Agricultural Experiment Station

OF THE

University of Tennessee

BULLETIN NO. 119 DECEMBER, 1917

GROUND LIMESTONE AND PROSPERITY ON THE FARM

BY

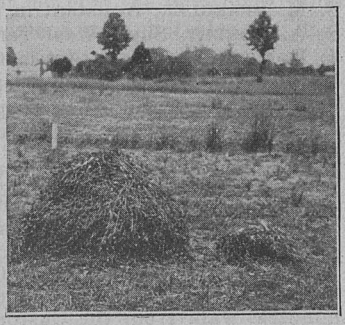
C. A. MOOERS

CLOVER HAY FROM EXPERIMENTAL PLOTS, KNOX COUNTY



LIMED UNLIMED

WITH FERTILIZER



LIMED UNLIMED

WITHOUT FERTILIZER

KNOXVILLE, TENNESSEE

The Agricultural Experiment Station
OF THE UNIVERSITY OF TENNESSEE

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The Experiment Station building, containing the offices and laboratories, and the plant house, are located on the University campus, 15 minutes' walk from the Custom House in Knoxville. The experiment farms, the barns, stables, dairy building, etc., are located one mile west of the University, on the Kingston Pike. The fruit farm is adjacent to the Industrial School, and is easily reached by the Lonsdale car line. Farmers are cordially invited to visit the buildings and experimental grounds.

Bulletins of this Station will be sent, upon application, free of charge, to any farmer in the State.

GROUND LIMESTONE AND PROSPERITY ON THE FARM

INTRODUCTORY

For the past twelve years the Tennessee Agricultural Experiment Station has conducted experiments in all parts of the State to determine the value of liming. In these experiments a wide variety of crops has been used, from legumes with high lime requirements, such as alfalfa, to non-legumes, with low lime requirements, such as cotton and sweet potatoes. In addition, the effects of liming on the nitrogen and humus contents of the soil have been carefully investigated. The purpose has been to find out not only the immediate value of liming in crop production for the various soils, but also the final effect on the soil itself. This was especially important in view of the widespread belief that liming, though profitable for a time, results in a loss of soil fertility. The evidence obtained has shown both that liming is generally profitable in all divisions of the State, and that, at least so far as ground limestone is concerned, there need be no fear of harmful after-effects, but that on the contrary a permanent increase in fertility is to be expected.*

Since a large part of the experimental work has been done with ground limestone, the use of this material applied at the rate of 2 tons per acre may be assumed by the reader, unless otherwise specified.

The writer wishes to place especial emphasis upon the fact that throughout the bulletin the aim is to give a true impression of the value of liming under practical conditions. The results are believed to be representative of the various soils and crops, and not in any sense exceptional in nature.

* See Bulletin 118, pp. 147 and 148.

RESULTS OF FIELD EXPERIMENTS

LIMING VERY BENEFICIAL TO ALFALFA AND THE CLOVERS

The effect of liming on alfalfa has been especially marked. In fact, the getting of a profitable crop without liming is so unusual as to attract attention. This exceptional case is found in all parts of the State, but is generally limited to a small area, and may not prove a trustworthy indication for the surrounding district. In five series of experiments, on representative soils in different sections of the State, the average yield with lime was 3.13 tons per acre of cured hay, but without lime only 1.16 tons. These results were obtained the first season after seeding. As a rule the unlimed alfalfa is more or less smothered out the second year by crab grass, whereas the limed alfalfa is then at its best.

Red and alsike clovers are very sensitive to a deficiency of lime, though not to the same extent as alfalfa. In eleven series of experiments the average yield of clover hay on common soils of East, Middle, and West Tennessee was 2.31 tons per acre with lime, but only 1.48 tons, mixed with weeds, where no lime was used.

White clover, so far as the writer's observation goes, can be classed with red and alsike in lime requirement. Crimson clover, on the other hand, may be benefited by liming, but responds less than any other kind.

LIMING FOR CORN, WHEAT AND OTHER GRAINS

Numerous experiments have been made to determine the effects of liming on both corn and wheat under common farm conditions. The results show a marked and rather uniform increase in yield from liming. In twelve series the average yield of corn was 36.5 bushels per acre where limed, but where unlimed, the average was only 30.8 bushels. Some of the experiments were carried out for several years, and the favorable effects continued from year to year. At the Ford farm, in Knox County, plots which received 6 tons of manure every other year gave, in eight years of continuous cropping in corn, a total yield of 279 bushels per acre. In the same period, and under the same conditions, except that an application of 2 tons per acre of ground limestone was made at the outset, adjoining plots produced 350 bushels per acre, or a gain of 71 bushels. At 75 cents per bushel, the value of the increase was $53.00 for the eight-year period. At the present war price of $1.25 per bushel the value of the increase would be $88.75. In this case the increased yield was above the average, but the writer wishes to emphasize the fact that

the good effects of liming are not limited to the first year or two after the application.

The actual increase in bushels per acre for wheat on limed land is not so great as for corn, but the percentage increase is about the same. Seventeen series of experiments conducted on various types of soil show an average yield of 16.8 bushels per acre on the limed plots, and 14.0 bushels on the unlimed, or an increase of 20 per cent due to liming. Of course the fertilizers used and the time of seeding were the same in each case; that is, every precaution was taken in these, as in all the experiments cited, to make the conditions the same except as to the one condition of lime as compared with no lime.

LIMING FOR FORAGE CROPS AND GRASSES

Both forage crops and grasses have been included in the experiments. The average yield of thirteen series with soy beans was 1.78 tons of cured hay per acre under liming, and 1.45 tons without lime. The average of eight series with cowpeas was 1.13 tons of hay per acre under liming, and 0.85 ton without lime. Both of these crops have shown a ready response to liming. In fact, land that will produce them equally well whether limed or unlimed is exceptional, and is limited chiefly to the most fertile soils. This exception naturally applies also to other crops, such as corn, wheat and grass.

Experiments with the common cultivated grasses, such as orchard, tall oat, Kentucky blue grass, timothy, and red top, have been made in different parts of the State. The results have shown that the first four grasses usually respond to liming, which may even be essential to their successful culture. Red top, however, may thrive without liming where the others fail.

LIMING FOR GARDEN CROPS

A plentiful supply of lime is important to most garden crops, among which beets, lettuce and asparagus may be mentioned in particular. Tomatoes and peppers have been moderately helped by liming in our experiments, while watermelons, sweet potatoes, and a few other crops appear indifferent to such treatment. It should be mentioned that the long-continued and heavy manuring practiced by many gardeners would be expected to take the place of liming so as to render it in most instances unnecessary for garden crops.

THE DURATION OF THE EFFECT OF LIMING

The effect of even a moderate liming lasts for a number of years. In our experiments appreciable increases in crop yields from a single application have continued for at least eight years. At the West Tennessee Station, at Jackson, in a five-year general-farm rotation a single application of 2 tons per acre of ground limestone gave, in the next eight years, the following increases:

Crops	Increase per acre from one liming	Value per unit	Calculated value of increase
2 crops of cowpea hay	0.92 ton	$12.00	$11.04
2 crops of wheat	6.10 bu.	1.00	6.10
2 crops of clover hay	2.29 tons	12.00	27.48
1 crop of cotton	46.00 lbs. (seed cotton)		2.50
1 crop of corn	6.10 bu.	.75	4.58

Total value of increase for eight years, as compared with adjoining unlimed plots $51.70

At present war prices the total value of the increase would amount to over $75.00.

At the Knoxville Station the increased yields from a single application of burnt lime, applied at the rate of 1 ton per acre, resulted in the following increases during the course of the next ten years:

Crops	Increase per acre from one liming	Value per unit	Calculated value of increase
2 crops of corn	4.90 bu.	$ .75	$ 3.68
2 crops of wheat	2.00 bu.	1.00	2.00
2 crops of clover and grass	1.50 tons	12.00	18.00
2 crops of soy-bean hay	0.28 tons	12.00	3.36

Total value of increase for ten years, as compared with adjoining unlimed plots $27.04

In connection with the latter series it should be noted that moderate and equivalent applications of farmyard manure and commercial fertilizers were made both to the limed and unlimed areas. The soil was a fertile brown-colored loam. Even under these conditions, which were favorable to good crops without liming, liming proved highly profitable and the effects were evident throughout the ten years.

THE IMPORTANCE OF LIMING IN SOIL UPBUILDING

To build up a soil poor in lime without the aid of liming is an especially difficult task for several reasons. One reason is that the greatest of all soil-improvement crops, red clover, cannot be satisfactorily grown where lime is deficient. With the aid of ground limestone, clover would be found to flourish on farms where it has long been a stranger. On many other farms where clover now makes but meager growth or is lacking somewhat in color and thrift, liming would cause it to grow luxuriantly. Grasses of all kinds grown with clover do better the second year than those grown without clover, and a good grass sod means a mellow, friable soil, capable of producing a first-class corn crop. It has already been shown that liming increases nearly all farm crops. This means that larger residues of vegetable matter are left in the soil and that as a result soil fertility is conserved for the crops that follow. There is one precaution neces-

sary, however, and that is that we bear in mind the fact that liming does not take the place of either phosphate or potash, so that a soil deficient in one or both of these fertilizer elements should have the deficiency supplied the same as if no lime were used. On the other hand, liming increases the soil supply of available nitrogen, especially by increasing the growth of legumes, as the experimental data amply show. If the leguminous crops be either pastured off or made into hay which is fed on the farm, and the manure saved and returned to the land, the increase in fertility should be very material.

NEED OF LIME FOR VARIOUS TYPES OF TENNESSEE SOILS

INDICATIONS OF THE NEED OF LIMING

The growth of red clover is perhaps as good an indication as any of the need of lime. If this crop cannot be grown satisfactorily, producing from 2 to 3 tons of cured hay per acre, when aided by fertilizer and a light dressing of manure, the need of liming is strongly indicated. So accustomed are many farmers to a soil poor in lime that they do not seem to realize that a 2-to-3-ton crop can be expected on a well-limed soil of fair fertility. "Sour dock" and "poor Joe" are common weeds on soils needing lime. Through liming they are largely crowded out, and become less noticeable. A light green color in either cowpeas or soy beans generally means lime deficiency.

SOIL TESTS

Of the soil tests that are sometimes advocated, the old litmus test seems about the most reliable. If the blue litmus paper when dipped into a paste of soil and pure water soon turns red, the need of lime is indicated.

SOILS OF EAST TENNESSEE

The soils of East Tennessee are chiefly of limestone origin. Even the shale, or slate, which produces the so-called slaty soils, contains an appreciable quantity of lime. East Tennessee soils, however, regardless of origin, analyze poor in lime, practically no carbonate, the form found in the limestone rock, being present. However, there is a difference in the extent to which the different soils respond to liming. In general the brown or chocolate-colored soils need lime less than either the gray or the yellowish-colored soils. It is a common occurrence in the experimental work to find long-cultivated soils which at one time produced excellent crops of red clover but which now require liming in order to make this crop a success. In fact, it may be assumed for practically all uplands long in cultivation and much depleted in fertility, or "worn out," that liming will prove highly beneficial.

SOILS OF THE CUMBERLAND PLATEAU

The soils of the Cumberland Plateau are especially poor in lime, so that liming is profitable from the outset on the newly cleared land. It should be considered one of the first essentials to the successful farming of this promising section.

SOILS OF THE HIGHLAND RIM

Generally speaking, the Highland Rim soils are in need of liming. Even on the best of the brown, or mulatto-colored, soils, such as are found in Franklin County, it has been amply demonstrated that liming is required in order to produce alfalfa successfully. Also soils of this type which at one time yielded excellent crops of red clover



TALL OAT GRASS AND RED CLOVER ON LIMED LAND AT CLARKSVILLE TOBACCO STATION—LAND UNSUITED TO CLOVER WITHOUT LIME

are now often found to require lime in order to make clover a success. The gray lands of the Barrens type are naturally very poor in lime, which has repeatedly been found, in the Station's experiments, to be helpful to practically all crops.

SOILS OF THE CENTRAL BASIN

The soils of the Central Basin are less apt to require liming than are those of any other large area in the State. However, numerous trials have convinced the writer that liming will prove profitable on the majority of the uplands in the Basin. Not only is the seeding of alfalfa on unlimed land rarely advisable, but as a rule, in our cooperative experiments, the yield of red clover has been materially increased by liming. Recent experiments at various points

on the red-colored soils of Rutherford County have uniformly shown an increased yield of soy beans under liming, with indications that other crops will respond in a similar manner.

SOILS OF WEST TENNESSEE

The soils of West Tennessee, though not of limestone origin, except along the eastern border, are about as well supplied with lime as are the average soils in the other portions of the State. In certain places, such as the rich alluvial lands of Lake County and the rich lowlands of Obion County, alfalfa is grown successfully without the aid of liming. If, however, the soils at the Jackson Station be taken as representative of West Tennessee, liming is fundamentally im-



RED CLOVER AND TALL OAT GRASS ON LIMED LAND AT JACKSON STATION —YIELD 3 TONS CURED HAY PER ACRE—LAND UNSUITED TO CLOVER WITHOUT LIME

portant. At that Station liming proved essential to the getting of both alfalfa and clover, and greatly increased all the common crops, with the possible exception of cotton. Even the growth of Japan clover was found to be appreciably increased by liming. Recent experiments conducted by the Station on the demonstration farm of the Nashville, Chattanooga & St. Louis Railway at Martin confirm the results obtained over a period of nine years at Jackson.

THE HOME-GRINDING OF LIMESTONE

GENERAL CONSIDERATIONS

Since limestone of good quality is well distributed over both East and Middle Tennessee, and is also found along the eastern border of West Tennessee, the matter of grinding it either on the farm or within easy hauling distance has aroused considerable interest among the farmers. Undoubtedly local grinding is the best practice wherever the freight or the distance from the nearest railroad siding makes the cost of transported material excessive. On the other hand, proximity to a mine or quarry which produces ground rock as a by-product, may make home-grinding uneconomical.

A number of firms are manufacturing small portable limestone grinders which do excellent work. The prices of these small machines vary at present from $260.00 to $750.00, or more. Naturally the higher-priced machines possess advantages over the lower-priced. The latter may, however, be used to advantage in some instances because of their low first cost, especially if only a moderate acreage is to be limed.

The cost of home-grinding varies considerably—according to reports received, from 75 cents to $1.50 per ton. In many instances, however, little or no allowance has been made in the estimate for interest on the investment and wear and tear of machinery.

FINENESS OF GRINDING

The best degree of fineness to which the rock may be ground in practice has not been determined. About all the guide we have is the practical guess or opinion of those who have had experience and have given thought to the matter. At present the Station is advising that the rock need be ground no finer than will pass through a ¼-inch-mesh screen; that is, the coarsest particles may be in the neighborhood of ¼ inch in size and the rest from that to "flour." A fair condition for ground limestone is as follows:

Size of sieve	Per cent retained
20-mesh*	26
40 "	28
60 "	12
80 "	6
100 "	3
Total	75

* This refers to a sieve having 20 square openings to the linear inch.

This leaves 25 per cent of material fine enough to pass through a 100-mesh sieve.

As demonstrated in our rate-of-liming experiments, a 2-ton application of high-grade limestone of this grinding has proved ample for alfalfa, which seems to have the highest lime requirement of all

farm crops. There is no doubt that the finer the particles the greater is the immediate efficiency. On the other hand, the coarse particles, while being slowly reduced in size, will remain longer in the soil than the finer ones, and a heavy application will do away with the necessity of frequent though light applications of a flour-like material, which can be obtained, though at greatly increased cost. Some practical farmers even prefer to make an extremely heavy application, of 15 tons or more to the acre, of a coarsely but cheaply ground rock with a view to liming only once in a lifetime.

QUALITY OR GRADE OF ROCK

Although some variation is found in the quality, or degree of purity of Tennessee limestones, a rock of good grade (90 per cent or more) is within the reach of nearly every community in the limestone sections of the State. Low-grade rock is apt to be undesirable, not only because of increased cost in grinding—estimated by one company manufacturing grinders as 1 cent per ton increase in wear and tear of machinery for each 1 per cent of impurity—but also because of less ready solubility in the soil and the increased application which the low grade necessitates. However, conditions may be present which justify the use of a rock of very low grade. Since the grade of a rock is not always known and cannot be told by inspection, the safe plan is to have it analyzed before grinding. This is especially advisable in a section like East Tennessee, where choice may be had of several kinds of rock within easy hauling distance.

THE VALUE OF DOLOMITE

Since dolomite, or magnesian limestone, is a common formation in East Tennessee, the question as to its value for liming purposes is important. This Station has made some field experiments with dolomite furnished by the American Ballast Co. The product averages about 50 per cent calcium carbonate and 38 per cent magnesium carbonate. In these experiments, which were made with alfalfa on a soil much in need of lime, the dolomite gave fully as good results as the high-grade marble used for comparison. In experiments made at other stations dolomite appears to have been nearly or quite the equal of the common calcium limestone. There appears therefore no reason why dolomite should not be recommended.

OTHER FORMS OF LIME THAT MAY BE USED

Burnt lime, or its close relative, hydrated lime, and wood ashes, have been used extensively in liming. The latter material contains some readily soluble potash, to which popular impression attributes almost its whole worth. However, it is valuable on Tennessee soils largely because of its lime content, which varies from 25 to 40 per cent and is, roughly, equal to twice these amounts of ground limestone.

A few years ago "liming" meant applying burnt lime. One ton of this material is practically equal to two tons of ground limestone, but if immediate availability be considered it must be rated much higher than that. Burnt lime is expensive and troublesome to apply, and a heavy application may result in some waste of soil organic matter, including nitrogen. Under some circumstances its use may be advisable, but the ground rock, on account of its keeping qualities and ease of handling, as well as its cheapness and efficiency, has nearly everywhere displaced the burnt lime.

Hydrated lime is made by treating burnt lime with steam. The product contains about 22½ per cent of combined water, but is in a fine powdery condition, which fits it for immediate use on the lawn, garden or field. It is practically the same thing as burnt lime so far as effects on crops and soil are concerned.

HOW AND WHEN TO APPLY GROUND LIMESTONE

Several makes of distributors which handle ground limestone are on the market, and though none is beyond criticism, their use is advisable under general farm conditions; that is, they reduce the labor and make a more even distribution than can be got otherwise. The manure spreader may be used, but is not considered equal to the special distributor. Ground rock can, however, be satisfactorily spread by hand, so that the small farmer need not buy a distributor. Perhaps the best plan is to throw out the limestone in small heaps and then scatter it. This method helps to get a definite quantity to the acre and is an aid to even distribution. Forty-pound heaps 21 feet each way make 2 tons per acre.

Ground limestone may be applied at any season of the year, and for any crop, to suit the convenience of the worker. The main thing is to get it on the land. It is, of course, especially desirable previous to clover rather than to cotton, for example. To insure full benefit, the application should be well mixed with the soil. A good plan is to apply to unplowed ground, disc well into the soil, and follow with the turn plow.

CONCLUSION

After diligent study for many years the writer has reached the conclusion that even under conditions which existed prior to the war liming offered more immediate and greater rewards to the Tennessee farmer than any other simple resource at his command. Under present war conditions this possibility has been greatly increased, and full advantage of it should unhesitatingly be taken.