Clover as a Fertilizer.

[An address delivered before the Farmers' Institute at Portage la Prairie in February, by Frank T. Shutt, M. A., Chemist of the Experimental Farms.]

The subject that I have been asked to address you on this afternoon is the maintenance of soil fertility by the growth of clover. It is a subject that has engaged our careful attention for some years past at Ottawa, and which for the last two years has also been investigated at the branch experimental farms, so that now we can present to you a considerable amount of reliable data, all of which go to show the great value of clover as a soil improver.

In conversation with many of your best and most observant farmers, I learn that the soils of this Province that have been successively cropped with wheat for a number of years now show a marked decrease in yield. This is only to be expected, for you have annually been taking plant food from the soil and returning none. We have pursued an irrational course of farming, neglecting—entirely losing sight of the fact that soil is not inexhaustible. It is quite true that our crops take a large proportion of their nourishment from the air, but it is just as true that they also draw upon the soil for a necessary part of their food. This food must be replaced if the soil's fertility is to be maintained.

Let us briefly review a few fundamental principles. What is the nature of a plant? It is a living thing, because it can increase in size, in weight, and reproduce its kind. As a living thing it requires food; it cannot create anything. What are the sources and nature of that food? The sources are the air and the soil. From the former the plant abstracts a gas known as carbonic acid (a product of animal life), which, by means of the green coloring matter in the presence of sunlight, is converted into starch, sugar, gum, etc., in the plant's tissues. From the latter the plant takes moisture, mineral matter (such as lime, phosphoric acid, potash), and the nitrogen necessary for its existence and growth. The food taken from the soil is absorbed through the roots as a dilute solution. The nitrogen of the soil, before it can be made of use by crops, must first be converted into compounds, known to the chemist as *nitrates*. This conversion is brought about by certain germs that live in the soil, and is known as nitrification. It is assisted by warmth and a right degree of moisture. It proceeds rapidly in summer in mellow, rich, aerated soils.

We will now revert to our argument. Science and practice have demonstrated that of all the elements of plant food abstracted by crops from the soil, there are practically three which we must return if the soil's fertility is to be maintained. Of the others, there is, generally speaking, a sufficient supply. The three I refer to are: Nitrogen, phosphoric acid, and potash. Constant cropping reduces the soil's store of these. For instance, let us illustrate the truth of this statement with the case of wheat. In twenty years a crop of wheat of 15 bushels per acre will have abstracted from the soil of that area about 650 lbs. nitrogen, 200 lbs. phosphoric acid, and 300 lbs. potash. These facts explain why fields lose their productiveness unless plant food is returned.

Now, plant food may be said to exist in the soil in two conditions: the one, inert, locked up and useless (because insoluble) to plants; the other, available, assimilable (because soluble), to plants. The latter, even in the richest soils, exists only in very small quantities, but its store is becoming constantly replenished by good culture. It is the store of available food that is more particularly reduced by growing crops. This is a very important point.

We must now consider for a few moments the two great classes of constituents that make up a fertile soil. The one is the disintegrated and semi-decomposed mineral or rock matter (which furnishes the lime, potash, phosphoric acid, etc., for our crops); the other is humus or vegetable matter (furnishing the nitrogen) resulting from the decomposition of the remains of past generations of plants. Humus is a most important and valuable ingredient of soils, as well from a mechanical as from a chemical standpoint. It is present to a large extent in all fertile soils; indeed, it characterizes such. It is the natural storehouse of nitrogen. By its further decay in the soil it liberates not only nitrogen but also the small amounts of mineral matter it contains, in forms suitable for absorption by crops. The percentage of nitrogen marks chiefly the fertility of a soil, and this percentage depends upon the amount of humus present. Moreover, as the humus disappears by continuous culture, so is the nitrogen dissipated. So that in order to have a soil rich in nitrogen we must keep up and replace humus-forming materials. Further, humus has a great retentive power for moisture, and improves a soil's tilth, making it mellow. It is highly important that for our crops the soil should be moist (to supply them with the water necessary for their growth) and that it should be mellow to allow root extension, to allow air to freely permeate it (for roots, as well as leaves, require air). Under such conditions nitrification will proceed rapidly.

To sum up this brief review, we see that continuous cropping, as for example, with wheat, reduces the soil's store of nitrogen, phosphoric acid, potash and humus. Further, it tends materially to injure the mechanical condition or tilth, which latter is a property of soils that must be closely attended to if our crops are to be well supplied with moisture and have a comfortable bed or medium in which their seeds can germinate and their roots forage for food. It will now be our business to learn how the growing of clover may improve a soil in these respects.

I have said that farm crops obtain their required nitrogen by absorption of nitrates formed from the nitrogenous organic matter (humus) of the soil. There is an exception to this rule. The exception is the legumes, a family to which clover, peas, beans and vetches belong. These are able to utilize—in a way I shall shortly tell you—the free nitrogen of the atmosphere. All other crops, cereals, field roots, potatoes, Indian corn, fruit trees, etc., must depend upon nitrates formed in the soil. If we take up carefully a plant of clover and wash the earth from its roots, we shall most probably find upon the rootlets numerous small nodules or tubercles. An examination of the contents of these nodules under the high power of a miscroscope reveals the presence of a swarm of minute bodies, known to science as bacteria, but popularly called germs. They are simply one-celled, microscopic plants. It is through the agency of these that their host plant, the clover, appropriates the free nitrogen that exists (in the air) between the particles of the soils. Without them, clover, like all other plants, would have to obtain its nitrogen from the nitrates, but since these germs are widely distributed in our soils there can be no doubt that the larger proportion of the nitrogen in the roots, stem and leaves of clover is derived from the air in the soil. Hence, the growth of clover enriches a soil in nitrogen, while other crops impoverish it in this particular. We come, then, to recognize two great classes of plants, the nitrogen-collectors, the legumes (of which clover is the most prominent member), and the nitrogen-consumers, to which all other crops belong. You will readily understand, therefore, that by plowing under a crop of clover we can materially increase the percentage of nitrogen in a soil. Subsequent decomposition of the clover in the soil serves to convert its nitrogen into forms available to other crops. Since wheat is a crop that particularly responds to an application of available nitrogen, you can realize the importance and value of this method of manuring to Manitoba and the Northwest Territories. Moreover, it is an exceedingly cheap method. We have found that a soil can be enriched with nitrogen from a crop of clover sown at the rate of 8 lbs. per acre to an extent equal to that from an application of 10 tons of barnyard manure. Chemical analysis has proved this.

In a rather vague way it has been known from the time of the ancients that a crop of clover improved rather than impoverished a soil, and in this respect differed from other farm crops, but it has only been within the past ten years that we have learnt the reason for this improvement, and the extent to which it may take place. For this knowledge we have to thank certain German scientists, who worked patiently for years before they could satisfactorily establish the fact that I have to-day brought before you, namely, that clover, through the agency of certain bacteria residing in nodules upon its roots, can appropriate and build up into its tissues free nitrogen gas, present in the air and existing as such between the particles of soil. The investigations that led up to this discovery were of the most careful, thorough and scientific character. The discovery is worth untold millions to the agricultural world, and must be considered the most useful and valuable to the farming community of those which mark the present century.

We must not lose sight of the fact that without these bacteria, clover, in common with other plants, must obtain its supply of nitrogen from nitrates in the soil. These bacteria are not necessarily present in the soil, though I have reason to believe they will be usually found in soils that have grown clover for any length of time. In the neighborhood of Ottawa, we find all fairly good soils produce clover having these nodules on their roots, showing the presence of clover bacteria in the soil. Mr. Bedford tells me that clover grown at Brandon has plenty of nodules on its roots, so there is every probability that the germs are to be found in the soils of those I am now addressing. I think it only right, however, to inform you that we have, both at Ottawa and Brandon, induced a much more luxurious growth of clover by introducing the germs in quantity. This we have done by "inoculating" the clover seed or the soil upon which it was grown with a preparation or culture containing the germs, and which is manufactured or prepared by Meister, Lucius & Bruning, of Hoechstam Main, Germany. The preparation is sold under the name of nitragin—a rather unfortunate term, as it so closely resembles our word nitrogen. It is made by growing the bacteria taken from the nodules in suitable media, and comes to us in the form of a jelly. The bottles containing it must be kept from light and heat. The contents are dissolved out with a sufficiency of lukewarm water (not above 100° Fah.) and the resulting solution (in the case of seed inoculation) poured over the clover seed. Some sand or dry loam is then mixed with the seed, to facilitate sowing, and at once sown. Soil inoculation is carried out by pouring the well-diluted contents of a bottle over, say, 300 lbs. of soil, and this scattered over the acre about to be sown, and harrowed in. A bottle of nitragin will cost about 75 cents, and is said to be sufficient for an acre. The vitality of the germs is not guaranteed for longer than six weeks after the preparation leaves the factory.

It is very doubtful to me, however, whether it is necessary for you to obtain this nitragin. By taking a few hundred pounds of surface soil that has grown clover well—and for this work it is well to select a cloudy day—and scattering it over the field to be inoculated, you will, in the majority of instances, be introducing the germs. This plan has been tried, with success, both in Europe and on this continent. It is advisable to harrow the field as soon after the inoculation as possible.

I have already said that we do not find any difficulty in getting clover to grow in any fairly good soil at Ottawa, but I should add that inoculation, using nitragin, has always given an increase of yield amounting to from 10 to 15 per cent. A detailed account of the results of our investigations in this matter for the past three years is to be found in the reports of the Chemist of the Experimental Farms. In these reports you will find fuller details and explanations concerning these germs and their work than I have been able to give you this afternoon.

For the past three or four years we have at Ottawa been in the habit of sowing eight to ten pounds of clover seed with the cereal crop of the rotation. This we find does not diminish the crop of grain and very much improves the productiveness of the soil. Cereals grown after clover have always given us an increased yield. When potatoes, corn or roots are to follow, we plow the clover under in the following spring, after there is a fair growth. The plan of sowing the clover with wheat or other grain is not, I believe, suitable in Manitoba, as in most years there will not be, in all probability, sufficient moisture to serve both crops. It will be necessary for you to grow the clover by itself, for it is a crop that makes great demands upon soil moisture, if it is to give a good stand.

Though, speaking in a general way, nature has endowed Manitoba and the Territories with soils far richer in plant food than those occurring in either the East or West Provinces of this Dominion, I am firmly of the belief that you will find the more extensive growing of clover to be of great advantage. It is always well to lock the stable while the horse is still there. It is always easier and less costly to maintain than to regain soil fertility. We know as a scientific fact, as well as from practical experience, that cropping with wheat continuously for a number of years lowers a soil's productive power, through the abstraction of available plant food and from the inevitable destruction of humus. The latter constituent we have learnt is not only a natural storehouse of nitrogen, but its gradual decay in the soil sets free mineral nutrients for our crops. It improves tilth by increasing a soil's water-holding capacity. It guards a soil against extremes of temperature. It furnishes food for the myriad of germs so necessary to fertility and whose special function is to prepare both nitrogenous and mineral food and present them in assimilable forms to our crops. Clover will add from 50 to 100 pounds of nitrogen per acre to the soil—gained from the atmosphere—and it will further enrich the soil with a large amount of humus-forming material. Let every one of you determine to try, at first, if you like, on a small area, the truth of what I have been saying regarding the value of the legumes—and especially clover—as a fertilizer. We shall be very much surprised if your older cultivated lands do not show an immediate response in increased yields of wheat. In conclusion, I would say that both Mr. Bedford and myself will always be glad to give you such further information as we have on this important subject, and to help you in any way possible.

Sowing Rape with Oats.

The praises of the rape plant are being sung louder each year, especially as a plant for fall pasture for sheep and hogs. In order to find out whether conditions were favorable to the growth of two crops in one season an experiment was begun in seeding oats with rape. Fearing the rapid growth of rape might injure the oat crop, the rape seed was sown ten days after oat seeding. Various quantities of both kinds of seed were used, but the best results were obtained from sowing six pecks of oats and one pound of rape per acre. The oats in this experiment yielded 60 bushels per acre, while the rape produced 18 tons green weight in the month of October. The strong growth of rape interfered slightly with harvesting the oat crop, and we are of the opinion that sowing rape two or three weeks after oat seeding would give excellent results. On poorer land good results are obtained when both are seeded at the same time.

The above clipping was taken from bulletin No. 45, which was issued from Iowa Agricultural College Experiment Station, and prepared by Prof. Jas. Atkinson, B. S. A., who thus reports on field experiments conducted by him last year. While Iowa conditions are somewhat different from those in Canada, still there is a lesson in Prof. Atkinson's report that is worthy of notice by our readers who would like to sow something among oats or barley (not seeded to grass or clover) that will produce fall pasture for cattle, sheep or hogs.

Re "Canada's Ideal."

LUTHER FOSTER, Agricultural Experiment Station, Lagan, Utah.—"Certainly a very handsome picture, and your company deserves great credit for its effort. The animals are truly ideals and will give anyone who looks at the picture a better idea of form and figure than he would ordinarily obtain in this country."