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## Response of Coastal Bermudagrass to Phosphorus on Limed East Texas Soil

V. A. HABY, J. B. HILLARD, J. V. DAVIS, AND  
A. T. LEONARD

### Summary

Coastal bermudagrass response to limestone and phosphorus was evaluated on a strongly acid (pH 4.5) Lilbert loamy fine sand which tested low in phosphorus (P), calcium (Ca), and magnesium (Mg) and very low in potassium (K). Limestone treatments of 0, 600, and 3,400 lb/A were applied in early July 1983. Phosphorus treatments were applied at this same time at rates of 0, 30, 61, 92, 123, 245, and 491 lb P<sub>2</sub>O<sub>5</sub>/A. Two harvests of grass were made in 1983. The grass was killed by a freeze in December 1983, and resprigged in 1984. The regrowth covered the plot area completely by mid-summer 1985.

Optimum yield of Coastal bermudagrass occurred at about 12 parts per million (ppm) residual soil P. Coastal bermudagrass grew equally well at pH levels of 4.51, 4.65, and 6.19, resulting from application of 0, 600, and 3,400 lb/A, followed by 2 years of nitrogen (N) fertilization. Phosphorus fertilization of this soil at rates from 0 to 982 lb/A in two applications increased soil P<sub>2</sub>O<sub>5</sub> from 4.7 to 38 ppm at zero lime, and from 2.7 to 55 ppm at the 3,400 lb/A rate of limestone. Fertilizing with P<sub>2</sub>O<sub>5</sub> lowered available manganese (Mn) and K in the soil. Liming, as expected, decreased soil Mn and increased Ca and Mg. Phosphorus taken up by Coastal bermudagrass continued to increase as the P fertilizer rate was increased. Phos-

phorus uptake at the zero P check was 5.3 lb P<sub>2</sub>O<sub>5</sub>/ton of dry matter, compared to 10.3 lb at the high rate of P fertilization. Limestone application increased Ca and Mg in the plant from 0.248 and 0.140 percent to 0.366 and 0.165, respectively.

### Introduction

East Texas soils are becoming increasingly acidic. A summary of soil test results evaluated in the late 1960's revealed that 2 percent of these soils were testing below pH 5.2. A similar evaluation in the early 1980's indicated that 12 percent of these soils were testing below pH 5.0. In addition, the acidity levels in farm ponds are increasing rapidly from 37 percent of samples tested at a pH level of 6.5 and below in 1982, to 57 percent testing in this sub-lethal range for fish production in 1984. Pond acidity levels are likely related to pH of the watershed soils.

As soil acidity increases, plant utilization of phosphorus becomes less efficient. This study was designed to evaluate the effect of limestone on forage production and phosphorus use efficiency when applied to a strongly acid soil. Results will be applied directly to overcoming forage production problems on area farms and ranches.

### Procedure

This study was initiated in July 1983, on a Lilbert loamy fine sand with a surface 6-inch depth pH of 4.5. Limestone and P<sub>2</sub>O<sub>5</sub> rates are detailed below:

Limestone/P <sub>2</sub> O <sub>5</sub>	Limestone/P <sub>2</sub> O <sub>5</sub>	Limestone/P <sub>2</sub> O <sub>5</sub>
Pounds/Acre		
0/ 0	600/ 0	3,400/ 0
0/ 30	600/ 30	3,400/ 30
0/ 61	600/ 61	3,400/ 61
0/ 92	600/ 92	3,400/ 92
0/123	600/123	3,400/123
0/245	600/245	3,400/245
0/491	600/491	3,400/491

Each of these treatment combinations was replicated eight times. Phosphorus was supplied as triple superphosphate. Limestone was applied as 100 percent minus 7-mesh and 27 percent minus 100-mesh agricultural grade limestone consisting predominantly of CaCO<sub>3</sub> with 10 to 15 percent MgCO<sub>3</sub>. Limestone rates were main plots and P rates were sub plots of a split-plot design. Each plot was 9-feet wide by 15-feet long. Limestone treatment was planned for only one application. Phosphorus rates were applied twice. The soil test P level had an adequate range for evaluation of residual available soil P.

Samples were collected from the surface 6-inch soil depth in spring 1984. Soil pH was 4.71, 4.81, and 5.66 in response to limestone rates of 0, 0.3, and 1.7 tons/A, respectively, averaged over all P levels. Soil P increases of 5.28, 5.53, 6.85, 8.79, 10.63, 13.54, and 39.78 ppm were measured in response to 0, 30, 61, 92, 123, 245, and 491 lb/P<sub>2</sub>O<sub>5</sub>/A, respectively, averaged over three pH levels.

KEYWORDS: East Texas/Coastal bermudagrass/acidity levels/phosphorus.

TABLE 7. EFFECT OF PHOSPHORUS AND LIMESTONE TREATMENTS ON pH, AND CONCENTRATIONS OF SELECTED PLANT NUTRIENTS IN SOIL SAMPLES COLLECTED IN JULY 1985

Treatment P <sub>2</sub> O <sub>5</sub> lb/A	Soil pH and Plant Nutrient Concentrations					
	pH	Mn	P	K	Ca	Mg
	ppm					
0	5.11 a	15.8 d	3.4 a	129 c	263 a	14.2 a
30	5.18 a	14.6 cd	4.7 ab	121 bc	314 a	15.1 a
61	5.12 a	14.1 c	7.6 b	116 ab	277 a	13.9 a
92	5.10 a	13.8 bc	11.5 c	114 ab	303 a	14.3 a
123	5.13 a	13.4 abc	13.9 c	109 ab	304 a	15.7 a
245	5.11 a	12.2 a	23.6 d	109 ab	335 a	14.1 a
491	5.07 a	12.3 ab	44.4 e	107 a	320 a	14.4 a
Limestone, lb/A						
0	4.51 a	16.3 b	14.1 a	117 a	143 a	10.2 a
600	4.65 b	16.6 b	13.9 a	117 a	184 a	11.4 b
3,400	6.19 c	8.2 a	18.7 b	111 a	580 b	21.9 c

<sup>1</sup>Values within columns, followed by the same letter are not statistically different at the p<0.05 level of probability.

### Application of Results

Coastal bermudagrass continued to increase in yield as the soil test phosphorus level increased up to approximately 12 ppm. Dry matter yield remained relatively constant as the soil phosphorus level increased above 12 ppm. This indicated that a level of 12 ppm soil test phosphorus was adequate for optimum yields of Coastal bermudagrass on this acid, Lilbert, loamy fine sand. Phosphorus uptake by Coastal bermudagrass was approximately 4.3 lb P (10 lb P<sub>2</sub>O<sub>5</sub>) per ton of 12 percent moisture hay produced. Application of 45 lb P<sub>2</sub>O<sub>5</sub>/A increased soil test P by one ppm.

With these values in mind, a Coastal bermudagrass hay crop of 4.5 tons/A will, theoretically, reduce the soil test level of P by 1 ppm. Likewise, a 9 ton/A hay crop should reduce the soil test P level by 2 ppm. If the soil test for P is well above 12 ppm, fertilization with P<sub>2</sub>O<sub>5</sub> could be omitted for one year. However, if soil test P is only a few ppm above 12, it would be wise to continue fertilizing with phosphorus each year until a greater buildup has occurred. These statements are theoretical, based on only one year of data, and therefore need several years more evaluation to verify that they are accurate.

Limestone treatment dramatically increased the soil test P level when soil P was already high. When soil test P was in the very low, low, and medium ranges, limestone treatment had only a small effect on increasing soil test P level.

Coastal bermudagrass used 43 lb of potassium per ton of dry matter (46 lb K<sub>2</sub>O/ton of 12 percent moisture hay) produced in this study. This verifies the importance of continued high application rates of potash for optimum hay production. Decreased yields of grass due to low potash fertilization will probably not be evident the first few years of hay production because the soil is able to supply the potassium needs of the plant. Once the soil has been depleted of its potassium reserves, Coastal bermudagrass production will decline rapidly.

At pH 4.5, Coastal bermudagrass tolerated soil acidity. At this pH level, limestone application did not increase

dry matter yield. This does not imply that Coastal bermudagrass does not need to be limed. This grass can grow in extremely acid soils, but the nutritional quality of the grass deteriorates as the soil becomes more acid. A pregnant yearling (750 lb) heifer gaining 1.9 lb/day needs a calcium concentration of 0.26 to 0.37 percent in the forage. A lactating cow requires 0.30 percent calcium in her forage diet. That same cow requires 0.2 percent magnesium in her diet during early lactation. Unlimed Coastal bermudagrass did not meet these calcium and magnesium requirements. Coastal bermudagrass limed with 3,400 lb low Mg-lime/A contained an adequate level of calcium for this cow. However, the magnesium concentration was not increased to the level considered adequate to meet her requirements, but this can be accomplished by feeding mineral supplements.

Numerous experiments have demonstrated that calcium utilization is affected by the amount of P in the diet. Long-term experiments with pregnant heifers showed better absorption of both calcium and phosphorus when fed a 2:1 compared to a 1:1 ratio of these two elements. In this study, liming at the 3,400 lb/A rate resulted in a 1.8:1 ratio compared to a 1.2:1 ratio for the unlimed check.

Magnesium absorption by cattle is enhanced by increasing Mg and Ca intake. Magnesium absorption was depressed on low Mg rations when inorganic phosphorus replaced organic P supplementation. Winter pastures of small grains, ryegrass, or clovers sod seeded into Coastal bermudagrass will not tolerate acid soils. Soils must be limed to pH 6.0 or above if a farmer is to be successful at producing cool season forages. Phosphorus efficiency is significantly improved by liming acid soils.

at the 491 lb/A rate of P<sub>2</sub>O<sub>5</sub>. These data indicated that limestone application can change available soil P from the medium to the high soil test level.

The effect of residual P and limestone on forage nutrient content is indicated in Tables 4, 5, and 6. As expected, an increase in residual soil P increased the plant concentration of P at all harvests. Deficient plant concentrations of P appeared to have occurred below about 0.25 percent based on harvest 2 data. Limestone treatment had no significant effect on P concentrations in Coastal bermudagrass.

Plant potassium content was not affected by residual P or limestone at harvests 1 and 2. Limestone and P appeared to have indirectly caused a reduction in K content of the grass at harvest 3. This may have occurred due to increased uptake, and reflects the reduction in soil K indicated by the soil test (Table 7).

**TABLE 4. EFFECT OF RESIDUAL PHOSPHORUS AND LIMESTONE ON FORAGE NUTRIENT CONTENT, HARVEST 3**

Residual P ppm	Plant Nutrient Concentrations <sup>1</sup>				
	P	K	Ca	Mg	Mn ppm
	Percent				
3.4	0.204 a	2.165 a	0.238 a	0.140 a	160 a
4.7	0.234 b	2.132 a	0.259 a	0.146 a	129 a
7.6	0.231 c	2.107 a	0.233 a	0.137 a	165 a
11.5	0.260 d	2.153 a	0.246 a	0.150 a	169 a
13.9	0.261 e	2.181 a	0.248 a	0.146 a	170 a
23.6	0.272 f	2.182 a	0.252 a	0.145 a	165 a
44.4	0.288 g	2.172 a	0.265 a	0.150 a	178 a
Limestone, lb/A					
0	0.249 a	2.152 a	0.215 a	0.136 a	192 b
600	0.248 a	2.149 a	0.237 a	0.143 a	180 b
3,400	0.253 a	2.166 a	0.294 b	0.155 b	155 a

<sup>1</sup>Values within columns, followed by the same letter are not statistically different at the p<0.05 level of probability.

**TABLE 5. EFFECT OF RESIDUAL PHOSPHORUS AND LIMESTONE ON FORAGE NUTRIENT CONTENT, HARVEST 2**

Residual P ppm	Plant Nutrient Concentrations <sup>1</sup>				
	P	K	Ca	Mg	Mn ppm
	Percent				
3.4	0.213 a	2.521 a	0.296 a	0.140 b	133 a
4.7	0.227 b	2.471 a	0.299 b	0.139 a	125 a
7.6	0.247 c	2.607 a	0.313 c	0.142 c	138 a
11.5	0.267 d	2.596 a	0.331 f	0.150 e	128 a
13.9	0.271 e	2.472 a	0.330 e	0.151 f	134 a
23.6	0.290 f	2.498 a	0.322 d	0.149 d	138 a
44.4	0.331 g	2.437 a	0.340 g	0.153 g	151 a
Limestone, lb/A					
0	0.257 a	2.491 a	0.254 a	0.136 a	164 b
600	0.262 a	2.508 a	0.287 b	0.142 a	145 b
3,400	0.273 a	2.544 a	0.415 c	0.162 b	97 a

<sup>1</sup>Values within columns, followed by the same letter are not statistically different at the p<0.05 level of probability.

**TABLE 6. EFFECT OF RESIDUAL PHOSPHORUS AND LIMESTONE ON FORAGE NUTRIENT CONTENT, HARVEST 3**

Residual P ppm	Plant Nutrient Concentrations <sup>1</sup>				
	P	K	Ca	Mg	Mn ppm
	Percent				
3.4	0.161 a	1.899 e	0.280 a	0.141 a	203 a
4.7	0.176 b	1.916 f	0.276 a	0.144 a	208 a
7.6	0.194 c	1.968 g	0.316 a	0.152 a	222 a
11.5	0.203 e	1.856 d	0.312 a	0.154 a	206 a
13.9	0.202 d	1.803 b	0.304 a	0.153 a	211 a
23.6	0.221 f	1.806 c	0.287 a	0.154 a	210 a
44.4	0.241 g	1.740 a	0.303 a	0.157 a	183 a
Limestone, lb/A					
0	0.206 a	1.929 b	0.248 a	0.140 a	261 b
600	0.199 a	1.856 ab	0.277 a	0.147 a	229 b
3,400	0.194 a	1.780 a	0.366 b	0.165 b	128 a

<sup>1</sup>Values within columns, followed by the same letter are not statistically different at the p<0.05 level of probability.

Residual soil P significantly increased Ca and Mg content of Coastal bermudagrass only at harvest 2. Limestone significantly increased Ca and Mg content of the grass at the 3,400 lb/A lime rate. Six hundred pounds of limestone tended to increase the Ca and Mg content of the grass, but the amount of the increase was insufficient to be significant.

Residual P had no effect on plant concentration of Mn, but, as expected, limestone application decreased plant Mn concentration significantly at each harvest.

Soil pH and nutrient concentration changes relative to P and lime treatments are indicated in Table 7. Phosphorus had no effect on soil pH but did significantly lower DTPA extractable Mn. As expected, P fertilization dramatically increased available soil P. This highly significant, linear increase is expressed by the equation  $Y = 2.993 + 0.0423(X)$  with an  $R^2 = .998$ . Y equaled yield and the X value represented two times the P<sub>2</sub>O<sub>5</sub> rates indicated in Table 3, because these rates were applied twice. This response indicated that at low available soil P levels, about 45 lb P<sub>2</sub>O<sub>5</sub>/A was needed to increase available soil P by 1 ppm in this Lilbert loamy fine sand. At the higher soil test levels of available P, 25 lb P<sub>2</sub>O<sub>5</sub>/a will increase available soil P by 1 ppm.

Increasing fertilizer P decreased extractable soil K. It was not certain what caused this decrease in K, but possibly part of the decrease could be attributed to plant uptake due to higher grass production, or may be due to insoluble precipitation or fixation of some K. Increasing fertilizer P had no effect on the levels of extractable soil Ca or Mg.

Limestone, as expected, had a dramatic effect on soil pH. The 600 lb/A rate was expected to increase pH more than 0.14 units. Extractable Mn was lowered by the high rate of limestone. This also was expected. It is noteworthy that the high rate of limestone significantly increased the level of available soil P, but this is also a well-known response. Limestone significantly increased extractable Ca and Mg.