Effect of Calcium and Irrigation Treatments on Peanut Yield, Grade and Seed Quality[1]

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ABSTRACT

The effect of irrigation and/or Ca (calcium) application on yield, grade and seed quality was studied using Florigiant peanuts planted on three dates. Calcium application resulted in a small, but consistent, yield increase at all planting dates. Irrigation resulted in a large yield response on early planted peanuts and no response on late planted ones. Grade, specifically sound mature kernel percentage, was improved by both Ca and irrigation treatments but the effects were only slightly additive. Similar interaction effects were noted as these treatments increased the germination percentage of the seed produced and decreased the percentage of kernels with the form of damage termed dark plumule. Both treatments also decreased the amount of watery hypocotyl damage and increased the Ca concentration in the seed. Germination was 89 to 94% when the seed Ca level was greater than 420 ppm, but fell linearly to 52% when the seed Ca decreased from 420 to 200 ppm.

Additional Index Words: Planting date, Harvest date, Germination, Dark plumule, Watery hypocotyl, Seed, Soil, **Arachis hypogaea** L.

Large seeded Virginia-type peanuts (*Arachis hypogaea* L.) often need additional Ca supplied to the pegging zone to insure maximum pod fill and minimum concealed damage (Colwell and Brady, 1945; Bledsoe and Harris, 1951; Cox and Reid, 1964). The materials used to supply this are calcium sulfate anhydrite (landplaster) and gypsum.

Responses to applied Ca, however, have been inconsistent. Hartzog and Adams (1973) obtained a response only when the soil test Ca level was less than 224 kg/ha (200 lb/acre) when extracting with the North Carolina double acid mixture (0.05 N HCl + 0.025 N H_2SO_4). Also in contrast with other work, they noted no difference in response between Virginia and Runner types. Slack and Morrill (1972) found that the Spanish type is more efficient than the Virginia type peanut in Ca uptake for kernel development. Walker (1975) recently reviewed this aspect as well as the theoretical effect of soil K level on Ca availability.

In North Carolina, responses to gypsum have not been related to soil test Ca level (Daughtry and Cox, 1974), nor to the Ca/K ratio. It has been surmized that responses are greater during dry years, but field studies on this subject have not been reported. Skelton and Shear (1971) found in a greenhouse study that a lack of water in the fruiting zone resulted in more pops, fewer two-segmented pods, and a lower Ca content of the pericarp and seed. Similar effects have been noted with tomatoes (van der Boon, 1973) in which temporary drought decreased the Ca concentration in the fruit. In Africa, it has been observed

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that the response of peanuts to Ca was very marked in dry years (IRHO Report, 1970), and a close relationship existed between the Ca content of the seed and the quality of the embryo.

Pallas, Stansell, and Bruce (1975) found that peanut seed germination was low following dry years in Georgia. They reported that low soil water availability lowered seed germination of sound, mature kernels up to 40%. Germination was reduced more in Virginia type than in either the Runner or Spanish type peanuts. They suggested irrigation in dry years to insure good seed germination the following year.

Abnormalities in peanut seedlings attributed to Ca deficient seeds have been identified as either dark plumule and/or watery hypocotyl. Hartley and Bailey (1959) found that seeds with dark plumules performed poorly in germination tests and termed the abnormal condition of the seedlings as stub-leaf. They associated these symptoms with seed produced under drought condition.

Cox and Reid (1964) related dark plumules in peanut seeds to a nutritional deficiency of Ca. Applications of gypsum were effective in reducing plumule damage. Seed containing 600 ppm or more Ca did not have the dark plumule abnormality. Harris and Brolmann (1966) reported that the deteriorative effect of Ca deficiency was concentrated within the vascular system at the base of the plumule. Sullivan, Jones, and Moore (1974) found the watery hypocotyl abnormality to be associated with Ca deficiency in peanut seedlings. The first symptom of watery hypocotyl is a leaky, liquid-logged area about midway of the elongated hypocotyl. The leaky area gradually enlarges and often completely encircles the hypocotyl. Such seedlings subsequently are invaded by fungi and deteriorate rapidly. The objective of the work reported herein was to determine the effect of Ca application and irrigation on the yield, grade, and seed quality of peanuts grown in the field.

Materials and Methods

A field experiment was conducted on a Norfolk sandy loam (Typic Paleudult; fine loamy, siliceous, thermic) at the Peanut Belt Research Station in 1974. The North Carolina double acid soil test levels for Ca and K were 572 and 106 kg/ha, respectively. Other levels were pH 5.4, 41 kg Mg/ha, and 150 kg P/ha. In order to have plants at different stages of growth during dry periods, three planting dates were employed; April 22, May 8, and May 31, or Julian days 112, 128, and 152. The cultivar planted was Florigiant. Three irrigation treatments were established to include a check or no irrigation, irrigation when 25% of the available water remained, and irrigation when 40% of the available water remained. An irrigation was sufficient to recharge the top 30 cm of soil. There was enough variability in the moisture content of the plots at the time irrigation was needed, however, that it was difficult to differentiate between the two irrigated treatments. Therefore, they were watered at the same time and should be labeled irrigation when 25 to 40% of the available water remained. This corresponds with one to two bars moisture tension in this soil. Moisture content was determined in the surface 30 cm of soil with a neutron probe. Available water was considered to be that between 0.1 and 15 bars tension.

The planting date and irrigation treatments served as the whole plots in a split plot design. These plots were 18 m x 18 m and, where irrigated, were served from a single sprinkler in the center of the plot. Each whole plot was divided for Ca treatments; half receiving none and half receiving 840 kg actual $CaSO_4$/ha applied in a 45 cm band over the row using calcium sulfate anhydrite.

Since it was expected that the various plantings would mature at different times, the plots were further divided into three digging dates; September 25, October 7, and October 18. However, there was a severe frost on October 4 (Day 277) and the minimum temperature was -4 C. This presented an opportunity to evaluate the effect of such a frost on the rate of fruit drop, so the final date was split into non-replicated observations on October 11, October 14, and October 18. Therefore, the Julian harvest days were 268, 280, 284, 287, and 291. Since only the first two digging dates were properly replicated, statistical analysis of all treatment effects except digging time was limited to the results of the first two dates; 268 and 280.

Two rows 0.914 m wide and 12.19 m long were dug from each subplot each date. After combining and curing, harvested yields were recorded and samples taken for determining % SMK. Samples of sound mature kernels were used for germination tests and Ca analyses. The Ca level was determined by atomic absorption. The peanuts remaining on and in the soil to a depth of 10 cm after combining were also salvaged. The soil was screened from a 1.8 m x 2.05 m area for pods which were then cured and a salvage yield determined. Total yield was then calculated from the summation of harvested and salvaged yields.

For the germination test, one-hundred seeds from each plot were placed in rolled paper towels and kept at 25 C. There were four replications of 25 seeds each. Seeds were treated with Captan-Maneb mixture (37.5% each). Diseased and dead seeds and seedlings were removed on the fourth day of the germination test. Final counts and evaluations were made after 8 days.

Results and Discussion

Rainfall distribution and planting, irrigation, and harvest dates are shown in Figure 1. Only those rains which are greater than 3 mm are shown. Two irrigations were applied; one on July 18 (Day 199) and the other on August 27 (Day 239). The rates were 38 and 28 mm, respectively. Rain occurred on July 25 and August 29. Therefore, the periods of drought stress relieved by irrigation were for 7 and 2 days.

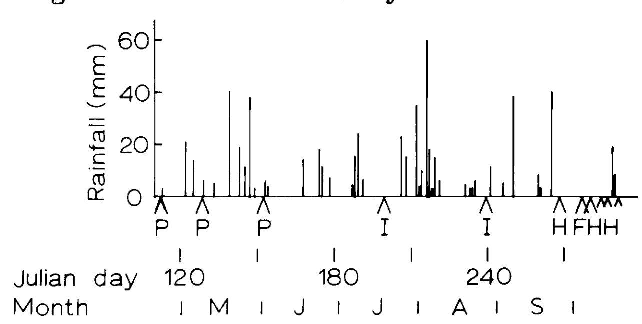

Fig. 1. Rainfall during the 1974 growing season. Planting dates (P), irrigations (I), harvest dates (H), and frost date (F) are also idicated.

There was a marked decrease in yield as the digging day was extended for the early (Day 112) planted peanuts (Figure 2). The effect was less marked for those planted Day 128 and there was no effect on those planted Day 152. From our experience this amount of dropoff seemed normal.

Hence, the frost probably had little effect.

Total yield was computed as the summation of harvested (combined) and salvage yields. As the planting day was extended from 112 to 152 there

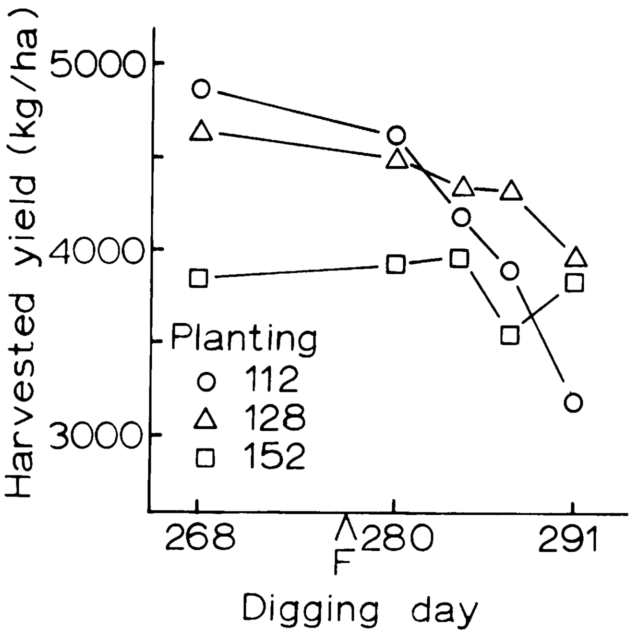

Fig. 2. Effect of planting and digging dates on the harvested yield of Florigiant peanuts when averaged over irrigation and calcium treatments. Frost date (F) is also shown.

was a linear decrease in total yield (Figure 3). Also, there was an average response of 245 kg/ha to the application of Ca at each planting. Salvage yield also decreased as planting date was extended. There was no difference in salvage yield related to Ca application. The slight effect noted on those planted on Day 128 is considered an abnormality. Generally, the salvage decreased from 619 to 372 kg/ha between the early and late plantings.

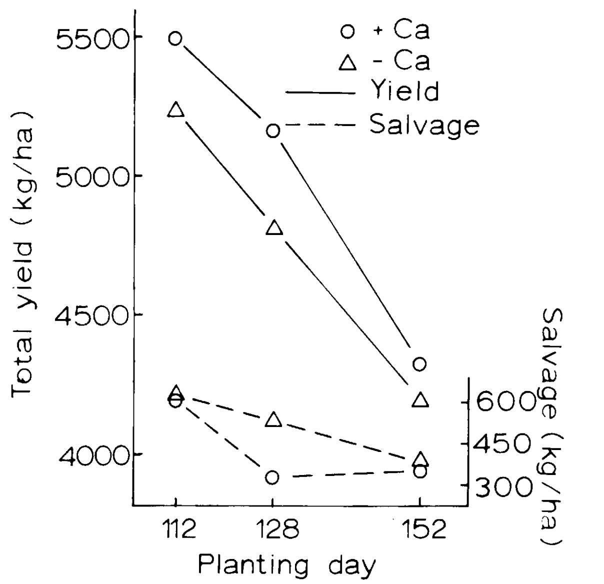

Fig. 3. Effect of planting date and calcium treatment on total and salvage yields from the first two diggings of Florigiant peanuts when averaged over irrigation treatments.

Irrigation resulted in a large response in total yield (1060 kg/ha) for the early (Day 112) planted peanuts (Figure 4). This response was much less (268 kg/ha) if the crop was planted Day 128, and there was no effect for those planted Day 152. Apparently the early planted peanuts were at a fairly critical stage of growth during the 7-day drought period in July. This period was 87-94 days after planting and 38-45 days after initial flowering. Klepper (1973) on reviewing periods of drought stress concluded the peanut to be most sensitive during the time of vigorous flowering. From our observations the early planted peanuts had just passed the time of peak flowering while the later planted ones had not quite reached that stage.

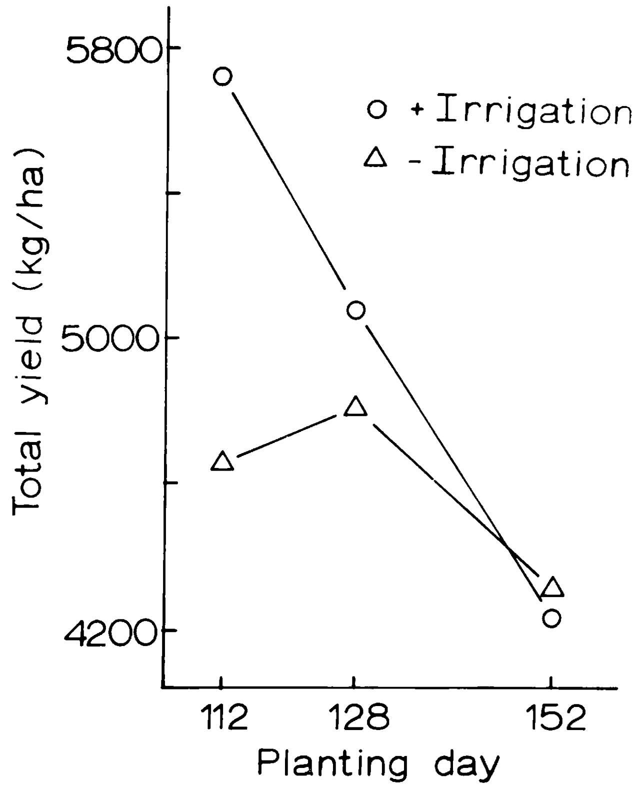

Fig. 4. Effect of planting date and irrigation treatment on the total yield of Florigiant peanuts from the first two digging dates when averaged over Ca treatments.

The grade of peanuts is largely determined by the percentage sound mature kernels (SMK). This factor is also a sensitive indicator of Ca deficiency. There was an interaction between the Ca and irrigation treatment effects on SMK (Table 1) in this study. Application of either treatment resulted in a large increase (3.2 to 4.5%) in % SMK, whereas if one had been added the increase due to the other was less (0.6 to 1.9%). Thus, the response to Ca apparently is greater under dry conditions and the Ca application enhanced drought tolerance in peanuts. Irrigation increased the availability of Ca which probably affects the pod

Table 1. Effect of calcium and irrigation treatments on the percentage sound mature kernels (SMK) of Florigiant peanuts.

Irrigation	Calcium		Irrigation mean
	None	840 kg $CaSO_4$/ha	
	SMK (%)		
No	66.4	70.9	68.7
Yes	69.6	71.5	70.6
Calcium mean	68.5	71.3	

$LSD_{0.05}$: Irrigation = 1.0, Calcium = 0.7, and their interaction = 1.3.

fill as well as the overall growth of the plant.

There was a slight, but significant, effect of planting date on % SMK, being 70.8, 69.4, and 69.6% for planting days 112, 128, and 152, respectively. Unlike the situation with yield, this effect was fairly consistent regardless of irrigation treatment.

Changing the planting date did not affect seed quality characteristics except for the seed Ca level. The seed Ca content was higher for planting date 112 than for the other two planting dates.

It was noted that the seed Ca concentration of peanuts planted on Day 112 was increased more by Ca treatment than were those planted on Days 128 or 152. Also, the effects of the Ca and irrigation treatments were additive for those planted Day 112 while they were not for the other dates of planting. The effect of these interactions is rather minor, however, especially in relation to the effect of the Ca application.

The data presented in Table 2 show that all peanut seed quality characteristics were significantly improved by both Ca application and irrigation.

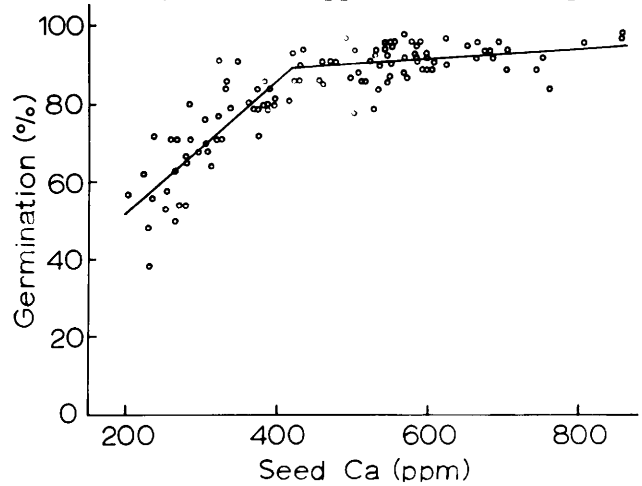

Fig. 5. Relationship between germination percentage and seed calcium concentration.

The major abnormalities contributing to reduced seed quality were dark plumule and watery hypocotyl. Both abnormalities have been previously associated with seed Ca content. These data support the concept that seed quality in Virginia type peanuts can be improved by increasing seed Ca content. The relationship between seed germination and seed Ca content is presented in Figure 5. The critical level of Ca in the seed for good

Table 2. Effect of planting date, calcium, and irrigation on selected seed quality characteristics.*

Treatment	Germination	Dark plumule	Watery hypocotyl	Seed Ca
	-%-	-%-	-%-	-ppm-
Planting date				
112	84a	6.3a	3.7a	516a
128	82a	6.9a	4.6a	440b
152	84a	5.1a	3.8a	451b
Calcium				
0	75a	10.6a	6.5a	344a
840 kg $CaSO_4$/ha	92b	1.6b	1.6b	594b
Irrigation				
No	77a	10.0a	5.8a	411a
Yes	86b	4.1b	3.1b	498b

* Values followed by a different letter within each column are significantly different at the P = 0.05 level according to Duncan's Multiple Range.

Table 3. Effect of calcium and irrigation treatments on the germination and dark plumule percentages of peanut seed.*

	% Germination			% Dark plumule		
	$CaSO_4$			$CaSO_4$		
Irrigation	None	840 kg/ha	Average effect of irrigation	None	840 kg/ha	Average effect of irrigation
No	64	90	77	17.5	2.4	10.0
Yes	80	92	86	7.2	1.1	4.2
Average effect of landplaster	75	92		10.6	1.6	

* Main effects and interactions significant at P = 0.05 level.

germination was 420 ppm. This was calculated statistically with a linear-plateau technique (Anderson and Nelson, 1975) and the proportion of the variation explained by regression (R^2) was 0.80. Below 420 ppm Ca, germination percentage declines approximately 17 percent for each 100 ppm reduction in seed Ca.

These data support previous findings that irrigation and Ca applications can improve peanut seed quality. The improvement effected by irrigation is apparently related to an increase in Ca concentration in the seed. Pallas, Stansell, and Bruce (1975) reported that dry weather during the growing season reduced the germination of Virginia type peanuts whereas dry weather had little effect on the germination quality of the Spanish type. Other researchers, as reviewed by Walker (1975), have shown that the required field Ca level for the Spanish type is much less than for the Virginia type. Thus, the effect of irrigation is to increase the availability of soil Ca to the developing pod.

A significant interaction was noted between the effects of the Ca and irrigation treatments on germination and dark plumule percentages (Table 3). Irrigation did improve seed quality in the absence of Ca application, but the Ca application was more effective in improving seed quality. When a Ca application was made, subsequent irrigation did not significantly improve seed quality.

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