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The differential response of Virginia peanut genotypes to calcium fertiliser

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Abstract

A field experiment conducted during 1982–83 compared yield and quality parameters of 10 genotypes of Virginia peanuts (*Arachis hypogaea* L.) at nil, 136 and 318 kg Ca/ha as gypsum.

Without calcium application Shulamit and a selection of Early Bunch peanuts produced yields of kernels and kernel contents superior (P = 0.05) to those of Virginia Bunch, AK10 and Altika. Calcium at 136 kg/ha increased kernel yield and kernel content of all genotypes, but Virginia Bunch was most responsive. Kernel weight of all genotypes except NC. ACC 343, PI 162857 and one selection of Early Bunch increased with calcium application. Shulamit and Early Bunch had higher mean kernel calcium concentrations than Virginia Bunch, NC. ACC 343 and PI 162857. Mean kernel calcium concentration was increased by calcium at 136 kg/ha and again at 318 kg/ha.

Virginia peanut genotypes differ in their response to varied levels of soil calcium. Some are better suited than the commercial variety to conditions of low soil calcium availability.

INTRODUCTION

The role of calcium in the nutrition of the peanut (*Arachis hypogaea* L.) fruit has been widely studied. Calcium, additional to that required for normal vegetative growth, is needed to reduce the number of unfilled ovarian cavities or pops (Colwell and Brady 1945*a*). The calcium is taken up by the gynophore and shell of the developing fruit (Bledsoe *et al.* 1949) with comparatively low efficiency (Keisling and Walker 1982). Extra Ca, above the rate required to prevent kernel abortion, improves many quality aspects of peanut kernels including percentage sound mature kernels (SMK) (Walker *et al.* 1976), kernel size, and kernel Ca concentration (Hallock and Allison 1980). Factors which influence the availability and absorption of Ca by the developing peanut fruit include soil Ca levels, source of Ca, time and method of application (Colwell and Brady 1945*a*), particle size (Adams 1978), and soil moisture (Balasubramanian and Yayock 1981).

Middleton *et al.* (1945) showed that large-seeded cultivars of the Virginia type were more responsive in yield to applied Ca than the smaller-seeded Spanish types. A later study by Walker and Keisling (1978) to characterise the response to Ca of two new varieties demonstrated differences in yield response to gypsum application between varieties within both Runner and Virginia market types.

Our study is complementary to the research of Armour *et al.* (1985) which developed a correlation between additional Ca requirements of Virginia Bunch and exchangeable soil Ca in the Mareeba–Dimbulah irrigation area. As the cultivar Virginia Bunch is expected to be replaced, it was important to determine if the other large-seeded genotypes being considered as replacements, respond similarly to different levels of Ca. This is important in order to minimise Ca application costs.

MATERIALS AND METHODS

A field experiment was planted on 9 Dec. 1982 on a sandy loam (gleyed podzolic, Stace *et al.* (1968), Dg 2.81, Northcote (1971)). The exchangeable calcium content of the soil was 0.47 me/100 g. It is typical of areas of light textured soil being used for peanut production in the Mareeba–Dimbulah irrigation area and is located 8 km ENE of Mareeba (145°25′E 17°00′S) in north Queensland. Average annual rainfall is 914 mm.

A split plot design with four replicates was used. Main plots comprised nil and two rates (136 and 318 kg/ha) of Ca as gypsum (21.6% Ca) which was broadcast by hand and incorporated in the soil to a depth of 120 mm before hand planting single rows on ridges 0.9 m apart. Subplots were planted to 10 genotypes of large-seeded Virginia type peanuts as single rows 2 m long. The 10 genotypes were two selections, one from each Kingaroy (K) and Mareeba (M), of Virginia Bunch and Early Bunch and six other varieties or lines being considered for commercial release. Each was increased for one generation in pots of similar soil in a glasshouse. Seed of each line was divided into four sizes; one size was used to plant each replicate. Mean seed sizes for all genotypes were 73.6, 84.4, 94.0, and 108.7 g/100 seeds (LSD 0.71, $P = 0.05$).

All plots received 20 kg P/ha as diammonium phosphate, 40 kg K/ha as potassium sulphate, 15 kg Mg/ha as magnesium sulphate, 4 kg Cu/ha as copper sulphate pentahydrate, 4 kg Zn/ha as zinc sulphate heptahydrate, 3 kg Mn/ha as manganese sulphate pentahydrate and 0.2 kg Mo/ha as sodium molybdate dihydrate which was broadcast and incorporated before planting.

Soil samples from 0 to 100 mm were air dried and sieved to remove material greater than 2 mm. The pH of 5.1 was determined in 1:5 soil to water suspension. Soil Ca was extracted overnight in 1 M NH_4Cl (pH=7) at a soil to solution ratio 1:20 while kernels were dry ashed (Salayar and Young 1984) before determining calcium concentrations by atomic absorption spectrophotometry.

Irrigation equivalent to 164 mm was applied for establishment and early growth while rainfall (512 mm) was considered adequate for pod filling. In total, water received by the crop was 83% of that normally expected for the period.

At maturity of the majority of pods, plants were dug with forks (26 April to 6 May 1983). Pods were removed by hand and air-dried before weighing. Mechanical shelling to determine kernel content (100 × total kernel weight/total pod weight), and grading using a sieve of 7.9 mm diameter holes into SMK (> 7.9 mm) and oil grade (< 7.9 mm) was employed. Mean weights of 100 seeds planted and kernels harvested were determined by hand.

Analyses of variance were conducted on all measurements. Where significant differences were detected, pairwise comparisons were made using Student's *t*-test.

RESULTS

No statistically detectable difference between replicates was recorded in any of the properties measured despite differences in the size of seed planted.

A significant interaction occurred between genotypes and Ca treatments for kernel content, yield of SMK and weight of 100 SMK.

Kernel content (%) of harvested pods

Without supplementary Ca Early Bunch (M), Shulamit, NC. ACC 343 and NC. ACC 5 had similar kernel contents (52.9 – 57.9%) which were higher than PI 162857, AK 10 and

Virginia Bunch (32.4 - 46.5%) (*P*<0.05, Table 1). Calcium at 136 kg/ha increased kernel content for all genotypes but there was no significant increase to additional Ca. Virginia Bunch responded to Ca more than other genotypes and at 318 kg Ca/ha attained kernel contents similar to NC. ACC 343, NC. ACC 5, Altika, AK 10, and PI 162857 (69.9 - 74.7%).

Table 1. Kernel content (%) of harvested pods of peanut genotypes at three rates of calcium fertiliser

Peanut genotype	Kernel content (%)		
	Calcium fertiliser (kg/ha)		
	0	136	318
Virginia Bunch (K)*	32.4	71.4	72.2
Virginia Bunch (M)	34.0	67.7	72.1
Shulamit	55.5	67.6	65.8
Early Bunch (M)	57.9	66.6	64.3
Early Bunch (K)	51.0	61.4	66.7
NC. ACC 343	54.9	74.6	74.7
NC. ACC 5	52.9	73.3	71.3
Altika	47.1	69.2	70.8
PI 162857	46.5	67.1	69.9
AK 10	34.0	66.5	70.8
LSD Genotype within calcium treatment (*P* = 0.05)		6.2	
Other		8.6	

* Source of seed, Kingaroy (K) or Mareeba (M).

Yield of sound mature kernels

Without applied Ca Shulamit, Early Bunch (M), and NC. ACC 343, had higher yields of SMK (1245 - 1309 kg/ha) than Virginia Bunch, AK 10 and Altika (442 - 556 kg/ha) (*P*<0.05, Table 2). Yield of SMK of all genotypes increased with 136 kg Ca/ha but only Early Bunch (K) and Virginia Bunch (M) responded further to 318 kg Ca/ha. With 318 kg Ca/ha Virginia Bunch produced the highest yield of SMK being similar to PI 162857 and AK 10 (3245 - 2757 kg/ha).

Weight of 100 sound mature kernels

Without Ca the weight of 100 SMK of Early Bunch (M) (78.7 g) was similar to NC. ACC 343, Virginia Bunch (K), AK 10, and PI 162857 (75.6 - 74.8 g, *P*<0.05, Table 3), but heavier than other genotypes (73.5 - 67.1 g). The weight of 100 SMK of all genotypes except Early Bunch (M), and NC. ACC 343 increased with 136 kg Ca/ha. At 318 kg Ca/ha Shulamit (86.3 g) produced heavier kernels than all other genotypes except Altika (83.7 g) while NC. ACC 5, NC. ACC 343 and PI 162857 produced the lightest (75.0 - 78.4 g).

Calcium concentration in sound mature kernels

Mean calcium concentration in SMK was increased by both Ca application rates (*P*<0.05, Table 4). Early Bunch had the highest Kernel Ca concentration and Virginia Bunch the lowest.

There was no significant relationship (*r* = 0.21) between kernel size and kernel Ca concentration once the effects of genotype and applied Ca had been accounted for.

Table 2. Yield of sound mature kernels (kg/ha) of peanut genotypes at three rates of calcium fertiliser

Peanut genotype	Yield SMK (kg/ha)		
	Calcium fertiliser (kg/ha)		
	0	136	318
Virginia Bunch (K)*	556	2783	3139
Virginia Bunch (M)	521	2368	3245
Shulamit	1309	2103	2220
Early Bunch (M)	1261	1905	2152
Early Bunch (K)	730	1380	2261
NC. ACC 343	1245	2656	2561
NC. ACC 5	1042	2725	2591
Altika	728	1974	2470
PI 162857	948	2604	3023
AK 10	442	2301	2757
LSD Genotype within calcium treatment ($P = 0.5$)		517	
Other		574	

* Source of seed, Kingaroy (K) or Mareeba (M).

Table 3. Weight of 100 sound mature kernels (g) of peanut genotypes at three rates of calcium fertiliser

Peanut genotype	Weight of 100 SMK (g)		
	Calcium fertiliser (kg/ha)		
	0	136	318
Virginia Bunch (K)*	75.0	80.3	80.7
Virginia Bunch (M)	69.0	77.8	81.4
Shulamit	73.5	83.9	86.3
Early Bunch (M)	78.7	80.5	81.4
Early Bunch (K)	72.9	77.9	80.9
NC. ACC 343	75.6	79.5	74.4
NC. ACC 5	67.1	74.2	75.0
Altika	72.9	81.6	83.7
PI 162857	74.8	79.3	78.4
AK 10	74.7	83.7	81.9
LSD Genotype within calcium treatment ($P = 0.5$)		4.1	
Other		4.4	

* Source of seed, Kingaroy (K) or Mareeba (M).

DISCUSSION

The main effects on peanuts of Ca application to a soil of low Ca status were to increase kernel content, yield of kernels, kernel weight and kernel Ca concentration. These results are similar to the findings of many researchers including Colwell and Brady (1945*a,b*), Hallock and Allison (1980) and the local work of Armour *et al.* (1985).

However, the results show that genotypes differ in response to variation in soil Ca levels. Virginia Bunch yielded poorly without applied Ca but responded spectacularly to its use. In contrast Shulamit performed better without additional Ca and responded less to its application. The superior performance at low levels of Ca of some genotypes compared to Virginia Bunch can be seen in relative terms (result at nil Ca/result at 316 kg/ha Ca). The relative yield of kernels for Shulamit was 0.59 and Virginia Bunch (K) 0.18 and the relative kernel content of Shulamit was 0.82 and Virginia Bunch (K) 0.45.

Table 4. Mean calcium concentration in sound mature kernels (mg/kg) of peanut genotypes and for calcium fertiliser

Peanut genotype	Mean SMK Ca concentration (mg/kg)
Virginia Bunch (K)*	209*e*†
Virginia Bunch (M)	204*e*
Shulamit	250*bc*
Early Bunch (M)	259*b*
Early Bunch (K)	289*a*
NC. ACC 343	209*e*
NC. ACC 5	248*bc*
Altika	237*cd*
PI 162857	218*de*
AK 10	240*bc*
Calcium fertiliser (kg/ha)	**Mean Ca concentration (mg/kg)**
0	158*c*
136	224*b*
318	326*a*

* Source of seed, Kingaroy (K) or Mareeba (M).

† Means with a letter in common do not differ ($P < 0.05$).

The better performance of varieties with larger kernels at low levels of soil Ca was contrary to expectations from earlier work between market types (Middleton *et al.* 1945). However, differential response of three Virginia type peanut cultivars to two levels of Ca were reported by Walker and Keisling (1978).

Application of 136 kg Ca/ha to this soil was generally adequate to obtain optimum kernel content and kernel weight. Calcium at 318 kg/ha further improved kernel quality in terms of Ca concentration. This is in agreement with the findings of Walker *et al.* (1976).

Some genotypes, including Shulamit, compensated for low Ca supply by producing smaller kernels. Hartzog and Adams (1973) deduced that kernel size was not directly related to soil Ca levels.

The calcium concentration in SMK is not related to kernel size. This agrees with the findings of Keisling, Hammons and Walker (1982).

Unfortunately, soil Ca levels, modified by Ca application, are unknown. This prevents the development of a relationship between the critical soil Ca level for Virginia Bunch derived by Armour *et al.* (1985) and the genotypes observed in this study. Keisling and Walker (1982) found no differences between cultivars in efficiency of Ca absorbtion from nutrient solutions but Keisling, Hammond and Walker (1982) calculated that large-seeded fruit need to transport Ca from a greater distance than small-seeded fruit to satisfy nutritional needs. Without applied Ca, Shulamit and Early Bunch (M) each absorbed more Ca than Virginia Bunch to meet the requirements of their higher yields, larger kernel sizes and higher kernel Ca concentrations. This indicates that Shulamit and Early Bunch (M) are more efficient than Virginia Bunch at absorbing soil solution Ca at 0.47 me/100g.

Yields and kernel contents of Virginia Bunch in the present study compare favourably with yields from the higher yielding responsive sites of Armour *et al.* (1985). Kernel Ca concentrations were generally lower than 263 to 533 mg/kg reported for Florigiant by Hallock and Allison (1980) and the critical Ca value for germination of 420 mg/kg (Cox *et al.* 1976). Pod yields of Virginia Bunch in the presence of Ca were similar to the 4.2 t/ha mean yield of Virginia Bunch from 21 variety trials in North Queensland. However, in those trials the mean pod yield of Shulamit was 5.3 t/ha (R. Norman, pers. comm. 1987).

The importance of adequate soil moisture for Ca uptake was shown by Balasubramanian and Yayock (1981). The effects of irrigation were similar to those of Ca addition (Cox *et al.* 1976). Su and Lu (1963) found that the most critical period for moisture shortage on yield of peanuts was from peak flowering to early fruiting. In this experiment the prime flowering and pegging phases of Shulamit corresponded with periods of net moisture losses of 2.3 mm and 18.1 mm respectively, compared to net moisture gains of 23.7 mm and 11.0 mm for the same physiological stages of Virginia Bunch. Moisture stress at a critical stage could explain the comparatively low kernel yield of Shulamit obtained in this experiment. Soil moistures of less than 10% experienced during pegging may have contributed to the low kernel Ca concentrations generally.

For this reason and because hand threshing increases downgrades and reduces sample value, an economic analysis using this data should be interpreted with caution when considering commercial application. The value of fair average quality peanuts of 57% edible and 13% oil kernels for 1986 was $594.70/t nut in shell. Gross margins for Shulamit and Virginia Bunch without additional Ca in this experiment were $753/ha and minus $43/ha, respectively. With 136 kg Ca/ha as gypsum the respective gross margins were $1,522/ha and $2,197/ha. An economic comparison of Shulamit and Virginia Bunch derived from North Queensland variety trials shows respective gross margins of $3,025/ha and $2,423/ha (R. Norman, pers. comm. 1987). Shulamit was economical to grow in a low soil Ca regime and both varieties responded economically to Ca application.

This research shows that Virginia peanut genotypes perform differently at low levels of soil Ca and that some varieties are better adapted than Virginia Bunch to soils of low Ca availability. The peanut industry of north Queensland is expanding into marginal areas with lower soil Ca and/or rainfall and it is likely that Shulamit and Early Bunch could be grown more cheaply and more reliably than the commercial variety Virginia Bunch in these areas under dryland conditions.

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