UNIVERSITY OF MISSOURI

COLLEGE OF AGRICULTURE

Agricultural Experiment Station

BULLETIN 146

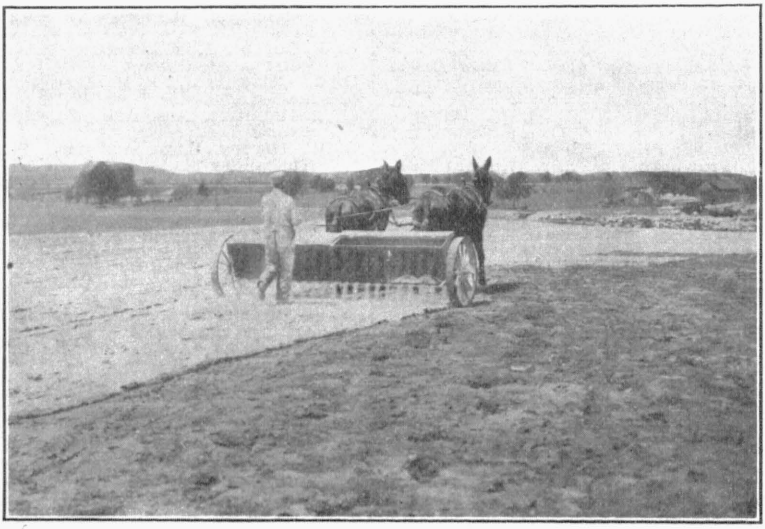

FIG. 1.—A LIME SPREADER AT WORK.

Agricultural Lime

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Agricultural Lime

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Many Missouri soils are strikingly in need of lime. This has been shown by chemical tests and by field experiments. The development of acidity or sourness in the soil, which is the principal reason for applying lime, takes place sooner or later in all soils of the humid region which are subjected to constant cropping. In the eastern states liming has been practiced almost since the beginning of agriculture in that region. This has been due partly to the fact that many eastern soils were originally poorly supplied with lime and partly to the more intensive agriculture practiced. The soils of the corn belt were originally rather well supplied with lime, altho in recent years they have begun to show a need of it. As a result liming is extending westward and it is now more or less common in all the corn belt states. The extent of the interest in liming among Missouri farmers is shown by the numbers of such inquiries which are being received by the Experiment Station.

SOILS NEEDING LIME

The soil analyses which have been made at the Experiment Station are not sufficient in number to make possible an accurate statement of the needs of all the soil types in the state, but a sufficient amount of data is available to show that large areas of soil need liming. Of the total number of samples examined, representing in all 112 soil types, approximately two-thirds have shown some need of lime. This need varies from insignificant quantities, to five or six tons of ground limestone per acre, considering the surface seven inches of soil as the basis for comparison. Approximately one-fourth of the samples have shown a lime need of two tons or more in this surface soil layer.

No very accurate statement can be made as to the lands needing lime most, since this varies materially in the same soil type. In general, however, the level prairies of Northeast and Southwest Missouri commonly need lime. Considerable areas of the rolling prairie in both North and South Missouri also need it, as well as much of the

older farmed timber lands. Many of the better limestone lands of the state need little lime, altho the poorer limestone lands often need it badly. The fact that a soil is derived from limestone does not necessarily mean that the surface soil or the upper subsoil is sufficiently supplied with lime, since it may have been removed almost entirely since the soil's formation. Many farmers believe that bottom land soils are usually sour, but such is not necessarily the case. As a matter of fact the best bottom lands, particularly the newer bottoms, subject to occasional overflow, rarely need lime. The rough to rolling brown timber land known as loess (Knox silt loam) bordering the bottom lands of the Missouri and Mississippi rivers and found in largest areas from the center of the state to the northwest corner needs little lime.

The foregoing statements are necessarily general. They do not apply to all soils in the regions mentioned but to the more important ones. A careful test is the only means of determining with certainty a soil's need of lime. It can be said with a reasonable degree of confidence however, that where red clover grows well, little or no lime is needed. On the other hand, red clover failures are not always due to a sour soil. Poor drainage, a lack of fertility, unfavorable weather conditions or the lack of organic matter and available phosphates may cause a failure or a poor growth of clover even where a soil has sufficient lime. Liming alone, therefore, may not always bring good clover stands. As a rule, liming is beneficial to clover where it is failing on well drained land, and it may sometimes almost insure a stand, altho manuring or the use of phosphates may often be necessary in addition. There is a general belief among farmers that the presence of red sorrel (*rumex acetosella*) indicates soil acidity. This plant thrives on a sour soil and often, where it has once been seeded on land which is very sour, it will grow luxuriantly, excluding more desirable plants. Patches of this plant are more or less common in all parts of Missouri but these usually come from the seed introduced with red clover and they may occur on any soil. It is only where this plant predominates to the exclusion of other plants, that soil acidity is indicated by its presence.

TESTS FOR SOIL ACIDITY

Simple tests for soil acidity are often inaccurate or otherwise unsatisfactory. What is known as the muriatic or hydrochloric acid test is of considerable value. This test is made as follows: Take a small quantity (an ounce or two) of strong hydrochloric acid (some-

times called muriatic acid) and dilute with an equal amount of water. Take a handful of the soil to be tested, preferably wet and worked into a mud ball, and add a drop of this weakened acid. If an unmistakable and distinct bubbling takes place the soil is practically certain to need no lime; the more pronounced the bubbling, the more certain it is that no lime is needed. If no distinct bubbling takes place the soil either contains very small amounts of lime carbonate (the lime compound which keeps soils sweet) or it is in need of lime. While it may contain too small a quantity of lime carbonate to give an unmistakable test, it may still contain enough that the soil is not sour. Hence this test gives a conclusive result only when the soil contains considerable lime carbonate.

The litmus paper test, of which so much is said, is fairly satisfactory in the hands of one who has had experience with it, but it is very likely to give the wrong impression to one who is using it for the first time. The test is based on the fact that the chemically prepared paper, known as blue litmus paper, turns pink in contact with acid. The principal difficulty in using it is in knowing just what shade of pink really indicates soil acidity. The paper will lose its blue color even in a neutral soil and turn a purplish color which may be mistaken for the proper pink color. Again the length of time the paper is in contact with the soil influences the color. The paper should turn a distinct and even pink within ten minutes if the soil is very acid. The department of soils has prepared a sheet of directions for the purpose of assisting farmers in making this test and this will be sent on application.

A rather simple chemical test, known as the Truog test, has come into use recently which farmers may use with a fair degree of satisfaction if they will supply themselves with the necessary apparatus and materials. The method is being tried at the Experiment Station with good results.

The standard chemical test known as the Veitch test is the one used in most laboratories. The Experiment Station is now making considerable numbers of the Veitch and Truog tests for farmers where the soil samples are carefully taken. A sheet giving directions for taking samples for such tests will be sent on application to the College of Agriculture.

THE PURPOSE OF LIMING

The purpose of liming is primarily to sweeten the soil. There are other effects which lime has upon the soil, such as that of making

clay more friable. The ground limestone acts rather slowly in loosening the soil, however, and it must be applied in considerable quantities for a marked physical effect.

A soil that is sour is not in condition for the proper action of beneficial soil bacteria. Those found in the nodules on the roots of important legume crops, such as clover and alfalfa, are especially injured by soil acidity. Other beneficial bacteria are more or less injured. Consequently a very acid soil should be limed if best results are to be secured. Lime is therefore not a fertilizer in the true sense of the word, since a fertilizer is a substance added to the soil for the purpose of supplying needed plant food directly. Lime is generally known as a soil amendment, a material added for its indirect effect upon the important plant foods in the soil. Its action is therefore not so immediate as that of a fertilizer, but it extends over a longer time, provided the soil is seriously in need of sweetening and provided a considerable quantity of lime is applied. In such cases the effect upon clover or alfalfa may be immediate and striking.

THE RESPONSE OF DIFFERENT CROPS TO LIMING

Considerable experimental work has been done at experiment stations[1] in determining the response of various crops to liming. The

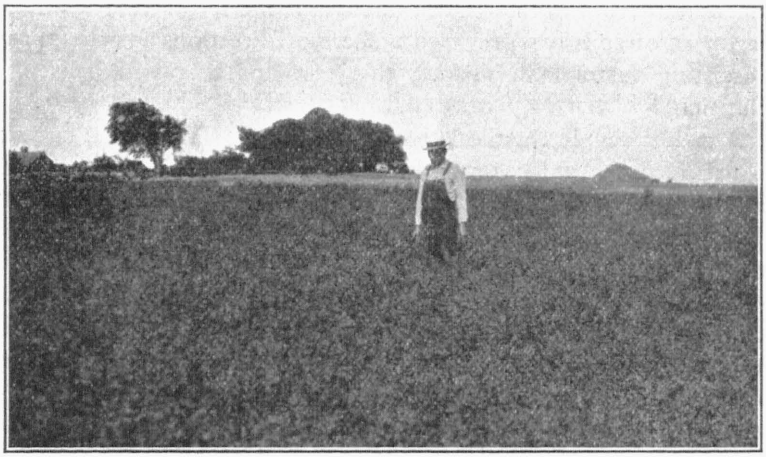

FIG. 2.—ALFALFA ON THE CARTHAGE EXPERIMENT FIELD
Two and one-fourth tons of ground limestone increased the yield of alfalfa on this field 3307 pounds per acre, as an average of two years' cuttings.

[1]Hartwell, B. L. and Damon, S. C. The Comparative Effect on Different Kinds of Plants of Liming an Acid Soil. R. I. Exp. Sta. Bul. 160. Mooers, C. A. Liming for Tennessee Soils. Tenn. Exp. Sta. Bul. 97.

results secured are naturally influenced by the degree of acidity of the soil, as well as other factors, so that the evidence is rather conflicting in the case of certain crops. There is however a striking agreement in the case of some crops and a rather general agreement in the case of others.

Among the legume crops which respond best to liming are alfalfa and the common clovers. Canada field peas, garden peas and soybeans usually give a fair response. Alsike clover will do better than red clover on wet land and an impression has spread among the farmers that it will do better than red clover on acid soil. The indications are, however, that it will respond to liming almost as well as red clover on either drained or undrained land which is very acid, altho it is probably not quite so susceptible to acidity as red clover. Alfalfa seems the most injured of any of the legumes.

Among the legumes which usually are little benefited by liming are Japanese clover, beans, cowpeas and peanuts.

The common non-legumes which are more or less benefited by liming include corn, oats, wheat, timothy, orchard grass, Kentucky blue grass and sorghum. Those giving little or no response to lime

FIG. 3.—CLOVER ON THE VANDALIA EXPERIMENT FIELD

A stand of clover secured by liming, on the northeast Missouri level prairie. It will be noticed that the plots which received no lime (shown behind the man in the picture) have practically no clover.

are rye, Irish potatoes, sweet potatoes, cotton, strawberries and red top grass. Lime has been found directly injurious to watermelons.

The foregoing statements have to do with the direct effect of the lime upon the various crops. It must be understood, however, that crops which may give little or no direct response to liming may be greatly benefited thru growing clover or other legumes on land which would not grow these legumes without lime.

The results obtained by the use of lime on the various outlying soil experiment fields of the Experiment Station give an idea of the results to be expected from the use of lime in Missouri. These experiments have been in progress for a number of years and many of the important soil types in the state have been included. While the fields represent medium to poor lands, which in most cases are somewhat more in need of lime than are the better lands of the state, the average results give a good idea of what may be expected. The table following shows the average returns, which have been secured on the four crops commonly grown, calculated on the basis of a four year rotation of these crops. The increases are the averages of all the trials for the various crops. The lime used in every case was in the form of ground limestone, which was applied at somewhat different rates, but the returns obtained are largely the result of applying approximately one ton once in four years, before either corn or wheat. Consequently it is charged as one ton of ground limestone during each rotation of four years. The cost of the lime has varied, rarely reaching $3 a ton applied, but this price has been used in the calculations since it has been considered that this might well represent the maximum figure a man should pay for it, spread on the field.

EFFECT OF LIMESTONE ON CROP YIELDS. AVERAGE OF ALL EXPERIMENT FIELDS 1907-15

Crop	No. of tests	Average increase per acre due to limestone	5 year av. price	Value of increase per A.
Corn	109	2.7 bu	$ .59	$1.59
Oats	36	1.8 bu.	.395	.71
Wheat	86	.7 bu.	.91	.63
Clover hay	26	466. lbs.	12.35	2.87
Cowpea hay	54	60. lbs.	12.17	.36
Soybean hay	14	215. lbs.	12.17	1.30

Return from limestone in four years with rotation of corn, oats, wheat, clover $5.80

Applied at rate of one ton in four years cost 3.00

Experiments in liming alfalfa have been carried on as a part of a series of cooperative experiments with farmers for a number of years, and in addition certain trials have been made on some of the regular outlying experiment fields. These have been reported in previous publications[1] from this station. While some of these experiments have given no return from liming on this crop, some have given very striking returns.

It will be seen from what has been said that lime cannot be used as a fertilizer is used, in small quantities or even in large quantities, and a remunerative return expected on the first crop of wheat, oats or corn, altho large returns may sometimes be secured on the first crop of clover or alfalfa. The effect of lime is rather that of a general soil improving agency, for most crops, which raises the general level of yields, largely thru its effect on beneficial soil bacteria. Its principal function is that of sweetening a sour soil so that the very important soil building legumes may be more satisfactorily produced. Sweetening a soil may well be compared to drainage in being one of the fundamental methods of soil improvement which on sour soils should precede fertilization and other methods of increasing yields.

FORMS OF LIME

There are three lime compounds which may be used for agricultural purposes. These are the lime oxide, commonly called burned lime or lump lime; the lime hydrate, usually called water-slaked lime, and the lime carbonate, such as ground limestone or old air slaked lime. The lump lime which is commonly sold in barrels in this state cannot be applied in this form without slaking. In the eastern states where lump lime is much used, it is often piled in the fields, covered with earth and allowed to slake by absorbing moisture from the earth or from rains, after which it is scattered and worked into the soil. In this slaked form the lime is largely in the form of the hydrate of lime. In some localities the lump lime is ground to about the fineness of corn meal, then scattered and worked into the soil where it is allowed to slake. There is difficulty in handling it, however, because of its caustic nature and the danger of air-slaking during shipping. It must also be scattered sometime before a crop is put in because of the danger of injuring the seed.

[1]Miller, M. F. and Hutchison, C. B. Cooperative Experiments with Alfalfa. Missouri Agr. Exp. Sta. Bulletin 106.

Hutchison, C. B. and Douglas, T. R. Experiments with Farm Crops in Southwest Missouri. Missouri Agr. Exp. Sta. Bulletin 123.

Water slaked lime or lime hydrate, is being sold, to a certain extent, for agricultural purposes. It is put out in bags by certain lime companies in a form convenient for distribution. Like the ground lump lime, water slaked lime should not be used in large quantities

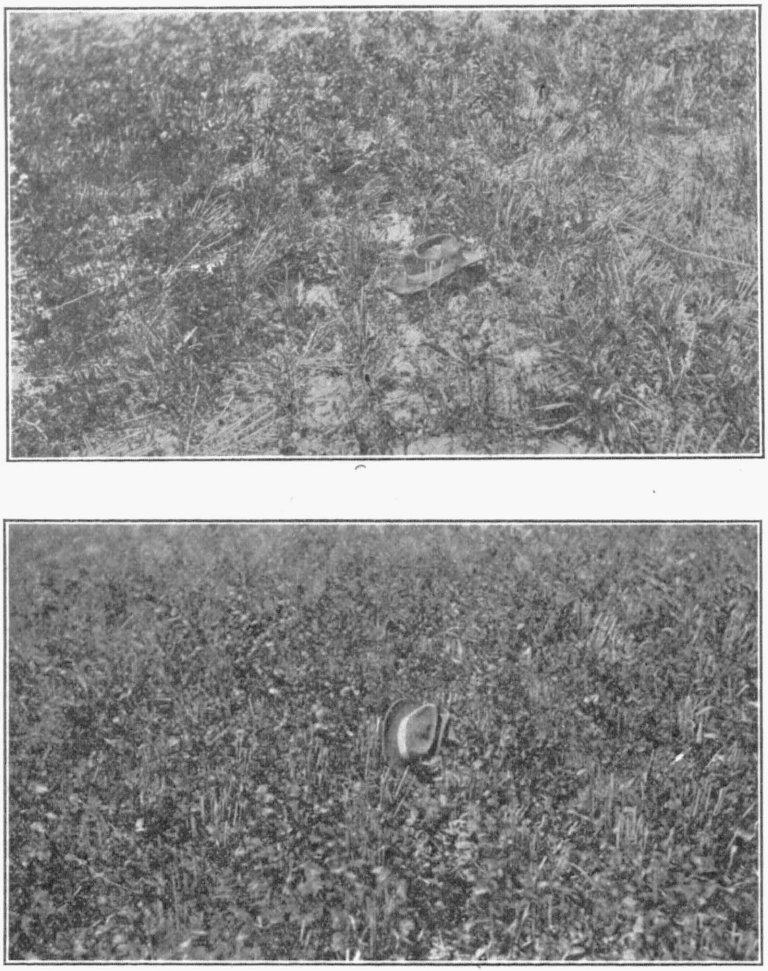

FIG. 4.—YOUNG CLOVER ON THE HURDLAND SOIL EXPERIMENT FIELD

The plot shown above received no lime; the one shown below received ground limestone at the rate of 8000 pounds per acre or enough to sweeten the surface seven inches of soil. Otherwise these plots were treated exactly the same.

at the time of putting in the crop as it is somewhat caustic, altho much less so than the lump lime.

The lime carbonate, represented on the market principally as ground limestone, is the most common form of agricultural lime in Missouri. It is being put out by a number of companies and is being ground to the fineness of corn meal or finer. This form of lime has no caustic properties and may be applied at any time. Old air slaked lime is practically all calcium carbonate and has therefore approximately the same composition as ground limestone. Fresh air slaked lime contains large quantities of lime hydrate, since it has taken up moisture from the air in slaking. Air slaked lime from the kilns may contain considerable quantities of lump lime, cinders or trash and must usually be sifted if it is to be scattered with a lime distributer.

The kind of lime to use should be determined almost entirely by the kind which gives the greatest sweetening power for a dollar invested. In order to determine this it should be remembered that approximately one ton of ground limestone or old air slaked lime is required to equal 1100 pounds of lump lime, or 1500 pounds of fresh water slaked lime, where all are made from a good quality of high calcium limestone. With a delivered price on each, one can figure the cheapest form in terms of sweetening power when hauled and spread. It will be found that in most localities, excepting those within wagon haul of a lime kiln, the ground limestone will be the cheapest form to apply.

Just how much one can afford to pay for lime depends on its quality, the sourness of the soil, the crops grown and the intensity of the system of farming. Experiments indicate that as a general rule $3 is about the maximum price one should pay for a good grade of ground limestone spread on the field. The usual cost of this material is about $1 per ton in loose car lots at the crusher, and since a fair price for hauling and scattering on the land, not over three miles from the railroad, is $1 per ton, the freight rate should not exceed this amount. The distance which one can afford to haul it will depend on the roads and the price laid down at the station. Few farmers can afford to haul it more than five miles. It must be remembered that $3 is given as the maximum cost at which limestone can be profitably used under average conditions, and while this figure may be exceeded, under some circumstances, it is desirable that the applied cost be reduced as much as possible.

SMALL GRINDERS FOR HOME GRINDING LIMESTONE

Farmers remote from the railroad or from a satisfactory lime supply will doubtless find it more economical to grind their own limestone where a good rock is available.[1] Various companies are now putting small portable limestone grinders on the market. The cost of these grinders depends principally upon their size, but it can be said in general that those suitable for the use of individual farmers, or of groups of farmers cooperating in grinding stone will cost from $500 to $1400. Such grinders have a capacity of from one to five tons an hour, depending upon the size of the machine, the kind and dryness of the rock and the fineness of grinding. They require engines varying from eight to twenty-five horse power. Smaller sizes are on the market but they have a correspondingly lessened capacity. A fair size for community work is a machine having a capacity of around two or three tons an hour, costing $750 to $1000 and requiring an eighteen to twenty horse power engine. A somewhat larger machine will often be more advantageous where many farmers are cooperating and where a large acreage is to be limed.

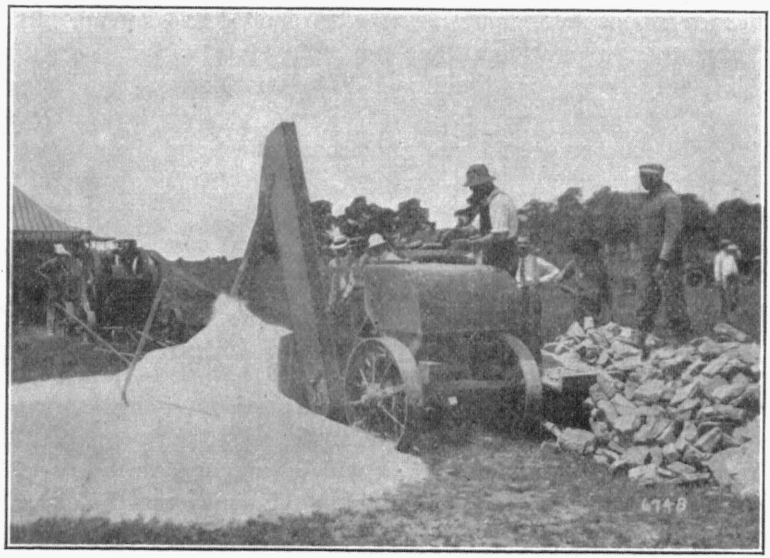

FIG. 5.—A PORTABLE LIMESTONE GRINDER IN OPERATION

[1]Those interested in grinding limestone should write the College of Agriculture with reference to having the quality of the stone tested before preparing to grind.

In selecting a grinder care should be taken to see that it will handle pieces of stone at least four inches in thickness. Some grinders will not handle rock that has not first been crushed by another machine or broken by hand. The best of these large sized portable machines will take in stone measuring five to seven inches thick and eight to twelve inches wide.

THE FINENESS OF GRINDING LIMESTONE

There is considerbale difference of opinion regarding the fineness to which limestone should be ground. The basis for comparison is that of the fineness of the sieve thru which it passes. For instance a large part of the limestone on the market is ground fine enough to pass a ten-mesh sieve, that is a sieve with ten holes to the linear inch or one hundred to the square inch. Some of the coarser of these commercial grades will pass a four-mesh sieve only, while some of the finer grades will pass a twenty-mesh sieve.

The few experiments which have been made in comparing limestone pulverized to different degrees of fineness indicate that it is the fine dust, that is, the part which will pass a sixty- to one hundred-mesh sieve, that gives quickest results in sweetening the soil. There is of course some immediate effect of the coarser material but this is slight. While accurate experimental evidence is not available the indications are that it is fairly safe to estimate the proportion of limestone which passes the forty-mesh sieve as representing the amount which is active during the first year. Consequently in using limestone it is of interest to know the percentages of the various grades of particles composing it. A ground limestone which will pass a ten-mesh sieve will contain from twenty to forty per cent passing a one hundred-mesh sieve, or from fifty to sixty per cent passing a forty-mesh. The percentages are influenced by the hardness of the rock. A ground limestone which is so coarse that it passes but a four-mesh sieve will contain only ten to twenty per cent that will pass thru a one hundred-mesh and twenty to forty per cent that will pass a forty-mesh sieve. Thus it contains less immediately active material. In using such coarsely ground stone sufficiently large amounts should be applied to give the same quantities of fine material as supplied in finer ground rock, if equally good immediate returns are to be expected. Since coarse material may be produced more cheaply, and since the coarser portion will have an effect in time, there are cases in which the application of larger quantities of this coarsely ground stone will be most

economical. This matter is so dependent upon the relative costs of the coarse and fine material spread on the land and these costs vary so much with conditions that no definite statement can be made.

THE COST OF GRINDING LIMESTONE

The price at which ground limestone is sold at the different commercial crushers in Missouri varies from 25 cents to $2 a ton. This material varies considerably both in purity and in fineness of grinding. Most of the large rock crushing plants which crush rock for concrete and road building purposes sell the finer material for agricultural use at prices ranging from 25 cents to $1 a ton. This product is usually the screenings which pass a four-, eight- or ten-mesh sieve.

In estimating the cost of grinding limestone on the farm the interest and depreciation on the outfit, the labor, fuel, oil, repairs and the cost of quarrying the stone must be considered. While the cost of quarrying varies widely under different conditions, it seems that 50 cents a ton is a fair estimate. The cost of grinding varies from 50 cents to $1.50 a ton. In some localities a man owning a portable crusher goes from farm to farm and grinds rock which the farmers have already quarried. A group of farmers cooperating in buying a grinder with a capacity of two to three tons an hour might reasonably expect to get the stone quarried and ground to a ten-mesh fineness, at a cost varying from $1 to $1.50 a ton, where the crew is efficient. It is not unusual, however, to have the cost reach $1.75 a ton. So much depends upon the accessibility and ease of quarrying the rock, the cost of power and the efficiency of the crew that the price is certain to vary widely under varying conditions. A consideration which must not be overlooked is the accessibility of the stone. Very often the limestone is found in deep valleys or rough country so that hauling the stone becomes an important item. A mistake is sometimes made in not providing sufficient power for efficient grinding, which greatly decreases the output. It must be remembered, too, that the rock must be comparatively dry to grind readily and this often necessitates loss of time when the quarried stone is wet or covered with snow.

An investigation has been made of the cost of furnishing ground limestone among the men using these portable crushers in Missouri. While the estimates given vary rather widely a fair statement of the costs of the separate items under what might be termed favorable conditions would be as follows:

Engineer and 18 H. P. engine, per day	$ 7.50
Fuel, about one ton coal	3.00

Labor, 3 men at $1.75	5.25
Depreciation and repairs	3.00
Cost of grinding 25 tons	$18.75
Cost of grinding per ton	.75
Cost of quarrying per ton	.50
Total cost per ton	$ 1.25

Whether it will be cheaper to grind the limestone in the neighborhood or buy it and ship it in will depend upon the delivered price at the station, the length of the haul, the quality and accessibility of the limestone in the community and the cost of grinding. It would seem from the information available at this time that, generally speaking, the local grinding of stone will be limited to those communities in which good stone is readily accessible and which are located at such a distance from the railroad that the cost of hauling becomes excessive.

AMOUNT OF LIME TO USE

The amount of lime to use depends primarily on the degree of acidity of the soil and the kind of lime. As ground limestone is almost invariably the cheapest form to apply in Missouri, recommendations are usually based upon this material. The determinations, which have been made as to the amount of ground limestone required to sweeten the surface seven inches of an acre of the various soils of Missouri, show a variation from nothing up to five or six tons. A few have shown even higher lime requirements. These determinations are based on the surface seven inches of an acre because it is in this layer that beneficial bacteria are most active.

As a general rule it can be said that applications of one to two and one-half tons of a good grade of ground limestone would be likely to give results. The amount to apply depends not only upon the sourness of the soil but also upon its fertility. Crops grown on fertile soils do not seem to be injured so much by soil acidity as when grown on poorer soils. Since lime is being continually removed from the soil it is necessary to lime at more or less regular intervals. Applications of one and a half to two tons of ground limestone once in four to six years would be considered reasonable rates on soils showing enough acidity to seriously affect the growth of clover. On very acid soils larger amounts may often be applied with profit.[1]

[1]The College of Agriculture will give such assistance as is possible in determining the acidity of soils.

METHODS OF APPLICATION

Lime should be applied on plowed land and worked into the surface three to five inches of soil with disk and harrow. It may be plowed under, particularly where the land is disked before plowing, but for most satisfactory results the lime should be well mixed with the soil. Top dressing is recommended only in the case of permanent pastures or meadows, in which case the loose, porous nature of the sod allows the lime to wash into the soil much better than on other lands.

The fall is usually the best time to apply lime since the roads are generally best at that time and the soil is not likely to be wet. There is also more leisure of men and teams at that season. Where wheat is grown, lime can well be applied on land prepared for this crop. Little return must be expected on the wheat but the clover crop following should be greatly benefited, assuming of course that the soil needs liming, that it is sufficiently fertile to grow clover and that it is well drained. It may be applied, however, at any time when the land is being prepared for a crop. If the land is plowed and then leveled by a disk or drag harrow before scattering the lime, the working in of the lime may serve as the final preparation of the seedbed. It is unfortunate that it must be scattered on loose land for best results, since this necessarily increases the cost of spreading, but it is the most satisfactory way. It may be scattered on stubble land and thoroly disked into the surface before plowing, but if the mixing of the lime with the soil is thoroly done it will be practically as expensive as where it is spread on plowed land.

Lime should be applied with a lime spreader, several kinds of which are now on the market.[1] These spreaders broadcast a strip from six to ten feet, depending on the size, and the spreading is done evenly. They may be hitched behind the wagon and the lime shoveled into the hopper from the wagon box or they may be filled at intervals and handled as a drill. As this is an implement which is used but a very few days during the year it is best for several farmers in a neighborhood to buy one in cooperation.

A manure spreader may be used for spreading lime by throwing some manure or dirt in the bottom or by tacking canvas over the apron to prevent the lime sifting thru. The apron must be run slowly and only a thin layer of lime allowed to come in contact with the beater.

[1]Lists of companies handling ground limestone and lime spreaders will be furnished on application to the College of Agriculture.

Where a canvas is used the lime may be piled in the front end of the spreader and then worked down into a thin layer as the spreader proceeds. Experience only will determine the proper speed of the apron and the thickness of the layer of lime in the spreader. Endgate seeders are sometimes used, but they are not very satisfactory, particularly if the lime is fine and dry.

A fertilizer attachment on a grain drill may be used for applying limestone but unless the amount to be applied per acre is small this method is slow. Few drills will handle more than 500 pounds per acre so that the ground must be gone over more than once. Some drills having larger capacities have been placed on the market recently but where much lime is required a lime spreader is to be preferred. The drill has the advantage of drilling the limestone into the soil but further mixing is necessary if the work is properly done.

It is possible to build homemade lime spreaders at a moderate expense. All that is necessary is a good sized hopper mounted on substantial wheels with a shaft passing lengthwise thru the hopper. This shaft should bear agitators which stir the lime out of holes in the hopper bottom. The rate of spreading can be regulated with a slide which opens or closes the holes.[1]

It has been found that all lime spreaders are influenced by the wetness of the limestone. Very wet stone is often difficult to spread. Where farmers grind their own stone it is often found advantageous to spread the limestone as fast as it is ground and not allow it to get wet before spreading. Limestone which is shipped in is best handled in closed box cars and it should be spread as the car is unloaded. If possible the work should be arranged so that two teams haul while one spreads the limestone in the field.

Lime may be scattered by hand satisfactorily if the area to be covered is small, but for large areas hand scattering is too expensive It may be scattered with a shovel from a wagon if the limestone is not too fine and dry. It may be hauled to the field, dumped in piles and then scattered from the ground. Two hundred pound piles approximately fifty feet apart each way will give about two tons per acre.

MISSOURI LIMESTONE SUITABLE FOR AGRICULTURAL PURPOSES

The increasing interest shown in the grinding of limestone for agricultural purposes, particularly by individual farmers and groups of farmers, makes it important that information be supplied as to the

[1]The College of Agriculture has prepared a complete description of a homemade spreader and this will be sent on application.

location in Missouri of suitable limestone outcrops. There is no doubt that the grinding of limestone is to become a very important industry. At present there are fewer than a dozen companies in the state supplying ground limestone in quantity for agricultural purposes. An extension of home grinding would result in a more widespread use of this material and doubtless would decrease the cost to the individual farmer.

Missouri contains great deposits of high grade limestone that lend themselves ideally to grinding. The wide range of geological formations which have the proper chemical composition for making agricultural lime affords an inexhaustible supply of raw material so situated as to be available for economic production. There are few counties in Missouri that are entirely lacking in limestone formations, altho many of the rock strata in the southern part of the state are not well suited for development. Missouri is the largest producer of lime among the states west of the Mississippi river, and the state is excelled in lime production by only five others. This large production indicates the possibilities in supplying ground limestone, for in general limestone that is suited for the making of lime for the trades is also adapted for use in agriculture.

The quality of limestone varies both chemically and physically, within wide limits. Consequently only those limestones should be used that are relatively pure carbonate. It is the lime and magnesium carbonates that possess the alkaline properties for neutralizing the soil acids. The impure limestones contain more or less material other than carbonates, such as iron compounds, silica and clay. These impurities when present in sufficient amounts give rise to cherty or flinty limestones, to argillaceous or clayey limestone, and others, depending on the amount and character of the impurity present.

The composition which a limestone should have for making good ground limestone for agricultural purposes, depends somewhat on conditions, but in general it may be stated that more than ten per cent of impurity is objectionable, except in special cases. The greater the proportion of impurity, the greater is the amount of stone required in order to produce a given amount of calcium and magnesium carbonate. Thus, a ton of pure limestone will produce one ton of carbonate, but to produce a like amount from a stone only 80 per cent pure, would require the pulverizing of one and one-fourth tons of the material. The greater cost of quarrying, grinding, hauling and applying the impure stone is at once apparent. In those regions where only the relatively impure limestones are available, however, their use even

at the increased cost of handling may be more economical than the use of the higher grade material which must be shipped in at a considerable cost in freight. This is a matter which must be determined locally. High grade stone contains 95 per cent or more of calcium carbonate, or its equivalent in combined calcium and magnesium carbonates; medium grade contains 85 to 95 per cent; low grade 75 to 85 per cent. and inferior grade under 75 per cent.

A large amount of limestone in Missouri is of high grade, and considered from an agricultural viewpoint, it constitutes one of the most valuable resources of the state. While most limestones contain the carbonate largely in the form of calcium carbonate, which is usually considered the most desirable form for agricultural purposes, many of them contain greater or less quantities of magnesium carbonate also. The rocks now being ground for agricultural purposes in Missouri are almost entirely high calcium stones but as shown in the accompanying map a large part of the limestones of south Missouri are high in magnesium. So far as soil sweetening is concerned, the magnesium carbonate is not objectionable[1] and limestones may contain almost one-half the carbonate in the form of magnesium carbonate, as in the case of the true dolomites, and still be ground for agricultural purposes. The application of very large quantities (five tons or more) of magnesium carbonate is not considered desirable on most soils, however, so that the high calcium stones are generally preferred, except on soils which are naturally low in magnesium.

As far as its physical properties are concerned, any kind of limestone is suitable for agricultural lime. Fine-grained, dense stone is as valuable as the coarsely crystalline stone, provided the purity is the same. Evidently one of the first points to be considered in the manufacture of ground limestone is the selection and opening of a suitable deposit. It should be ascertained that the quality is reasonably uniform thruout the deposit and that a sufficient quantity of stone is above drainage level, so that the quarry floor will not be continually under water. Transportation facilities and other details of similar importance should be carefully considered.

The various limestone formations occurring in this state differ widely in chemical composition and physical characteristics. Their

[1]Chemically considered, magnesium carbonate is slightly more effective than calcium carbonate as a neutralizing agent, one part of magnesium carbonate being equivalent to one and nineteen hundredths parts of calcium carbonate. One hundred pounds of stone containing sixty-five per cent calcium carbonate and thirty per cent magnesium carbonate with five per cent impurity would actually have a neutralizing power equal to one hundred pounds of pure calcium carbonate.

value, however, depends not only upon their chemical composition, but upon their thickness, location, the quantity of stripping necessary and their general accessibility. In the succeeding paragraphs is given a general description of the major groups of limestones occurring in Missouri, which are suitable for agricultural purposes. No attempt is made to describe each formation occurring in the several groups, and only such characteristics are given as will assist in determining the general utility of the strata under consideration. For a detailed report on the limestone resources of Missouri the reader is referred to Volume II, Second Series, of the publications of the Missouri Bureau of Geology and Mines, Rolla, Missouri.

Figure 6 shows the general distribution of the major groups of limestone formation suitable for the manufacture of agricultural lime.[1]

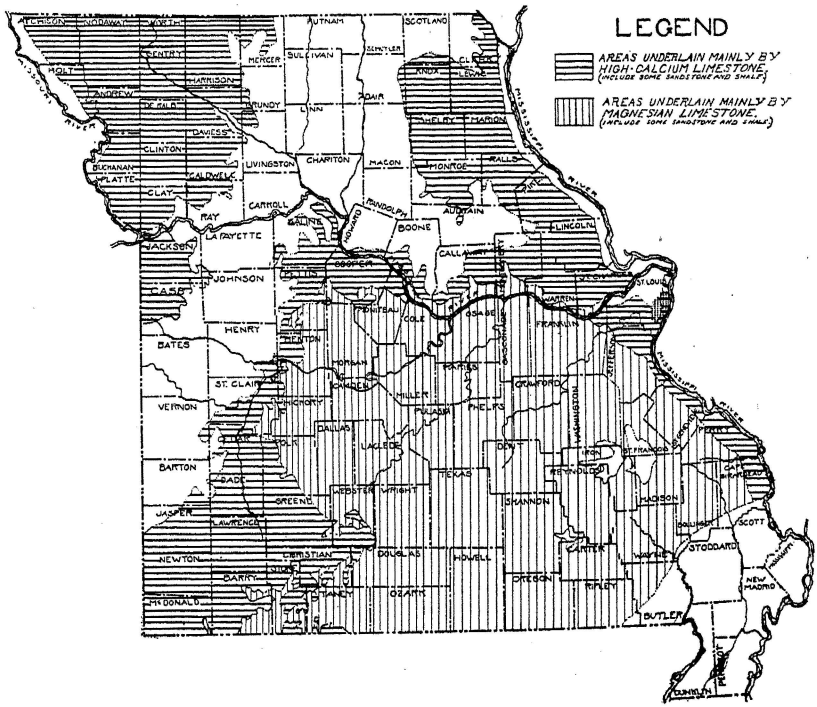

Fig. 6.—Map of Missouri showing the areas underlain mainly by high calcium and by magnesian limestone.

[1]State Geological Map. Published by H. A. Buehler, State Geologist, Rolla, Missouri.

LIMESTONE OF NORTHWEST MISSOURI

THE UPPER COAL MEASURES

The Upper Coal Measures (Missourian) of the Pennsylvanian series contain very large quantities of high grade limestone. This formation underlies the greater part of northwest Missouri, including all the territory west of a line drawn from near the central part of Cass county to the northwest corner of Mercer county. The strata composing it have a total thickness of more than twelve hundred feet, and consist of interstratified limestone and shale, with occasional beds of sandstone. The beds of the former vary in thickness from a few inches to fifteen or twenty feet, with occasional beds of greater thickness. In general, the thicker beds underlie the shale and sandstone and are most exposed in Jackson, Platte, Clay, Buchanan, Clinton, Caldwell, Daviess, and Mercer counties. Only a few of the more important and thicker beds have been named. Of these, the most widely exposed is known as the Bethany Falls limestone. It can be traced from Cass county north to the Iowa line. It is rather pure and well suited for ground limestone. The Iola, Dennis and Mound Valley limestones, exposed in Jackson county, and numerous other limestone ledges outcropping thruout the northwestern part of the state, have sufficient thickness, as well as the correct composition, for use in the manufacture of agricultural lime. More than one hundred limestone quarries are found in the region of the Upper Coal Measures in northwest Missouri. The greater proportion of these are producing stone of such purity that it would be well adapted for agricultural lime.

The thick deposits of glacial drift and loess occurring in this region often make good stone inaccessible. In general, it is in the bluffs bordering the larger stream valleys and the Missouri river in the southern part of the Upper Coal Measure area, that the limestone ledges are exposed. Where no bluffs occur, the necessity of removing (stripping) the thick beds of soil overlying the limestone adds so much to the cost of quarrying usually to make it impracticable.

LOWER COAL MEASURES

The region occupied by the Lower Coal Measures is a rather irregular belt of varying width, extending from Jasper county in a northeasterly direction to the Iowa state line. It consists mainly of shale and sandstone with comparatively thin and unimportant interstratified beds of limestone. The latter are rarely exposed and with few exceptions are too thin and impure to warrant exploitation.

LIMESTONES OF SOUTHWEST, CENTRAL AND NORTHEAST MISSOURI

The most extensive and by far the most important region of high grade limestone in Missouri extends from the southwestern part of the state in a northeasterly direction to the Missouri river, where it turns eastward and finally spreads out covering the eastern portion of the state both north and south of the river. (See Fig. 6) The several formations occurring in this region consist mainly of limestone and are known as the Mississippian series. A small disconnected area occurs along the eastern edge of St. Genevieve and Perry counties. The Mississippian limestone is mostly high calcium stone and is the most suitable for the manufacture of ground limestone to be found in the state. Much opportunity exists for developing local crushing plants.

The most important formation of this series is known as the Burlington limestone. It has a maximum thickness of 350 feet and is the surface rock over the greater part of the area occupied by the Mississippian series. It is identified by its coarsely crystalline and fossiliferous texture and white to buff color. Varying amounts of chert (often incorrectly called flint, which is black) occur thruout the formation, either in layers or scattered thru the rock, but when quarried this is easily separated from the limestone. This stone is exceptionally free from impurities, and the ledges which are quarried contain from 90 to 99.5 per cent of calcum carbonate.[1] Excepting in portions of northeast Missouri, this limestone is usually covered with a slight amount of stripping and can be quarried with comparative ease.

The St. Louis limestone has its maximum development in St. Louis county, but it also occurs in the northeastern part of the state and in St. Genevieve county. The formation consists of thin to heavily bedded, fine grained, white to gray-colored limestone. The content of calcium carbonate varies from 70 to 95 per cent, which would indicate that much of this formation is suitable for use in the preparation of ground limestone.

Several other formations of the Mississippian series, such as the Chouteau and Louisiana limestones consist dominately of calcium carbonate, but on account of their limited distribution, and because they are generally associated with the Burlington limestone, they are of comparatively little importance. For the most part these formations outcrop in the eastern part of the state and along the Missouri river between Warren and Cooper counties. On account of their varying

[1]Buehler, H. A. Lime and Cement Resources. Missouri Geological Survey, Vol. VI. Second Series, pp. 233-239

thickness and irregular distribution their fitness for utilization must be determined locally.

Thruout the region of occurrence of the Mississippian limestones, outcrops of ledge rock are numerous, and as a rule are accessible and easily quarried. In fact, in the more broken parts of this region there is hardly a square mile of territory that does not have ledges of stone that could be utilized for manufacturing agricultural lime. Even the development of the many quarries, now used for the production of coarse building stone, could be made to produce an unlimited supply of crushed limestone. Large quarries are located in Lincoln, Greene and Jasper counties, but possibilities for similar development are found thruout the belt of Mississippian rock.

LIMESTONES OF SOUTHEAST MISSOURI

The relatively pure limestones of the extreme eastern part of the state south of St. Louis county can supply an unlimited amount of material for ground limestone. They belong to a wide range of geological ages, but they are much alike in being rather pure, chert-free limestones. Their total thickness is several hundred feet, and they are therefore present in sufficient quantity wherever they occur to warrant working.

These formations lie along the eastern edge of the Ozark Region extending from the Missouri river in the western part of St. Louis County southward to the lowlands of Cape Girardeau county. They also are exposed in the eastern part of Lincoln, Pike and Ralls counties in the northeastern part of the state, and the southern parts of St. Charles and Warren counties.

In color these limestones vary from gray to blue, and in texture from coarse grained to fine grained. Probably the most important formations of this series are the Kimmswick and Plattin, formerly called the Trenton limestone. They vary from coarsely crystalline to fine grained, while occasional beds contain chert nodules. The purity of the formations and the thickness of the exposed ledges fit them for the manufacture of ground limestone. They are extensively quarried in St. Louis and Cape Girardeau counties for the manufacture of lime and building stone.

LIMESTONES OF THE OZARK REGION

The limestones of the Ozark Region are almost entirely magnesian stones, the amount of magnesium carbonate varying from a

few per cent to as high as forty per cent. They are available at almost any place along the streams or by stripping the overlying material which varies in thickness according to the region. In most places away from the streams the covering is too thick to warrant stripping. The varying composition of closely associated beds makes it impossible to state the value of these stones for agricultural purposes, without an examination of the individual ledges.

Figure 7 shows the distribution of some of the larger limestone quarries in the state, the total number being approximately two hundred and eighty. The majority of these are quarrying relatively pure rock.

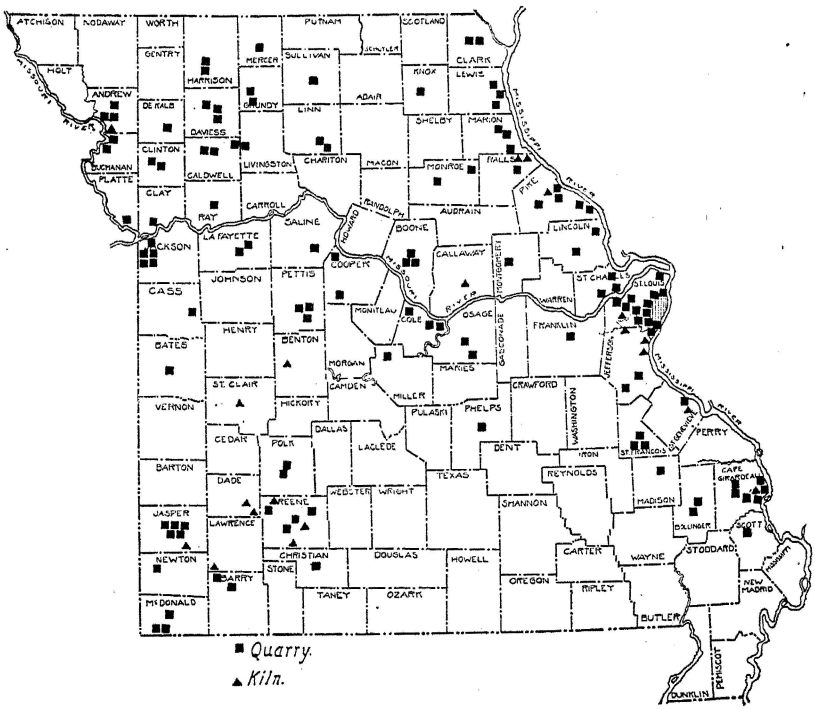

Fig. 7.—Map of Missouri showing the location of limestone quarries and kilns. (Compiled from reports of U. S. Geological Survey.)

SUMMARY

1. Approximately two-thirds of the samples of Missouri soils examined have shown a greater or less need of lime. About one-fourth of these have shown a lime need of two tons or over in the acre seven inches.

2. The satisfactory production of red clover or alfalfa may be taken as an indication that a soil is in no serious need of lime, altho not all clover or alfalfa failures are due to a lack of lime in the soil.

3. The kind of lime to apply depends principally upon the cost. In determining this matter it must be remembered that it is the applied cost per unit of soil sweetening power that is the important consideration. As a rule in Missouri, ground limestone is the cheapest form to apply.

4. Limestone can be ground by portable grinders at a moderate cost per ton. In regions more than three or four miles from the railroad this means of securing ground limestone is often most economical.

5. The finer a limestone is ground the more active it is in soil sweetening, but since the cost increases with the fineness of grinding, a fineness that will allow the material to pass a ten-mesh sieve may be considered a standard grade. The coarser the material the larger the application required for immediate results.

6. The amount of limestone to apply depends primarily upon the needs of the soil and the quality and fineness of the stone, but the usual application is from one and one-half to two and one-half tons per acre. Applications of one and one-half to two tons of a good grade of stone once in four to six years would be considered reasonable on soils showing enough acidity to seriously affect the growth of clover.

7. Lime is best applied with a lime spreader on land plowed for a crop, allowing the preparation of the seedbed to work it thoroly into the surface four or five inches. It may be plowed under if it is disked into the surface soil before plowing.

8. Missouri has much limestone suitable for agricultural purposes. The most extensive region of high grade, high calcium stone extends from Southwest Missouri in a northeasterly direction to the Missouri river, spreading out and covering the eastern part of the state both north and south. The Ozark limestones contain much magnesium, and while these are not usually considered so desirable as the high calcium stones they are yet very satisfactory for agricultural purposes.