Nodules and Leguminous Crops.

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The nineteenth century has been styled an age of progress. If we accept this statement what name shall we apply to the twentieth? It is true that great advances have been made in every line during this century, but we are simply laying the foundations for a broader and more rapid development in the next. That progress in all lines of industry has not gone on at a uniform rate is evident to all. One industry that seems to us to be lagging behind is the great and fundamental industry — farming. We do not mean to say that farming has not been raised and developed by the general rise of all industries, nor that progress has not been made in agriculture, but we do mean to say that agriculture, on the whole, has not developed so rapidly as other industries.

At the beginning of the twentieth century the outlook is very promising. Not only are agriculturists becoming better educated, more interested, and more alive to matters relating to agriculture, but men of science, at all times leaders in

progress, are making a special study of economic agriculture. They are thus augmenting the knowledge of the farmer and supplementing his efforts to reach better things.

There are many reasons ascribed for the lack of progress in agriculture. Not the least of these is ignorance of the chemistry of the soil and the conditions of plant growth. Farmers are beginning to understand that no soil, however rich, can produce crops year after year without loss of fertility, unless something be returned to replace the elements taken away by the crops. Chemists have found that there are about eleven elements necessary to plant growth and that all normal soils there is found a sufficient of all these except three. — The three elements usually occuring in insufficient quantities are potassium, phosphorus, and nitrogen.

Of the first two, potassium and phosphorus, it may be said, that when they become deficient, the only to return them to the soil is in the form of a fertilizer. But nitrogen may be returned in a much easier and more economical manner as we

shall presently describe.

In all soils there is a greater or less amount of these three important elements depending on the nature of their deposit and succeeding treatment. This fertility of the soil is spoken of as natural fertility. In general soils which have never been cropped possess a maximum natural fertility and those which have been cropped for years without application of fertilizers are likely to show a minimum fertility. It is this natural fertility which should be carefully husbanded. Once gone, at least two of the elements, potassium and phosphorus, can only be replaced at a considerable expenditure of time and money.

Natural fertility may be maintained by judicious cropping. If the farmer has no fertilizer to apply to his fields their fertility may be maintained by the rotation of crops. Different crops use different elements and in different proportions, and in proper rotation the land may recuperate, not being subjected to a continuous strain in the same line. To illustrate, let us take the ordinary rotation

practiced by Kansas farmers, corn, oats, wheat. We find that, though all use the same elements in general, still the soil will maintain its fertility much longer under such a rotation than it will under continuous planting with any one of these crops.

The rotation is much more beneficial if it includes plants of different character and drawing different elements from the soil. By some such systematic rotation natural fertility may be kept up for an indefinite time. Natural fertility can not be entirely destroyed because the soil is continually being changed by the weathering process. It may, however, be so reduced that it is no longer profitable to work without addition of fertilizers. The farmer would gain then not only by a study of the best rotations but also by study of the best treatment of his ground in order to secure the best results through the wearing down of the soil by weather.

Soils are at all times subject to agencies which tend to diminish the natural

fertility. Here in Kansas perhaps the most wide spread and serious loss is through the agency of the wind. The wind carries off both good and poor soil in direct ratio to their looseness and weight. But water is the agent which soonest robs the soil of its most precious qualities. No plant can utilize any substance contained in the soil unless it be soluble in the soil water or becomes soluble through chemical agencies when in contact with the roots. The ability of a plant to take up any material, depends, up to a certain limit, upon that material's solubility. Now the compounds of phosphorus and potassium found in the soil are not, as a rule, too easily soluble in water. The compounds of nitrogen, on the other hand, are extremely soluble and therefore, when the soil is subject to active leaching, the nitrogenous plant food is soonest exhausted.

The most active agent in the destruction of plant food is the crop itself. If any one doubts this let him calculate for instance, the amount of albuminoids that are removed

from a field which produces annually twenty five bushels of corn per acre. This yield is within the average production of the state of Kansas. According to a table prepared after an examination of a large number of varieties of corn, grown under many conditions, and in many many soils, there is, on an average, about 10.56% of albumnoids in corn. At this rate twenty five bushels of corn would contain about 147 pounds of albumnoids or 211 pounds to the ton of corn, not taking into account the stalk or cob, which, of course, would raise the total very appreciably. Now albumenoids are very rich in nitrogen, and if this amount is removed year after year the inevitable result is exhaustion of the soil.

The farmer who grows one crop exclusively or grows grain exclusively will exhaust the soil much more quickly than he who grows a variety of crops, or keeps stock and returns the elements of fertility to his soil. Diversified farming is an advantage, not only from the standpoint of safety and economy in the present, but also from its bearing on the future.

Soils that have become exhausted under special cropping, have been through skill and proper employment of diversified farming, built up to their former standard of fertility.

The question of fertilizers becomes more and more important as the natural fertility is gradually consumed. By inspection of the Experiment records of eastern states, we find that the question of fertilizers occupies most of their attention, a certain proof that natural fertility is on the wane in those states. The territory which demands the use of fertilizers is rapidly increasing. Ohio Experiment Station records show that the Buckeye state is now within the confines of the belt which will eventually include in its grasp the Sunflower state. Indeed in some places in Riley County we see marked evidences of soil exhaustion. The longer the farmer can ward off the time when becomes necessary to use fertilizers, the heavier will be his purse. Commercial fertilizers are expensive and the labor necessary for their application is always

considerable though it varies widely with the character of the material used.

There is one method of replacing the nitrogen - the one element most commonly deficient, to which we wish to direct attention in the remainder of this article. One great order of plants, known as the Leguminosæ, from the pod-encased fruit which they bear, has the desirable quality, under certain conditions, of increasing the supply of nitrogen in the soil in which they grow. Nitrogen makes up about 78% of the air we breathe, but, though so abundant, it has been conclusively proved that plants can not make use of this enormous until it is changed to other forms. Plants can not assimilate free nitrogen. They will die from nitrogen starvation when grown in an atmosphere containing 78% of this element. Nitrogen of the air does change to an available form through the action of certain organisms found in the soil, but though their action is very important we do not mean to speak of that.

It has long been known that growing of leguminous crops placed the ground in better condition for succeeding crops. That is, the farmer saw that a wheat crop following beans, was larger than a crop of the same grain, grown on equally good land, which followed oats or some other cereal. Scientific investigators in studying these legumnous plants found their roots infested with small nodules. They found, that in general, the better developed plants had the greater number of tubercules upon their roots. It was also found that when these nodules were not present or not developed the succeeding cereal crop would not be benefitted. In view of these facts, the investagators began to suspect some connection between the development of the nodules and the growth of the plant and also some relation between the nodules and the better condition of the soil for succeeding crops. Such they found to be the case.

These nodules seem to be formed by the growth of organisms. The nodule

on the root is the home of the organism and it is thought that the organism feeds on the free nitrogen of the air and that the waste matter which is thrown off becomes food for the plant. Each species of plant appears to be infested with a particular species of organism. It has been found by experiment that ground containing bacteria producing nodules on one plant will in many cases not benefit other plants closely related. The nodules of each plant are easily distinguished by their shape and manner of growth by those who have made a study of the matter. Thus on clover and alfalfa we find club-shaped nodules and on peas oval or egg-shaped ones.

Among the experimenters to whose work we are indebted for our present knowledge of this matter may be mentioned Hielriegel, Daws and Gilbert and Atwater of the Storrs Experiment Station in our own country. The first theory of the early experimenters was that leguminous plants are able to take up the free nitrogen of the air, and, indeed

the early experiments, not having been been conducted with due precision seemed to indicate this to be the case. But no one in the light of proven data would support such a theory at this time.

These organisms, which produce the nodules, seem to lie dormant in the soil, when once established, until the plant upon which they develops is placed there. They seem to be able to withstand great variations of temperature. It requires a high degree of heat to kill them when in the spore stage. These organisms when they once gain a foothold seem to be readily distributed. Thus we find nodules on the roots of alfalfa wherever planted, notwithstanding the fact that this plant is of recent introduction. The spore of the organisms must therefore be so small as to be readily scattered by the wind. The important point in regard to the nitrogenous elements is that they may thus be replaced in the soil by these little organisms without any trouble or expense to

man if they once become established.

Leguminous plants when inoculated will not only maintain the fertility of the soil if they have a place in the rotation but will actually build up the fertility. What is the practical application for the Kansas farmer? If there be any means by which he can avoid the necessity for expensive commercial fertilizers it is high time to be considering the matter and working at the solution of the problem.

In the first place let him understand, that though these minute organisms will work wonders for him, they are not all powerful. They will do their work of replacing nitrogen and do it speedily and well but the soil must also contain sufficient quantities of phosphorus and potassium. Therefore it behooves him to carefully conserve and apply the natural fertilizer incident to the keeping of domestic animals.

In the second place the Kansas farmer should bear in mind that it is infinitely easier to preserve

fertility than to restore it to a wasted soil. Kansas is blessed with a fertile soil. In general the only limiting condition to crops within her boarders is the inadequate amount and unequal distrobution of moisture. That the soil may remain thus productive its tillers should practice a systematic rotation of crops. Some member of the leguminous family should be prominant in this rotation.

Over a considerable portion of Kansas a very dry climate prevails for the greater part of the year. We must therefore, in order to make a success of our rotation secure a leguminous plant that is able to withstand long periods of drought. Such a plant can be produced. Alfalfa, the great dry weather crop, can be grown on any soil that is underlaid by an open porous sub-soil. Alfalfa, however, is not well adapted to rotation, since, when once well established it is very hard to plow on account of its large roots.

There are other plants that have

shown their ability to grow and produce a crop under unfavorable conditions. There are several members of the bean and pea family which have demonstrated this possibility. The soy bean (Glycine hispida) recently introduced from Japan appears to be especially adapted to withstand drought. These beans when dry weather prevails simply wait for more favorable weather and then go on developing as if they had received no check in growth. The ability to do this makes them a valuable crop, but unfortunately though they have been grown at the Kansas Station for several years no nodules have yet been produced. In Massachusetts, it was found that nodules were produced on these plants and the Kansas Station will no doubt be able to introduce and spread these valuable organisms from that state.

The farmer must go deeper into the question than a simple comparison of the gains to be secured from this or that crop. That is, it may be more profitable in the end, to plant beans

So far from being the most unfortunate and downtrodden of all mankind, it lies within his power to lift himself to a high intellectual and social plane, yes, and to a high financial plane also.

It is true that the scorching blighting, hot winds occasionally sweep over his lands and destroy the fruit of his toil, but by maintaining the fertility of his rich and fruitful soil, he will be able to produce, when seasons are favorable, more than enough to make up for the "off" years. He should learn that there are many questions of far more importance to him than the consideration of which political party shall rule in his county for the succeeding year. It would be far better for the farmer if there were found upon his reading table some of the standard periodicals which treat of matters related to agriculture instead of many layers of small inferior political papers as is usually the case. It would be well if the Kansas farmer could take a trip through the eastern states and see for himself the dangers

he is fast approaching at home. He would then be more keenly alive to questions of soils and crops and fertile Kansas might be spared the barren condition into which New England has long since passed.