The Effect of Rainfall and Irrigation on Recovery of Applied Ca From Soil Under Peanut Culture[1]

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ABSTRACT

Field experiments were conducted to obtain information on the effect of rainfall and irrigation on Ca mobility from application of powdered and granular gypsum to peanuts. After receiving 11.27 cm of water, only 15 kg/ha (23%) and 28 kg/ha (21%) of the applied Ca was recovered from the 0-2.54 cm soil depth at the 280 and 560 kg/ha rates of powdered gypsum, respectively. With the same amount of water, recovery of Ca from 560 kg/ha rate of granular gypsum was 30 kg/ha (19%); however, the data indicate that undissolved granules remained after extracting soil treated with this material. Increasing amounts of water applied to the plots decreased the amount of Ca recovered from plots treated with powdered gypsum through four successive samplings; whereas, there was an increase in the amount of Ca recovered from plots treated with granular gypsum. A similar response pattern was obtained when Ca recovery in the primary pegging zone (0-5.08 cm depth) was measured even though total quantities recovered increased with the increase in soil depth.

The 280 kg/ha application of powdered gypsum did not significantly increase available Ca in the 0-15.24 cm soil depth at harvest, but there was a slight increase from the 560 kg/ha rate. The 560 kg/ha rate of granular material significantly increased available Ca at harvest.

An adequate supply of Ca in the pegging zone has long been an established requirement for high yields of good quality peanuts (1,2,3,4,8). Calcium supplements are frequently required to maintain adequate Ca in the surface few centimeters for optimum pod development (3,5,8). This is particularly true of the large seeded varieties (4,11). For many years gypsum has been the dominant material used as a Ca supplement for peanuts (5,9,10); although alternative materials have been tested (4,9,10,11) and used on a limited basis by growers (7,11).

Since gypsum is a relatively soluble source of Ca (13) it is subject to almost complete loss from the Ap horizon by the time peanuts are harvested (5,13). To offset the leaching loss from the primary pegging zone, surface 5 cm of soil, high rates (336 to 1120 kg/ha) of gypsum are usually applied at early flowering to insure adequate Ca is present in the pegging zone for pod development. This practice has been common for varieties with large seed and sometimes has been used wth small seed varieties (7); though the validity of the practice for any variety has been questioned on well limed soils (6).

Rather rapid depletion of Ca from surface applied gypsum was indirectly indicated in studies which show little residual effect at harvest from gypsum applied at flowering (5,13). More direct indcations come from laboratory studies that showed a major part of the gypsum was leached beyond the critical 5 cm pegging depth (5,11) after applying the equivalent of 5 to 10 cm of rainfall. Little information could be found to indicate the rate of leaching loss of gypsum from the pegging zone of plants growing in the field.

The purpose of this investigation was to determine the loss of Ca from the Ap horizon of a soil in the field on which peanuts were growing as affected by the rate and form of gypsum and by water received by the soil.

Materials and Methods

Florunner peanuts (**Arachis hypogaea** L.) were grown on a two-row 162 cm bed at the Coastal Plain Experiment Station, Tifton, Ga. on a fuquay loamy sand (Arenic Plinthic Paleudults, loamy, siliceous, thermic family) during May through September 1974.

Plots were established by developing soil channels 10 cm deep around each plot $(1.63\ m)^2$ to prevent calcium movement from one plot to another. The resulting maze of channels permitted removal of all surplus water from the experimental area without surface contamination and the channels were maintained throughout the growing season. Calcium treatments were applied broadcast evenly over the top of plants at the rate of 0, 280, 560 kg/ha of powdered gypsum containing 77% $CaSO_4$ and 560 kg/ha of granular, (a slolw release material that was < 6 mesh, but > 50 mesh) gypsum[3] with 92% $CaSO_4$ and four replications each.

To obtain a measure of calcium movement in the soil, approximately 5 cm of irrigation water were applied four times at four or five day intervals, beginning when the plants were five weeks old (June 18). Irrigation was applied at close intervals to obtain data on initial Ca movement and to minimize variability in amount and intensity of water received by the plots in the form of rainfall. The last irrigation water was applied on July 2. During the period of June 18 through July 6, 1974, plots received 7.83 cm rainfall in addition to irrigation as indicated in Table 1. All subsequent water received on the experimental area was in the form of rainfall.

Irrigation water was applied at the rate of 5 cm/hr by use of overhead sprinklers, Rainbird 25PJDA, at 3.52 kg/cm^2 line pressure. A sprinkler was positioned in each of the four corners of the experimental area which gave uniform distribution of water to the entire area. Twelve one-liter cans were placed at random throughout the experimental area to estimate uniformity of water application. Irrigation was limited to a period during the day when wind movement was minimal to facilitate uniform distribution.

Prior to application of any Ca, soil samples were taken randomly throughout the treatment area at 0-2.54, 2.54-5.08 5.08-10.16, and 10.16-15.24 cm depths and subsequently analyzed for exchangeable Ca content. Soil samples were taken at these depths four days after each irrigation, one month after irrigation was terminated, and at harvest. All soil samples were obtained by use of a special sampling apparatus (12) that allowed the removal of a relatively undisturbed column of soil 5.08 x 5.08 cm to a depth of 15.24 cm. Calcium content of the soil at these depths was determined by taking a 20 gram soil sample and leaching it with 250 ml of 0.5 N HC1-0.25 N H_2SO_4

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[3]An experimental product of United States Gypsum Company.

(standard double acid extractant). The calcium content of the leachate was determined by atomic absorption spectroscopy. The quantity of applied Ca recovered from each depth was determined by subtracting the soil Ca content of check plot from the soil Ca content of treated plots. Standard statistical procedures were employed to analyze the data.

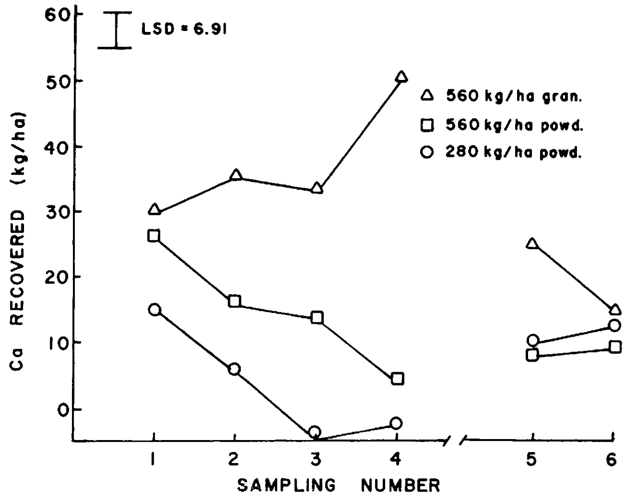

Fig. 1. Recovery of applied Ca from different Ca treatments at successive sampling dates, 0-2.54 cm depth. (Dates corresponding to sampling number given in Table 1.)

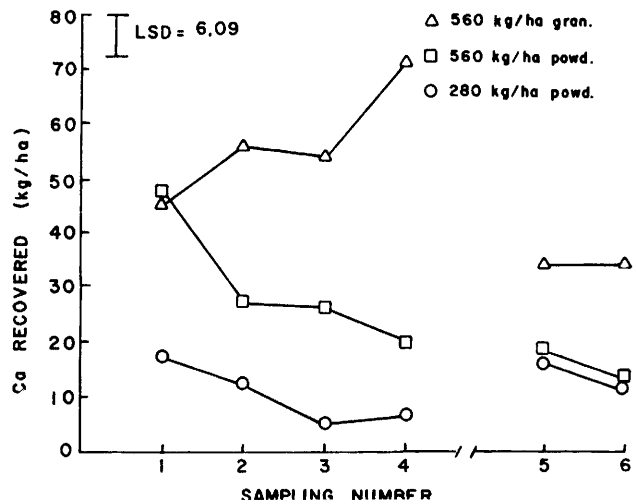

Fig. 2. Recovery of applied Ca from different Ca treatments at successive sampling dates in the primary pegging zone, 0-5.08 cm depth. (Dates corresponding to sampling number given in Table 1.)

Table 1. Rainfall and irrigation water received by plots during experimental measurements.

Time intervals	Sampling number	Irrigation	Rainfall	Interval total	Cumulative total
		cm			
June 18-24	1	5.61	5.66	11.27	11.27
June 24-28	2	4.70	0.83	5.53	16.80
June 28 - July 2	3	4.88	1.12	6.00	22.80
July 2-6	4	4.70	0.22	4.92	27.72
July 6 - Aug. 6	5	-	9.93	9.93	36.65
Aug. 6 - Sept. 9	6	-	25.62	25.62	63.27

Table 2. Percentage of applied Ca recovered by two extracation solutions.

Extractants	% of applied calcium recovered* Pow. gypsum	Gran. gypsum
Double acid	96	25
Double acid (shaken 12 hours)	92	--
.1N HCl	108	34
.1N HCl (shaken 12 hours)	125	--

* Average of 8 extractions.

Results and Discussion

Calcium Recovered from the Surface 0-2.54 cm Depth

The total amount of irrigation and rainfall received on the plot area, prior to each of six dates when soil samples were taken, are presented in Table 1. Throughout the discussion successive sampling numbers 1 through 6 will be used to identify sampling date as described in Table 1.

Table 3. Percentage of applied Ca recovered from the primary pegging zone, 0-5.08 cm soil depth.

Material	Rate	Calcium recovered 1	2	3	4	5	6
	kg/ha	%					
Powdered gypsum	280	25	18	8	10	28	20
Powdered gypsum	560	37	21	20	15	12	9
Granular gypsum	560	27	36	35	47	22	22

The first 11 cm of rainfall and irrigation leached a considerable amount of the applied Ca beyond the surface 2.54 cm of soil (Figure 1). By the first sampling at the 280 kg/ha rate of powdered gypsum (65 kg/ha of Ca) only 15 kg/ha or 23% of the applied Ca was recovered from this depth. Increasing amounts of water received on the plot area decreased the amount of Ca recovered for the first three samplings. By the third sampling, plots had received 22.8 cm of irrigation plus rainfall and the applied Ca had been leached beyond the 2.54 cm soil depth. However, at the fifth and sixth sampling, an increase in the amount of Ca recovered from the surface layer was noted. Since these latter samplings are much later in the growing season, the increase in Ca content of the surface was possibly due to return of Ca through lower leaf abscission.

For the first four successive samplings, increasing the application rate of powdered gypsum from 280 to 560 kg/ha significantly increased the amount of Ca recovered in the 0-2.54 cm depth. However, samples taken one month after the last irrigation (5th sampling) and at harvest (6th sampling) showed no significant difference in the amount of Ca recovered in the 0-2.54 cm depth between the 280 and 560 kg/ha rate of powdered gypsum.

Application of 560 kg/ha of granular gypsum material (151 kg/ha Ca) increased the amount of calcium recovered from the 0-2.54 cm depth over that recovered at the lower rate of regular gypsum at all sampling dates. The recovery of Ca was also higher than that observed at the same rate of powdered gypsum at all samplings except the first and last. Increasing amounts of water received on the plots increased the amount of applied calcium recovered at the 0-2.5 cm depth from the granular material. By the fourth sampling date the amount of calcium recovered from granular gypsum had increased from 30 kg/ha at the first sampling to 51 kg/ha. After the 4th sampling date applied calcium recovered in the surface 0-2.54 cm depth decreased and was not different from the amount recovered from the high rate of the powdered gypsum material at harvest.

These data show an inverse relationship between the amount of calcium retained in the soil surface at the 560 kg/ha rate of granular gypsum and the same rate of powdered gypsum. Since granular gypsum apparently releases Ca more slowly than the powdered material, it seems logical that smaller amounts would be released by the first increment of water received by the plots. Apparently, successive increments of water solubilized greater quantities of calcium from the granular material. Subsequent laboratory tests in which 73 mg of granular gypsum was mixed with 73 grams of soil and leached with a total of 5, 10, and 20 cm of water supported this theory. The first two successive 5 cm increments of water removed 14.1 and 23.3% of the added Ca, respectively, while the third increment (10 cm) of water removed 10%.

In addition laboratory tests revealed that an average of 95% of the applied calcium was recovered by double acid extraction of the soil in powdered gypsum treatments, whereas, in granular gypsum treatments only 25% of the applied calcium was recovered (Table 2). The relatively low amount of calcium recovered at the first field sampling was probably related to the incomplete recovery of undissolved calcium from soil samples by the double acid extraction, as well as the initial slower rate of granule dissolution. Daughtry and Cox (5) noted that the initial rate of leaching of calcium was considerably slower from granular gypsum.

CALCIUM RECOVERED FROM THE PEGGING ZONE (0-5 CM DEPTH)

Since peanut pod development occurs primarily within the surface 5 cm of soil in Spanish and runner types (unpublished data, R. H. Brown, University of Georgia), the amount of calcium retained in this layer of soil is of greatest importance. By combining the values for the amount of calcium recovered in the 0-2.54 and the 2.54-5.08 cm detph, an estimate of the calcium content of the pegging zone was obtained (Fig. 2).

As one might expect, recovery of applied Ca in the 5.08 cm depth (Fig. 2) followed the same response patterns as shown for the 0.2-54 cm depth although total quantities recovered increased with the increase in soil depth (Fig. 1). Thus, increasing the rate of powdered gypsum from 280 to 560 kg/ha also significantly increased the amount of Ca recovered from the pegging zone (0-5.08 cm depth) for the first four samplings (Table 3). Likewise, increasing the amount of water decreased the amount of Ca recovered from the pegging zone until leaf drop redeposited Ca at the soil surface. The fact that the granular gypsum apparently was less soluble and leached less readily is further supported by the data for the combined depth, 0-5.08 cm.

CALCIUM RECOVERED FROM THE 0-15.36 CM SOIL DEPTH

The amount of applied Ca recovered in the surface 0-15.36 cm of soil at successive sampling dates is presented in Table 3. Greater variability in the data was evident when Ca from the 5.08-15.24 cm depth was included along with the values for the 0-5.08 depth; therefore, treatment effects are not as evident.

In general the 280 kg/ha rate of gypsum resulted in a slightly higher Ca content in the 0-15.24 soil depth than the untreated check throughout the season; however, it was significantly higher only at the first, third and fourth sampling dates. Increasing the rate of application from 280 to 560 kg/ha increased the Ca recovered from the 0-15.24 cm depth at all sampling dates except at harvest. Addition of the first and second increments of water leached progressively larger amounts of Ca beyond the 15.24 cm depth. The amount of the applied Ca remained fairly constant from the second through fifth sampling, and then decreased at the sixth or harvest time sampling. Again, Ca from the granular material was recovered in larger quantities at the third through sixth sampling dates than was recovered from the comparable rate of the powdered material.

Table 4. Ca increase during the growing season in the 0-15.36 cm soil depth from applied Ca treatments.

Material	Rate	Sampling number 1	2	3	4	5	6
		kg/ha					
Powdered gypsum	280	22ab*	18b	24ab	39a	11b	19b
Powdered gypsum	560	89a	46bc	55b	59b	51b	28c
Granular gypsum	560	76b	47c	92ab	110a	57c	51c
Avg. Ca level of untreated check = 523 kg/ha							

* Data in the same line followed by the same letter and data in the same column covered by a vertical line do not differ at 5% probability level, Duncan's Multiple Range Test.

Conclusions

Although gypsum has been recognized as a relatively soluble source of Ca for a number of years (4,13), results from this study as well as from laboratory studies referred to by Walker (11) indicate that a surprisingly high proportion of Ca from gypsum applied to peanuts is leached beyond the pegging zone by the first increments of water (about 10 cm or less). Since the gypsum commonly used is a finely ground material, Ca losses from the pegging zone probably is the result of movement in percolating water of dissolved gypsum as well as physical displacement of undissolved parparticles. Information available at present does not permit quantitative separation of the two processes. The granular material used in this study and by others (5) appears to slow Ca loss from surface layers of the soil; thus probably reducing both the rate of solution and physical displacement of applied gypsum. The development of slow release materials, such as this granular material or possibly a product with yet a slower Ca release rate, shows promise as a way of providing an adequate Ca supply in the pegging zone with smaller applications of the material.

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