each plat.

Table 13.- Comparison of the random with systematic sampling methods. Alfalfa plants grown on the Brookston clay loam and Mancelona gravelly sandy loam, Isabella sandy loam and Fox sandy loam soils in 1932.

Sample No.	Soil treatment	Percent H_2O	Percent N	Percent CaO	Percent P_2O_5
		Mancelona gravelly sandy loam			
1R	Check	10.68	3.18	5.09	0.37
2R	Check	10.59	3.22	4.86	0.37
	Average	10.64	3.20	4.98	0.37
1S[2]	Check	10.80	3.11	4.67	0.36
2S	Check	10.85	3.11	4.60	0.37
3S	Check	11.53	3.07	4.75	0.36
4S	Check	12.21	3.18	4.99	0.36
5S	Check	11.32	3.08	4.68	0.37
6S	Check	11.41	3.13	4.48	0.33
7S	Check	11.89	3.15	4.62	0.35
8S	Check	12.25	3.16	4.76	0.36
9S	Check	11.68	3.02	5.05	0.36
10S	Check	12.44	3.07	4.79	0.37
11S	Check	11.72	3.19	4.87	0.39
12S	Check	11.41	3.29	4.70	0.39
	Average	11.63	3.13	4.75	0.36
		Brookston clay loam			
1R	Check	9.61	2.86	3.23	0.51
2R	Check	10.96	3.09	3.46	0.47
	Average	10.29	2.98	3.35	0.49
1S	Check	9.46	2.88	3.39	0.49
2S	Check	9.18	3.41	3.21	0.61
3S	Check	9.55	2.87	3.26	0.49
4S	Check	8.77	2.92	2.87	0.51
5S	Check	10.11	3.10	3.83	0.55
6S	Check	9.34	2.84	3.71	0.54
7S	Check	9.40	2.75	3.24	0.47
8S	Check	9.69	3.00	3.26	0.50
9S	Check	9.69	2.96	2.31	0.51
10S	Check	10.45	3.03	2.62	0.57
11S	Check	9.99	2.80	2.51	0.48
12S	Check	10.84	3.20	2.58	0.52
	Average	9.71	2.98	3.06	0.52

R[1]- Random sampling; S[2] - Systematic sampling.

Table 13.- Continued.

Isabella Sandy loam

Sample No.	Soil treatment	Percent H_2O	Percent N	Percent CaO	Percent P_2O_5
1R	300 lbs. 0-16-0	9.50	2.92	1.81	0.66
2R	300 lbs. 0-16-0	10.63	2.93	1.92	0.67
	Average	10.06	2.93	1.87	0.67
1S	300 lbs. 0-16-0	10.80	2.85	2.13	0.61
2S	300 lbs. 0-16-0	10.72	2.92	1.82	0.69
3S	300 lbs. 0-16-0	11.95	3.12	2.18	0.68
4S	300 lbs. 0-16-0	13.27	3.33	1.91	0.68
5S	300 lbs. 0-16-0	12.94	3.23	1.91	0.69
6S	300 lbs. 0-16-0	14.56	3.15	1.80	0.72
7S	300 lbs. 0-16-0	9.85	3.10	1.76	0.69
8S	300 lbs. 0-16-0	9.70	3.28	1.78	0.73
9S	300 lbs. 0-16-0	10.04	3.30	2.27	0.74
10S	300 lbs. 0-16-0	10.11	3.10	2.12	0.74
11S	300 lbs. 0-16-0	10.17	3.39	2.34	0.72
12S	300 lbs. 0-16-0	10.30	3.09	2.04	0.77
	Average	11.20	3.16	2.01	0.71

Brookston clay loam

Sample No.	Soil treatment	Percent H_2O	Percent N	Percent CaO	Percent P_2O_5
1R	300 lbs. 0-20-0	8.92	3.23	2.43	0.63
2R	300 lbs. 0-20-0	9.02	3.21	2.63	0.63
	Average	8.97	3.22	2.53	0.63
1S	300 lbs. 0-20-0	8.96	3.55	2.63	0.73
2S	300 lbs. 0-20-0	8.83	3.98	2.22	0.72
3S	300 lbs. 0-20-0	9.10	3.24	2.58	0.68
4S	300 lbs. 0-20-0	9.33	3.26	2.30	0.68
5S	300 lbs. 0-20-0	9.05	3.25	2.32	0.63
6S	300 lbs. 0-20-0	9.70	3.29	2.92	0.63
7S	300 lbs. 0-20-0	9.63	3.15	2.90	0.60
8S	300 lbs. 0-20-0	11.10	3.06	2.65	0.67
9S	300 lbs. 0-20-0	9.34	3.30	2.71	0.64
10S	300 lbs. 0-20-0	10.08	3.27	2.60	0.67
11S	300 lbs. 0-20-0	9.58	3.38	2.40	0.63
12S	300 lbs. 0-20-0	9.72	3.01	2.46	0.64
	Average	9.53	3.23	2.47	0.66

Table 13.-Continued.

Mancelona gravelly sandy loam

Sample No.	Soil treatment	Percent H_2O	Percent N	Percent CaO	Percent P_2O_5
1R	600 lbs. 0-0-15	11.84	2.94	2.66	0.39
2R	600 lbs. 0-0-15	11.68	2.83	2.43	0.40
	Average	11.76	2.89	2.55	0.40
1S	600 lbs. 0-0-15	11.82	2.89	2.32	0.37
2S	600 lbs. 0-0-15	13.58	2.98	2.72	0.34
3S	600 lbs. 0-0-15	9.29	2.86	2.71	0.33
4S	600 lbs. 0-0-15	10.23	3.03	2.62	0.33
5S	600 lbs. 0-0-15	9.41	2.80	2.58	0.35
6S	600 lbs. 0-0-15	10.30	2.83	2.57	0.35
7S	600 lbs. 0-0-15	9.30	2.77	2.36	0.35
8S	600 lbs. 0-0-15	9.60	2.87	2.36	0.40
9S	600 lbs. 0-0-15	9.30	2.71	2.41	0.37
10S	600 lbs. 0-0-15	10.63	2.87	2.64	0.39
11S	600 lbs. 0-0-15	10.49	2.93	2.48	0.40
12S	600 lbs. 0-0-15	9.68	2.94	2.76	0.40
	Average	10.30	2.87	2.54	0.37

Isabella sandy loam

Sample No.	Soil treatment	Percent H_2O	Percent N	Percent CaO	Percent P_2O_5
1R	300 lbs. 4-16-4	10.73	3.12	2.44	0.61
2R	300 lbs. 4-16-4	10.51	3.01	2.23	0.63
	Average	10.61	3.07	2.34	0.62
1S	300 lbs. 4-16-4	10.52	3.06	1.88	0.68
2S	300 lbs. 4-16-4	10.54	3.02	1.94	0.65
3S	300 lbs. 4-16-4	10.74	3.29	2.82	0.67
4S	300 lbs. 4-16-4	10.94	3.01	2.15	0.63
5S	300 lbs. 4-16-4	10.62	3.03	2.11	0.67
6S	300 lbs. 4-16-4	10.09	3.16	2.29	0.69
7S	300 lbs. 4-16-4	13.02	3.32	2.59	0.69
8S	300 lbs. 4-16-4	14.25	3.12	2.35	0.67
9S	300 lbs. 4-16-4	13.52	3.34	2.14	0.70
10S	300 lbs. 4-16-4	15.02	3.41	2.59	0.70
11S	300 lbs. 4-16-4	10.74	3.17	2.31	0.59
12S	300 lbs. 4-16-4	10.51	3.33	2.16	0.65
	Average	11.79	3.19	2.28	0.67

Table 13.- Continued.

Fox sandy loam (Cass County farm)

Sample No.	Soil treatment	Percent H_2O	Percent N	Percent CaO	Percent P_2O_5
1R	250 lbs. 0-20-20	11.31	3.14	1.85	0.55
2R	250 lbs. 0-20-20	12.13	3.14	1.91	0.58
	Average	11.72	3.14	1.88	0.57
1S	250 lbs. 0-20-20	12.98	3.27	1.86	0.71
2S	250 lbs. 0-20-20	13.87	3.26	2.04	0.79
3S	250 lbs. 0-20-20	9.55	3.26	1.93	0.67
4S	250 lbs. 0-20-20	10.45	3.35	2.14	0.58
5S	250 lbs. 0-20-20	10.44	3.37	2.11	0.59
6S	250 lbs. 0-20-20	10.57	3.35	2.16	0.59
7S	250 lbs. 0-20-20	10.01	3.32	1.98	0.68
8S	250 lbs. 0-20-20	10.58	3.34	1.91	0.62
9S	250 lbs. 0-20-20	10.63	3.43	2.00	0.67
10S	250 lbs. 0-20-20	10.66	3.09	2.01	0.60
11S	250 lbs. 0-20-20	10.85	3.29	1.94	0.66
12S	250 lbs. 0-20-20	11.43	3.34	1.92	0.67
	Average	11.00	3.30	2.00	0.65

Fox sandy loam (Hansen farm Cass County)

Sample No.	Soil treatment	Percent H_2O	Percent N	Percent CaO	Percent P_2O_5
1R	250 lbs. 0-20-20	10.07	3.49	1.99	0.69
2R	250 lbs. 0-20-20	10.35	3.52	1.83	0.72
	Average	10.21	3.51	1.91	0.71
1S	250 lbs. 0-20-20	10.61	3.37	2.17	0.70
2S	250 lbs. 0-20-20	10.96	3.50	2.26	0.72
3S	250 lbs. 0-20-20	10.75	3.50	1.99	0.73
4S	250 lbs. 0-20-20	11.62	3.38	2.04	0.71
5S	250 lbs. 0-20-20	11.68	3.62	2.13	0.75
6S	250 lbs. 0-20-20	13.07	3.80	2.24	0.77
7S	250 lbs. 0-20-20	9.65	3.78	2.10	0.77
8S	250 lbs. 0-20-20	9.45	3.66	2.04	0.78
9S	250 lbs. 0-20-20	9.44	3.45	1.93	0.81
10S	250 lbs. 0-20-20	10.24	3.64	1.81	0.76
11S	250 lbs. 0-20-20	9.48	3.68	2.08	0.76
12S	250 lbs. 0-20-20	9.81	3.68	2.29	0.75
	Average	10.56	3.59	2.09	0.75

SUMMARY

1. This paper reports experimental data obtained from a partial chemical analysis of alfalfa grown on the several soil types, Isabella sandy loam, Montcalm sandy loam, Mancelona gravelly sandy loam, Fox sandy loam, Brookston loam, Brookston clay loam, Brookston silt loam, Gilford loam, and Miami silt loam.

2. The first cuttings of alfalfa grown on the several soil types, exhibited a much lower ratio of leaves to stems than the second cuttings at the one-half bloom stage. Also, the weight of stems exceeded that of the leaves in the first cuttings, which was just the opposite of the condition for the second cutting.

3. The water content of both the stems and leaves of plants grown on Isabella sandy loam soil was higher in the second than in the first cuttings.

4. In both the stems and leaves the nitrogen content was higher in the second than the first cuttings of alfalfa cut in the one-half bloom stage and grown on Isabella sandy loam soil.

5. Regardless of soil type and soil treatment the calcium content of alfalfa leaves was from two to three times greater than that of the stems.

6. In case of plants grown on Isabella sandy loam soil the calcium content of the stems was higher in the second than the first cuttings, but in case of the leaves, the opposite was true.

7. Plants grown on the soil just mentioned, show clearly that all soil treatments increased the nitrogen content of both the stems and leaves in all cases, and all limestone treatments depressed the phosphorus content of both the stems and leaves.

8. In general, the plants grown on soils which did not receive applications

of limestone showed increases in the phosphorus content of both the stems and leaves with fertilizer treatments containing superphosphate alone or with potash.

9. Plants from the medium soil types, the Gilford loam, are markedly higher in calcium content in both the stems and leaves than that of plants from either the heavier or lighter soil types.

10. Alfalfa grown on the lighter soil, the Isabella sandy loam, showed a decidedly higher phosphorus content in both the stems and leaves over that of plants from either the medium or heavier soil types.

11. It is clear that plants grown on the Montcalm sandy loam soil in the greenhouse require very heavy applications of phosphate in order to materially increase their phosphorus content.

12. The data presented in this paper indicate no advantage of the systematic over the random method of taking samples of alfalfa for chemical analysis.

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