EFFECT OF BORON ON PEANUTS

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The mineral requirements of peanuts, both the major elements (2, 3, 4, 9, 11, 13) and the so-called minor elements (3, 4, 9, 10), have for some time been of interest to Florida workers. The condition of the soils of the state, which are generally sandy and frequently relatively low in available nutrients, prompted a critical reinvestigation of these requirements. A boron deficiency in some of these sandy soils was suspected and our results with that element have progressed far enough to be of general interest and the subject of this report. Piland et al. (14) obtained results indicating a possible improvement in quality of nuts due to this element and Smith (17) commented on unpublished results to the effect that boron deficiency inhibited peg development, but no one in the knowledge of the writers has reported any marked beneficial effect on peanuts when boron was applied to the soil.

EXPERIMENTAL

First experiment

The soil was Blanton fine sand, level phase, from the Suwannee Valley Experiment Station at Live Oak, Florida. It was taken from a weedy area where fertilizer treatments had not been applied in several years. The soil was brought to the greenhouse, screened to remove trash, thoroughly mixed, and used in greenhouse cultures. It had a pH value of 5.3, and the readily available nutrients in pounds per acre were as follows: CaO, 56; MgO, trace; P_2O_5, 18; K_2O, 22; and NO_3, very low. The boron content of the soil was 0.05 ppm.

Fifteen-gallon soft-glass carboys (15 inches inside diameter) were cut in half, and the neck portions, used as containers, were inverted and supported by 4-gallon crocks. A small piece of plastic screen and a soft-glass watch glass were put into the neck of the container to retain the soil while still permitting free drainage. Each container was filled with 60 pounds of air-dry soil. The outside of each glass container was painted with asphaltum base aluminum paint to keep out light and cut down heat.

The chemicals utilized were either reagent grade or the best obtainable without repurification. The treatments were applied as indicated in the tables. Considering an acre as equal to 2 million pounds of soil, the following rates in pounds per acre were applied in the complete treatment: Ca(H_2PO_4)_2·H_2O, 142; KCl, 127; CaSO_4·2H_2O, 500; Mg(C_2H_3O_2)_2·4H_2O, 167; CO(NH_2)_2, 119; CuCl_2·2H_2O,
5; ZnCl₂, 5; MnCl₂·4H₂O, 5; H₃BO₃, 1.7; and Na₂MoO₄·2H₂O, 0.3. When calcium alone was applied in the fruiting zone, calcium lactate was used at the per acre rate of 880 pounds.

The top 2½ inches (approximately) of soil was considered the fruiting zone and the lower portion the rooting zone. Treatments designated for the different zones were mixed in the soil of that zone. The two zones were separated by a layer of approximately 1½ inches of soil to which no treatment was added.

The treatments were applied May 10, 1955, and the soil watered well. Deionized water was used throughout this experiment. The treatments were replicated four times in randomized blocks.

Four Early Runner variety peanut plants were grown in the center of each culture. The seed were inoculated with the legume organism and were planted May 11, 1955. The plants were harvested at maturity on September 1, 1955. The soil was washed out of the root system and the fruits were cured while still attached to the plant by air-drying in the greenhouse in the cleaned glass container in which they were grown.

The mature fruits were graded in the following manner: the peanuts were shelled and the plump peanuts separated from shrivels by use of a sieve with oblong openings 15/₆₄ inch wide by ¾ inch long. The plump-shelled peanuts were opened, inspected for internal defect, and separated into sound, hollow-heart-defect, and dark-embryo groups. Percentage values on the basis of total weight of unshelled peanuts were obtained. Other imperfections or damages were not noticeable.

The shelled peanuts were analyzed for oil and mineral content. The percentage composition was expressed on a sand-free, oven-dry basis. Nitrogen was determined by the Kjeldahl-Gunning method, calcium and potassium by flame-photometry, and magnesium and phosphorus by colorimetric methods. Sulfur was determined by the magnesium nitrate method of the Association of Official Agricultural Chemists. Oils were extracted with petroleum ether using a Soxhlet apparatus.

Second experiment

The soil was identical to that of the first experiment, being saved from the previous year, and chemicals and rates were the same as the previous year. All treatments were applied in the fruiting zone.

The deionized water used in the first experiment was carefully prepared, but evaluations at other times indicated that the boron content could be variable. The analyses for boron in µg per liter in the deionized water on different dates were as follows: 2, 15, 2, 12, and 2.5. Since a test on distilled water gave 3 µg per liter, distilled water was used in 1956.

The Early Runner and the Dixie Runner varieties of peanuts were compared in 1956. The varieties and treatments were replicated three times in randomized blocks.

The peanuts were germinated in washed quartz sand. When the plants were a week old, the sand was washed from the roots and three plants were set in the
center of each culture on March 16, 1956. Legume inoculation was applied. All other operations were the same as in the previous experiment. The peanuts were harvested August 30, 1956.

RESULTS

First experiment

The peanuts seemed to grow normally and no differences in them could be detected until about 10 days before harvest. At that time, the peanuts without boron seemed to develop stubby or rosette terminal branching (fig. 1) and the foliage, in general, seemed larger than plants with boron. These differences were not, however, especially striking.

The shells of peanuts without boron frequently had cracks as shown in figure 2. This condition was not detected where boron was applied.

Yields are given in table 1. Boron slightly decreased foliage yields but greatly increased nut yields. The latter amounted to almost 300 per cent. Placement of treatments in the fruiting zone as compared to the root zone made no great difference when it was calcium that was applied in the fruiting zone.

Grades of peanuts are given in table 2. The hollow-heart defect observed is shown in figure 3. Those peanuts tended to be somewhat hollow and ranged from slightly off-color inside to badly rotten. A few peanuts which seemed sound but had a hollow appearance were not put in the defective group. The dark-embryo group, which was only a small percentage, was composed of seed which had dark embryos suggesting that they were dead.

In general, it is the quantity of sound and plump seed that determines the grade or value of peanuts. Without boron, there were about as many seed defective as good. Boron almost eliminated the imperfection and more than

Fig. 1. Branch terminals of Early Runner Variety Peanut, (left) without boron application in the fertilizer and (right) with boron application, 10 days before harvest.
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![Fig. 1. Branch Terminals of Early Runner Variety Peanut. (left) Without Boron Application in the Fertilizer and (right) With Boron Application, 10 Days Before Harvest](image)
doubled the percentage of good seed. Again the placement position of the treatment had no material effect.

The ovary of the peanut does not develop unless the peg forces it into the soil. By making a count of all the fruits which contacted the soil, an estimate of the total number of possible seeds can be made. From this value and the number of well-developed seed actually produced, the percentage of seed which developed can be calculated. The values in table 3, which were derived in this manner, indicate that a deficiency of boron had an adverse effect on the percentage of seed which developed.
TABLE 2  
**Effect of fertilizer treatment, with and without boron, on mean shelling percentage of different fractions of Early Runner peanuts (1955)**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Sound and plump</th>
<th>Hollow-heart defective</th>
<th>Shriveled</th>
<th>Dark embryo</th>
<th>Total shelling percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roofing zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>Complete</td>
<td>68.7</td>
<td>2.4</td>
<td>2.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Complete</td>
<td>Calcium</td>
<td>66.8</td>
<td>2.7</td>
<td>2.7</td>
<td>0.1</td>
</tr>
<tr>
<td>Complete except boron</td>
<td>Calcium</td>
<td>32.5</td>
<td>30.4</td>
<td>2.5</td>
<td>1.3</td>
</tr>
<tr>
<td>L.S.D. at 5% level</td>
<td></td>
<td>6.3</td>
<td>3.4</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
<tr>
<td>L.S.D. at 1% level</td>
<td></td>
<td>8.6</td>
<td>4.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 3.** **Sound Peanuts** (top), and **Hollow-Heart Defect** (bottom) *Associated with Boron Deficiency*

In the analyses of peanuts given in table 4, there are statistically significant differences in the values obtained but the magnitude of the differences is not especially great. About all that can be said is that if peanuts are developed and not shrivels, the treatment had no great effect on oil or mineral composition. It is well known that immature peanuts (13, p. 108) do differ in composition from mature ones.

**Second experiment 1956**

The growth characteristics of the peanuts in 1956 were similar to the previous year, although the symptoms did not seem so pronounced. The Early Runner
TABLE 3
Effect of fertilizer treatment, with and without boron, on number of Early Runner peanuts contacting the soil and on possible seed development (1955)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean Quantity of Fruit Per Culture Contacting the Soil</th>
<th>Percentage of Possible Seeds Well Developed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rooting zone</td>
<td>Fruiting zone</td>
<td>Mature</td>
</tr>
<tr>
<td>None</td>
<td>Complete</td>
<td>95.8</td>
</tr>
<tr>
<td>Complete</td>
<td>Calcium</td>
<td>93.8</td>
</tr>
<tr>
<td>Complete except boron</td>
<td>Calcium</td>
<td>36.3</td>
</tr>
</tbody>
</table>

TABLE 4
Effect of fertilizer treatment, with and without boron on oil and mineral composition of sound- and plump and hollow-heart-defective fractions of shelled Early Runner peanuts (1955)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fraction* Analyzed</th>
<th>Mean Oil And Mineral Content of Shelled Peanuts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rooting zone</td>
<td>Fruiting zone</td>
<td>Oil</td>
</tr>
<tr>
<td>None</td>
<td>Complete</td>
<td>SP</td>
</tr>
<tr>
<td>Complete</td>
<td>Calcium</td>
<td>SP</td>
</tr>
<tr>
<td>Complete</td>
<td>Calcium</td>
<td>HH</td>
</tr>
<tr>
<td>Complete†</td>
<td>Calcium</td>
<td>SP</td>
</tr>
<tr>
<td>Complete†</td>
<td>Calcium</td>
<td>HH</td>
</tr>
</tbody>
</table>

L.S.D. at 5% level ... 1.3 0.02 0.1 0.02 0.05 0.004 0.01
L.S.D. at 1% level ... 1.7 0.03 0.2 0.03 0.06 0.005 0.02

* SP = sound and plump; HH = hollow heart.
† Except boron.

TABLE 5
Effect of fertilizer treatment, with and without boron on yield of Early Runner and Dixie Runner varieties of peanuts (1956)

<table>
<thead>
<tr>
<th>Variety and Treatment</th>
<th>Mean Yield of Air-dried Material per Culture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Foliage</td>
</tr>
<tr>
<td></td>
<td>g.</td>
</tr>
<tr>
<td>Early Runner with B.</td>
<td>132.0</td>
</tr>
<tr>
<td>Early Runner without B</td>
<td>146.7</td>
</tr>
<tr>
<td>Dixie Runner with B.</td>
<td>155.0</td>
</tr>
<tr>
<td>Dixie Runner without B</td>
<td>158.7</td>
</tr>
</tbody>
</table>

L.S.D. at 5% level ... 17.7 13.0 11.8
L.S.D. at 1% level ... 26.9 19.7 17.9

variety seemed more susceptible to boron deficiency than Dixie Runner and cracked hulls (fig. 3) were not detected in the case of the Dixie Runner variety. Both varieties developed long, large cracks in the stems of the branches when boron was not applied but this was not observed when boron was applied.

An application of boron markedly increased the yield of nuts of both varieties
TABLE 6
Effect of fertilizer treatment, with and without boron, on shelling percentage of Early Runner and Dixie Runner varieties of peanuts (1956)

<table>
<thead>
<tr>
<th>Variety and Treatment</th>
<th>Mean Shelling Percentage of Peanuts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sound and plump</td>
</tr>
<tr>
<td>Early Runner with B</td>
<td>69.7%</td>
</tr>
<tr>
<td>Early Runner without B</td>
<td>25.7%</td>
</tr>
<tr>
<td>Dixie Runner with B</td>
<td>69.7%</td>
</tr>
<tr>
<td>Dixie Runner without B</td>
<td>35.7%</td>
</tr>
</tbody>
</table>

L.S.D. at 5% level: 10.7 NS
L.S.D. at 1% level: 16.3 NS

NS = not significant.

TABLE 7
Effect of fertilizer treatment, with and without boron on number of fruits contacting the soil of Early Runner and Dixie Runner peanuts, and on the percentage of possible seeds which developed for each variety (1956)

<table>
<thead>
<tr>
<th>Variety and Treatment</th>
<th>Mean Quantity of Fruit Per Culture Contacting the Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mature fruits</td>
</tr>
<tr>
<td>Early Runner with B</td>
<td>96.0</td>
</tr>
<tr>
<td>Early Runner without B</td>
<td>75.3</td>
</tr>
<tr>
<td>Dixie Runner with B</td>
<td>74.3</td>
</tr>
<tr>
<td>Dixie Runner without B</td>
<td>61.3</td>
</tr>
</tbody>
</table>

of peanuts (table 5), and associated with this was a corresponding decrease in yield of foliage. Early Runner showed approximately 88 per cent increase of shelled peanuts and Dixie Runner about 44 per cent. Without an application of boron, yields of the two varieties were approximately the same, but with an application of boron the Early Runner variety produced significantly more nuts than Dixie Runner. A varietal interaction is indicated where boron is more beneficial on Early Runner than on Dixie Runner.

The grades of the peanuts are given in table 6. Both varieties without boron had a large amount of the hollow-heart defect. An application of boron essentially eliminated it in both varieties. The grade results are much the same as in the first experiment.

The percentage of possible seed which developed was calculated as previously and the values are given in table 7. Again a boron deficiency seemed to decrease the percentage of seed which developed.

DISCUSSION

Boron had a pronounced beneficial effect on both varieties of peanuts. The effect appears to have been greater on Early Runner in 1955 than in 1956. Why
that is true is not clear since it was the same soil and the experiments were conducted in essentially the same way. Four plants were, however, grown in each culture in 1955 but only three per culture in 1956, and the water used in 1955 was deionized while in 1956, it was distilled. Possibly these, as well as seasonal differences, had an effect on the magnitude of the response.

The foliage of peanuts was smaller with boron than without it while the nut yields were larger. There are a number of reports (4, 9) of treatments which resulted in poor nut formation and larger foliage. The relatively high production of fruit or seed yields associated with relatively low production of vegetative tissues seem to be characteristic on many crop plants. Probably the explanation is related to the utilization of carbohydrates from the foliage into fruit formation.

Shear and Miller (15) showed that the fruits nearer the base of the plant were the ones that developed, unless the pegs in that position were removed.

The plants apparently have a limited capacity to produce nuts, and after that capacity is utilized, the outer pegs on the branches may not develop nuts. In each of our peanut cultures, the soil area in the glass container where the fruits could develop was a circle 15 inches in diameter. This fruiting area may have met the capacity requirements. Evaluating the percentage of possible seed which developed on the basis of the fruits contacting the soil in our experiments is empirical, but it is suggestive. It must be admitted, however, that all factors which inhibit seed development are not known.

Since boron plays a role in the metabolism and translocation of organic compounds in plants (7, 16), it was thought that the oil content of peanuts might be affected by a deficiency, but the seed analyzed were moderately well developed, and no appreciable effect of boron deficiency on oil content was found. The results suggest that as long as there is enough boron for normal fruit development, the composition is not materially affected. The deficiency seems to manifest itself mainly in failure to develop fruit.

For years workers have found what has been termed "concealed damage" or "hidden damage" of peanuts. Apparently they referred to any damage or defect of the shelled nut which adversely affected quality and which could not be detected until the nut was opened. Carver and Hull (5) indicated that as much as 20 per cent damage was sometimes found and that there were varietal differences. Bledsoe et al. (1) also suggested varietal differences. Long (13, p. 284) and Wilson (18) mentioned three types of interior damage, two of which seemed to be associated with organisms, but the third appeared to be physiological. Possibly some other term, such as defective or imperfect, might better describe abnormalities of the nuts due to nutrient deficiencies or other physiological disturbances. The writers do not know how many types of internal imperfection are possible, but what was found in these experiments does not seem to be associated with an organism. So far, an organism that might be causal has not been isolated from the defective fruit. The abnormality was essentially eliminated by an application of boron in the fertilizer.

The writers are indebted to T. E. Freeman, Department of Plant Pathology, who attempted to isolate a causal organism after the defective seed had been opened.
Boron has been applied in field experimentation with peanuts for years (6, 12), and yet little or no effect has been reported on yield or quality. Why is this the case when this element appears to be so important in these experiments? The answer seems to be that our experiments were better controlled than field experiments. Furthermore, it is well-known (8) that many lime and fertilizer materials contain boron. Lime is generally applied to peanuts and whether responses to lime and other materials are confounded with the effect of boron, which is present as an impurity, requires further investigation.

SUMMARY

Two experiments were conducted in the greenhouse to determine the effect of an application of boron to Blanton fine sand level phase on the yield and quality of peanuts. In the first, Early Runner yields and grades were evaluated and oil and mineral content of the shelled peanuts determined. In the second, the Early Runner and Dixie Runner varieties were compared.

The findings were, in summary:

(a) A boron application markedly increased the yield of nuts on both varieties. Associated with this increase in nut production was a decrease in the foliage yields.

(b) A varietal difference in response to boron was obtained, the Early Runner variety giving the largest difference in yield of nuts.

(c) The grades of nuts of both varieties were greatly improved by the application of boron. Peanuts without boron had a large amount of hollow-heart defect, which was practically eliminated by the boron application.

(d) The percentage of well-developed seeds appeared to be relatively low where boron was not applied.

(e) The mineral and oil content of the mature shelled peanuts of the first experiment was not greatly affected by the boron treatment.

The possible reason why boron applications under field conditions may not be beneficial is also discussed.

REFERENCES


(7) DUGGER, W. M., JR., et al. 1966 The influence of boron on starch phosphorylase and
its significance in translocation of sugars in plants. *Plant Physiol.* (Supplement) 31: 17 (abstract of papers at Storrs Meetings).


