ULUSLARARASI TARIMDA BOR SEMPOZYUMU BİLDİRİLER KİTABI

PROCEEDINGS OF INTERNATIONAL SYMPOSIUM ON BORON IN AGRICULTURE
ULUSLARARASI TARIMDA
BOR SEMPOZYUMU BİLDİRİLER KİTABI

PROCEEDINGS OF INTERNATIONAL
SYMPOSIUM ON BORON IN AGRICULTURE
Interactive Effect of Elevated Carbon Dioxide and Boron Toxicity on Wheat Growth

Muhammad Asif¹, Cevza Esin Tunç¹, Abdul Rehman², Levent Öztürk¹

¹Sabanci University, Faculty of Engineering and Natural Sciences, Istanbul, Turkey (lozturk@sabanciuniv.edu), ²University of Agriculture, Faisalabad, Pakistan

INTRODUCTION
Boron is an essential micronutrient involved in a range of metabolic activities from cell wall synthesis to sugar transport, RNA, phenol, carbohydrate and protein metabolism along with root elongation (Marschner, 2012). The range of boron deficiency and toxicity is narrow and its concentration must stay within a very strict range for optimum plant growth (Bonilla and González-fontes, 2011). Boron toxicity occurs mostly in dry environments and sometimes as a consequence of irrigation as well (Nable et al., 1997). Boron toxicity has been a serious problem for agricultural soils around the world.

Increased atmospheric carbon dioxide (CO₂) have been extensively reported to affect nutrition and final yield of crop plants. Meta-analysis studies revealed that shoot and grain concentration of essential macro- and micronutrients are declining in crops grown under elevated CO₂ conditions, mainly due to dilution by enhanced biomass and yield formation brought by the “CO₂ fertilization effect” (Duval et al., 2012, Myers et al., 2014). From a different point of view, elevated CO₂ might also help ameliorate nutrient toxicities such as boron toxicity. Here we hypothesized that boron concentration in shoots and roots of wheat plants grown under elevated CO₂ and boron toxic conditions will be decreased as a consequence of (i) enhanced biomass production and (ii) decreased transpiration (i.e. typically due to elevated CO₂) and thus boron uptake which would finally ameliorate the effects of B toxicity.

MATERIAL AND METHODS
Bread wheat (Triticum aestivum cv Ceyhan 99) was cultured in nutrient solution with adequate (1 μM) or toxic (900 μM) B levels in two identical growth chambers with ambient (400±10 μmol mol⁻¹) or elevated (700±10 μmol mol⁻¹) atmospheric CO₂ supply. The experimental design was completely randomized full factorial. Plants were harvested at early vegetative stage and analyzed for root length, shoot and root dry weight, root-to-shoot ratio, and root and shoot boron concentration. Biomass enhancement ratio (BER) was calculated by the ratio of dry matter production under elevated CO₂ to that of ambient conditions.

RESULTS AND DISCUSSION
Both shoot and root dry weight was significantly reduced with boron toxicity under ambient as well as elevated CO₂ conditions (Table 1). However, the reduction in shoot and root weight dry weight was ameliorated by elevated CO₂. Under ambient conditions boron toxicity reduced shoot and root dry weight by 16% and 33 % respectively whereas under elevated CO₂ shoot and root dry weight was reduced by 9% and 20% respectively. Boron toxicity severely reduced root length as well (Table 1) and in accordance with the root dry weight results its effect on root length was also ameliorated under elevated CO₂. Boron toxicity reduced root length by 33% under ambient CO₂ as compared to 18% under elevated CO₂ conditions. Biomass enhancement ratio (BER) due to elevated CO₂ was increased from 1.18 in adequate-boron plants to 1.32 in boron-toxic plants. Shoot boron concentration in plants treated with boron toxicity was reduced by 8% by elevated CO₂ whereas root boron concentration increased a little under elevated CO₂ (Table1) but the effect was statistically non-significant.

It was shown that elevated CO₂ stimulates growth of wheat plants under boron toxicity in terms of root length, root dry weight and shoot dry weight. However, the interaction of elevated CO₂ and boron was non-significant for the said parameters. Elevated CO₂ reduced shoot boron concentration of boron toxic plants as compared to ambient CO₂ although the effect was non-significant. The decreased shoot boron
concentration under elevated CO₂ may be due to the dilution effect of increased shoot weight. The increased biomass under elevated CO₂ is generally attributed to increased canopy photosynthesis but the cause of the ameliorating effect of elevated CO₂ on boron toxicity is not well understood and needs further research.

We conclude that elevated CO₂ reduces severity of boron toxicity and in future plant productivity in soils affected by boron toxicity may increase due to rising atmospheric CO₂ levels.

Table 1. Root length, shoot dry weight (DW), root DW, root:shoot ratio and shoot and root boron concentrations of wheat plants as affected by boron toxicity under ambient and elevated CO₂ conditions.

<table>
<thead>
<tr>
<th></th>
<th>Root Length (cm plant⁻¹)</th>
<th>Shoot DW (g plant⁻¹)</th>
<th>Root DW (g plant⁻¹)</th>
<th>Root:Shoot</th>
<th>Shoot B (mg kg⁻¹)</th>
<th>Root B (mg kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ambient</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adv. B</td>
<td>1496 ± 155</td>
<td>0.19 ± 0.02</td>
<td>0.09 ± 0.01</td>
<td>0.45 ± 0.03</td>
<td>4.52 ± 0.1</td>
<td>4.86 ± 0.2</td>
</tr>
<tr>
<td>Tox. B</td>
<td>994 ± 158</td>
<td>0.16 ± 0.01</td>
<td>0.06 ± 0.01</td>
<td>0.35 ± 0.04</td>
<td>710 ± 9.4</td>
<td>82.2 ± 3.6</td>
</tr>
<tr>
<td><strong>Elevated</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adv. B</td>
<td>1639 ± 233</td>
<td>0.23 ± 0.01</td>
<td>0.10 ± 0.00</td>
<td>0.43 ± 0.02</td>
<td>5.80 ± 0.5</td>
<td>3.44 ± 0.4</td>
</tr>
<tr>
<td>Tox. B</td>
<td>1343 ± 122</td>
<td>0.21 ± 0.03</td>
<td>0.08 ± 0.01</td>
<td>0.37 ± 0.02</td>
<td>643 ± 6.9</td>
<td>86.8 ± 6.9</td>
</tr>
<tr>
<td>B</td>
<td>***</td>
<td>*</td>
<td>***</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>CO₂</td>
<td>*</td>
<td>***</td>
<td>***</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td>CO₂xB</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

*p<0.05 *, *p<0.01 **, *p<0.001 *** and n.s. non significant

REFERENCES


