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LIME FOR ALABAMA SOILS

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LIME FOR ALABAMA SOILS

BY J. F. DUGGAR AND M. J. FUNCHESS

HOW LIME ACTS.

Soils that are deficient in available lime compounds, may be greatly benefited by the application of lime. Whatever favorable results follow the use of lime may be due to one or more of its several beneficial effects. Lime may increase the productiveness of a soil by any of the following means:

(1) By overcoming a sour condition in acid soil.

(2) By making more available the mineral plant food in the soil.

(3) By improving the physical condition, or texture, of the soil.

(4) By serving as a plant food.

Correcting the acidity of the soil. Practically all farm crops are less thrifty in a sour or acid soil, and make their best growth in one that is neutral or slightly alkaline. In case the plant itself is not directly injured by this acidity it may be indirectly affected unfavorably by an acid condition. Hence, the prime object in liming a soil is to overcome or prevent an acid or sour condition in that soil. Examples of plants which are affected both directly and indirectly by lime are most leguminous or soil-improving plants. Most of these are very sensitive to acidity, and make a very poor growth in sour soils. While these plants themselves are so greatly affected by this acidity, the bacteria that form beneficial enlargements on their roots are probably still more sensitive to this harmful condition. Under favorable conditions the bacteria attack root hairs of the legumes, forming nodules or tubercles; and through the action of these nodule-forming bacteria this type of plant is able to make use of the free nitrogen of the air. The growth of the legume, then, is one great factor in the building up of the soil, especially in maintaining the supply of nitrogen. Now, if the legumes and their co-operating bacteria are both so much injured by a sour condition, this acidity should

certainly be overcome or prevented by the use of lime in some form.

There is a second very important group of bacteria living in the soil, the development of which is greatly retarded by acids. When cotton seed meal, dried blood, tankage, barnyard manure, and pea vines are plowed into the soil, they must first be fermented, or decomposed, before their contained nitrogen is made available to plants. This fermentation is caused by a number of groups of bacteria in the soil. In the presence of small amounts of acid, their desirable activity is retarded or even stopped. Hence, if the farmer is to get full returns for his organic fertilizers or barnyard manure, the soil to which these are added must not be sour. If it is sour, the evil must first be remedied by the use of some form of lime.

Still a third more or less important group of soil bacteria is also affected by the reaction of the soil. This is the type of nitrogen-fixing bacteria, which, unlike the legume bacteria, do not need any host plant. If supplied the necessary food and the proper conditions for growth, these bacteria have the power of using the free nitrogen of the air, thereby actually increasing, to at least a slight extent, the store of nitrogen in the soil. In the absence of lime compounds to neutralize acidity, if present, these organisms fails to grow, and they are even absent from soil that is strongly acid.

Rendering mineral compound more available. Aside from the effect of lime in overcoming acidity, it has an important bearing on the availability of the mineral plant food of the soil. Many of the complex soil-forming minerals contain potash, locked in unavailable or insoluble form. Soluble lime salts react with these complex minerals, taking the place of the potash in the mineral, while the potash is set free in the soil in available form. Where there is a large supply of potash in the soil, but in unavailable form, it is good practice to make use of lime in this way; but if the soil be deficient in potash, it would be dangerous to rely solely on the lime to supply the potash needed for the crop, since this stimulation would soon bring about soil exhaustion. In the latter case, it would be advisable to replace at least a part of the potash removed by crops.

Lime also has considerable effect on the availability of phosphates in the soil. If the soil is deficient in lime, most of the phosphate in it is in the form of insoluble phosphate of iron and aluminum. In such soil, lime reacts with these iron and aluminum phosphates, forming phosphate of lime, a more available phosphate. The acid or soluble phosphate found in most fertilizers, when added to a soil, "reverts," or goes back, to a more insoluble form soon after it is applied. If there be a deficient amount of carbonate of lime in the soil the reversion will be largely to the most unavailable forms, namely phosphates of iron and aluminum. However, if there is a sufficiency of lime, the reverted product will be largely the more available compound, namely, dicalcium phosphate.

Improving the texture of the soil. Besides its action in neutralizing acidity, and in making more available the plant food in soil, lime may have a very good effect on the texture, or "workableness" of certain heavy soils. Soils containing a high percentage of clay, and that are at the same time deficient in lime, may be very hard to cultivate; such soils are very sticky and heavy when wet, and bake and crack badly on drying. The addition of lime to such a soil causes the very small clay particles to group themselves together into clusters, each of which acts somewhat like a single grain of sand, making the soil more porous, less retentive of water, and less liable to baking and cracking.

Lime has quite a different effect on light porous soil. In this case, the larger particles or sand grains are cemented to each other to a certain extent, thus rendering a sandy soil more compact.

Lime as a plant food. Plants require lime as well as potash, nitrogen, and a number of other elements or compounds. However, most soils contain enough lime to supply that actually used as food by ordinary crops, but often not enough to bring about the indirect beneficial effects previously discussed. The indirect effects of lime on the plant in neutralizing the acidity of the soil, in permitting the soil to become more abundantly stocked with helpful bacteria, and in causing the soil minerals to become more available, are all more important than is the supplying of lime to be taken in by the plant.

Need for Lime in Alabama Soil.

Among the numerous soils of Alabama there are many that contain only small amounts of lime, less than is needed for the successful growth of lime-loving plants. But there are regions, the soils of which are comparatively well supplied with lime. The most extensive of these lime areas are the following:

(1) The Central Prairie Region, which is a rather narrow belt extending from near Union Springs westward into Mississippi, passing near or through Montgomery, Selma, Marion Junction, Demopolis, Livingston, and Geiger.

(2) Parts of the Tennessee Valley Region in northern Alabama.

(3) Several very narrow valleys in the northeastern part of the State.

(4) Very small detached areas of so-called lime hills in Clark county.

(5) Probably parts of the flat-woods soils in the northeastern part of Alabama.

On the soils just mentioned there is usually no decided need for lime, except possibly in growing alfalfa, for which plant it may sometimes be needed even in these soils, except in the Central Prairie Region.

During the past fifteen years the agriculturist of this Station, while traveling over the State, has made a number of simple tests by using litmus paper to determine whether the soils examined are acid. As a rule these tests have shown that a large proportion of the sandy soils in the southern part of the State are acid; that much of the sandy upland soils in the northeastern plateau or mineral region is acid; and that at least the lighter colored and more poorly drained spots in the Tennessee valley show acidity.

How to Determine Whether a Soil is Acid.

A very simple and inexpensive test can be made by any one to determine whether a soil is sour. Have your local druggist order from a wholesale druggist a small bottle of blue litmus paper, which will usually retail at 15 to 25 cents per bottle. This contains enough for testing a large number of samples. In the soil to be tested dig down to moist earth and then with

a knife, or otherwise, make a slit in the moist soil; take a slip of blue litmus paper and touching it at only one end, thrust it into the slit in the soil and press the damp soil tightly against both sides of the paper, leaving the paper and moist soil in contact for five minutes. Then take out the paper and dry it. If the color has changed from a blue to a pinkish tint, the soil may be regarded as slightly acid. If the change is to a deeper reddish color, the soil is quite acid and probably needs lime for most crops.

In making the litmus paper test, be careful not to mistake for an evidence of acidity in the soil the reddish coloring brought about by the perspiration from the fingers that touched on the end of the paper which has been handled.

The litmus paper test simply determines (1) that the soil is more or less acid; or (2) that it has the opposite property of being alkaline, which might be due to the presence of lime; or (3) that it is neutral, that is, neither acid nor alkaline.

Whether it will pay to use lime on neutral or on a very slightly acid soil will depend largely upon the crop that is to be grown.

Lime-Loving Crops.

Alfalfa and red clover are extreme examples of lime-loving plants. These require for their best growth a soil that is naturally alkaline, or made so by the application of liberal amounts of some form of lime. Indeed, it is generally true that most of the leguminous plants, such as peanuts, clover, vetches, etc., are unthrifty on acid soils and pay well for the application of lime. Among other such lime-loving plants are sweet clover, or mellilotus, crimson clover, bur clover ,and the vetches.

On the other hand, cow peas and lespedeza (commonly called Japan clover) are able to grow successfully on either slightly acid or lime soil. Among the weeds that are especially partial to acid soil—are sorrel (*Rumex acetosella*); bluets (*Houstonia coerulea*), rushes, and sedges.

Wheat and barley require considerable lime in soil or fertilizer, while oats are less particular. Corn, and indeed most grass-like plants, are usually helped by lime on acid soils. However, red top grass is an exception, preferring acid soil; and

hence this grass is especially suitable for growing on poorly drained, acid soils. The cotton plant, though often helped by lime, is able to make thrifty growth in slightly acid soil. Among the crops which have been found to thrive on acid soils are watermelons. The use of lime is not generally advised for Irish potatoes because lime favors the growth of potato scab, which is one of the most common and troublesome diseases of the Irish potato.

Many of the garden vegetables are especially helped by liberal applications of lime; for example, beets, onions, lettuce, turnips and cabbage, and other members of the mustard family, which includes also Dwarf Essex rape.

A more extended list of the plants which have been found to respond to or to be indifferent to lime may be had by applying to the U. S. Department of Agriculture at Washington for Farmers' Bulletin No. 77.

Sources of Lime.

At present most of the lime offered for agricultural uses in Alabama is in the form of quick or builders' lime. A few of the lime manufacturers have also offered hydrated lime, that is, lime slacked at the kiln. But little, if any, crushed limestone or calcium carbonate has been manufactured within the limits of Alabama; though in recent months this article has been advertised for sale by a few companies. The advertisers of crushed limestone in localities easily accessible to Alabama farmers, which have been brought to our attention, are the following:

Manufacturers of Ground Limestone

Southern Lime and Phosphate Co., 927 Woodward Building Birmingham, Ala.
Foster Creighton Gould Co., Rockwood, Franklin Co., Ala.
Keystone Lime Co., Keystone, Shelby County, Ala.
Banks & Parson, Nashville, Tenn.

Most of the lime now manufactured in Alabama is from the hard limestone of the Calera and Anniston regions. This limestone has usually a purity of about 97 per cent. Limestone, of similar quality, and probably equally as suitable for the manufacture of any grade of lime, occurs also in other localities in the northern part of the State. Doubtless the State

Geologist, Dr. E. A. Smith, Tuscaloosa, Ala., would furnish to inquirers full information as to the localities in which other outcrops of pure limestone may be found.

The following is a list, doubtless incomplete, of all the Alabama manufacturers of quick lime, whose addresses the writers have been able to obtain:

MANUFACTURERS OF QUICK LIME.

Longview Lime Works, Longview, Shelby County, Alabama.

Keystone Lime Works, Keystone, Shelby County, Alabama.

O'Neal Lime Works, Calera, Shelby County, Alabama.

Saginaw Lime & Lumber Co., Saginaw, Shelby County, Alabama.

Bowdon Lime Works. Saginaw, Shelby County, Alabama.

Calcis Lime Works, Calcis, Alabama.

Anniston, Lime Works, Anniston, Ala.

A source of crushed limestone that has thus far been unused commercially is the rotten limestone underlying all of the Central Prairie Region in central Alabama. This rotten limestone, also called "the Selma chalk," varies considerably in composition and usually contains too much impurity to be burned for builders' lime. Rotten limestone usually consists of about 60 to 90 per cent of calcium carbonate. Theoretically every pound of lime (CaO) contained in it should be as valuable as that in the somewhat purer limestone of the Calera and Anniston regions. Doubtless the cost of crushing the softer rotten limestone would be less than in crushing the hard limestone of the regions just mentioned.

The value of limestone is practically in proportion to the fineness of the grinding.

A third source of lime for agricultural purposes consist of oyster shells. These may be either burned, so as to make quicklime; or finely crushed, so as to form calcium carbonate, a material practically identical with crushed limestone. However, adhering dried mud makes oyster shell lime somewhat less pure than other kinds.

A fourth source of lime consist of wood ashes. Wood ashes usually contains from 10 to 50 per cent of lime. Their composition is quite variable; the ashes from pine are usually less

rich in lime, as well as in potash, than the ashes from hard-wood trees.

A fifth source of lime consist of marls, beds of which are occasionally found in South Alabama. Marls contain a very low percentage of lime, often one to twenty per cent, which usually restricts their usefulness to the fields immediately around such beds.

Several commercial fertilizers may be mentioned as containing small amounts of lime. However, in most of these fertilizers, the lime is in a form in which it cannot neutralize acidity, though capable of supplying lime as plant food and of making certain other mineral compounds of the soil more available. Among these fertilizers are ground phosphate rock, acid phosphate, and land plaster, in which latter the lime may constitute 20 per cent or more of the total weight.

None of these are ordinarily advisable as sources of lime because of the form in which the lime exists, the small amount of lime, and the cost of most of these fertilizers.

Basic slag or Thomas phosphate is a common phosphatic fertilizer in Europe and is imported to some extent into the United States to be used for the same purposes as acid phosphate.

About half of the weight of basic slag consists of lime, only 2 to 10 per cent of which is in the free form, that is, in condition to netralize acidity most effectively.

While the composition of all sources of lime varies considerably, the following figures represent their most usual approximate composition.

Percentage of Lime (calculated as CaO) in Different Sources of Lime and in Certain Commercial Fertilizers.

Important Sources of Active Lime.	*Approximate % of lime (CaO).*
Quick lime (97% purity)	97
Slacked lime (97% purity)	70-73
Ground limestone (97% purity)	54
Rotten limestone, or Selma chalk	35-45
Oyster shells (90% purity)	50
Wood ashes	30

Fertilizers Containing Some Lime, Mostly Inactive.

Thomas phosphate, or basic slag.....32-40
Ground rock phosphate (72% purity) 38-42
Acid phosphate (15% available).....19-22
Land Plaster (commercial) 20-25

Effect of Lime on Organic Matter.

Under another heading, it has been shown that lime hastens the decomposition of organic matter, humus, in the soil, by overcoming acidity, thus favoring bacterial action. The store of humus in the soil may be excessively exhausted by the addition of quick or freshly slacked lime, on account of its caustic action. Besides overcoming the acidity, lime in these forms has a marked effect on the humus by purely chemical action, that is, it "burns out" the humus. So that *where much caustic or quicklime is used ample return of organic matter in the form of stable manure, green manure, or crop residue must be made* if soil exhaustion is to be prevented.

Crushed lime, or calcium carbonate, has not this bad effect, since it is not caustic and has no exhausting effect on the humus. For this reason it should be used instead of the caustic lime where it can be cheaply obtained. Moreover, crushed limestone is not so disagreeable to handle as is the caustic lime.

Quicklime Equivalents.

Where the crushed limestone cannot be had cheaply and other forms of lime must be bought, the buyer should consider the following relations in determining what is the most economical form of lime for him to use:

100 pounds of chemically pure, freshly burned lime (CaO) is equivalent to 132 pounds of fresh slacked lime ($Ca(OH)_2$).

100 pounds of quicklime is equivalent to 178 pounds of crushed limestone ($CaCO_3$).

132 pounds of slacked lime is equivalent to 178 pounds of crushed limestone.

The relative values of equal amounts of the above forms of lime for overcoming acidity are, in terms of dollars and cents, when quicklime costs $10.00 per ton, (about 80 cents per barrel), about as follows:

Slacked lime, about $7.60.

Crushed limestone, about $5.60.

It is doubtful whether the use of lime will ever become general in Alabama until crushed limsetone can be delivered at the farmers' depot at a price around two or three dollars per ton.

In the absence of cheap crushed limestone, it is cheaper and more economical to buy the quicklime and slack it on the farm than to buy lime already slacked, or hydrated lime. In the first case the cost of freight is less, and the farmer can slack the lime cheaper on the land than the manufacturer can at the kiln. If a farmer buys hydrated lime he must pay the freight on 2640 pounds of slacked lime instead of on 2,000 pounds of quicklime, the difference being water. Quicklime or any kind of lime for agricultural purposes ought to be bought on a written statement showing what per cent of it consist of pure calcium oxide (CaO).

Slacking Lime.

Probably the easiest and best way to slack quicklime is to haul it directly to the field and pile it in small piles over the area to be limed. Then cover these piles with a layer of moist soil two or three inches thick, letting it stand so for several weeks. At the end of that time the lime will usually be found in the form of a fine white powder, thoroughly slacked. The slacked lime from the piles may then be scattered over the fields. If the farmer be pressed for time and cannot wait for this slow process of slacking, water may be hauled and a little may be added to each pile of lime to hasten the process. But care must be taken not to add too much water, or a paste will result instead of the fine dry powder desired.

Applying Powdered Lime.

Where the lime is slacked in the field it is most conveniently applied to the land by shovels. After slacking, the piles are torn down and the lime scattered over the surrounding area. If it is desired to put one-half of a ton of quicklime per acre, 25 pounds of lime in a pile every thirty-three feet each way will give the desired distribution. A man can easily throw the powder sixteen or eighteen feet with a long-handle shovel.

This is rather disagreeable work, for the caustic lime burns and irritates the skin. Therefore, lime is best distributed early in the morning when there is little wind blowing and when dew is on the ground.

If the lime be bought in crushed or powdered form in car lots, it is best to distribute the lime directly from the wagon as it is hauled from the car. The wagon is driven to the field to be limed, and the lime is thrown out by shovels, as in the case of field-slacked lime.

Lime-spreading machines can be had on the market, that do satisfactory work; besides, it is much less disagreeable to spread by machines than by hand, since the laborer is not so much troubled by the flying lime dust. Several farmers might buy such a machine on the co-operative plan, thereby reducing the expense. Machine spreaders are advertised by the following manufacturers:

Belcher & Taylor, A. T. Co., Chicopee Falls, Mass.
Empire Drill Co., Shortsville, N. Y.
Hench & Dramgold Co., York, Pa.
International Harvester Co., Springfield, Ohio.
Ontario Drill Co., Deposit, N. Y.
Spangle Manufacturing Co., York, Pa.

Lime should never be plowed deeply into the soil, since its tendency is to work downward. The soil should first be well turned, the lime then scattered and harrowed or disked into the top three inches of soil. The harrowing should be thorough so as to get the lime well mixed with the soil.

Time to Apply Lime.

There is probably no "best" time to apply lime. The kind of rotation followed, the crops that are to follow the liming, labor conditions, etc., all bear on this point. Generally it is best to apply lime broadcast on land that has recently been fallowed, or "plowed flushed" or broadcast.

Lime should not be used in immediate contact with acid phosphate, since it hastens the reversion of the phosphate to a less available form. Nor should lime be mixed with stable manure, cotton seed meal, and other organic manure, nor with sulphate of ammonia, because of the chemical action of lime,

by which it tends to liberate some of the nitrogen in these manures and fertilizers. Apply the lime alone on the plowed land, and disk it well into the soil before adding manure and fertilizer.

Amount of Lime to Apply.

On soils that are not markedly sour, one thousand pounds of quicklime, or two thousand pounds of crushed limestone thoroughly incorporated with the surface soil will usually be sufficient. However, many soils may be found in which the above amounts would be insufficient to overcome the acidity in the surface foot of soil. Very good results may be obtained, however, by these comparatively small amounts, which may be sufficient to neutralize the acidity in the upper three or four inches, even though these light applications may leave the subsoil still sour.

On ordinary soils, one to two tons of lime should be sufficient to last three or four years. It would be unsafe to use large amounts of quicklime on the lighter, sandier grades of soil, on account of its "burning out" the organic matter. On the other hand, large applications of the crushed limestone may be made without harmful effect, and with beneficial results extending through a number of years.

RESULTS OF EXPERIMENTS WITH LIME IN ALABAMA.

Lime Experiments at Auburn.

With the exception of two tracts of bottom land, the soils of the Experiment Station farm at Auburn are not acid; hence, but few experiments with lime have been conducted at Auburn. The table below shows that on one of the tracts of sour bottom land the increase in the corn crop or the limed plot by using 1,760 pounds of slacked lime per acre was in one experiment 41 per cent and in another experiment the same year 10 per cent.

Table I. Lime experiments, sour bottom land, on Experiment Station Farm at Auburn

	Auburn, '08 Bottom, no cover crop		Auburn, '08 Bottom, after cr. clover, uncut.	
	Crop per acre	Increase, %	Crop per acre	Increase, %
Corn, yield bushels, limed	43.4		48.6	
Corn, yield bushels, not limed	30.7		44.0	
Corn, gain from liming	**12.7**	**41**	**4.6**	**10**

Attention is here called to the increase attributable to the crimson clover plowed under in April. This increase in the corn crop was, in the case of the limed plot 5.2 bushels, and on the plot not limed 13.3 bushels attributable to clover.

The same year slacked lime at the rate of about one ton per acre was applied to cotton by scattering the lime over a luxuriant growth of crimson clover just before the latter was plowed under in preparation for cotton, on April 8. This was done to ascertain whether on neutral sandy upland soil the rotting of a large mass of green crimson clover would produce enough acidity to require the correcting effects of lime. Evidently the plowing under of green clover on April 8, did not have an injurious effect nor make necessary the use of lime, as shown by the fact that on the limed plots the increase in the cotton crop was only 2 per cent.

For several years the Alabama Experiment Station has had conducted lime experiments in parts of the State where it was believed that the soil was more or less acid. The results of these earlier co-operative experiments, together with the results of local lime experiments made in 1911 under the State appropriation made for local experimental work, are presented below. While the amount of slacked lime varied slightly it is as a rule one ton per acre.

LIME EXPERIMENTS IN ESCAMBIA, HOUSTON AND DALE COUNTIES.

All of the soils on which the experiments reported in Table II were conducted are sandy and tests made on other similar soils in the same neighborhood indicated acidity. The soils in the experiments at Dothan showed an acid reaction to litmus paper and it is believed that the other soils were also acid.

Table II. Yields and increases in pounds per acre from use of slacked lime for corn, corn stover, cotton, peanuts, cowpeas, sweet potatoes, sorghum and soy beans.

CROP	DOTHAN '06		BREWTON '06		BREWTON '07		ELBA '11		DALEVILLE '09	
	Per acre	Increase, %	Per acre	Increase, %	Per acre	Increase, %	Per acre	Increase, %	Per acre	Increase %
Corn, yield bushels, limed			*20.7						*13.1	
Corn, yield bushels, not limed			*19.1						*14.1	
Corn, gain from liming			*** 1.6**	**8**					***—1.0**	**—8**
Corn (forage), limed					4400					
Corn (forage), not limed					3440					
Corn (forage) gain from liming					**960**	**28**				
Cotton, seed cotton, limed	416		1024		552				592	
Cotton, seed cotton, not limed	608		928		408				592	
Cotton, seed cotton, gain from liming	**192**	**31**	**96**	**10**	**147**	**36**			**0**	**0**
Peanuts, nuts, limed			576		1056		2048			
Peanuts, nuts, not limed			576		864		1408			
Peanuts, nuts, gain from liming			**0**	**00**	**192**	**22**	**640**	**45**		
Cowpeas, seed, limed			1224		532		2048			
Cowpeas, seed, not limed			1056		782		1504			
Cowpeas, seed, gain from liming			**168**	**16**	**—250**	**—32**	**544**	**36**		
Sweet potatoes, limed			6144		3946				5888	
Sweet potatoes, not limed			6336		5616				5888	
Sweet potatoes, gain from liming			**—192**	**—3**	**-1670**	**—30**			**0**	**0**
Sorghum hay, limed					4080					
Sorghum hay, not limed					2992					
Sorghum hay, gain from liming					**1088**	**36**				
Soy beans, seed, limed					828					
Soy beans, seed, not limed					610					
Soy beans, seed, gain from liming					**218**	**36**				

*Bushels.

The test at Brewton, Escambia county, was made by I. E. Watson. On his soil, lime afforded notable increases in the yield of corn forage, cotton, peanuts (in 1907), sorghum hay, and soybeans, but a loss with cowpeas (in 1907), and with sweet potatoes. In the case of the cowpeas this loss seemed due to the caustic effect of the lime which injured the young cowpea plants, many of which were killed and others turned yellow, though later they recovered. This injurious effect was noted from the application of 2,000 pounds of slacked lime applied two or three days before planting.

The experiment at Dothan, Houston county, was conducted by E. J. Whidden, on a slightly acid soil. Here the yield of cotton was less on the limed plot.

The experiment at Daleville, Dale county, was conducted by E. A. Thompson. Here limed and unlimed plots afforded practically the same yields for all crops.

In the experiment made at Elba, Coffee county, by M. V. B. Farris, on soil which was very slightly if at all acid, the limed plots of peanuts and cowpeas afforded much the larger yields.

Lime Experiments at Wetumpka and Tallassee, Elmore County.

The experiment at Wetumpka, Elmore county, was made by Prof. B. W. Scheib, on the farm of the Fifth District Agricultural School, having an acid soil. Here lime afforded an increase with all crops, namely, cotton, soybeans, peanuts, corn, cowpeas, German millet, and sorghum.

Table III. Yields and increases in pounds per acre from use of slacked lime for corn, cotton, peanuts, cowpeas, sorghum hay, soy beans and German millet hay

CROP	WETUMPKA '07		WETUMPKA '10		TALLASSEE '11	
	Per acre	Increase, %	Per acre	Increase, %	Per acre	Increase, %
Corn, yield, bushels, limed			331		* 51.4	
Corn, yield, bushels, not limed			252		* 55.7	
Corn, gain from liming			**79**	**36**	*—3.7	**—7**
Cotton, seed cotton, limed			960		1065	
Cotton, seed cotton, not limed			420		1018	
Cotton, seed cotton; gain from liming			**540**	**129**	**47**	**5**
Peanuts, Spanish, nuts, limed			3160			
Peanuts, Spanish, nuts, not limed			2280			
Peanuts, Spanish, nuts, gain from liming			**880**	**39**		
Cowpea, seed, limed			1460			
Cowpea, seed, not limed			1220			
Cowpea, seed, gain from liming			**240**	**20**		
Sorghum hay, limed	8780		1140			
Sorghum hay, not limed	6316		1080			
Sorghum hay, gain from liming	**2464**	**39**	**60**	**6**		
Soy beans, seed, limed			240			
Soy beans, seed, not limed			140			
Soy bean seed, gain from liming			**100**	**71**		
German millet hay, limed			2600			
German millet hay, not limed			2340			
German millet hay, gain from liming			**260**	**11**		
Peanuts, (N. C.) nuts, limed			1760			
Peanuts, (N. C.) nuts, not limed			1100			
Peanuts, (N. C.) nuts, gain from liming			**660**	**60**		

*Bushels.

The experiment at Tallassee, Elmore county, was made by W. E. Sistrunk, on second bottom reddish clay loam soil which was not acid. There was no decided effect of lime on either cotton or corn.

LIME EXPERIMENTS IN BUTLER AND CONECUH COUNTIES.

The experiment at Georgiana, Butler county, was made by J. C. Lee, on gray sandy soil, found to be slightly acid. With lime there was an increase in the crop of peanuts, cotton and soybeans, but no increase in case of the chufas.

Table IV. Yields and increases in pounds per acre from use of slacked lime for peanuts, soy beans, cotton, corn, cowpeas and chufas

CROP	GEORGIANA 1911		CASTLEBERRY, 1911 (Davis)		CASTLEBERRY, 1911 (Green)	
	Per acre	% Increase,	Per acre	% Increase,	Per acre	% Increase,
Peanuts, yield limed	2688		3712		1024	
Peanuts, yield not limed	2474		3392		889	
Peanuts, gain from liming	**214**	**9**	**320**	**9**	**135**	**15**
Soy beans, yield hay, limed	6368					
Soy beans, yield hay, not limed	4480					
Soy beans, gain from liming	**1888**	**42**				
Cotton, yield seed cotton, limed	744		554			
Cotton, yield seed cotton, not limed	672		469			
Cotton gain from liming	**72**	**11**	**85**	**18**		
Corn, yield bushels, limed			* 38.4			
Corn, yield bushels, not limed			* 33 3			
Corn, gain from liming			* **5.1**	**13**		
Cowpeas in hull, limed					928	
Cowpeas in hull, not limed					889	
Cowpeas, gain from liming					**39**	**4**
Chufas, limed	2112					
Chufas, not limed	2112					
Chufas gain from liming	**0**	**0**				

*Bushels.

In the experiment made by J. B. Davis, Castleberry, Conecuh county on acid soil, there was an increased yield of peanuts, cotton, and corn on the limed plots.

In the experiment made by J. R. Green, at Castleberry, Conecuh county, on soil that was distinctly acid, the yield of peanuts and cowpeas was greater on the limed plots.

LIME EXPERIMENTS IN MOBILE COUNTY.

At Irvington, Mobile county, the experiment was made by the Irvington Land Company, on reddish sandy loam soil, close to the depot, on land that apparently had been long in cultivation.

Table V. Yields and increases, in pounds per acre, in Mobile County from applying slacked lime for peanuts, cotton, corn, cowpeas, sweet potatoes and velvet beans

CROP	IRVINGTON 1911		MOBILE 1911	
	Per acre	% Increase,	Per acre	% Increase,
Peanuts, yield, limed	53.7		1008	
Peanuts, yield, not limed	50.3		780	
Peanuts, gain from liming	**3.4**	**7**	**228**	**29**
Cotton, yield, seed cotton limed	800		248	
Cotton, yield, seed cotton, not limed	592		288	
Cotton, gain from liming	**208**	**35**	**—40**	**—14**
Corn, yield bushels, limed			20.2	
Corn, yield bushels, not limed			29.8	
Corn, gain from liming			**—9.6**	**—32**
Cowpea hay, limed	2048		896	
Cowpea hay, not limed	1920		816	
Cowpea hay, gain from liming	**128**	**7**	**80**	**10**
Cowpeas, seed, limed			344	
Cowpeas, seed, not limed			256	
Cowpeas, seed, gain from liming			**88**	**34**
Sweet potatoes, yield bushels, limed	96.4			
Sweet potatoes, yield bushels, not limed	186.8			
Sweet potatoes, loss from liming	**90.4**	**94**		
Velvet bean hay, limed	5184		4800	
Velvet bean hay, not limed	4112		3216	
Velvet bean hay, gain from liming	**1072**	**21**	**1584**	**49**

*Bushels

On the limed plots, there was an increase of 35 per cent in the cotton crop, of 21 per cent with velvet bean hay, and of only 7 per cent with peanuts and cowpeas The very large apparent decrease on the limed plots of sweet potatoes is not understood.

The experiment on the property of the Mobile Farm Land Company, was on land recently cleared and stumped. The limed plots afforded an increase of 49 per cent with velvet bean hay, 34 per cent with cowpea seed, 29 per cent with peanuts, 10 per cent with cowpea hay, and a loss with corn and cotton.

LIME EXPERIMENTS AT ABBEVILLE, HENRY COUNTY.

In 1906, Prof. J. B. Espy began, in co-operation with the Alabama Experiment Station, co-operative lime experiments on the farm of the Third District Agricultural School at Abbeville, Ala., using each year 2,000 pounds of slacked lime per acre in addition to commercial fertilizer, the latter usually consisting of 400 pounds per acre of a complete fertilizer. The sandy loam soil was originally acid; slacked lime at the rate of 2,000 pounds per acre was applied annually to the same plots. The results have been as follows:

Table VI. Results of lime experiments on farm of Third District Agricultural School, Abbeville, Ala.

	1906 Increase		1907 Increase		1908 Increase		1909 Loss	
	Amt.	%	Amt.	%	Amt.	%	Amt.	%
Seed cotton, pounds	124	22	476	48	300	40	366	26
Corn, bushels	2.2	21					25	10
Soy bean hay, pounds	1210	30	2184	51	4890	120		
Sweet potatoes, bushels	3	4	21	13			15	10
Sorghum hay, pounds	1110	46						
Cowpea hay, pounds	926	31						
Peanuts, bushels			4.1	29				

In these tests cotton, corn, sorghum, sweet potatoes, soybeans, cowpeas and peanuts, were all largely increased by the use of lime except that in the fourth year, 1909, there was a decrease with all crops on the limed plots. Possibly this unfavorable effect after the application of a total of 8,000 pounds of slacked lime per acre may have been due to the exhaustion of the humus in the soil.

RESULTS OF LIME TESTS IN ALABAMA, ARRANGED BY CROPS.

The discussions below are based on results of experiments the details of which are presented in Tables I to VI. These tests were in most cases made on soils more or less acid and the usual amount of slacked lime per acre was 2,000 pounds.

Cotton	Increase, per cent.	Loss, per cent.
Auburn (neutral, sandy upland)	2	...
Tallassee (neutral, sandy loam)	5	...
Brewton, 1906 (sandy)	10	...
Brewton, 1907 (sandy)	36	...
Dothan (sandy, acid)	31	...
Daleville (sandy)	0	...
Wetumpka (acid)	129	...
Georgiana (barely acid)	11	...
Castleberry (acid)	18	...
Irvington	35	...
Mobile	...	14
Abbeville, 1906	22	...
Abbeville, 1907	48	...
Abbeville, 1908	40	...
Abbeville, 1909	...	26
Average increase	23	

In the majority of cases the crop of cotton was notably increased by the use of lime. Indeed, in every case where there was positive proof that the soil was acid there was a large increase in the cotton crop on the limed plots. The average increase in all tests, including several on neutral soil, was 23 per cent.

Corn	Increase, per cent.	Loss, per cent.
Auburn (bottom land, acid)	41	...
Auburn (bottom land, after clover)	10	...
Tallassee (neutral, sandy loam)	...	7
Brewton, 1906 (sandy), grain	8	...
Brewton, 1907 (sandy), forage	28	...
Daleville (sandy)	8	...
Wetumpka (acid)	36	...
Castleberry (acid)	13	...
Mobile	...	32
Abbeville, 1906	21	...
Abbeville, 1909	...	10
Average increase	11	

In all but three experiments the use of lime increased the crop. The average increase was 11 per cent, or less than with cotton.

Cowpeas	*Increase, per cent.*	*Loss, per cent.*
Seed; Brewton, 1906	16	...
Seed; Brewton, 1907	...	32
Seed; Wetumpka	20	...
Seed; Elba	36	...
Seed; Castleberry	4	...
Seed; Mobile	34	...
Hay; Mobile	10	...
Hay; Irvington	7	...
Hay; Abbeville	31	...
Average increase	14	

The increase was only 14 per cent in spite of the fact that the greater proportion of the soils where these tests were made were acid.

Peanuts	*Increase. per cent.*
Brewton, 1906 (sandy)	0
Brewton, 1907 (sandy)	22
Wetumpka (Spanish) (acid)	39
Wetumpka (N. C.) (acid)	60
Elba (sandy)	45
Georgiana (barely acid)	9
Castleberry, Davis (acid)	9
Castleberry, Green, (acid)	15
Irvington	7
Mobile	29
Abbeville	29
Average increase	24

In all tests except one lime increased the yield of peanuts, the average increase being 24 per cent.

The use of lime is considered especially important in the case of the running peanuts, tending to reduce the percentage of pops. It should be noted that at Wetumpka, on acid soil, the increase with the North Carolina running peanuts was 60 per cent as the result of liming.

Sweet Potatoes	*Increase, per cent.*	*Loss, per cent.*
Brewton, 1906	...	3
Brewton, 1907	...	30
Daleville, 1909	...	...
Irvington, 1911	...	94
Abbeville, 1906	4	---
Abbeville, 1907	13	---
Abbeville, 1909		10
Average loss	...	17

In two of these tests sweet potatoes showed a notable decrease in yield where lime was employed. In two other tests lime was practically without effect on the yield, and in only one test there was a moderate increase. Apparently, sweet potatoes are not very responsive to lime.

	Increase.
Velvet Bean Hay	*per cent.*
Irvington, 1911	21
Mobile, 1911	49
Average increase	**35**

This plant was notably improved by the use of lime.

	Increase.
German Millet Hay	*per cent.*
Wetumpka, 1909	11
Chufas	
Georgiana, 1911	0
Soy Bean	
Seed; Brewton	36
Seed: Wetumpka	71
Hay; Georgiana	42
Hay; Abbeville	46
Average increase	**49**

The yield of soybeans was in every case greatly increased by liming.

	Increase.
Sorghum hay	*per cent.*
Brewton, 1907	36
Wetumpka, 1907	39
Wetumpka, 1909	6
Abbeville, 1906	30
Abbeville, 1907	51
Abbeville, 1908	120
Average increase	**47**

The yield of sorghum hay was considerably increased by liming.

SUMMARY.

(1) Lime increases the yield of crops on many soils.

(2) The beneficial effects of lime may be due to any of the following:

(a) To its correcting or neutralizing an acid condition in the soil;

(b) To its effect in hastening the fermentation of organic matter;

(c) To its action in making conditions in the soil more favorable for the growth of nitrogen-fixing bacteria and other beneficial bacteria;

(d) To its indirect action in making certain mineral ingredients of the soil more available; and,

(e) To its power of improving the texture of the soil.

(3) In Alabama there are large areas of acid soils, the exact extent of which has not been determined; however, these acid soils are especially abundant and extensive in the Southern part of the State. On most acid soils, as well as on some other soils, the use of lime generally increases the yield of most crops.

(4) Any one can determine whether his soil is acid by the simple test described on page 304.

(5) Among the plants that most need lime are alfalfa, red clover and wheat. Indeed most of the leguminous or soil improving plants are especially helped by lime; among other lime-loving plants are the cabbage, turnip, and other members of the mustard family, beets, onions, lettuce and many others.

In the lime tests made in various parts of Alabama the average increase in yield attributable to the use of lime were as follows:

Cotton	23 per cent.
Corn	11 per cent.
Cowpeas (seed and hay)	14 per cent.
Peanuts	24 per cent.
Velvet bean hay	35 per cent.
Soy beans (seed and hay)	49 per cent.
German millet hay	11 per cent.
Sorghum hay	47 per cent.
Chufas	0 per cent.
Sweet potatoes, loss	17 per cent.

(6) Alabama is rich in limestone, suitable either for burning or for crushing. Notable among these limestones

are those occurring at Calera and Anniston, and the rotten limestone, or Selma chalk, underlying the central prairie region. The latter has not been utilized commercially in agriculture. Other materials rich in lime are oyster shells and wood ashes.

(7) Slacked lime has heretofore been the form in which lime has been chiefly used in agriculture in Alabama. However, crushed limestone used in large amounts has the advantage of not causing such rapid disappearance of the organic matter of the soil.

(8) Different forms of lime are valuable in agriculture about in the proportions in which they contain calcium and magnesium oxides. Classed in this way, one ton of quick lime is theoretically equivalent to 2,680 pounds of slacked lime or 3,560 pounds of crushed limestone.

(9) When quick or builders' lime sell at $10.00 per ton delivered, farmers could just as well afford to pay about $7.60 per ton for slacked lime, or about $5.60 for crushed limestone, provided all were made from the same limestone and so prepared as to be of equal firmness. But all of these places are so high as to prohibit the general use of lime in agriculture.

(10) Methods of slacking and distributing lime are described on page 310.

(11) Lime should be applied at least several weeks before the time of planting and preferably harrowed in rather than plowed in.

(12) Do not let lime come in immediate contact with most commercial fertilizers. However, the use of lime should not cause any one to fail to apply either manure or fertilizer. Lime is not a substitute for fertilizers, but rather increases the need for fertilizers. A light application of lime is 1,000 pounds of slacked lime per acre or one ton of crushed limestone. Much larger amounts of crushed limestone may be used with entire safety. It is usually sufficient to apply any form of lime once every three or five years.

(13) At Auburn, on acid bottom land, lime increased the yield of corn; however, on neutral, sandy, upland soil, in good condition, the yield of cotton was not increased by lime.