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Legume Growth as Affected by Lime and Gypsum

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Summary

Soil acidity, aluminum (Al) toxicity and calcium (Ca) deficiency tend to occur together in soils, and it is difficult to isolate the effect of each of these soil conditions on plant growth. This greenhouse experiment was conducted to study the effect of varying the Al/Ca ratio of acid soils, by adding lime or a neutral salt (gypsum), on the establishment and growth of tropical legumes.

Soil pH, Ca, and Al were measured at 4 and 8 weeks after planting. At 8 weeks, plants were harvested and dry matter yield, N concentration, and N uptake were determined.

Both legumes grew better in the clay in which the N fertility was not so low as in the sand, even though the extractable Al was higher in the clay. Siratro growth improved with raised pH due to liming, while gypsum had a detrimental effect attributable to a slight decrease in pH. Thus, siratro response to lime seemed evidence of low tolerance to acidity.

Stylo responded to Ca application regardless of Ca source. However, increased pH from liming had a detrimental effect on stylo yields. Stylo response to Ca rather than to pH increase indicates a high tolerance to acidity.

KEYWORDS: Soil acidity/Al toxicity/forage plants/*Macroptilium atropurpureum* cv. siratro/*Stylosanthes hamata* cv. verano, Rhizobium.

Introduction

Legume growth can be inhibited by low soil pH and toxic levels of some elements such as aluminum and manganese (Mn). When lime is used to combat these problems, it also provides calcium which is essential to the plants. Some tropical legumes have developed a certain tolerance to acidity and Al and Mn toxicity;

however, they require levels of Ca greater than present in such soils. It has not been fully established that liming is the most adequate practice to correct such a soil problem for maintaining legume species tolerant to acidity and Al and Mn toxicities. This study was designed to study the influence of changing the Al/Ca ratio of two acid soils by adding either lime or gypsum both of which would supply Ca, but the pH would only be changed by the lime.

Procedure

The experimental design of this greenhouse study was a randomized complete block, in a factorial arrangement of two soils, two sources of Ca, two tropical legumes, five Al/Ca ratios and three replications.

Two acid soils of contrasting textures were used: a sandy soil of the Silstid series which is classified as a loamy siliceous thermic Paleustalf, and a clayey soil of the Hearne series classified as a clayey mixed thermic Typic Haplustult. The soils were analyzed and a complete basal nutrient solution (minus N and Ca) was added to the pots to prevent any other nutrient deficiency. Calcium was added to the soils as lime ($CaCO_3$) or as gypsum ($CaSO_4 \cdot 2H_2O$).

Al/Ca ratios were varied by adding different amounts of Ca to the soils as either lime or gypsum. The highest ratio was that of the native soil and the lowest ratio was from the amount of Ca in lime needed to raise the soil pH to about 6.0 (Table 1). The lime requirement of both soils to reach pH 6.0 was determined prior to the study by incubating with lime for 1 week (Fig. 1).

Two tropical legumes, siratro (*Macroptilium atropurpureum*) and stylo (*Stylosanthes hamata* cv. verano), were planted in pots filled with 2.5 kg of the treated soils. The legumes were inoculated with a commercial peat inoculum (Cowpea miscellany group—Nitragin Company). An excess of seeds was planted and later thinned to five plants per pot siratro and 10 stylo. The plants were grown for 8 weeks during which soil moisture was replenished to field capacity as needed. Soil samples from selected pots were taken at 4 and 8 weeks for determination of pH, Al, and Ca. Shoots were harvested and prepared for dry matter yield and total N analysis. Statistical analysis was done using analysis of variance.

Results and Discussion

Dry matter yield of tropical legumes (siratro and stylo) as influenced by Ca source (lime and gypsum) and Ca rate in a clay soil are shown in Table 2. Although the main effects did not cause significant differences in dry matter yield, siratro yields generally tended to be lower when treated with gypsum than with lime. In contrast, stylo yields were generally lower in the lime treatments than in gypsum. Neither legume responded to added Ca regardless of Ca source.

Dry matter yields of the legumes as influenced by Ca source and rate in the sandy soil are shown in Table 3. Siratro dry matter yields increased significantly when Ca was supplied as lime, but were significantly depressed by gypsum source. This detrimental effect of gypsum on siratro growth occurred even at the lowest applied rate. By contrast, stylo dry matter yield was significantly increased by the gypsum source but not by the lime source. This lack of response to lime may be due to increased soil pH.

The analysis of variance of the tropical legumes in sand showed significance in all main effects as well as in most interactions. When the data were analyzed separately by cultivar, it became apparent that siratro yields were affected by Ca source and rate of application. Siratro responded significantly to lime application, at the medium and higher application rate, while the gypsum source of Ca significantly depressed yields. This detrimental effect of gypsum may be attributed to its inability to raise pH.

Stylo responded significantly to Ca rate regardless of source. Liming tropical legumes is usually to correct Ca deficiencies rather than to correct pH. The present study indicates that this may be the case with stylo since the response appeared to be more due to Ca than to pH increase.

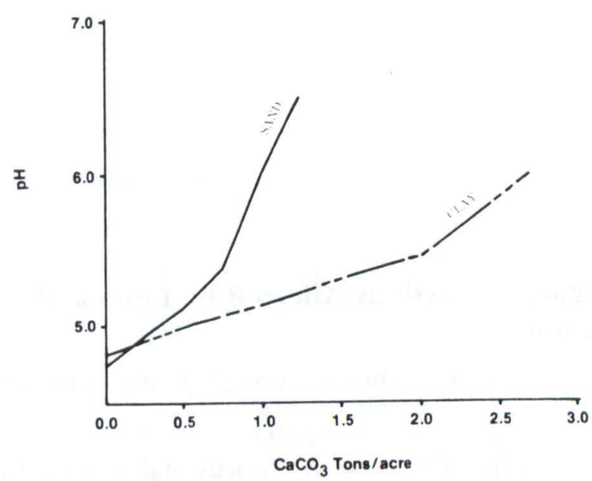

Figure 1. Lime requirement determination of a sand and a clay soil after 1 week incubation.

TABLE 1. CALCIUM TREATMENTS APPLIED TO EACH SOIL AND RESULTING pH AND Al/Ca RATIOS

	Silstid (Sand)					Hearne (Clay)				
Al/Ca (ratio)	1.8	1.4	1.0	0.7	0.5	1.0	0.85	0.7	0.5	0.45
Ca (g pot^{-1})	0	0.1	0.3	0.7	1.1	0	0.4	1.0	2.2	2.7
Gypsum (Mg ha^{-1})	0	0.5	1.4	2.7	4.5	0	1.8	3.9	8.7	10.7
Lime "	0	0.3	0.8	1.6	2.6	0	1.0	2.2	4.9	6.2
pH	4.6	4.9	5.1	5.3	6.4	4.7	4.9	5.2	5.6	6.0

TABLE 2. DRY MATTER YIELD OF TROPICAL LEGUMES (SIRATRO AND STYLO) AS INFLUENCED BY Ca SOURCE (LIME AND GYPSUM) AND Ca RATE IN A CLAY SOIL

Added Ca	Al/Ca ratio	Siratro		Stylo	
		Lime	Gypsum	Lime	Gypsum
g pot^{-1}		Mg pot^{-1}			
0	1.0	553 ab[1]	443 ab	456 ab	556 a
0.44	0.85	510 a	403 a	563 b	733 a
1.05	0.7	553 ab	460 b	600 b	400 a
2.23	0.5	740 b	436 b	423 ab	430 a
2.75	0.45	540 ab	393 ab	296 a	633 a

[1]Means within columns with the same letter are not significantly different by Duncan's Multiple Range Test at P=0.05.

TABLE 3. DRY MATTER YIELD OF TROPICAL LEGUMES (SIRATRO AND STYLO) AS INFLUENCED BY Ca SOURCE (LIME AND GYPSUM) AND Ca RATE IN A SAND SOIL

Added Ca	Al/Ca ratio	Siratro		Stylo	
		Lime	Gypsum	Lime	Gypsum
g pot^{-1}		Mg pot^{-1}			
0	1.8	173 a[1]	156 b	233 ab	143 a
0.12	1.4	230 ab	070 a	186 a	190 a
0.35	1.0	366 bc	076 a	290 ab	253 b
0.75	0.7	446 c	080 a	346 b	283 b
1.14	0.5	373 bc	060 a	226 ab	273 b

[1]Means within columns with the same letter are not significantly different by Duncan's Multiple Range Test at P=0.05.