THE EFFECT ON THE GROWTH OF PEANUTS OF NUTRIENT DEFICIENCIES IN THE ROOT AND THE PEGGING ZONE

HENRY C. HARRIS

(WITH TWO FIGURES)

Received August 6, 1948

Introduction

The peanut plant produces flowers above ground, and the flowers when fertilized form gynophores (fig. 1) or pegs. The pegs then push into the soil where they develop into fruit (fig. 2). For this reason both the roots and the fruit of the plant grow in the soil.

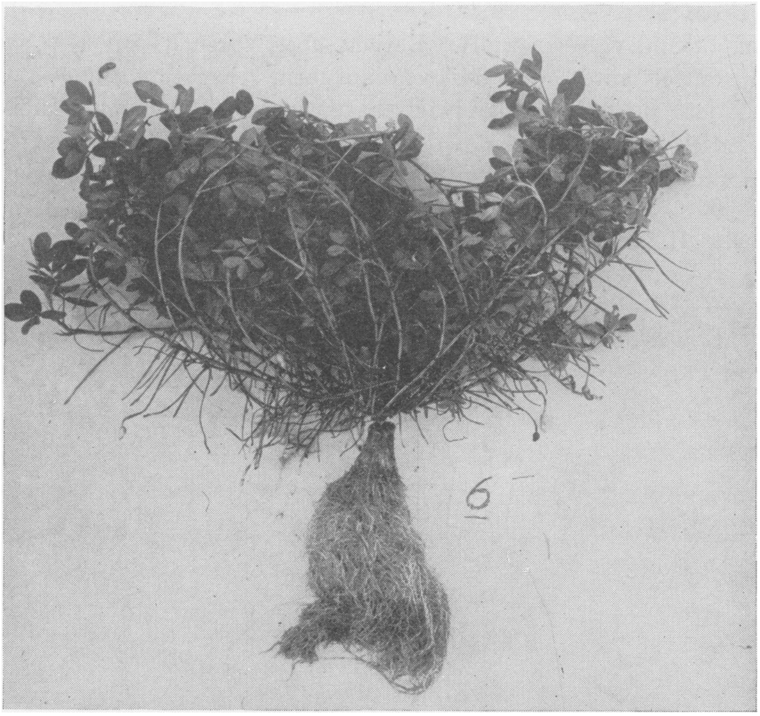

FIG. 1. Peanut plant which received a complete nutrient solution in the root zone and everything except calcium in the pegging zone. Note the abundance of gynophores extending downward from the branches, but developing into very few fruits.

Several authors (**11, 14, 17**) have found root-hair-like growths on the pegs of peanuts. Growths of that nature also have been observed by the writer. Some varieties are known to have similar or root-like formations (**14, 17**) on the hull of the fruit. PETTIT (**11**) as early as 1895 reported evidence indicating that the gynophores may absorb water and nutrients. VAN DER VOLK (**16**) found that the gynophores would develop fruit in a soil extract but not in rain water, and WALDRON (**17**) suggested the possibility of absorption through the pegs. SHIBUYA (**12**) apparently felt that mineral nutrients in contact with the pegs were not necessary for fructification. More recent evidence (**3, 4, 5, 6, 7, 8**) as well as some unpub-

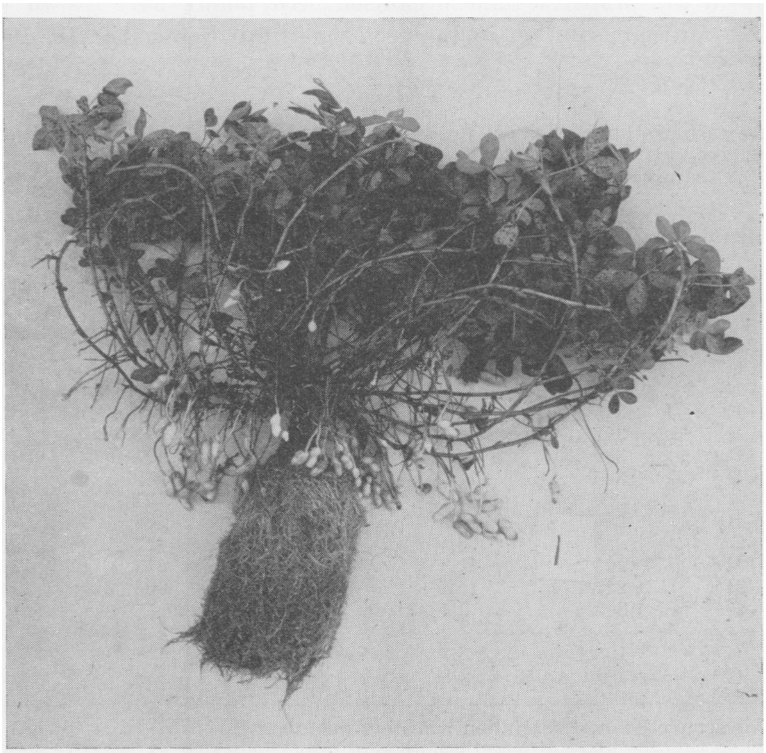

FIG. 2. Peanut plant which received a complete nutrient solution in both the root and pegging zone. Note that many of the gynophores have developed into peanuts.

lished results at the Florida Agricultural Experiment Station indicate that at least calcium is beneficial in the pegging zone and that merely supplying the roots with adequate nutrients will not result in proper nut development.

The purpose of the present investigation was to secure information on the nutrient requirements of the root system as compared to the peg or fruit system.

Methods

The technique of growing peanuts in sand culture with the roots completely isolated from the pegs so that a different nutrient solution can be applied to the roots and to the pegs at the same time has been published (**2**). The same technique of growing the peanuts was used. Peanuts, under field conditions in Florida, sometimes develop on the branches, in contact with the soil, small adventitious roots which disappear in dry weather or by harvest time. A string mesh stretched approximately 1 inch above the sand in the pegging area prevented the branches from coming in contact with the fruiting media and the formation of such roots.

Dixie Runner peanuts were planted June 13, 1946. They were inoculated with the proper legume organism. All plants were grown with a complete nutrient solution in the root zone until September 10, 1946, 89

TABLE I

MEAN NUMBER OF GYNOPHORES PER PLANT AND MEAN PERCENT. PER PLANT OF GYNOPHORES PRODUCING FRUIT AS AFFECTED BY WITHHOLDING VARIOUS ELEMENTS FROM THE ROOT OR PEGGING ZONE LAST 51 DAYS OF THE 140 DAYS GROWING PERIOD

Treatment[1]		Number gynophores	Gynophores producing fruit, %	Treatment		Number gynophores	Gynophores producing fruit, %
Root zone	Peg zone			Root zone	Peg zone		
C	C	239	17	O	C	151	18.5
C	O	326	4	–N	C	210	16.5
C	–N	315	16.5	–P	C	230	21
C	–P	315	12	–K	C	273	10.5
C	–K	308	15.5	–Ca	C	215	11.5
C	–Ca	366	1	–Mg	C	191	13.5
C	–Mg	305	11.5	–S	C	339	14.5
C	–S	250	13	–B	C	191	19.5
C	–B	285	12.5	–Cu*	C	228	7.5
C*	–Zn	220	6.5	–Mn	C	427	6
C	–Mn	285	12.5	–Zn	C	255	17.5
C*	–Mo	222	15.5	–Mo	C	206	14.5
C*	–Cu	249	9.5				
L. s. d. (5%)		128.4	5.7			128.4	5.7
L. s. d. (1%)		....	7.8			....	7.8

[1] C is complete nutrient solution including the minor elements. Element left out of the nutrient solution after differentiations were begun indicated by negative sign. The O is distilled water.

* Plants were ten days younger, hence not comparable to the others, and the values were not used in the statistical analysis.

days after planting, when differentiation in root and peg treatments were begun. (At that time pegs were developing freely and only distilled water had been applied to the pegging area.) The peanuts were then grown on the different nutrient combinations for 51 days until harvested October 31, 1946, 140 days after planting.

The major elements were applied to the roots at ¼ the molar concentration of HOAGLAND and ARNON's No. 1 nutrient solution (**10**) until July 15, 1946. After this date all major elements were applied at ½ the concentration used by these authors. The minor elements were applied at 1/10 (in parts per million) of the concentration used by Hoagland and Arnon. Some trouble was encountered from the lack of iron so the concentration of that element was changed from time to time, and the foliage was even sprayed with ferrous salts. The various nutrient treatments are given in table I. They were formulated by modifying or leaving out the elements desired as Hoagland and Arnon did. Distilled water was used throughout the experiment.

Two liters of the proper nutrient solution were applied to the roots of a plant every two days and 1750 ml. of the proper solution twice a week to the pegs of a plant by the method previously described.

The treatments were applied in duplicate and each culture consisted of one plant.

The plants were grown outside on benches and, with the exception of the first few days and the last few days of the period, under one thickness of cheesecloth.

The peanuts were carefully harvested, roots and everything, and both the green and dry weights (at 70° C.) of the various parts of the plant obtained. The fruiting parts (gynophores and peanuts of varying size) were picked off the green plants and divided into three groups as follows: (1) fruit, (2) pegs which had contacted the sand in the fruiting zone but had not appreciably enlarged, and (3) pegs which had not contacted the sand. The first group was considered the fruit yield and consisted of all fruit or gynophores which were enlarging. Some of the smaller of these did not contain seed.

In addition to the main experiment described above, some plants 15 days younger were grown the same way except that the jug containing the roots of a plant was put in a 2 gallon coffee urn liner and around the jug was placed the acid-washed sand in which the pegs could develop. By such an arrangement radioactive elements could be applied either in the rooting or pegging zone as desired. These plants were grown on a complete nutrient solution in both the root and pegging zone until treated with the radioactive elements.[1] Individual plants were selected, and to one, radioactive cobalt was applied in the root area, and to another, in the pegging zone. Different plants were treated in the same way with radioactive phosphorus. A plant was allowed to absorb the element for four days, after which the plant was harvested, by parts, and the amount of the radioactive element in the different parts evaluated by means of a Geiger counter. Cobalt was applied October 10, and phosphorus October 22, 1946. The plants at that time were large and had many pegs.

Results

The roots of the peanuts appeared healthy at harvest time and nodules were present on all of them.

Number of gynophores

The number of gynophores produced per plant and the percentage of

[1] The radioactive studies were conducted through the cooperation of Dr. C. L. Comar, Department of Animal Industry, Florida Agricultural Experiment Station.

those gynophores which develop into fruit are given in table I. In general the differences in peg treatment do not seem to have greatly affected the number of gynophores produced, and deficiencies in the root area seem to have resulted generally in a smaller number of gynophores but there appears to be no particular significance to the differences.

Only a fraction of the total number of gynophores in any case developed into fruit. The lack of calcium in the pegging area and distilled water in the same area resulted in the pegs forming very few fruit.

Total growth

Differences in peg treatment had relatively little effect on total plant growth (table II), but leaving out any one of the major elements in the root zone (with the exception of sulfur), considerably decreased the total yield.

TABLE II

MEAN TOTAL DRY WEIGHT (ROOTS AND EVERYTHING) PER PEANUT PLANT AS AFFECTED BY WITHHOLDING VARIOUS ELEMENTS FROM THE ROOT OR PEGGING ZONE THE LAST 51 DAYS OF THE 140 DAYS GROWING PERIOD

Treatment[1]		Mean weight, grams	Treatment		Mean weight, grams
Root zone	Peg zone		Root zone	Peg zone	
C	C	124.4	O	C	59.2
C	O	123.7	–N	C	78.5
C	–N	129.1	–P	C	95.6
C	–P	122.3	–K	C	87.0
C	–K	117.4	–Ca	C	76.8
C	–Ca	122.3	–Mg	C	69.3
C	–Mg	112.1	–S	C	123.1
C	–S	93.1	–B	C	93.7
C	–B	111.1	–Cu*	C	90.0
C*	–Zn	79.1	–Mn	C	134.7
C	–Mn	125.0	–Zn	C	111.8
C*	–Mo	101.7	–Mo	C	86.0
C*	–Cu	87.6			
L. s. d. (5%)		38.2			38.2

[1] C is complete nutrient solution including the minor elements. Element left out of the nutrient solution after differentiations were begun indicated by negative sign. The O is distilled water.

* Plants were ten days younger, hence not comparable to the others, and the values were not used in the statistical analysis.

Peanut yields

The yields of unshelled and shelled peanuts are given in table III. The striking thing about the yields of the peanuts in the hull is the effect of the different treatments in the pegging zone. The results show that distilled water or a nutrient solution minus calcium in this zone resulted in the production of a very small amount of peanuts (table III and figs. 1 and 2), suggesting that calcium is necessary in the pegging zone for good peanut development. No other element left out of the nutrient solution for the pegging zone resulted in such a failure. However, when sulphur was left out of the solution for this zone there was a statistical significant decrease in yield of peanuts in the hull.

The effect of variation in root treatment on the yield of unshelled peanuts is also given in table III. Leaving calcium, magnesium, or potassium out of the nutrient solution for the root zone gave a statistically significant decrease in yield of unshelled nuts. Leaving any element out

TABLE III

MEAN YIELD OF UNSHELLED AND SHELLED PEANUTS PER PLANT AS AFFECTED BY WITHHOLDING VARIOUS ELEMENTS FROM THE ROOT OR PEGGING ZONE THE LAST 51 DAYS OF THE 140 DAYS GROWING PERIOD

Treatment[1]		Unshelled nuts, grams	Shelled nuts, grams	Treatment		Unshelled nuts, grams	Shelled nuts, grams
Root zone	Peg zone			Root zone	Peg zone		
C	C	33.7	23.1	O	C	23.6	15.2
C	O	2.7	0.2	–N	C	26.9	18.6
C	–N	34.5	21.8	–P	C	25.6	14.2
C	–P	24.1	15.0	–K	C	16.8	9.0
C	–K	26.4	14.1	–Ca	C	19.0	13.0
C	–Ca	1.0	0.2	–Mg	C	18.7	13.2
C	–Mg	24.8	15.7	–S	C	31.9	20.0
C	–S	19.1	10.7	–B	C	28.0	18.8
C	–B	27.0	16.1	–Cu*	C	20.8	13.5
C*	–Zn	6.5	2.4	–Mn	C	29.0	18.4
C	–Mn	25.8	15.0	–Zn	C	31.6	19.8
C*	–Mo	27.6	17.4	–Mo	C	27.6	18.0
C*	–Cu	11.1	5.2				
L. s. d. (5%)		14.1	11.4			14.1	11.4
L. s. d. (1%)		19.1	15.4			19.1	15.4

[1] C is complete nutrient solution including the minor elements. Element left out of nutrient solution after differentiations were begun indicated by negative sign. The O is distilled water.

* Plants were ten days younger, hence not comparable to the others, and the values were not used in the statistical analysis.

of the root zone resulted in a lower yield, but only the decreases mentioned above were statistically significant.

No other treatment produced as high a yield of shelled nuts (table III) as a complete nutrient solution in both the peg and root zone, although the absence of only some of the elements gave a statistically significant decrease in the yield of shelled peanuts. The various root and peg treatments had essentially the same effect on the yield of shelled nuts that the same treatments had on the yield of peanuts in the hull, the principal difference being a slight change in the degree of significance.

Top growth

Only two peg treatments had any significant effect on top growth. The highest yield of tops (table IV) were obtained where either distilled water or the minus calcium treatment was applied to the pegging area. The yields of tops for these treatments are statistically higher than the yield for the complete nutrient solution in both the areas. As has been pointed out, these were the treatments that produced very few peanuts. In other words, the best tops were obtained where nuts failed to develop.

TABLE IV

MEAN DRY WEIGHT OF TOPS PER PLANT AS AFFECTED BY WITHHOLDING VARIOUS ELEMENTS FROM THE ROOT OR PEGGING ZONE THE LAST 51 DAYS OF THE 140 DAYS GROWING PERIOD

Treatment[1]		Dry weight grams	Treatment		Dry weight grams
Root zone	Peg zone		Root zone	Peg zone	
C	C	63.8	O	C	24.7
C	O	82.6	–N	C	27.9
C	–N	68.1	–P	C	46.6
C	–P	64.8	–K	C	46.6
C	–K	66.6	–Ca	C	37.8
C	–Ca	82.7	–Mg	C	34.1
C	–Mg	61.2	–S	C	60.5
C	–S	52.5	–B	C	46.7
C	–B	56.1	–Cu*	C	54.2
C*	–Zn	51.1	–Mn	C	77.0
C	–Mn	69.7	–Zn	C	52.6
C*	–Mo	52.5	–Mo	C	42.8
C*	–Cu	53.7			
L. s. d. (5%)		18.3			18.3
L. s. d. (1%)		24.9			24.9

[1] C is complete nutrient solution including the minor elements. Element left out of nutrient solution after differentiations were begun indicated by negative sign. The O is distilled water.

* Plants were ten days younger, hence not comparable to the others, and the values were not used in the statistical analysis.

On the other hand, some of the root treatments resulting in relatively low nut yields, for example, minus potassium, calcium or magnesium, did not give large tops. Thus there was no very consistant relation between top yield and nut production.

Distilled water, the lack of nitrogen, calcium, magnesium, and molybdenum in the root zone resulted in a significant decrease in top growth. Furthermore, leaving several other elements out of the root zone resulted in poor top growth, but the differences were not sufficient to be statistically significant.

Foliage symptoms

Variations in peg treatments produced no noticeable foliage symptoms. The characteristics of the foliage as affected by a deficiency of the major elements in the root zone were similar to that previously noted[2] but not as

[2] In some unpublished experiments conducted at this station in a similar manner during 1945 by R. W. Bledsoe and the writer, deficient nutrient solutions in the root zone, begun 75 days after germination, resulted in striking foliage deficiency symptoms

pronounced, except that the peculiar leafspot associated with magnesium deficiency (**2**) did not appear this year.

Movement of radioactive phosphorus and cobalt

The preliminary experiments dealing with the intake of radioactive phosphorus and cobalt indicate that the pegs (table V) did absorb a small amount of the phosphorus and cobalt and some of each was translocated to

TABLE V

THE ACCUMULATION OF RADIOACTIVE PHOSPHORUS AND COBALT IN VARIOUS PARTS OF THE PEANUT PLANT AFTER TREATING FOR 4 DAYS THE ROOTING OR PEGGING ZONE WITH THE SAME DOSAGES

	Phosphorus		Cobalt	
	Plant with peg treatment	Plant with root treatment	Plant with peg treatment	Plant with root treatment
	Percent. of total dose found	Percent. of total dose found	Percent. of total dose found	Percent. of total dose found
Roots	0	29.6	0.028	23.9
Pegs and nuts	0.04	6.1	0.039	0.83
Main branches	0.008	10.0	0.13	6.3
Tips of branches	0.006	16.2	0.12	6.1
Total plant	0.054	61.9	0.317	37.13

other parts of the plant. The roots absorbed more than the pegs, and it should be noted that the pegs and nuts secured far more phosphorus and cobalt through the roots of the plants than did the pegs and nuts directly in contact with the radioactive elements.

Discussion

Peanuts as grown under the conditions of this experiment produced variable yields. This is indicated by the fact that it takes relatively large differences in yields to be statistically significant. More replications would have been desirable.

In these experiments calcium left out of the pegging zone resulted in the formation of few peanuts. Distilled water in the pegging zone gave the same kind of results. The fact that calcium was supplied to the roots all the time it was withheld from the pegs apparently indicates that this

as follows: phosphorus, stunted growth and small bluish green leaves; potassium, stunted growth, dark green leaves and some reddening and dying of the tissue near the tips of the branches; calcium, stunted plant, breaking down of the bud area, and numerous fine brown spots on the leaves, producing a bronze color. A deficiency of almost any of the major elements in the root zone greatly decreased the yield of fruit and fruit failed to develop when only distilled water was applied to the pegging zone.

element cannot be taken up through the roots and translocated to the developing fruit sufficiently to supply the needs in that region. The amount required, the time required, and its function in the pegging area are not known.

The results obtained in these experiments with calcium deficient treatments in the pegging zone apparently are more marked than others have found. WALDRON (**17**) was able to grow two peanuts by putting the gynophores in darkened glass tubes of tap water. Apparently some of the workers in China[3] do not consider nutrients in the pegging zone necessary for fruit development, and SHIBUYA (**12**) of Japan seems to have the same point of view. BRADY, et al., (**4**) appeared to obtain with distilled water treatments about one-fourth of ordinary yields. Why the lack of calcium in the pegging zone had a more pronounced effect in the experiments herein reported than obtained by others is not known, but there might be some varietal difference in response. However, large-seeded peanuts (**7**) are supposed to respond more to lime than small-seeded ones such as the Dixie Runner which was grown in these experiments.

Sulphur was the only element other than calcium when left out of the pegging zone that resulted in a statistically significant decrease in yield of nuts. It, therefore, appears that the sulphate ion in the pegging area is beneficial. In view of the fact that these experiments were conducted in the open where sulphur was brought down by rain, the sulphur requirements of the pegs seem to be more than is in the rain water, and a complete absence of the sulphate ion in the pegging zone might have had a more pronounced effect. These results emphasize the common practice under field conditions of dusting the foliage (**13**) of peanuts with sulphur. The general idea is that the dust controls diseases and for this reason results in an increased yield. In the light of the present experiment this increase in yield could be due in part to the sulphur getting onto the soil and properly supplying the pegs with the sulphate ion, as well as other direct and indirect effects.

BRADY, et al., (**4**) did not obtain a beneficial effect from the sulfate ion in the pegging zone. The reason for this difference in results might be due to varietal differences in response as well as a difference in the amount of sulphur brought down in the rain. Presumably little sulphur is brought down by rains in Florida since the soils in this state frequently respond to the sulfate ion (**1, 9**).

Fertilizers are applied to peanuts under field conditions usually before seeding. Since the peanut is a long growing plant, the nutrient supply probably becomes low during the later part of the growing season. For this reason the different treatments in the root zone were applied the last 51 days of the growing period (140 days) to see what effect late deficien-

[3] Correspondence with Dr. P. S. Tang, Dean, College of Agriculture, National Tsing Hua University, Peiping, China.

cies would have. Several elements when left out of the nutrient solution for the root zone at this late date decreased the yields of peanuts, but the results were not as striking as those referred to in footnote 2 when differentiations in nutrient solutions for the roots were begun at an earlier date. The indications are that various nutrient deficiencies in the rooting zone during the latter part of the growing season will have an effect on the growth of peanuts, but that only the earlier deficiencies are important.

The failure of the plants to develop striking deficiency symptoms probably was due largely to the existence of only slight deficiencies, since the differentiations in nutrient treatments were begun very late.

An accident to some of the plants (indicated in the tables) in the minor element phase of this experiment makes that part of the experiment unsatisfactory. Furthermore, ordinary c.p. chemicals were used without special purification. However, the fact that the lack of molybdenum in the root area seemed to decrease the yield of tops suggests that minor elements might be important in the production of peanuts.

The relative importance of nutrient absorption through the pegs as compared to that through the roots is not well understood. This experiment indicates that calcium is important in the fruiting area and that the sulphate ion is beneficial there. THORNTON and BROADBENT (**15**) found that nitrogen was absorbed by the pegs and that there was a greater absorption of nitrogen by the pegs when the roots were somewhat nitrogen starved. Their results suggest that a deficiency in the root area might increase peg absorption. In the present experiments the plants with minus calcium and minus sulfate peg treatments had liberal amounts of calcium and sulfates in the root area which would further emphasize the importance of these two elements in the pegging zone. The absorption of radioactive phosphorus and cobalt in small amounts by the pegs and the translocation of these elements to other parts of the plant suggest that almost any element might be absorbed in small amounts by the pegs. However, the fact that the pegs obtained far more radioactive phosphorus and cobalt through the roots than when the pegs were directly in the radioactive solution indicates that the roots are more effective in absorbing some elements than the pegs. In view of the limited evidence it would seem that some calcium, and possibly the sulphate ion, is very important in the pegging area, but it is probable that the larger part of most elements in the fruit is obtained through the roots. Possibly an acute deficiency in the root area would increase peg absorption.

Summary

The nutrient requirements of the roots and pegs of Dixie runner peanuts were studied by withholding various elements from the root and pegging zone the last 51 days of the growing season with the following results:

1. Very few fruit developed without calcium in the pegging zone.
2. The sulphate ion in the pegging zone appeared to be beneficial.

3. Leaving several of the major elements out of the root zone the last 51 days of the growth period resulted in lower nut yields but the results are not as striking as previously obtained when differentiation in root treatments were begun earlier in the growing season.

4. The minor element part of the experiment was not conclusive, because of the different ages of some of the plants. However, leaving molybdenum out of the root zone seemed to decrease the yield of tops.

5. Small amounts of radioactive phosphorus and cobalt were absorbed by the pegs and translocated to other parts of the plant, but the pegs received more of these elements when applied to the roots than when the pegs were directly in the radioactive solutions.

6. There was no consistent relation between top growth and nut production.

7. A discussion of the relative importance of root and fruit absorption of nutrients is given. It appears that a balanced supply of nutrients in the root zone as well as calcium and, perhaps, sulphur in the pegging zone are necessary for the best production of nuts.

UNIVERSITY OF FLORIDA
AGRICULTURAL EXPERIMENT STATION
GAINESVILLE, FLORIDA

LITERATURE CITED

1. BLEDSOE, R. W., and BLASER, R. E. The influence of sulfur on the yield and composition of clovers fertilized with different sources of phosphorus. Jour. Amer. Soc. Agron., **39**: 146–152. 1947.
2. BLEDSOE, R. W., HARRIS, HENRY C., and TISDALE, W. B. Leafspot of peanut associated with magnesium deficiency. Plant Physiol., **21**: 237–240. 1946.
3. BRADY, N. C., and COLWELL, W. E. Yield and quality of large-seeded type peanuts as affected by potassium and certain combinations of potassium, magnesium, and calcium. Jour. Amer. Soc. Agron., **37**: 429–442. 1945.
4. BRADY, N. C., REED, J. F., and COLWELL, W. E. The effect of certain mineral elements on peanut fruit filling. Jour. Amer. Soc. Agron., **40**: 155–167. 1948.
5. BURKHART, LELAND, and COLLINS, E. R. Mineral nutrients in peanut plant growth. Soil Sci. Soc. Amer. Proc., **6**: 272–280. 1941.
6. COLWELL, W. E., and BRADY, N. C. The effect of calcium on certain characteristics of peanut fruit. Jour. Amer. Soc. Agron., **37**: 696–708. 1945.
7. COLWELL, W. E., and BRADY, N. C. The effect of calcium on yield and quality of large-seeded type peanuts. Jour. Amer. Soc. Agron., **37**: 413–428. 1945.

8. HARRIS, HENRY C. Some recent findings concerning the nutrition of the peanut. Proc. Asso. Southern Agr. Workers, **44**: 192–193. 1947.
9. HARRIS, HENRY C., BLEDSOE, R. W., and CALHOUN, P. W. Response of cotton to sulfur fertilization. Jour. Amer. Soc. Agron., **37**: 323–329. 1945.
10. HOAGLAND, D. R., and ARNON, D. I. The water-culture method for growing plants without soil. California Agr. Exp. Sta. Cir. 347. 1939.
11. PETTIT, ANNA S. Arachis hypogaea L. Mem. Torrey Bot. Club, **4**: 275–296. 1895.
12. SHIBUYA, T. Morphological and physiological studies on the fructification of peanut. Mem. Fac. Sci. and Agr., Taihoku Imp. Univ., **17**: 1–120. 1935.
13. SMITH, J. LEE. Producing peanuts in Florida. Florida Agr. Ext. Cir. 75. 1944.
14. STOKES, W. E., and HULL, FRED H. Peanut breeding. Jour. Amer. Soc. Agron., **22**: 1004–1019. 1930.
15. THORNTON, G. D., and BROADBENT, F. E. Preliminary greenhouse studies of the influence of nitrogen fertilization of peanuts on nodulation, yield, and gynophore absorption of this element. Jour. Amer. Soc. Agron., **40**: 64–69. 1948.
16. VAN DER VOLK, P. C. Researches concerning geocarpy. Pub. Sur la Physiologie Vegetale, Nimeque, 1914.
17. WALDRON, R. A. The peanut, its history, histology, physiology, and utility. Contr. Bot. Lab. Univ. Pennsylvania **4**: 302–338. 1919.