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Crop Response To Lime On Loess Soils

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Summary

Experiments were conducted on Brown Loam soils at Holly Springs and Raymond to determine the effects of source (calcite and dolomite), placement (on the soil surface and mixed with the surface 6 inches), and rate (0 to 7 tons) of lime on yield of alfalfa, white clover, and Coastal bermudagrass. The results are summarized as follows:

Calcitic and dolomitic limestone sources produced similar yields for any given crop.

Placement of lime on the soil surface or mixed with the top 6 inches of soil produced similar yields for any given crop. Lime significantly increased the yield of alfalfa and white clover during each year of the study. Rates greater than 1 ton per acre did not further increase white clover yields, and rates greater than 3 tons did not further increase alfalfa yields. Alfalfa did not respond to molybdenum.

Lime significantly increased the yield of Coastal bermudagrass on Grenada silt loam at Holly Springs during the last two years of a 4-year study but was ineffective on Falaya silt loam at Raymond.

Liming substantially reduced the exchangeable manganese and aluminum in the surface 6 inches of Grenada silt loam which may be important in preventing die out of alfalfa. Furthermore, liming and fertilizing the surface soil with 400 pounds of N per acre per year created a more favorable chemical environment for roots in the subsoil.

CROP RESPONSE TO LIME ON LOESS SOILS

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The Loess or Brown Loam area is one of the leading cattle-producing areas of Mississippi. The higher production of better quality forages needed to sustain this industry requires higher rates of nitrogen fertilizer. Since high nitrogen rates may lead to soil acidity, this would intensify the need for lime[4]. Already the use of lime in the Brown Loam is known to be far short of needs[5].

While it is generally recognized that lime must be applied to most Brown Loam soils for growth of alfalfa and white clover, little information is available concerning the response of Coastal bermudagrass to lime on these soils.

The purposes of this study were to determine the response of alfalfa, white clover, and Coastal bermudagrass to both calcic lime (calcite) and dolomitic lime (dolomite) on Brown Loam soils and the effects of these sources on certain soil properties, especially pH.

Experimental Procedure

Two experiments were conducted at each of two locations as described in Table 1.

A split-plot experimental design with treatments replicated four times was used at all locations. Calcite applied on the surface, dolomite applied on the surface, and dolomite mixed with the top 6 inches of soil were the three whole-plot treatments. Five rates of lime were the sub-plot treatments. The liming rates and criteria for establishing these rates are shown in Table 2.

Fertilizer for establishment and annual maintenance for each experimental site was applied at the rate of 100 pounds per acre each of P_2O_5 and K_2O. An additional 15 pounds of fertilizer-grade borax was included in the establishment fertilizer for alfalfa.[6] In addition, Coastal bermudagrass received 100 pounds of N as ammonium nitrate before growth started in the spring and after each clipping except the last clipping in the fall. Coastal was clipped once in 1959, twice in 1960, and three times in 1961 and 1962. A fourth clipping was made at Raymond in 1961.

Molybdenum treatments were superimposed on the dolomitic lime treaments in the alfalfa experiment during the fifth year. For this study, the old alfalfa stand was plowed and disked in the fall of 1962. Two ounces of molybdenum per acre in superphosphate was broadcast on one-half of the renovated plots prior to disking. Plots were then reseeded.

Oven-dry yields were determined by clipping a 5- x 20-foot area in the center of each plot. No yield data were obtained for white clover in 1960 due to loss of stand.

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[1]Contribution from the Southern Branch, Soil and Water Conservation Research Division, Agricultural Research Service, USDA,in cooperation with the Mississippi Agricultural Experiment Station.

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[4]Jones, U. S., and C. Dale Hoover. 1953. More lime needed with change in nitrogen picture. Mississippi Farm Research 16(4):8.

[5]Data furnished by L. E. Gholston, Soil Testing Service, State College, Mississippi.

[6]Arnold, B. L. 1961. Good hay crop from alfalfa in North Mississippi. Mississippi Farm Research 24(10):1,4.

Soil samples from the top 6 inches of each plot were collected in March of each year for pH measurement. Additional soil samples were collected in 1964 6 years after liming from the no-lime and 4.8-ton-per - acre calcite treatments of the grass experiment at Holly Springs for measurements of pH, calcium (Ca) aluminum (Al) and manganese (Mn).

Results and Discussion

The following statements can be made for all experiments: (1) Similar yields for a given crop were produced by either calcite or dolomite; (2) method of application of dolomite made no difference in the yield of a given crop; and (3) calcite tended to produce a slightly higher pH than did dolomite, but this was of no importance in crop production.

Since source and method of application of lime produced no yield difference, data presented for rates of lime are for main effects.

Effect of lime on alfalfa and white clover: Each increment of lime increased the yield of alfalfa on Grenada silt loam (pH 5.3) each year of the 4-year study. The greatest increase was obtained with the first increment of lime applied 1.5 tons per acre; however, the yield increase obtained from the 3 - ton-per - acre treatment was also significant (Table 3). Differences among the 3-, 4.5-, and 6.75- ton- per - acre rates were not significant. This indicates that the soil test accurately predicted the lime requirement.

During the first season alfalfa began to "die out" on the no-lime treatment, and by the end of the fourth year had completely disappeared on many of these plots. Throughout the study, plants that survived on the no-lime plots were light green to pale yellow.

Molybdenum added to the soil in the fifth year did not affect the yield or color of alfalfa.

In view of the high amount of exchangeable manganese found in the un-

Table 1. Experimental locations, soils and crops.

Location	Soil type	Initial pH	Crop grown	Date crop established	No. years' data
Holly Springs	Grenada si 1	5.3	Alfalfa (Buffalo)	Fall 1958	4
Holly Springs	Grenada si 1	5.7	Coastal bermuda	Spring 1959	4
Raymond	Falaya si 1	5.5	White clover	Fall 1958	3
Raymond	Falaya si 1	5.5	Coastal bermuda	Spring 1959	4

Table 2. Rates of lime used at each location.

Rate No.	Criteria	Lime Rate		
		Holly Springs		Raymond[1]
		Alfalfa	C.B.	
		tons/acre		
1	No lime, check	0	0	0
2	One-half of rate no. 3	1.5	1.0	1.0
3	Lime requirement as per soil test	3.0	2.2	3.0
4	Amount required to raise soil pH to 7.0	4.5	3.2	5.0
5	50% more than amount required to raise pH to 7.0	6.75	4.8	7.5

[1] Rates were the same for both white clover and Coastal bermudagrass at Raymond.

limed surface soil in the Coastal experiment (Table 5), manganese and/or aluminum toxicity probably caused the die out. Liming reduced exchangeable manganese and aluminum to levels alfalfa can tolerate.

White clover showed a significant yield response to lime during each year of the study. One ton of lime increased the yield of clover forage by 458 pounds per acre in 1959, 1169 pounds in 1961, and 1441 pounds in 1962. Rates greater than 1 ton per acre did not further increase yields (Table 3).

Effect of lime on Coastal bermudagrass: Lime improved the yield of Coastal bermudagrass on Grenada silt loam at Holly Springs during the last two years of the 4-year study but was ineffective on Falaya silt loam at Raymond (Table 4). One ton of lime tended to improve the yield at Raymond but the small increase was not significant. The lower yields in 1959 and 1960 at both locations reflect the difficulty in establishing a good stand due to competition from weeds and other grasses. Although Coastal was sprigged in the spring of

Table 3. Yield of alfalfa and white clover as influenced by rate of lime.

Lime treatment	pH of soil 1959	pH of soil 1962	4-Year Average Yields[1] 1959-1962
tons/acre			lbs/acre
	Alfalfa on Grenada silt loam at Holly Springs		
0	5.3	5.4	3096 a
1.5	5.6	5.9	6774 b
3	5.9	6.1	7315 c
4.5	6.0	6.3	7492 c
6.75	6.3	6.6	7606 c
	White clover on Falaya silt loam at Raymond		
0	5.8	5.2	2357 a
1	6.3	5.7	3380 b
3	6.6	6.3	3338 b
5	6.8	6.5	3322 b
7.5	7.0	6.7	3298 b

[1]Means followed by the same letter are not significantly different at the 5% level of probability.

Table 4. Yield of Coastal bermudagrass as influenced by rate of lime.

Lime treatment	pH of soil 1959	pH of soil 1962	Yield of forage[1] 1959	1960	1961	1962	Mean
tons/acre			lbs/acre				
			Grenada silt loam at Holly Springs				
0	5.6	5.3	3474 a	6211 a	8349 a	13935 a	7992 a
1.05	6.0	5.8	3594 a	5957 a	8899 ab	14662 b	8278 ab
2.15	6.3	6.1	3594 a	6265 a	9813 c	15104 c	8694 bc
3.2	6.4	6.3	3834 a	6800 a	9550 bc	15399 cd	8896 c
4.8	6.6	6.7	3848 a	7198 a	9521 bc	15653 d	9055 c
			Falaya silt loam at Raymond				
0	5.5	5.3	3663	5275	10193	10846	7494 a
1	6.0	5.8	3844	5401	10468	11267	7745 a
3	6.4	6.5	4026	5427	10029	11562	7761 a
5	6.6	6.8	3919	5703	10115	11320	7764 a
7.5	6.8	7.0	3793	5928	9927	11351	7750 a

[1]Means within a column followed by a common letter are not significantly different at the 5% level of probability.

Table 5. The effects of lime on certain chemical properties of Grenada silt loam 6 years after liming and continuous cropping to Coastal bermuda, Holly Springs, Mississippi.

Profile depth	Lime Treatment: No lime pH	No lime Exchangeable Ca	No lime Exchangeable Al	No lime Exchangeable Mn	4.8 tons calcite/acre pH	4.8 tons calcite/acre Exchangeable Ca	4.8 tons calcite/acre Exchangeable Al	4.8 tons calcite/acre Exchangeable Mn
(in)		lbs/acre				lbs/acre		
0-6	5.4	1120	106	180	7.4	4240	36	32
6-12	5.2	1160	152	90	6.2	2560	108	48
12-24	5.2	880	214	60	5.3	1280	200	56

1958 and sprayed for weed control several times, a pure stand was not obtained until late in the summer of 1960.

The high forage production of about 8 tons per acre in 1962 on Grenada silt loam was obtained with about 20 inches of rainfall distributed in June, July, August, and September. This level probably represents the potential forage production on this type of soil under intensive management. During the same summer period, about 6 tons of forage were produced on Falaya silt loam soil with only 7 inches of rainfall. However, the soil profile was probably near field capacity at the beginning of this 4-month period.

Effect of lime on pH and other soil properties: A lime application of about 2 tons per acre to Brown Loam soils with an initial pH of 5.3 maintained the pH near 6.0 for at least 4 years after application (Tables 2 and 3). The study was terminated before the pH showed signs of declining.

The importance of liming soils to prevent the development of subsoil acidity and increased avialability of aluminum and manganese is clearly demonstrated in Table 5. For example, the pH in the 0 - to 6-inch layer of unlimed soil changed from 5.7 to 5.4, but, of even greater significance, the subsoil pH changed from 5.5 to 5.2. A 4.8-ton application of lime to the surface soil raised the pH to 6.2 in the 6-to 12-inch zone and reduced exchangeable aluminum and nanganese. These chemical changes undoubtedly created a more favorable subsoil environment for growth and development of roots.

Recommendations

For alfalfa and white clover, 3 tons per acre of either calcic or dolomitic lime should be applied initially to Brown Loam soils if the pH is about 5.3. This quantity of lime should maintain the pH above 6.0 for about 5 years. Additional lime should be applied in accordance with soil test recommendations to maintain the soil pH above 6.0.

For Coastal bermudagrass, sufficient lime should be applied to bring the pH up to 5.5 - 6.0. The pH of the surface 6 inches should be maintained within this range by surface applications of lime. It is especially important to maintain a liming program for Coastal bermudagrass to prevent the development of subsoil acidity even though the surface soil may have a pH of about 5.5.