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RESPONSE OF MARSHALL RYEGRASS TO RESIDUAL SOIL PHOSPHORUS AND pH

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SUMMARY

Marshall ryegrass production was evaluated relative to residual soil phosphorus (P) and to soil pH change due to limestone treatments applied in 1983. Ryegrass harvested in 1986 was strongly influenced by the level of lime applied in 1983. Dry matter production for plots receiving no lime was 3423 lb/ac, whereas, yields for plots treated with 0.3 and 1.7 tons of limestone/ac were 4576 and 7417 lb/ac, respectively. Increased residual levels of soil phosphorus produced higher dry matter yields, with the magnitude of the effect being mitigated by the level of limestone applied. Increasing residual soil P had a smaller impact on ryegrass yield at the 3400 lb/ac limestone rate (pH 6.2) than observed at the zero lime or at the 600 lb/ac limestone rate. Soil pH increases produced by limestone application had a much greater effect on ryegrass yields than did residual soil P. Optimum yields were estimated to occur above pH 6, implying that exchangeable aluminum may have had a significant role in limiting yields at lower soil pH.

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. As soil acidity increases, plant utilization of P becomes less efficient. The main objective of this study was to evaluate the effect of limestone and phosphorus application on forage production in a strongly acidic soil.

PROCEDURE

This study was initiated in July 1983, on a Lilbert loamy fine sand. The surface 6-inch depth pH was 4.5. Limestone treatments of 0, 0.3, and 1.7 tons/ac were applied as main plots in a split-plot design. The subplot treatments were P_2O_5 rates of 0, 30, 61, 92, 123, 245, and 491 lb/ac roto-till incorporated into the soil along with the limestone. The same P_2O_5 rates were reapplied to the individual plots in 1984. Each treatment combination 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. It was predominantly $CaCO_3$ with a minute amount of $MgCO_3$. Individual plots were 9 x 15 ft. Soil samples were collected from the surface 6-inch soil depth in the summer of 1985. Marshall ryegrass was seeded into the plots in October, after the final Coastal bermudagrass harvest. Urea was applied to the experiment at the rate of 60 lb N/ac in mid-December, in early February, and following each of the first two cuttings. The site was adequately fertilized with potassium and sulfur. Three harvests were made in 1986. Approximately 64 ft^2 of each plot was cut, weighed, and sampled for moisture content. Yields were calculated from these data. Coastal bermudagrass was sorted from the ryegrass in subsamples of the second and third harvests. Yields were adjusted according to the weight percent ryegrass each plot contained. Yield data were analyzed statistically using SAS.

RESULTS

The effects of applied limestone and phosphorus on annual ryegrass production are presented in the analysis of variance (Table 1). Limestone and phosphorus rates had a significant impact on dry matter yields, as did the lime x P interaction.

TABLE 1. ANALYSIS OF VARIANCE RESULTS FOR LIME AND PHOSPHORUS TREATMENT EFFECTS ON RYEGRASS DRY MATTER YIELDS. TAES-OVERTON

	Significance of Effect[1]			
Source	Harvest 1	Harvest 2	Harvest 3	Total
Lime	**	**	**	**
Phosphorus	NS	**	**	**
Lime x Phosphorus	*	*	NS	**

[1] * - significant at $p<0.05$ ** - significant at $p<0.01$
NS - nonsignificant

Ryegrass yield was strongly influenced by limestone, especially at the highest lime rate (Table 2). Dry matter yields, as a function

TABLE 2. RYEGRASS RESPONSE TO LIMESTONE RATES. TAES-OVERTON

Limestone Rate	Soil pH	Dry Matter Yield			
		Harvest 1	Harvest 2	Harvest 3	Total
Tons/Ac		Pounds/ac			
0	4.50	387	1215	1821	3423
0.3	4.65	432	1769	2375	4576
0.7	6.20	721	3284	3412	7417

of limestone rates averaged across all P treatments, showed an 1153 lb/ac increase in yield for the 0.3 ton/ac rate compared to the 0 lime check. The 1.7 ton/ac lime treatment increased yields 3994 lb/ac over the 0 lime check and 2841 lb/ac above the 0.3 ton/ac lime rate.

Results shown in Table 3 represent the effects of residual soil P

TABLE 3. RYEGRASS RESPONSE TO RESIDUAL SOIL P. TAES-OVERTON

Residual Soil P	Dry Matter Yield			
	Harvest 1	Harvest 2	Harvest 3	Total
(ppm)	Pounds/ac			
3.4	494	1920	2292	4706
4.7	478	1981	2492	4951
7.6	510	2022	2335	4867
11.5	474	2001	2577	5052
13.9	515	2039	2583	5137
23.6	536	2207	2584	5327
44.4	585	2460	2890	5935

on ryegrass yields when averaged across all limestone treatments. Ryegrass dry matter yield increased with increasing residual soil P. These data indicate that ryegrass yield and soil P are linearly related. The data provide more meaningful information when the effects of lime and phosphorus are viewed at the same time by examining the lime x P interaction. Analysis of variance indicates this interaction is significant ($p<0.05$) for harvests 1 and 2, and the combined annual total yield. Effects of this interaction are shown in Table 4.

TABLE 4. INTERACTIVE EFFECTS OF LIMESTONE AND RESIDUAL SOIL PHOSPHORUS ON TOTAL RYEGRASS DRY MATTER YIELDS. TAES-OVERTON

Residual Soil P (ppm)	Dry Matter Yield Limestone Rates (lb/ac) 0	 600	 3400
	---Pounds/ac---		
3.4	2966	4273	6853
4.7	3393	4197	7392
7.6	3172	3816	7615
11.5	2963	4546	7649
13.9	3209	4882	7266
23.6	3680	4709	7594
44.4	4621	5613	7569

These interaction data indicate that ryegrass yield is increased to a much lesser extent by increasing residual soil P at the high lime rate than occurred at the 0 and 0.3 ton lime/ac rates. A significant lime x P treatment interaction on soil P availability was indicated by soil analysis in 1985 (Table 5). However, this interactive effect on soil P does not explain the lime x phosphorus effect on ryegrass yield. Exchangeable Al decreases as soil acidity declines due to application of limestone, making P uptake more efficient in the absence of exchangeable Al. Limed soil may show less effects of residual soil P because P uptake by plants is more efficient in the absence of aluminum.

TABLE 5. INTERACTIVE EFFECTS OF LIMESTONE AND PHOSPHORUS RATES ON SOIL P AVAILABILITY

P_2O_5 Rate lb/ac	Limestone Rate, lb/ac 0	 600	 3400
	---ppm---		
0	4.73	2.80	2.73
30	5.13	4.08	4.83
61	6.98	7.63	8.23
92	10.48	11.25	12.70
123	14.32	11.67	15.55
145	19.50	19.85	31.38
491	37.85	39.97	55.40

These data were fitted to a regression equation using two approaches. Ryegrass yield was regressed against applied limestone and residual soil P. The best fit equation for the data was:

$$Y = 2791.1 + 2.25xLime + 39.8xP - 0.0094xLimexP - 0.00027xLime^2$$

where Y equals ryegrass dry matter yields. With all parameters significant, this equation implies that ryegrass responds to applied limestone in a curvilinear fashion that is influenced by the level of residual soil P.

The yield potential of Marshall ryegrass in this strongly acidic soil was greatly enhanced by raising the soil pH. Yield increases occurred as a result of increased plant nutrient availability and the amelioration of phytotoxicity induced by the presence of significant levels of exchangeable Al and Mn in acid soils. Increasing residual soil P increases dry matter yields, but to a lesser extent than achieved through limestone application.