

ABNORMAL STEM GROWTH OF SOYBEANS IN SAND CULTURES WITH SHIVE'S THREE-SALT SOLUTION

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In a recent paper (1) Shive has shown that several monobasic phosphate salts, when added to soil or to solution cultures, are toxic to soybean plants growing in the media. This toxicity not only retarded the growth of the plants but also produced certain specific injuries to the plant tissue. These tests involved three sets of experiments: (a) plants grown in soil cultures to which the salts were added singly in solutions; (b) plants grown in soil cultures to which the phosphates were applied in connection with a complete fertilizer treatment; and (c) plants grown in solution cultures in which the mixed solutions employed in the soil series were used without alteration.

Each of the phosphates used singly in his soil cultures caused specific injury to the soybean plants when the initial concentration of the solution was above one atmosphere, the mono-potassium phosphate being least injurious and the mono-calcium phosphate producing the greatest injury. The plants from a number of soil cultures in which the phosphates were used in connection with a complete fertilizer also suffered pronounced injury, while the plants grown in solution cultures sustained more pronounced injuries than those grown in the corresponding soil cultures.

The nature of the injury sustained by the soybean plants grown by Shive in the different culture media, was identical and appeared to be directly related to some property common to all of the solutions employed. The injury was first marked by a retardation in growth, after which, evidence of specific injury appeared in the form of dark brown discolorations around the margins of the cotyledons. In cases of severe injury the discoloration spread rapidly over the entire surface of the cotyledons and soon appeared on the foliage leaves. Leaf injury appeared first near the margin in the form of small yellowish, round spots which rapidly turned brown. In severe cases the spots gradually increased in size until they covered the entire leaf surface, causing death and the falling of the organ.

In his soil cultures with complete fertilizer rations evidence of disturbed growth did not appear until the third week of the growth period. The group of cultures to which Shive's original three-salt solution alone was added, suffered no specific injury.

The growth period for these cultures extended over a period of 30 days.

During the past two years, the writers have had occasion to study the behavior of the soybean plant growing in sand cultures and supplied with Shive's 3-salt solution having a total initial osmotic concentration of 1.75 atmospheres. Using this 3-salt solution it was desired to determine the proportions of mono-potassium phosphate, calcium nitrate and magnesium sulfate that would give the best growth of the soybean plant at different stages of its development.

Since the dry weight was to be used as a measure of the growth rate during the different periods, it was of course impossible to carry through to maturity the same individuals. According to the plan adopted, the first series of cultures was grown for a period of 30 days, when it was harvested and the dry weights determined. A second series of cultures was then started from the same lot of seed as that used for the first series. During the first 30 days these plants of the second series were given a nutrient solution containing the same proportion of the three salts as had been found to give the best growth rate during the first growth period. From the close of the first 30-day period to the end of 60 days the individual cultures of the second series were supplied with the same different proportions of the three salts as were employed in the first series. At the end of 60 days the second series was harvested and from the dry weights the best proportion of salts for the second period was obtained. In a similar manner the plants for the third series were to be grown from the same lot of seed and supplied with the best proportions of salts during the first and second periods, after which they were to be given the differential feeding and harvested at maturity.

Ten days after transplanting the first series, the plants in the cultures receiving solutions high in mono-potassium phosphate began to show signs of specific injury. When viewed from above the first leaves (the cotyledons having been removed) were marked by dark brown spots. When viewed from below these leaves showed a distinct enlargement and reddening of the midribs and veins (plate 1). The leaves that developed later were of a pale green color and exhibited the characteristic reddening of the veins on the under side.

Of this series, culture R_2C_6 gave the largest dry weight yield. This culture was supplied with a solution having two-tenths of its total concentration derived from mono-potassium phosphate, six-tenths from calcium nitrate and two-tenths from magnesium sulfate. After the first series was harvested the second lot of plants was started and all of the cultures were supplied alike with the above mentioned proportions of the three salts used during the first 30-day period, after which the differential feeding was inaugurated. An inspection of the plants at this time revealed no evidence of specific injury although a few plants appeared to have been injured at the point where the cotyledons were removed.

At the middle of the second growth period, when the plants were approximately 45 days old, the specific injuries which had characterized certain

cultures in the first growth period made their appearance. In this instance, however, the injury was not confined to the plants growing in the cultures receiving solutions high in mono-potassium phosphate. As growth proceeded the injury to the leaves became more pronounced and was accompanied by a thickening of the stems to approximately twice the normal size and a gradual cessation of the growth in height. Plate 2 shows the characteristic appearance of the plants at the end of the 60-day growth period. An examination of cross-sections taken through the affected regions, revealed the fact that the increased diameter of the stem was not the result of a thickening of a particular tissue, and showed that growth in thickness had increased in all of the tissue of the swollen stems except the extreme outer layers. The thickening was less pronounced, however, in the pith than in the vascular ring. Starch was abundant in the swollen tissue. The cultures in which the most pronounced injury occurred were as follows:

R₁C₇ with one-tenth of its total concentration derived from mono-potassium phosphate, seven-tenths from calcium nitrate and two-tenths from magnesium sulfate; R₂C₃ with two-tenths from mono-potassium phosphate, three-tenths from calcium nitrate and five-tenths from magnesium sulfate; R₃C₆ with three-tenths from mono-potassium phosphate, five-tenths from calcium nitrate and two-tenths from magnesium sulfate; R₃C₈ with three-tenths from mono-potassium phosphate, six-tenths from calcium nitrate and one-tenth from magnesium sulfate.

Since this injury was present in cultures growing in solutions of such widely varying salt proportions, it would appear that instead of being correlated with a high concentration of a particular salt, the abnormal growth in the soybean plants must have been the result of some property which was common to all of the Shive 3-salt solutions.

REFERENCE

- (1) SHIVE, JOHN W. 1918 Toxicity of monobasic phosphates towards soybeans grown in soil and solution cultures. *In* Soil Science, v. 2, p. 87-122.

PLATE 1

CHARACTERISTIC ENLARGEMENT OF MIDRIBS AND VEINS OF SOYBEAN PLANTS GROWN IN
SAND CULTURES WITH SHIVE'S THREE-SALT SOLUTION. *A* AND *C*, UNDER
SIDE; *B*, UPPER SURFACE; *D*, NORMAL LEAF

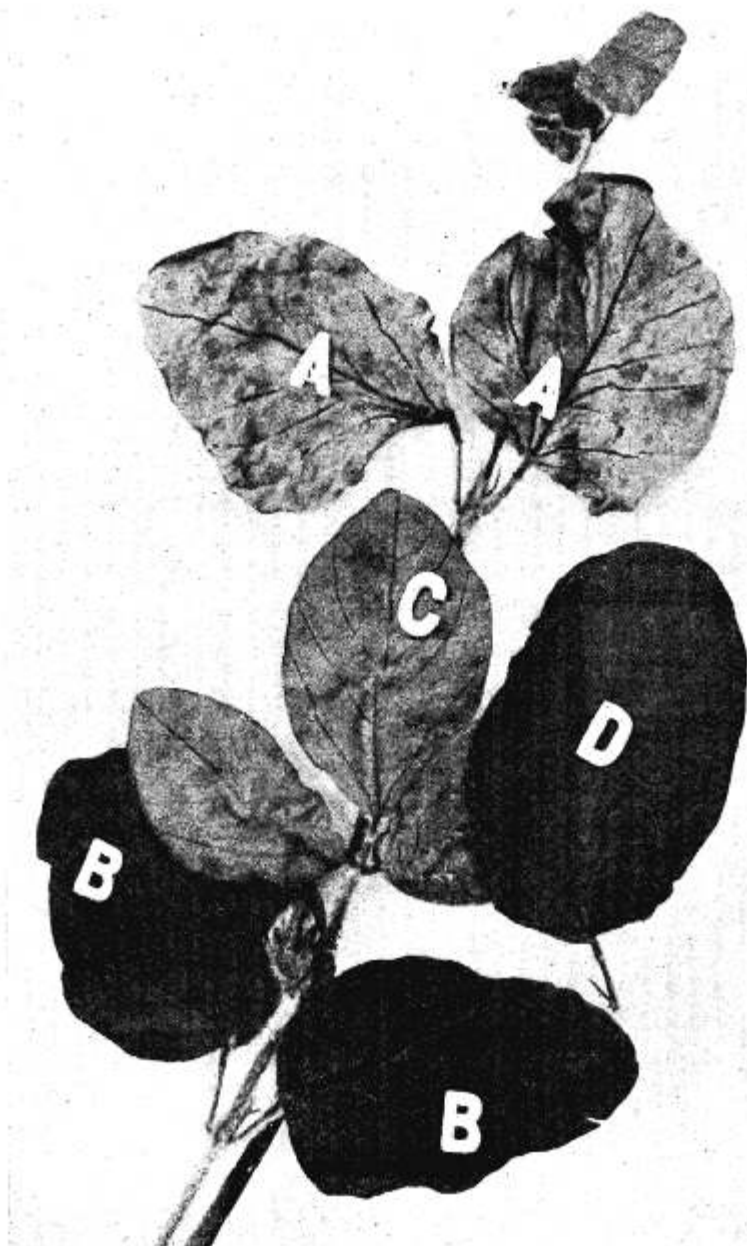


PLATE 2

ABNORMAL STEM DEVELOPMENT OF SOYBEAN PLANTS GROWN IN SAND CULTURES WITH
SHIVE'S THREE-SALT SOLUTION

