Soil Survey Circular No. 1: Nitrogen From the Air

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NITROGEN FROM THE AIR
By J. G. HUTTON
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SUMMARY
1. Nitrogen is necessary for the growth of crops.
2. Nitrogen is disappearing from cultivated soils.
3. Maintain the nitrogen supply by growing legume crops.
   a. See to it that the soil is not sour.
   b. Inoculate the seed.
4. Don’t burn stalks or straw, because
   a. A ton of wheat straw contains $4 worth of nitrogen.
   b. A ton of oats straw contains $4.80 worth of nitrogen.

WHAT CROPS ARE MADE OF
There are 10 chemical elements absolutely necessary for the growth of plants. These are: Carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, sulphur, calcium, iron and magnesium. The first three, carbon, hydrogen, and oxygen, are secured by the plant from the atmosphere and from the water which it absorbs through its roots. The other seven elements of plant food are taken from the soil. It is our purpose to discuss here the element nitrogen only.

NITROGEN
Nitrogen constitutes about four-fifths of the atmosphere, but the ordinary plant is unable to use a single atom of this element from the air. Before it can be used by the ordinary plant, the nitrogen must be combined with other elements and be stored in the soil. In these compounds it is absorbed by the plant roots and goes to help build the plant-body and produce the seed. The larger portion of the nitrogen in the soil is contained in the dark surface layer. The dark color of the surface soil is due to the presence of organic matter. The organic matter has accumulated in the soil by the partial decomposition of plant roots,
stems and leaves. It has been more or less mixed with the surface layer by the action of burrowing insects, worms, and higher animals. The further decomposition of this organic matter sets free the nitrogen which it contains so that it may be absorbed by the plant roots.

DECREASE IN AMOUNT OF NITROGEN IN A CULTIVATED SOIL

It requires about a pound of nitrogen to produce a bushel of oats and the straw. One and one-half pounds of nitrogen is required to produce a bushel of corn and the stalks, and two pounds of nitrogen to produce a bushel of wheat and the straw. The removal of these grain crops from the soil necessarily decreases the supply of soil nitrogen when the supply of nitrogen is reduced to such a point that the plant is unable to secure an adequate supply, the crop yield is limited by this element. Heavy cropping of soils for many years reduces the nitrogen supply and it is necessary to restore it if profitable crops are to be produced.

NITROGEN CONTENT OF CROPS

<table>
<thead>
<tr>
<th>Crop</th>
<th>Amount</th>
<th>Approximate amount of nitrogen contained</th>
<th>Source of nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>100</td>
<td>77</td>
<td>Soil</td>
</tr>
<tr>
<td>Corn</td>
<td>100</td>
<td>100</td>
<td>Soil</td>
</tr>
<tr>
<td>Oats</td>
<td>100</td>
<td>66</td>
<td>Soil</td>
</tr>
<tr>
<td>Potatoes</td>
<td>100</td>
<td>21</td>
<td>Soil</td>
</tr>
<tr>
<td>Rye</td>
<td>100</td>
<td>90</td>
<td>Soil</td>
</tr>
<tr>
<td>Wheat</td>
<td>100</td>
<td>142</td>
<td>Soil</td>
</tr>
<tr>
<td>Barley Straw</td>
<td>1</td>
<td>12</td>
<td>Soil</td>
</tr>
<tr>
<td>Corn Fodder</td>
<td>1</td>
<td>16</td>
<td>Soil</td>
</tr>
<tr>
<td>Oats Straw</td>
<td>1</td>
<td>12</td>
<td>Soil</td>
</tr>
<tr>
<td>Rye Straw</td>
<td>1</td>
<td>8</td>
<td>Soil</td>
</tr>
<tr>
<td>Wheat Straw</td>
<td>1</td>
<td>10</td>
<td>Soil</td>
</tr>
<tr>
<td>Timothy Hay</td>
<td>1</td>
<td>24</td>
<td>Soil</td>
</tr>
<tr>
<td>Alfalfa Hay</td>
<td>1</td>
<td>50</td>
<td>Air</td>
</tr>
<tr>
<td>Red Clover Hay</td>
<td>1</td>
<td>40</td>
<td>Air</td>
</tr>
<tr>
<td>Sweet Clover Hay</td>
<td>1</td>
<td>40 to 50</td>
<td>Air</td>
</tr>
</tbody>
</table>

“COMMERCIAL” NITROGEN

Nitrogen may be bought in the form of nitrate of soda, sulphate of ammonia, calcium cyanamid and in various organic substances such as dried blood and fish scrap. However, the cost of this element in the form of these commercial fertilizers is too great to enable them to be used in maintaining the nitrogen supply for farm crops. Nitrogen, at present prices, in the cheapest form available would cost on the farms of South Dakota not far from 40 cents a pound. This would mean a cash outlay of from 40 cents to 80 cents for every bushel of grain produced, provided, of course, that the grain and the straw and stalks are removed from the soil, as is most frequently the case in South Dakota. How, then, shall the nitrogen supply be maintained?
THE VALUE OF LEGUME CROPS

The legume family of plants includes such common crops as peas, beans, clover, sweet clover and alfalfa. These crops have the peculiar property of being able to use nitrogen from the atmosphere and to store it up in their bodies and in their seed. By growing such crops, nitrogen may be made ready for the use of other crops not having the power of using the atmospheric nitrogen and no money need be expended for freight or profit.

HOW THE LEGUME CROPS TAKE THE NITROGEN FROM THE AIR

If the roots of a healthy legume plant are examined there will be found certain little nodules varying in size and shape depending upon the kind of plant which is examined. The nodules are due to the action of certain bacteria which have entered the plant roots and have caused a peculiar kind of growth in the tissues of the plant. These bacteria are in some way capable of taking the nitrogen from the atmosphere and combining it with other elements so that the legume crops are able to grow in a soil which is absolutely barren of the element nitrogen. When the legumes are plowed under the nitrogen, of course, goes with them and is mixed with the soil. When the plants decompose, the nitrogen may be used by non-leguminous crops. Careful investigations show that one ton of clover hay contains about 40 pounds of nitrogen taken from the air. A ton of alfalfa hay contains about 50 pounds of nitrogen taken from the air. It may be seen that a ton of clover or alfalfa hay is worth $16 to $20 for the nitrogen alone. It is also evident that it does not cost this much to produce a ton of hay. If the legume crop is plowed under all of the nitrogen which it contains will of course, be added to the soil.

In South Dakota it is usually desirable to feed the legume crops to stock and to return the manure to the field. From 50 to 75 per cent of the nitrogen contained in the feed may be recovered in the manure and spread upon the fields, depending, of course, upon the care which is given the manure after it is produced. Knowing the amount of nitrogen contained in a bushel of the various grains produced, it is a matter of simple arithmetic to compute the total amount removed from the soil by any given crop. See table on another page. The practical farmer may at the close of the year determine approximately how much nitrogen has been removed from his soil. If the straw and stalks are returned the amount removed may be reduced by about one-third. If all of the grain, straw and stalks are fed to animals, the total amount may be reduced by 50 per cent or more. On dividing this final amount by the number of pounds of nitrogen contained in a ton of a given legume hay it is easy to determine how many tons of hay must be grown on the farm in order to restore the nitrogen supply. If the hay is fed before it is turned under, the amount should be nearly or quite doubled. It should also be borne in mind that the roots of the legume plants add no nitrogen to the soil, as the legume crop growing on the average soil does not secure all of its nitrogen from the air, but approximately only an amount equivalent to that which is contained in the hay.

INOCULATION OF LEGUME CROPS

In order that legume crops may secure the nitrogen from the air, it is absolutely necessary that the bacteria be present. These bacteria are not usually present in soils which have not grown legume crops. Consequently, in seeding down land new to legume crops such as clover, alfalfa or sweet clover, the bacteria must be supplied from some source. It is easy in some instances to secure soil from some field which has been growing the kind of legume crop which is to be seeded, scatter it over the field and harrow it in without allowing the sunshine to fall upon it. The seed when sown in the soil will become inoculated.
There are on the market at the present time, artificial preparations of legume bacteria which may be secured for a relatively small price. These are handled by the various seed and nursery companies of South Dakota and other states. Directions for applying to the seed are always furnished with these preparations and are easily followed. The Bureau of Plant Industry, United States Department of Agriculture, Washington, D. C., also furnishes a sufficient amount of inoculating material to inoculate one bushel of seed. A card for applying for this inoculating material may be secured directly from the Bureau of Plant Industry, Washington, D. C., or from the Agronomy Department, Brookings, South Dakota. The Agronomy Department of the South Dakota Experiment Station does not supply inoculating material because no appropriations have ever been made for carrying on this work.

When sowing clover, alfalfa, or sweet clover upon soil that has not grown the crop, it is only a matter of good business to inoculate the seed. This is especially true when the seed is marketed at such a high price as now prevails.

**ACID SOILS UNFAVORABLE TO GROWTH OF LEGUMES**

All good soils normally contain considerable quantities of calcium carbonate, commonly called limestone. Where the limestone has been leached away or never existed the soil becomes sour. Most legume plants themselves and the bacteria which grow on their roots are very sensitive to acid soils. For this reason soils on which alfalfa, red clover, and sweet clover are sown should be tested to determine whether or not they are acid. Samples may be sent to the Agronomy Department, soil survey, for testing. A number of acid soils have been received at the soil survey laboratory, but owing to the fact that they are widely scattered it is impossible at this time to outline the areas where acid soils may be expected to occur. It usually happens however that the sandier soils are more frequently acid than those of heavier texture.

Circular No. 2 of the South Dakota Soil Survey, soon to be issued, discusses in detail the question of soil acidity, the methods of testing for it and the manner in which the acidity may be corrected.

**QUESTION OF PERMANENT SOIL FERTILITY**

Nitrogen is the only element of plant food the supply of which may be increased by any system of farming where no feed is bought from adjoining farms. The nitrogen supply can be maintained only by growing a sufficient acreage of legumes and by plowing them under directly or by feeding them and plowing under the manure. Owing to the fact that nitrogen is the most expensive element of plant food to buy, Nature has been especially kind to the manager of land by making it possible for him to secure this element from the atmosphere through the growth of legumes without paying any freight to transportation companies or profit to manufacturers or distributors of fertilizers.

Phosphorus is the element of plant food which is scarcest in most soils. The supply of this element, however, cannot be maintained by the growth of any kind of crop or by any system of farming, which does not employ the purchase of phosphorus in some form. This question will be discussed in later circulars.

**THE PURPOSE OF THE SOIL SURVEY**

It is only through an intimate and accurate knowledge of soil facts that the fertility of South Dakota soils may be maintained and that the food supply of the state and nation may be assured. Permanent and profitable agriculture is based upon permanent soil fertility. The purpose of the soil survey is to find out the facts about South Dakota soils and to place them in the hands of farmers for their benefit. Farmers are urged to avail themselves of the services of their soil survey.