Effects of Boron Deficiency on Geranium Grown under Different Nonphotoinhibitory Light Levels

Apart from a role in cell wall structure, specific functions for boron (B) in plants are unclear; hence, responses and adaptations to B stress are incompletely understood. It is thought that with B deficiency, alterations in carbohydrate metabolism may be a key adaptation. The objective of this study was to investigate the early effects of B deficiency on photosynthesis and how carbohydrate status might affect plant responses to B deficiency.

Geranium (*Pelargonium* x *hortorum* L.H. Bailey cv. Nittany Lion Red) were grown hydroponically and then exposed to normal (45 µM) or deficient (0 µM) B at two light levels [100 or 300 $\mu mol \cdot m^{-2} \cdot s^{-1}$ photosynthetically active radiation (PAR)]. Photosynthesis [net CO_2 uptake, carboxylation, and photosystem II (PSII) efficiency] was monitored for 5 days, as were concentrations of B, chlorophyll, soluble sugars, total protein, and several photosynthetic and stress proteins.

As expected, B deficiency generally decreased the concentration of B in most tissues at both light levels. Steady state photosynthesis (P_n) and carboxylation efficiency (CE), which is proportional to rubisco activity (rubisco concentration and activation state), decreased significantly by acute B deficiency, but effects were delayed under higher light conditions (Figure 1). PSII was not damaged by B deficiency.

Growth of plants in high light increased the concentration of soluble sugars in leaves over those in low light; however, the reverse was true in roots (Figure 2). Acute B deficiency had no effect on the sugar concentration of tissues. Chlorophyll concentration decreased, and Mn-SOD increased transiently with B deficiency at both light levels, but no other effects of acute B deficiency were observed. Thus, in geranium, photosynthesis is affected by B deficiency before effects on leaf growth, and higher light can temporarily ameliorate B deficiency, perhaps partly due to enhanced carbohydrate status.

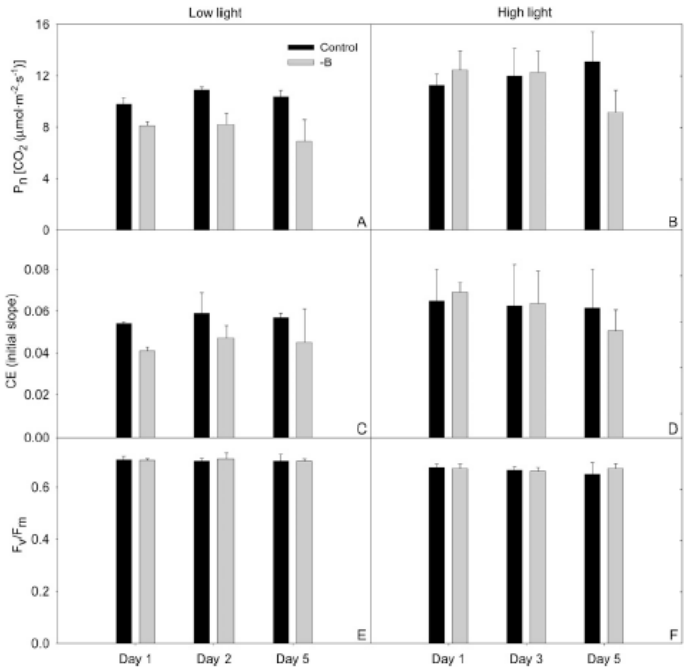

Figure 1. Effects of acute boron (B) deficiency on net photosynthesis (P_n) (A–B), carboxylation efficiency (CE) (C–D), and PSII efficiency (F_v/F_m) (E–F) in geranium plants grown under low- or high-light conditions (100 or 300 $mmol \cdot m^{-2} \cdot s^{-1}$ PAR). Plants were measured repeatedly over 6 d of B treatment (control = 45 µM B, -B = 0 µM B). P_n was measured at ambient CO_2 concentration (400 $mmol \cdot mol^{-1}$); CE is the initial linear slope of the response of P_n to leaf internal (CO_2); F_v/F_m is the ratio of variable-to-maximum chlorophyll fluorescence in dark-adapted leaves (arbitrary units). Results are means (n = 3) + SD.

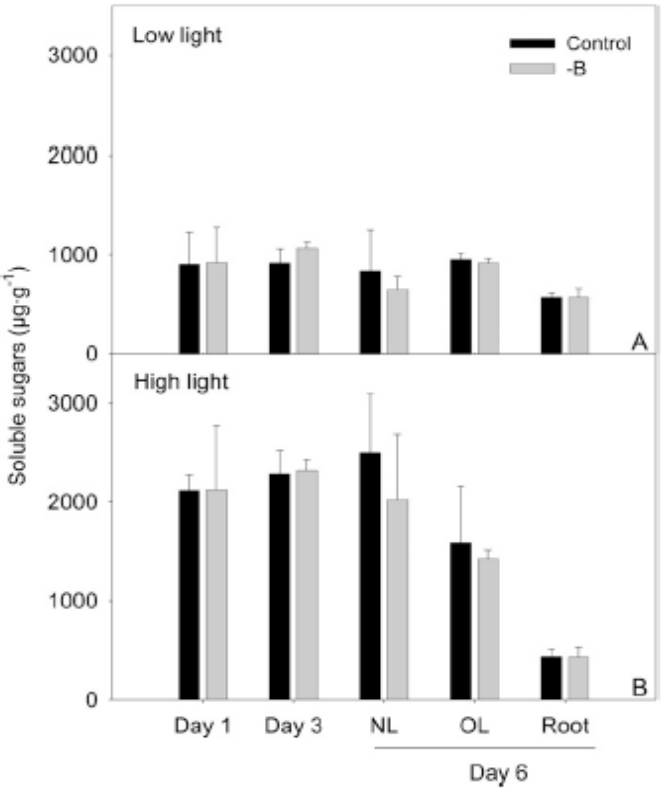

Figure 2. Effects of acute boron (B) deficiency on concentration of total soluble sugar (per unit dry weight) in leaves of geranium plants grown under low- or high-light conditions (100 or 300 $mmol \cdot m^{-2} \cdot s^{-1}$ PAR). Plants were measured after 1, 3, and 6 d of B treatment (control = 45 µM B, -B = 0 µM B). Expanding leaves were measured on days 1 and 3; on day 6, expanding new (NL) and mature older (OL) leaves and roots were measured. Results are means (n = 3) + SD.

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