Peanut Pod Rot Complex: A Geocarposphere Nutrient Imbalance

A. S. CSINOS, Department of Plant Pathology, and T. P. GAINES, Department of Agronomy, University of Georgia, Coastal Plain Experiment Station, Tifton 31793

ABSTRACT

Csinos, A. S., and Gaines, T. P. 1986. Peanut pod rot complex: A geocarposphere nutrient imbalance. Plant Disease 70:525-529.

Gypsum ($CaSO_4 \cdot 2H_2O$), magnesium sulfate ($MgSO_4$), potassium sulfate (K_2SO_4), ammonium nitrate (NH_4NO_3), and gypsum + magnesium sulfite, gypsum + potassium sulfate, and gypsum + ammonium nitrate were evaluated for their influence on the development of peanut pod rot in field test plots at Tifton, GA, in 1983–1984. *Pythium myriotylum, Rhizoctonia* sp., and *Fusarium* sp. were isolated from decaying pods, and fungal propagules from the soil were enumerated during the season. The involvement of these fungi in the disease was inconclusive. Peanut (Early Bunch) treated with gypsum tended to be higher in yield, lower in pod rot, and higher in percent sound mature kernels (%SMK) regardless of the accompanying treatment. Gypsum tended to ameliorate the harmful effects of potassium sulfate, magnesium sulfate, or ammonium nitrate by reducing concentrations of magnesium and nitrogen in the fruit compared with those found in peanuts treated with magnesium sulfate, potassium sulfate, or ammonium nitrate. Calcium in the fruit was negatively correlated ($P = 0.01$) with nitrogen, phosphorus, potassium, magnesium, other minor elements, and pod rot at harvest and was positively correlated with %SMK and yield. Evidence is presented for the hypothesis that the peanut pod rot complex is initiated by the same conditions that cause blossom-end rot of fruits.

Peanut pod rot is a serious disease worldwide (2,6,9). It occurs on fruits that develop below ground, and diseased plants do not have readily visible aboveground symptoms. Often the disease problem remains unnoticed until the peanut is dug and inverted just before harvest. Garren (9) demonstrated the involvement of both *Pythium myriotylum* Drechs. and *Rhizoctonia solani* Kühn, two major soilborne pathogens, in the peanut pod rot complex. Hallock and Garren (13) reported that potassium sulfate (K_2SO_4) and magnesium sulfate ($MgSO_4$) increased pod rot, and Boswell and Thames (2), Garren (9), and Walker and Csinos (21) demonstrated that applications of gypsum ($CaSO_4 \cdot 2H_2O$) decreased pod rot. However, Moore and Wills (17) reported that calcium did not influence the susceptibility of peanut to infection by *P. myriotylum* or *R. solani*. Garcia and Mitchell (8) indicated that *P. myriotylum* was the major pathogen involved in the disease complex but that disease and reisolation was influenced by several other fungi. Boswell and Grichar (1) and Boswell and Thames (2) reported decreases in pod rot disease with chemicals in some instances but found other areas to respond with greater success to gypsum application. Clear lines of evidence for the role of soilborne pathogens in the peanut pod rot complex have been difficult to establish.

Accepted for publication 31 December 1985 (submitted for electronic processing).

Recently, Csinos et al (3) reported that using fungi-specific fungicides against organisms implicated in the disease complex was ineffective in controlling pod rot. However, peanuts treated with calcium-containing materials that increased the calcium content of the fruit showed decreased pod rot. This led to the speculation that the involvement of plant pathogens is secondary to the disease and that calcium deficiency or nutritional imbalance is the primary cause.

Calcium sources for peanut may have an influence on disease severity by their availability to pods. The competitive nature of elements in soil has long been known, but little work has been conducted on the effect of competitive ions in the geocarposphere on uptake of calcium by the peanut fruit.

This research was initiated to investigate the effects of potassium and magnesium sulfates and ammonium nitrate (NH_4NO_3) on the peanut pod rot complex with and without available calcium. Also, isolations from diseased tissue were made, soil and fruit nutrient levels monitored, disease levels determined, and yield and quality determined.

MATERIALS AND METHODS

Plots were established in 1983 and 1984 on a Tifton loamy sand. Peanut (*Arachis hypogaea* L. cv. Early Bunch) was seeded at 140 kg/ha on 12 May 1983 and 11 May 1984. The experimental design was a randomized complete block with treatments replicated four times. Plots were four rows 0.91 m apart and 7.6 m long. Two rows were used for sampling during the season, and two rows were maintained for yield and quality determinations. Annual fertilization was 560 kg/ha of 5-10-15 (NPK) fertilizer broadcast and plowed under with moldboard turning plows. Cultural and production practices were consistent with University of Georgia Extension Service recommendations (22). Plots were irrigated as required. Treatments were: gypsum at 280 kg of calcium per hectare, gypsum at 280 kg of calcium + magnesium sulfate at 112 kg of magnesium per hectare, gypsum at 280 kg of calcium + ammonium nitrate at 28 kg of nitrogen per hectare, gypsum at 280 kg of calcium + potassium sulfate at 112 kg of potassium per hectare, magnesium sulfate at 112 kg of magnesium per hectare, ammonium nitrate at 28 kg of nitrogen per hectare, potassium sulfate at 112 kg of potassium per hectare, and a nontreated control. Treatments were applied at early bloom, 1 July 1983 (50 days after planting [DAP]), and 19 June (40 DAP) in 1984 in a 0.45-m band over the row.

Soil cores (2.5 cm in diameter) were taken from the top 10 cm in the pegging zone before treatment application, 7 days after application (DAA), and 87 DAA (just before inverting) in 1983. In 1984, soil samples were taken 9, 34, and 90 DAA (just before inverting). In 1983, pegs were collected 87 DAP and pods were collected 87, 108, 118, and 136 DAP (at inverting). In 1984, pods were collected 104 and 131 DAP (at inverting). Pegs and pods were rated for percent rot by visually inspecting 100 pods from each plot and determining if decay had progressed through the shell. If discoloration appeared on the surface of the shell but did not progress through the shell, it was not considered a rotted pod. Tissue was surface-disinfected with 70% ethanol, trisected, and aseptically plated on pimaricin-ampicillin-rifampicin (PAR) medium (15) for isolation of *Pythium* spp., tannic acid benomyl (TAB) medium (20) for isolation of *Rhizoctonia* spp., and PCNB medium (18) for isolation of *Fusarium* spp.

Soil, peanut hulls, and peanut kernels were analyzed for chemical constituents by the methods described by Gaines and Mitchell (7) with Mehlich No. 1 reagent. Yield per plot and quality as percent sound mature kernels (%SMK) were determined after drying, 136 and 131 DAP in 1983 and 1984, respectively. Data were analyzed by ANOVA and regression statistical procedure, and differences

Table 1. Percent diseased pegs and pods, percent sound mature kernels (%SMK), and yield of peanut treated with fertilizer materials at pegging in 1983

		Diseased pods (%)							
		87 days[y]		108 Days	118 Days	136 Days			
Treatment	Rate per hectare	Pegs	Pods	Pods	Pods	Pods	%SMK	Yield (kg/ha)
$CaSO_4$	280 kg Ca	8 c[z]	2 b	8 c	10 d	10 a	66	5,025 a
$CaSO_4 + MgSO_4$	280 kg Ca + 112 kg Mg	14 bc	6 b	14 bc	16 cd	10 a	64	4,651 a
$CaSO_4 + NH_4NO_3$	280 kg Ca + 28 kg N	16 bc	6 b	14 bc	25 abcd	11 a	63	4,920 a
$CaSO_4 + K_2SO_4$	280 kg Ca + 112 kg K	8 c	7 b	16 bc	18 bcd	12 a	61	4,790 a
NH_4NO_3	28 kg N	17 bc	10 b	28 abc	38 a	17 a	46	3,547 ab
K_2SO_4	112 kg K	24 ab	23 a	32 ab	27 abc	17 a	39	2,806 b
$MgSO_4$	112 kg Mg	31 a	21 a	31 ab	33 ab	18 a	41	2,960 b
Control	···	12 bc	8 b	38 a	31 abc	18 a	48	4,269 ab

[y] Days after seeding.
[z] Means in columns followed by the same letter are not significantly different according to Duncan's multiple range test ($P = 0.05$).

among treatments were determined with Duncan's multiple range test.

RESULTS

Soil tests showed plots were uniform, and no differences (P = 0.05) were detected in soil pH, phosphorus, potassium, calcium, or magnesium among plots before application of test materials. Soil pH was 6.0, phosphorus ranged from 73 to 88 kg/ha, potassium ranged from 96 to 111 kg/ha, calcium ranged from 378 to 443 kg/ha, and magnesium ranged from 27 to 33 kg/ha.

Sclerotium rolfsii occurred sporadically over the area in both years, but severity was very light. Disease loci counts made before harvest in 1984 indicated 5% or less damage to plants in plots, and the disease was not considered as a factor in the data collection.

Pods that were trisected, surface-disinfected with 70% ethanol, and plated to PAR, TAB, and PCNB media yielded all three microorganisms: *P. myriotylum, Rhizoctonia* sp., and *Fusarium* sp. Other fungi and bacteria also were recovered. Percent recovery in both years appeared to be more dependent on sampling time than on treatment. Differences in percent recovery occurred among treatments for *R. solani*, but these relative differences were inconsistent across sampling dates. Little can be concluded from the isolation data, except that all three fungal species could be isolated from decaying pods during the growing season.

Soil population data for *Pythium* spp. and *Rhizoctonia* spp. were erratic. Differences in numbers of propagules occurred occasionally among treatments; however, these differences were not consistent across sampling dates.

In both 1983 and 1984, peanuts treated with only magnesium sulfate, potassium sulfate, or ammonium nitrate had foliage that was more vigorous and green than those treated with gypsum. This phenomenon was most striking as peanuts approached maturity.

Peg and pod decay were most severe in treatments not receiving gypsum (Table 1). Peanuts treated with only magnesium sulfate had more diseased pegs and pods than peanuts treated with both magnesium sulfate and gypsum or just gypsum at 87 DAP. All peanuts receiving gypsum had fewer diseased pods than the control at 108 DAP, but only peanuts treated with gypsum alone had fewer diseased pods than the control at 118 DAP. Fewer diseased pods were recovered at 136 DAP (at inverting) for all treatments, suggesting that a large number were lost in the soil during the inverting process. All peanut plots treated with gypsum had higher %SMK than those not treated with gypsum. All peanuts treated with gypsum tended to be higher in yield than peanuts not treated with gypsum, but only peanuts treated with potassium sulfate and magnesium sulfate were lower in yield.

Similar results were observed in 1984 (Table 2). Pod rot was reduced by gypsum at 104 and 131 DAP. All gypsum treatments increased %SMK over nongypsum treatments, and potassium sulfate and magnesium sulfate reduced %SMK and yield compared with the nontreated control. Peanut yields were higher for peanut treated with gypsum than other treatments, except for the nontreated control, which was not

Table 2. Percent diseased pods, percent sound mature kernels (%SMK), and yield of peanut treated with test materials at pegging in 1984

		Diseased pods (%)			
Treatment	Rate per hectare	104 Days[y]	131 Days	%SMK	Yield (kg/ha)
$CaSO_4$	280 kg Ca	4 b[z]	4 b	71 a	5,555 a
$CaSO_4 + MgSO_4$	280 kg Ca + 112 kg Mg	4 b	3 b	71 a	5,478 a
$CaSO_4 + NH_4NO_3$	280 kg Ca + 28 kg N	2 b	4 b	70 a	5,402 a
$CaSO_4 + K_2SO_4$	280 kg Ca + 112 kg K	3 b	5 b	70 a	5,640 a
NH_4NO_3	28 kg N	22 a	20 a	59 bc	3,039 bc
K_2SO_4	112 kg N	16 a	23 a	51 d	2,225 c
$MgSO_4$	112 kg Mg	23 a	8 a	54 cd	1,943 c
Control	···	16 a	16 a	63 b	4,374 ab

[y] Days after planting.
[z] Means in columns followed by the same letter are not significantly different according to Duncan's multiple range test ($P = 0.05$).

Table 3. Elemental analysis of soil in the pod zone 7 and 87 days after application of test materials in 1983

		Days after application									
		7					87				
			Nutrient levels (kg/ha)					Nutrient levels (kg/ha)			
Treatment	Rate per hectare	pH	P	K	Ca	Mg	pH	P	K	Ca	Mg
$CaSO_4$	280 kg Ca	5.9 ab[z]	83 a	95 c	410 a	30 b	5.9 abc	78 a	68 b	485 a	30 b
$CaSO_4 + MgSO_4$	280 kg Ca + 112 kg Mg	5.5 c	80 a	92 c	533 a	86 a	5.8 c	67 a	62 b	452 a	46 ab
$CaSO_4 + NH_4NO_3$	280 kg Ca + 28 kg N	5.5 c	74 a	85 c	510 a	27 b	5.9 abc	65 a	55 b	411 a	27 b
$CaSO_4 + K_2SO_4$	280 kg Ca + 112 kg K	5.5 c	83 a	217 b	507 a	26 b	5.8 c	69 a	67 b	428 a	30 b
NH_4NO_3	28 kg N	5.6 c	80 a	93 c	393 a	27 b	5.8 c	72 a	65 b	340 a	32 b
K_2SO_4	112 kg K	5.6 c	79 a	276 a	405 a	28 b	5.9 abc	64 a	123 a	354 a	34 b
$MgSO_4$	112 kg Mg	5.7 bc	80 a	88 c	370 a	111 a	6.0 a	71 a	75 b	346 a	55 a
Control	···	6.0 a	77 a	95 c	387 a	27 b	5.9 abc	64 a	76 b	350 a	33 b

[z] Means in columns followed by the same letter are not significantly different according to Duncan's multiple range test ($P = 0.05$).

significantly different.

In 1983, all treatments except gypsum alone reduced pH at 7 DAA, and in 1984, all treatments except magnesium sulfate and gypsum + magnesium sulfate reduced pH temporarily (Tables 3 and 4). The phosphorus level was not altered by treatments. As expected, potassium levels were highest in plots treated with potassium sulfate 7 and 9 DAA (Tables 3 and 4). However, potassium levels remained higher in plots treated with potassium sulfate but decreased to control levels in plots treated with potassium sulfate + gypsum by the end of the season. Similarly, magnesium levels fell to control levels in plots treated with magnesium sulfate + gypsum, but plots treated with magnesium sulfate remained higher in magnesium. In 1983, although gypsum-treated plots tended to be higher in calcium than non-gypsum-treated plots, there were no differences in soil calcium among plots (Table 3). In 1984, gypsum-treated plots were higher in soil calcium than other treatments early in the season but were not different from other treatments at the end of the season (Table 4). In 1983, 4.9 cm of rain fell from application to first soil sample, whereas in 1984, only 2.1 cm of rain fell from application to first soil sample. The higher rainfall in 1983 may have leached the calcium below the 10-cm zone, thus reducing the detectable calcium in the soil.

Hull concentrations of nitrogen, phosphorus, and magnesium were lower ($P = 0.05$) and calcium tended to be higher in gypsum-treated peanut plots (Table 5). Identical trends were observed for elemental analysis of peanut hull tissue in 1984. Elemental kernel analysis of kernels followed the same trends as were observed in hull tissue for both years, but kernel values were lower than hull values.

Correlation coefficient data for elemental analysis of hulls at harvest, diseased pods, %SMK, and yield are presented in Table 6. Percent pod rot at harvest was positively correlated ($P < 0.01$) with nitrogen, phosphorus, and magnesium levels in hull tissue in 1983. In 1984, potassium and zinc, in addition to those noted previously, were correlated positively ($P < 0.01$) with pod rot. Percent pod rot was similarly correlated with phosphorus, potassium, and magnesium for peanut kernel analysis. Calcium content in hulls and kernels was negatively correlated ($P < 0.01$) with pod rot in both 1983 and 1984. Calcium was negatively related to most elements analyzed in both hulls and kernels in both 1983 and 1984.

Correlation coefficients among elemental concentrations of soil from the pod zone 9 DAA of test materials, pod rot at harvest, %SMK, and yield are presented

Table 4. Elemental analysis of soil in the pod zone 9, 35, and 61 days after application of test materials in 1984

		Days after application														
		9					35					61				
		Nutrient levels (kg/ha)						Nutrient levels (kg/ha)					Nutrient levels (kg/ha)			
Treatment	Rate per hectare	pH	P	K	Ca	Mg	pH	P	K	Ca	Mg	pH	P	K	Ca	Mg
$CaSO_4$	280 kg Ca	5.3 cd[z]	78 a	68 b	551 a	21 b	5.4 b	82 a	52 b	489 ab	16 c	5.9 a	77 a	92 b	448 a	15 b
$CaSO_4$ + Mg SO_4	280 kg Ca + 112 kg Mg	5.5 ab	81 a	102 b	562 a	217 a	5.5 b	72 a	54 b	480 ab	63 b	5.9 a	67 a	81 b	429 ab	37 b
$CaSO_4$ + NH_4NO_3	280 kg Ca + 28 kg N	5.2 cd	75 a	72 b	533 a	19 b	5.3 b	68 a	47 b	505 a	15 c	5.7 a	66 a	73 b	396 abc	12 b
$CaSO_4$ + K_2SO_4	280 kg Ca + 112 kg K	5.2 cd	90 a	263 a	569 a	26 b	5.4 b	81 a	78 b	480 ab	19 c	5.7 a	71 a	86 b	448 a	15 b
NH_4NO_3	28 kg N	5.4 bc	84 a	85 a	310 b	20 b	5.4 b	77 a	62 b	320 c	21 c	5.7 a	71 a	95 b	287 bc	21 b
K_2SO_4	112 kg K	5.4 bc	69 a	248 a	321 b	28 b	5.8 a	75 a	151 a	329 c	29 bc	5.8 a	66 a	142 a	296 abc	25 b
$MgSO_4$	112 kg Mg	5.5 ab	78 a	95 b	319 b	180 a	5.7 a	73 a	78 b	280 c	118 a	5.8 a	68 a	81 b	274 c	65 a
Control	...	5.6 a	77 a	79 b	314 b	22 b	5.7 a	77 a	73 b	354 bc	29 bc	5.9 a	63 a	95 b	297 abc	22 b

[z] Means in columns followed by the same letter are not significantly different according to Duncan's multiple range test ($P = 0.05$).

Table 5. Elemental analysis of peanut hulls at harvest treated with test materials at pegging in 1983

		Percentage of tissue					Parts per million			
Treatment	Rate per hectare	N	P	K	Ca	Mg	S	Zn	Mn	Cu
$CaSO_4$	280 kg Ca	1.55 c[z]	0.13 c	1.06 ab	0.24 a	0.13 c	0.26	12 b	27.3 ab	10 a
$CaSO_4$ + $MgSO_4$	280 kg Ca + 112 kg Mg	1.43 c	0.11 c	1.01 ab	0.22 ab	0.13 c	0.27	17 ab	26.8 b	11 a
$CaSO_4$ + NH_4NO_3	280 kg Ca + 28 kg N	1.55 c	0.10 c	0.94 b	0.21 abc	0.12 c	0.28	12 b	26.5 b	11 a
$CaSO_4$ + K_2SO_4	280 kg Ca + 112 kg K	1.59 c	0.12 c	1.03 ab	0.23 a	0.13 c	0.29	18 a	27.8 ab	11 a
NH_4NO_3	28 kg N	2.23 ab	0.18 ab	1.04 ab	0.15 cd	0.18 ab	0.24	16 ab	29.8 a	11 a
K_2SO_4	112 kg K	2.36 a	0.20 a	1.13 a	0.16 bcd	0.20 a	0.27	18 a	27.5 ab	11 a
$MgSO_4$	112 kg Mg	2.32 a	0.18 ab	1.05 ab	0.14 d	0.20 a	0.24	22 a	25.3 b	10 a
Control	...	1.87 bc	0.15 bc	0.90 b	0.14 d	0.14 bc	0.19	12 b	26.8 b	10 a

[z] Means in columns followed by the same letter are not significantly different according to Duncan's multiple range test ($P = 0.05$).

Table 6. Correlation coefficients among elemental concentrations in peanut hulls, pod rot at harvest, percent sound mature kernels, and yield in 1983

	N	P	K	Ca	Mg	S	Zn	Mn	Cu	%PR[a]	%SMK[a]	YLD[a]
N	1.00	...	...	...	...	...	...	...	...	...	...	...
P	0.93**[b]	1.00	...	...	...	...	...	...	...	...	...	...
K	0.53**	0.63**	1.00	...	...	...	...	...	...	...	...	...
Ca	−0.55*	−0.47**	0.27	1.00	...	...	...	...	...	...	...	...
Mg	0.89**	0.92**	0.65**	−0.34*	1.00	...	...	...	...	...	...	...
S	0.05	0.06	0.58**	0.56**	0.12	1.00	...	...	...	...	...	...
Zn	0.65**	0.65**	0.64**	−0.20	0.68**	0.40*	1.00	...	...	...	...	...
MN	0.25	0.32	0.29	−0.11	0.18	0.11	0.19	1.00	...	...	...	...
Cu	0.02	0.07	−0.04	−0.13	0.08	0.08	0.18	0.13	1.00	...	...	...
%PR	0.60**	0.60**	0.07	−0.58**	0.48**	−0.15	0.27	0.10	−0.02	1.00	...	...
%SMK	−0.88**	−0.83**	−0.31	0.73**	−0.76**	0.13	−0.55**	−0.14	−0.15	−0.65**	1.00	...
YLD	−0.84**	−0.83**	−0.51**	0.55**	−0.76**	−0.11	−0.65**	−0.22	−0.06	−0.55**	0.89**	1.00

[a] %PR = percent pod rot at harvest, %SMK = percent sound mature kernels, and YLD = yield.
[b] * = Significant at $P = 0.01–0.05$, ** = significant at $P < 0.01$.

in Table 7 for 1984. Calcium in the soil pod zone was positively and significantly ($P < 0.01$) correlated with %SMK and yield and negatively and significantly correlated with percent pod rot at harvest for both 1983 and 1984.

DISCUSSION

Peanuts treated with gypsum tended to have less pod rot and higher %SMK and yield. Calcium in fruits correlated negatively with percent decayed pods and positively with %SMK and yield. Although the three major disease organisms implicated in disease development, *P. myriotylum, Rhizoctonia* sp., and *Fusarium* sp., were recovered from decaying pods and from soil in the geocarposphere, the isolation frequency and soil populations were seldom different among treatments. When differences were detected, they were inconsistent among sampling dates, and differences did not occur even where significant differences in percent pod rot occurred among treatments. Similar findings were reported by Csinos et al (3) in another study where a secondary role for these pathogens was suggested.

Applications of magnesium sulfate, potassium sulfate, and ammonium nitrate alone tended to increase pod rot and decrease grade and yield of peanuts. Application of gypsum ameliorated these effects. We suggest that in soils with a high content of another ion in the geocarposphere, the application of calcium in the form of gypsum may remedy this imbalance. Superficially, it appears the peanut fruit preferentially absorbs calcium over magnesium, potassium, or ammonium ion. Concentrations of these other elements tended to remain the same while calcium was increased. However, the decline of both soil potassium and magnesium in the geocarposphere where gypsum was added in combination with potassium sulfate or magnesium sulfate suggests that potassium and magnesium levels remained low in tissue because gypsum, through a soil reaction, affected potassium and magnesium removal below the pod development zone. Where magnesium sulfate and potassium sulfate were the sole treatment, magnesium and potassium levels remained high throughout the season in both soil and tissue.

Several scientists (2,3,13,21) have reported the beneficial effects of gypsum, and Hallock and Garren (13) have reported the detrimental effects of magnesium sulfate and potassium sulfate on peanut. However, this is the first report of the beneficial effects of gypsum on peanut when magnesium, potassium, and ammonium ion levels were artificially increased in the geocarposphere. These data would suggest that the addition of gypsum may remedy situations where gross imbalances of other detrimental elements occur in the geocarposphere.

A calcium:potassium ratio is used to a limited extent by extension specialists to determine calcium requirements for peanuts. However, these data lead us to suggest that other elements such as potassium, magnesium, nitrogen, and perhaps other elements yet untested should also be considered in calcium requirements for peanut fruit. Negative correlations between calcium in hulls and nitrogen, phosphorus, potassium, magnesium, and other minor elements were noted. Competitive effects of these elements in the geocarposphere may cause calcium deficiency symptoms and/or pod rot to develop.

Striking similarities of the peanut pod rot complex and blossom-end rot of fruits are evident from this study and those of Csinos et al (3), Boswell and Thames (2), and Hallock and Garren (13). Blossom-end rot of fruits is characterized by a green water-soaked area at the blossom end of the fruit that turns gray to dark brown, then shrinks and collapses. This area is commonly invaded by microorganisms, resulting in further fruit decomposition (16). Evans and Troxler (5) and Geraldson (10) reported that applications of calcium that increased the calcium concentrations of fruit prevented blossom-end rot. In addition, Geraldson (11) reported that excessive soluble ammonium, potassium, magnesium, and sodium salts or a deficiency of soluble calcium increased blossom-end rot. Raleigh and Chucka (19) indicated from a nutrient study on tomato that the balance among elements is more important as a cause of blossom-end rot than the actual concentration of the elements. Gerard and Hipp (12) concluded in their studies that climatic stress where calcium movement was limited by poor water relations in the plant was a major contributor to blossom-end rot of tomato. Similarly, DeKock et al (4) implicated water relations and nitrogen sources as contributors to the disorder.

The key factor in reduction of peanut pod rot or pod breakdown in the studies of Csinos et al (3) and Hallock and Garren (13) has been the increased concentration of calcium in the peanut fruit. Boswell and Thames (2) have indicated that where high sodium levels in water exist, pod rot of peanut can be reduced with appplications of gypsum. Although water relations have not been studied extensively in the peanut pod rot system, it is well accepted that calcium must be in an aqueous form to be absorbed by the fruit. From the data presented here and presented previously on nutrition as a factor in peanut pod rot (2,3,13), we suggest that peanut pod rot is similar to blossom-end rot as described on other fruits, with the dissimilarity being that the peanut fruit develops beneath the soil. The fact that peanut fruit are subterranean may make them very susceptible to colonization by microorganisms (such as those implicated in the disease complex) when they become predisposed by a nutrient imbalance or deficiency. Unquestionably, microorganisms are involved in the expression of the final symptoms associated with pod rot.

Jacobson et al (14), studying the influence of calcium on selectivity of ion absorption, suggested that calcium affects a screening of ions at the cell surface, presumably nonmetabolic in nature, which is followed by a metabolic absorption step. In their studies, calcium drastically altered the ratio of absorption by several plant roots of sodium and potassium from a mixture of the two. They further suggest that the inhibitory effects on absorption of ions appear to preclude the role of calcium as a simple protective agent.

Little is known about the effects of specific calcium sources on the pod rot complex and how effectively they can be absorbed by the peanut fruit. Specific mineral relationships in the soil and in the fruit need further study before we can fully understand how to control of the disorder.

Table 7. Correlation coefficients among soil elemental concentrations from the pod zone 9 days after application of test materials, percent pod rot at harvest, percent sound mature kernels, and yield in 1984

	pH	P	K	Ca	Mg	%PR[a]	%SMK[a]	YLD[a]
pH	1.00	...	...	...	...	...	...	...
P	−0.07	1.00	...	...	...	...	...	...
K	−0.34	−0.14	1.00	...	...	...	...	...
Ca	−0.45**[b]	0.18	0.16	1.00	...	...	...	...
Mg	0.36*	−0.03	−0.07	0.19	1.00	...	...	...
%PR	0.27	−0.13	0.09	−0.67**	−0.19	1.00	...	...
%SMK	−0.39*	0.16	−0.11	0.79**	0.03	−0.75**	1.00	...
YLD	−0.33	0.06	0.03	0.77**	0.12	−0.72**	0.93**	1.00

[a] %PR = pod rot, %SMK = percent sound mature kernels, and YLD = yield.
[b] * = Significant at $P = 0.05$–0.01, ** = significant at $P < 0.01$.

ACKNOWLEDGMENTS

This research was supported by funds from state, federal Hatch, and the Georgia Commodity Commission for Peanuts. We thank L. K. Mullis, W. G. Tillery, and D. Garrick for technical assistance.

LITERATURE CITED

1. Boswell, T. E., and Grichar, W. J. 1982. Evaluation of fungicides for Pythium pod rot control. Proc. Am. Peanut Res. Educ. Soc. 12:42.
2. Boswell, T. E., and Thames, W. H. 1976. Pythium pod rot control in South Texas. Proc. Am. Peanut Res. Educ. Assoc. 8:89.
3. Csinos, A. S., Gaines, T. P., and Walker, M. E.

1984. Involvement of nutrition and fungi in the peanut pod rot complex. Plant Dis. 68:61-65.
4. DeKock, C. P., Hall, A., Boggie, R., and Inkson, R. H. E. 1982. The effect of water stress and form of nitrogen on the incidence of blossom-end rot in tomatoes. J. Sci. Food Agric. 33:509-515.
5. Evans, H. J., and Troxler, R. V. 1953. Relation of calcium nutrition to the incidence of blossom-end rot in tomatoes. Proc. Am. Soc. Hortic. Sci. 61:346-352.
6. Frank, Z. R. 1968. Pythium pod rot of peanut. Phytopathology 58:542-543.
7. Gaines, T. P., and Mitchell, G. A. 1979. Chemical methods of soil and plant analysis. Univ. Ga. Coastal Plain Exp. Stn. Agron. Handb. 1.
8. Garcia, R., and Mitchell, D. J. 1975. Interactions of *Pythium myriotylum* with several fungi in peanut pod rot. Phytopathology 65:1375-1381.
9. Garren, K. H. 1970. *Rhizoctonia solani* versus *Pythium myriotylum* pathogens of peanut pod breakdown. Plant Dis. Rep. 54: 840-843.
10. Geraldson, C. M. 1957. Control of blossom-end rot of tomatoes. Proc. Am. Soc. Hortic. Sci. 69:309-317.
11. Geraldson, C. M. 1957. Factors affecting calcium nutrition of celery, tomato and pepper. Proc. Soil Sci. Soc. Am. 21:621-625.
12. Gerard, C. J., and Hipp, B. W. 1968. Blossom-end rot of "Chico" and "Chico Grande" tomatoes. Proc. Am. Soc. Hortic. Sci. 93:521-531.
13. Hallock, D. L., and Garren, K. H. 1968. Pod breakdown yield and grade of Virginia type peanuts as affected by Ca, Mg, and K sulfates. Agron. J. 60:253-257.
14. Jacobson, L., Hannapel, R. J., Moore, D. P., and Schaedle, M. 1961. Influence of calcium on the selectivity of the ion absorption process. Plant Physiol. 36:58-61.
15. Kannwischer, M. E., and Mitchell, D. J. 1981. Relationship of numbers of spores of *Phytophthora parasitica* var. *nicotianae* to infection and mortality of tobacco. Phytopathology 71:69-73.
16. McColloch, L. P., Cook, H. T., and Wright, W. R. 1968. Market disease of tomatoes, peppers and eggplants. Agric. Res. Serv. U.S. Dep. Agric. Agric. Handb. 28:10-11.
17. Moore, L. D., and Wills, W. H. 1974. The influence of calcium on the susceptibility of peanut pods to *Pythium myriotylum* and *Rhizoctonia solani*. Peanut Sci. 1:18-20.
18. Papavizas, G. C. 1967. Evaluation of various media and antimicrobial agents for isolation of *Fusarium* from soil. Phytopathology 57:848-852.
19. Raleigh, S. M., and Chucka, J. A. 1944. Effect of nutrient ratio and concentration on growth and composition of tomato plants and on the occurrence of blossom-end rot of fruit. Plant Physiol. 19:671-678.
20. Sumner, D. R., and Bell, D. K. 1982. Root diseases induced in corn by *Rhizoctonia zeae*. Phytopathology 72:86-91.
21. Walker, M. E., and Csinos, A. S. 1980. Effect of gypsum on yield, grade, and incidence of pod rot in five peanut cultivars. Peanut Sci. 7:109-113.
22. Womack, H., French, J. C., Johnson, F. A., Thompson, S. S., and Swann, C. W. 1981. Peanut pest management in the southeast. Coop. Ext. Serv. Univ. Ga. Bull. 850.