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LIMING IOWA SOILS

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LIMING IOWA SOILS

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Iowa soils are by no means generally deficient in lime, yet there is a large interest in Iowa in the question of liming. The Iowa Agricultural Experiment Station is receiving a great many inquiries about the subject and farmers are quite generally anxious to know whether or not they may apply lime to their lands with profit.

That is so partly because the practice is being urged for the small areas of slightly acid soils that are found here and there in the state and partly because of the extensive work in other states to restore fertility to soils that are seriously short of lime.

It is not hard to find out whether a particular soil needs liming.

In the first place, any farmer who wants to know the condition of his land may send a sample of its soil to the soils laboratories of the Iowa Agricultural Experiment station and have it examined free of charge. The station experts will not only tell him whether he ought to apply lime or not, but also answer other questions regarding fertilizing, cropping, etc.

But acid soils bear certain outward signs which the farmer may easily read and determine for himself whether or not his soil needs liming. For example, if crops of timothy or clover fail to grow properly and red top and sorrel make their appearance, the soil is usually in need of lime. Furthermore, the presence of moss or the growth of bluets, horse tails, and similar weeds, is evidence of a scarcity of lime in the soil.

There is a still more definite test for soil acidity which may be made on the farms—the litmus paper test, based on the power of acids to turn blue litmus paper red. If the blue litmus paper turns red when it is used to test the soil by this method, then the soil is acid. To make the test, secure a small sample of soil free from roots and grass and put it in some clear glass receptacle like a water glass. Insert two strips of blue litmus paper in the soil so that they are half covered. Then add pure water very carefully until the soil is thoroughly saturated. After the test has stood for several minutes the paper is removed and rinsed thoroughly. If the portion of it which was in contact with the soil has become red then the soil is acid and would be benefited by liming. The litmus paper may be bought at almost any drug store.

THE SITUATION IN IOWA.

But whatever may be found to be the facts as to individual farms here and there in Iowa, the soils of Iowa in general are by no means comparable with those of the eastern states or even with those of southern Illinois where large areas are strongly acid and applications of lime are absolutely necessary for the growth of profitable crops. It is extremely unlikely that Iowa soils will ever reach a similar state of infertility, but of course, proper methods of farming must be practiced to prevent such a catastrophe.

Most Iowa soils contain moderately large amounts of lime, the loess soils showing greater quantities than the drift soils, but there is great variation in soils of the same origin and type, and in many sections, particularly in the drift areas, the lime content is probably becoming rather low. As will be pointed out later, there is a constant removal

of lime from all cultivated soils, and consequently even although the normal lime content may be rather large, there is great danger of soils becoming deficient in lime, more or less rapidly, depending on various conditions.

Thus, while the question of liming in this state has not the importance attached to it that it has in many other states, there is evidence that more attention should be given to maintaining a proper reaction in the soil. Even although medium yields are being obtained, applications of lime may increase crop production and also lessen the rapidity of the loss of fertility.

It must not be understood from these statements, however, that lime alone will keep a soil fertile. Such is far from being the case. The rotation of crops, the application of barnyard manure or of green manure, the growth of legumes, proper methods of treatment, etc., should all be practiced and when that is done, applications of lime will play an important part in maintaining the soil in a fertile state.

THE BENEFICIAL EFFECTS OF LIMING.

The use of lime in agriculture is an exceedingly old practice and was prevalent many years before the cause of its beneficial action was even dreamed of. The investigations of the early agricultural chemists and physicists, and more recently of the soil bacteriologists, have shown that the action of lime on soils may be three-fold in nature.

CHEMICAL.

In the first place, lime may bring about or alter certain chemical reactions in the soil. Perhaps its main chemical value lies in its neutralizing action. Various organic substances are produced in the growth of plants and in the decay of plant remains and if they accumulate to any extent, they exert a decidedly depressing effect on crop production. Lime neutralizes these various substances and thus improves the "sour" condition of the soil. Lime also acts chemically as an indirect potassic or phosphatic fertilizer. By reacting with insoluble, unavailable compounds of potassium or phosphorous, assimilable compounds are produced in a state ready for plant food; thus complex silicates may be changed into soluble potassium carbonate, or unavailable iron, or aluminum phosphate may be changed into assimilable calcium phosphate.

PHYSICAL.

The physical effects of liming are quite diverse, depending on the character of the soil involved. On heavy, clayey soils, lime causes a flocculation of the fine particles and thereby materially improves the tilth, increasing the aeration and facilitating the circulation of water. On light, sandy soils, on the other hand, the addition of lime reduces its porosity, makes it more compact and consequently more retentive of moisture and subject to less intense oxidative processes which cause a depletion in organic matter. In both cases these changes lead to increased bacterial activities with consequently greater plant food production and subsequently to greater yields.

BACTERIOLOGICAL.

Bacteria are the active agents which bring about the transformation of insoluble compounds in the soil into soluble, assimilable, forms. Various groups of organisms are involved in the different processes. In the first place, and of perhaps the greatest importance in most soils, there occurs the transformation of complex animal and

plant remains into nitrates. The process of ammonification which constitutes the first stage in this simplification leads, as the term indicates, to the production of ammonia. Ammonia never accumulates in the soil to any extent but is transformed into nitrates by the nitrifying bacteria almost as rapidly as it is produced, the process being known as nitrification. The action of lime in increasing the extent, both of ammonification and of nitrification, is well proven. In the case of the latter process, the presence of lime is absolutely essential for its continuance.

Increased bacterial activities in the soil lead to the production of greater amounts of carbon dioxide, and this passing into solution in the soil water attacks the insoluble potassium and phosphorus compounds in the soil and renders them soluble. Thus, by encouraging various bacterial activities, lime may increase materially the supply, not only of nitrates, but also of available potassium and phosphorus in the soil.

There are other important groups of soil bacteria which are materially affected by the reaction of the soil. The organisms which utilize the nitrogen of the atmosphere, fixing it in the soil, and which are known as azotobacter, refuse to grow in acid soils and the addition of lime may lead to a large increase in the nitrogen content of the soils.

The bacteria which live in the nodules on the roots of legumes and by whose aid these plants are able to take the nitrogen from the atmosphere and utilize it in building up their tissues are rendered weak and useless by the absence of lime and the well-known beneficial effects of lime on leguminous crops are therefore not due entirely to the improved chemical and physical condition of the soil but also to the effect on the bacteria which bring about the inoculation of the plants.

It is evident from the facts just discussed that the presence of lime is essential for the best possible crop production in so far as it makes the soil more favorable chemically, physically and bacteriologically for the growth of plants.

LIME AND CROP PRODUCTION.

As has been stated, most Iowa soils contain moderately large amounts of lime, in many cases enough to keep them in a fertile condition. But if in some instances the lime content has decreased below a certain per cent, then the crop producing power of such soils will be low and the yields will be smaller than they should be. Of course, different crops are differently affected by the absence of lime; alfalfa, clover and other legumes are the most sensitive to such a deficiency, while potatoes, rye, oats and barley continue to give profitable yields when very little lime is present.

LOSSES OF LIME FROM THE SOIL.

There are two factors which bring about a depletion of the lime content of soils. In the first place, the removal of crops carries away quite large amounts of it; one ton of alfalfa hay, for example, will remove about fifty pounds of lime, and since a good stand of alfalfa may be maintained six to seven years and will average four to six tons per acre per year, the depletion of the lime in a soil by an alfalfa crop is very great. A large supply of lime in the soil will evidently be necessary to obtain a satisfactory yield of alfalfa. Other crops do not remove nearly as large amounts of lime as does alfalfa, but the losses, nevertheless, are quite appreciable and even although certain agencies are at work restoring small amounts to the soil, it is evident that the continuous cropping of a soil would eventually remove all the lime present.

The removal of lime by drainage water is very much greater and of more importance than the removal by plants. Soluble calcium bicarbonate is produced through the action of carbon dioxide on calcium carbonate and this bicarbonate may be leached out of the soil. The loss of lime by this means has been estimated as equivalent to 100 to 1,000 pounds of carbonate of lime per acre annually.

In ordinary farm practice, therefore, considerable lime is removed by these two means just discussed, and unless the soil is naturally very rich in lime, applications of it in some form will be necessary together with the usual treatment and fertilization in order to keep the crop producing power of the soil at the highest point possible.

THE CLASSES OF LIME.

Two classes of lime, quite different in character, may be employed for soil improvement. There are first the natural forms such as limestone, marl, shells, marble, etc.; and second, caustic lime, which may be used freshly burned, or in the hydrated form as slaked lime or as air-slaked lime.

THE KIND OF LIME TO USE.

The use of caustic lime has been very generally recommended because of the fact that more lime (CaO) is obtainable from a certain weight of caustic lime than can be obtained from the same weight of limestone (CaCO₃). In fact, if the materials were chemically pure, one hundred pounds of CaO, would be equivalent to only fifty-six pounds of quicklime. The advantage, therefore, of this latter material is dependent largely on the difference in bulk, with the consequently cheaper freight rates per pound of actual lime. When the material must be transported for long distances, the difference here may be quite considerable. It is possible that under particular conditions it would be cheaper for the farmer to purchase quicklime than to buy the cheaper, more bulky limestone and pay the freight charges.

In general, however, in this state there is no question but that ground limestone or fine limestone screenings are more easily and more cheaply obtainable. Furthermore, there are certain objections to the use of caustic lime which have been pointed out from time to time. Although it is acknowledged that in most cases crop yields are increased more quickly by the use of caustic lime than by limestone, the action of the former is mainly as a soil stimulant and the soil may be left in a poorer condition than before the treatment. There occurs a too rapid destruction of the organic matter with a consequent over-production of available plant food and a loss of valuable humus and other constituents is occasioned. On soils very rich in organic matter, such as swampy or peaty soils, the use of hydrated lime in their reclamation would probably be advisable, but under ordinary soil conditions ground limestone will yield just as satisfactory results and there is absolutely no danger of adding too much and thus injuring the crop and causing a serious depletion in the organic matter. In the case of legumes it has been shown by many experiments that, if it is easily obtainable, ground limestone is better and cheaper than caustic lime.

In general, therefore, it may be said that ground limestone or fine limestone screenings, seems the logical material to be used by Iowa farmers for remedying acid conditions in their soils.

It has usually been believed that when ground limestone is applied to a soil, the finer the state of division of the particles the better will be the results, but of late the idea has become prevalent that limestone may be in too fine a state of division and there may be too rapid a loss

of the material. The statement has been made that a ground limestone or screenings composed partly of powder and partly of coarse particles will give better results and persist longer in the soil than a material composed entirely of fine particles. In general it may be said that limestone should consist of at least 60 to 70 per cent powder to be of the most value.

There are both magnesian and non-magnesian limestones in Iowa. That is, there are those which consist mainly of magnesium carbonate ($MgCO_3$) and those which contain mostly calcium carbonate ($CaCO_3$). These two carbonates act very similarly in the soil and while it has been claimed that one may be more beneficial on certain soils than the other, no definite statement can be made for particular soil conditions in Iowa.

We believe that the ease of obtaining the limestone and its cost should govern in its choice rather than the content of lime or magnesia in it.

THE METHOD OF APPLYING LIMESTONE.

The application of limestone to a soil should be made after plowing and it should then be thoroughly disced or harrowed in. It is not advisable to apply before plowing, as lime tends to move downward in the soil, and the full benefits from the application may not be obtained if the material is not thoroughly incorporated with the surface soil.

The uniform distribution of the limestone may be accomplished by the use of a regular lime spreader such as is now being made by manufacturers of grain drills. Sometimes it is applied by means of a manure spreader, but with little satisfaction, and often it is spread by hand with a shovel either from the wagon or from piles of the limestone placed at equal intervals over the field.

The amount of ground limestone which should be applied to a soil will depend, of course, on the acidity and general character of the soil, and also on the crop which is to be grown. For grain and grass crops, an application of 2,000 to 3,000 pounds of lime per acre every fourth season would probably be sufficient, while where alfalfa, clover, and other legumes are to be grown, 3,000 to 4,000 pounds per acre should be used once in the rotation. Of course, there will be exceptions to this rule and soils which show a distinctly acid reaction by the litmus test should receive applications of 4,000 to 6,000 pounds or even larger quantities per acre.

WHERE LIMESTONE MAY BE OBTAINED.

There are several firms in Iowa which are prepared to furnish limestone for agricultural purposes, and among them may be noted the following:

McManus & Tucker, Keokuk, Iowa: Will furnish a material composed of fine particles down to dust and consisting of sixty (60) per cent dust, at 50 cents per ton, F. O. B. their quarry.

The Ellsworth Stone Company, Iowa Falls, Iowa: Offer screenings consisting of sixty (60) per cent dust at \$5 per carload of thirty tons, F. O. B. their quarry.

The Peru Stone & Cement Company, East Peru, Iowa: Offer material similar to above, free of charge for carload lots, *during 1913*. If less than carload lots are purchased, they charge 20 cents per cwt. to cover the cost of bagging, etc.

Dolese Bros. Co., at 1310 Otis Building, Chicago, Illinois, with quarries at Buffalo, Iowa: Offer a limestone consisting of 92.68 per cent CaCo₃ and in a fine state of division, at 25 cents per ton, F. O. B. cars, their quarry, Buffalo, Iowa.

The Fort Dodge Portland Cement Corporation, Gilmore City, Iowa: Offer a very fine, pure limestone at 50 cents per ton, F. O. B. their quarry.

The Burlington Quarry Co., 19 S. 7th St., Keokuk, Iowa, with quarries at Montrose, Iowa: Prepared to furnish a limestone at 25 cents per ton, F. O. B. their quarry.

J. A. Green & Sons, Stone City, Iowa: Will furnish a material consisting of sixty to seventy-five (60-75) per cent dust, at 50 cents per ton, F. O. B. their quarry.

H. Dearborn's Sons, Stone City, Iowa: Offer limestone composed of fifty (50) per cent dust at 15 cents per ton, F. O. B. their quarry.

F. Erickson & Company, Stone City, Iowa: Will furnish a material containing twenty-five (25) per cent dust at 25 cents per ton, F. O. B. their quarry.

The Linwood Quarries Co., Davenport, Iowa: Offer limestone screenings from the size of a pea down to dust at 25 cents per ton, F. O. B. their quarry.

Bartlett & McFarland, Waterloo, Iowa: Will furnish a limestone at 50 cents per ton, F. O. B. their quarry.

B. N. Arquitt & Sons, Farley, Iowa: Will supply a material at 80 cents per ton.

Charles Chilton, Ottumwa, Iowa: Will furnish material at 75 cents per ton.

John Boland, Bettendorf, Iowa: Will furnish limestone at \$1.15 per ton, F. O. B. their quarry.

John Rowen, Stone City, Iowa: Will supply material ranging from fine dust to one-eighth inch in size at 25 cents per ton, F. O. B. quarry.

There may be other concerns in the state which are prepared to supply the demand for agricultural lime in their immediate locality, but the above constitutes the complete list of those who replied to a circular letter which was sent out from the Iowa Agricultural Experiment Station, to ascertain the sources from which limestone suitable for application to the soil might be obtained.