EFFECT OF ELEVATED ATMOSPHERIC CO_2 ON CADMIUM AND MINERAL ACCUMULATION IN TWO ISOGENIC LINES OF WHEAT

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Introduction

Increasing carbon dioxide concentrations in the atmosphere pose a serious threat to the environment as well as the economy. Global atmospheric concentrations are expected to reach around 550ppm in the next 40 to 60 years. Several studies have shown that plant yield and growth increased but the studies on nutrient concentrations in plants grown in elevated CO_2 concentrations is still unclear. Some controlled chamber experiments have shown that mineral concentrations decrease in crops while open top chamber experiments have shown no change in mineral concentrations in plants at elevated CO_2 concentrations (Manderscheid et al., 1995; Lieffering et al., 2004; Myers et al., 2014).

Since the majority of the world's population relies on cereal crops such as rice and wheat for their caloric intake, most efforts focus on improvement of seed nutritional quantity and quality. There is a simultaneous need to reduce the accumulation of toxic metal analogs (e.g., cadmium) of essential micronutrients (e.g., zinc (Zn)) in seeds. Plants can readily accumulate cadmium (Cd), transferring this element to edible portions such as the leaves, fruits, and seeds. In the United States, the largest source of Cd exposure in non-smoking adults and children is through the diet (ASTDR, 2008). It is estimated that in the United States, the average person consumes about 30 mg of Cd per day in food, with the largest contribution from grain cereal products, and vegetables.

Two near isogenic wheat lines (8982 TL-L and 8982 TL-H) were used as a model in which to study these processes. These lines differ in grain Cd concentrations by 2.5 fold but are otherwise similar. The low Cd line retained more Cd in the roots and translocated less Cd to the shoots than the high Cd lines (Clarke et al., 1997; Hart et al., 1997). The comparison between the two lines will prove essential to the understanding and characterization of both Cd and nutrient transport and accumulation in the grains as a result of elevated carbon dioxide concentrations in the atmosphere. The main objective of the study is to understand the effect of elevated carbon dioxide on the nutrient and cadmium uptake and accumulation in the grains.

Fig 1: *Triticum turgidum* lines grown in hydroponic solution in elevated and ambient CO_2 conditions

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Materials and Methods

Seeds of the two isogenic lines of wheat (*Triticum turgidum* var. *durum*, TL-L (low grain Cd) and TL-H (high grain Cd) were used for the study. These lines differ 2.5 fold in grain Cd concentrations but are otherwise similar. Seeds of both lines were surface sterilized and imbibed overnight and then be germinated on filter paper. Germinated seedlings were then transferred to pots containing complete nutrient solution. The nutrient solution comprised of 2.0 mM KNO_3, 1.0 mM $Ca(NO_3)_2$, 1.0 mM $MgSO_4$, 1.0 mM KH_2PO_4, 25 μM H_3BO_3, 25 μM $CaCl_2$, 2.0 μM $MnSO_4$, 2.0 μM $ZnSO_4$, 0.5 μM $CuSO_4$, 0.5 μM H_2MoO_4, 0.1 μM $NiSO_4$, 20 μM FeHEDTA N(2Hydroxyethyl)ethylenediaminetriacetic acid, and the solutions were buffered with 2 mM MES[2(morpholino)ethanesulfonic acid] so that the pH level can be regulated at 5.5. The solution was continuously aerated and was replaced weekly.

The plants were treated with cadmium chloride at the 2 leaf stage. The Cd treatment chosen for the study was 0.5μM. The Cd concentration chosen for the studies represent the upper bound concentration usually found in Cd contaminated soils. The plants were grown under two carbon dioxide conditions – ambient and elevated CO_2. For the ambient CO_2 condition, the plants were placed in a growth chamber where the CO_2 concentrations were 400ppm. For the elevated CO_2 conditions, the plants were placed in a CO_2 controlled chamber where the CO_2 concentrations were 550ppm. Both control and Cd treated plants were placed in ambient and elevated CO_2 conditions for the duration of the study. Growth chamber conditions were set to 16-h day and 8-h night photoperiod, 25 ± 3 °C day/23 ± 3 °C night. There were 10 replicates per treatment.

Relative chlorophyll content (RCC) was recorded weekly using SPAD 502 Chlorophyll meter to ensure proper growth and to assess the physiological status of the plants. The plants will be harvested at reproductive maturity to assess the concentration of Cd in the different tissues. The harvested will be ground and digested and analyzed for Cd using SpectrAA 220FS atomic absorption spectroscopy (Varian, Walnut Creek, CA) in flame and the furnace mode.

Fig 2: Relative chlorophyll content measurement

Fig3: Elevated CO_2 controlled growth chamber

References

- ATSDR (2008) Cadmium.
- . Clarke, J.M., et al. (1997) Crop Science, 1997. 37(1): 297-297
- Hart, J.J., et al. (1997). New Phytologist, 2006. 172(2): p. 261-271
- Lieffering, M et al. (2004) Field Crops Res. 88, 279–286
- Manderscheid, R et al., (1995) . Agric. Ecosyst. Environ. 54, 175–185
- Meharg et al. (2009) Environ. Sci. Technol. 43(5): 1612-7.
- Wash, L, M, et al. (1977) Environ. Health Perspect. 19, 67-71.

Results and Conclusions

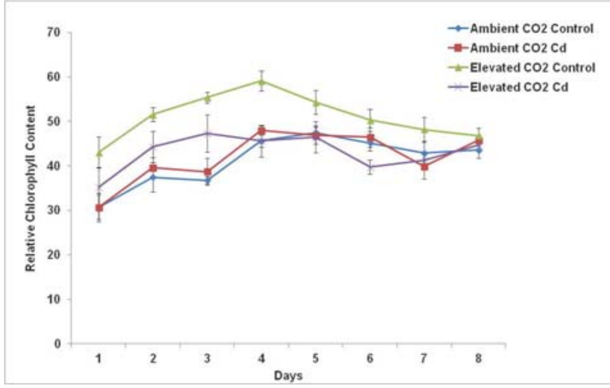

Fig 4: Relative Chlorophyll Content (RCC) of Triticum durum(LINE L) grown with Cd under ambient and elevated CO_2 conditions

In the L line, under elevated CO_2 conditions controls had higher RCC when compared to the other treatments. Elevated CO_2 control was significantly higher than ambient control . There were no significant differences between the two ambient treatments. However, the elevated control was significantly higher than the elevated Cd treatment. This suggests that Cd did not have much effect on RCC at ambient CO_2 conditions compared to elevated conditions.

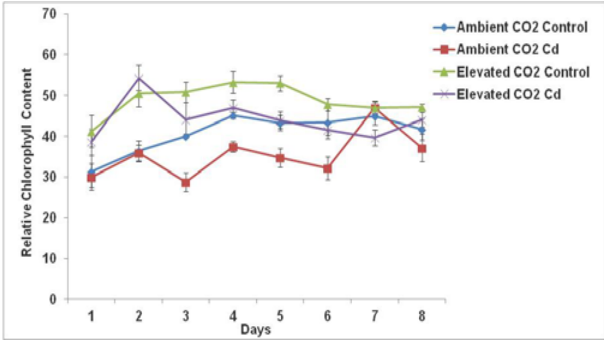

Fig 5: Relative Chlorophyll Content (RCC) of Triticum durum(LINE H) grown with Cd under ambient and elevated CO_2 conditions

In the H line, under both ambient and elevated conditions, controls had significantly higher RCC compared to Cd treatments. Plants in elevated CO_2 treatments generally had higher values when compared to their respective ambient treatment plants. This suggests that Cd had an effect in both CO_2 conditions.

Grain Cd and mineral concentrations will be analyzed in both lines for all the treatments. The results will help us understand the effect of elevated CO2 on mineral and contaminant transport and accumulation.