Do maize crop models catch the impact of future [CO_2] on maize yield and water use ?

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Introduction

Maize is a major crop in the world. The ability of crop models to predict the complexity of the interactions behind the yield response to climate and especially to air CO_2 concentration [CO_2] needs to be tested (Bassu et al., 2012). Furthermore, the water use is a key issue for assessing our ability to sustain maize yields under future climate, since hotter and dryer conditions may become more frequent. In the study reported here, a Free Air CO_2 Enrichment (FACE) showing a very large impact of [CO_2] on yield

under drought (Manderscheid et al., 2014) was used to test the ability of 20 maize models to simulate the observed responses of yield and water use.

Materials and Methods

The Experiment combined two [CO_2] air concentrations: ambient and 550 ppm, approximately, crossed with two irrigation regimes bringing about contrasted soil water contents. Yield, water use, leaf area index, soil water content and [CO_2] levels were recorded in 2007 and 2008. However, only 2008 exhibited a significant water deficit. On that year a 40 % increase of yield, approximately, was observed under 550 ppm [CO_2], the crop water use remaining unaltered.
20 modelling groups using different crop models were given the same instructions and input data. Following a preliminary calibration (cultivar parameters) based on non-limiting water conditions and under ambient [CO_2] treatments of both years, a simulation was undertaken for the other treatments: High [CO_2] (550 ppm) 2007 and 2008, both irrigation regimes, and DRY AMBIENT 2007 and 2008.

Results and Discussion

As in the experiment, simulations showed virtually no yield responses to [CO_2] under non-limiting water conditions. Only under severe water deficits did models simulate an increase in yield for CO_2 enrichment, which was related to a higher harvest index and, for those models which simulated it, a higher grain number. However, the CO_2 enhancement under water deficit simulated by the 20 models was 20 % at most and 10 % on average only. As in the experiment, the simulated impact of [CO_2] on water use was negligible, with a general displacement of the water deficit toward later phases of the crop along with a longer green leaf area duration.
The very large impact of CO_2 reported in that experiment was mainly due to the coincidence of a strong water stress with anthesis, a short and sensitive phase of the growth cycle bringing about a large decrease in grain number. This was not detected properly by models which simulated a maximum water stress in later phase of the growing cycle. Both the ability of current models to catch the water use induced positive impact of CO_2 on yield and their difficulty to match the actual increase will be discussed.

References

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