THE INFLUENCE OF MINERAL DEFICIENCY ON VEGETATIVE GROWTH, FLOWER AND FRUIT PRODUCTION, AND MINERAL COMPOSITION OF THE PEANUT PLANT[1]

ROGER W. BLEDSOE AND HENRY C. HARRIS[2]

(WITH FOUR FIGURES)

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Introduction

The peanut plant, *Arachis hypogaea* L., is one of the few plants in which the ovary of the aerial flower must be transferred by a gynophore to a subterranean position before maturation of the fruit will normally occur. The morphology and anatomy of the peanut plant as described by PETTIT (**16**), WALDRON (**23**), REED (**17**), and JACOBS (**11**) indicate that the gynophore has a stem-like anatomy and a root-like behaviour. Pettit (1895)

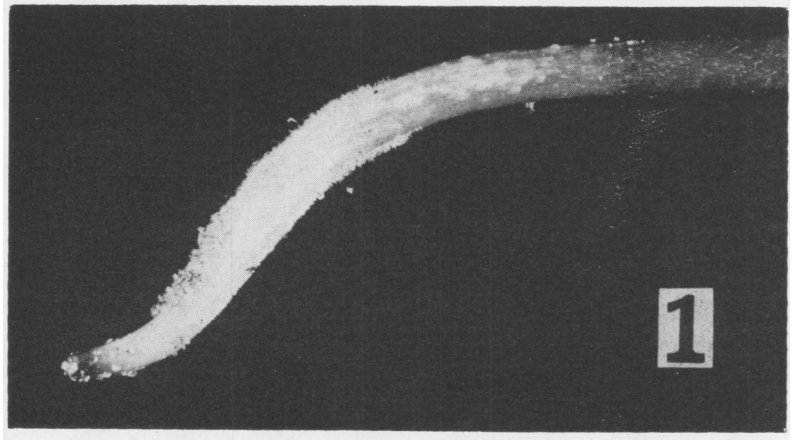

FIG. 1. Gynophore with root-hair-like epidermal outgrowths.

reported that the hypogeal portion of the gynophore forms root-hair-like epidermal outgrowths and suggested that the organ was a part of the absorptive system since few root hairs were found on the root of the plant. Waldron also assumed that the hairs on the gynophore might absorb water and nutrients, while MOHAMMAD, *et al.*, (**15**) and Reed considered absorption by the hairs to be of little importance. The authors have observed the epidermal outgrowths of the gynophore on field grown plants, and at various periods of the year when that organ developed in solution, sand and/or soil under greenhouse conditions, figure 1.

[1] Published with the approval of the Director, Florida Agricultural Experiment Station.

[2] A part of this paper was presented before the American Society of Agronomy in Columbus, Ohio, 1946.

At the initiation of the present study the literature offered little information on the nutrition of the peanut. VAN DER WOLK (**21**) observed that water and darkness were essential to fructification, and that a soil extract was beneficial. SHIBUYA (**18**) reported that only the first two factors are necessary. BURKHART and COLLINS (**6**) demonstrated the uptake of lithium by the fruiting organs and reported that fruit quality was benefited by the presence of calcium in the fruiting medium.

BRADY, *et al.* (**4**), from studies initiated concurrent with and since the present investigation, reported a significant increase in fruit filling when a single calcium salt was added to the fruiting medium. Subsequent work by HARRIS (**10**) showed fructification to be negligible when a minus calcium nutrient solution was applied to the fruiting medium. Results of MEHLICH, *et al.*, (**14**) also indicate that fruit filling is related to the available external calcium supply. THORNTON and BROADBENT (**20**) demonstrated the uptake and movement of isotopic nitrogen from the fruiting organs to the vegetative portions of the plant. Recent work with radioactive calcium by BLEDSOE, *et al.* (**3**) indicates that the need of an external supply of calcium by the developing fruit might be the result of poor translocation of that ion from the plant to the fruit.

This report deals with the results of a study conducted in 1945 relative to the necessity of an external supply of nutrients to the fruiting organ for normal fructification and to an evaluation of salt movement from the fruiting organs to the vegetative tissue when differential nutrient treatments were applied to the root medium of the peanut plant.

Experimental

Peanut seeds of the Dixie Runner variety were placed in moist chambers to germinate on April 11, 1945. After five days the most vigorously germinating seeds were selected and single seedlings were transferred to one-gallon jugs filled with acid-water-washed sand which had been inoculated with Nitragen E Culture. When the plants were about 5 cm. high, selected containers with the more uniform individuals were placed in boxes of sand. The method of isolating the rooting and fruiting media, the basic and supplementary nutrient solutions used, and their method of application have already been described (**2**). The pH of all solutions was adjusted to approximately 5.5.

The complete nutrient solution was added to the fruiting medium of 24 plants throughout the experiment, while differential nutrient treatments were started on the roots of the plants after they had received the complete solution for 80 days. At that time a mean of 43 gynophores per plant had penetrated the sand of the fruiting medium. The plants were then divided into eight groups of three replicates of single plants and the following nutrient treatments, with concentrations modified as reported previously (**2**), were begun on the rooting media: complete, minus phosphorus,

minus potassium, minus calcium, minus magnesium, minus sulphur, minus micro-nutrients, and distilled water. Plants which received the complete solution in root and fruiting media throughout the experiment are referred to hereafter as control plants.

Each of three boxes of sand held eight glass jugs with single plants. The eight nutrient treatments on the rooting media were randomized and each treatment occurred once to a single plant in each box. A fourth box contained the ninth group of three jugs of single plants which received the complete nutrient solution on the roots, and distilled water on the fruiting medium throughout the experiment.

The glass jugs, which held the roots of the plants, were originally filled with sand to within 1 inch of the tops. To allow for root growth, portions of the sand were removed April 24 and June 8 by carefully washing it through the drain holes of the jugs. Since the plants made satisfactory growth after each removal of sand it is assumed that the roots were little affected by the operation. The top of each glass jug was placed $1\frac{1}{2}$ to 2 inches above the surface of the sand in the boxes and drainage holes in the bottom of the latter permitted the escape of any excess rain water. Thus, the possibility of nutrients from the fruiting medium contaminating the solutions applied to the roots of the plant within the glass jugs was eliminated. A string mesh across the tops of the boxes prevented the branches and foliage from touching the fruiting medium.

During the course of the experiment, flowers of all plants were counted daily. Since the peanut flower is ephemeral and wilts after a few hours, an accurate record of flower production is obtained easily.

When the plants were 130 days old and had received the deficient solutions on the roots for 50 days, they were harvested; the entire plant and portions thereof were immediately weighed and subsequently dried at 70° C. Harvesting of plants was accomplished by first carefully flushing the sand from the roots and fruits through the drain holes of their respective containers. The glass jugs were then broken and the roots were washed free of sand. This permitted a complete recovery of all fruit and essentially the entire root system of the plant.

The middle leaves of lateral branches and the following stages of fruit development were selected from each plant for mineral analysis: (1) gynophores prior to entering the sand of the fruiting medium, (2) gynophores in sand with slight basal enlargement, and (3) shells of mature fruit. Samples for mineral analysis (phosphorus, potassium, magnesium and calcium) were ashed for four hours in an electric muffle at 500° C. Total nitrogen was determined on separate samples. Nitrogen, phosphorus and calcium were determined by the Official Method of Analysis (**1**), while magnesium was determined by the method of DROSDOFF and NEARPASS (**8**), and potassium by the sodium-cobaltinitrite method of BROWN, ROBINSON and BROWNING (**5**).

TABLE I

THE MEAN GREEN WEIGHT, FLOWERS AND GYNOPHORES PER PLANT OF THE PEANUT AS AFFECTED BY NUTRIENT TREATMENT. ROOTS OF PLANTS GROWN IN COMPLETE SOLUTIONS TO JULY 1 (80 DAYS) AND DEFICIENT SOLUTIONS TO AUGUST 20 (50 DAYS).

NUTRIENT TREATMENT		MEAN GREEN WEIGHT			FLOWER PRODUCTION AT 10-DAY INTERVALS AFTER DEFICIENT SOLUTIONS APPLIED. JULY 1 TO AUGUST 20 (50 DAYS).					MEAN TOTAL FLOWERS July 1 to Aug. 20	MEAN TOTAL GYNOPHORES July 1 to Aug. 20
ROOT ZONE	FRUIT ZONE	TOP (*gms.*)	ROOT (*gms.*)	TOTAL (*gms.*)	July 10	July 20	July 30	Aug. 9	Aug. 19		
Complete*	Complete*	770	103	873	109	84	100	87	96	476	325
Complete	D. Water	848	135	983	114	92	104	94	185	589	447
D. Water	Complete	138	51	189	44	2	9	17	14	86	35
– K	"	484	83	567	100	83	78	50	15	326	180
– P	"	337	73	410	81	81	91	47	24	324	203
– Ca	"	241	49	290	115	78	46	2	0	241	138
– Mg	"	449	77	526	107	109	112	60	55	443	270
– S	"	466	61	527	64	52	61	61	59	297	200
– Micro Nutrients	"	293	32	325	54	64	33	15	17	183	75
L.S.D. 5%		124	29	148						179	125
L.S.D. 1%		170	40	204						246	172

* Referred to in text as control treatment.

TABLE II

MEAN NUMBER AND MEAN PER CENT. PER PEANUT PLANT OF FLOWERS, GYNOPHORES, AND FRUITS AS AFFECTED BY NUTRIENT TREATMENT. ROOTS OF PLANTS GROWN IN COMPLETE SOLUTIONS TO JULY 1 (80 DAYS) AND DEFICIENT SOLUTIONS TO AUGUST 20 (50 DAYS)

NUTRIENT TREATMENT		MEAN FLOWERS	MEAN GYNOPHORES	MEAN SOUND MATURE FRUIT	FLOWERS PRODUCING GYNOPHORES %	FLOWERS PRODUCING FRUIT %	GYNOPHORES ENTERING FRUITING MEDIUM %	GYNOPHORES IN FRUITING MEDIUM PRODUCING FRUIT %
ROOT ZONE	FRUIT ZONE							
C†	C†	644	378	59.3	58.7	9.2	64.3	24.4
C*	O**	758	495	1.5	65.3	0.2	44.2	0.7
O	C	250	74	3.7	29.6	1.5	78.4	6.4
– K	C	481	229	41.5	47.6	8.6	76.8	23.6
– P	C	475	243	29.7	51.2	6.3	72.8	16.8
– Ca	C	392	179	21.0	45.7	5.4	69.8	16.8
– Mg	C.	583	312	13.7	53.5	2.3	52.9	8.3
– S	C	423	236	37.7	55.8	8.9	66.9	23.9
– Micro-Nutrients	C	324	122	1.7	37.7	0.5	53.3	2.6
L.S.D. 5%		164	130					
L.S.D. 1%		225	179					

* = Complete nutrient solution.
** = Distilled water.
† = Referred to in text as control treatment.

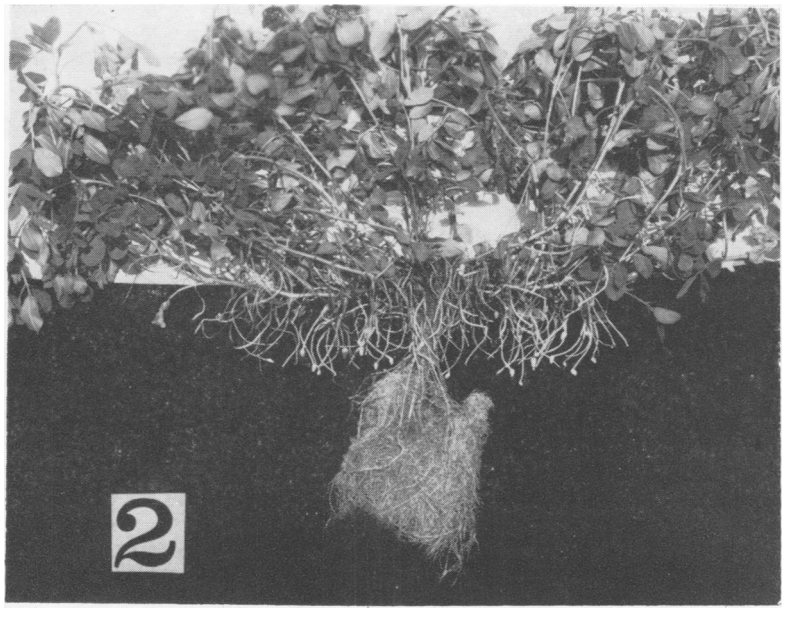

FIG. 2. Peanut plant which received a complete solution in the rooting medium and distilled water in the fruiting medium.

TABLE III

THE MINERAL COMPOSITION OF PEANUT LEAVES, GYNOPHORES BEFORE AND AFTER ENTERING SAND OF FRUITING MEDIUM AND SHELLS OF MATURE FRUIT

MEAN PERCENTAGE COMPOSITION—OVEN DRY BASIS

NUTRIENT TREATMENT		NITROGEN				CALCIUM			
Rooting medium	Fruiting medium	Middle leaves	Young gyno.*	Gyno. in sand	Shells of fruit	Middle leaves	Young gyno.	Gyno. in sand	Shells of fruit
Complete**	Complete**	4.29	3.08	2.96	2.35	2.12	0.36	0.48	0.19
Complete	Water	4.02	3.26	3.08	.....	1.91	0.41	0.39	0.13
Water	Complete	3.85	.....	3.36	.....	0.92	0.49	0.39	0.09
− K	"	3.84	3.53	3.27	2.41	3.23	0.56	0.44	0.14
− P	"	3.08	2.74	2.87	2.39	1.89	0.48	0.37	0.13
− Ca	"	3.88	2.51	2.84	2.22	0.71	0.16	0.25	0.13
− Mg	"	3.81	2.68	2.71	2.21	1.85	0.76	0.63	0.12
− S	"	4.33	3.16	2.95	2.41	2.14	0.37	0.44	0.17

NUTRIENT TREATMENT		MAGNESIUM				PHOSPHORUS				POTASSIUM			
Rooting medium	Fruiting medium	Middle leaves	Young gyno.	Gyno. in sand	Shells of fruit	Middle leaves	Young gyno.	Gyno. in sand	Shells of fruit	Middle leaves	Young gyno.	Gyno. in sand	Shells of fruit
Complete**	Complete**	0.72	0.26	0.21	0.20	0.26	0.31	0.26	0.15	4.24	3.68	4.56	2.37
Complete	Water	0.74	0.23	0.17	0.20	0.22	0.30	0.26	0.31	3.91	3.50	3.23	1.70
Water	Complete	0.29	0.13	0.18	0.09	0.22	0.31	0.29	0.17	2.47	1.42	1.17	0.47
− K	"	1.38	0.35	0.34	0.17	0.55	0.43	0.46	0.17	0.21	0.68	1.49	1.41
− P	"	0.50	0.20	0.17	0.16	0.08	0.15	0.11	0.06	3.63	2.37	2.72	1.46
− Ca	"	0.71	0.43	0.28	0.21	0.33	0.35	0.36	0.19	6.44	4.80	5.30	2.99
− Mg	"	0.06	0.07	0.09	0.08	0.25	0.42	0.37	0.13	4.88	3.46	3.44	2.20
− S	"	0.50	0.26	0.28	0.25	0.26	0.29	0.25	0.12	3.36	3.05	4.11	2.22

* Gynophores.

** Referred to in text as control treatment.

Results

The necessity of an external supply of nutrients in both the rooting and fruiting media of the peanut plant for optimum growth and fruit production is shown in tables I, II, and III. Without exception it was found that plants supplied with the complete solution in the rooting medium, irrespective of the nature of the fruiting medium, notably surpassed the plants of all other cultures not only in the total amount of vegetative growth, flower and gynophore production, but also in the character of growth and general appearance of the plants. However, the absence of an external supply of nutrients in the fruiting medium resulted in a highly significant decrease in fructification. Fruit development was negligible when distilled water only was used in the fruiting medium (fig. 2) in contrast to the number of fruit produced by the control plants (fig. 3).

FIG. 3. Peanut plant which received a complete nutrient solution in the rooting and fruiting media.

The former plants had a favorable appearance and exceeded the control plants in vegetative vigor and in the number of gynophores produced. A mean number of 219 gynophores per plant had entered the fruiting medium, but there was limited hypogeal development beyond the initial stage of enlargement after penetrating the sand. This indicates the necessity of some nutrients in the fruiting medium of the peanut plant for favorable fructification.

The necessity of a nutrient balance in the rooting medium is clearly indicated by the results from the deficient cultures. Vegetative growth

and mineral composition of plants were obviously affected by the withholding of any ion or ions from the external supply of the roots when the fruiting organs were supplied the complete solution. Withholding all nutrients from the roots after July 1, resulted in the smallest plants in the experiment. Highly significant differences are demonstrable between data of the latter and control plants in all characters used as criteria for vegetative vigor and fruitfulness. When only distilled water was applied to the roots, flowering practically ceased after four days and slight vegetative growth was made thereafter. The extreme retarded growth of previously vigorously growing plants in such a short period after all nutrients were withdrawn from the roots and the limited amount of growth thereafter when there were many gynophores and some fruits developing in the medium supplied

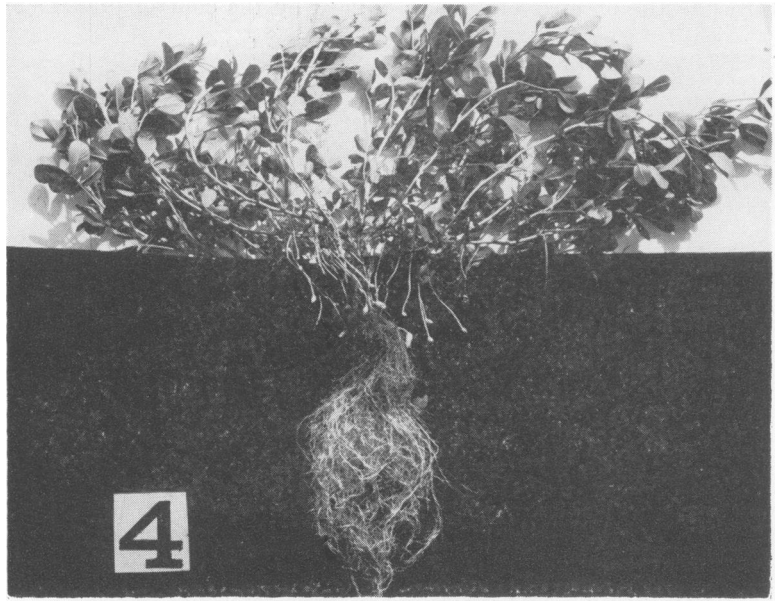

FIG. 4. Peanut plant which had micronutrients withheld from the roots after 80 days while the fruiting medium received a complete solution throughout the experiment.

the complete nutrient solution leads to the conclusion that there was a limited movement of minerals from the fruiting organs to the vegetative tissue of the plants under conditions of this experiment. Likewise, the rapid development of foliar deficiency symptoms for mineral elements which resulted from the deletion of the external supply to the roots when the fruiting media were supplied the complete solution further supports that conclusion.

Plants were grown under conditions conducive to fruitfulness and during the period when peanuts are usually grown in the field. The deficient solutions were applied to the roots of the plants during the most active period of flowering. Many gynophores produced in August by plants

grown on the complete solution were from stems which extended over the sides of the culture boxes. The yields reported for the control plants indicate that the rooting and fruiting media of the cultures had a favorable supplying power for nutrients. All plants were harvested approximately 20 days short of the usual growth period because of the severe nutrient deficient condition of some plants. As a result, the control plants had many immature fruits which resulted in less difference between yields of control and deficient cultures than would have occurred had plants been harvested at a later date.

Summarization of data from tables I and II shows that when the complete solution was supplied to the fruiting media continuously and to the roots of plants for an 80-day period followed by a 50-day treatment to the roots with nutrient deficient solutions, it resulted in a statistically significant decrease between data of the latter and that of the control plants in the following characters: (1) the mean green weight of all cultures, (2) the mean number of flowers of all except the minus potassium and minus magnesium cultures, (3) the mean number of gynophores of all except the minus magnesium cultures, and (4) the mean number of fruits for all except the minus potassium cultures.

Figures of mineral composition (table III) represent the mean of duplicate analyses of each of three plants. The mineral composition of middle leaves from lateral branches is assumed to be representative of the nutritional status of the vegetative portion of the plants. Likewise, the mineral content of gynophores before and after they entered the sand of the fruiting zone, and shells of mature fruit indicate the influence of nutrient treatment on the mineral composition of those organs.

The withholding of all nutrients from the roots of the plant in general resulted in a much lower percentage mineral content of plant parts analyzed than did the omission of nutrients from the fruiting zone of the plant. Withholding an element from the roots resulted in a decreased percentage of that element in the leaves and all fruiting organs. However, there was a tendency for the calcium and especially the potassium concentrations in the gynophores to increase after entering the fruiting zone supplied with the complete nutrient solution. This occurred when the complete solution was applied to both rooting and fruiting media and when the minus potassium, minus calcium, and minus sulphur solutions were applied to the roots of the plants. There was a slight decrease in the concentration of all minerals in the gynophores after entering sand to which only distilled water had been applied. When all nutrients were withheld from the roots of the plant after 80 days, it is questionable if the data of mineral content of the gynophores are comparable because thereafter very few gynophores entered the sand of the fruiting medium.

When the roots of the plants received the minus phosphorus or minus magnesium solution, the phosphorus and magnesium concentrations, re-

spectively, of the gynophores did not increase after those organs entered the zone supplied the complete solution. The shells of mature fruit likewise had a very low concentration of those ions. Thus, the data suggest that after the gynophore enters the fruiting medium, it has a greater absorptive intensity for potassium and calcium than for phosphorus or magnesium, which might indicate a greater uptake of potassium and calcium from the external supply in that zone.

Mineral deficiency symptoms

Reports of symptoms of mineral nutrient deficiencies other than for the young peanut plant do not occur in the literature (**6**). For that reason, a description of nutrient deficiency symptoms of older plants as they occurred in this investigation will be recorded briefly with appropriate comments.

The early stages of leaf symptoms under conditions of phosphorus deficiency became evident within two weeks after phosphorus was withheld from the roots (**6**). Top growth was greatly restricted and in the later stages there was premature defoliation of the yellow basal leaves, but stem discoloration did not occur (**6**).

Three weeks after the potassium deficient solution was applied to the roots of the plant the foliage became a darker green in color. In later stages there was some abscission of lower leaves, but marginal necrosis of leaflets was very limited. After 40 days the terminal portion of stems and adjacent petioles became distinctly red, then brown, which was followed by death of the tissue. Fructification of the potassium deficient plants was significantly greater than plants of the other deficient cultures.

Magnesium deficiency as previously reported by BLEDSOE, *et al.*, (**2**) did not show the orange coloration of leaflet margins reported by BURKHART and COLLINS (**6**). It is interesting that while flower and gynophore production of the minus magnesium cultures was not significantly less than that of the control plants, fructification was significantly decreased. Data in table II and results reported by SOMMER and BAXTER (**19**) indicate the importance of magnesium in nut production.

Within two weeks after treatments were started, symptoms of calcium deficiency became apparent by restricted growth and the appearance of small interveinal brown pitted areas accompanied by marginal chlorosis on the upper surface of fully developed leaflets proximal to the growing tips. At 27 days the leaflets at the tips were very small, chlorotic, crinkled and distorted. Pitted areas were then present on both leaf surfaces and had coalesced to form numerous larger necrotic spots which resulted in a bronze leaf color. Basal stem cracks and die-back of the affected shoots occurred in the later stages. Roots of plants were stunted and decomposing when harvested. Blossoming had decreased sharply within 10 days and was entirely suppressed prior to termination of the experiment. Gynophore and fruit production was also significantly less than that of the control plants. Re-

sults indicate the necessity of an ample supply of calcium in the rooting medium of the peanut plant irrespective of the nature of the fruiting medium.

External deficiency symptoms for sulphur were not recognizable. Shoot and root growth was significantly decreased and nodulation was less than that of the control plants. Flower production remained rather constant throughout the period that the plants received the sulphur deficient solution on the roots.

The omission of the micro-nutrients (Cu, Mn, Zn, B and Mo) from the roots of the plants after 80 days resulted in a highly significant decrease in all characters used as criteria for vegetative vigor and fruitfulness, figure 4. Flowers were pale yellow in color and a high percentage failed to produce gynophores. Interveinal chlorosis of the terminal leaflets appeared at 27 days and all new growth of lateral branches was affected as age advanced. The failure of the gynophores to supply micro-nutrients to the plants shoots in quantities sufficient for growth indicates that the absorption by those organs was of a low order under conditions of this experiment.

The withholding of all nutrients from the roots of the plant at 80 days greatly restricted top growth and blossoming within a 10-day period. That was followed by early maturation, defoliation of some basal leaves, and the appearance of cracks in the basal portion of stems. Necrotic spots appeared on the terminal leaflets, and the meristematic region was affected in a similar manner to the plants grown on the minus calcium solution. Chlorotic effects occurred on the young growth and had spread progressively toward the older leaves when the experiment was terminated.

Discussion

In this investigation, those plants supplied with a deficient solution to the root medium and a complete solution to the fruit medium were considered as deficient cultures. The reserve of the deficient ion in the foliage, absorbed during the preliminary period when the plants were grown on the complete solution, and the redistribution of the reserve within the plant after the external supply of the ion had become deficient to the root system probably in part accounts for the differences in quantity of fruit produced by plants grown on a given deficient solution.

Results indicate that the root is the primary absorbing organ of the peanut plant and an inadequate supply of nutrients in that region will have a deleterious effect on both vegetative growth and fructification. The rapid development of foliar deficiency symptoms after the deficient solutions were applied to the roots of the plants, when the fruiting medium was supplied the complete solution, indicates that if elements were absorbed by the fruiting organs from the external supply in the fruiting zone, then there was a small amount translocated to the plant shoot. In some instances it appeared as if the developing fruit drew on the reserves of the leaves, thus accelerating breakdown of the vegetative tissue. This is consistent with the general

view that the mineral requirements of the fruit are satisfied at the expense of the vegetative tissue if the external supply falls short of supplying the needs of both. However, it has been demonstrated by HAMNER (**9**), LOEHWING (**12**), and WADLEIGH (**22**) that the lack of balance may accentuate a given deficiency or be more detrimental to growth than generally realized.

It is assumed that absorption of some elements would occur by an organ having the hypogeal structure of the gynophore (fig. 1). BURKHART and COLLINS (**6**) demonstrated the uptake of lithium by the fruiting organ and its distribution within the plant. The nutritional status of the plant might have an influence on the absorption by the gynophores as shown by the work of THORNTON and BROADBENT (**20**), where the absorption of N^{15} was negligible when an ample supply of nitrogen was available to the roots, but it was considerably increased when the roots were given a low nitrogen supply. However, in all cases the amount of N^{15} absorbed by the gynophores represented only a small part of the total nitrogen of the plant. HARRIS (**10**) reported the uptake of radioactive phosphorus and cobalt by the fruiting organs to be insignificant when compared with that absorbed by the roots of the plants. The fruiting organs received a much greater amount of those ions when applied to the root medium of the plant than when the fruiting organs were in direct contact with the radioactive substances.

There are no data available on the ratio of surface of roots to hypogeal portion of gynophores. In all probability the absorptive area of the latter would represent only a small portion of the former and consequently the total amount of absorption by the fruiting organs would be expected to be relatively small as compared to the root system. Furthermore, some investigators assume that absorption by the fruiting organs occurs primarily during the early stages of fruit development, which, if true, would further limit the absorption period of those organs.

Obviously, the results of this investigation give no indication of the ionic requirements for fructification. This, of necessity, follows from the nature of the experimental set-up, which does not permit a measurement or even an approximation of the external ions needed, the amounts or the stage of fruit development when such are essential. However, data of mineral composition (table III) suggest that the fruiting organs had a greater absorption intensity for potassium and possibly calcium from the external supply in the fruiting medium than for phosphorus or magnesium. These results also show that the nutrient deficient solutions had a greater effect on the potassium content of fruiting organs than that of other elements determined. Results by BURKHART and COLLINS (**6**) and BRADY, *et al.*, (**4**) indicate that the known antagonism between potassium and calcium may come into play when the fruiting medium has a low available calcium supply. It is probable that an excessive potassium absorption by the roots of the plant or by the developing fruit may influence the transport of calcium from the vegetative organs to the fruit or the direct intake of calcium by the fruit.

The importance of an available calcium supply in the fruiting medium for favorable fructification has been emphasized by a number of investigators (**4, 6, 10, 14**). BLEDSOE, *et al.*, (**3**) recently reported that when radioactive calcium was administered to the fruiting medium there was a very active absorption of Ca^{45} by gynophores, shells and seed of fruit as compared with the small amount of absorption by those organs when Ca^{45} was supplied to the root of the plant. In the latter case, the young gynophore had a relatively high concentration of Ca^{45} but the concentration per unit of dry weight decreased as that organ developed and the shells of fully developed green fruit contained only a small concentration of labeled calcium while never more than a trace could be detected in the seed. Thus, it appears that the transport of calcium from the plant to the rapidly growing gynophore is sufficient for its elongation but probably inadequate for conditions of protoplasm, wall formation, etc., required in fruit growth and development. The relative immobility of calcium and some other ions as reported by MASON and PHILLIS (**13**) will be recalled in this connection.

The available calcium supply in the fruiting medium has been demonstrated to have a greater influence on fruit filling than the availability of any other known element. However, from data of table II, those reported by other investigators (**4, 7, 10,**) and unpublished results by the authors, it appears obvious that factors other than the available calcium supply in the fruiting medium are important in fructification. The number of well developed fruit even with the best known nutrient treatments represents a small per cent. of the gynophores which enter the fruiting medium. Whether that failure of development is related to organic or inorganic supply is as yet undetermined. Whatever the role of the external supply of calcium in fruit development may be, it would appear that its role would be also other than that of merely adding calcium to the seed.

Summary

Peanut plants of the Dixie Runner variety were grown in sand culture with a complete nutrient solution applied to the isolated fruiting media, while the roots of the plants received various deficient nutrient solutions following 80 days of growth on a complete solution. Nutrient deficiency symptoms which developed under the above conditions are described. Vegetative growth, fruit production, and mineral composition of plant parts were adversely affected when any macro-element was withheld from the roots of plants after 80 days. Fruit production was negligible when the roots received the complete solution, and distilled water was added to the fruiting zone of the plant. Mineral composition of gynophores before and after entering that zone supplied with the complete solution suggests that those organs have a greater absorptive intensity for potassium and calcium from the external supply in the fruiting medium than for phosphorus or magnesium. Results show that the root is the primary absorbing organ of the

peanut plant and the necessity of a nutrient balance in the root zone for optimum growth and fruit production is emphasized. In no case was the absorption of an element by the gynophores sufficient to offset the appearance of nutrient deficiency symptoms of that element when it was omitted from the roots of the plants.

UNIVERSITY OF FLORIDA
AGRICULTURAL EXPERIMENT STATION
GAINESVILLE, FLORIDA

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