Effect of Calcium Source, Rate, and Time of Application on Soil Calcium Level and Yield of Peanuts (**Arachis hypogaea L.**)[1]

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ABSTRACT

Studies were conducted both in the laboratory and in the field to determine the relative availability of calcium from several calcium sulfate materials, and their effect on the yield and grade of peanuts. The initial rate of Ca leaching in the laboratory study was greatest for Phosphogypsum, medium for the regular finely-ground anhydrite landplaster and least for the granular anhydrite landplaster. With continued leaching the Ca level extracted after applying the three sources became similar. Some differences were noted in the rate of leaching that were associated with soil properties, primarily cation exchange capacity.

In the field, the materials were applied early in the season and at flowering. No consistent difference existed among the sources in soil test Ca or SO_4-S levels during the growing period. These levels were lower, however, late in the season if the materials had been applied early rather than at flowering. Similar conclusions were reached when evaluating the temporary pH drop caused by applying the Ca sources.

Yield and grade of peanuts were affected by applying the Ca sources in one field study. The positive response was similar from the three materials which, in this particular study, were applied only at flowering.

Large-seeded peanuts often need supplemental calcium in the surface few inches of soil for proper fruiting (Brady, 1947; Reed and Brady, 1948; Colwell and Brady, 1945; Bledsoe and Harris, 1950). For the past 25 years, the method most commonly used to supply this element was described in a review by York and Colwell (1951) as follows: "The best method of applying gypsum to peanuts appears to be that of dusting the material on the plant at the early flowering stage. This relatively soluble source of calcium falls around the plant in the zone of pod formation and is present at the time when the need for calcium is the greatest. It is essential that the gypsum be well distributed throughout the zone of fruit formation. Since there is little residual effect of normal applications of gypsum (300 to 600 pounds per acre), it is necessary to make annual additions of this material."

Many pertinent factors concerning the method of supplying calcium are included in this description. The source of calcium specified is gypsum. Data from other investigators (Reed and Cummings, 1948; Colwell and Brady, 1945; Robertson, Lundy and Thompson, 1965; Hallock, 1960) indicate that gypsum is superior to less soluble sources such as lime. It must be assumed that the particle size is very fine, as indicated by the term "dusting." No studies concerning the effect of particle size of gypsum applied to peanuts have been reported. It is unknown if the finely divided source was selected on the basis of material availability, logic or both. This particle size may have been selected since gypsum must be dissolved and the calcium moved from the surface into the fruiting zone by rainfall.

The time of application was set at early flowering which begins about 40 days after seeding, depending on variety and climatic conditions, and continues for 70-90 days (Schenk, 1961). Approximately 10 days after a flower forms the gynophore, or peg, which elongates from its base enters the soil. Brady (1947) found that the critical period in which additional calcium was needed was 15-35 days after each peg reached the soil. From this observation and data regarding the fruiting period (Harris and Bledsoe, 1951) it may be assumed that supplemental calcium is needed in the fruiting zone from 70 to 135 days after planting.

Since this period encompasses much of the last half of the growing season, it would be logical to expect that an application during early flowering would be more likely to insure adequate calcium when needed than an earlier application, as at planting. Reed and Brady (1948) found this tended to be true when they compared gypsum applied at seedling emergence and at early bloom. However, in three studies where a response to gypsum had been obtained the later application was significantly better in only one.

One reason why an early application of gypsum might be less efficient is that calcium from this source is subject to leaching. York and Colwell (1951) stated there is little residual effect of 300 to 600 pounds of gypsum per acre. Cox (1961) showed no difference at harvest time in soil test calcium levels between such rates. Therefore, when dealing with a relatively soluble material, time of application may be very important.

For the past 25 years, the calcium source used in the North Carolina-Virginia area was a powdered calcium sulfate anhydrite containing over 90% $CaSO_4$. As a bagged material it was spread in a band over the row with small equipment. However, alternative materials are now available that lend themselves to bulk spreading. Texasgulf, Incorporated, has a byproduct, called Phosphogypsum, from their phosphate processing plant near Aurora, North Carolina. United States Gypsum Company has begun producing granular landplaster at their plant in Norfolk, Virginia.

To gain information on materials and their application, studies were conducted to determine (a) the rate calcium leaches from each material under a set laboratory condition and (b) the effect of

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time of application and source of material on soil test Ca and SO_4-S levels and on yield and grade of peanuts.

Materials and Methods

Three commercial materials used to supply calcium were investigated in all studies. The first was the regular "landplaster" that has been used in this area for many years. It is a dry, powdered calcium sulfate anhydrite containing 91% $CaSO_4$. The second was a $-6 + 50$ mesh granular material with the same composition as the first. Both of these were supplied by United States Gypsum Company. The third material was "Phosphogypsum'. It has also been called wet landplaster and wetplaster. It is a byproduct from the phosphate processing plant near Aurora, North Carolina, which is operated by Texasgulf, Incorporated. The sample of Phosphogypsum used contained 30% H_2O and 51% $CaSO_4$ calculated on a wet basis. It is variable-sized aggregate.

LABORATORY STUDIES

The rate of dissolution and leaching of the calcium sources was studied by adding the sources to soil in leaching tubes, applying water, and analyzing the leachate for calcium. A fiber glass plug, then filter pulp, and finally a filter paper were first inserted in a 3.1 cm diameter tube. On this, 65 g of soil were placed and covered with another filter paper. This gave a soil depth of 6.5 cm (2.6 inches).

Three soils were used in the laboratory. Some of their properties are given in Table 1. The Norfolk (Typic Paleudult; fine-loamy, siliceous, thermic) and Rains (Typic Ochraquult; fine-loamy, siliceous, thermic) had similar quantities of extractable Ca, Mg, and K, while the Lakeland (Typic Quartzipsamment; siliceous, thermic, coated) had considerably less. The Norfolk and Lakeland had pH values of 5.8 and 5.7, respectively, but the Rains was more acid with a pH of 5.0.

Table 1. Soil test data concerning the soils used in the laboratory and field studies.[1]

Soil	pH	Ca	SO_4-S	Mg	K	P	V.W.	O.M.
		- - - -(Kg/ha to 20 cm) - - -					(g/cc)	(%)
		Soils used in laboratory studies						
Norfolk sl	5.8	1120	--	135	287	360	1.68	0.8
Lakeland ls	5.7	290	--	26	38	36	1.67	0.7
Rains fsl	5.0	1200	--	146	233	194	1.40	2.4
		Soils used in field studies						
Norfolk sl	6.1	960	10	134	138	191	1.29	0.7
Goldsboro fsl	5.2	420	8	49	101	126	1.56	0.8
Norfolk sl[2]	5.5	620	5	35	90	276	1.48	0.8

1/ Analyses conducted by the Agronomic Division, North Carolina Department of Agriculture, Raleigh. Results are calculated on a weight basis.

2/ Located at the Peanut Belt Research Station, Lewiston, and referred to as Norfolk II.

After the three soils were placed in the tubes, water was added until it just began to drain out the bottom. Each day thereafter, 10 ml (0.52 inches) of water was added and the leachate collected for the analysis. This quantity was selected as it would replace most of the water present in the soil. The tubes were covered to reduce evaporation.

A preliminary study was conducted with a laboratory grade precipitated gypsum ($CaSO_4 \cdot 2H_2O$, 79% $CaSO_4$). At the time the fourth 10 ml increment of water was to be applied the gypsum was added by either of two methods. In one case, 57 mg gypsum were spread under the surface filter paper and then the next 10 ml H_2O added. The other method was to make a suspension of that quantity of gypsum in 10 ml H_2O and add it to the tube. The Ca content of the leachate was checked for 17 successive increments of water. In these and all subsequent analyses, Ca was determined by atomic absorption in a 0.5% La solution.

In the final laboratory study the three commercial calcium materials were applied to the surface of the soils as just described. The rates of the materials were 64 mg of the regular and granular landplaster and 113 mg of Phosphogypsum per tube. An identical procedure was followed with these except that a total of 33 increments of water were added. In both laboratory studies each treatment was run in duplicate.

FIELD STUDIES

Field studies were conducted in 1973 utilizing two application dates, two rates, and three sources of calcium materials. The two times of application were early, as near to planting as possible, and normal, or at the beginning of flowering. Rates were a check, or zero rate, and an amount to give 760 kg actual $CaSO_4$ per ha (680 lb/acre). The latter was broadcast over the entire plot. Each plot was 15 m (50 ft) long and two 90-cm rows wide. Sources were the three commercial materials indicated previously. A randomized complete block design with six replications was used. Two check plots were included in each replication, making a total of eight treatments per replication.

One experiment was initiated on the W. B. Gilliam, Jr. farm near Harrellsville, Hertford County, North Carolina, on a Norfolk sandy loam. Florigiant peanuts were planted April 23 and the calcium materials applied May 22 and July 3. Rainfall was recorded during the season. Soil samples were collected each three weeks after the initial application until harvest. Each sample was composed of 20 cores per plot taken to a depth of 10 cm (4 inches). Soil analyses were made by the Agronomic Division, North Carolina Department of Agriculture. The crop was dug September 10 and after curing, the yield and grade from each plot determined.

A similar study was initiated on a Goldsboro fine sandy loam (Aquic Paleudult; fine-loamy, siliceous, thermic) at the Peanut Belt Research Station near Lewiston in Bertie County. Peanuts were planted on May 3 and the early treatment applied May 4. This experiment was discontinued in midseason because the entire study received an unscheduled application of landplaster at early flowering.

Another study was then initiated on a Norfolk sandy loam in Field A2 on the Station. The sources were applied only once, July 3, on Florigiant peanuts that had been planted in early May. The same procedures as outlined previously were followed and the crop dug September 12.

The 3 sites indicated above will be identified hereafter as Norfolk, Goldsboro, and Norfolk II, respectively. Soil test data from the check plots are presented in Table 1.

Results and Discussion

LABORATORY STUDIES

Applying the material in suspension beginning with the 4th increment of water caused much more rapid leaching of calcium than applying it dry to the soil surface (Figure 1). Maximum calcium concentration from the suspended material was 250 ppm, whereas that from the dry surface applied was 90 ppm. When added in suspension the next 9 increments of H_2O (No. 4-12) removed essentially all the calcium that was readily leached. If applied dry, however, the initial rate of leaching was considerably slower for the first few increments than when applied in suspension.

The striking difference in leaching rate due to method of application indicates that if finely divided gypsum is applied in suspension, particles must be carried down into the soil. If spread in this manner, more water would be available to dissolve each particle. It would be expected that if gypsum were spread dry and then incorporated, as by disking, the rate of leaching would be similar to that when applied in suspension. In contrast, not incorporating gypsum will prolong the time that it will supplement the soil Ca level.

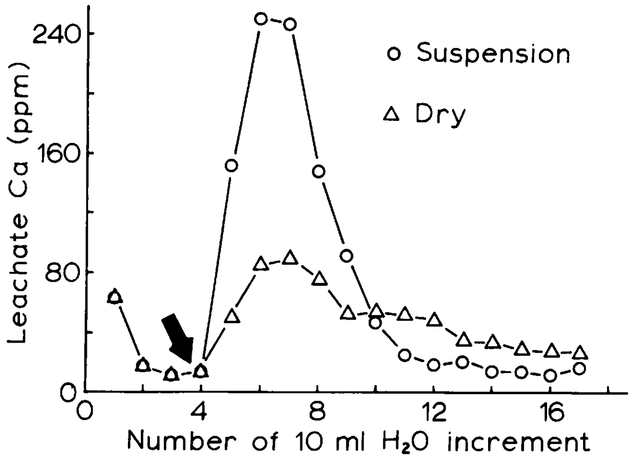

Fig. 1. Effect of 2 methods of applying gypsum on the leachate Ca concentration after applying increments of water. Gypsum applied at arrow just prior to 4th increment. Values are averages from duplicate analyses from 3 soils.

Minor differences associated with soil type were noted in the amount and rate of Ca leaching. More Ca leached through the Lakeland than the Norfolk or Rains soils.

Of the 57 mg gypsum (13,260 ug Ca) applied in suspension 87% of the calcium was recovered from the Lakeland soil between about the 4th and the 12th extractions. During this same period 67 and 60% were recovered from the Norfolk and Rains soils, respectively. When applied dry, the percentages recovered between the 4th and 17th extractions for the above three soils were 62, 41, and 30%. This difference due to soil type would be expected from the lower exchange capacity of the Lakeland. Similar amounts of Ca were extracted from the Norfolk and Rains soils, but the rate of leaching through the Rains was slightly slower. Whereas maximum Ca concentration in the leachate occurred with the Norfolk at increment number 6, it occurred with the Rains at increment number 7.

In view of the above results, it was concluded that in future studies, any material should not be applied in suspension but should be spread on the soil surface. This was done in the second laboratory study and three commercial materials were evaluated on the three soils.

The results of the second laboratory study indicated that the initial rate of Ca leaching from the materials was in the order: Phosphogypsum > regular landplaster > granular landplaster (Figure 2). The rates became more nearly similar as additional water was added, though, and were essentially the same after increment number 14.

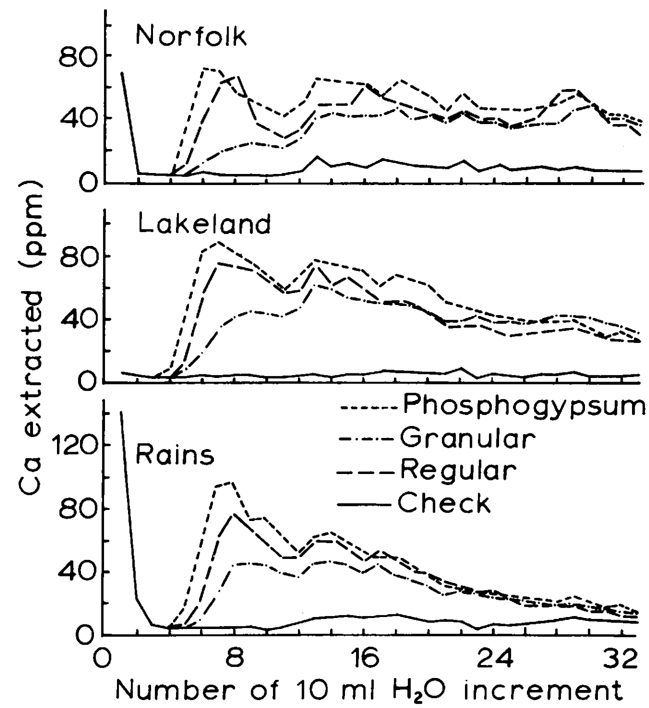

Fig. 2. Calcium leaching rate by increments of water on 3 soils with and without the application of 3 calcium sulfate sources.

It was expected that since the initial rate of leaching was least from the granular landplaster, it would eventually have a higher rate than the other materials. This did not occur, however.

In the early stages of this study, more Ca leached through the Rains and Lakeland soils than through the Norfolk. These results with the Rains differ from those in the preliminary experiment. Although source of material differs between the studies there seems no logical explanation for this discrepancy.

At the end of this study much less Ca was being leached from the Rains than from the Norfolk and Lakeland soils when the materials were applied. It is possible that the effective exchange capacity with a salt present is greater for the Rains than for the other soils. If so, Ca may be retained longer on exchange sites in the Rains.

When the first increment of water was leached through these soils, marked differences were observed in the Ca concentration of the extracted solution. The order from the soils was: Rains > Norfolk > Lakeland. This reflects a difference in the amount and type of exchange capacity.

FIELD STUDIES

Three experiments were conducted in the field. Average soil test Ca and SO_4-S levels to a depth of 20 cm from the check plots during the season are given in Table 1. In the Norfolk and Norfolk II studies both Ca and SO_4-S varied somewhat, especially in the first samples taken. There did not seem to be any association with rainfall pattern or any other factor that might explain this. There was a considerable range in Ca levels among soils, but the SO_4-S levels were all quite low.

The increase in soil test Ca and SO_4-S over that of the check plots resulting from application of the 3 commercial materials is shown in Figure 3. There was no consistent difference among the materials in increasing the soil test Ca or SO_4-S. In 3 of the 4 cases the increase due to granular landplaster tended to be less than that from the other two sources. This tendency decreased with time.

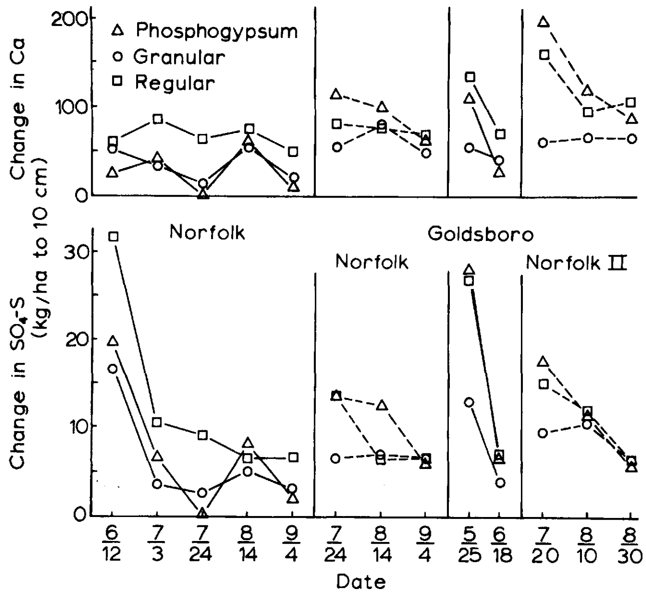

Fig. 3. Change in soil test Ca and SO_4-S levels during the season in relation to that in the check plots when the 3 materials were applied.

Since little difference existed among sources in increasing soil test Ca and SO_4-S the results were averaged. The data are presented in Figure 4 with time after application. No data are reported for the sampling immediately after application because the results were too variable. Although there is some scatter in these points due to location differences, the general trend is for both Ca and SO_4-S to decrease with increasing time after application. From 3 to 6 weeks after application Ca decreased from an average of 90 to 60, while SO_4-S decreased from 17 to 4 kg/ha to a depth of 10 cm.

Even at the 3-week sampling values were much lower than the actual amount applied, which was about 225 kg Ca and 180 kg SO_4-S/ha. Thus, in 3 weeks time Ca apparently had decreased to 40% of that applied, while SO_4-S had decreased to 9% of that applied. Some of this could have been lost in surface runoff, but it is likely that much of it had been leached below the surface 10 cm (4 inches) of soil.

Another means of evaluation of the amount of salt in a soil is by the decrease in pH. When salt is added it causes the pH to decrease. As the salt is removed by leaching the pH is increased. The soil pH values of the check plots during the season on the Norfolk soil are shown in Figure 5. During the first 3 weeks, between sample 0 and 1, the pH decreased from about 6.2 to 5.9 The only explanation possible for this seems to be that surface evaporation caused salts to accumulate in that layer of soil. During the next 12 weeks the pH increased to almost 6.6, and remained there the next 3 weeks. This increase was likely due to leaching of salts from the 0-10 cm horizon.

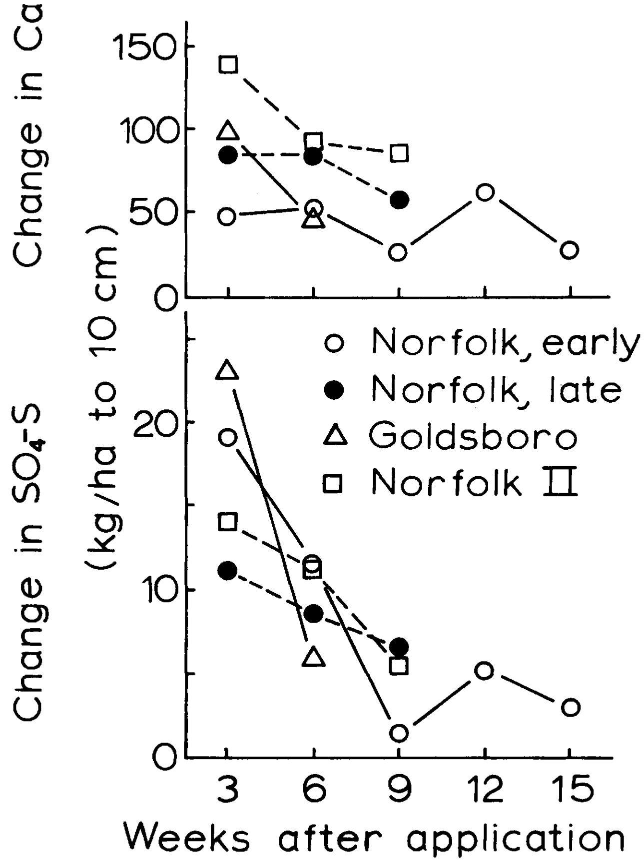

Fig. 4. Change in soil test Ca and SO_4-S in relation to that in the checks at the 3 locations with increasing time after application. Values are averaged across the 3 sources.

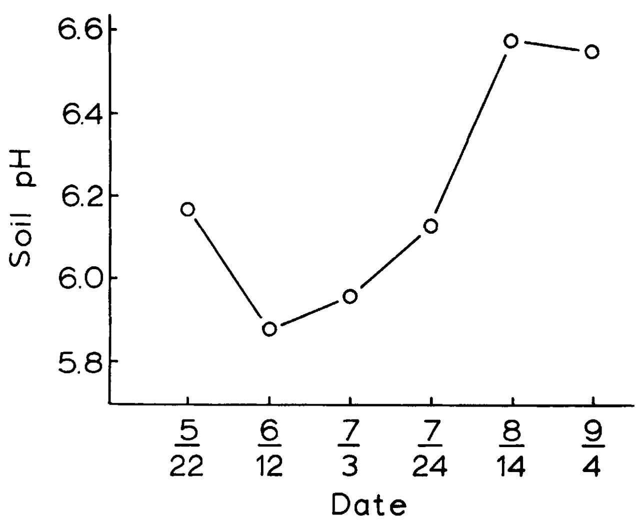

Fig. 5. Soil pH of 0-10 cm samples from the Norfolk check plots during the season.

The change in soil pH after applying the 3 commercial materials early and at flowering is given in Figure 6. In that applied May 22, Phosphogypsum decreased the soil pH more than the other sources in the early samplings, while the granular landplaster had the greatest effect in the later samplings. The latter data may indicate that granular landplaster may provide more Ca in solution late in the season.

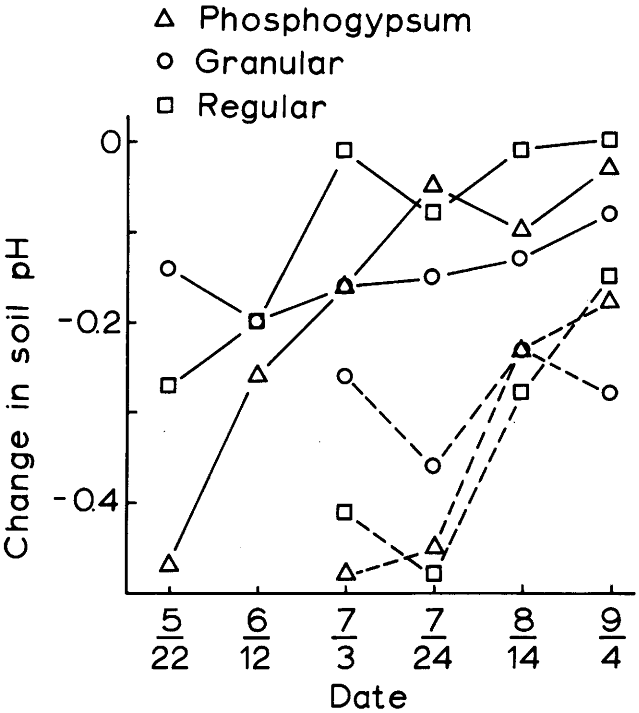

Fig. 6. Change in soil pH at the Norfolk site during the season after application of 3 materials early in the season and at flowering.

When the materials were applied at flowering their effect in decreasing the soil pH appeared greater than when applied May 22 (Figure 6). Also, the effect remained greater for 3 samplings or 9 weeks. This would suggest less leaching during the latter part of the season.

On the Goldsboro site the pH was lower (5.1 average) and showed little change with either sample number, Ca rate, or source of material. On the Norfolk II site, however, the pH of the check plots increased from 5.6 to 6.0 during 4 samplings. All sources initially decreased the pH in a similar manner. During the last 3 samplings the pH increased from 5.2 to 5.7. Thus, at the last sampling the pH was 0.3 units lower if the Ca materials had been applied.

Peanut yields were not affected by treatment at the Norfolk site. Colwell and Brady (1945) estimated that if the soil contained over 670 kg Ca/ha by soil test a response to supplemental Ca was not likely to occur. The soil at the Norfolk site tested 960 kg Ca/ha to a depth of 20 cm, so these results concur with their estimate.

Yields were also determined from the crop grown at the Norfolk II location. This soil contained 620 kg Ca/ha. Application of the 3 materials increased the yield from 4700 to 5500 kg/acre). No difference was noted among the 3 commercial materials, which were all applied at flowering in this case.

Other differences noted in the crop between the check and the plus Ca treatments at the Norfolk II location were:

	Check	Landplaster
SMK (%)	63.7	70.6
ELK (%)	32.6	45.6
Value ($/acre)	656	861
Leaf Ca (%)	1.60	1.73
Leaf S (%)	0.18	0.24

All of the differences in these measurements were statistically significant ($P = 0.01$) except that for leaf Ca which was just a trend toward being increased when landplaster was applied. Thus, the crop grade and value were increased substantially by each of the commercial materials applied. Leaf S was also increased by their use.

At the Norfolk site leaf Ca and S were not affected by treatment and averaged 1.65 and 0.18%, respectively. No plant samples were collected in August from the Goldsboro site as that study had been terminated by that time.

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