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Effects of atmospheric CO_2 enrichment on biomass production of spring wheat: comparison of chamber and field exposure systems

Introduction

In order to investigate the effects of elevated atmospheric carbon dioxide (CO_2) concentration on future crop production, spring wheat (*Triticum aestivum* L. cv. Triso) was grown in two different exposure systems at the Universität Hohenheim (Stuttgart, Germany). The study was performed within the framework of the integrated DFG-project "Structure and Functions of Agricultural Landscapes under Global Climate Change - Processes and Projections on a Regional Scale" (PAK 346).

Material and Methods

(i) Wheat was grown in a Mini-FACE (free-air CO_2 enrichment) system under field conditions in 2008 using three CO_2 treatments: ELE (elevated CO_2 (550 ppm) with technical installation), AMB (ambient CO_2 with technical installation) and CON (ambient CO_2 without technical installation);
(ii) Plants were grown in a Climate Chambers using the climatic profiles from the field exposure under ambient (380 ppm) and elevated (550 ppm) CO_2 concentration.
In both experiments, three harvests were performed at growth stages DC31, DC65, and DC93 according to the BBCH scale [1]. Harvested plants were separated into different fractions depending on development stage and dried until constant weight.
The data were analysed by SPSS version 15.0 for Windows using analyses of variance (ANOVA).

Results and Discussion

Results from both experiments were compared concerning future CO_2 effects on wheat biomass production. At stage DC31, the total biomass production was slightly increased under CO_2 enrichment in both exposure systems (Fig. 1). Significant CO_2 effects on biomass fractions were limited to the increase in roots (P=0.013) in the climate chambers. The total aboveground biomass was significantly higher under ambient (P=0.029) and elevated (P=0.003) CO_2 in the Mini-FACE as compared to the chamber experiment. Biomasses of stems and roots differed significantly between the exposure systems. At DC65, biomass production was not significantly affected due to CO_2 (Fig. 2). The total aboveground biomass was significantly higher in the chambers under elevated CO_2 (P=0.016; chambers *vs.* FACE), and significant differences were observed between leaf and root biomass. At final harvest, CO_2 enrichment had a strong positive effect on total aboveground biomass (+9.8%, P=0.008) and ears (+13.9%, P =0.001) in the chambers (Fig. 3), whereas in the Mini-FACE system only roots were significantly increased (P=0.05). In comparison, the total aboveground biomass was significantly higher in the chambers under high-CO_2 (P=0.007). Leaf, stem and root biomasses were significantly different between the exposure systems.
Overall, the biomass production of spring wheat in a Mini-FACE experiment showed less responses to elevated CO_2 compared to the chamber experiment.

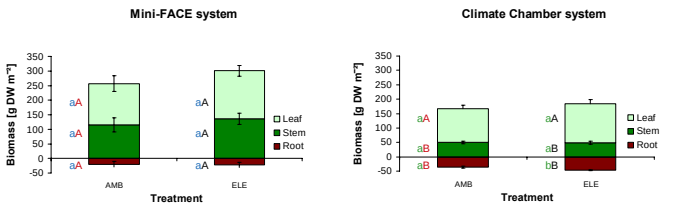

Fig. 1. Biomass production at stage DC31 of spring wheat under ambient and elevated CO_2. Given are the averages and standard deviations of five replicates (Mini-FACE) or three replicates (Climate Chambers) per treatment. Different lowercase letters indicate a statistically significant difference within the exposure systems and different capital letters between the exposure systems.

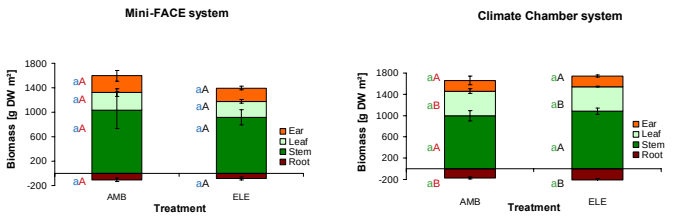

Fig. 2. Biomass production at stage DC65 of spring wheat under ambient and elevated CO_2. Given are the averages and standard deviations of five replicates (Mini-FACE) or three replicates (Climate Chambers) per treatment. Different lowercase letters indicate a statistically significant difference within the exposure systems and different capital letters between the exposure systems.

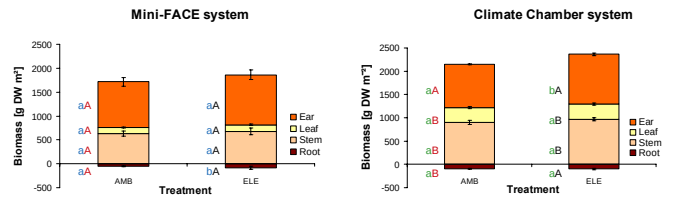

Fig. 3. Biomass production at final harvest of spring wheat under ambient and elevated CO_2. Given are the averages and standard deviations of five replicates (Mini-FACE) or three replicates (Climate Chambers) per treatment. Different lowercase letters indicate a statistically significant difference within the exposure systems and different capital letters between the exposure systems.

References

1. Meier U. (ed), 2001. Growth stages of mono- and dicotyledonous plants. BBCH-Monograph. Federal Biological Research Centre for Agriculture and Forestry. Blackwell, Oxford, pp 622.

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