NITROGEN GATHERING ABILITY OF LEGUMES

UNDER DIFFERENT SOIL CONDITIONS

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MASTER OF SCIENCE

by

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I N T R O D U C T I O N

As each year goes by we become more and more impressed with the necessity of retaining and restoring fertility in our soils. The population of ourcountry is rapidly increasing and will soon demand a maximum amount of food supplies from the soil. To meet this demand the soil must be kept in a high state of fertility as cheaply as possible.

The three important fertilizing elements that we find it necessary to supply to the soil are nitrogen, phosphorus and potassium. The average cost of these elements in commercial fertilizers are about as follows: Nitrogen, 15 cents per pound; Phosphorus, five cents per pound; and Potassium, five cents per pound. It is seen that nitrogen is by far the most expensive of the three. However, we luckily have a cheaper form of nitrogen than that in commercial fertilizers. It has been known for a long time that the legumes takes free nitrogen from the atmosphere and store it up in the plants. When the roots, or stalks, or both, of these leguminous plants are plowed under and decay, the nitrogen in them becomes available for the use of other plants. By the proper use of legumes in the crop rotation an abundent supply of nitrogen can be kept in the soil.

However, it has beenshown that legumes must have certain soil conditions before they will make the best growth. Practically all growing plants exude organic acids. These organic acids with probably some inorganic acids will in time cause the soil to become acid unless some thing is used to neutralize the acid. Nitrogen gath-

ering bacteria can not live under acid conditions. Nor do most plants grow well in acid soils. To rectify this condition large quantities of lime are being used. Lime has caustic properties which neutralize the acid and make the soil "Sweet".

While we know that the addition of lime to an acid soil increases the nitrogen gathering ability of the Legume, we do not know just what quantity of lime will give ideal conditions. One ton of ground limestone or one-half a ton of burned lime per acre may put the s soil in such a condition that the nitrogen gathering bacteria can live in it, but twice that amount may really be needed to give the best conditions for them to work in. Of course, the amount will not be the same in all cases. Some soils contain a great deal more acid than others. There are several methods now of determining the lime requirements of a soil, but even these do not give a hard fast rule for applying lime.

STATEMENT OF PROBLEM

The purpose of this experiment is to determine, if possible, the relative amounts of nitrogen gathered by a legume in soils containing different amounts of lime. Also to see if an application of nitrogen, phosphoric acid, and potash fertilizers, singly and in the various combinations, will in anyway affect the nitrogen content of the plant.

WORK AT OTHER STATIONS

So far as known no experiment has ever been conducted before to find the amount of nitrogen gathered by legumes in soils containing different amounts of lime. However, there have been numerous experiments that show lime is beneficial to the growth of legumes. A number of experiments have also been carried on to find the value of fertilizers on legumes, although chemical anaylses were not made to compare the nitrogen contest.

Ohio Bulletin No. 279 finds that clover responds readily to liming , the rate of increase being greater for it than any of the other crops in a five year rotation of corn, oats, wheat, clover

and timothy. There is nothing in this to show that the nitrogen content of the clover has been increased but we may safely assume that it h has increased in proportion to the yield. This bulletin also brings up the point; are nitrogen fertilizers beneficial to legumes. The experiments carried on with them on unlimed plats showed an increased yield for nitrate of soda but linseed oilmeal, dried blood and sulphate of ammonia gave no better yields than the fertilizers containing no nitrogen. A suggestion is made that the sodium in the nitrote is probably responsible for it giving a higher yield. However, it seems as if this idea were disproven by the results on the limed plats. There is a slight increase for all the nitrogen fertilizers here over the ones not having it. If it was the alkaline effect of the sodium and not the presence of the nitrogen on the unlimed plats that gave the increase, there should have been no increase on the limed plats for nitrate of soda because a base had already been supplied in sufficient quantities.

Rhode Island Bulletin, No. 160, found that soy beans yielded about one-fourth more hay on limed plats than unlimed. It also says that the height of the beans was greater on limed than unlimed plats when fertilized with sulfate of ammonia but just about the same when fertilized with nitrate of soda. In other words the sulfate of ammonia had little effect on soy beans when used without lime, while the nitrate of soda gave almost as good results without the lime as with it. The same explanation may be made of this as Dr. Thorne suggested for the experiment at the Ohio Station, but there is no proof of it. The Rhode Island Station carried on rather extensive experiments with lime on a great variety of crops, the results of which are given in Bulletin No. 160.

A review of a report by Wagner in Dent. Landro Presse says "Labaratory and pot experiments show that when ammonium salts are applied to soils containing considerable amounts of calcium carbonate there is a considerable loss of nitrogen in the form of ammonium carbonate, especially if the ammonium salts are applied on the surface of a moist soil and allowed to lie sometime before being cultivated. These facts explain why ammonium salts give better results as a rule upon soils poor in lime than those containing an abundance of this material, and why they are more efficient when thoroughly mixed with the soil than when applied as a top-dressing." This was confirmed by the experiment stations of Bonn. Bernberg, Halle, and Roslin but, on the other hand it is diametrically opposed to the results that have just been given from the Rhode Island experiments. They showed that soy beans did much better on a limed than unlimed soil when fertilized with sulfate of ammonia. Just how this is to be reconciled to what the German station found is a question. It is possible, though, that the unlimed plats at the Rhode Island Station were so acid that soy beans could not grow in them either with or without sulfate of ammonia. The most definite conclusion that we can arrive at is, that we are not yet ready to stop experimental work along these lines.

Charles S. Phelps of the Comn. Agricultural College says that soy beans should be liberally fertilized with phosphoric acid, potash and lime. Then if some care is used to inoculate the beans all the nitrogen necessary will be obtained from the air. This bears out the much accepted idea that nitrogen fertilizers are not needed on legumes.

An abstract of a report by Richard Ulbricht says that experiments made in 1896 to 1903 with various plants grown in cylinders showed that an

application of lime resulted in a slightly diminished assimulation of nitrogen and phosphoric acid in the case of lupins, vetches and serradella, whilst the potassium was increased in the lupins and serradella but not in the vetches. Thus again we see that nitrogen need not be added to legumes with lime. This experiment also indicates that phosphoric acid is not needed when lime is used but that idea can not be accepted here on our American soils. It may be true enough in Germany.

P R O C E D U R E

A quantity of Price Mountain soil, known to be acid, was obtained near Blacksburg. It was screened and mixed thoroughly so that it would be uniform throughout. Forty-eight galvanized pots were filled with this soil, each one containing eighteen pounds. These pots were divided in eight series with six to a series. Ground limestone was added to these pots in the following way: No. 1 in each series was left as a check, no limestone being used; all No. 2's had one per cent of limestone; all No. 3's, two per cent; all No. 4's, three per cent; all No. 5's, four per cent; and all No. 6's, five per cent.

To the first series of pots nitrogen was added in the form of nitrate of soda at the rate of 200 pounds per acre. To the second series, phosphoric acid was added in the form of 16% acid phosphate at the rate of 600 pounds per acre. To the third series, potash was added in the form of muriate of potash at the rate of 400 pounds per acre. To the fourth series, a mixture of nitrogen and phosphoric acid was added at the rate of 500 pounds per acre. To the fifth series, a mixture of nitrogen and potash was added at the rate of 500 pounds per acre. To the sixth series, a mixture of phosphoric acid and potash was added at the rate of 500 pounds per acre. To the seventh series, a mixture of all three were added at the rate of 500 pounds per acre. All of these mixtures were made in the proportion of one pound of nitrate of soda, two pounds of muriate of potash and three pounds of acid phosphate. The eight series had no fertilizer at all, being used as a check on the others.

The lime and fertilizer was mixed thoroughly with the soil in each pot and after the pots had warmed up in the green house soy beans were planted in them. Ideal conditions were furnished for the growth of the beans, as far as possible. The moisture content of the soil was kept constant and the pots were kept in the open air whenever the weather permitted. When the beans reached maturity they were harvested and weighed. They were then allowed to dry out thoroughly and were weighed again. After this weighing the plants from each pot were ground up and put in jars numbered like the pots.

Chemical analyses were made to find the nitrogen content of the beans. All were made in duplicate and the average of the two are given in Table No. 1. A moisture determination was made of each duplicate sample. This was done by heating two grams of the material for five hours in a water bath and reweighing after cooling in a dessicator. The results of these determinations are given in Table No. II. Table No. III gives the dry weight of the beans grown in each pot.

A sample of the soil was drawn before placing in the pots and a determination made of the lime required for it. This was found to be 2160 pounds per acre. The Jones method of determination was used.

T A B L E N O . I

		PERCENTAGE OF NITROGEN					
		Pot 1	Pot 2	Pot 3	Pot 4	Pot 5	Pot 6
		Check	1% Lime	2% Lime	3% Lime	4% Lime	5% Lime
Series No. 1	N	2.95	3.25	2.91	2.98	3.70	3.01
Series No. 2	P	2.19	2.51	2.75	2.65	2.43	2.79
Series No. 3	K	1.95	2.72	2.81	2.57	2.91	2.79
Series No. 4	NP	2.19	2.69	2.88	2.81	2.46	3.02
Series No. 5	NK	2.45	2.75	3.38	3.47	3.08	2.83
Series No. 6	PK	1.93	1.96	3.10	2.17	2.21	2.78
Series No. 7	NPK	2.28	2.15	2.94	2.71	2.44	2.66
Series No. 8	Check	2.01	2.86	3.25	2.54	2.49	2.49
AVERAGES		2.24	2.61	3.00	2.73	2.71	2.79

TABLE NO. II.

		PERCENTAGE OF MOISTURE .					
		Pot 1	Pot 2	Pot 3	Pot 4	Pot 5	Pot 6
		Check	1% Lime	2% Lime	3% Lime	4% Lime	5% Lime
Series No 1	N	7.53	8.67	9.04	7.24	8.47	7.87
Series No 2	P	9.31	7.76	8.20	7.21	8.45	9.26
Series No 3	K	10.43	9.11	7.63	9.85	8.49	7.86
Series No 4	NP	8.15	9.33	9.00	8.58	7.32	8.41
Series NO 5	NK	8.41	12.11	8.26	8.48	7.48	8.65
Series No 6	PK	9.27	9.17	11.33	7.65	9.79	7.97
Series No 7	NPK	8.83	9.07	7.98	9.01	9.27	8.40
Series No 8	Check	8.59	10.10	8.98	7.43	7.66	7.56

T A B L E N O . III .

		WEIGHT OF BEANS IN GRAMS						
		Pot 1	Pot 2	Pot 3	Pot 4	Pot 5	Pot 6	
	P	Check	1% Lime	2% Lime	3% Lime	4% Lime	5% Lime	Average
Series No 1	N	14	10½	26½	23½	17	16½	18.0
Series No 2	P	9	15½	17½	19	20	13½	15.7
Series No 3	K	7½	15	16	16	8½	16½	13.2
Series No 4	NP	10½	21	14	18½	23	12½	16.6
Series No 5	NK	13	16½	9½	15½	17	15	14.4
Series No 6	PK	10	19½	15½	16½	18	15	15.7
Series No 7	NPK	10	16	10½	18	18	15½	14.6
Series No 8	Check	8	9	12½	9½	19½	18	12.7

D I S C U S S I O N

At the first glance over Table No. I, it would seem that no conclusions whatever could be drawn from the results. The percentages appear to have no semblance of order. However, by looking a little more carefully it can be seen that there is an increase in the nitrogen from the check up through 2% lime. The averages give an increase from 2.24 to 3.00. Series Nos. 1 and 7 are not consistent in this increase but all of the others are. Above 2% lime the averages drop back slightly and all are ready the same, there being a variation of only .08. It appears from this that 2% lime puts the soil in the best condition for the legume to gather nitrogen and all over this amount is useless.

The amounts of lime used in this experiment were all too large, making it rather impractical. If we estimate that our soils weigh 2,500,00 to the acre foot we could never afford to apply even 1%. The amounts should have been from .1% up to .5%.

The moisture content of the beans as given in Table No. II is of little value, though interesting to note that neither the fertilizers nor the amount of lime used affects it. While they vary from 7.24% to 12.11%, this is probably due to imperfect drying of the beans rather than any difference in their growth.

The weight of the beans given in Table No. III shows that fertilizers are valuable to the growth of the plant. However, these results are decidedly in favor of nitrogen fertilizers which is rather

opposed to the popular belief that legumes do not need nitrogen furnished them. The results might have been different had care been exercised to inoculate the soil when the beans were seeded. In that case the plants would have had a better chance to take their nitrogen from the air and not depend on the fertilizer for it. This brings up another point. Just what is the effect that lime produces on the soil that makes it better for the growth of legumes? Does it simply "Sweeten" the soil so that nitrogen gathering bacteria can work in it or does it furnish food for the growth of the plant? Our experiment was not extensive enough to touch on this so no discussion of the subject will be entered into. We will only say that so many factors enter into the lime and fertilizer question that it will be a long time before definite conclusions can be had.

C O N C L U S I O N .

1st: Lime added to an acid soil incresses the amount of nitrogen gathered by soy beans. Even though too much lime was added to the pots in this experiment there was an increase in every case except one, from 1% lime over the check. The amounts of lime used will not justify any statement as to what quantity is the best.

2nd: Phosphate and potash fertilizers and also nitrogen fertilizers under some conditions, are beneficial to the growth of legumes. There have been other experiments as well as our own that derived benefit from the use of nitrogen, but on the other hand, experiments have been conducted that show that legumes will grow as well without as with nitrogen. We can only wait till this has been tried out more thoroughly.

B I B L I O G R A P H Y

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