UNIVERSITÄT HOHENHEIM
INSTITUTE FOR LANDSCAPE AND PLANT ECOLOGY (320)
PLANT ECOLOGY AND ECOTOXICOLOGY

Ivan Guzman Bustamante*, Petra Högy, Iris Schmid, Jürgen Franzaring, Andreas Fangmeier

Effects of elevated CO_2 and different climatic conditions on photosynthesis of leaves and pods of oilseed rape (*Brassica napus*)

INTRODUCTION

Atmospheric CO_2 will reach a concentration that is ca. 50% higher than present at the end of the 21st century. Beside indirect effects due to temperature increase and alteration in precipitation pattern, elevated CO_2 will directly affect photosynthetic rates and biomass production of C3 plants in agricultural ecosystems, with greater stimulations occurring during the vegetative growth stage than in the reproductive growth stage (Srivastava et al., 2002). The main enzyme of the photosynthesis Ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco) is not saturated at the current CO_2 concentration for carboxylation. Elevated CO_2 concentration may cause a higher efficiency of Rubisco, making the leaf more efficient for light, nutrients and water (Zelitch 1973). However, climate conditions such as temperature may also affect photosynthesis and thus regional agricultural production.

The aim of this study is to determine the effects of elevated CO_2 concentration on photosynthetic parameters of oilseed rape (OSR), taking also into consideration the different regional climate conditions of the three experimental sites (Table 1).

MATERIALS AND METHODS

In order to investigate the effects of elevated CO_2 concentration on photosynthetic parameters of OSR, a mini-free-air carbon dioxide enrichment (FACE) system was used at the Heidfeldhof (HFH) in the south of Stuttgart (Germany). Spring OSR was grown under ambient (AMB, 380 ppm CO_2) and elevated (ELE, 550 ppm CO_2) conditions. CO_2 response curves (A/C_i curves) on leaves and pods were measured twice weekly using a LI-6400 infrared gas analyzer (LI-COR, Lincoln, USA). By fitting the A/C_i curves to the Farquhar photosynthesis model, the parameters Vc_{max} (maximum carboxylation rate µmol CO_2 m^{-2} s^{-1}), J_{max} (RuBP limited rate of electron transport µmol e^- m^{-2} s^{-1}) and R_{day} (daytime respiration rate µmol CO_2 m^{-2} s^{-1}) were estimated.

In order to investigate the effect of different climate conditions on photosynthetic parameters of winter OSR, light response curves were measured biweekly at the experimental sites in the Kraichgau and Swabian Alb area. The light compensation point (LCP; µmol m^{-2} s^{-1}), quantum yield (Φ; mol CO_2 mol photons^{-}) and photosynthetic capacity (A_{max}; mol CO_2 m^{-2} s^{-1}) were estimated from each light curve.

RESULTS AND DISCUSSION

Elevated CO_2 concentration had no significant effects on photosynthetic parameters such as Vc_{max} (Figure 1), although slightly lower values were observed in the ELE treatment at growth stages 65 to 69 (full flowering until end of flowering). Regardless of CO_2 treatment, slightly higher carboxylation rates were observed in leaves at growth stages 65 to 69 while pods showed only a small photosynthetic activity. Nevertheless, pods may contribute substantially to the seed growth of OSR (Sheoran et al., 1991). Since high temperature sped OSR development and gas exchange measurements can only be conducted at good weather conditions the number of replicates may be not sufficient to find significant differences between CO_2 treatments.

With regard to the different climate conditions at the experimental sites Kraichgau and Swabian Alb, no differences were found for all parameters derived from the light response curves (Figure 2).

Table 1: Climate conditions for the three experimental sites.

Site	Data from	Elevation (m asl)	Annual mean temperature (°C)	Annual precipitation sum (mm)	Agricultural use
HFH	HFH	400	8,5	685	Intensive
Kraichgau	Pforzheim-Eutingen	246	9,1	782	Intensive
Swabian Alb	Geislingen an der Steige-Stötten	734	6,8	1069	Extensive

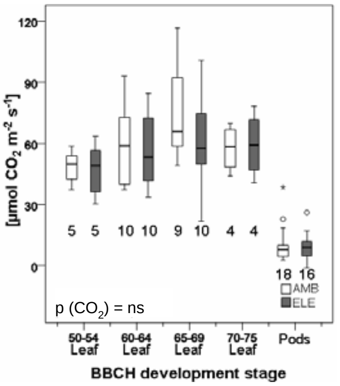

Figure 1. Maximum rate of carboxylation (Vc_{max}) at different development stages under ambient (AMB) and elevated (ELE) CO_2 concentration at the HFH. The number of replicates is indicated under each box plot.

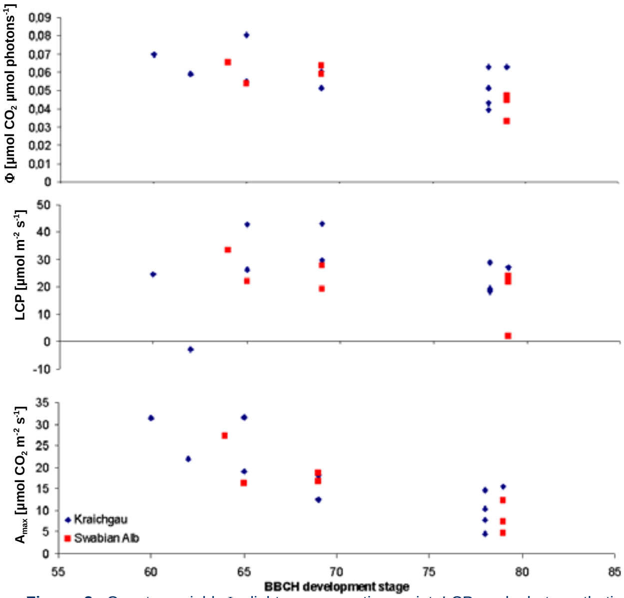

Figure 2. Quantum yield Φ, light compensation point LCP and photosynthetic capacity A_{max} at different development stages of OSR on the study sites Kraichgau and Swabian Alb. Each point represents one measurement.

Overall, decreases in all parameters were observed in the reproductive growth stages due to senescence processes. The slight differences in light response curve parameters on a growth stage basis at both experimental areas were most likely cultivar specific.

Further data analysis is necessary for a better understanding of how elevated CO_2 and climate impacts may affects photosynthesis of OSR. Moreover, the evaluation of other gas exchange parameters such as water use efficiency (WUE) and stomatal conductance (g_s) will help to understand the likely impacts of climate change on crops.

*Contact: guzman@uni-hohenheim.de

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