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Response of CROPS to LIME in Alabama

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INTRODUCTION

A NUMBER of factors govern the growth of plants. The various soil properties affecting plant growth are factors that man must determine and control if he is to realize optimum returns from his land. One of the most important properties of a soil is its storehouse of available plant nutrients.

CALCIUM AND MAGNESIUM

Just as with nitrogen, phosphorus, and potassium, calcium and magnesium must be replenished when the supply available to the crop has been seriously reduced. Calcium and magnesium are usually supplied to the soil in the form of *lime*. In agricultural terminology, lime usually refers to calcium and/or magnesium carbonate. The commonly used liming materials are listed in Table 1.

TABLE 1. LIMING MATERIALS AND THEIR EQUIVALENT NEUTRALIZING VALUES

Kind	Pounds of material equivalent to 1 ton of pure calcium carbonate	Other available plant nutrients present
High calcitic lime	2,100-2,350	
Dolomitic lime	1,850-2,100	
Ground shells	2,200-2,500	
Basic slag	2,800-3,000	8-10% P_2O_5
Blast furnace slag	2,700-3,000	
Calcium silicate slag	2,700-3,000	
Flue dust (lime-ox)	2,100	3% K_2O

* The data reported by the author are from field and laboratory investigations by the Agricultural Experiment Station of the Alabama Polytechnic Institute extending over a 25-year period. The experiments were conducted by members of the Department of Agronomy and Soils working cooperatively with Superintendents of the Substations and Experiment Fields, and with farmers.

Soil Acid

As calcium and magnesium are removed from the soil, their place is taken by *soil acid.* Observing farmers have known for many years that *sour* soils could be made *sweet* by adding lime. The word *sour* denotes the presence of an acid, whereas *sweet* implies the absence of an acid.

Acids are ordinarily thought of as being liquids, such as the acid in sour milk, the acid in lemon juice, or the acid bought in a bottle from the druggist. However, soil acid is different – it is not a liquid. If soil acid were liquid, rainwater would leach it from the soil as it moved down through the soil to the water table below. Actually, the soil particles themselves make up soil acid. However, it is only the very small soil particles (clay and organic matter) that can become soil acid.

When rocks first begin to decay and soil begins to form, the process of acidification sets in. The rate of acid production is affected by environment under which the soil develops. The percolating water moving through the soil dissolves and carries with it a quantity of bases (non-acids), namely calcium, magnesium, and potassium. As these bases are removed from the soil, they are replaced by soil acid. Thus, soils become acid rapidly in a climate such as found in Alabama where the rainfall is abundant.

Many of Alabama's soils originated from materials containing an abundance of lime and contained adequate lime when first cultivated. However, losses by leaching and continuous cropping have depleted many soils of their supply of lime. Thus, such soils have become acid and nonproductive.

Soil pH

Chemists devised a means of determining the strength of acid present and introduced the symbol "pH" to mean acid. The strength of the acid was then identified by adding a number to the symbol "pH."

A devised pH scale ranges from 0 to 14. The exact middle of this scale, pH 7, is where there is no excess acid. This is the pH of pure water. If there is excess acid, the pH will be below 7. The greater the acidity, the smaller the pH number becomes.

These same values have been adapted for use in expressing the strength of soil acid. Soil pH is actually a measure of the percentage of clay and organic particles that have become acid. A soil with pH 7 is said to be *neutral.* If the soil pH is less than 7, the soil is *acid.* If the soil pH is greater than 7, the soil is *alkaline.* The pH value of soils in Alabama varies widely from calcareous soils (about pH 8) to very acid soils (less than pH 5). Acidity of the majority of Alabama soils falls between pH 5 and pH 6. For most crops, a soil pH between 6 and 7 is desirable.

Effects of Lime

Proper use of lime will replenish the soil's supply of calcium and magnesium as well as neutralize the accumulated soil acid. Thus, lime not only adds essential plant nutrients, but it also conditions the soil so that plants derive greater benefits from other plant nutrients present. In addition to the foregoing functions, lime added to an acid soil will (1) increase the availability of phosphorus and molybdenum (an essential minor element), (2) promote the growth of useful soil micro-organisms, (3) influence the plant's uptake of potassium, and (4) reduce the availability of iron, manganese, boron, and zinc (essential elements for growth of plants).

Over-liming

There have been many instances where adding lime to an acid soil has actually reduced crop yields. This is not the usual effect of lime, but it does occur sufficiently often that an explanation is required. Reduced yields will occur on soil in which both lime and other plant nutrients have been reduced to a very low level. At high pH values resulting from liming, the amounts of iron, manganese, boron, and zinc available to the plant are reduced. This occurs because the solubility of these particular plant nutrients decreases with increasing pH. These plant nutrients are required in small amounts but are essential. Therefore, in a soil where the quantity of one or more of the above plant nutrients are dangerously low, the increased pH caused by the lime reduces the amount of the plant nutrient in question to the point where the plants cannot absorb all they need. In addition, an application of lime may increase the plant's demand for potash. An application of the plant food in short supply will correct the so-called, "over-liming injury" and the benefits of lime are realized. In Alabama, soils usually need an application of potassium, boron, or zinc where over-liming damage occurs. Over-liming usually occurs where too much lime has been added at one time. This can be avoided by a soil analysis, which will indicate how much lime and other plant nutrients should be added to the soil to realize optimum benefit from the lime.

LIME REQUIREMENTS OF DIFFERENT SOILS

There is no present means whereby visual appearance of a soil or growing plants will give a measure of needed lime. The only safe and accurate way of determining a soil's need for lime is a laboratory test for pH and lime requirement.

The pH of a soil is a measure of how strong the soil acid is, but it is not a measure of the total amount of soil acid present. This can only be determined by knowing the pH of the soil and the amount of clay and organic matter present. A clay soil will have considerably more soil acid than a sandy soil with the same pH value. Thus, the pH of a soil and the amount of soil acid must be known for judicious use of lime.

Since materials from which the soils of Alabama developed differ, types of soil and their present lime status also vary. In general, the agricultural land of Alabama can be divided into five soil areas, Figure 1. These areas are (1) Coastal Plains, (2) Black Belt, (3) Sand Mountain, (4) Limestone Valley, and (5) Piedmont.

The Coastal Plains is the largest single soil area. Its soils are acid with most having a pH of less than 6. Lime requirements differ sharply since the clay contents vary.

Black Belt soils are clays. The pH values of these soils vary considerably. Some are very acid with a pH of less than 5, whereas others have a pH of over 8. These high pH soils were developed from Selma chalk, which is sufficiently high in lime to be used as a liming material. Just how acid the surface soil is depends upon the depth of the soil above the chalk. The shallow gray soils are high in lime with a pH of 8 or above. The deep black soils of the low areas are about neutral. Intermixed with these calcareous and neutral soils are heavy acid clay soils. Most of these soils have a pH of about 5.0 to 5.5.

Sand Mountain soils were developed from sandstones that produced mostly sand and little clay. Little lime was present in this region so that soils with a low pH cover the area. The low pH indicates the need for lime and the low clay content indicates the need for small amounts of lime at any one time.

Limestone Valley soils are those that occur in areas where limestone was the dominant rock from which the soil developed.

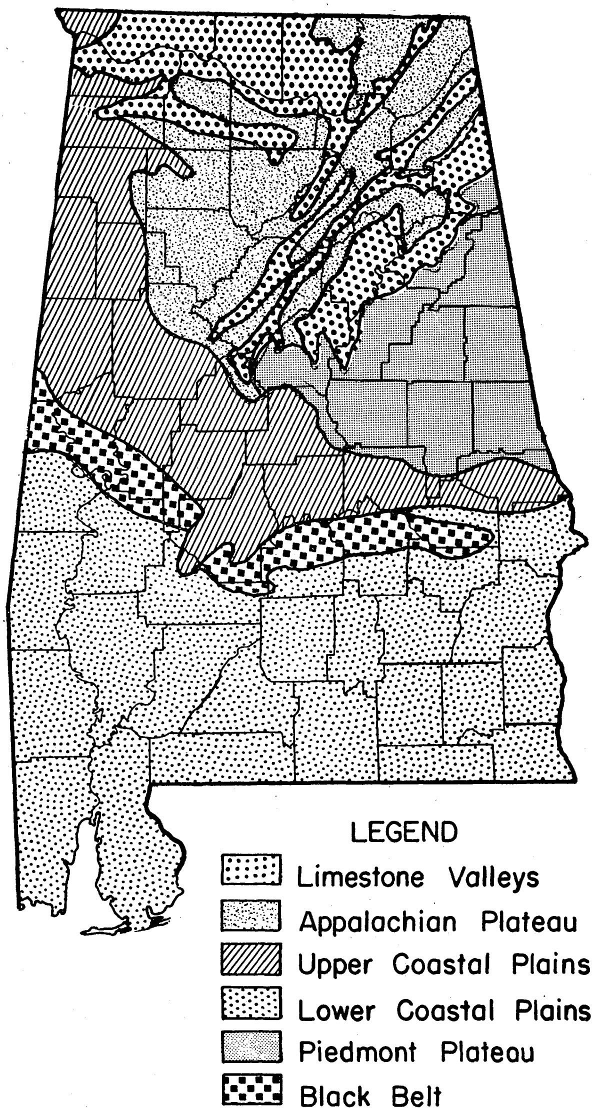

FIGURE 1. Soil areas of Alabama and their locations.

They are present in northern and northeastern Alabama and are represented by the Tennessee Valley, Coosa Valley, and many smaller valleys. These soils were developed from material high in lime, but cropping and leaching have made many of them quite acid.

The Piedmont soils are the oldest in the State. Fertility of these soils varies considerably. The pH, clay content, and lime requirements also vary within the region. In general, these soils are moderately acid.

Lime Requirements of Different Crops

Just as soils vary in their lime requirement, crops differ widely in their need for lime as a nutrient and in their abilities to grow at low soil pH. Most crops will grow well in soils with a pH of 6 to 7. Alfalfa has as high a lime requirement as any crop grown in Alabama, requiring a soil pH of about 7. Such crops as carpetgrass and lespedeza grow well in quite acid soils.

Since both soils and plants vary in their need for lime, the lime requirements of various Alabama crops will be discussed according to soil area and crop.

COTTON

The cotton plant is tolerant of moderate amounts of soil acid. However, small but profitable yield increases from liming are frequent on moderately acid soils. Large yield increases will not result from liming until sufficient soil acid has accumulated for the soil pH to be between 5.0 and 5.5.

Cotton is frequently grown in rotation with a legume so that lime is actually beneficial to cotton in two ways: (1) an increased supply of calcium and magnesium and (2) the increased supply of other soil nutrients, particularly nitrogen, resulting from the increased organic matter produced by the legume receiving lime.

The cotton-producing soils, as a rule, have been relatively well fertilized in the past. The fertilizers used have contained small supplies of calcium and magnesium as superphosphate or dolomitic limestone. Dolomitic limestone is added to mixed fertilizers in manufacturing non-acid-forming grades. Thus, lime has been added annually in small amounts to cotton lands. This is why, in general, only small gains in cotton yields have been realized from direct applications of lime. With increased usage of acid-forming

FIGURE 2. Effect of lime on cotton on an acid Magnolia sandy loam at Monroeville. Top—unlimed; bottom—lime applied.

fertilizers, more and more direct applications of lime will be needed to offset the acidity produced in the soil by these fertilizers.

"Crinkle leaf" of cotton has been noted in Pickens, Limestone, Lauderdale, and Tallapoosa counties. In some instances, a complete loss of the crop has resulted. "Crinkle leaf" is found only on very acid soils (pH of less than 5.4). It is caused by an excess of manganese in acid soils and may be further aggravated by poor drainage and low organic matter content. The condition of "crinkle leaf" in cotton is corrected by adequate liming.

Experimental Results

Results from several years of experiments with lime applications have shown that cotton yields were increased by liming most Coastal Plains soils, Table 2. No lime was needed at Aliceville for cotton production, since the soil already contained adequate calcium and magnesium as indicated by its pH of 6.3. Annual yield increases of about 300 pounds per acre of seed cotton were obtained from adding lime at Brewton and Monroeville where the soil pH was 5.8 and 5.6, respectively. Soil at Prattville had a higher pH and showed only a slight, though profitable, increase in cotton yields from lime, Tables 2 and 4. Results of experiments on the sandy soils of the Wiregrass Area (Headland) showed that small but frequent lime applications increased the yield of cotton, whereas a large application may have induced "over-liming" damage, Tables 2 and 4.

In soils where lime content is critically low, the use of higher rates of fertilizer will further exaggerate the lime need of cotton (see Table 2, Brewton and Monroeville locations). As higher rates of fertilizer are used on cotton, the yield increases brought about by liming become even greater.

Table 2. Effect of Limestone on the Yield of Seed Cotton in a 2-Year Rotation with Vetch and Corn at Various Sites During a 25-Year Period

Treatment	Average annual seed cotton yield per acre							
	Coastal Plains soils					Crossville[5]	Limestone Valley soils	
	Aliceville[1]	Brewton[1]	Monroeville[2]	Prattville[3]	Headland[4]		Alexandria[6]	Belle Mina[6]
1930-48[7]	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Unlimed	1,475	1,139	1,220	1,397	1,412	1,750	1,204	1,562
Limed	1,436	1,241	1,375	1,447	1,450	1,879	1,148	1,450
1949-55[8]								
Unlimed	1,165	1,431	1,556	1,585	1,708	1,524	1,334	1,434
Limed	1,185	1,754	1,809	1,595	1,646	1,549	1,370	1,394
pH of unlimed soil in 1946	6.3	5.8	5.6	5.9	5.8	5.6	6.0	6.0

[1] Kalmia sandy loam.
[2] Magnolia sandy loam.
[3] Greenville sandy clay loam.
[4] Norfolk sandy loam.
[5] Hartsells fine sandy loam.
[6] Decatur clay loam.
[7] All plots received 100 pounds nitrate of soda, 600 pounds superphosphate, and 75 pounds muriate of potash per acre per rotation.
[8] All plots received 400 pounds nitrate of soda, 800 pounds superphosphate, and 100 pounds muriate of potash per acre per rotation.

The amount of acid-forming nitrogen fertilizers used is continually increasing. Unless these materials are effectively neutralized, the soil becomes more acid and less fertile with continued use. However, adequate liming in conjunction with the use of these fertilizers gives excellent cotton yields, Table 3. Cotton yields were almost doubled at Monroeville and Headland when lime was used with ammonium sulfate. The need for lime was not as great when ammonium nitrate was used. Nevertheless, lime was needed with ammonium nitrate on acid soils. There is no doubt that increased use of acid-forming fertilizer materials will require even more lime. Liquid and anhydrous ammonia applied on acid soils will also require neutralization with lime.

It made little difference whether the lime was drilled in small amounts for each cotton crop or whether a larger broadcast application was made every few years except possibly at Headland, Table 4.

Cotton is not grown to any extent on the heavy Black Belt soils of Alabama. Where cotton is grown in the Black Belt, it is usually found on the sandy soils scattered through that area. Liming practices for cotton on these soils should be the same as for the Coastal Plains soils.

TABLE 3. EFFECT OF LIME ON COTTON GROWN IN ROTATION WITH CORN AND RECEIVING ACID-FORMING NITROGEN FERTILIZERS AT FOUR DIFFERENT SITES, 1946-1953

Nitrogen fertilizer[1]	Limestone added per acre	Average annual yield of seed cotton per acre			
		Coastal Plain soils		Crossville[4]	Limestone Valley
		Monroeville[2]	Headland[3]		Belle Mina[5]
		Lb.	*Lb.*	*Lb.*	*Lb.*
Ammonium nitrate	None	1,311	891	1,448	1,564
Ammonium nitrate	3,000 lb.[6]	1,482	939	1,504	1,622
Ammonium sulfate	None	794	587	154	1,419
Ammonium sulfate	281 lb. each rotation	1,438	988	1,570	1,608
pH of unlimed soil with ammonium sulfate in 1954		----	5.1	4.4	5.0
pH of unlimed soil with ammonium nitrate in 1954			----	5.1	5.3

[1] All plots received 600 pounds per acre of 8-10-10 per rotation.
[2] Magnolia sandy loam.
[3] Norfolk sandy loam.
[4] Hartsells fine sandy loam.
[5] Decatur clay loam.
[6] Lime applied once in 1946.

TABLE 4. EFFECT OF LIME OVER 20 YEARS ON AVERAGE ANNUAL YIELD OF SEED COTTON IN A 2-YEAR ROTATION WITH CORN AND VETCH AT FOUR DIFFERENT SITES

Limestone applied, rate per acre, and method[1]	Average annual per-acre yield of seed cotton, 1930-1949			
	Prattville[2]	Headland[3]	Crossville[4]	Belle Mina[5]
	Pounds	*Pounds*	*Pounds*	*Pounds*
None	1,407	997	1,374	1,670
Drilled every 2 years				
200 pounds	1,428	1,218	1,478	1,710
400 pounds	1,547	1,157	1,544	1,747
600 pounds	1,467	1,012	1,477	1,697
Broadcast every 10 years				
1,000 pounds	1,458	1,204	1,499	1,707
2,000 pounds	1,456	1,020	1,497	1,701
3,000 pounds	1,470	954	1,431	1,684
pH of unlimed soil in 1940	5.6	5.4	5.0	5.4

[1] 600 pounds per acre of 6-8-4 applied to all plots in each rotation.
[2] Greenville sandy clay loam.
[3] Norfolk sandy loam.
[4] Hartsells fine sandy loam.
[5] Decatur clay loam.

Soils of the Sand Mountain Area produce satisfactory cotton yields where adequate fertilization is practiced. The lime requirement of cotton grown on these soils fertilized with non-acid fertilizers has been small. Over a 20- to 25-year period, lime applications at the Sand Mountain Substation, Crossville, resulted in small cotton yield increases, irrespective of whether lime was applied frequently in small amounts or in larger amounts less frequently, Tables 2 and 4. The lime need of cotton is greatly increased on these poorly buffered soils by use of acid-forming fertilizers. In an 8-year experiment at the Sand Mountain Substation, the average yield was 154 pounds of seed cotton per acre from annual applications of ammonium sulfate. When lime was applied with the ammonium sulfate, the yield of seed cotton averaged 1,570 pounds per acre, Table 3.

Much of the soil found in the Limestone valleys is supplied with adequate calcium and magnesium (lime) for production of cotton. Soil at Alexandria with a pH of 6.0 showed practically no need of lime for cotton. A soil with the same pH in the Tennessee Valley gave similar results, Tables 2 and 4.

The acid soils of these valleys, however, need lime. A Tennessee Valley Substation soil made acid by the continued use of ammonium sulfate gave an average increase of almost 200 pounds of seed cotton per acre where lime was added, Table 3.

Available data showing cotton response to liming on Piedmont soils are limited. However, the more acid soils can be expected to respond to lime.

CORN

Corn is tolerant of moderate amounts of soil acid, growing well in soils with a pH of as low as 5.5. However, the addition of lime to the more acid soils having adequate supplies of other nutrients will increase corn yields. Grown in a rotation with legumes, the increased corn yield may come directly from the lime or indirectly from better growth of legumes as a result of the lime application.

Past production of corn in Alabama has been so low that it has been difficult to ascertain the lime requirements of corn. In recent years, higher fertilization rates and improved hybrid varieties have raised corn yields to a level where more lime in the soil will prove to be invaluable in producing greater corn yields.

There are a number of soils in Alabama that need lime for best corn production; yet in some instances, the yield may not be altered or may be seriously reduced by the addition of lime. To realize the benefits of liming, the soil's supply of all other plant nutrients must be adequate. For example, the need for zinc by corn on some limed soils in Alabama has only been realized in recent years. Thus, results from many of the older experiments

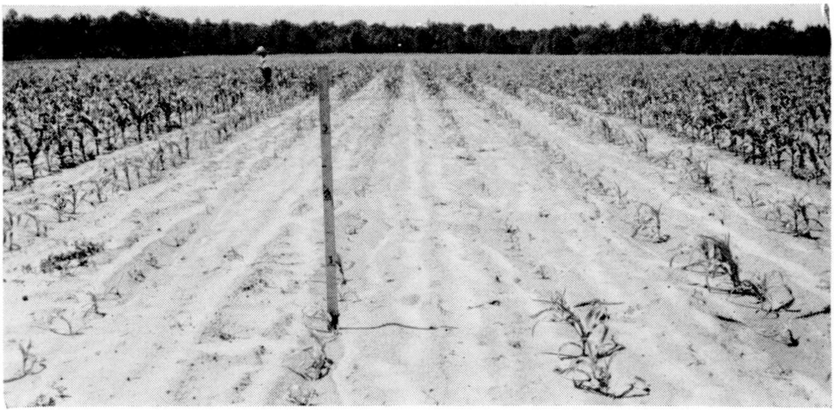

FIGURE 3. Effect of lime on corn on a very acid (pH 4.4) Hartsells fine sandy loam soil at Sand Mountain Substation, Crossville. The center plot received no lime, whereas lime was applied on both sides.

TABLE 5. EFFECT OF LIMESTONE ON THE YIELD OF CORN IN A 2-YEAR ROTATION WITH COTTON AND VETCH AT VARIOUS LOCATIONS IN THE STATE, 1930-1954

Treatment	Yield of corn grain in bushels per acre							
	Coastal Plains soils					Crossville[4]	Limestone Valley soils	
	Aliceville[1]	Brewton[2]	Monroeville[3]	Prattville[3]	Headland[1]		Alexandria[3]	Belle Mina[4]
	Kalmia sandy loam	Kalmia sandy loam	Magnolia sandy loam	Greenville sandy clay loam	Norfolk sandy loam	Hartsells fine sandy loam	Decatur clay loam	Decatur clay loam
1930-48[5]								
Unlimed	41.9	38.8	42.3	46.6	34.4	54.4	26.8	40.5
Limed	42.9	42.3	42.5	44.8	33.8	56.1	34.0	42.0
1949-54[6]								
Unlimed	37.5	50.6	50.0	47.1	33.2	70.2	35.4	50.9
Limed	37.6	54.1	54.2	44.9	33.2	71.2	32.6	52.3
pH of unlimed soil in 1946	6.3	5.8	5.6	5.9	5.8	5.6	6.0	6.0

[1] One ton of lime each in 1929 and 1954.
[2] One ton of lime each in 1929, 1939, 1954.
[3] One ton of lime each in 1929, 1933, 1954.
[4] Two tons of lime in 1929 and 1 ton in 1954.
[5] Corn received 100 pounds of nitrate of soda per acre and the complete fertilizer was added to cotton in the rotation.
[6] Corn received 200 pounds per acre of nitrate of soda and cotton received a complete fertilizer in the rotation.

with lime on corn show no need for lime because the soil's deficiency of zinc was not corrected.

Most experiments with lime on Coastal Plains soils have been with corn yields of 50 bushels per acre or less. With such yields, the benefit from lime has been less than 10 bushels. Limed soil at Brewton, growing 50 bushels of corn or less, has consistently yielded about 4 to 5 bushels per acre more than unlimed soil, Tables 5 and 9.

Corn yields at the Wiregrass Substation have been low in most of the past experiments with lime. However, small drilled applications of lime every year or two have increased the acre yields by 2 to 5 bushels, Tables 6 and 7. Broadcast applications of a ton of lime or more have had no effect, or have actually reduced corn yields at the Wiregrass Substation, Tables 5, 6, and 9, unless zinc sulfate was added with the lime, Table 9.

Lime has had little effect on corn yields at Aliceville (pH 6.3), Prattville (pH 5.6 and 5.9), Monroeville (pH 5.6), and Auburn (pH 5.5), Tables 5, 6, 7, and 8. The soil at the Main Station, Auburn, actually produced about 10 bushels less with lime than without lime or with lime plus zinc sulfate, Table 8.

Several cooperative field tests with lime and the minor nutrients on corn were conducted in 1955 on Coastal Plains soils. Lime was beneficial, especially as the yields became greater, Table 10.

TABLE 6. EFFECT OF DIFFERENT LIME RATES AND METHODS OF APPLICATION ON THE YIELD OF CORN GROWN IN A 2-YEAR ROTATION WITH COTTON AND VETCH, 10-YEAR AVERAGE

Limestone applied, amount and method[1]	Average yield of corn grain per acre			
	Prattville 1940-49[2]	Headland 1930-39[3]	Crossville 1940-49[4]	Belle Mina 1940-49[5]
	Bushels	*Bushels*	*Bushels*	*Bushels*
None	50.3	25.9	40.4	51.5
Drilled every 2 years				
200 pounds	51.2	29.4	50.3	52.6
400 pounds	51.7	27.8	53.9	54.1
600 pounds	49.3	25.8	53.5	52.8
Broadcast every 10 years				
1,000 pounds	52.0	29.4	51.5	52.2
2,000 pounds	50.9	27.2	53.3	55.1
3,000 pounds	49.5	25.7	55.3	53.4
pH of unlimed soil in 1940	5.6	5.4	5.0	5.4

[1] No fertilizer was added to corn, but 600 pounds per acre of 6-8-4 was added to cotton in the rotation.
[2] Greenville sandy clay loam.
[3] Norfolk sandy loam.
[4] Hartsells fine sandy loam.
[5] Decatur clay loam.

TABLE 7. EFFECT OF LIME ON THE YIELD OF CORN GROWN IN ROTATION WITH COTTON RECEIVING NITROGEN FERTILIZER AS AMMONIUM NITRATE OR AMMONIUM SULFATE, 1946-53

Nitrogen fertilizer[1]	Limestone added per acre	Average yield of corn grain per acre			
		Monroeville[2]	Headland[3]	Crossville[4]	Belle Mina[5]
		Bushels	*Bushels*	*Bushels*	*Bushels*
Ammonium nitrate	None	48.3	21.2	37.4	40.8
Ammonium nitrate	3,000 pounds in 1946	48.4	23.6	41.3	40.4
Ammonium sulfate	None	44.8	19.0	21.7	38.2
Ammonium sulfate	281 pounds annually	45.8	23.7	37.1	38.5
Ammonium sulfate	pH of unlimed soil in 1954	--	5.1	4.4	5.0
Ammonium nitrate	pH of unlimed soil in 1954	..	--	5.1	5.3

[1] Cotton received 600 pounds per acre of 8-10-10 in the rotation.
[2] Magnolia sandy loam.
[3] Norfolk sandy loam.
[4] Hartsells fine sandy loam.
[5] Decatur clay loam.

TABLE 8. EFFECT OF LIMESTONE AND BLAST FURNACE SLAG WITH AND WITHOUT MINOR ELEMENTS ON THE YIELD OF CORN GROWN IN ROTATION WITH CRIMSON CLOVER, 1947-49

Lime added[1]		Minor elements added	Average yield of corn per acre		
Kind	Amount per acre		Auburn[2]	Boaz[3]	Camp Hill[4]
	Pounds		*Bushels*	*Bushels*	*Bushels*
	None	None	41.5	26.7	30.6
Coarse slag	4,000	None	42.5	41.8	40.7
Medium slag	4,000	None	40.5	40.2	45.9
Agricultural slag	4,000	None	41.0	47.2	43.8
Agricultural limestone	4,000	None	31.5	42.0	52.7
Agricultural slag	4,000	B, Zn, Mn[5]	51.1	49.2	51.2
Agricultural limestone	4,000	B, Zn, Mn	41.5	48.6	45.6
pH of unlimed soil			5.5	5.1	5.8

[1] All plots received 300 pounds per acre of 0-14-10 annually.
[2] Norfolk sandy loam.
[3] Hartsells fine sandy loam.
[4] Lloyd sandy clay loam.
[5] 5 pounds of borax, 10 pounds of zinc sulfate, and 10 pounds of manganese sulfate.

TABLE 9. EFFECT OF LIME ON CORN YIELDS ON TWO COASTAL PLAINS SOILS, 1954-55

Limestone added per acre	Zinc sulfate added per acre	Yield of corn grain per acre		
		Brewton[1] 1954	Brewton[1] 1955	Headland[2] 1954
	Pounds	*Bushels*	*Bushels*	*Bushels*
None	None	23.6	52.5	47.0
1 ton	None	28.1	53.4	37.5
None	10	22.6	50.4	47.0
1 ton	10	28.4	52.2	49.5
pH of unlimed soil		4.9		5.8
pH of limed soil		5.8		6.5

[1] Kalmia loamy sand.
[2] Norfolk sandy loam.

The greatest benefit from lime was realized on most fields when zinc sulfate was added, the greatest yield increase being 19 bushels per acre.

Corn is usually grown only on the sandy soils of the Black Belt area. The lime needs for these soils are the same as for the Coastal Plains soils.

Corn yields are usually increased several bushels by liming Sand Mountain soils. Yields frequently have been increased 10 to 20 bushels per acre by a lime application, Tables 5, 6, 7, and 8, whether drilled in small amounts frequently or broadcast in larger amounts less frequently. A very acid soil (pH 4.4) resulting from the use of ammonium sulfate produced only about one-half as much corn as did the limed soil, Table 7.

TABLE 10. EFFECT OF LIMESTONE AND ZINC ON THE YIELD OF CORN GROWN IN COOPERATION WITH FARMERS ON SOME COASTAL PLAINS SOILS, 1955

Liming program[1]	Zinc sulfate added per acre	Yield of corn grain per acre				
		Auburn[2]	Union Springs[3]	Thomas-ville[4]	Inver-ness[5]	Locha-poka[6]
	Pounds	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Unlimed	0	34.5	99.9	75.6	53.9	54.0
Limed	0	37.3	91.2	78.9	65.6	58.6
Unlimed	10	33.4	108.2	79.9	54.1	55.2
Limed	10	37.5	112.0	82.3	72.8	62.9
pH of unlimed soil		5.4	6.0	5.8	5.4	5.5
pH of limed soil		6.0	6.4			

[1] 400 pounds per acre 4-12-12 and 300 pounds per acre of ammonium nitrate.
[2] Lakeland sand on farm of George Baker.
[3] Kalmia fine sandy loam on farm of J. W. McCall.
[4] Farm of O. W. Nichols.
[5] Norfolk loamy sand on farm of J. T. Cope.
[6] Norfolk loamy sand on farm of G. C. Calhoun.

TABLE 11. EFFECT OF LIME AND MINOR ELEMENTS ON YIELD OF CORN GROWN IN ROTATION WITH LESPEDEZA ON DICKSON SILT LOAM, LIMESTONE COUNTY

Limestone added per acre	Yield of corn grain per acre	
	Without minor elements[1]	With minor elements[2]
Pounds	*Bushels*	*Bushels*
None	32.8	41.6
1,000	31.6	41.9
3,000	27.9	45.0
5,000	20.0	44.6
7,000	5.2	45.3

[1] 1941 yields from plots receiving 600 pounds per acre of 6-0-0.
[2] 1946 yields from plots receiving 600 pounds per acre of 6-8-8. The minor elements applied were boron, zinc, and magnesium.

Some soils of the Limestone valleys have a pH of 6 or above and need no lime for corn production, Tables 5 and 7. These soils were fairly well supplied with native lime so that added lime had little effect on the corn crop. However, slight yield increases have resulted from liming soils at the Tennessee Valley Substation, Tables 5 and 6.

On the gray lands of the Tennessee Valley, lime had a considerable effect on corn yields, Table 11. Yields were increased by liming, provided the other plant nutrients were adequately supplied. "Over-liming" damage was severe in one experiment where the minor nutrients were not added.

Field tests for lime needs of corn in the Piedmont area are insufficient for results to be reliable. On an acid soil of pH 5.8, corn grown in rotation with crimson clover produced 30 bushels per acre on unlimed soil, whereas a lime application increased the yield to more than 50 bushels per acre, Table 8. Some, if not most, of the increased corn yields resulted from the increased nitrogen added by higher crimson clover yields on the limed plots.

PASTURE LEGUMES

(White Clover, Crimson Clover, Lespedeza)

Pastures are the bases for economical production of meat or milk. Many of the less satisfactory returns from pasture feeding may be traced to a misunderstanding of soil fertility problems.

In the past, the Black Belt Area has been considered the major pasture section of Alabama. However, pasture production in other areas of the State is important. Even though climatic adaptation of pasture plants is vital, an understanding of the soil

TABLE 12. EFFECT OF LIME ON FORAGE PRODUCTION OF WHITE CLOVER-GRASS PASTURE MIXTURES GROWN ON COASTAL PLAINS SOILS

Limestone added per acre[1]	Average annual yield of forage per acre					
	Site 1[2] 1945-50 green forage	Site 2[3] 1950-51 dry forage	Site 3[4] 1948-52 dry forage	Site 4[5] 1952-54 dry forage	Site 5[6] 1952-54 dry forage	Site 6[7] 1943-44 dry forage
Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
0	9,278	2,689	2,045	1,740	3,894	238
2,000	13,507	3,332	----	1,870	----	----
3,000	----	----	2,028	----	----	1,458
4,000	12,944	3,478	----	----	5,428	1,402
6,000	----	----	2,236	----	----	----
pH of unlimed soil	6.5	6.2	----	5.7	5.4	5.4

[1] All plots received adequate applications of phosphate and potash.
[2] Wickham fine sandy loam on Henderson Brothers' Farm at Miller's Ferry.
[3] Wickham sandy loam at Lower Coastal Plain Substation.
[4] Iuka silt loam at Upper Coastal Plain Substation.
[5] Izagora fine sandy loam on Warren Farm at Comer.
[6] Susquehanna fine sandy loam on Brabham Farm at Comer.
[7] Norfolk sandy loam at Auburn.

TABLE 13. EFFECT OF LIME ON FORAGE PRODUCTION OF WHITE CLOVER-GRASS PASTURE MIXTURES IN THE BLACK BELT AREA

Limestone added per acre[1]	Average annual yield of forage per acre							
	Site 1[2] 1950 dry hay	Site 2[2] 1950 dry hay	Site 3[2] 1950 dry hay	Site 4[3] 1949-53 dry hay	Site 5[4] 1943-46 green hay	Site 5[4] 1950-52 dry hay	Site 6[5] 1943-52 green hay	Site 7[6] 1944-46 green hay
Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
0	1,868	5,212	4,614	----	21,560	4,426	1,372	5,976
2,000	1,586	6,113	----	3,391	25,652	4,348	12,623	6,416
4,000	2,420	5,654	5,466	4,044	28,746	6,138	10,782	8,282
6,000	2,146	5,859	----	----	----	----	----	----
8,000	----	----	----	4,927	28,165	5,556	17,252	----
16,000	----	----	----	----	27,218	5,430	----	----
pH of unlimed soil	5.2	5.2	5.3	5.0	4.6		4.7	----

[1] Adequate phosphate and potash applied to all soils.
[2] Vaiden clay at Marion Junction.
[3] Lufkin clay at Catherine.
[4] Susquehanna clay loam.
[5] Oktibbeha clay on Moss Farm at Lamison in Wilcox County.
[6] Leaf silt loam on Colley Farm near Safford.

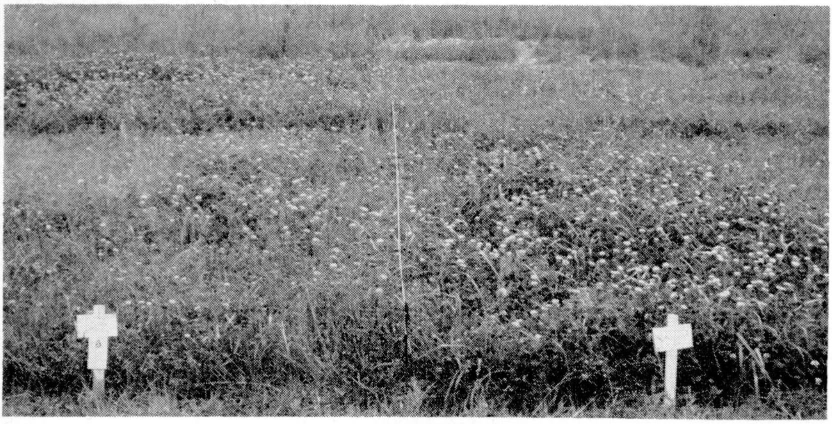

FIGURE 4. White clover at left is unlimed (pH 5.4); plot at right received 2 tons of lime. Soil is Susquehanna fine sandy loam.

needs is just as important. A vital part of any successful pasture program is good legume growth. Legumes are high-protein producers and are valuable sources of high-quality livestock feed.

Clovers are the most important legumes grown in pasture mixtures in this State. Vetches, alfalfa, and Caley peas are also important forage legumes. In general, all require a soil well supplied with lime and a pH of 6 to 7.

Lespedeza is probably the only other important pasture legume for Alabama. Even though lespedeza does better on an adequately limed soil, it is quite tolerant of moderate amounts of soil acid, growing satisfactorily over a pH range of 5.5 to 7.0.

White clover has been tested at several locations for its lime needs, Tables 12, 13, and 14. The forage yield of white clover

TABLE 14. EFFECT OF LIME ON FORAGE PRODUCTION OF WHITE CLOVER-GRASS PASTURE MIXTURE ON PIEDMONT SOILS

Limestone added per acre[1]	Average annual yield of dry forage per acre	
	Camp Hill[2] 1953	Gold Hill[3] 1952-53
Pounds	*Pounds*	*Pounds*
0	7,464	3,665
2,000	8,822	4,047
4,000	7,291	----
pH of unlimed soil	5.9	5.7

[1] Each soil received adequate phosphate and potash.
[2] Cecil sandy loam.
[3] Lloyd clay loam.

TABLE 15. EFFECT OF LIME ON FORAGE PRODUCTION OF CRIMSON CLOVER GROWN ON COASTAL PLAINS SOILS

Limestone added per acre[1]	Average annual yield of forage per acre				
	Site 1[2] 1944-45 dry forage	Site 2[3] 1952-53 dry forage	Site 3[4] 1948-50 green forage	Site 4[5] 1942-45 green forage	Site 4[5] 1946-48 green forage
Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
0	1,877	1,856	11,940	720	0
1,500	4,013	----	----	20,000	1,600
2,000	----	2,342	----	----	----
3,000	4,534	----	----	22,600	10,200
4,000	4,487	----	12,940	----	----
8,000	4,920	----	----	----	----
pH of unlimed soil	5.3	6.5	5.5	5.7	5.7

[1] All plots received added phosphate and potash.
[2] Norfolk sandy loam at Auburn which received borax in addition to other nutrients.
[3] Kalmia fine sand on Henderson Brothers' Farm at Miller's Ferry.
[4] Norfolk loamy sand near Auburn.
[5] Lime applied in 1941 to Norfolk sandy loam at Auburn.

on Coastal Plains soils was increased several hundred pounds by a 1- or 2-ton per acre application of lime every few years, Table 12.

The calcareous and neutral soils of the Black Belt area do not require added lime for good white clover production, whereas results from a number of experiments on the acid clay soils of that area have shown a definite need for moderate to heavy lime applications, Table 13. Lime was particularly necessary for maintaining legume stands. Observations are convincing evidence that the continued greater production of limed pastures is due, to a large extent, to the more abundant growth of clover.

Increased forage production of a white clover-grass mixture at two separate locations in the Piedmont area was obtained from the application of 1 ton of lime, Table 14.

The necessity of maintaining an adequate supply of lime for crimson clover has been shown by results of several experiments, Tables 15 and 16. Lime can mean the difference between a crop failure and a good crop, Table 15-site 4.

TABLE 16. EFFECT OF LIME ON FORAGE PRODUCTION OF CRIMSON CLOVER, 1947-49

Limestone added per acre[1]	Average annual yield of green forage per acre	
	Hartsells very fine sandy loam	Lloyd sandy clay loam
Pounds	*Pounds*	*Pounds*
0	5,680	12,120
4,000	12,300	20,020
pH of unlimed soil	5.1	5.8

[1] All plots received adequate phosphate, potash, boron, zinc, and manganese.

Adequate soil lime not only greatly influences the production of clover forage, but it also affects seed production. However, it is pointed out that adequate soil boron is also essential for the benefits from liming to be realized in clover seed production. The yield of crimson clover seed was markedly increased on Norfolk sandy loam by an application of lime when the soil received an application of borax, Table 17.

Much of the South's leguminous pasture in the past has resulted from the tolerance that lespedeza has toward soil acid. However, the need for lime by lespedeza may be considered in much the same light as clover, keeping in mind its greater tolerance for soil acidity. Results of experiments with lespedeza show that forage yields increase considerably from liming an acid soil,

TABLE 17. EFFECT OF LIME ON PRODUCTION OF CRIMSON CLOVER SEED ON NORFOLK SANDY LOAM RECEIVING BORAX APPLICATIONS, MAIN STATION

Limestone added per acre	Average annual yield of seed per acre	
	Site 1 1942-48	Site 2 1954
Pounds	*Pounds*	*Pounds*
0	232	599
1,500	433	----
2,000	----	1,170
3,000	482	----
4,000	552	1,132
8,000	696	995
pH of unlimed soil	5.3	5.0

TABLE 18. EFFECT OF LIME ON PRODUCTION OF ANNUAL LESPEDEZA AND SERICEA IN 1945

Limestone added per acre[1]	Yield per acre			
	Sericea[2] dry hay	Annual lespedeza[2]		Annual lespedeza[3] dry hay
		Dry hay	Seed	
Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
0	1,983	671	110	1,982
1,000	----	----	----	1,544
1,500	----	2,223	350	----
2,000	2,692	----	----	----
3,000	----	2,648	372	2,554
4,000	----	2,984	507	----
5,000	----	----	----	2,363
7,000	----	----	----	2,325
8,000	----	3,005	533	----
pH of unlimed soil		5.3		

[1] Adequate phosphate and potash supplied to all soils.
[2] Norfolk sandy loam at Auburn.
[3] Dickson silt loam in Limestone County.

TABLE 19. COW DAYS OF GRAZING AND WEIGHT GAINS OF BEEF CATTLE ON CLOVER-GRASS PASTURES ON EUTAW CLAY, LIMED AT 2- AND 4-TON RATES, BLACK BELT SUBSTATION, 1946-48[1]

Limestone added per acre[2]	Average annual grazing	Average annual beef gains per acre
Pounds	*Cow days per acre*	*Pounds*
0	174	272
4,000	205	314
8,000	205	315

[1] Pasture mixture included white clover, Persian clover, lappacea clover, lespedeza, and Dallisgrass.
[2] Adequate phosphate added to each plot.

Table 18. Not only has forage production increased by liming the soil, but seed yield of lespedeza also increased.

The ultimate purpose of greater forage production is greater animal production. It was found at the Black Belt Substation that limed soil growing a pasture mixture provided beef cattle grazing for a longer time and produced greater beef weight gains than pasture on unlimed soil, Table 19.

SOIL IMPROVING LEGUMES – WINTER AND SUMMER

(Vetch, Austrian Winter Peas, Soybeans, Alyce Clover, Crotalaria)

Farmers have observed, and there is abundant supporting experimental evidence, that most of their fields produced more when legumes were grown in the crop rotation. One of the most important uses of lime is in promoting legume growth. In general, yields of legumes grown on acid soils are increased by the application of lime, and many of the failures with these crops may be caused by the lack of lime.

The practice of interplanting summer legumes with corn has decreased considerably in recent years. The more common practice now is the use of a winter cover crop in the rotation.

Legumes grown in rotation with other crops on acid soils will consistently produce more organic material where lime has been

TABLE 20. EFFECT OF RATES OF LIME AND APPLICATION METHOD ON WEIGHT OF VETCH PRODUCED IN A 2-YEAR ROTATION WITH COTTON AND CORN AT VARIOUS LOCATIONS, 1931-50

Limestone applied, rate per acre, and method[1]	Average annual weight of green vetch per acre			
	Prattville[2]	Headland[3]	Crossville[4]	Belle Mina[5]
	Pounds	*Pounds*	*Pounds*	*Pounds*
None	10,822	6,863	4,485	9,776
Drilled every 2 years				
200 pounds	11,430	9,437	6,931	10,616
400 pounds	13,249	9,445	7,670	11,247
600 pounds	12,990	9,356	7,795	11,264
Broadcast every 10 years				
1,000 pounds	13,067	10,040	7,145	10,463
2,000 pounds	13,367	9,783	8,174	11,580
3,000 pounds	12,721	9,526	8,169	11,851
pH of unlimed soil in 1946	5.6	5.4	5.0	5.4

[1] Complete fertilizer added to cotton in the rotation.
[2] Greenville sandy clay loam.
[3] Norfolk sandy loam.
[4] Hartsells fine sandy loam.
[5] Decatur clay loam.

TABLE 21. EFFECT OF LIMESTONE ON WEIGHT OF VETCH PRODUCED IN A 2-YEAR ROTATION WITH COTTON AND CORN AT VARIOUS SITES DURING A 25-YEAR PERIOD

Treatment[1]	Average annual weight of green vetch per acre							
	Coastal Plains soils					Crossville[5]	Limestone Valley soils	
	Aliceville[2] Kalmia s.l.	Brewton[3] Kalmia s.l.	Monroeville[4] Magnolia s.l.	Prattville[4] Greenville s.c.l	Headland[2] Norfolk s.l.	Hartsells f.s.l.	Alexandria[4] Decatur c.l.	Belle Mina[5] Decatur c.l.
1930-48	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Unlimed	11,609	6,839	11,658	12,949	10,561	9,356	10,105	11,774
Limed	11,829	10,272	14,141	12,545	12,224	11,613	10,698	13,276
1949-55								
Unlimed	15,575	11,067	15,098	21,625	4,644	13,519	14,758	16,852
Limed	15,542	15,527	16,962	20,358	3,387	18,352	15,129	17,478
pH of unlimed soil in 1946	6.3	5.8	5.6	5.9	5.8	5.6	6.0	6.0

[1] Cotton received a complete fertilizer in the rotation.
[2] One ton of lime each in 1929 and 1954.
[3] One ton of lime each in 1929, 1939, and 1954.
[4] One ton of lime each in 1929, 1933, and 1954.
[5] Two tons of lime in 1929 and 1 ton in 1954.

TABLE 22. EFFECT OF RATES OF LIME AND APPLICATION METHOD ON WEIGHT OF SOYBEANS AND CROTALARIA INTERPLANTED WITH CORN IN A 2-YEAR ROTATION OF COTTON-VETCH-CORN AT SEVERAL LOCATIONS

Limestone applied, rate per acre, and method[1]	Average annual green weight of plants per acre						
	Prattville[2]		Headland[3]	Crossville[4]		Belle Mina[5]	
	Soybeans 1931-34	Crotalaria 1937-45	Crotalaria 1938-40	Soybeans 1930-34	Crotalaria 1936-45	Soybeans 1930-45	Crotalaria 1937-45
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
None	7,345	2,383	2,004	3,948	2,026	7,414	2,778
Drilled every 2 years							
200 pounds	7,787	2,852	1,801	4,142	1,917	7,828	2,705
400 pounds	8,431	3,444	2,374	5,216	2,235	7,979	3,127
600 pounds	8,575	3,114	2,185	5,349	2,174	8,465	3,233
Broadcast every 10 years							
1,000 pounds	8,478	3,229	2,047	4,815	2,092	7,328	2,896
2,000 pounds	8,408	3,137	2,301	5,388	1,958	8,326	3,220
3,000 pounds	9,061	2,877	2,454	5,858	2,294	8,775	3,125
pH of unlimed soil in 1946	5.6		5.4	5.0		5.4	

[1] 600 pounds per acre of 6-8-4 added to cotton in the rotation.
[2] Greenville sandy clay loam.
[3] Norfolk sandy loam.
[4] Hartsells fine sandy loam.
[5] Decatur clay loam.

added. Results of experiments at several locations throughout the State have shown that vetch growth was increased by liming, Tables 20, 21, and 24. Growth of Austrian winter peas was almost doubled by liming in a test at Brewton, Table 23.

Similarly, yields of summer legumes grown on acid soil were increased. Lime has been highly beneficial to soybeans, crotalaria, and Alyce clover grown on acid soils, Tables 22, 23, and 24. Crotalaria is probably the least responsive to liming, while Alyce clover is the most responsive.

TABLE 23. EFFECT OF LIME ON WEIGHT OF AUSTRIAN WINTER PEAS AND CROTALARIA GROWN IN A 2-YEAR ROTATION WITH COTTON AND CORN ON KALMIA SANDY LOAM, BREWTON EXPERIMENT FIELD, 1934-44

Grade of fertilizer added to cotton in rotation[1]	Kind of lime and per-acre rate of application every 6 years	Average annual green weight per acre	
		Austrian winter peas	Crotalaria
Grade		*Pounds*	*Pounds*
6-0-4	None	2,208	7,131
6-0-4	2,000 pounds dolomite	3,225	7,256
6-5-4	None	3,629	7,488
6-5-4	2,000 pounds dolomite	6,980	7,830
6-10-4	None	4,836	6,858
6-10-4	2,000 pounds dolomite	8,368	7,773
6-10-4	2,250 pounds basic slag	8,234	6,548
6-15-4	None	5,601	5,794
6-15-4	2,250 pounds basic slag	8,595	6,626

[1] Applied at rate of 600 pounds per acre.

TABLE 24. EFFECT OF LIME ON PRODUCTION OF ALYCE CLOVER, VETCH, AND SOYBEANS, ON NORFOLK SANDY LOAM, MAIN STATION

Limestone added per acre	Average annual weight of plants per acre		
	Alyce clover dry matter 1945	Soybeans dry matter 1942-44	Vetch green matter 1942-48
Pounds	*Pounds*	*Pounds*	*Pounds*
0	383	2,619	3,402
1,500	2,843	5,037	9,004
3,000	5,285	4,899	10,808
4,000	4,952	5,545	----
8.000	4,646	4,730	
pH of unlimed soil	5.3	5.3	5.4

GRASSES

(Johnsongrass, Sudangrass, Grain Sorghum, Sweet Sorghum, Oats)

Most grass plants grow satisfactorily within a rather wide pH range, about 5.5 to 7.0. Grasses require only a moderate supply of soil calcium for good growth. Bermudagrass is probably the most tolerant of the grasses to soil acid. However, on soils with a pH of less than 5.5, the growth of grasses is favorably influenced by lime application.

The necessity of lime for grasses on a very acid soil has been dramatically demonstrated at Auburn. A field that had received annual applications of the acid-forming ammonium sulfate for 25 years was tested for lime response, with sweet sorghum and oats as the test crops, Table 25. Different rates of lime were added and ammonium sulfate applications were continued. After 8 years, almost all benefit from lime at rates of 2 tons or less per acre had disappeared. The soil was practically incapable of producing any crop where no lime was added. The crop yield was good when lime was first added but continued to decrease each year as the soil lime was exhausted.

Another test at Auburn definitely established the need for lime

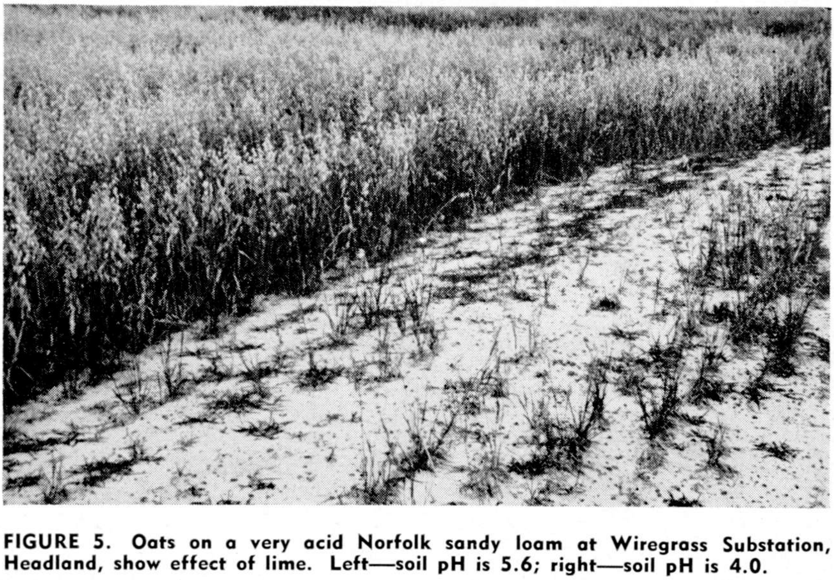

FIGURE 5. Oats on a very acid Norfolk sandy loam at Wiregrass Substation, Headland, show effect of lime. Left—soil pH is 5.6; right—soil pH is 4.0.

TABLE 25. EFFECT OF LIME ON THE YIELD OF SWEET SORGHUM AND OATS IN ROTATION ON NORFOLK SANDY LOAM MADE VERY ACID BY CONTINUOUS USE OF AMMONIUM SULFATE FERTILIZER SINCE 1911, MAIN STATION

Limestone added per acre[1]	Average annual yield of crop by periods								Soil pH in 1953
	Sweet sorghum stover per acre			Oats grain per acre					
	1936-39	1940-43	1944-45	1936-39	1940-43	1944-46	1947-50	1951-53	
Pounds	*Lb.*	*Lb.*	*Lb.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	
None	516	457	101	15.4	12.1	6.5	8.9	8.6	4.3
210 annually	4,408	3,756	1,813	27.2	28.1	18.2	30.3	36.7	4.7
420 annually	4,871	7,145	5,631	33.0	30.1	19.8	34.5	43.2	5.5
1,144 in 1934 and 1947[2]	3,652	560	78	25.9	16.5	6.2	32.2	39.7	4.7
2,608 in 1934 and 1947[2]	7,326	2,198	84	34.7	24.7	12.0	34.9	39.6	5.2
4,072 in 1934 and 1947[2]	8,444	7,051	162	31.2	25.5	16.5	36.5	37.2	5.8
5,536 in 1934 and 1947[2]	9,143	9,163	2,849	36.6	24.9	18.8	39.4	40.5	6.4

[1] A complete fertilizer was added each year.
[2] Only one treatment was applied in the case of the sweet sorghum.

by oats on an acid soil. Oat yields were increased by at least 50 per cent where adequate lime was applied, Table 26.

The lime need of grain sorghum must be met if good growth is to be obtained. Increased yields of grain sorghum resulted from application of lime on the acid gray lands of the Tennessee Valley, Table 27. Similar results have been obtained at Auburn for both grain and stover yields, Table 27.

TABLE 26. EFFECT OF LIME ON YIELD OF OATS IN ROTATION WITH LESPEDEZA ON NORFOLK SANDY LOAM, MAIN STATION, 1944-45

Limestone added per acre[1]	Average annual yield of oats per acre		pH of unlimed soil
	Straw	Grain	
Pounds	*Tons*	*Bushels*	
None	1.22	40.0	5.8
1,500	1.58	57.0	
3,000	1.78	65.9	
4,000	1.69	64.1	
8,000	1.82	77.0	

[1] Lime added in 1941 and adequate amounts of complete fertilizer added annually.

FIGURE 6. Effect of lime on grain sorghum growing on Norfolk sandy loam at Wiregrass Substation, Headland. Left—lime applied; right—unlimed.

TABLE 27. EFFECT OF LIME ON YIELD OF GRAIN SORGHUM ON ACID SOILS AT TWO WIDELY SEPARATED LOCATIONS

Limestone added per acre[1]	Average annual yield per acre		
	Site 1[2] grain	Site 2[3]	
		Grain	Stover
Pounds	*Bushels*	*Bushels*	*Tons*
None	37.2	55.6	5.40
1,000	34.4	--	--
2,000		71.1	6.63
3,000	45.2	--	--
4,000		65.6	6.82
5,000	45.2	--	--
7,000	46.4	--	--
8,000		61.9	7.06
pH of unlimed soil		5.0	

[1] A complete fertilizer was applied to all plots.
[2] Dickson silt loam in Limestone County in 1945.
[3] Norfolk sandy loam at Auburn in 1954.

Johnsongrass on unlimed acid soil was almost a complete failure at Auburn. Liming the soil increased yields several-fold, Table 28. A lime application on an acid Black Belt soil gave a 3-fold increase in hay production, Table 28.

Sudangrass is similar to Johnsongrass in its need for lime. Its growth on very acid soils is considerably increased by liming, Table 28.

TABLE 28. EFFECT OF LIME ON HAY PRODUCTION OF JOHNSONGRASS AND SUDANGRASS

Limestone added per acre[1]	Annual yield of dry hay per acre		
	Johnsongrass 1945		Sudangrass 1942-46
	Site 1[2]	Site 2[3]	Site 3[2]
Pounds	*Pounds*	*Pounds*	*Pounds*
None	106	1,696	2,150
1,500	3,284	----	7,460
3,000	3,846	----	9,500
4,000	4,001	----	----
6,000	----	4,868	----
8,000	4,048	----	----
pH of unlimed soil		4.7	5.7

[1] A complete fertilizer was added to all plots.
[2] Norfolk sandy loam at Auburn.
[3] Vaiden clay loam at Browns.

ALFALFA, SWEET CLOVER, AND CALEY PEAS

Alfalfa and sweet clover have a high requirement for soil calcium. The lime requirement of Caley peas is also high but may be somewhat less than that for alfalfa and sweet clover. All three plants thrive in a soil that has sufficient calcium for a soil pH range of 6.5 to 7.5. Crop failures may result if very much soil acid is permitted to develop in soils devoted to growing these crops. The pH of most Alabama soils is too low to maintain production of these crops without heavy lime applications.

An abundance of soil calcium is also vital for maintenance of stand over several years. Sufficient soil calcium may be present for the first year's growth of alfalfa, but the stand will become progressively poorer each year, unless adequate lime is present or supplied.

Alfalfa was first grown successfully in Alabama on the neutral and calcareous soils of the Black Belt. These are the only soils in the State that still have sufficient native lime to support and maintain satisfactory alfalfa growth. Probably every other soil in the State will require lime applications to maintain a satisfactory growth of alfalfa, sweet clover, and Caley peas.

Unlimed Coastal Plains soils will produce practically no alfalfa hay, but satisfactory yields are produced when these soils are limed, Tables 29 and 30.

The neutral and calcareous soils of the Black Belt need no additional lime for good growth of these three crops. However, the acid soils of that area need heavy applications of lime for good growth of Caley peas, Table 31. Complete crop failures may result on unlimed acid Black Belt soils, Table 31.

Sand Mountain soils are much too low in soil lime to grow alfalfa, sweet clover, and Caley peas unless lime is added, Tables 29 and 30.

The Limestone Valley soils are higher in soil lime than many other Alabama soils. Still, alfalfa yields have been doubled there by liming, Table 32.

The yield of alfalfa on Piedmont soils was greatly increased by a lime application. Production on unlimed soil was practically a failure, Table 29.

TABLE 29. EFFECT OF LIME ON HAY YIELD OF ALFALFA ON SOILS OF THE COASTAL PLAINS, SAND MOUNTAIN, AND PIEDMONT AREAS DURING A 2- TO 3-YEAR PERIOD

Limestone added per acre[1]	Average annual yield of dry hay per acre					
	Coastal Plains soil		Sand Mountain soil		Piedmont soil	
	Site 1[2] 1943-45	Site 2[3] 1947-49	Site 3[4] 1943-45	Site 4[5] 1947-49	Site 5[6] 1944-45	Site 6[7] 1947-49
Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
0	426	1,352	----	352	----	381
2,000	6,742	----	4,225	----	6,465	----
4,000	9,569	6,403	4,917	6,617	6,539	5,353
8,000	7,484	----	----	----	6,553	----
pH of unlimed plots	----	5.5	----	5.1	----	5.8

[1] All plots received phosphate and potash.
[2] Norfolk sand at Auburn.
[3] Norfolk loamy sand at Auburn.
[4] Hartsells fine sandy loam at Crossville.
[5] Hartsells fine sandy loam at Boaz.
[6] Madison clay loam at Auburn.
[7] Lloyd sandy clay loam at Camp Hill.

TABLE 30. EFFECT OF LIME ON YIELD OF ALFALFA HAY ON VARIOUS ACID SOILS IN THE STATE

Limestone added per acre	Average annual yield of hay per acre								
	Coastal Plains soil					Sand Mt. soil	Limestone Valley soil	Piedmont soil	
	Prattville[1] 4-yr. av.	Winfield[2] 6-yr. av.	Atmore[3] 5-yr. av.	Fairhope[4] 3-yr. av.	Tuskegee[5] 4-yr. av.	Crossville[6] 4-yr. av.	Alexandria[7] 5-yr. av.	Auburn[8] 4-yr. av.	Camp Hill[9] 4-yr. av.
Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
2,000			6,600	8,143					
4,000	6,137	5,367	7,658	7,712	4,048	7,806	6,396	7,041	5,216
6,000	9,287	6,609				8,473	6,738		
8,000	8,419	7,432	8,555	7,695	4,371	6,815	6,355	8,584	5,559
16,000			8,738	8,310	5,201			8,283	5,546

[1] Greenville fine sandy loam.
[2] Atwood fine sandy loam.
[3] Orangeburg fine sandy loam.
[4] Norfolk sandy loam.
[5] Susquehanna fine sandy loam.
[6] Hartsells fine sandy loam.
[7] Decatur clay loam.
[8] Madison clay loam.
[9] Lloyd clay loam.

TABLE 31. EFFECT OF LIME ON HAY YIELD OF CALEY PEAS GROWN ON ACID SOILS OF THE BLACK BELT AREA

Limestone added per acre[1]	Yield of hay per acre						
	Site 1[2] 1944-45 green wt.	Site 2[3] 1945 green wt.	Site 3[4] 1945 green wt.	Site 4[5] 1944-45 green wt.	Site 5[5] 1945 dry wt.	Site 6[4] 1945 green wt.	Site 7[4] 1945 green wt.
Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
0	2,267	1,725	419	0	396	746	
3,000	8,202						
4,000		19,470	5,157	4,502		5,550	11,250
6,000	8,810				3,105		
8,000		14,160	6,551	8,702		6,586	17,500
pH of unlimed soil	5.3		5.2	4.7	4.7	4.6	4.5

[1] Phosphate and potash added to all plots.
[2] Flint sandy loam at Tuskegee.
[3] Eutaw clay at Marion Junction
[4] Vaiden clay at Marion Junction.
[5] Vaiden clay loam at Browns.

TABLE 32. EFFECT OF LIME ON YIELD OF ALFALFA ON DECATUR CLAY LOAM, TENNESSEE VALLEY SUBSTATION

Limestone added per acre	Average annual yield of dry hay per acre	
	First planting 1931-36	Second planting 1937-41
Pounds	*Pounds*	*Pounds*
0	2,363	2,723
3,000	3,317	4,701
6,000	3,852	5,700
12,000	----	6,637

PEANUTS

Commercial peanut production in the State is centered on the sandy Coastal Plains soils of southeastern Alabama. Because of the nature of sandy soils, high rainfall leaches the soil minerals and prevents the soil from storing large reserves of plant nutrients. The soil's supply of potassium, certain minor elements (e.g., zinc), and the liming nutrients of calcium and magnesium are rapidly removed from Alabama's peanut producing soils.

PEANUT SOILS ARE RAPIDLY EXHAUSTED

The rapid loss of soil minerals to the peanut plant and to leaching water is soon reflected in sharp reductions in yield. On a test area at the Wiregrass Substation, peanuts were grown continuously from 1932 to 1949 without fertilizer or lime. The soil was yielding about 1 ton of dry peanuts per acre in 1932; by 1949, the yield was 360 pounds or less, Tables 33 and 34.

TABLE 33. EFFECT OF LIME, GYPSUM, AND FERTILIZERS ON YIELD OF RUNNER PEANUTS IN 1949-50 AFTER CONTINUOUS CROPPING OF PEANUTS SINCE 1932 ON UNFERTILIZED AND UNLIMED NORFOLK SANDY LOAM, WIREGRASS SUBSTATION

Kind and amount of fertilizer added per acre[1]	Calcium material per acre[2]	Average annual yield of nuts per acre
		Pounds
None	None	360
200 pounds muriate of potash	None	796
400 pounds superphosphate 200 pounds muriate of potash	None	895
400 pounds superphosphate 200 pounds muriate of potash	500 pounds gypsum	1,857
400 pounds superphosphate 200 pounds muriate of potash	2,000 pounds limestone	1,942

[1] Fertilizer included the minor nutrients of boron, zinc, copper, and manganese.
[2] Liming material included 100 pounds per acre of magnesium sulfate.

TABLE 34. EFFECT OF LIME AND FERTILIZER ADDED IN 1950 ON YIELD OF RUNNER PEANUTS GROWN CONTINUOUSLY ON UNFERTILIZED AND UNLIMED NORFOLK SANDY LOAM SINCE 1932, WIREGRASS SUBSTATION

Fertilizer added per acre	Minor nutrients added[1]	Limestone added per acre[2]	1950 yield of dry peanuts per acre
		Pounds	*Pounds*
None	No	None	109
None	No	2,000	762
None	Yes	2,000	774
400 pounds superphosphate 200 pounds muriate of potash	No	2,000	1,948
400 pounds superphosphate 200 pounds muriate of potash	Yes	2,000	2,043

[1] Minor nutrients consisted of 5 pounds borax, 10 pounds zinc sulfate, 10 pounds copper sulfate, and 30 pounds manganese sulfate per acre.
[2] Lime included 100 pounds per acre of magnesium sulfate.

RESTORING EXHAUSTED PEANUT SOILS

Adding needed plant nutrients can restore an exhausted soil to its potential capacity for producing peanuts. Peanut yields from depleted soil at the Wiregrass Substation were immediately restored to about 1 ton of nuts per acre by an application of phosphorus, potassium, calcium, magnesium, and minor elements, Tables 33 and 34. The necessity for calcium and magnesium is clearly demonstrated by the 1,000-pound yield increase obtained from either gypsum or lime along with magnesium sulfate, Table 33.

The potential benefit from lime is not realized unless all other plant nutrients are adequately supplied, Table 34. The peanut yield on an unfertilized and unlimed soil at the Wiregrass Substation was 109 pounds of nuts per acre. An application of lime raised the yield to 762 pounds per acre. However, when other needed plant nutrients were added along with lime, the peanut yield increased to about 1 ton per acre.

ALABAMA'S PEANUT SOILS NEED LIME

The need for lime on Alabama soils devoted to growing peanuts was shown by this Station almost 50 years ago. Results from early experiments showed that most, but not all, limed peanut soils produced more than did unlimed soils.

Although the majority of past experiments proved the need for lime, the effort to obtain a clear-cut picture of lime requirements of peanuts was frustrated by numerous experiments in which lime had no effect on peanut yields, or caused serious reduction in yield. Based on the adage that "if a little is good, more is better," some peanut fields may have received too much lime at one application. For example, one field received sufficient lime to raise the soil pH to about 7.5. This field in 1950 produced only 63 pounds of peanuts per acre, Table 35. An application of potash brought the yield up to about 700 pounds. When zinc was applied in addition to potash, the yield was increased to about 1,400 pounds of nuts. A yield of 1,800 pounds was obtained when potash and four minor elements were applied to the heavily limed soil.

It is not enough to supply lime to an unfertilized soil in the peanut-growing area. Not only has the calcium and magnesium supply been greatly reduced but likewise the soil's supply of other nutrients, such as potassium, zinc, and boron. When the possible inadequacy of these other nutrients is overlooked, "over-liming" injury can result. The yield of peanuts was reduced by moderate

TABLE 35. EFFECT OF ZINC AND OTHER MINOR NUTRIENTS ON YIELD OF RUNNER PEANUTS IN 1950 GROWN ON A SOIL THAT HAD BEEN PREVIOUSLY "OVER-LIMED" TO A SOIL pH OF ABOUT 7.5

Fertilizer added	Minor nutrients added	Yield of dry nuts per acre	Percentage of sound mature kernels
		Pounds	*Per cent*
None	None	63	49.9
Potash	None	714	64.9
Potash	Zinc	1,390	68.1
Potash	All[1]	1,804	70.5

[1] 5 pounds borax, 5 pounds copper sulfate, 15 pounds zinc sulfate, and 25 pounds manganese sulfate per acre.

TABLE 36. EFFECT OF RATE OF LIME AND METHOD OF APPLICATION ON YIELD OF PEANUTS GROWN IN A 2-YEAR ROTATION WITH COTTON AND VETCH, NORFOLK SANDY LOAM, WIREGRASS SUBSTATION, 1941-49

Limestone added per acre[1]	Frequency of application	Method of application	Av. annual yield of dry peanuts per acre	Soil pH in 1940
Pounds			*Pounds*	
0			1,820	5.4
200	Every year	Drilled	1,872	5.7
400	Every year	Drilled	1,814	5.8
600	Every year	Drilled	1,494	6.0
1,000	Every 10 years	Broadcast	1,836	5.6
2,000	Every 10 years	Broadcast	1,507	5.7
3,000	Every 10 years	Broadcast	1,416	5.7

[1] 600 pounds per acre of 0-8-4 applied to cotton in the rotation.

rates of lime at the Wiregrass Substation where only a small amount of potash fertilizer was applied to cotton in the rotation, Table 36. Frequent small applications of lime slightly increased the peanut yields. In another experiment at the Wiregrass Substation where higher rates of fertilizer were used, there was an average yield increase of about 350 pounds per acre when 1 ton of lime was applied, Table 37. A comparison between these two effects of lime illustrates the necessity of satisfying all needs of the plant.

TABLE 37. EFFECT OF LIME ON PEANUT YIELDS GROWN IN A 3-YEAR ROTATION OF CORN-PEANUTS HOGGED-GREEN MANURE OATS-PEANUTS ON NORFOLK SANDY LOAM, WIREGRASS SUBSTATION, 1942-51

Limestone added per acre[1]	Av. annual yield of dry peanuts per acre
Pounds	*Pounds*
None	1,322
2,000 in 1942	1,587

[1] 300 pounds per acre of 0-8-12 was applied to peanuts.

UNDERSTANDING THE PEANUT-SOIL LIME PROBLEM

Many agricultural problems in the past can be explained in the light of present-day knowledge. Inadequate potash fertilization was responsible for some failures of peanuts to benefit from liming. No doubt, other failures have resulted from an insufficient supply of soil zinc or other minor nutrients.

Although the response of peanuts to liming had consistently pointed out the need for lime, there were always some results that defied simple explanations. The problem has been attacked on a broad scale during the last 12 years. Almost 100 experiments have been conducted on farmers' fields to better ascertain their lime needs and to gain insight into the problem of lime and peanuts in Alabama. No concerted effort was made to eliminate all instances of "over-liming," but it was avoided as much as possible by using light applications of lime. In view of this, some erratic results were to be expected.

SOIL LIME AND PEANUT YIELDS

Results from numerous field tests established a definite relationship between the soil's supply of lime and the effect of a lime application on peanut yields, Table 38. If the soil's supply of lime was above 700 to 800 pounds per acre, there was little chance of

TABLE 38. EFFECT OF LIME AND GYPSUM ON YIELD OF RUNNER PEANUTS GROWN ON SOILS WITH DIFFERENT AMOUNTS OF NATIVE LIME AT NUMEROUS LOCATIONS IN SOUTHEASTERN ALABAMA, 1943-54

Native supply of soil lime per acre	Tests	Average per acre yield of unlimed soil	Limestone added to soil: Yield increases per acre, Average	Most	Least	Tests affecting yield: Increase	Decrease
Lb.	*No.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*No.*	*No.*
< 450	15	1,182	322	600	–85	8	1
450-549	13	1,233	217	554	–33	8	2
550-649	14	1,204	82	373	–166	9	3
650-749	16	1,568	74	442	–207	8	6
750-899	13	1,297	22	165	–200	6	4
900-1,299	13	1,530	14	377	–288	6	7
> 1,299	8	1,441	18	313	–233	4	4
			Gypsum added to soil: Yield increases per acre, Average	Most	Least	Tests affecting yield: Increase	Decrease
			Lb.	*Lb.*	*Lb.*	*No.*	*No.*
< 450	15	1,182	266	447	59	12	0
450-549	13	1,233	333	649	6	11	0
550-649	14	1,204	105	395	–467	8	2
650-749	16	1,568	89	653	–110	6	4
750-899	13	1,297	73	221	–102	8	2
900-1,299	13	1,530	62	286	–158	7	4
> 1,299	8	1,441	62	386	–106	4	3

receiving benefits from added lime. However, as the supply of soil calcium decreased below this level, the frequency and magnitude of yield increases brought about by liming became greater, Table 38 and Figure 7.

An abundant supply of calcium in the "pegging" zone appears to be essential for good peanut production. As a rule lime is used as the calcium carrier. However, gypsum (land plaster) has been successful in promoting better peanut yields, Table 38. The effect of gypsum dusted on peanuts at blooming time is similar to that from a broadcast application of lime, Table 38 and Figure 7. Gypsum applications will avoid cases of "over-liming" where an unfavorble pH would have resulted from the use of lime. However, the very acid soils may benefit more from lime than from gypsum because of the acid-neutralizing property of lime. In general, gypsum is only considered as a supplement to lime, since lime is needed occasionally to adjust the soil pH to a more favorable level.

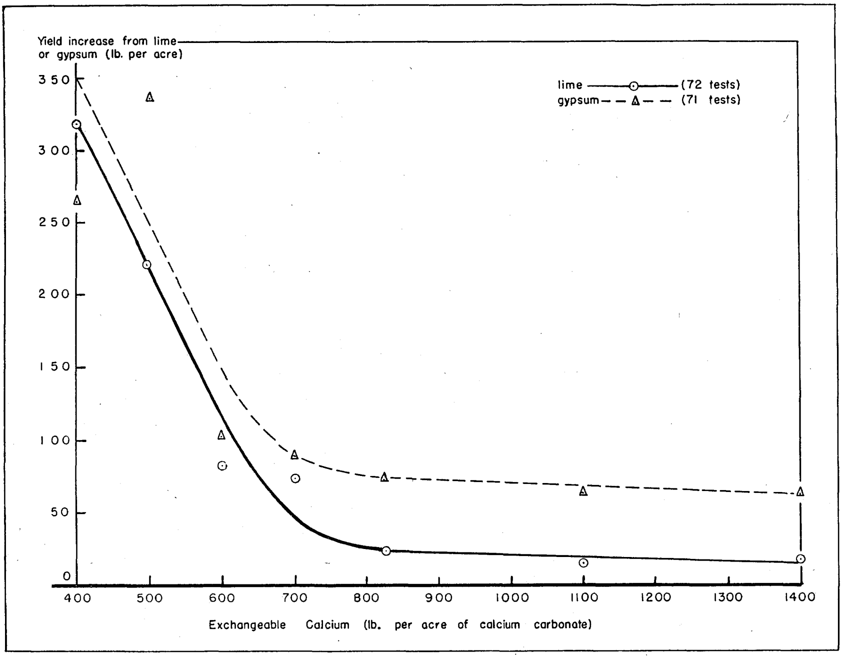

FIGURE 7. Effect of native soil lime on the response of runner peanuts to lime or gypsum.

Soil pH and Peanut Yields

Since the soil pH reflects the lime status of a soil, there is a relationship between soil pH and the effect of lime on peanut yields, Table 39. The more acid a soil is, the greater is the probability of a yield increase from a lime or gypsum application. However, the results obtained from using the pH values exclusively are quite erratic. The primary value of knowing the soil pH appears to be its usefulness in avoiding "over-liming."

In determining lime needs of peanut soils, the soil pH and soil lime measurements supplement the usefulness of each other.

TABLE 39. EFFECT OF LIME AND GYPSUM ON YIELD OF RUNNER PEANUTS GROWN ON SOILS OF VARIOUS pH VALUES AT NUMEROUS LOCATIONS IN SOUTHEASTERN ALABAMA, 1943-54

Soil pH range	Tests	Av. per acre yield of unlimed soil	1 ton of limestone per acre added				
			Yield increases per acre			Tests affecting yield	
			Average	Most	Least	Increase	Decrease
	No.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*No.*	*No.*
< 5.1	14	1,212	154	554	–41	10	3
5.1-5.3	15	1,104	158	555	–166	9	4
5.4-5.5	15	1,425	86	348	–288	6	5
5.6-5.8	15	1,219	184	494	–55	9	2
5.9-6.0	12	1,845	–5	253	–207	4	7
> 6.0	15	1,383	10	303	–233	8	7
			500 pounds of gypsum per acre added				
			Yield increases per acre			Tests affecting yield	
			Average	Most	Least	Increase	Decrease
			Lb.	*Lb.*	*Lb.*	*No.*	*No.*
< 5.1	14	1,212	184	543	–158	11	2
5.1-5.3	15	1,104	214	653	–94	11	1
5.4-5.5	15	1,425	139	649	–140	7	4
5.6-5.8	15	1,219	220	676	–110	7	2
5.9-6.0	12	1,845	99	189	–99	8	1
> 6.0	15	1,383	70	388	–467	10	4

PER CENT SOUND MATURE KERNELS AND PEANUT YIELDS

The percentage of sound mature kernels (S.M.K.) determines the quality of nuts produced and their value. A number of factors, including soil conditions, determine the S.M.K. in the harvested crop. An unfavorable balance of soil nutrients will adversely affect S.M.K. values, Table 35. The S.M.K. value of peanuts produced on lime-deficient soil can be increased by liming. The increased S.M.K. values are reflected in the increased yields obtained.

A low S.M.K. does not necessarily mean that the soil needs lime. On the other hand, if the harvested nuts have an S.M.K. value of about 65 or above, there is small likelihood that benefits will be gained by liming, Table 40.

TABLE 40. EFFECT OF LIME AND GYPSUM ON THE YIELD OF RUNNER PEANUTS WITH VARIOUS S.M.K. VALUES[1] FROM UNLIMED SOIL AT NUMEROUS LOCATIONS, 1943-54

S.M.K.[1] from unlimed soil	Tests	Av. per acre yield of unlimed soil	1 ton of limestone per acre added				
			Yield increases per acre			Tests affecting yield	
			Average	Most	Least	Increase	Decrease
Pct.	*No.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*No.*	*No.*
< 55.0	17	977	189	494	–118	5	1
55-59.9	15	1,157	206	555	–288	7	4
60-64.9	21	1,298	58	377	–341	12	5
65-69.9	20	1,526	–22	152	–494	10	10
> 69.9	12	1,562	–78	44	–269	3	9
			500 pounds of gypsum per acre added				
			Yield increases per acre			Tests affecting yield	
			Average	Most	Least	Increase	Decrease
			Lb.	*Lb.*	*Lb.*	*No.*	*No.*
< 55.0	17	977	250	543	–102	16	1
55-59.9	15	1,157	208	653	–78	11	3
60-64.9	21	1,298	128	649	–286	15	5
65-69.9	20	1,526	46	313	–328	12	7
> 69.9	12	1,562	–46	221	–467	6	6

[1] S.M.K. means per cent sound mature kernels.

SOYBEANS FOR OIL

The soybean plant is capable of producing good yields over a rather wide pH range of about 5.5 to 7.0. It is considered to be a heavy feeder on calcium; in addition it is capable of obtaining adequate calcium from moderately acid soils.

In Alabama, soybeans are decreasing in importance as a hay and green manure crop, but are becoming increasingly more important as an oil crop. It is a plant with wide climatic adaptations that can be grown throughout the State.

Since soybeans feed heavily on calcium, they will soon deplete the lime supply of soils poorly supplied with lime. Adequate testing throughout the State to determine lime requirement of soybeans has not been carried out. However, an experiment at Auburn gives an insight into the possible lime needs of soybeans. In 1955, unlimed soil with a pH of 4.3 yielded only 14.6 bushels of soybeans per acre. Liming the soil to a pH of 4.8 brought the yield to 20.0. When limed to a pH of 5.9 the yield was 30.3 bushels per acre of soybeans, Table 41.

TABLE 41. EFFECT OF LIME ON YIELD OF SOYBEANS ON VERY ACID NORFOLK SANDY LOAM, MAIN STATION

Limestone added per acre[1]			Yield of soybeans per acre in 1955[2]	Soil pH in 1955
1946	1952	1955		
Pounds	*Pounds*	*Pounds*	*Bushels*	
None	None	None	14.6	4.3
2,000	1,000	250	20.0	4.8
4,000	2,000	1,000	30.3	5.9

[1] The soil was adequately fertilized.
[2] The area was planted to peanuts until 1955.

No definite conclusion can be drawn from these limited data. However, there are good indications that the soil's lime supply will play an important role in greater soybean production.

RECOMMENDATIONS

The variable amounts of soil acidity and the efficiency of different liming materials make a hard and fast rule for liming impossible. The amount of lime needed to neutralize soil acidity depends upon (1) soil pH, (2) clay content, (3) type of clay, (4) organic matter content, (5) crop, and (6) kind and fineness of liming material. Using a soil test is the only reliable method of ascertaining lime needs. The soil test shows degree of acidity and amount of lime needed to neutralize that acidity.

The Soil Testing Laboratory at the Agricultural Experiment Station of the Alabama Polytechnic Institute analyzed 19,187 soil samples by the end of 1955, Table 42. Of these samples, 34 per cent had a pH of 5.5 or less and needed lime for even the more acid-tolerant crops, such as cotton, corn, and oats. Approximately 74 per cent of the samples showed need for lime for legumes (pH

TABLE 42. SOIL pH VALUES FOUND BY THE SOILS TESTING LABORATORY BY SOIL AREAS, 1953-1955

Soil area	Number of samples	Soil pH			
		Less than 5.0	5.0-5.5	5.6-6.0	More than 6.0
	Number	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Limestone Valleys	2,471	2.1	32.3	32.0	33.6
Sand Mountain	2,109	1.2	38.5	40.3	20.0
Highland Rim	567	6.3	44.8	24.7	24.2
Piedmont	1,325	0.6	22.1	39.2	38.1
Black Belt	651	2.0	16.6	13.5	67.9
Coastal Plains	12,064	2.4	32.5	43.0	22.1
State average	19.187	2.2	32.2	39.5	26.1

6 or less). Thus, it can be concluded that a large portion of the agricultural land in Alabama to some degree suffers from inadequate lime.

Lime is not a soil amendment that should be added annually. Lime needs of most crops on an acid sandy soil will be satisfied by a 1-ton application every 5 to 6 years. An acid clay soil will need 2 to 3 tons of lime every 7 to 8 years. An exact recommendation of amounts at specified intervals is impractical because of variation in farmland management.

The most commonly used liming materials are given in Table 1, along with the relative neutralizing value of each. For greatest benefit to be realized from these materials, the degree of fineness is important. The finer the material, the more soil comes in contact with the lime particles and the more benefit is realized immediately. Coarse particles of lime are ineffective in neutralizing soil acidity. A liming material used should be of sufficient fineness so that 90 per cent passes through a 10-mesh sieve and 50 per cent through a 60-mesh sieve.

In addition to neutralizing soil acidity, the liming material is an important carrier of plant nutrients. All liming materials contain calcium. Certain liming materials also contain other nutrients; for example, basic slag contains phosphorus, flue dust (lime-ox) contains potassium, and dolomite contains magnesium. Where magnesium is not included in the fertilizer program, dolomitic lime is desirable because it supplies calcium and magnesium and corrects soil acidity as well.