LEGUMES AS A SOURCE OF NITRATE FOR FARM CROPS

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The maintenance of an adequate supply of available nitrogen is probably the most important practical soil problem with which the farmer of today has to deal. This problem is not limited to any particular area or to any one country, for the production of agricultural products the world over is limited by an insufficient supply of nitrogen. This is by no means a difficulty of recent origin, because there are records showing that a shortage of nitrogen caused some apprehension among the old Roman farmers.

The peculiarity of the nitrogen supply is that there is a superabundance of free nitrogen in the atmosphere which must be combined with other elements before it may be utilized for growing crops. It is said that there is in the atmosphere 5.8 tons of free nitrogen for each square yard of earth surface, and it is estimated that there is less than one ounce of combined nitrogen per square yard of earth surface in the service of man. The supply of free nitrogen is almost inexhaustible, and in comparison the supply of combined nitrogen now in use seems insignificant.

Converting free atmospheric nitrogen into combined nitrogen is a process which is of vital importance to all classes of people. There are several practical methods for manufacturing combined nitrogen, but at present these processes are not sufficiently developed to furnish economically any considerable amount of available nitrogen which might be used on a large scale as a soil fertilizer. In the production of our grain crops at the present time, it is necessary to look to some other source for a supply of combined nitrogen. The most economical and practical means of securing this nitrogen supply for farm crops at present is by the utilization of the various leguminous plants.

It has long been known that leguminous plants have the power of enriching the soil, but it was not until comparatively recent years that the process has been well

understood. The old Roman farmers (Ill. Bul. 179, p. 472) knew that beans possessed the power of enriching the land, and these early farmers followed the practice of plowing under lupines as a means of adding nitrogen and enriching their cultivated lands. There are many early writings which indicate that legume plants were considered valuable for soil enrichment, but it was not until after 1886 that Hellriegel first announced the discovery that bacteria living in symbiotic relationship with leguminous plants have the power to fix free atmospheric nitrogen. From the time of Hellriegel's discovery down to the present day there has been much experimental work done looking toward the utilization of legumes as a means of furnishing a supply of combined nitrogen sufficient to meet the requirements of crops in general farm practice.

After the fact was thoroughly established that legumes do have the power to fix free atmospheric nitrogen, there have been efforts made to determine the approximate amount fixed by these plants. The amount of nitrogen fixed is influenced by different soil conditions and other factors. It is apparent that when legumes properly inoculated are grown in a soil rich in available nitrogen they will utilize the supply in the soil rather than make use of the free atmospheric nitrogen. On the other hand, if legumes properly inoculated are grown in a sandy soil or other soil low in nitrogen they will at once fix comparatively large amounts of free nitrogen in order to make proper growth.

Some experimental work conducted by the late Dr. Hopkins(Ill. Bul. 76) shows a comparison of inoculated and uninoculated alfalfa when grown on common corn belt prairie land. The results of this test show that the alfalfa when properly inoculated fixed about 40 lbs. more nitrogen per acre than did the uninoculated alfalfa. The amount of nitrogen fixed as indicated by this experiment might vary with different soil conditions; however, this test serves to show the possibilities of the utilization of free atmospheric nitrogen by legumes under field conditions.

There are many legume plants which adapt themselves to general farm practice, and some of these are particu-

larly desirable for furnishing on a large scale a part at least of the available nitrogen needed in producing farm crops. One of the most outstanding of these legumes at the present time is sweet clover (Mellilotus Alba). There are many interesting and valuable facts regarding the influence of sweet clover as a soil enriching crop under the various soil and climatic conditions found in Illinois. In 1905 the Illinois Experiment Station began the use of sweet clover for soil improvement on the Odin Experiment Field (Marion county). The object of this experiment as stated in the field records was "to test the value of sweet clover as a leguminous green manure crop." Starting with this test the Experiment Station has made practical use of sweet clover for soil improvement purposes in many parts of the state. Sweet clover has been very successful under field conditions as a means of securing available nitrogen for the production of general farm crops.

Some very valuable facts have been brought out by the Illinois Experiment Station regarding the available nitrogen created in the soil when sweet clover is plowed under as a green manure crop. (Ill. Bul. 233.) The following table gives some results obtained on the Minonk Experiment Field (Woodford county) during the season of 1919. The land on this field is typical of the common prairie corn belt soil. In this test a spring growth of sweet clover was plowed under late in April and the land planted to corn. The figures represent pounds per acre of available nitrogen found in the surface soil at various dates on treated and untreated land.

Soil treatment	April 26	May 30	July 1	Aug. 12
Sweet clover turned under.....	38.7	76.8	67.2	143.6
No soil treatment.....	10.1	8.1	11.8	11.8

Limestone and rock phosphate had been applied to the land where the sweet clover was turned under. Limestone is usually essential to the successful growing of sweet clover on average corn belt land. The above results show that as compared with the untreated land the decomposition of the green sweet clover when plowed under does greatly increase the supply of available nitrogen. It requires about 1½ pounds of nitrogen to pro-

duce one bushel of corn, and on August 12 there was sufficient available nitrogen in the soil to produce about 95 bushels of corn. Comparing the untreated land with the treated land it may be seen that the sweet clover contained about 3½ to 12 times as much available nitrogen as when no sweet clover was turned under.

The farm lands in southern Illinois are very different in composition and productiveness from those in the central and northern parts of the state. On these lighter soils of the south part of the state clovers cannot be grown successfully without the judicious use of limestone. When limestone and sweet clover as a green manure are used on these lands the supply of available nitrogen is greatly increased.

The following table gives results obtained on the Newton Experiment Field (Jasper county) during the season of 1919. (Bul. 233.) The land on this field is typical of the light prairie soils of southern Illinois. The figures represent pounds per acre of available nitrogen in the surface soil at various dates.

Soil treatment	May 12	June 18	July 4	Aug. 19
Sweet clover turned under.....	18.6	36.8	30.6	78.2
No soil treatment.....	14.0	22.6	9.2	25.9

Limestone and rock phosphate were used in addition to the sweet clover. The decomposition of the sweet clover furnished available nitrogen far in excess of that on the untreated land. On August 19, the available nitrogen on the treated land was sufficient to produce 50 bushels of corn while on the untreated land there was enough for about 16 bushels of corn.

The data above cited show that legume crops when worked into the soil do increase greatly the supply of available nitrogen. This plan of soil management is practical and fits into the scheme of general farm practice, and there is no question regarding its economy when compared with the cost of commercial nitrogen as sold on the market today.

It has been demonstrated clearly that sweet clover as a green manure crop may add large amounts of available nitrogen to the soil; now it is well to look at actual crop yields and note the influence of this treatment. The

Experiment Station has followed the plan of locating soil experiment fields at various points in the state, and thru the operation of these fields by the University much reliable information is secured from year to year regarding the permanent improvement of Illinois soils. In the following tables some twelve experiment fields are considered upon which sweet clover has been used as a green manure crop during the past eight years. These fields are distributed widely so that they represent in general the predominating soil types of the state, and are located in regions of varying climatic conditions.

The following table gives corn yields obtained from three experiment fields located in northern Illinois and representing the Brown Silt Loam soil which is the predominating soil type of that region.

CORN YIELDS 8 YEAR AVERAGE (1915-22) BUSHELS PER ACRE.

Soil Treatment	Dixon	Mt. Morris	LaMoille	Average
Crop residues and limestone—sweet clover.	56.5	60.7	53.4	56.9
Crop residues only.....	49.1	49.1	50.0	49.4
Gain for lime — sweet clover	7.4	11.6	3.4	7.5

The average of these three fields gives an eight year average increase of 7.5 bushels of corn per acre for the use of the lime-sweet clover treatment. This is a very substantial increase on land which is maintaining an average corn yield of almost 50 bushels per acre.

The following table gives the corn yields obtained from three experiment fields located in the central part of the state and also representing the Brown Silt Loam soil which is the common corn belt prairie farm land.

CORN YIELDS 8 YEAR AVERAGE (1915-22) BUSHELS PER ACRE.

Soil treatment	Urbana	Carthage	Clayton	Average
Crop residues and limestone—sweet clover.	68.7	51.6	52.2	57.5
Crop residues only.....	57.5	43.2	43.3	48.0
Gain for lime — sweet clover	11.2	8.4	8.9	9.5

The average gain for the lime-sweet clover treatment on these three fields on corn belt soil is 9.5 bushels of corn per acre. This type of soil has often been referred to as inexhaustible, and yet these experiments demon-

strate that the corn yields may be increased greatly by the addition of nitrogenous organic matter and limestone.

The following table shows the corn yields obtained on three experiment fields located in southern Illinois. These fields are on a soil type known as Gray Silt Loam On Tight Clay, and this type predominates over a large area of the southern part of the state.

CORN YIELDS 8 YEAR AVERAGE (1915-22) BUSHELS PER ACRE.

Soil treatment	Ewing	Oblong	Toledo	Average
Crop residues and limestone—sweet clover.	31.7	36.8	27.7	32.0
Crop residues only.....	12.9	26.6	17.3	18.9
Gain for lime—sweet clover	18.8	10.2	10.4	13.1

The average gain for the lime-sweet clover treatment on these three fields is 13.1 bushels of corn per acre. This type of soil is much less fertile than that of the corn belt, as indicated by the corn yields, but these experiments show that the productiveness of this soil may in some cases be almost doubled by the application of the soil treatment indicated.

The following table shows the corn yields obtained from three experiment fields located in the extreme part of southern Illinois. These fields are on a type of soil known as Yellow Gray Silt Loam. This land was formerly timbered, and is the predominating type over a large area of the southern part of the state.

CORN YIELDS 8 YEAR AVERAGE (1915-22) BUSHELS PER ACRE.

Soil treatment	Raleigh	Unionville	Enfield	Average
Crop residues and limestone—sweet clover.	38.8	39.2	40.8	39.6
Crop residues only.....	20.8	22.6	29.7	24.4
Gain for lime—sweet clover	18.0	16.6	11.1	15.2

The average gain for the lime-sweet clover treatment on these three fields is 15.2 bushels of corn per acre. This is the largest increase on any of the types of soil mentioned, and indicates to what extent corn yields may be increased on these less fertile soils of southern Illinois.

The corn yields on the twelve experiment fields named show an increase of 11.3 bushels per acre as an average of the past eight years. It would seem from the distri-

bution of these fields that this figure is fairly representative of what might be accomplished under average farm conditions throughout the state. As an average of the past eight years the state has grown annually approximately 9,500,000 acres of corn, and on the basis of the 11.3 bushel increase this would add over 107,350,000 bushels of corn to the total annual production of the state. This increase would amount to almost 1/3 of the present annual corn production of the state, and would add much to the agricultural wealth of Illinois for the corn crop alone. The experimental evidence obtained shows that not only is the corn yield increased by the addition of legume nitrogen, but the yields of wheat, oats, clovers and other crops have been increased materially by the lime-sweet clover treatment.

These experimental results show that our agricultural production may be increased greatly by the proper utilization of the common legume crops which may be grown successfully on every Illinois farm. This also indicates that science has made much advancement toward the solution of practical soil problems.