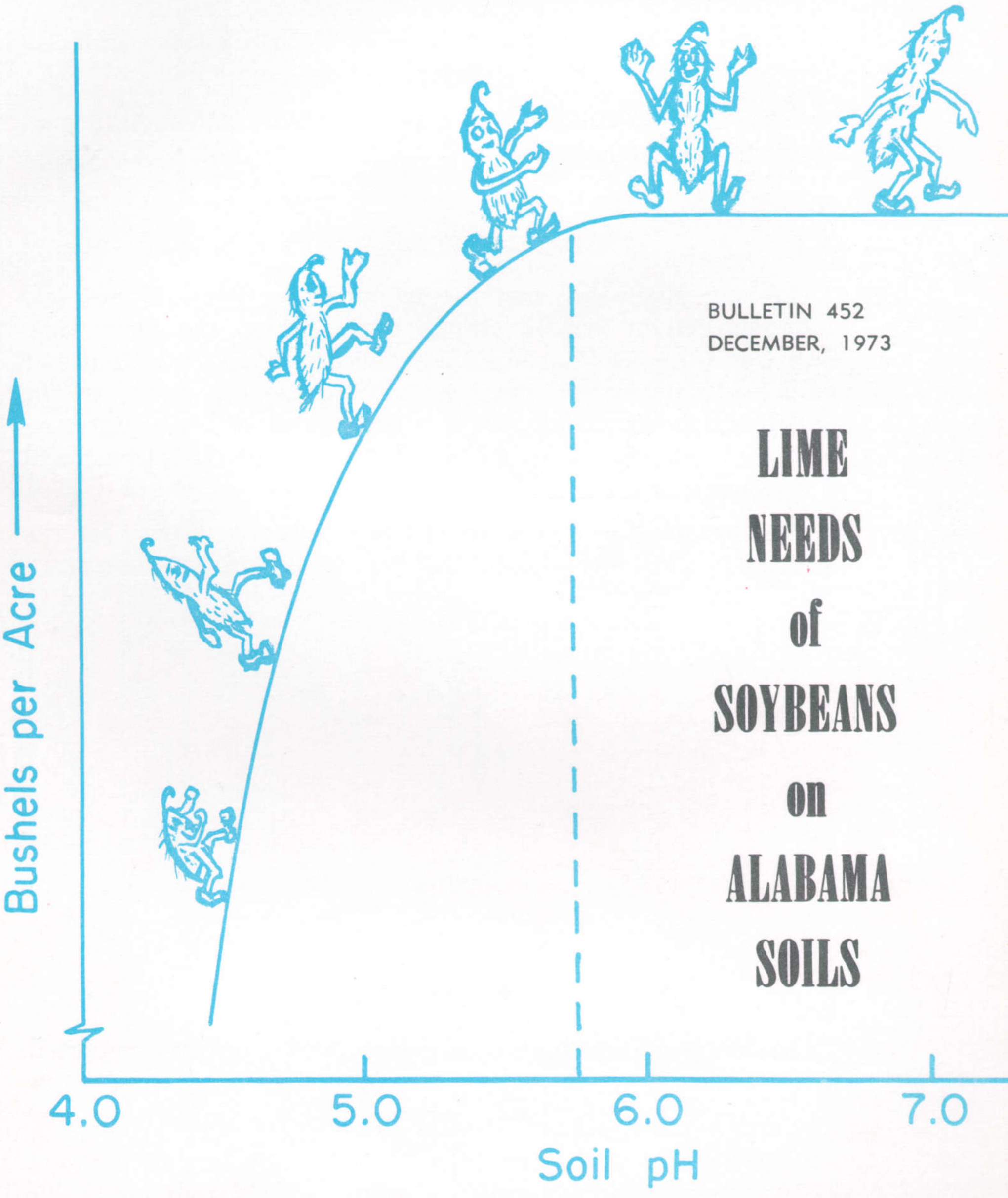


BULLETIN 452
DECEMBER, 1973

LIME NEEDS of SOYBEANS on ALABAMA SOILS

AGRICULTURAL EXPERIMENT STATION/AUBURN UNIVERSITY
R. DENNIS ROUSE, Director
AUBURN, ALABAMA

COVER PHOTOS

(Upper left) Response to lime on Benndale sandy loam, Brewton. Left, soil pH 5.0; right, soil pH 6.0.

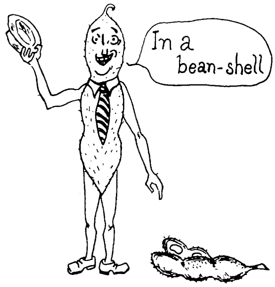
(Upper right) Response to lime on Dothan loamy sand, Auburn. Left, lime (pH 6.1); Right, no lime (pH 4.9).

(Blue chart) Typical lime response curve on soils high in soluble aluminum at low pH.

ACKNOWLEDGMENTS

Credit is given for assistance in obtaining much of the yield data reported in this bulletin to personnel on the Black Belt, Gulf Coast, Lower Coastal Plain, Sand Mountain, and Tennessee Valley substations, and the Brewton, Monroeville, and Prattville experiment fields. Recognition is also given of important contributions from E. M. Evans and J. I. Wear of the Department of Agronomy and Soils.

The authors give special thanks to Frances A. Rogers for the sketches of "Soja Bean" doing his best to capture **your** interest.



CONCLUSIONS

The following conclusions are drawn from research reported in this bulletin:

1. The number one soil fertility problem for soybean production in Alabama is low soil pH. Fifty-four per cent of the soil samples sent to Auburn University Soil Testing Laboratory for 1972 soybean recommendations needed lime.

2. Fifty-two tests conducted over a 7-year period at 12 locations showed increases in yields for liming soils ranging in pH from 4.8 to 5.5. Average increases ranged from 5 to 27 bushels per acre. At 5 of the 12 sites lime more than doubled the yield. Average yields on the limed soils varied from 27 to 38 bushels per acre.

3. Soybean response to lime varies greatly on different soils at the same pH. Based on the data presented, the Auburn University Soil Testing Laboratory recommends lime for soybeans when the soil pH is below 5.8, except on clays and clay loams, where lime is recommended below pH 5.5.

4. Soybeans responded to magnesium (Mg) from dolomitic lime at two of seven locations tested. Hartsells fine sandy loam on Sand Mountain and Benndale sandy loam near Brewton needed Mg. Soil-test Mg was "low" in these two soils and "high" in the five soils which produced as well with calcitic as with dolomitic lime. Fifteen per cent of the soil samples tested for soybeans in 1972 by the Auburn Soil Testing Laboratory needed Mg.

5. Field experiments on eight different soils showed a yield increase for molybdenum (Mo) only on one soil, Eutaw clay at pH 4.9 on the Black Belt Substation near Marion Junction. Liming this soil eliminated the need for application of Mo.

6. Manganese (Mn) *toxicity*, described as "crinkle-leaf" of soybeans, was identified in 1970 on a Geneva County soil, Dunbar sandy loam at pH 4.9. A number of agriculturally important soils in Alabama contain large amounts of Mn, but proper liming will prevent this element from becoming a problem. Mn *deficiency* on soybeans was identified on one field in Escambia County, but is not considered a widespread problem in the State.

7. Reports from USDA-ASCS county directors in 28 important soybean-growing counties showed the cost of aglime in 1973 to range from $3.50 to $12.50 per ton spread on the land. Half of the counties reported the cost to be $8 to $9 per ton.

8. Benefits from liming a soil at recommended rates can be expected to last about 3 years. Based on numerous experiments, an 8-bushel-per-acre increase for liming soils with pH between 5.0 and 5.4 would be a conservative estimate. This increase for investing $18 in 2 tons of lime per acre would return $14 above the cost of the lime, assuming $4 beans, the **first year.**

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FIRST PRINTING 6M, DECEMBER 1973
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LIME NEEDS of SOYBEANS on ALABAMA SOILS

HOWARD T. ROGERS, FRED ADAMS, and DONALD L. THURLOW[1]

ALABAMA FARMERS harvested only 135,000 acres of soybeans as recently as 1960. In 1973, the harvested acreage was estimated to be 860,000. The crop now occupies more acreage in the State than corn, cotton, or peanuts. The average season price paid to farmers from 1960 through 1972 ranged between \$2.13 and \$3.50 per bushel. During this period, the average per-acre yield in Alabama ranged from a low of 20 to a high of 27 bushels. Three times since 1955, per-acre yields in Alabama have exceeded the United States average.

Soybeans was the top income-producing crop in the U.S. in 1972. In spite of a 23 per cent increase in planted acreage in 1973, the average price received by farmers October 15 was \$5.63 per bushel. These facts show the importance of the crop and indicate the need for more efficient production.

In 1971, Auburn University (Alabama) Agricultural Experiment Station Bulletin 413 *(2)* presented some data on response of soybeans to lime. This is a more in-depth report on lime for soybeans and includes most of the significant research conducted in Alabama on this practice in the last decade. The last section of the report will give results of a recent survey of lime costs in the State and make estimates of dollar returns from liming with assumed bean prices and a range in expected yield increases. From this information, the individual grower can pick the combination of factors to fit his situation in answering the question, "Will it pay?".

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[1] Professors, and Associate Professor, respectively, Department of Agronomy and Soils.

SOIL TESTS SHOW LIME IS NEEDED

Soybean yield on a particular field is the result of many interacting factors, including soil fertility. The number one soil fertility problem for soybean production in Alabama appears to be low soil pH.

Fifty-four per cent of the soil samples sent to the Auburn University Soil Testing Laboratory in 1972 for soybean recommendations (excluding the calcareous or "native lime" lands of the Black Belt) had pH values of 5.7 or lower and needed lime.

As the soybean acreage is expanded in the State, unimproved pastures, semi-abandoned areas, and newly cleared forest lands are being planted to this crop. Many of these areas are likely to have strongly acid soils and need lime and fertilizer for top soybean yields.

Although Alabama farmers use about 1,000,000 tons of lime annually, this is not enough to correct the acidity produced each year. Some 40 years ago, Pierre *(5)*, a research soil chemist at Auburn, developed the official method for determining the acidic (or basic) effects of fertilizers on soils. Until the late fifties Alabama regulations required that all fertilizers be labeled as to their acid-forming properties. By this time, ammonia, which has a residual acidic effect on soil, had become the primary source of most nitrogen in fertilizers. Large quantities of acidic nitrogen fertilizers are used annually on corn, cotton, small grain, grass pastures, and hay crops. Insufficient lime has been used to correct this acidity and, as a consequence, many fields in Alabama are showing a serious lime deficiency.

What evidence is available that lands planted to soybeans in Alabama need lime? Will the crop respond enough to lime to make a profit for the grower who uses it?

RESPONSE OF SOYBEANS TO LIME ON VARIOUS SOILS

The Alabama Agricultural Experiment Station conducted experiments with lime on soybeans soon after the turn of the century. As early as 1907 *(3)*, in one experiment on an acid soil near Brewton, Alabama, lime increased yields of beans from 10.2 to 13.8 bushels per acre. Most of the early research with soybeans was concerned with use of the crop for hay rather than bean


How Sweet it is!
Fine Lime Co.

TABLE 1. SOYBEAN RESPONSE TO LIME ON VARIOUS LOW pH SOILS[1]

Location	Soil	Years	pH of unlimed soil	Average yield/acre			
				No lime	Lime[2]	Increase	
				Bu.	*Bu.*	*Bu.*	*Pct.*
Agronomy Farm, Auburn	Dothan loamy sand	1968-72	4.8	8.8	36.0	27.2	309
Agronomy Farm, Auburn	Norfolk sandy loam	1969-72	4.8	18.1	36.3	18.2	101
Black Belt Sub., Marion Jct.	Eutaw clay	1967-72[3]	4.9	17.2	28.5	11.3	66
Black Belt Sub., Marion Jct.	Vaiden clay	1970-72	5.4	24.9	30.8	5.9	24
Brewton Exp. Field	Benndale sandy loam	1968-71	5.0	11.2	30.2	19.0	170
Gulf Coast Sub., Fairhope	Malbis fine sandy loam	1966-72	5.1	29.8	34.6	4.8	16
Lower Coast. Plain Sub., Camden	McLaurin sandy loam	1967-71	5.5	24.1	29.2	5.1	21
Macon County, Ft. Davis (J. R. Kirkland Farm)	Vaiden silty clay loam	1972	5.1	14.6	37.3	22.7	155
Monroeville Exp. Field	Lucedale sandy loam	1968-71	4.9	24.6	35.1	10.5	43
Prattville Exp. Field	Lucedale sandy loam	1968-72	4.8	26.5	34.2	7.7	29
Sand Mt. Sub., Crossville	Hartsells fine sandy loam	1968-72	5.1	18.0	37.9	19.9	111
Tenn. Valley Sub., Belle Mina	Decatur clay loam	1968-72	5.3	17.4	27.4	10.0	58

[1] See Figure 1 for other experiments.
[2] Limed by soil test recommendations.
[3] Yields in 1968 not included in averages due to crop failure from drouth.

production, and these varieties produced low seed yields.

Since 1966, 16 experiments located from the Tennessee Valley and Sand Mountain in northern Alabama to Baldwin County on the Gulf Coast measured lime response by soybeans. Results from 12 of these tests are reported in Table 1 and show that increases for the use of lime ranged from 5 to 27 bushels per acre. Lime increased yields on all of these soils, which ranged in pH from 4.8 to 5.5. At 5 of the 12 sites, lime more than doubled the yield.

These experiments were located on agriculturally important soils, ranging in texture from loamy sand to clay loam. In six of the experiments reported in Table 1, soybeans were grown as a double crop after small grain. In several cases, other crops in the rotation also benefited from lime.

In all cases, adequate phosphorus and potassium fertilizers were used, but increasing the amount of fertilizer did not replace the need for lime. Fertilizer **never** reduces the soybean's need for lime. In fact, higher rates of fertilizer generally aggravate the need for lime, rather than compensate for it. This is especially true of nitrogen fertilizers, which many growers continue to use on soybeans even though numerous experiments have shown no yield benefit *(9)*.

SOIL pH AND LIME NEEDS

No measurement made on a soil sample is easier to make or more accurate, if made by a reliable soil testing laboratory, than pH. Unfortunately, the meaning of the pH value will vary with (a) time of year the sample was taken, (b) crop to be grown, and (c) other properties of the soil itself. Although there still exists uncertainties on some of the many ways soil pH affects plant growth, enough is known from field and laboratory experiments to make practical lime recommendations.

Time of Sampling Soil

Soil pH in a field seldom remains the same throughout the year but generally changes in a regular, predictable manner. The kind and amount of fertilizer added will affect pH of the soil. In the spring, before any fertilizer is applied, soil pH will be the highest of any time during the year. The addition of fertilizer causes a drop in soil pH. This decrease in pH is commonly as much as 0.5 pH unit on sandy soils, which show the least resistance to change. Soil pH will be the lowest during the summer and will rise gradually as crops mature and winter rains leach out residual soluble salts. Then, assuming no additional fertilizer has been added, soil pH will reach its maximum in the spring. The need for lime has not changed due to these seasonal fluctuations.

Lime recommendations from Auburn University Soil Testing Laboratory are based on research studies in which most soil pH values were taken in the spring prior to fertilization. These recommendations provide a reasonable safety margin to allow for such things as seasonal changes in soil pH and sampling every 2 to 3 years.

Influence of Crop

Fortunately, most crops tolerate a fairly wide range in soil pH; some are more tolerant than others. There is no "one" exact pH value at which soybeans grow best on all soils. Some varieties become chlorotic due to iron deficiency on high pH soils, such as the calcareous soils of the Black Belt with a pH of 7.5 to 8.2. On the other hand, low soil pH is a widespread problem in Alabama for soybean production. The soybean is a legume with nitrogen-fixing bacteria in its root nodules. These bacteria do not persist in the soil in large numbers and function efficiently at extremely low soil pH. Proof of this was obtained in the experiment on the Kirkland Farm in Macon County, reported in Table 1. In this soil, as many as 1,000 times more bacteria were found in the soil at pH 6.0 than at pH 5.1.[2]

Low soil pH often is not recognized as a problem from the appearance of the soybean plant. Stunted plants with distorted leaves and poorly developed root systems may be an indication, but there is no consistent describable, and easily identifiable, symptom for diagnosis. A field with low soil pH is seldom uniform in plant growth. Usually there is an irregular pattern of fairly normal appearing plants and areas of stunted, yellow or spindly plants. Increasing soil acidity is an insiduous condition which will put a ceiling on bean yields before crop failure occurs. Crop failures seldom occur until soil pH falls below 5.0; but yield reductions can be expected between pH 5.0 and 5.7, the magnitude of which will depend on the soil.

Variations Among Soils—Why?

Many field experiments with soybeans in Alabama, as well as other crops, have shown striking differences among soils in response to lime at a given pH value. This is well illustrated in Figure 1, where yields are plotted against soil pH in similar experiments on four different soils. Benndale sandy loam near Brewton and Lucedale fine sandy loam near Monroeville needed lime for soybeans when soil pH was 5.5 or less. In contrast, Malbis sandy loam near Fairhope and Lucedale sandy clay loam near Prattville did not show the need for lime until soil pH approached 5.0.

[2] Unpublished data from A E. Hiltbold, Professor, Department of Agronomy and Soils.

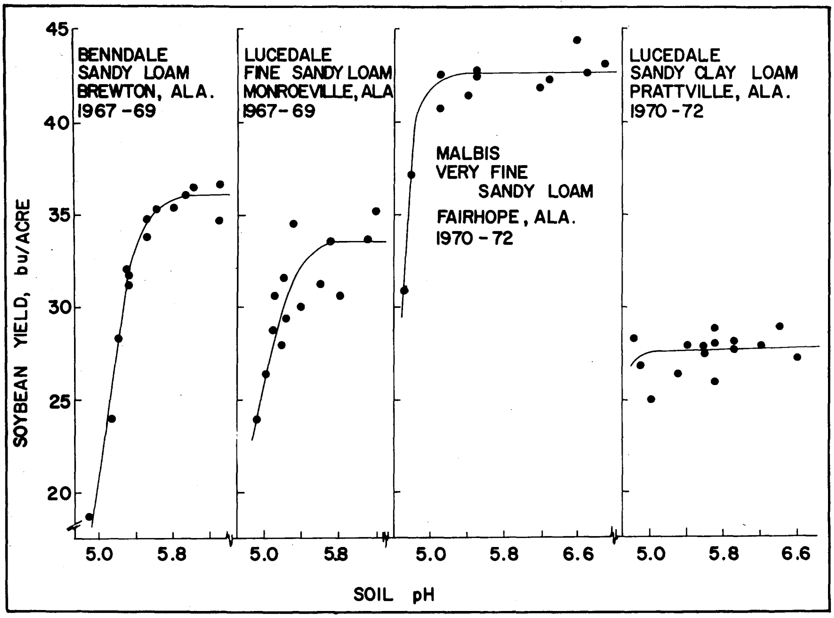


FIG. 1. Effect of soil pH on soybean yields on four different soils in field experiments.

Although other factors may have accounted, to some degree, for the magnitude of responses in the experiments at different locations in Table 1, it is obvious that yields were not affected alike by the same soil pH. Why do soils behave so differently toward lime? Within reasonable limits, soybeans are affected very little by soil pH *per se.* Certain toxic elements, notably aluminum and manganese, are released by soils in varying amounts at low pH. These elements are less soluble and nontoxic to plants at pH levels above 5.5. The amount of aluminum and manganese in solution at a specific pH value varies greatly in different soils. This is the primary reason why some soils need lime at higher pH values than others for "optimum" plant growth. The solubility of certain other elements, such as molybdenum, is also affected by soil pH. This will be covered more adequately in a later section of the bulletin.

MAGNESIUM DEFICIENCY AND DOLOMITIC LIME

Although the primary reason for liming is to raise the soil pH, lime is frequently used as a source of magnesium (Mg). Many

Alabama soils are well supplied with available Mg, but others are deficient in this plant nutrient. Magnesium is determined routinely on all samples sent to the Auburn University Soil Testing Laboratory. If the soil needs both lime and Mg, **dolomitic** lime, which contains Mg, is recommended. When the soil test report shows "high" Mg, either dolomitic lime or **calcitic** lime may be used. Much of the aglime sold in Alabama is calcitic and contains only small amounts of Mg. Based on analyses of aglime samples by the State Chemical Laboratory of the Alabama State Department of Agriculture and Industries, about 25 per cent of the aglime used in the State in 1972 was dolomitic.

Seven experiments comparing dolomitic with calcitic lime for soybeans were conducted in Alabama in recent years. Table 2 shows the soil test level of Mg and yield response to this element. Hartsells fine sandy loam on Sand Mountain and Benndale sandy

TABLE 2. DOLOMITIC COMPARED WITH CALCITIC LIME FOR SOYBEANS[1]

Location	Soil	Years	Soil-test rating & index for Mg[2]	Average yield/acre		Increase for dolomitic over calcitic lime	
				Calcitic lime	Dolomitic lime		
				Bu.	*Bu.*	*Bu./A*	*Pct.*
Sand Mt. Sub., Crossville	Hartsells fine sandy loam	1968-72	L 90	31.6	37.2	5.6	18
Brewton Exp. Field	Benndale sandy loam	1968-71	L 90	24.1	30.6	6.5	27
Monroeville Exp. Field	Lucedale fine sandy loam	1968-71	H100	33.7	32.9	–0.8	–2
Lower Coast. Plain Sub., Camden	McLaurin sandy loam	1967-71	H280	28.6	29.2	0.6	2
Prattville Exp. Field	Lucedale sandy loam	1968-72	H120	29.4	30.1	0.7	2
Tenn. Valley Sub., Belle Mina	Decatur clay loam	1968-72	H300	26.4	28.8	2.4	9
Gulf Coast Sub., Fairhope	Malbis fine sandy loam	1966-72	H220	32.6	34.6	2.0	6

[1] Soybeans double-cropped after wheat in rotation with corn at all locations, except on Gulf Coast Substation at Fairhope and on Lower Coastal Plain Substation at Camden. Soybeans were planted at Fairhope each year as full-season crop since land was cleared of pine forest in 1965. Soybeans at Camden were planted as full-season crop on land formerly cropped to cotton.

[2] Mg is magnesium, a plant nutrient in dolomitic lime not found in calcitic lime in significant quantities. "L" preceding the index value means the soil is rated low and "H" means high in Mg.

loam near Brewton were low in "available" Mg and responded to dolomitic over calcitic lime. Soils at the other five locations showed little or no response to this element. In 1972, only 15 per cent of the soil samples tested for soybeans at the Auburn University Soil Testing Laboratory needed Mg, and received a recommendation for dolomitic lime.

While soluble sources of Mg can be added in fertilizers, and frequently are used for Irish potatoes, dolomitic lime is a practical and economic source of this nutrient for soybeans. If a farmer in the State finds that his soil is deficient in Mg and a local source of dolomitic lime is not available, it is probable that liming every other time with dolomite would correct his problem and provide sufficient Mg.

LIME AND THE MICRONUTRIENTS—MOLYBDENUM AND MANGANESE

The solubility of micronutrients in the soil, and availability to plants, is greatly influenced by soil pH. Generally, micronutrient availability is not a major problem to Alabama soybean growers, but there are exceptions.

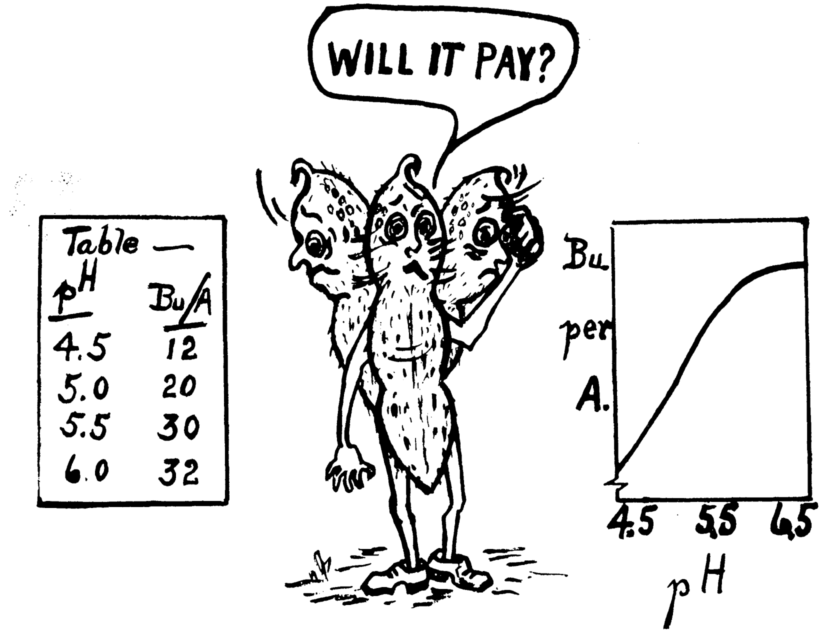
MOLYBDENUM (Mo). Although required in extremely small amounts, Mo has a role in nutrition of the soybean plant itself, as well as in the functioning of nitrogen-fixing bacteria in the root nodules. Field experiments at eight locations in Alabama, from 1964 to 1972, showed response to Mo on only one soil, Eutaw clay at pH 4.9, on the Black Belt Substation near Marion Junction *(2)*. The addition of lime to this soil, which was needed for top yields, eliminated the need for Mo. Obviously, liming increased the availability of the soil Mo.

These experiments with Mo were conducted on soils ranging in texture from clay to sandy loam and in pH from 4.9 to 5.9. If the soil pH is much below 6.0, and for some reason lime is not applied one ounce of sodium or ammonium molybdate per bushel, added as a seed treatment at planting time, may increase bean yields.

Although some Southeastern States *(4,8)* have reported responses to Mo on soils with pH above 6.0, research in Alabama to date has failed to identify such soils. Further experiments are planned to determine if there are important soils in the State which need Mo for soybeans when limed at recommended rates.

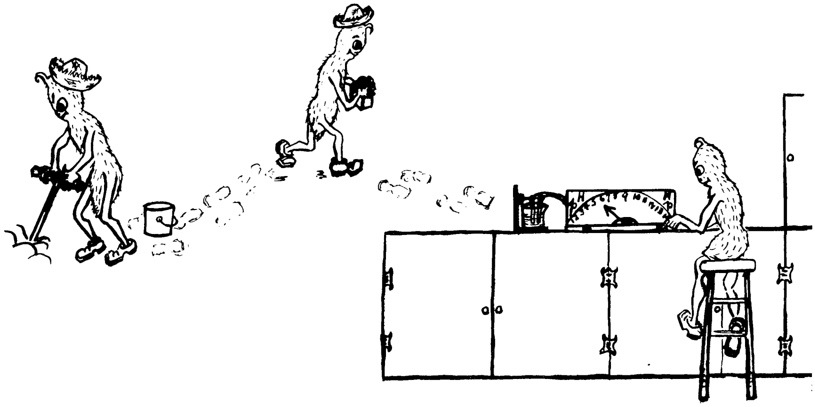
MANGANESE (Mn). In contrast to Mo, the availability of soil Mn increases with decrease in soil pH. Because of this, toxic amounts of Mn appear in soil solution as the pH of some soils becomes too low. This toxicity was observed when "crinkle-leaf" symptoms appeared in 1970 on soybeans growing on Dunbar sandy loam at pH 4.9. Some Alabama soils are quite high in Mn *(1)*. Although severe toxicity from Mn is not a general problem on soils planted to soybeans in this State, the potential exists, but is easily avoided by proper liming.

Mn **deficiency** in soybeans has been reported on some high organic matter soils in the Midwest *(7)*, on Coastal plain soils of North Carolina *(10)*, and on a fine sand with high pH in Florida *(6)*. Such reports may have led some Alabama farmers to suspect a deficiency of this element in their soils for this crop. Insufficient Mn is not likely to be a widespread problem for soybean growers in Alabama, although it has been identified in one field in Escambia County.



LIME COSTS AND DOLLAR RETURNS

The key question which every grower asks before deciding whether to lime is "Will it Pay?" Because many farmers fail to lime soils that need lime, it is assumed that they are not convinced that liming is profitable for soybean production in Alabama. Three major factors determine how profitable liming will be: (a) need for lime, and amount of yield increase, (b) cost of lime, and (c) price of beans.



How Much Lime is Needed and What Yield Increase to Expect

Only a soil test can tell the grower whether a soil needs lime and how much to use. Soil tests, to be reliable, must be based on field experiments, such as reported in Table 1 and Figure 1. Increases in bean yields from liming 12 different soils, all needing lime, was shown to range from 5 to 27 bushels per acre. Average location yields on the limed soils ranged from 27 to 38 bushels per acre. Fifty-two tests were conducted over a 7-year period at 12 locations, Table 1. However, the true meaning of a soil pH value, so far as predicting yield increase from liming a particular soil, is shown more accurately by the shape of response curves, such as those in Figure 1. Most sandy soils show large increases from lime when the pH is below about 5.5. Soils with more silt and clay, or more organic matter, frequently produce top yields at lower pH values than coarse-textured sandy soils.

The Auburn University Soil Testing Laboratory recommends lime for soybeans on soils with pH below 5.8, except on clays or clay loams for which lime is recommended if testing below pH 5.5. A special lime requirement test is run on all soil samples to determine **amount** of lime needed. Soils high in clay and organic matter require more lime to raise their pH to 6.5 than do sandy soils at the same pH.

Cost of Lime

A survey in 1973 of USDA-ASCS county directors in 28 important soybean-growing counties showed the cost of aglime spread on the land ranged from $3.50 to $12.50 per ton. Half of the counties reported the cost to be between $8 and $9 per ton, with an overall average of $8.30. As would be expected, the lowest price lime was near quarries in northern Alabama and the highest in southern Alabama where few local sources are found.

Price of Beans and Estimated Returns

The price of beans in the future is anybody's guess. To help the individual grower make a decision on the economics of liming, based on the information in this bulletin, Figures 2 and 3 were prepared. In Figure 2, a price of $5 per bushel was assumed,

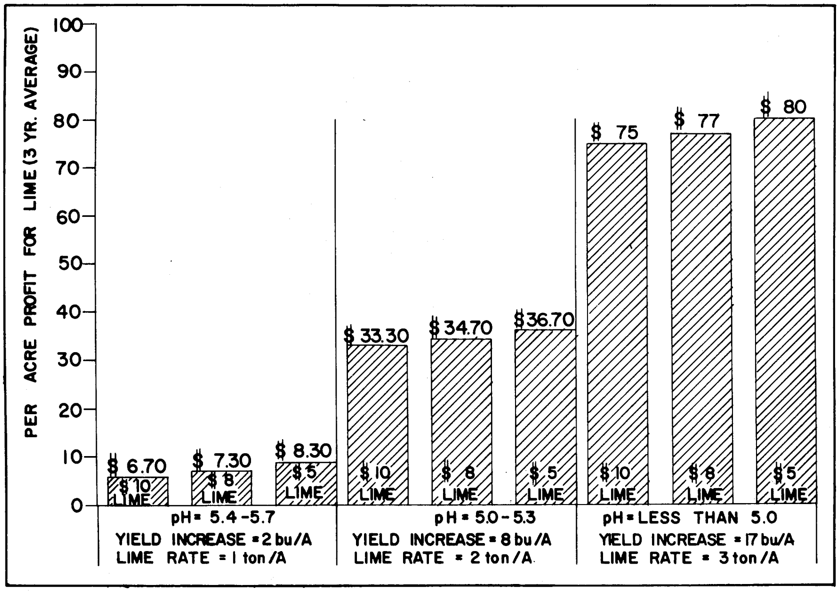


FIG. 2. Annual value per acre of increased yields, above lime cost, at different soil pH ranges, assuming $5-per-bushel soybeans.

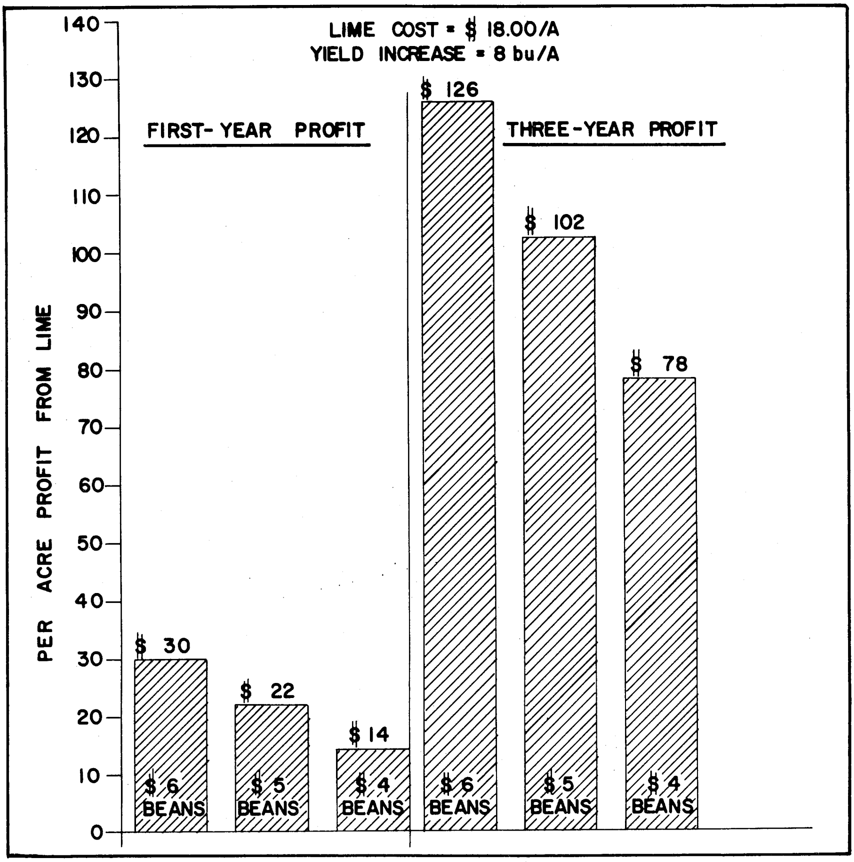


FIG. 3. First-year returns, above lime costs, compared with returns over a 3-year period for the investment of $18 per acre in two tons of lime, assuming an 8-bushel-per-acre increase in soybean yield.

while Figure 3 shows estimates of "profits"[3] per acre based on $4, $5, or $6 beans.

Research has shown that it is reasonable to charge off the cost of lime over a 3-year period. Based on a typical lime response curve and beans at $5 per bushel, Figure 2 shows the dollar returns per acre above the cost of lime for different soil pH values. For example, 1 ton of lime every 3 years on a soil testing between

[3] Interest on money invested in lime and the small additional costs of harvesting, hauling, and storing the increased yields from liming were not deducted from calculated "profits" in this report.

pH 5.4 and 5.7, and increasing yields only 2 bushels per acre, would return $7.30 per acre each year above the cost of $8 for the lime. Similarly, 2 tons of lime on a soil with pH between 5.0 and 5.3, and increasing yields by 8 bushels per acre, would return annually $34.70 above the cost of the lime.

One-third to one-half of the soybeans grown in Alabama are produced on rented land. Frequently, there is only an oral year-by-year agreement between the renter and the landowner. As a result, the renter often hesitates to invest in lime, even though it may be needed. Figure 3 compares dollar returns above the cost of lime for the first year with 3-year "profits." Assuming an 8-bushel increase, which would be conservative for most soils testing between pH 5.0 and 5.4, 2 tons of $9 lime would return the first year $14 per acre for $4 beans, $22 for $5 beans and $30 for $6 beans above the cost of lime. How can a grower, even on rented land, afford not to lime for soybeans when it is needed?

Obviously, if the benefits from liming are figured over a 3-year period, also shown in Figure 3, the practice becomes much more attractive.

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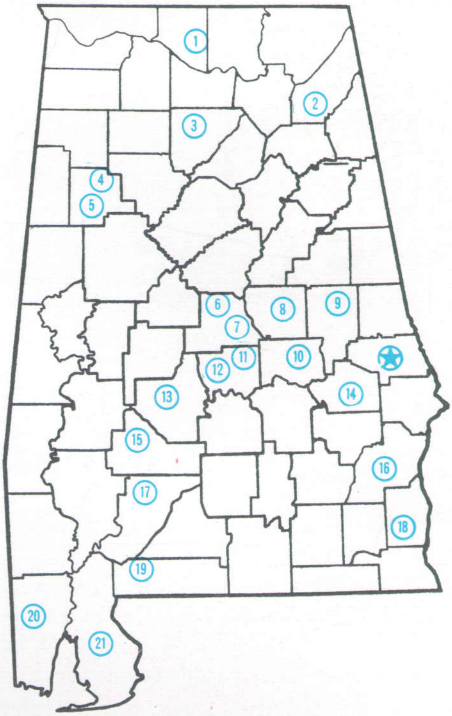
AGRICULTURAL EXPERIMENT STATION SYSTEM OF ALABAMA'S LAND-GRANT UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

Main Agricultural Experiment Station, Auburn.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Thorsby Foundation Seed Stocks Farm, Thorsby.
7. Chilton Area Horticulture Substation, Clanton.
8. Forestry Unit, Coosa County.
9. Piedmont Substation, Camp Hill.
10. Plant Breeding Unit, Tallassee.
11. Forestry Unit, Autauga County.
12. Prattville Experiment Field, Prattville.
13. Black Belt Substation, Marion Junction.
14. Tuskegee Experiment Field, Tuskegee.
15. Lower Coastal Plain Substation, Camden.
16. Forestry Unit, Barbour County.
17. Monroeville Experiment Field, Monroeville.
18. Wiregrass Substation, Headland.
19. Brewton Experiment Field, Brewton.
20. Ornamental Horticulture Field Station, Spring Hill.
21. Gulf Coast Substation, Fairhope.