Elevated CO_2 in air changes photosynthetic response of *Hordeum vulgare* and *Bromus secalinus* to cadmium pollution in soil

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Abstract

The aim of this study was to investigate the response of photosynthetic system and growth of summer barley (*Hordeum vulgare* L.) and rye brome (*Bromus secalinus* L.) to different cadmium concentrations effect under elevated CO_2 in atmosphere.

The growth and response of photosynthetic system were evaluated. The results showed that barley was more sensitive to Cd impact under all investigated CO_2 concentrations. Increasing CO_2 concentration increased photosynthetic rate and decreased the negative effect of Cd. The effect of Cd increased stomatal conductance of barley under elevated CO_2, while for brome it decreased. Photosynthetic pigments of barley also were more sensitive to Cd effect, but the losses were lower under elevated CO_2.

Keywords: climate change, cadmium, photosynthesis

1. Introduction

The integrated effects of increased atmospheric CO_2 and heavy metals pollution may have important implications for plant growth (Huang et al., 2017; Jia et al., 2017). Elevated atmospheric CO_2 can affect plant defences through its significant effects on plant growth (Kim, Kang, 2011). Some studies have found that elevated CO_2 can decrease oxidative stress and lead to increased rates of growth and development (Guo et al., 2015). Among the numerous heavy metals contaminants, cadmium (Cd) is one of the most toxic and prevalent pollutants of surface soils (Jia et al., 2017). Cd is a toxic heavy metal that can be readily taken up by plants, and contamination of soils with Cd is a widespread problem that affects plant growth, defence, development, and metabolite production (Januškaitienė, 2012; Jia et al., 2017).

2. Material and Methods

To study the combined effect of cadmium (300 mgCd/kg and 500 mgCd/kg substrate) and elevated atmospheric concentration of CO_2 (400, 700 and 1400 ppm CO_2) on photosynthetic parameters and growth of barley and brome, the pot experiments were conducted in closed controlled environment plant growth chambers. One plant per pot of each pot per treatment were used for the measurements of leaf gas exchange by LI-COR 6400 analyser (USA). The fully expanded leaves were harvested for the photosynthetic pigment determination at the end of the experiment. The photosynthetic pigments were analysed using a spectrophotometer and 100% acetone extracts were prepared according to Wettstein's method (Wettstein, 1957).

3. Results and Discussion

Our previous studies had explored the effects of Cd on photosynthesis and growth of plants at different development stages (Januškaitienė, Dikšaitytė, 2014), and the effect of warmed climate on different plants (Kaciene et al., 2017; Januskaitiene et al., 2018). In this reaserch barley was more sensitive to Cd impact under all investigated CO_2 concentrations (Fig. 1). The strongest negative effect of Cd on photosynthetic performance was detected under current CO_2 concentration for both plants. Cd negatively affected the efficiency of PSII, photochemistry and photosynthetic electron transport chain (Januškaitienė, Dikšaitytė 2014). Increasing CO_2 concentration increased photosynthetic rate and decreased the negative effect of Cd. Enhanced plant growth under elevated CO_2 has been shown in previous studies also; however, the magnitude of increase was dependent on plant species (Khanboluki et al., 2018). The effect of Cd on stomatal conductance under elevated CO_2 also varied: for barley it increased, while for brome it decreased and the result of that was decreased water use efficiency for barley and increased – for brome. Chlorophyll synthesis is the first step in photosynthesis, and our results show that at the three CO_2 levels, the chlorophyll content of barley decreased with the increasing Cd concentration in the soil, which is consistent with the findings of Khanboluki et al. (2018) and others. While the changes of chlorophylls of brome were insignificant in most cases. Statistically significant effect of Cd on biomass was detected only for barley and elevated CO_2 it reduced but only at 700 ppm.

4. Conclusion

This study highlights that the photosynthetic response of investigated plants under cadmium stress at elevated CO_2 concentrations changes and the response is species dependent.

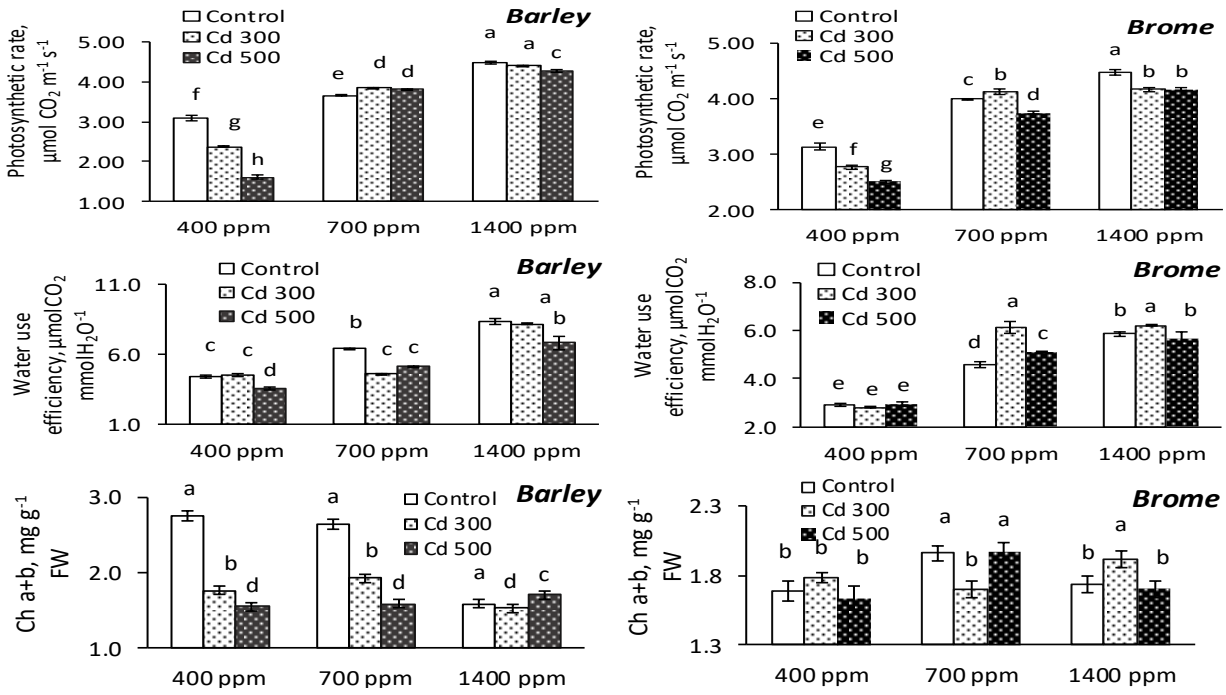

Figure 1. The changes of photosynthetic rate, water use efficiency and chlorophyll *a+b* content of summer barley and rye brome under different cadmium concentrations effect and different CO_2 concentrations in air.

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