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Boron-Iron Relationships in the Growth of Tomato

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BORON-IRON RELATIONSHIPS IN THE GROWTH OF TOMATO

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The work of Sommer and Lipman [1] and of Johnston and Dore [2] indicates that boron is required for the growth of plants representing eight families. Their results suggest that boron in small quantities may be an essential element for all plants. Before such a conclusion can be fully established it will, of course, be necessary to grow all plant species under the exacting conditions required for the elimination of boron from the culture medium. In the mean time any data which indicate that boron has a specific and indispensable function in the growth of any plant should be of value in the solution of this problem. Dr. Lewis Knudson, in a personal communication, suggested to the authors the possibility that boron served to balance other elements present in water cultures and particularly to reduce the toxic action of iron, rather than to function as a specifically essential element. The experiments reported here were performed to check the work of Johnston on the necessity of boron for the tomato and to determine whether any beneficial effects were correlated with the prevention of iron toxicity.

EXPERIMENTAL RESULTS

The Bonny Best variety of tomato was used for the first experiments in 1930 and the very similar John Baer for the experiments of 1933. The seeds were started on cloth screens over a dilute nutrient solution containing no added boron. When the plants were about two weeks old they were transferred to quart mason jars containing nutrient solutions made up as follows:

SALT	PPM.	SALT	PPM.
KCl	300	NaCl	25
$MgSO_4.7H_2O$	450	$MnSO_4$	0.5
$Ca(NO_3)_2.H_2O$	600	H_3BO_3	0 to 5
KH_2PO_4	300	$FeCl_3$	0 to 160

Four replications of two plants each were used for each culture,

[1] *Sommer, A. L., and C. B. Lipman.* Evidence of the indispensable nature of zinc and boron for higher green plants. Plant Physiol. 1: 231-249. 1926.

[2] *Johnston, E. S., and W. H. Dore.* The influence of boron on the chemical composition and growth of the tomato plant. Plant Physiol. 4: 31-62. 1929.

and all plants received the same basic nutrient solution containing the elements other than boron and iron. Ordinary c.p. salts were used and the occasional partial recovery of the minus boron cultures after a solution change indicated the presence of this element in small quantities. The solutions were changed at 3 to 1 week intervals, the shorter intervals being used as the plants grew larger. The plants receiving the full nutrient solutions compared favorably with pot grown plants of the same age and were apparently normal in their development.

The plants which did not receive iron developed typical chlorotic symptoms in the younger leaves and the roots of these plants were thicker and less branched than those of the plants receiving iron. Plants grown without boron showed symptoms which were equally typical and quite distinct. In this case the growing regions were affected; first the apical bud, then the growing leaves and finally the lateral buds died. The older portions of the plant apparently were not directly affected but became thickened and succulent in a manner characteristic of debudded plants. Iron and boron deficiency symptoms are illustrated in figure 1; and the boron is shown to have had a more marked effect upon the early development of the plants than the iron. Boron deficiency symptoms appeared suddenly in both series of experiments when the plants were 5 weeks old from seed. In some cases there was a partial recovery with the temporary growth of lateral buds when fresh solutions containing boron as an impurity were added. Later these shoots also lost their terminal buds.

In the 1930 experiments iron chloride at 40 ppm. gave slight evidences of toxicity which was not affected by boron variations between 0.25 on 1.0 ppm. In the 1933 experiments boric acid was added to as much as 5 ppm. and iron chloride to 160 ppm.

The data in table 1 show that 0.1 and 5.0 ppm. of boric acid were slightly inferior to 0.5 ppm. Some of the plants on 0.1 ppm. showed boron deficiency symptoms while others, sometimes in the same vessel, appeared normal. There was no evidence of any interaction of iron and boron applications when $FeCl_3$ was used at concentrations of 40 ppm. or less. At 160 ppm. $FeCl_3$ the plants were all dead within five days with no significant differences in the behavior of plants receiving 0.1 and 5.0 ppm. of boric acid. At 80 ppm. $FeCl_3$, both the survival and growth of the plants receiving the heavier boron applications were distinctly superior although still far from normal. The roots of these high boron cultures were apparently as quickly injured as were the others, but

Table I. The Effect of Boron and Iron Upon the Growth of Tomato. 1933

Culture Series No.	Iron as $FeCl_3$ (ppm.)	Boron as H_3BO_3 (ppm.)	Plants Growing (%)	Ave. Height (in.)	Ave. Weight (g%s.)	Ave. Day Weight (gms.)
1	0.0	0.5	100	7.5	10.5	0.84
2	2.5	0.5	100	14.4	28.3	2.67
3	2.5	5.0	100	11.4	22.0	2.19
4	10.0	0.0	87	4.6	6.5	0.53
5	10.0	0.1	100	10.7	23.1	2.44
6	10.0	0.5	100	17.0	29.3	2.80
7	10.0	5.0	100	15.3	27.1	2.99
8	40.0	0.1	100	12.6	28.2	2.66
9	40.0	0.5	100	16.7	32.9	3.42
10	40.0	5.0	100	14.6	29.8	3.27
11	80.0	0.1	25	1.8	0.4	.03
12	80.0	0.5	56	2.0	0.4	.03
13	80.0	2.0	100	6.3	4.0	0.29
14	80.0	5.0	87	6.3	4.8	0.38
15	160.0	0.1	0	---	---	---
16	160.0	0.5	0	---	---	---
17	160.0	2.0	0	---	---	---
18	160.0	5.0	0	---	---	---

they developed little or no secondary fungus infection. This observation suggests an antiseptic rather than an antagonistic action for the boric acid.

Hydrogen ion determination on the solutions as made up indicated that the solutions showing toxic effects of iron had pH

Fig. 1. The effects of boron and iron on the growth of tomato. (Left to right —Fe, —B; —Fe, +B; +Fe, —B; +Fe, +B).

values below 3.5 and that the boric acid concentration did not appreciably affect the pH of the solutions used.

Summary

Tomato plants did not develop without added boron when grown in soft glass containers in nutrient solutions made from c.p. salts.

No evidence was obtained that the action of boric acid was antagonistic or other than that of the carrier of an essential element, a deficiency of which results in the death of the meristematic tissues of the tomato.

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