

Effects of a Lime Slurry on Soil pH, Exchangeable Calcium, and Peanut Yields

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ABSTRACT

The effectiveness of a low rate of lime slurry for peanut (*Arachis hypogaea* L.) production was evaluated on four Coastal Plain soils of southeastern Alabama. The four experimental sites were selected on farmers' fields because of their low soil pH and low exchangeable Ca. Lime was applied just prior to planting at a 560-kg/ha rate and at the recommended rate; lime sources included a slurry, an equally-fine dry limestone, and an agricultural-grade limestone. Soil pH and exchangeable Ca of the Ap horizon were measured by depth increments when crop was harvested. Lime slurry and dry lime at equivalent rates had identical effects on soil pH and peanut yields. The 560-kg/ha rate was inadequate for maximum peanut yields on Ca-deficient soils. The recommended rate of agricultural-grade limestone was more reactive than the low rate of lime slurry, and it also produced higher peanut yields.

Key Words: peanut, lime, lime slurry, soil pH, exchangeable calcium.

A recent innovation in liming soils is the use of finely ground limestone suspended in water. The suspension usually consists of about 50% limestone in 48% water and is stabilized with 2% attapulgite clay. Commonly used terms to identify this material include: lime slurry, fluid lime, liquid lime, and lime suspensions. Several recent articles have appeared in the trade journal "Fertilizer Solutions", pointing out the adaptability of this material to the equipment of the fluid-fertilizer dealer and listing its advantages as (i) uniform spread, (ii) no dust, (iii) rapid increase in soil pH, and (iv) precise pH adjustment (3, 4, 7, 8, 9).

The so-called "advantages" of lime slurry appear to be particularly applicable to peanuts (*Arachis hypogaea* L.) growing on the acid, low-base, sandy soils of the southeastern USA. Peanuts are susceptible to Ca deficiency on these soils while being relatively tolerant to Al phytotoxicity and sensitive to over-liming injury. Thus, low rates of highly reactive, uniformly spread lime might be a feasible practice for peanut fields.

Because agricultural-grade limestone usually contains a significant fraction of relatively coarse particles, the lime slurry, because of its fineness, should be more effective on a pound-for-pound basis of actual material. This has led commercial applicators in southeastern Alabama to use about 1,120 kg per hectare (560 kg of actual limestone) on the premise that this would be enough to supply Ca and raise

soil pH in the pegging zone above critical levels. The objective of the field experiments reported here was to determine if a low rate of lime slurry would meet the Ca and pH requirement for maximum yield of 'Florunner' peanuts where either was deficient.

Materials and Methods

Experimental sites were chosen on four different farms in southeastern Alabama. Each site represented a different soil type and was selected because a yield response to lime was indicated by a relatively low pH and low extractable Ca (Table 1). Reasonably uniform areas were large enough in three fields to accommodate six treatments, four replications, with each plot measuring 5.5 x 30 m. Physical constraints at the fourth field allowed only three treatments.

Three liming materials were chosen from local dealers in the area: (i) a fine, calcitic limestone used by the "lime slurry" dealer, (ii) a bagged, fine, dolomitic limestone, and (iii) a bulk, ag-grade, dolomitic limestone (Table 2). The "lime slurry" was applied by the commercial applicator (Ashford Gin Company, Ashford, Ala.) after calibration of the equipment. The dry limestones were uniformly spread with a small tractor-drawn fertilizer spreader. Lime was spread in April 1978 on turned land and incorporated into the top 7 to 10 cm of soil with a disk and rototiller. Lime was deliberately concentrated in the pegging zone of peanuts, where it was thought to be most critical, in order to provide the most favorable comparison for the low lime rates.

Table 1. Some chemical properties of Ap horizon (~22 cm) of experimental soil areas prior to establishment of liming experiments.

County	Soil type	Soil pH	Extractable nutrients [†]			
			Ca	Mg	K	P
Barbour	Dothan s1 (Plinthic Paleudults)	4.9	140	15	21	11
Henry	Faceville s1 (Typic Paleudults)	4.8	130	8	47	21
Henry	Esto 1s (Typic Paleudults)	5.0	260	11	63	64
Henry	Bonifay 1s (Grossarenic Plinthic Paleudults)	5.3	150	14	29	19

[†]Measured by double-acid (0.05 N HCl + 0.025 N H₂SO₄) extract procedure (5).

Table 2. Calcium carbonate equivalency (CCE), Mg content, and particle-size distribution of limestone.

Material	CCE	Mg	Particle size	
			<10 mesh	<60 mesh
	%	%	%	%
Slurry (calcitic)	98.4	0.4	100	99
Dry, fine (dolomitic)	101.7	11.7	100	94
Dry, ag-grade (dolomitic)	104.2	12.2	96	50

[†]Analyses were made by Chemical Laboratory, Alabama State Department of Agriculture and Industries, Auburn, Alabama.

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Table 3. Effect of lime sources and rates on soil pH and exchangeable Ca at different depths in the Ap horizon of four soils.

Lime source and rate	Dothan s1			Faceville s1			Esto ls			Bonifay ls		
	0-7 cm	7-15 cm	15-22 cm	0-7 cm	7-15 cm	15-22 cm	0-7 cm	7-15 cm	15-22 cm	0-7 cm	7-15 cm	15-22 cm
kg/ha	Soil pH [†]											
0	5.2	4.8	4.7	5.2	4.9	4.8	5.3	5.2	5.1	5.4	5.0	4.9
560 slurry	5.4	5.0	4.7	5.4	5.0	4.8	5.5	5.2	5.0	5.7	5.4	5.1
560 dry fine	5.5	5.0	4.7	--	--	--	5.7	5.3	5.0	5.7	5.4	5.2
Rec. s slurry	5.8	5.1	5.0	--	--	--	6.3	5.7	5.2	6.5	6.1	5.5
Rec. s dry fine	6.1	5.7	4.8	6.7	5.7	5.0	6.7	6.1	5.5	6.6	6.2	5.6
Rec. s ag-grade	5.8	5.2	4.7	--	--	--	6.4	5.9	5.3	6.0	5.8	5.3
	Extractable Ca (pp2m) [‡]											
0	158	120	105	110	110	113	217	198	193	153	123	135
560 slurry	203	143	115	190	135	115	310	238	203	218	200	160
560 dry fine	228	123	128	--	--	--	300	238	208	220	195	173
Rec. s slurry	428	125	178	--	--	--	944	508	308	693	425	248
Rec. s dry fine	425	248	128	590	208	125	703	358	208	438	363	188
Rec. s ag-grade	338	165	93	--	--	--	513	330	230	358	255	193

[†] Measured in 1:1 soil:water suspension

[‡] Measured by double-acid (0.05 N NCl + 0.025 N H₂SO₄) extraction (5)

[§] Rate recommended by Auburn's Soil Testing Laboratory as follows: 2,240 kg/ha for Dothan s1 and Bonifay ls; 3,360 kg/ha for Faceville s1 and Esto ls.

Table 4. Effect of lime rates and sources on yield and percent sound mature kernels (SMK) of Florunner peanuts on four soil types.

Lime source and rate	Dothan s1		Faceville s1		Esto ls		Bonifay ls [†]	
	Yield	SMK	Yield	SMK	Yield	SMK	Yield	SMK
kg/ha	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
0	3,660	71	2,410	67	3,570	69	3,630	74
560 slurry	4,390	77	2,590	71	3,470	70	4,040	76
560 dry fine	4,720	75	--	--	3,950	67	3,960	75
Rec. † slurry	4,970	76	--	--	3,950	73	4,100	74
Rec. † dry fine	5,070	75	3,320	75	3,930	70	4,160	75
Rec. † ag-grade	5,210	76	--	--	3,890	67	4,290	75
Dunnett's test at 5% prob.	1,070	2.8	890	5.8	1,140	5.2	980	3.1
C.V.	13.3%	2.2%	19.4%	5.0%	17.5%	4.4%	15.8%	0.6%

[†] Farmer topdressed all plots with 675 kg/ha of gypsum at blooming.

[‡] Rate recommended by Auburn's Soil Testing Laboratory; see Table 3 for rates.

'Florunner' peanuts were planted by the growers as part of a larger field, and each grower followed his usual cultural practices from preplant fertilizer and herbicide applications through digging. After peanuts were harvested by plot with each farmer's combine, they were weighed, dried, and graded. Soil samples were taken by 7½-cm increments to a depth of 22 cm from each plot as soon after harvest as soil moisture allowed (soil was too dry to sample at harvest). Soil samples were taken from the undisturbed areas between digger swaths. Each soil sample was analyzed for pH and extractable bases.

Results and Discussion

The major effect of each lime source and rate was manifested in the pH and Ca content of the

upper 7 cm of soil, although changes at the 7- to 15-cm depth were also apparent (Table 3). Soil pH and extractable Ca were slightly higher at the 15- to 22-cm depth with recommended lime rates but not with either low rate. The effects of the lime slurry and dry lime at the low rate were indistinguishable. Also, there were essentially no differences in soil pH among sources at the recommended lime rate. There were differences in exchangeable Ca, however, because the lime slurry was calcitic while both dry limestones were dolomitic.

Yield and percent sound-mature-kernels (SMK) of peanuts were increased by lime applications (Table 4). However, experimental precision was generally low because of the natural variability (particularly pH and Ca) of these Coastal Plain soils within the experimental areas and, possibly, because of the diverse genetic base of the Florunner variety. Nevertheless, the data are adequate to support general conclusions.

Dothan sandy loam. The experiment followed 10 years of Coastal bermudagrass (*Cynodon dactylon* L.). The crop was under moderate drought stresses during August and September, but yields exceeded 4 metric tons/ha. Each recommended lime rate (slurry, dry fine, ag-grade) increased yield about 40% while each 560-kg rate increased yield about 25%. Each lime source and rate increased percent sound mature kernels (SMK) about equally, suggesting that the 560-kg lime rate was adequate to supply Ca in the 0- to 7-cm soil zone for maximum podfill but was inadequate to raise soil pH enough for maximum production.

Faceville sandy loam. The experiment followed several years of continuous corn (*Zea mays* L.). The crop experienced drought stresses during August and September. Only three treatments were possible on this area because of physical restraints. The recommended rate of dry lime increased yield almost 40% and SMK by eight percentage points. In contrast, the 560-kg rate of slurry did not significantly affect yield and increased SMK only four percentage points. Thus, the 560-kg rate of lime slurry was inadequate to produce either maximum yield of maximum SMK.

Esto loamy sand. The experiment followed corn. The crop suffered moderate drought stresses during August and September, but yields approached 4 metric tons/ha. No lime source or rate increased yield or SMK significantly.

Bonifay loamy sand. The experiment was located in a field that was in planted pines (*Pinus taeda* L.) between 1960 and 1976; it was planted to corn in 1977. The crop was largely free of drought stresses, and yields topped 4 metric tons/ha. The farmer inadvertently added 675 kg/ha of gypsum in a band over the rows to all plots at blooming, which appeared to largely negate a potential response to lime sources. However, it should not have affected the pH data nor the relative soil Ca data among liming treatments, particularly since the final soil samples were taken between the digger swaths.

Because of the variability in soil pH, extractable soil Ca, and peanut yields found with these experiments, practical considerations dictate that some interpretations be made outside purely statistical evaluations. For example, extractable Ca of several "check plots" was below the critical value of about

200 pp2m for soils of this area (2, 6). Yet, only two of the four experiments showed a statistically significant yield increase due to liming. Unless all four "check" plots of a particular experiment had less than the "critical" Ca level, then no statistical yield increase was obtained. For example, "check plot" Ca in the Esto soil ranged between 150 and 300 pp2m, and Dunnett's test showed no significant response to liming.

In order to utilize more effectively the relationship between extractable Ca and yield, the relative yield of individual check plots ("yield of check" ÷ "average yield of recommended lime rate" for that replication) was plotted against its extractable soil Ca (Fig. 1). For those "check plots" with <190 pp2m extractable Ca, there was a highly significant correlation between soil Ca and yield. (The solid line in Fig. 1 fits data points with Ca at <190 pp2m; the dashed line fits data points with Ca at 190 pp2m or more). These "low Ca" check plots included four from the Faceville soil, three each from the Dothan and Bonifay soils, and one from the Esto soil. Whereas analysis of variance data for individual experiments showed no statistical significance between yields of limed and unlimed plots on Bonifay and Esto soils, the graphed data in Fig. 1 show that three replications on Bonifay soil and two replications on Esto soil showed a yield response to lime.

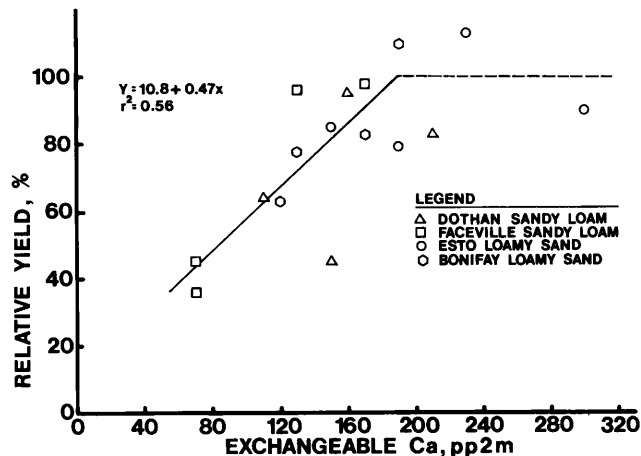


Fig. 1. The relationship between relative yield of peanuts and the exchangeable Ca level of the uppermost 7 cm of soil of unlimed plots (equation describes solid line).

Summary and Conclusions

The reactivity rate of calcitic limestone is generally greater than that of dolomitic limestone (1), and, consequently, the calcitic lime slurry could have been expected to increase soil pH more than the dry dolomitic material. However, there was no difference in the effects of lime slurry and dry lime at equal rates of material on soil pH or on peanut yield and quality. The low rate of lime (560 kg/ha) was inadequate for maximum yield in these experiments where there was a clear need

for additional Ca and an increase in soil pH. Even if the low lime rate had produced maximum yield, it is likely that it would have to be repeated annually. The reaction rate of agricultural-grade limestone at recommended rates was adequate to meet the needs of peanuts for maximum yields. There was no evidence from the soil data or the yield data to suggest that lime slurry reacted with the soil significantly quicker than agricultural-grade material. As long as the lime reacted quickly enough to supply adequate Ca during the pod-filling stage, there seems to be no advantage for a material that might react sooner. Furthermore, it is probable that the agricultural-grade limestone (50% was <60 mesh) at the recommended rate actually contained more fine lime particles than did the low rate of slurry.

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