Proceedings of the Iowa Academy of Science

Volume 36 | Annual Issue Article 6

1929

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THE EFFECT OF LIME ON NITRIFICATION IN THE GRUNDY SILT LOAM

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To secure information preliminary to the laying out of field experiments for a study of the value of liming and growing inoculated legumes on the Grundy silt loam, an important soil type in Southern Iowa, tests have been conducted on this soil during the past winter in the greenhouse and laboratory. These tests were planned to study the effect of various amounts of limestone and to determine the influence of lime alone and in combination with certain fertilizers on crop yields and on the biological and chemical conditions in the soil.

Unquestionably the best measure of the effects of lime and of any fertilizing materials on the fertility of the soil is the crop yield. Numerous experiments have demonstrated, however, that the bacteriological activities in a soil may serve as a measure of its productivity. A close correlation between yields and certain bacterial processes has been noted in many instances, especially in the case of nitrification. This has been shown by Brown (1), Gainey (3), Waksman (5), Walker (6) and others.

In this paper data will be presented which show the effect of lime alone and in combination with other fertilizing materials upon the nitrifying power of a typical Grundy silt loam.

Samples of this soil were taken from two typical areas, north of Osceola in Clarke county, and shipped to the college greenhouse. The soils were then screened and placed in four-gallon earthenware pots. One sample of the soil was used in Experiment I and the treatments made to duplicate pots were as follows:

Pots 1 and 2 — no treatment
Pots 3 and 4 — one ton of lime per acre
Pots 5 and 6 — two tons of lime per acre
Pots 7 and 8 — three tons of lime per acre
Pots 9 and 10 — four tons of lime per acre
Pots 11 and 12 — five tons of lime per acre
Pots 13 and 14 — six tons of lime per acre

In Experiment II the other sample of soil was employed and the treatments were as follows:

Pots 1 and 2 — no treatment
Pots 3 and 4 — lime
Pots 5 and 6 — lime and manure
Pots 7 and 8 — lime, manure and superphosphate

The amount of lime added to the soil in the second experiment was the same for all the limed pots, being sufficient to meet the lime requirement of the soil as shown by the Iowa tests, or three tons per acre. The manure was applied at the rate of eight tons and the superphosphate at the rate of 200 pounds per acre.

Throughout the experiment the soils were kept fallow and near the optimum moisture content for crop growth and bacteriological activities. Distilled water was used in all cases to maintain the proper moisture content. Samples were taken from the pots at intervals for the measurement of the nitrifying power of the differently treated soils.

Experiment I

In this experiment samples were drawn from the variously treated soils one month and two months after the experiment was

Table I — Results of Nitrification Tests on Soil Samples Taken One Month after applying Lime to the Soil. Nitrogen as Nitrate in Parts per Million

Soil Treatment (Tons of Lime)	Nitrification of Soils Own Nitrogen	Nitrification of Ammonium Sulfate Nitrogen	Nitrification of Ammonium Sulfate in Presence of Calcium Carbonate
None	28.5	139	271
One	27.7	172	290
Two	30.2	242	302
Three	28.7	284	313
Four	33.1	266	315
Five	31.0	348	370
Six	30.4	362	378

Table II — Results of Nitrification Tests on Soil Samples Taken Two Months After Applying Lime to the Soil. Nitrogen as Nitrate in parts per Million

Soil Treatment (Tons of Lime)	Nitrification of Soils Own Nitrogen	Nitrification of Ammonium Sulfate Nitrogen	Nitrification of Ammonium Sulfate in Presence of Calcium Carbonate
None	41.1	122	358
One	38.0	173	387
Two	37.9	186	366
Three	39.2	211	383
Four	38.2	242	371
Five	39.8	267	377
Six	41.8	306	389

A graphic representation of these data is shown in Figure 1.

started, and determinations of the nitrifying power of the soils were made. Waksman's (4) method for measuring the nitrifying power was followed. This involves three series of tests carried on in tumblers. Moist soil from each pot was weighed out in amounts equivalent to 100 grams on the dry basis and placed in six tumblers. To two of the tumblers (A) nothing was added in order to measure the power of the soil organisms to nitrify the nitrogen already present in the soil. To the other four tumblers (B) and (C), 30 milligrams of nitrogen as ammonium sulfate were added to measure the ability of the soil organisms to nitrify

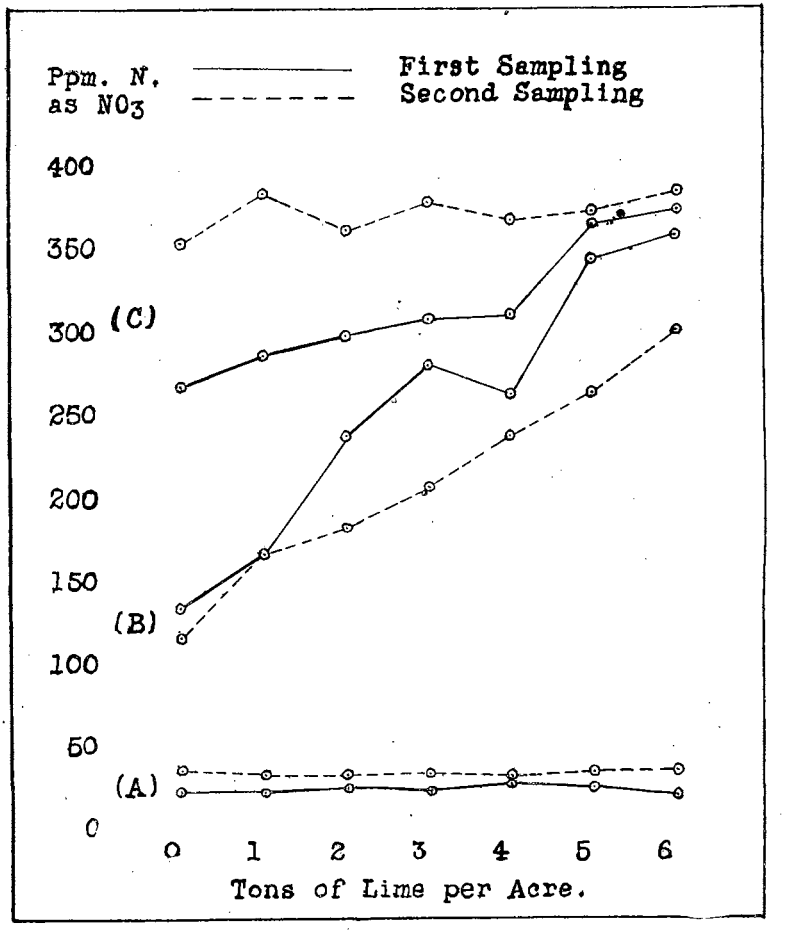

Fig. 1. Graph showing results of Nitrification experiments with soils treated with various amounts of lime.
(A) Nitrification of Soils Own Nitrogen.
(B) Nitrification of Ammonium Sulfate (30 mgms.).
(C) Nitrification of Ammonium Sulfate plus Calcium Carbonate (210 mgms.).

added nitrogen. To two of the tumblers receiving ammonium sulfate (C), 210 milligrams of calcium carbonate were also added. This is the theoretical amount of calcium carbonate that would be required to neutralize the nitric and sulfuric acids produced in the nitrification of the ammonium sulfate. The soils were brought up to the optimum moisture content and incubated at 25°C. for 28 days. After the incubation period the nitrate content of the soils was determined by the phenoldisulphonic acid method as modified by Harper (2). The results are presented in tables 1 and 2.

These results show very definitely the effect of lime upon the nitrifying power of this soil. The change in the nitrifying power induced by the lime as is indicated in the A series was very slight because of a deficiency of nitrifiable material in the soil. In the B series where ammonium sulfate was added the effect of the lime is very apparent. The amount of nitrates produced was increased from 139 and 122 parts per million of nitrogen at the first and second samplings respectively, in the soils that had received no lime up to 362 and 306 parts per million in the soils that had received six tons of lime per acre. In all but one case an increase in lime application resulted in an increase in the nitrifying power of the soil. In the C series where the calcium carbonate was added to all the soils when the nitrification tests were started the effects of the original lime applications to the soils in the pots was not so great but even in this case there was a definite increase in the nitrifying power of the limed over the unlimed soils.

The results of this series also show quite definitely that the nitrifying power of this soil was greater when calcium carbonate was added when the nitrification tests were started in the laboratory. The differences between series B and C were much greater in the soils receiving the lower lime treatments than where the larger amounts of lime had been applied. Where six tons of lime had been applied the results from these two series were not far different. This would seem to indicate that an application of six tons of lime was probably near the maximum for the needs of the nitrifying bacteria in this soil.

If it is assumed that the nitrifying power is a measure of the crop producing power of the soil, then it may be assumed that the crop producing power of the soil receiving six tons of lime per acre would be greater than that of the soil receiving smaller amounts of lime. Unpublished data indicate that this assumption is correct.

Experiment II

The purpose of this experiment was to study the effect of applications of manure or manure and superphosphate with the lime. The nitrifying power of these soils was determined in the same manner as described in Experiment I. The results are presented in tables III and IV.

Table III — Results of Nitrification Tests on Soil Samples Taken One Month After Applying Lime and Fertilizers to the Soil. (Nitrogen as Nitrate in Parts per Million)

Soil Treatment	Nitrification of Soils Own Nitrogen	Nitrification of Ammonium Sulfate Nitrogen	Nitrification of Ammonium Sulfate in Presence of Calcium Carbonate
Nothing	31	158	265
Lime	47	249	308
Lime and Manure	43	243	352
Lime manure and Phosphate	37	243	332

Table IV — Results of Nitrification Tests on Soil Samples Taken Two Months After Applying Lime and Fertilizers to the Soil. (Nitrogen as Nitrate in Parts per Million)

Soil Treatment	Nitrification of Soils Own Nitrogen	Nitrification of Ammonium Sulfate Nitrogen	Nitrification of Ammonium Sulfate in Presence of Calcium Carbonate
Nothing	53	121	320
Lime	57	258	365
Lime and Manure	46	254	336
Lime manure and Phosphate	50	248	370

A graphic representation of these data is shown in figure 2.

These results also show very definitely the effect of lime on the nitrifying power of this soil. In the B series at the second sampling the nitrates produced increased from 121 p.p.m. where no lime had been applied to 258 p.p.m. in the soil which had received three tons of lime per acre. The addition of manure or manure and superphosphate did not increase the nitrifying power of the soil, except in the series C tests where the calcium carbonate had been added to the soil when the nitrification tests were started. Probably the reason for this lack of influence of the manure and superphosphate was that the soil was still in need of lime to support maximum nitrification.

In general, the results show the pronounced effect of lime on the nitrifying power of this soil, and that nitrification is affeced much

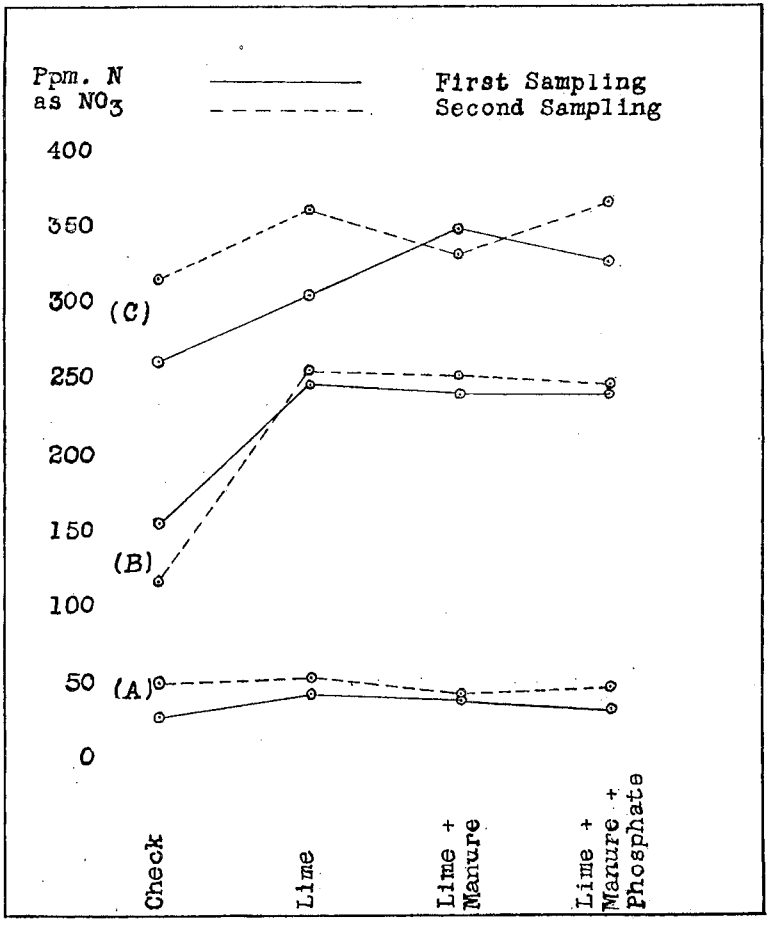

Fig. 2. Graph showing results of Nitrification experiments with soils treated with lime alone and in combination with manure and superphosphate.
(A) Nitrification of Soils Own Nitrogen.
(B) Nitrification of Ammonium Sulfate (30 mgms.).
(C) Nitrification of Ammonium Sulfate plus Calcium Carbonate (210 mgms.).

more by lime than by manure or superphosphate. In fact, the nitrifying power was as high in the soils that had received lime alone as it was where lime, manure and superphosphate had been applied.

In conclusion it may be pointed out that these data indicate quite definitely that the outstanding need for increased nitrification in the Grundy silt loam is sufficient lime to neutralize the acidity. If the nitrifying power of the soil is a measure of fertility then lime is certainly the treatment most needed for better crop growth on this soil. Unless sufficient lime has been added to correct the acidity of this soil the largest effects from the use of manure and commercial fertilizers cannot be expected.

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