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Effect of Three Ca Sources Applied on Peanuts II, Soil Ca, K, and Mg Levels[1]

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ABSTRACT

Field experiments were conducted on Kenansville lfs (Arenic Hapludult) in 1977 and on Rumford lfs (Typic Hapludult) in 1978 to compare two bulk-spread supplemental Ca sources with bagged landplaster. Bagged LP, 420 Landplaster Bulk (420-Bulk) and Texasgulf Gypsum (Tg Gypsum) were appplied on Florigiant peanuts (*Arachis hypogaea* L.) at rates equivalent to 260 kg/ha Ca broadcast and at three different dates: planting, early June just prior to flowering, and late June in early flowering stage. The relative effects of these Ca sources on changes in the contents of H_2O- and 1.0 N NH_4OAC-extractable soil Ca, Mg, and K in the 0- to 10-cm and 10- to 20-cm soil layers wre measured by analysis of periodic soil samplings taken during the peanut fruiting period.

All three Ca sources increased the contents of both H_2O- extractable Ca (H_2O-Ca) and NH_4OAc-extractable Ca (Ac-Ca) in both soil layers throughout the sampling period. In 1977, contents of H_2O-Ca in treated plots often were 100 to 125 μg/g of soil higher in the 0- to 10-cm layer and 50 μg/g higher in the 10- to 20-cm layer than in untreated plots. Increases in the contents of Ac-Ca in treated plots up to 150 μg/g of soil occurred in several cases in the 0- to 10-cm layer and up to 100 μg/g in the lower layer. The Ca applications in 1977 increased the initial extractable contents of H_2O-Ca and Ac-Ca more and the Ca persisted longer after Ca application than in 1978. Bagged-LP or Tg Gypsum generally increased the contents of H_2O-Ca and Ac-Ca in the 0- to 10-cm layer considerably more than 420-Bulk, particularly in 1977. Differences between Ca sources often diminished with time after application of the materials. This occurred to a greater extent in 1978. The contents of Ac-Ca, particularly, in plots amended with 420-Bulk usually increased considerably toward the end of the sampling period. The contents of H_2O-Ca and Ac-Ca in comparable samplings of the peanut fruiting layer generally were similar much of the time for all three times of applications.

Changes in NH_4OAc-extractable Mg contents extracted from the 0- to 10-cm and 10- to 20-cm layers following application of the Ca sources ranged from 10 to -25 and 28 to -22 μg/g of soil, respectively, in 1977. The ranges in 1978 were from 0 to -20 and 12 to -14 μg/g of soil, respectively. Similarly, changes in NH_4OAc-extractable K in the surface and lower layers ranged from 10 to -25 and 13 to -18 μg/g of soil, respectively, in 1977. The ranges in 1978 were from 11 to -20 and 14 to -24 μg/g of soil, respectively. These contents of Ac-Mg and Ac-K decreased more frequently than they increased after application of the Ca sources, particularly when applied at planting. Relatively more increases occurred after the later application.

Key Words: Groundnuts, Landplaster, Gypsum, Anhydrite, Water-extractable soil nutrients, NH_4OAc-extractable soil nutrients.

Supplemental Ca fertilization of large-seeded Virginia-type peanuts (*Arachis hypogaea* L.) is a routine cultural practice. This is done because of the unique requirement of developing peanut fruits which must absorb Ca from the soil. Bledsoe, et. al. (1) reported that little or no Ca was translocated from the other parts of the plant for fruit development. The research of others (2, 3, 10) also demonstrated the need for supplemental Ca fertilization to insure maximum fruit development of large-seeded peanuts.

For many years, finely ground $CaSO_4$ anhydrite called bagged landplaster (Bagged-LP) has been the principal supplemental Ca source for peanuts in Virginia. Recently, other formulations of $CaSO_4$ which can be bulk-spread became available. The two principal supplemental Ca sources now being bulk-spread are a granular landplaster called 420 Landplaster Bulk (420-Bulk) from the United States Gypsum Company and Texas-gulf Gypsum (Tg Gypsum), a phosphate processing by-product of Texasgulf Incorporated.

The availability of Ca from these products is important. Calcium sulfate is one of the more soluble mineral forms of Ca (9) and may leach considerably. In addition to their improved bulk-spreading properties, 420-Bulk and Tg Gypsum which contain coarser particles when spread in the field, may release Ca somewhat more slowly than Bagged-LP.

Daughtery and Cox (4) measured the relative Ca supplying capacity of regular Bagged-LP, Tg Gypsum, and an experimental granular landplaster (herein termed 650-LP and having most minimum particle diameters <3.35 mm and >300 μm) in the laboratory and field experiments. Initially, relative Ca mobility in laboratory studies was Tg Gypsum >Bagged-LP>650-LP, but relative leaching equalized with time. Soil test Ca in the peanut fruiting zone during the growing period did not differ consistently among sources. Jones, et al. (7) reported that powdered gypsum and 650-LP, broadcast over the peanut rows at 580 kg/ha, released 21% and 19%, respectively, of their Ca to the 0- to 2.54-cm soil layer under 11.3 cm of precipitation. Heavier rainfall decreased Ca recovery from gypsum during several samplings whereas, the opposite occurred from 650-LP. Only the 650-LP significantly increased available soil Ca in the plow layer at harvest. Keisling and Walker (8) compared the Ca-

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supplying characteristics of surface-applied powdered gypsum with a granular anhydrite (82% of particles had diameters <4.2 mm and >0.5 mm) coarser than the granular 650-LP included in the previous investigations (4, 7). The powdered gypsum was a more effective source of Ca in the fruiting zone early in the growing season than the granular anhydrite. Ultimately, the rainfull pattern was a key factor in the relative effectiveness of these materials. Under heavier leaching situations, Ca loss was not reduced where the coarse material was applied. When certain leaching conditions occurred early after application, Keisling and Walker (8) noted that the coarse material may persist longer and supply more Ca to the fruiting zone over a longer period than the finer substance.

Field experiments were conducted in 1977 and 1978 to compare the relative effectiveness of Tg Gypsum and 420-Bulk with Bagged-LP as supplemental sources of Ca. The effects of rates and times of application of these materials on several aspects of peanut productivity are given in a companion paper (5). This paper presents the effects of these treatments on contents of water- and 1.0 N NH_4OAc-extractable Ca, Mg, and K in the peanut fruiting zone, 0- to 10- cm, and the 10- to 20-cm root zone.

Materials and Methods

The experiment was conducted on a Kenansville lfs (Arenic Hapludult) in 1977 and on a Rumford lfs (Typic Hapludult) in 1978. Florigiant peanuts were grown each year according to generally recommended practice as described in the companion paper (5). Plots were four 91-cm rows wide by 12.2 m long. The peanuts were planted 2 May in 1977 and 18 May in 1978. Treatments were arranged in a completely randomized block design with three replications.

Three Ca sources were applied each year. Approximate particle sizes of these materials were as follows: Regular landplaster (Bagged-LP) had 14% particles > 150 μm and 64% <75 μm; 420 Landplaster Bulk (420-Bulk) had 2% >4.75 mm, 80% >850 μm, and 8% <150 μm; Texasgulf Gypsum (Tg Gypsum) (wet) had 31% >150 μm and 48% <75 μm, and Tg Gypsum (dry) had 15% >150 μm and 69% <75 μm. Tg Gypsum (wet) contained about 15% free water (Stored outside). Tg Gypsum (dry) is similar to the wet material except that it contains ca 3% free water. All Ca sources were applied by hand on the soil surface and foliage when present. Materials broadcast were spread uniformly over the whole plot area and banded materials were applied in a band 61 cm wide centered over the rows. Equivalent amounts of Ca per unit area of soil covered were applied in comparable broadcast or band treatments (i. e. 175 kg/ha banded = 260 kg/ha broadcast per unit area initially covered). Since there were no consistent differences between the effect of wet or dry Tg Gypsum or between band or broadcast treatments on contents of soil Ca, Mg or K, results are averaged for both methods. These materials were applied each year at planting, just prior to the first blooms, or during the early bloom stage of growth. No incorporation occurred except by natural forces until the flat lay-by cultivation just before heavy pegging commenced.

The plots were sampled just prior to application of the Ca-sources and then on 15 and 29 June, 13 and 27 July, and 16 and 29 August in 1977. Post-planting dates of soil sampling in 1978 were 13 and 29 June, 7 July, and 8 and 24 August. Ten cores at depths of 0 to 10 cm and 10 to 20 cm were obtained from the Ca-treated portion of the central two rows. Care was taken in subsequent samplings not to sample spots penetrated previously. The samples were air-dried and then passed through a 2-mm sieve.

The samples were analyzed for easily water-extractable and 1.0 N NH_4OAc-extractable Ca, Mg, and K contents. Twenty ml of distilled water were added to 10-g samples of air-dried soil in a flask and shaken in a revolving shaker for 30 minutes. The mixtures were filtered by use of buchner funnels and low suction, the flasks rinsed with five 10-ml portions of water, and the rinsings added to the soil and filtered. Hydrochloric acid was added to aliquots of the filtrates to make them approximately 0.5 N HCl before analysis. Ammonium acetate extractions were similar to those outlined by Jackson (6). The contents of Ca and Mg in both types of extracts were determined by flame absorption and the K contents by flame emission spectroscopy. The following equation can be used to relate these contents to field results: kg/ha = 2.24 x contents of nutrients in μg/g of soil extracted.

Nutrient contents determined in the soil samples of Ca-treated plots were adjusted to reflect seasonal variations which occurred in the untreated or check plots. Thus, the initial nutrient contents found in the plots before treatment were increased or decreased by changes found in check plots during the same period. These adjusted values were used to calculate the approximate changes in contents of extracted soil Ca, Mg, and K which occurred as a result of treatment.

Results

Precipitation

Total rainfall received during the 1977 peanut growing season (43.8 cm) was approximately 20 cm below that for 1978. The distribution of precipitation during the late fruit development period was less favorable in 1978 because of the extremely dry September (0.5 cm). The precipitation recorded near the experiment sites during the period of soil sampling in 1977 and 1978 is given in Table 1. Excessive precipitation occurred in both May and the early part of June in 1978 whereas, it was above average only during the first half of May in 1977. Thus, leaching conditions probably were greater than average following the first application of Ca sources in 1977 and especially in 1978.

Table 1. Precipitation during the 1977 and 1978 growing season.

	Precipitation			Precipitation	
Period	1977	Average†	Period	1978	Average†
	------cm------			------cm------	
5/1 to 6/15	19.7	14.6	5/18 to 6/13	30.6	10.2
6/16 to 6/29	0.9	5.3	6/14 to 6/29	8.2	7.0
6/30 to 7/13	4.5	7.1	6/30 to 7/17	4.7	7.4
7/13 to 7/27	0.4	6.4	7/18 to 8/18	15.1	12.4
7/28 to 8/16	10.2	11.8	8/18 to 8/24	3.4	8.6
8/16 to 8/29	4.6	6.0			
TOTAL	40.3	51.2		62.0	45.6

†Recorded at Tidewater Research and Continuing Education Center located 27 km southwest of experiments; Averages are 45-year means.

Initial Soil Ca, Mg, K Levels

The initial contents of water- and 1.0 N NH_4OAc-extractable soil Ca, Mg, and K before application of the Ca sources are given in Table 2. Levels of water-extractable soil Ca, Mg, and K (H_2O-Ca, -Mg, or -K) in the 0- to 10-cm layer, and to a lesser extent in the 10- to 20-cm layer, increased in 1977 before application of Ca sources. Little change in the levels of H_2O-Ca, -Mg or -K occurred during a similar period in 1978, except H_2O-K decreased somewhat in both layers. Levels of NH_4OAc-extractable soil Ca and K (Ac-Ca or -K) generally decreased, except Ac-Ca increased in the 0- to 10-cm layer in 1977 during that period. Contents of Ac-Mg did not change appreciably during this period either year.

Table 2. Contents of H_2O- or 1.0 N NH_4OAc-extractable soil Ca, Mg, and K in soil before application of Ca sources on Kenansville lfs in 1977 and Rumford lfs in 1978.

Soil depth zone	Nutrients	Kenansville lfs 5/2	6/2	6/29	Rumsford lfs 5/19	6/13	6/29
cm		kg/ha					
		H_2O-Extractable					
0 to 10	Ca	8	6	17	12	8	11
	Mg	4	4	10	3	2	3
	K	11	17	40	26	20	18
10 to 20	Ca	9	10	11	13	11	14
	Mg	6	7	9	3	4	4
	K	13	21	39	27	22	18
		1.0 N NH_4OAc-Extractable					
0.to 10	Ca	356	368	419	574	491	428
	Mg	85	83	86	70	72	67
	K	80	54	62	92	94	76
10 to 20	Ca	400	374	352	543	470	421
	Mg	96	104	86	81	81	75
	K	66	71	59	100	97	74

Kenansville Lfs Site (1977)

The effect of Ca sources and times of application on changes in contents of H_2O-Ca and Ac-Ca in the two soil zones of the Kenansville site are plotted in Fig. 1. In general, all sources increased both H_2O-Ca and Ac-Ca levels appreciably throughout most of the fruiting period whether applied at planting or later.

Levels of H_2O-Ca generally were not increased nearly as much by 420-Bulk as by Bagged-LP or Tg Gypsum. The 29 June application of the Ca sources increased H_2O-Ca levels more during most of the principal fruit initiation period (7/13 to 8/16) than earlier applications.

Each Ca source increased Ac-Ca contents in the

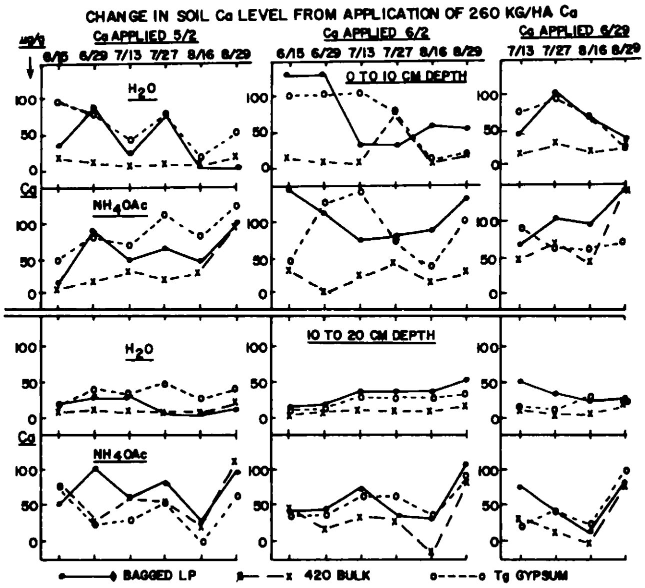

Fig. 1. Effect of three Ca sources and times of application on changes (adjusted for seasonal changes in untreated plots) in contents of H_2O- or 1.0 N NH_4OAc-extractable Ca in two soil layers of Kenansville lfs sampled during peanut fruiting in 1977. LSD's ($P = 0.05$) for contents of H_2O-Ca were 40 and 36 $\mu g/g$ in the surface and 12 and 25 $\mu g/g$ of soil in the lower layer, respectively. Plots were planted 2 May.

0- to 10-cm layer up to 150 $\mu g/g$ of soil sometime during the fruiting period. The largest increases in Ac-Ca generally were obtained where Bagged-LP or Tg Gypsum were applied. In general, the late applications of 420-Bulk increased Ac-Ca during the principal fruit initiation period slightly more than the earlier applications.

Both the H_2O-Ca and Ac-Ca levels in the 10- to 20-cm soil layer were increased less by the Ca sources than surface levels. Maximum increases in H_2O-Ca and Ac-Ca contents were approximately 50 and 100 $\mu g/g$ of soil, respectively. Differential effects among the Ca sources on these contents were less in this layer than in the 0- to 10-cm layer.

Bagged-LP and 420-Bulk were applied at rates equivalent to 520 kg/ha (as well as 260 kg/ha) of Ca (broadcast) in this experiment. Bagged-LP increased both the contents of H_2O-Ca and Ac-Ca in the 0- to 10-cm layer by approximately 250 $\mu g/g$ of soil over the untreated levels (Table 1). Increases from 420-Bulk at the 520-kg rate were approximately 50% less than from Bagged-LP. Soil Ca Levels in the 10- to 20-cm layer were increased approximately one-half as much in each case as in the surface layer. These data are not shown since the pattern of changes in amounts of Ca extracted was quite similar to that obtained from the 260-kg rate of Ca application (Fig. 1).

The effect of Ca sources and times of application on changes in contents of Ac-Mg and Ac-K in the two soil zones during peanut fruiting are plotted in Fig. 2. Data for changes in amounts of both H_2O-Mg and H_2O-K extracted from Ca- treated plots are not shown since they were less than 10 μg/g of soil in most samplings. The Ac-Mg and Ac-K levels after Ca application decreased below those found when Ca was not applied in many cases.

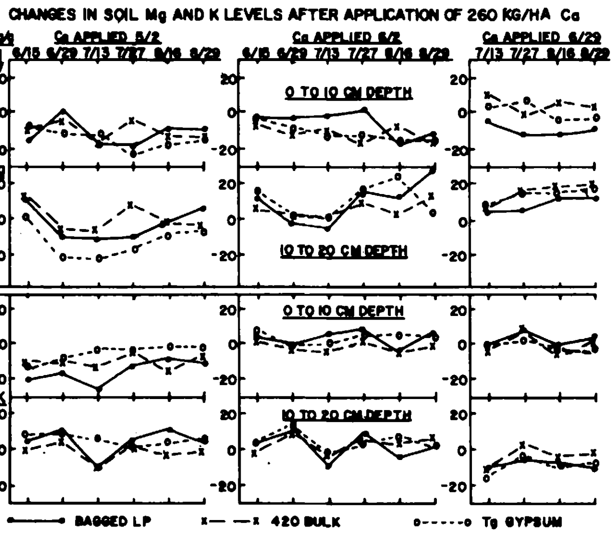

Fig. 2. Effect of three Ca sources and times of application on changes (adjusted for seasonal changes in untreated plots) in contents of 1.0 N NH_4OAc-extractable Mg and K in two soil layers of Kenansville lfs sampled during peanut fruiting in 1977. LSD's (P = 0.05) for contents of Ac-Mg and Ac-K were 6 and 6 μg/g in the surface and 10 and 5 μg/g of soil in the lower layer, respectively. Plots were planted 2 May.

Changes in contents of Ac-Mg extracted from the 0- to 10- and 10- to 20-cm zones varied from 10 to -25 and 28 to -22 μg/g of soil, respectively (Fig. 2). Samples from the 0- to 10-cm layer when Ca was applied 2 May or 2 June generally were lower in contents of Ac-Mg than check plots. The 29 June application of Bagged-LP decreased Ac-Mg levels over the remaining soil sampling period. When the Ca sources were applied 2 June, Ac-Mg levels in check plots and Bagged-LP-amended plots were not decreased until ca 60 days after treatment. Where 420-Bulk or Tg Gypsum were applied 2 June, Ac-Mg contents decreased during the sampling period from about 5 to 15 μg/g below check plot levels. In most cases, Tg Gypsum applied 2 May depressed Ac-Mg levels in the 10- to 20-cm zone during most of the sampling period. Following application of the Ca sources on 2 June or 29 June, contents of Ac-Mg in this layer increased as the sampling period progressed.

Changes in Ac-K contents after application of the Ca sources ranged from 15 to -25 μg/g of soil. The principal changes noted in levels of Ac-K were decreases in the 0- to 10-cm layer during much of the sampling period following the 2 May application of Bagged-LP, and in the first sampling of the 10- to 20-cm layer after 29 June applications of any Ca source.

Rumford Lfs Site (1978)

All sources increased both H_2O-Ca contents after application (Fig. 3). However, considerably more rainfall (22 cm) was received during the sampling period on this site in 1978 than in 1977, especially soon after planting (Table 1).

Tg Gypsum and Bagged-LP increased the amount of H_2O-Ca in the 0- to 10-cm layer considerably more than 420-Bulk, but this difference diminished with time. Highest increases in H_2O-Ca contents of 85, 55, and 95 μg/g of soil occurred in plots where Tg Gypsum was applied 19 May, 13 June, or 29 June, respectively. The lesser increase in H_2O-Ca after the 13 June Ca application may have been caused by greater leaching during the period 18 May to 13 June (Table 1).

Contents of H_2O-Ca in the 10- to 20-cm layer were increased only slightly during the soil sampling period (Fig. 3). Differential effects among Ca sources likewise were small. Changes in H_2O-Ca contents in the surface layer apparently did not effect H_2O-Ca contents of the lower soil layer, appreciably.

The largest increases in the amount of Ac-Ca in the 0- to 10-cm layer occurred immediately following application of the Ca sources and again toward the end of the sampling period (Fig. 3). This pattern was more evident in plots amended 19 May or 29 June than 13 June. Contents of Ac-Ca were increased up to 135 μg/g of soil by Bagged-

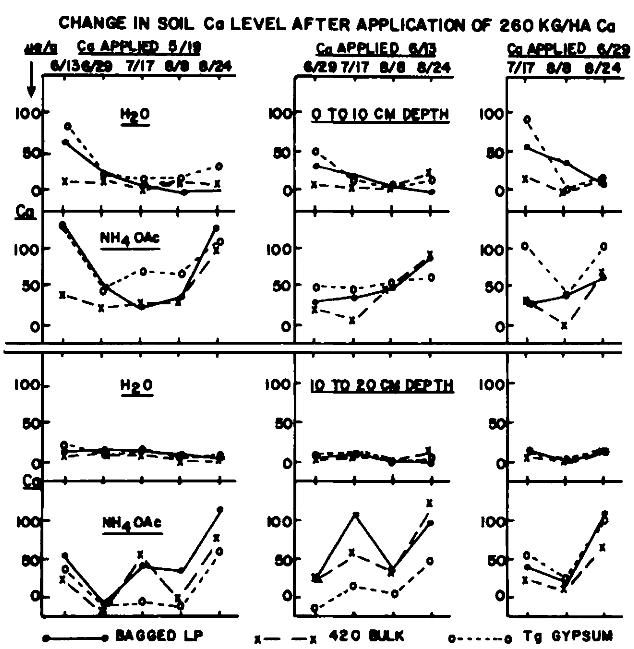

Fig. 3. Effect of three Ca sources and times of application on changes (adjusted for seasonal changes in untreated plots) in contents of H_2O- or 1.0 N NH_4OAc-extractable Ca in two soil layers of Rumford lfs sampled during peanut fruiting in 1978. LSD's (P =0.05) for contents of H_2O-Ca and Ac-Ca were 20 and 50 μg/g in the surface and 9 and 55 μg/g of soil in the lower layer, respectively. Plots were planted 18 May.

LP or Tg Gypsum applied 19 May. In general, as the growing season progressed, increases in the contents of Ac-Ca in plots amended with 420-Bulk became more nearly equivalent to those where Bagged-LP or Tg Gypsum was applied.

Changes in the levels of Ac-Ca in the 10- to 20-cm layer followed a pattern somewhat like that obtained in the surface layer (Fig. 3). These occurred at the end of the soil sampling period. Contents of Ac-Ca in the 24 August samples from plots amended 19 May were increased most by Bagged-LP, and least by Tg Gypsum. In the plots amended 13 June, 420-Bulk increased these levels most and Tg Gypsum least, and in plots amended 29 June, Bagged-LP or Tg Gypsum increased Ac-Ca contents most and 420-Bulk least.

The changes in contents of Ac-Mg and Ac-K which occurred in the Rumford soil during most of the peanut fruiting period are given in Fig. 4. The effect of the Ca treatments on H_2O-Mg and H_2O-K contents were small and are not plotted. Contents of both H^2O-Mg and H^2O-K in each layer were approximately 5 $\mu g/g$ of soil higher than in untreated plots for only 15 to 30 days following application of Bagged-LP or Tg Gypsum but not 420-Bulk.

Contents of Ac-Mg in both soil layers of Ca-treated plots generally were below the levels in untreated plots except for the 10- to 20-cm layer of plots amended 29 June. Differential effects among the Ca sources on changes in contents of Ac-Mg were consistently greatest in the 0- to 10-cm layer of plots amended 19 May. Unlike the results in plots amended previously, Ac-Mg levels were increased in the 10- to 20-cm layer of plots amended 29 June. These increases in the lower layer were approximately equivalent to the decreases found in the first and third samplings of the surface layer, but were much lower than the decreases found in the second sampling.

The contents of Ac-K in both layers generally were decreased in plots where the Ca sources were applied 19 May or 13 June (Fig. 4). Decreases greater than 10 $\mu g/g$ of soil occurred less often in the surface than in the 10- to 20-cm layer where the largest decrease of 25 $\mu g/g$ of soil in Ac-Mg contents occurred about a month after the 13 June application of Bagged-LP. However, appreciable differential effects among the Ca sources on the magnitude of changes in Ac-K levels occurred less often than similar effects. As with Ac-Mg, changes in contents of Ac-K in plots amended 29 June differed somewhat from those where the Ca sources were applied earlier.

Discussion

All three Ca sources included in these experiments increased the contents of both H_2O-Ca and

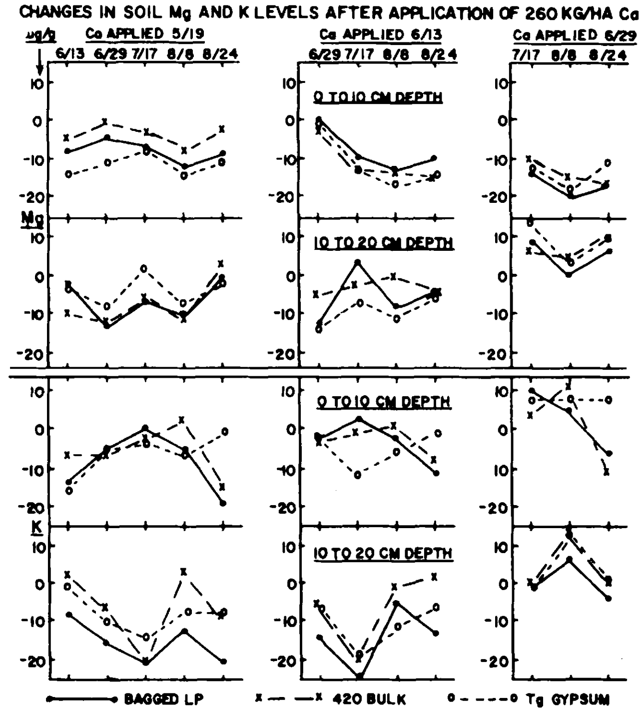

Fig. 4. Effect of three Ca sources and times of application on changes (adjusted for seasonal changes in untreated plots) in contents of 1.0 N NH_4OAc-extractable Mg and K in two soil layers of Rumford lfs sampled during peanut fruiting in 1978. LSD's (P = 0.05) for contents of Ac-Mg and Ac-K were 6 and 7 $\mu g/g$ in the surface and 9 and 7 $\mu g/g$ of soil in the lower layer, respectively. Plots were planted 18 May.

Ac-Ca in the peanut fruiting zone (0- to 10-cm soil depth). The largest increases in contents of Ac-Ca were only slightly higher than obtained in H_2O-Ca contents. There was considerable variability in the effects of the sources on these contents among the various samplings. Approximately 125 μg of Ca/g of soil (0 to 20 cm) were applied in the 260 kg/ha treatments. The Ac-Ca fraction should have included most or all of the Ca extracted by H_2O, but occasionally changes in H_2O-Ca contents exceeded changes in Ac-Ca. Some of the changes in Ac-Ca contents found in each layer, but more frequently the total changes found in both layers at a sampling were equivalent to or exceeded the amount of Ca applied in Bagged-LP or Tg Gypsum. Such changes where 420-Bulk was applied occurred in a few cases, but only at the last sampling. Much of this inconsistency may have been aggravated by variance in the amounts of both dissolved and/or undissolved particles of the Ca materials picked up in the soil samples, although the soil surface was scraped before penetration of the soil sampling tube.

Increases in both H_2O-Ca and Ac-Ca contents in excess of 100 $\mu g/g$ of soil occurred more often on Kenansville soil than on Rumford. When appreciable differences among plots treated with the Ca sources occurred, generally the increases in H_2O-Ca or Ac-Ca in plots amended with Bagged-LP or Tg Gypsum were greater than where 420-Bulk was applied. Such differences occurred more frequently at the Kenansville soil site, but generally diminished somewhat at both sites toward the end of the sampling period.

Peanut productivity in these experiments was somewhat higher in plots where the Ca sources were applied at the early flower stage than at planting (5). The contents of H_2O-Ca and Ac-Ca (Figs. 1 and 3) in comparable samplings generally were similar in the peanut fruiting layer during the period of principal fruit initiation through considerable fruit development for all three times of application of the Ca sources. However, there was a period at the Rumford site (1978) that H_2O-Ca and Ac-Ca levels in the plots amended 29 June were higher than levels in plots where the Ca sources were applied earlier. These differences were largest where Tg Gypsum was applied (Fig. 3). Perhaps this short-term increase in soil Ca levels was related to the higher productivity obtained from plots amended with 260 kg/ha (when broadcast) of Ca in late June (5).

Much of the variability which occurred in the changes in contents of Ac-Mg and Ac-K does not appear closely related to changes in the Ac-Ca levels. However, the Ac-Mg and Ac-K levels were decreased somewhat more often than increased after application of the Ca sources. In some cases, levels of Ac-Mg and Ac-K in the 10- to 20-cm layer increased as levels of these nutrients decreased in the surface layer. It is unlikely that changes in the soil Mg or K levels (Fig. 2 and 4) affected peanut productivity appreciably in these experiments.

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