UNIVERSITÄT HOHENHEIM
INSTITUT FÜR LANDSCHAFTS- UND PFLANZENÖKOLOGIE (320)
FG PFLANZENÖKOLOGIE UND ÖKOTOXIKOLOGIE

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Effects of atmospheric CO_2 enrichment on growth of spring wheat

Introduction

The ongoing increase in atmospheric CO_2 will result in changes with respect to temperature increase and precipitation pattern [1]. These alterations are expected to modify the phenology, growth and finally the yield and quality of crops. In order to investigate potential effects of CO_2 enrichment on crop growth and yield, two experiments were conducted on spring wheat (*Triticum aestivum* L. cv. Triso) at the University of Hohenheim (Stuttgart).

Material and Methods

(i) Wheat was grown in a Mini-FACE (Free Air Carbon Dioxide Enrichment) system at the research station "Heidfeldhof" in 2008 under three CO_2 treatments with five replicates each: ELE (elevated CO_2 (550 ppm) with technical equipment), AMB (ambient CO_2 (380 ppm) with the same technical installation as ELE plots) and CON (ambient CO_2 without technical equipment);

(ii) Plants were exposed in a Climate Chamber system at the Institute for Landscape and Plant Ecology from September 2008 to May 2009 under ambient (380 ppm) and elevated (550 ppm) CO_2 concentrations in combination with current and increased temperature (+4 °C).

In both experiments, phenological development, canopy height, leaf area index and chlorophyll content of wheat were examined from leaf emergence until crop maturity at weekly intervals. The growth stages were recorded using the BBCH codes [2]. The chlorophyll content was determined by using a portable chlorophyll meter (SPAD-502). LAI was measured by using a LAI-2000 Plant Canopy Analyzer. The results were analysed by SPSS version 15.0 for Windows using a one-way ANOVA.

Results and Conclusion

Results presented from both experiments were compared concerning the effects of future CO_2 concentrations on wheat growth. The interaction with increased temperature is not taken into consideration here.

The canopy height of plants in the Mini-FACE system was significantly increased under elevated CO_2 ($P \leq 0.01$) when the heading stage was completed (Fig. 1). However, only slight increases in canopy height were observed under CO_2 enrichment in the Climate Chamber system ($P > 0.05$).

In both experiments, elevated CO_2 did not show significant effects on the chlorophyll content of leaves. SPAD values of only flag leaves are shown in Fig. 2.

Maximum LAI in the Mini-FACE system was attained at the end of heading phase followed by a slow decline. Significant CO_2 effects were limited to DAS 76. In the climate chamber experiment, LAI values varied during the growth period and were unaffected under CO_2 enrichment (Fig. 3), which might have been caused by the chamber design.

Phenological development of plants varied among experiments. The crop phenology in both experiments was not affected due to elevated CO_2. The total duration of wheat development in the Climate Chamber system was extended (Fig. 4). Overall, only slight impacts of CO_2 enrichment were observed on growth parameters of spring wheat.

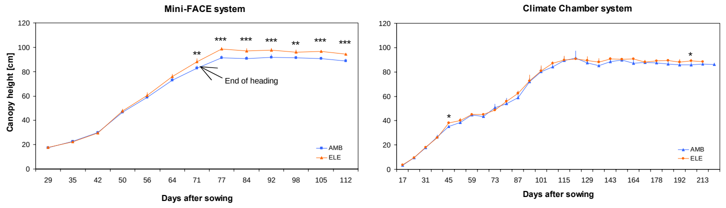

Fig. 1. Canopy height of spring wheat under ambient and elevated CO_2. Given are the averages. Error bars indicate the standard deviation. Results of the statistical analysis (one-way ANOVA) are presented as *P*-level: * $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$.

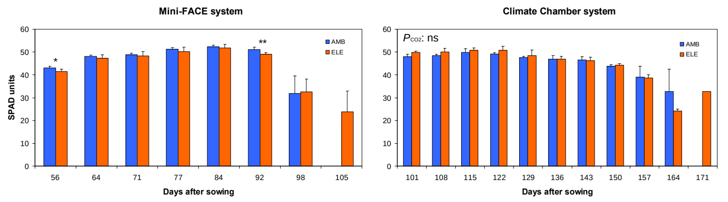

Fig. 2. Chlorophyll content in flag leaves of spring wheat. Given are the averages. Error bars indicate the standard deviation. Results of the statistical analysis (one-way ANOVA) are presented as *P*-level: * $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$.

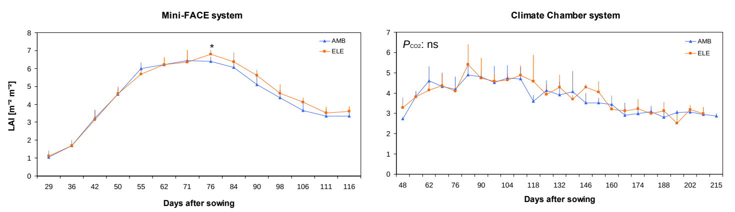

Fig. 3. Leaf Area Index (LAI) of spring wheat. Given are the averages. Error bars indicate the standard deviation. Results of the statistical analysis (one-way ANOVA) are presented as *P*-level: * $P \leq 0.05$; ** $P \leq 0.01$; *** $P \leq 0.001$.

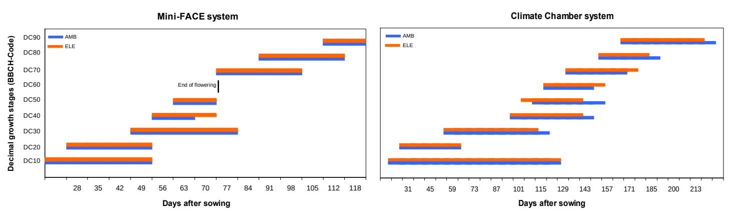

Fig. 4 . Duration of phenological phases after sowing of spring wheat. All developmental stages are based on observations on the main stem. DC stands for Decimal Code used to quantify the growth stages in cereals [2]. DC10: Leaf development; DC20: Tillering; DC30: Stem elongation; DC40: Booting; DC50: Inflorescence emergence, heading; DC60: Flowering; DC70: Development of fruit; DC80: Ripening; DC90: Senescence.

References

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