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# Atmospheric $CO_2$ concentration impacts on maize yield performance under dry conditions: do crop model simulate it right ?

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In most regions of the world, maize yields are at risk of be reduced due to rising temperatures and reduced water availability. Rising temperature tends to reduce the length of the growth cycle and the amount of intercepted solar energy. Water deficits reduce the leaf area expansion, photosynthesis and sometimes, with an even more pronounced impact, severely reduce the efficiency of kernel set. In maize, the major consequence of atmospheric $CO_2$ concentration ([$CO_2$]) is the stomatal closure-induced reduction of leaf transpiration rate, which tends to mitigate those negative impacts. Indeed FACE studies report significant positive responses to $CO_2$ of maize yields (and other C4 crops) under dry conditions only. Given the projections by climatologists (typically doubling of [$CO_2$] by the end of this century) projected impacts must take that climate variable into account. However, several studies show a large incertitude in estimating the impact of increasing [$CO_2$] on maize remains using the main crop models. The aim of this work was to compare the simulations of different models using input data from a FACE experiment conducted in Braunschweig during 2 years under limiting and non-limiting water conditions. Twenty modelling groups using different maize models were given the same instructions and input data. Following calibration of cultivar parameters under non-limiting water conditions and under ambient [$CO_2$] treatments of both years, simulations were undertaken for the other treatments: High [ $CO_2$ ] (550 ppm) 2007 and 2008 in both irrigation regimes, and DRY AMBIENT 2007 and 2008. Only under severe water deficits did models simulate an increase in yield for $CO_2$ enrichment, which was associated with higher harvest index and, for those models which simulated it, 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, i.e. twice less than observed in that experiment. 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 longer green leaf area duration at reduced transpiration rate. In general models which used explicit response functions of stomatal conductance to [$CO_2$] performed significantly better than those which did not. Our results highlight the need for model improvement with respect to simulating transpirational water use and its impact on water status during the kernel-set phase. We shall discuss the various ways of simulating the response of stomatal conductance to [$CO_2$] and the response of kernel set to water deficits.