Elevated CO_2 Affects Plant Responses to Variation in Boron Availability

The growth of most plants is enhanced at elevated (relative to current) levels of atmospheric CO_2, and this enhanced growth results in greater demand for mineral nutrients. The effects of elevated CO_2 on macronutrients have been well studied, but little research is available for those effects on micronutrients, especially boron (B). This study investigated the effects of elevated CO_2 on response to variation in B availability in three unrelated species: seed geranium (*Pelargonium* x *hortorum*), barley (*Hordeum vulgare*), and water fern (*Azolla caroliniana*).

Plants were grown at two levels of CO_2 (370 and 700 ppm) and low, medium, and high B (adjusted for each species). In geranium, there were interactive effects of B and CO_2 on leaf, stem, and total plant mass, root:shoot ratio, leaf [B], B uptake rate, and steady-state net photosynthesis (P_n) (Table 1).

Table 1. Results from statistical analysis (P values from ANOVA) of treatment effects of B, CO_2, and their interactions on various response variables. Geranium plants were grown at different levels of B (4.5, 45, and 450 µM) and CO_2 (370, 700 ppm).

Treatment effects			
Variables	CO_2	B	B x CO_2
Biomass:			
Leaf	0.66	0.59	0.02*
Stem	0.80	0.053	0.007*
Root	0.011*	0.730	0.36
Flower	0.211	0.552	0.240
Total	0.77	0.48	0.007*
Root:shoot	0.005*	0.84	0.029*
P_n	0.001*	0.149	0.042*
G_s	0.330	0.816	0.525
C_i	<0.0001*	0.914	0.962
Chlorophyll:			
Total	0.100	0.007*	0.078
Chl a/b	0.036*	0.016*	0.167
Sugar			
Leaf	<.0001*	0.046*	0.55
Root	0.0005*	0.166	0.526
Leaf [B]	0.0001*	<.0001*	0.00006*
Root [B]	0.082	<.0001*	0.112
B-uptake rate	<.0001*	0.0079*	0.0043*
BOR1	0.25	0.7	0.69

* Indicates significant differences among treatments at $P<0.05$

Interactive effects of B and CO_2 on growth were confirmed in barley grown at 0, 30, and 1000 µM B, wherein growth at high CO_2 was stimulated more at 30 µM B (Figure 1). Interactive effects of B and CO_2 were also confirmed with *Azolla* grown at 0, 10, and 1000 µM B, wherein growth at high CO_2 was stimulated at 0 and 10 µM B (Figure 2). Thus, low and high B both may limit growth stimulation under elevated versus current CO_2 levels.

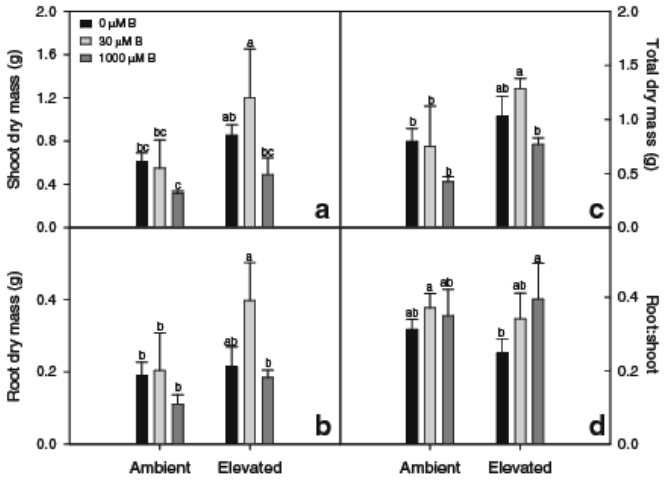

Figure 1. Effect of B (0, 30, and 1,000 µM) and CO_2 (ambient=370 and elevated= 700 ppm) on shoot and root mass of barley (*H. vulgare*). Each bar represents the mean (± 1 SD) of three independent replicates. Within each variable, different letters above the bars indicate a significant difference among treatments ($P<0.05$)

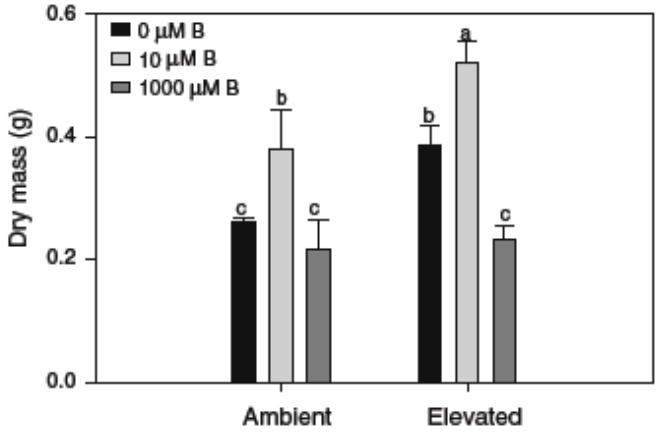

Figure 2. Effect of B (0, 10, and 1,000 µM) and CO_2 (ambient= 370 and elevated=700 ppm) on total plant biomass of water fern (*Azolla caroliniana*). Each bar represents the mean (± 1 SD) of four independent replicates. P values from ANOVA for treatments: B=<.0001, CO_2=<.0001 and B x CO_2=0.014. Within each variable, different letters above the bars indicate a significant difference among treatments ($P<0.05$).

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