ULUSLARARASI TARIMDA BOR SEMPOZYUMU BİLDİRİLER KİTABI

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Interactive Effect of Elevated Carbon Dioxide and Boron Toxicity on Wheat Growth

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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 (CO_2) 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 CO_2 conditions, mainly due to dilution by enhanced biomass and yield formation brought by the "CO_2 fertilization effect" (Duval et al., 2012, Myers et al., 2014). From a different point of view, elevated CO_2 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 CO_2 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 CO_2) 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 CO_2 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 CO_2 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 CO_2 conditions (Table 1). However, the reduction in shoot and root weight dry weight was ameliorated by elevated CO_2. Under ambient conditions boron toxicity reduced shoot and root dry weight by 16% and 33 % respectively whereas under elevated CO_2 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 CO_2. Boron toxicity reduced root length by 33% under ambient CO_2 as compared to 18% under elevated CO_2 conditions. Biomass enhancement ratio (BER) due to elevated CO_2 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 CO_2 whereas root boron concentration increased a little under elevated CO_2 (Table1) but the effect was statistically non-significant.

It was shown that elevated CO_2 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 CO_2 and boron was non-significant for the said parameters. Elevated CO_2 reduced shoot boron concentration of boron toxic plants as compared to ambient CO_2 although the effect was non-significant. The decreased shoot boron concentration under elevated CO_2 may be due to the dilution effect of increased shoot weight. The increased biomass under elevated CO_2 is generally attributed to increased canopy photosynthesis but the cause of the ameliorating effect of elevated CO_2 on boron toxicity is not well understood and needs further research.

We conclude that elevated CO_2 reduces severity of boron toxicity and in future plant productivity in soils affected by boron toxicity may increase due to rising atmospheric CO_2 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 CO_2 conditions.

		Root Length			Shoot DW			Root DW			Root:Shoot			Shoot B			Root B		
		(cm plant^{-1})			(g plant^{-1})			(g plant^{-1})						(mg kg^{-1})			(mg kg^{-1})		
Ambient	Adq. B	1496	±	155	0.19	±	0.02	0.09	±	0.01	0.45	±	0.03	4.52	±	0.1	4.86	±	0.2
	Tox. B	994	±	158	0.16	±	0.01	0.06	±	0.01	0.35	±	0.04	710	±	9.4	82.2	±	3.6
Elevated	Adq. B	1639	±	233	0.23	±	0.01	0.10	±	0.00	0.43	±	0.02	5.80	±	0.5	3.44	±	0.4
	Tox. B	1343	±	122	0.21	±	0.03	0.08	±	0.01	0.37	±	0.02	643	±	6.9	86.8	±	6.9
B		***			*			***			***			***			***		
CO_2		*			***			***			n.s.			n.s.			n.s.		
CO_2xB		n.s.			n.s.			n.s.			n.s.			n.s.			n.s.		

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

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