Metabolic Role of Boron in Germinating Pollen and Growing Pollen Tubes

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An essential role of boron has been persistently confirmed for angiosperms, especially in plants which possess well-developed xylem. Based on the available studies, the following putative major roles for this microelement may be assigned: I, at the whole plant level (control of growth and differentiation; II, at the physiological level (regulation of membrane permeability, absorption and translocation of sugar), and III, at the biochemical level (control of enzymes concerning metabolism of carbohydrates, polyphenols and lignin, auxin and nucleic acids biosynthesis) (Lewis, 1980). The primary and secondary roles of boron are not clearly delineated and an integrated picture in this regard is still illusive.

Present studies utilize pollen and pollen tubes as a convenient system for boron investigations since it is non-photosynthetic, lacks lignin etc. A direct relation between boric acid concentration (up to 10 µg/ml) and enhancement of tube length was noticed. This is attributed to enhancement in tube growth rate. Boron had a continuous effect on growth rate. It caused early appearance of pollen tubes and stimulated growth in the initial phases while the later phases were not affected. Addition of boron affected the tube growth in the first 60 min, whereas after its requirement diminished. Data from pre- and post-treatment indicated that initial supply of boron for 60 min induced sufficient stimulation compared with 90 or 105 min post-treatment. Boron also affected fresh weight, dry matter and moisture percentage.

Ethrel could replace the boron effect, but together did not produce a synergistic or additive effect. Compared with uracil, addition of thymine to the culture medium, stimulated tube length suggesting its role in nucleotide and nucleic acid metabolism by increased precursor availability.

The uptake of (U-14C) sucrose as affected by boron was

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studied at three stages of tube growth. First, $^{14}$C-sucrose uptake with increasing boron concentrations was not linear and gave no correlation as a function of tube growth. Second, boron reduced $^{14}$C-sucrose uptake in the later phases of tube growth. Growing pollen tubes metabolize actively and require considerable amount of sugars for respiration and tube growth. Maximum $^{14}$C-sucrose uptake was noticed during the period of activation rather than tube growth. In fact, boron addition at 10-20, 50-60 and 110-120 min decreased the uptake implying that boron may be involved in processes other than absorption.

Boron greatly reduced the leakage of carbohydrates, amino acids and proteins from the soaked and growing pollen. Boron possibly regulates the permeability and integrity of membranes.

The effect of boron on the activity patterns of glycosidases, acid phosphatase and invertase (cytoplasmic and wall fractions) was studied. Boron did not affect the cytoplasmic glycosidases. The present studies do not implicate the role of boron through glycosidases. We have studied the activity of pentose phosphate pathway by two methods: first, by the estimation of glucose-6-P-DH activity; second, by calculating the ratio of CO$_2$ evolved from 1-$^{14}$C or 6-$^{14}$C-glucose; and third, through cytochemical method by seeking a distinction between the levels of utilization of NADPH for electron transport involved with hydroxylation and biosynthetic activity (Altman, 1972). In the first 15 min, PMS addition did not significantly alter the activity in the absence of boron. Addition of boron, enhanced G-6-PDH activity enormously at all the stages when PMS was added. This points towards enhanced biosynthetic processes in the presence of boron. Boron decreased the C$_6$/C$_1$ ratio and the decrease was more in the initial 0-15 min of incubation (activation) than later phases. It appears that the carbon flow through PPP is stimulated at the expense of EMP pathway.

*Amaryllis* pollen has high amount of stored malate. The level of G-6-PDH is controlled in vivo by NADP:NADPH ratio. Conceivably, enhancement of PPP reduces the level of malate decarboxylation or vice versa by controlling this ratio. The amounts of NADP-malic enzyme, malate and C$_6$/C$_1$ ratios indicate that the addition of boron stimulates the production of NADPH via PPP while in the absence of boron, NADPH is supplemented