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Drilling Limestone for Legumes

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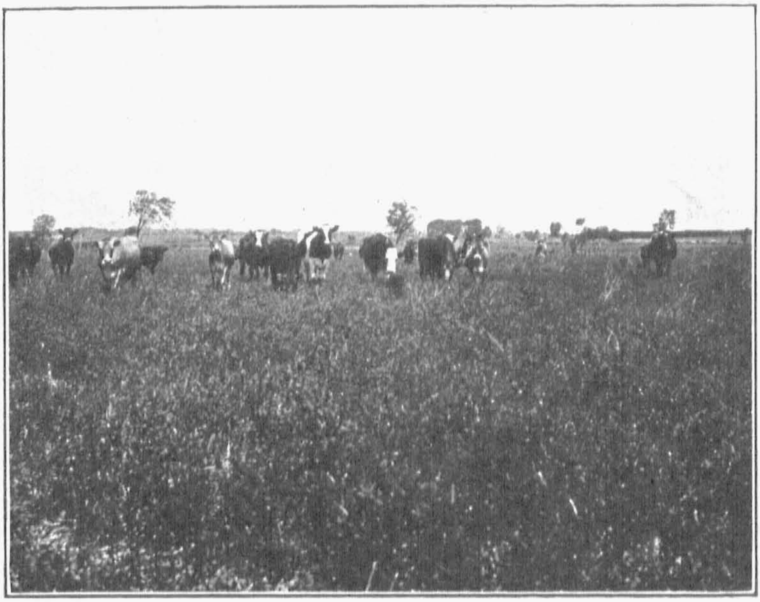

Sweet clover started by drilling limestone made the difference between an annual profit and a loss in this dairy.

COLUMBIA, MISSOURI

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Drilling Limestone for Legumes

Wm. A. Albrecht

The importance of limestone as a soil treatment, especially for legumes, has come to be widely appreciated, but its use has not become the general practice it deserves. Using limestone as the heavier applications of two or more tons per acre much in advance of the seeding has sometimes represented excessive cash outlay, prohibitive labor, and impossible schedule. Some of these handicaps to the wider adoption of the practice of liming the soil regularly may be overcome by drilling smaller amounts of agricultural limestone much in the same manner as fertilizers are applied with the fertilizer attachment to the grain drill.

EXPERIMENTAL STUDIES GIVE THE BASIS FOR DRILLING LIMESTONE

According to the common conception of the function of limestone, it is applied to the soil as a means of removing, or correcting, soil acidity. Experimental studies at the Missouri Experiment Station, however, have shown that limestone, or calcium carbonate, renders two services. One of these is the removal of the soil acidity This is accomplished by the carbonate part. The other is that of supplying calcium as a nutrient to the plants. In the past, emphasis on the removal of acidity has so completely overshadowed the importance of supplying the much-needed calcium for plants, that this latter function of lime has not been fully appreciated. Experiments have shown, however, that in terms of better plant growth, the application of calcium to the soil is more important than the removal of acidity. Compounds of calcium other than its carbonate (Figure 1), which do not remove soil acidity, will serve in place of limestone. Conversely, however, carbonate compounds that will remove the acidity but do not contain calcium do not have significant influence on plant growth. Since limestone is the cheapest source of both the calcium as a nutrient and the carbonate as the remover of acidity, such other compounds have not been substituted for it and these facts were not observed in practice. Thus, in using calcium carbonate to remove the soil acidity, the calcium needs of the plant have nevertheless been met without our ascribing to the limestone application this particular and important function.

Studies on calcium as an important nutrient for legumes have shown that the amount of this element required by these plants is large in comparison with the needs of non-legume plants. For 25 bushels of the non-legume crop wheat and a ton of

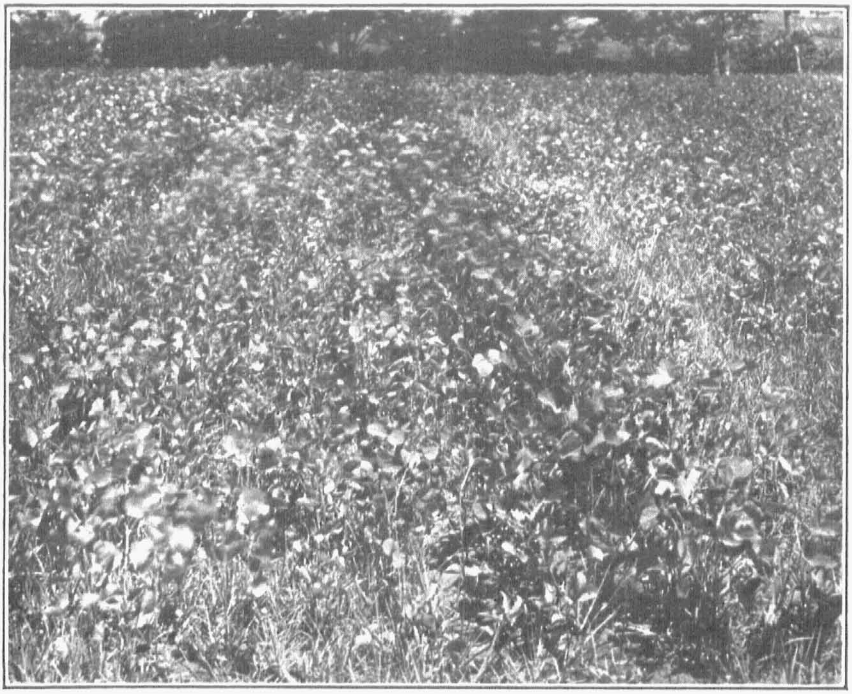

Fig. 1.—The effects on soybeans from drilling calcium chloride in the right hand sections of the drill. Calcium chloride is not a carbonate and did not remove the soil acidity, but served to supply calcium and improved the crop.

straw, only 5 pounds of calcium are needed. For 50 bushels of corn and a ton of fodder a like amount must be provided. But to produce two tons of clover hay—about the crop that might be expected on 50 bushel corn land—the soil must supply 80 pounds, or 16 times as much calcium. A two-ton hay crop of soybeans, often considered able to grow on sour soil, requires 55 pounds of calcium. One ton of Korean lespedeza will take from the soil 36 pounds of this nutrient. Legumes make large demands on the soil for calcium in comparison with other crops, and for this reason they represent the first group of crops to show disaster from a depleted supply of calcium in the soil. Non-legumes on such lime deficient soils may be failing in a measure though not to the point of complete crop failure.

In terms of the amount of limestone required to supply this required calcium, however, the figure is small. Pure limestone contains 40 per cent calcium, or 40 pounds per hundred, hence a crop of 50 bushels of corn and stover would take calcium from the soil, equivalent of only 12½ pounds of limestone. Red clover, a much heavier feeder on calcium, would take for a two-ton crop, the calcium that would be supplied by 200 pounds of pure limestone. Soybeans at the same acre yield would need about 150 pounds. Korean lespedeza with half as much forage would demand but 90 pounds.

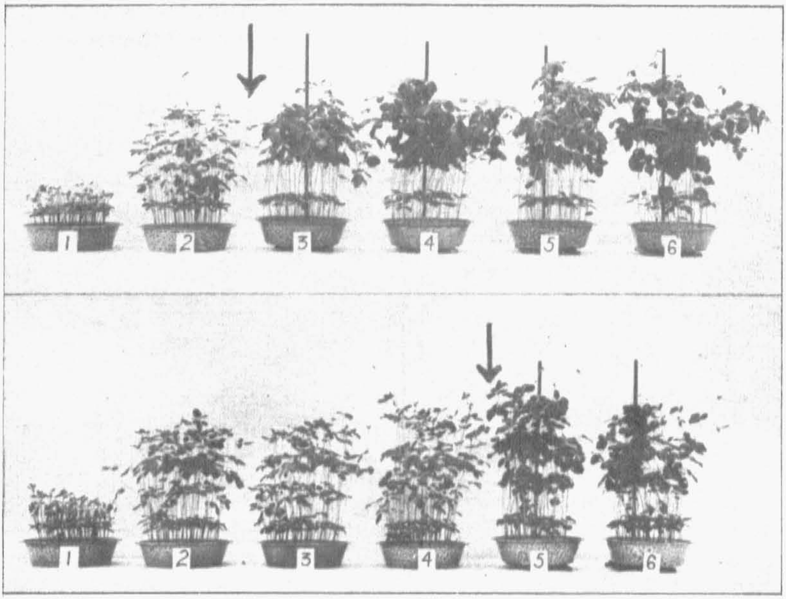

Fig 2.—Soybeans on soil with decreasing acidity (left to right) at high calcium level (above) and low calcium level (below). Pans 3 and 4 above with the same degree of acidity as these two below, grew better crops on this acid soil because more calcium was added.

Thus the actual calcium needs of the crop can be supplied in relatively small quantities of limestone if it can be delivered to the plants in such a way that they can use it completely. In respect to the crop needs for calcium as a nutrient, therefore, we may think of limestone in terms of pounds rather than tons required for acidity correction provided this is delivered to the plant in usable form (Figure 2).

Limestone Similar to a Fertilizer

When the limestone needs approach such small figures per acre, the liming treatment becomes similar to that of applying fertilizer. Then, too, since it becomes a matter of getting the lime, or calcium, into the plant, it further approaches fertilizer in the matter of providing limestone of ready solubility. Limestone is similar to fertilizer in still another respect, namely, that the effects of the lime are marked in the early life of the plant. Experiments have shown that legume plants given lime are larger and more able to take nutrients from the soil in their early life, when given access to lime for only the first ten days of their growth and then transplanted as seedlings to acid soil, than when lime is withheld. Also they are more active in forming root nodules, and are earlier as well as superior in nitrogen fixation as a consequence of access to calcium. It is even possible that the germination of the seed is more effective when calcium is supplied by the soil (Figure 3).

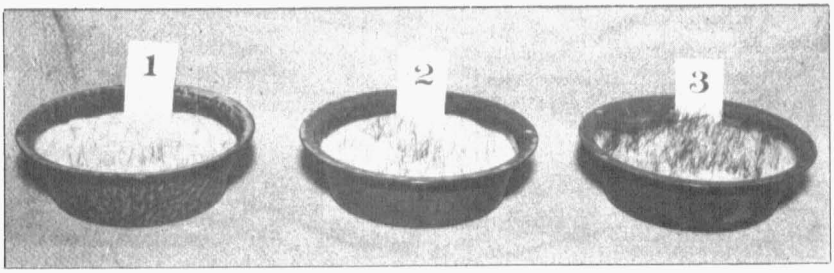

Fig. 3.—Bluegrass seedings gave better germination and stand of bluegrass as the soils delivered increasing amounts of exchangeable calcium, left to right. (White soil cover was used to aid photography.)

As a rock, limestone is usually considered insoluble, yet this is not the whole truth when one recalls the numerous caves dissolved out of limestone by running water. When finely ground, naturally, limestone becomes more soluble in the same way that powdered sugar dissolves more quickly than rock candy, yet both are the same chemical composition. When limestone is ground into a powder that is fine enough to pass a sieve with 100 holes per linear inch, or 10,000 holes to a square inch, its action in the soil is just about as rapid as that of the water soluble forms of lime, namely, quick lime and hydrated lime. The finer grinding of limestone with this resulting increase in solubility makes it behave like a fertilizer in speedy effects.

By drilling limestone into the soil at the time of seeding the crop, the approach to fertilizer is still closer in method of application and in use by the small plants in their first stages of growth. The effectiveness in starting legumes by drilling these smaller amounts, which do not remove the acidity of the entire soil layer, points to the fact that it is not necessary to correct all the soil acidity before legumes can be grown. Ground limestone has started sweet clover on soils whose degree of acidity was high, (pH 4.9, requiring more than two tons of limestone per acre on a silt loam), and this acidity was only slightly changed in no greater distance than two inches from the drilled stone (Figure 4). Even with heavy applications of limestone, legumes succeed when not all the soil acidity has been removed. In fact it has often been observed that clover will succeed in consequence of applications of limestone on soil whose test after treatment still shows considerable degree of acidity. Such soils are evidently delivering enough calcium to the plant for successful growth even though they are still acid.

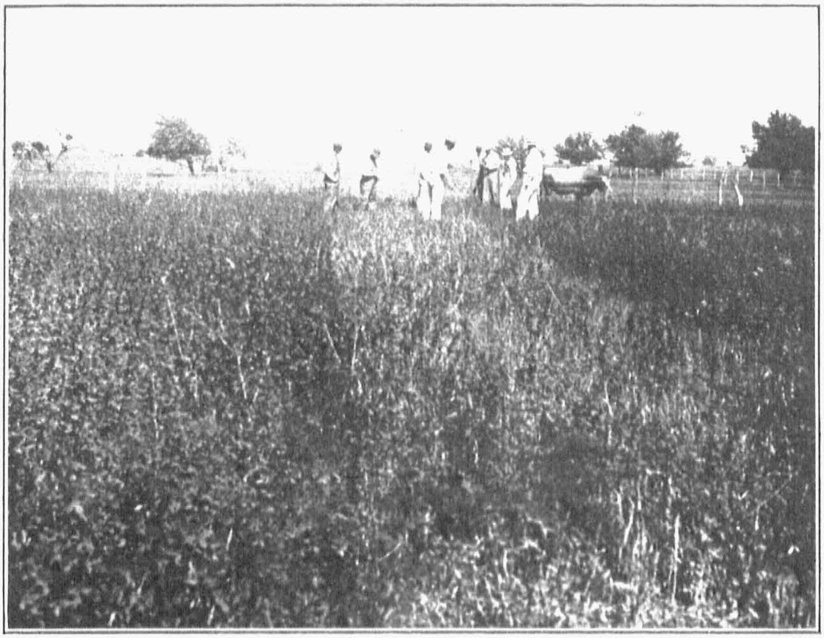

Fig. 4.—Withholding only the lime in one drill width shows as a strip of weeds in contrast to good sweet clover where lime and fertilizer were drilled on Cherokee silt loam of high degree of acidity.

When plants can be transplanted from limed to sour soil and are better there because of a short early period in the presence of limed soil; and when nodules are produced in the soil at some distance from the streak of limestone applied by the drill, as has been common observation; it is clearly evident that lime can serve the plants without neutralizing the acidity in the entire soil area. It is highly probable that it would be disastrous to plant growth in other respects if many soils were suddenly neutralized completely. Potato scab is encouraged by neutral soils and the potato grower may well consider drilling limestone as a means of growing legumes for organic matter addition to his soil without bringing on the scab disease that results from correcting the acidity completely. Excessive liming has given bad effects in a sufficient number of cases and experimental evidence is accumulating to lead us to believe that some degree of acidity is desirable. Under such circumstances limestone behaves as a fertilizer in that it supplies the calcium needed by the plants, and can be handled on this basis in farm practice on many soils without necessarily completely neutralizing the soil.

Fineness and Purity of Limestone Should Be Considered

The more finely the limestone is pulverized, the more rapid will be its action in the soil, and the more prompt the beneficial effects to the crop. Much of the agricultural limestone is now being produced under specifications of fineness and purity demanded by soil improvement associations, so that the general run of ten-mesh material now carries a larger share of it fine enough to pass a hundred-mesh screen than was the case not so long ago. Of two hundred samples recently submitted, more than half contained more than 25 percent of the hundred-mesh powder. More than a quarter of them had over 30 percent of this fineness. Half of them had more than 50 percent of the sample passing through a forty-mesh sieve. Only about ten years ago the quantity passing through the hundred-mesh screen was scarcely 25 percent by the majority of samples of the ten-mesh stone.

This marked improvement in limestone makes it approach more closely to the more soluble, or more rapidly effective, forms of calcium materials. It increases the possibility of drilling the regular ten-mesh limestones when they carry over 25 percent of the hundred-mesh material. One thousand pounds of such limestone drilled per acre would deliver 250 pounds of the finely powdered part for immediate effect which alone represents a liberal dosage for the crop. With one-seventh of the limestones tested carrying over 40 percent of hundred-mesh material, 250 pounds of it would be delivered by drilling slightly more than 600 pounds of such ten-mesh stone per acre. This improvement in the fineness, and with little of the stone coarser than the ten-mesh, limestone may well be handled by the fertilizer drills without danger of serious wear to this type of distributing machinery.

Other Forms of Lime, or Calcium May Be Used

Besides limestone, other compounds are often available which can supply calcium. Acetylene plant waste is a form of very finely powdered lime hydrate that on drying and exposure to air will change to calcium carbonate. It will serve effectively as limestone, though its fluffy nature prohibits easy drilling unless there is an agitator in the drill box. Lime tailings, residues from burning lime, are another by-product that deserves consideration. Lime hydrate in the commercial form will also serve. It carries as much calcium in 74 pounds as limestone does in 100 and one will need only three-fourths as much of this as of limestone. Granulated quick-lime may also be used, but is not as convenient to handle because of its caustic nature and, like the hydrate, may disturb germination if put into close contact with the seed in the soil. About 56 pounds of this are equivalent in calcium value to 100 pounds of limestone. When quicklime air slakes completely and changes from the stone to the powder form, it may also be used. Then it has no weight advantage and 100 pounds are required for the equivalent of 100 pounds of limestone. It also has the same chemical composition. Its fineness introduces difficulties in drilling it effectively. Other kinds of lime and lime waste may be considered and can be evaluated on basis of their calcium supplying power. Many of these miscellaneous forms of lime deserve more consideration as a soil treatment.

Smaller Applications of Limestone Should Be Drilled into the Soil

If smaller amounts of ground limestone are to be successful in supplying plants with calcium and establishing the crop, the limestone should be drilled into the soil. Broadcasting such small amounts as 500 pounds per acre is not significant in its effects. Yet when this same amount is drilled, each drill row represents small soil areas where the limestone is concentrated and the soil along the row is more highly saturated with lime. Experimental studies show that the higher the degree of saturation of the soil by lime, the more readily does the plant secure the lime (Figure 5). A larger share of the applied lime is taken as calcium by the crop and thus the economy of the application is improved. It is the more effective delivery of the necessary calcium in the drill row that encourages the plants to grow there (Figure 6). As is true for wheat and other drilled grains, so it is true for legumes—their establishment in the drill row only usually means plenty of plants per acre and a good stand.

Ground limestone need not be drilled deeply. It moves slightly downward in its reaction with the soil. Even if drilled right on top, it will be fairly effective but in this case the wind scatters it to reduce its effects. It is unnecessary, however, to make the drilling operation a heavy load by setting the drill deeply into the soil. If a quiet, or non-windy time is chosen, the drill can be run shallow, the limestone delivered in a very

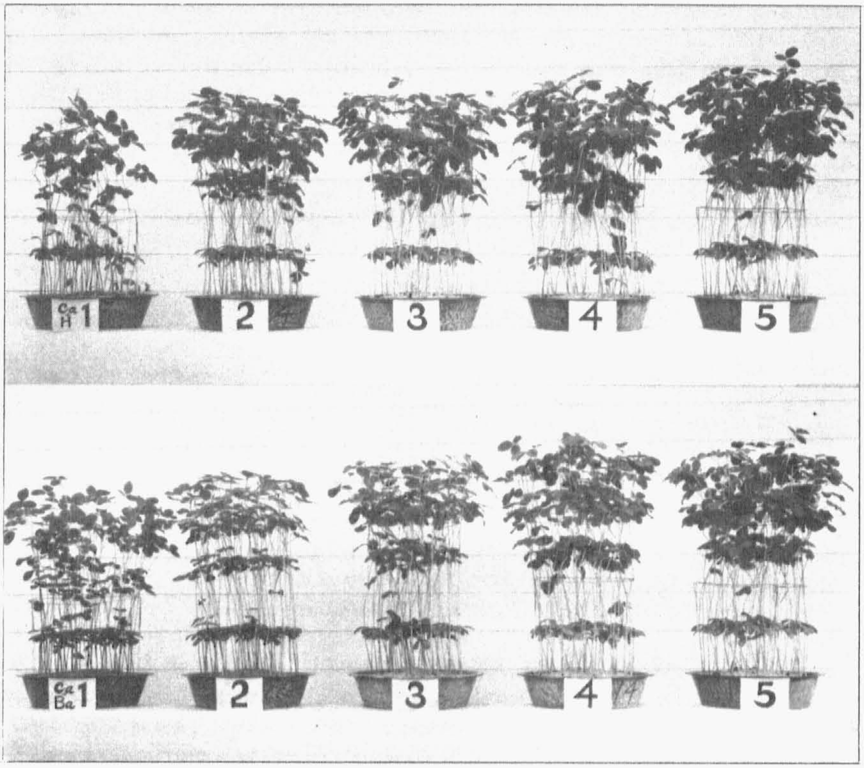

Fig. 5.—Even though the same total amount of calcium was offered in each pan, the crop growth was better as less soil was more completely saturated, (left to right), regardless of whether the acidity decreased (upper row) or all the soils were neutral (lower row).

narrow strip into the soil with light cover, and narrow, highly lime-loaded streaks of soil through the field provided. There the plants can find their needed lime supply early and get off to a good start. This early growth is essential in the life of the clovers if they are to get their roots down into the lower soil and establish themselves in competition with the nurse crop of wheat or oats for the soil fertility and moisture. Only as they do so can they survive the summer and make a paying crop later. Lighter applications of limestone cannot be promptly beneficial if scattered through the entire surface soil. They can be helpful, however, if drilled into the soil.

Fig. 6.—A vertical cut through a drill row of wheat and clover where limestone was drilled, showing the wheat and clover plants in the row. Arrows indicate the level of the limestone drilled into the soil. Nodules occur on the clover roots in soil areas away from the limestone. (Photo by Jordan).

SEASONS AND METHODS OF DRILLING LIMESTONE

Since limestone can be considered much like fertilizer naturally the season for drilling it might be expected to be that when the legumes are seeded. It has been found a good practice to drill the limestone in the spring when the clovers and other lime-loving legumes are sown. The fertilizer attachment of the grain drill will deliver the limestone, while the grass seed attachment delivers the seed. In this way one operation over the field completes the seeding. If the drill is not run into the soil deeply, the seed may be delivered down the spout and the seed and limestone put into immediate contact. The seed delivery spouts on the drill may be detached from the spouts leading down to the drill shoe, and the clover seed scattered on the surface of the soil. The seed spouts may also be extended to scatter them behind the drill, where they will fall into the drill furrows immediately over the limestone and be covered well enough by the first rain.

When drilling the limestone in the spring season, it should be done as early as possible because of the well known need for seeding clover early. This is sometimes impossible because the soil is too wet to permit going over it with the drill, and the wait for suitable soil conditions delays the seeding until the nurse crop is so large that the clover will be smothered out, or fail because of moisture shortage.

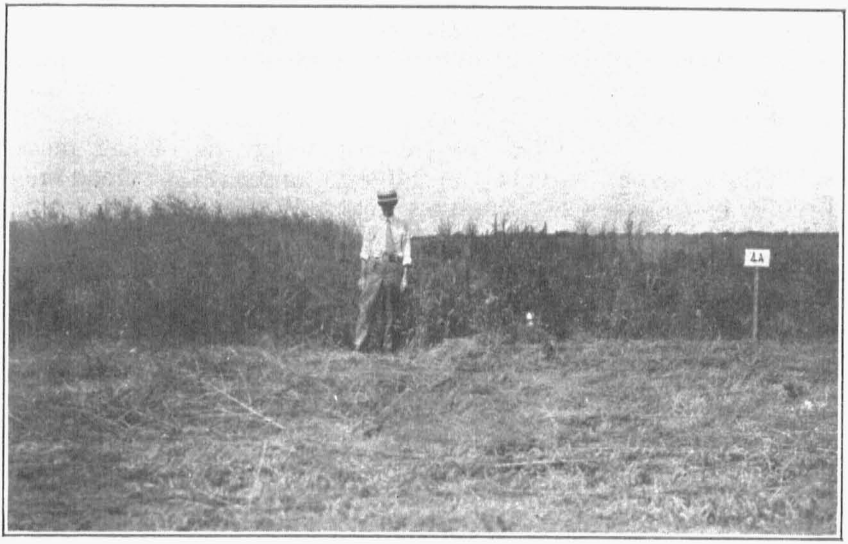

Fig. 7.—Spring seeding gave sweet clover (left) where limestone was drilled with wheat the preceding fall, but no treatment (right) gave only weeds. (Photo by Jordan).

It is not necessary that the limestone and the seed go on together, provided the soil is not cultivated or disturbed between these two operations. Consequently, the limestone may be drilled during the winter when soil conditions permit. The broadcast clover seeding may follow at the proper date (Figure 7). This will serve about as well as drilling the two together.

Just as heavy applications of coarse limestone are often made broadcast in connection with wheat seeding in the fall, so the drilling of the limestone may also be done at this season. The limestone may be drilled like a fertilizer directly with the wheat (Figure 7). Since the wheat and limestone cannot be mixed and seeded together very successfully through the grain section of the drill, the stone should be put on with the fertilizer attachment. Limestone so applied in the fall will be effective the following early spring when the clover is seeded broadcast in the customary manner.

If fertilizer is to be applied for the wheat this may be mixed with the limestone and both put on at the same time. Such a mixture may also be drilled with the clover seedings. There is no serious danger from interference of one with the other. On the contrary, there may be improvement in the effect of the fertilizer as a result of the presence of the limestone. Likewise, for the limestone effect on the wheat, this will not be detrimental but may be helpful. Inoculated soil may also be mixed with the limestone as a means of inoculating the following clover seeding (See Figure 12 on page 19).

Any of these mixings of materials with the limestone should be made just prior to, and not much in advance of, the application of the mixture.

As for the time when the limestone may be drilled most conveniently and effectively, the fall seeding season is a good one where wheat or barley is the nurse crop. If oats serves as such, the limestone may be drilled similarly with the oats in the spring and the clover broadcast later. When the legumes are seeded alone, then the limestone may well be drilled at their seeding season.

Drilling Limestone with the Grain Drill Without a Fertilizer Attachment.

The most effective method of drilling limestone is by means of the fertilizer attachment on the grain drill. This will handle limestone effectively though one cannot expect even this machine to operate without attention. One must always make sure that the stone is not failing to get down into the distributing machinery satisfactorily. It is also necessary to learn the rate of delivery. The ordinary grain drill will distribute limestone through the grain distributing section. Such machinery is not as convenient as the fertilizer section of a grain drill, but will serve and can be used to drill the stone. As coarser stone is used, the wear will be greater, but this is not a serious matter and should not prohibit drilling limestone by this method. It is important, however, that the drill be cleaned thoroughly thereafter.

As the declining fertility of our soil becomes more widely recognized and the use of fertilizers to replace it becomes a more general practice, the fertilizer drill will be a more common machine for applying limestone as well. In respect to farm machinery, the limestone drilling methods will fit into the already common stock of farm equipment and call for no special machinery of limited use.

LIMESTONE ALONE MAY NOT GUARANTEE CLOVER AND OTHER LEGUMES

It is not an uncommon experience in Missouri to find that an application of limestone alone does not secure a stand of clover. This has been true with heavy applications of limestone, but has come under more careful observation and with more emphasis in trials with limestone drilled into the soil in conjunction with fertilizer treatments. Clover often requires more than limestone for its successful stand and growth (Figure 8). It is true that liming increases root nodule production and, through the nodular bacteria, helps the plant to get its nitrogen

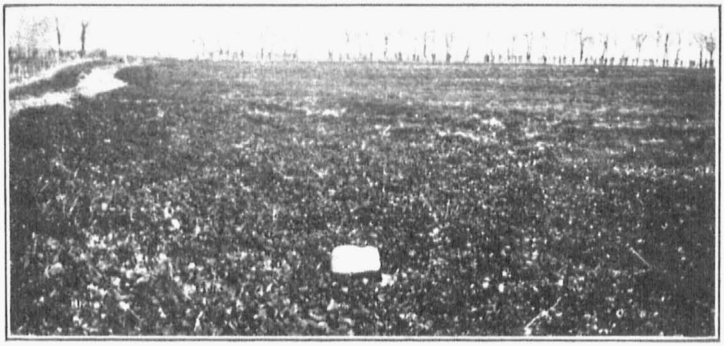

Fig. 8.—Red clover was obtained on Edina silt loam by drilling limestone and phosphate together when the untreated clover winter-killed.

from the unlimited supply in the soil air. In respect to this one nutrient, beside calcium, liming increases the supply of nitrogen for the legume plants by their improved nitrogen fixation. Limestone cannot substitute, however, for soil shortages in phosphorus, potassium, moisture or any other items required for plant growth. The addition of phosphorus to limestone has shown itself beneficial. The addition of potash is also noticeable in its effects so that on many soils of the state, the level of this nutrient is so low as to deserve consideration. Farm manure will supply some of this shortage and should

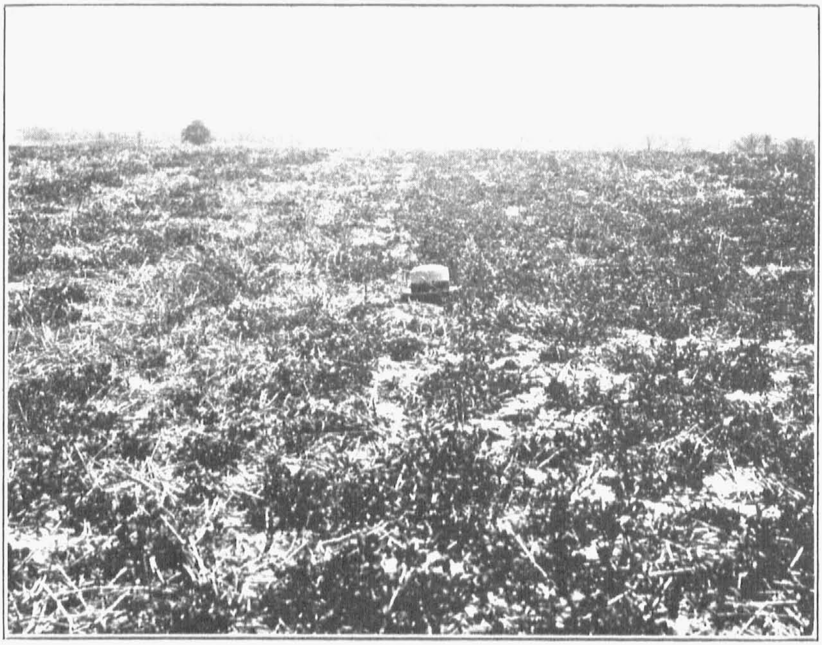

Fig. 9.—Limestone drilled on the river bluff lands (Memphis silt loam) made this improvement on the right in the April condition of alsike clover.

often be used for this reason in conjunction with liming for a legume stand. Resistance to drouth by clover was increased as limestone was supplemented with other treatments, possibly because these produce greater plant vigor and a deeper tap root. These illustrations indicate that more than liming is often required, and that if limestone has been drilled with the clover seeding which fails, that failure should not be wholly ascribed to the fault of the liming method. Rather, some other soil deficiency may be responsible. The method of drilling limestone will supply the needed calcium for the crop and will increase nodule production and consequent nitrogen fixation, but it cannot take the place of other requisites for this crop. When used alone limestone drilled into the soil should not always be considered as a guarantee for a good stand and crop of clover or other legumes demanding soil treatments to prevent their failure.

Limestone Use Emphasizes Declining Soil Fertility and the Need for Other Fertilizers.

As the soils in the regions of great rainfall and heavier crop production have become low in lime—now being especially recognized by clover failures—so have they also become correspondingly low in other nutrients not so grossly removed by plants. The soil deficiency in these is just as disastrous since the crop is impossible unless each of the required nutrients is amply supplied. The use of limestone drilled with wheat has sometimes improved the wheat crop, pointing out that the soil was low in calcium even for wheat, and doubtless for corn and other crops that require but small amounts of it. Liming ahead of corn has improved this crop, probably by indirect as well as by direct effects through the calcium supplied. Oats have sometimes been improved by liming and reports of improvement in soybeans from limestone drilled with them are not uncommon. Its benefit on oats and wheat as nurse crops, suggests similar effects from it on barley serving the same purpose, especially since barley is the most sensitive of the small grains to the lack of lime. The low supply of lime that may be disastrous to the extent of complete crop failure for legumes, is therefore not without injury to many other crops.

This declining supply of soil fertility may be responsible for clover failure where it is grown with a nurse crop as contrasted to success where grown alone. The fertility supply of the soil may not be sufficient for two crops. Illustrations are not uncommon of clover in wheat drilled around shocks of corn fodder. In such cases the clover may be large next to the shock where nutrients were leached from the fodder into the soil by rain, while farther from the shock where also no wheat was drilled and the clover grew alone it will be somewhat smaller. It will usually be still smaller within the wheat crop. The improved growth of clover around the shock from which the added fertility was leached into the soil points out that the fertility of the soil is low for clover, but especially so when it must grow in competition with the wheat for this limited fertility supply. Farm experience in growing clover alone successfully is testifying to this situation. When grass takes alfalfa, this is also a testimony that the fertility level will not meet the high demands for good alfalfa that would smother the grass. We are expecting too much of many soils when we seed a nurse crop and clover too, and expect both to succeed on the low level of soil fertility offered them.

This declining fertility level is evident in spite of the fact that a liming treatment, especially a heavy application, helps much in making other plant foods more effective. It is now known that liming helps the plants to obtain more potassium. Also it is instrumental in making a phosphorus treatment more beneficial. On limed land phosphorus is usually more effective than on unlimed soil. Lime also helps the plant to get nitrogen. It aids the plant in making much better use of the limited supplies of these other nutrients. It does not add these to the soil, hence the already low supply will be more rapidly depleted by liming. If, however, clovers can be grown and larger crop yields result, the restoration of the fertility should be quickly undertaken when this soil need is fully appreciated (Figure 10). As we use more limestone, attention must likewise be given to other deficiencies of soil fertility which this practice will help bring to our notice, and for which limestone cannot be a substitute.

MANY SOIL TYPES OF MISSOURI RESPOND TO DRILLED APPLICATIONS OF LIMESTONE

To date the drilling of limestone has been tried with successful results by farmer cooperators in many parts of the state. The soil types represented include the following: Boone, Cherokee, Crawford, Decatur, Edina, Gerald (Figure 10), Grundy,

Fig. 10.—June condition of a green manure crop of a red and sweet clover mixture started by an application of limestone drilled on Gerald silt loam.

Knox, Lebanon, Marshall, Memphis (Figure 11), Oswego (Figure 12), Putnam and Summit silt loams; the Shelby and Lindley loams; Clarksville and Baxter gravelly loams; Lintonia fine sandy loam; and Wabash clay loam. By no means have all soil types been included in this rather extensive list, but those of level topography, heavier subsoil and significant degree of acidity have been grown to acid sensitive crops by means of lighter applications of limestone drilled on them. They testify to the success of this practice on those soils most difficult to seed to clover. Not only red clover, but sweet clover, and in some cases, alfalfa has been started by this treatment. Unfortunately, liming cannot offset bad seed, summer drouth or infertility, but it can care for the calcium deficiency, or lime need, on most of the prevailing soil types in the state.

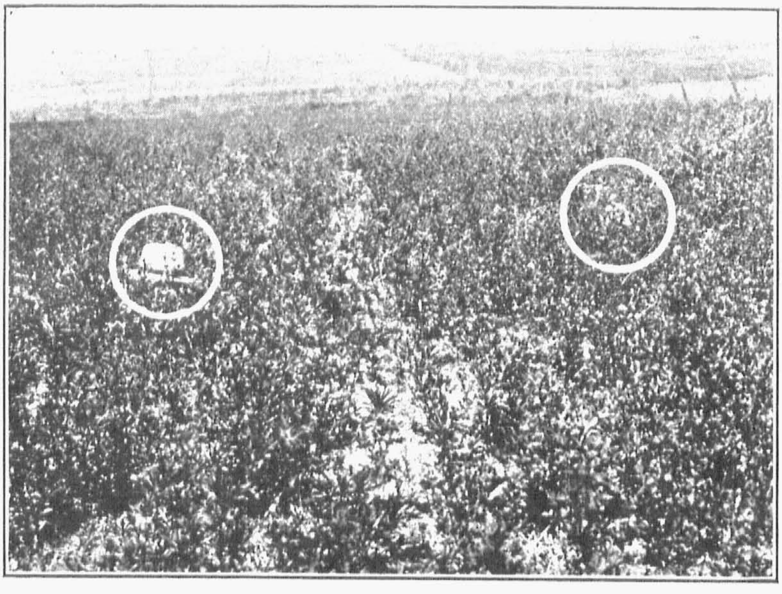

Fig. 11.—Spring condition of alfalfa started by limestone drilled on Memphis silt loam. Left—no limestone. Right—limestone.

PERIOD OF EFFECTIVENESS OF DRILLED LIMESTONE

"How long will the limestone last?" is a common question, when one contrasts this drilled method with that of broadcasting a heavy application that is effective to the legume crops in more than one round of the rotation. Legumes are the first among the crops to need lime, consequently, the stone is drilled with the legumes. The effect will last longer than this one crop if the soil is not disturbed (Figure 12). Sweet clover has reseeded itself after a start with drilled limestone, showing that the effect can carry over to the third year where the soil was not plowed. When only the small soil areas represented by the drill rows are treated and the ground plowed afterward, this small amount of limed soil is too thoroughly scattered through the great soil mass to lend much effect. When the next legume crop comes around in the rotation another drilling of limestone should be used.

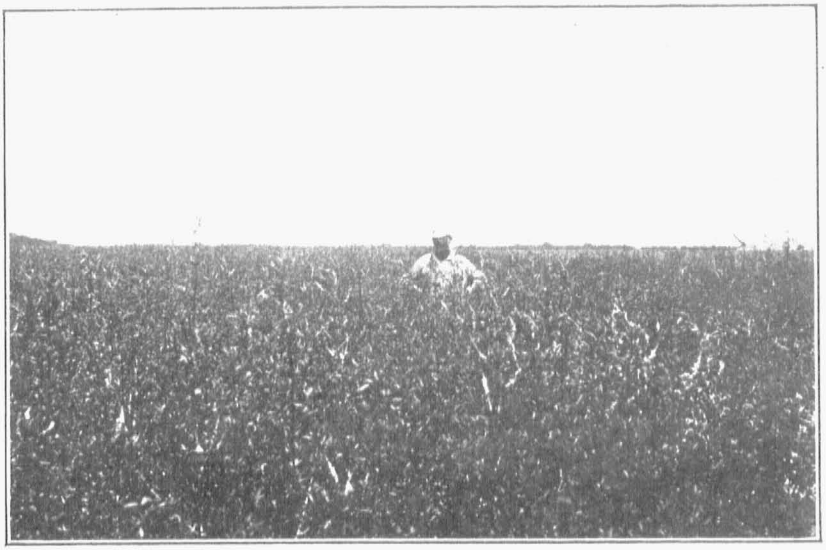

Fig. 12.—A volunteer, or self-seeded crop of sweet clover where a mixture of limestone, inoculated soil, and seed was drilled for the preceding crop on Oswego silt loam.

Because broadcast heavy liming is an arduous task and represents a significant investment, one naturally hopes that its effects will last a longer time than for one single four year rotation. Drilling the limestone is a simple, one-man operation of moderate cash outlay and it might be considered as a part of the treatment for every legume seeding.

ECONOMY OF DRILLING LIMESTONE

In terms of the labor of distribution, the drilling method effects a real saving. To drill 500-1000 pounds per acre on 20 acres is a one-man labor load, totaling five-ten tons of material, while the corresponding labor load of 40 tons broadcast might require the help of the neighbors. It is this labor requirement that should be considered as the significant advantage of drilling the limestone, and that makes this method lend itself to bringing limestone to soils where the other method might mean too great an initial cost. The smaller amount of limestone means less initial cash outlay; it permits the stone to be hauled to greater distance from railroads or delivery points, and makes possible liming within the farmer's own labor. The one-man labor load and smaller amounts of stone required make delivery possible at any time with storage for later use. When its use becomes more widespread, the stone may be stocked more generally by local dealers and thus still greater economies effected. Under such conditions, its costs when used regularly in every rotation should not exceed the costs of heavier applications of stone applied less often.

This method of handling the liming need of the soil reduces it from a complex problem of large cash outlay and extensive labor, to a regular farming practice that can be geared into the routine farm program without its disruption. On such a basis the drilling of limestone may be accepted as a regular part of the legume seeding whenever it comes around in the rotation just as fertilizing should be a part of wheat seeding. Under such conditions more legumes can be successfully grown, more fertility restored to the soils and higher profits returned by the land.