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Assessment of the ‘CO2 fertilization effect’ on crops with the AquaCrop model

Eline Vanuytrecht and Dirk Raes

K.U.Leuven, Division of Soil and Water Management, Department of Earth and Environmental Sciences, Heverlee, Belgium (eline.vanuytrecht@ees.kuleuven.be, +32 16 32 97 60)

The global climate is changing due to the augmented emission of greenhouse gases. Elevated air temperatures, increased evaporative demand of the atmosphere and altered rainfall patterns are expected and may have a detrimental impact on crop growth and production. In contrast, the steady increase of the atmospheric CO_2 concentration ([CO_2]), which is a main cause of the climatic changes, can have a positive effect on crop productivity and water use (‘CO_2 fertilization effect’). The combined impact of climatic changes and elevated [CO_2] on agricultural productivity can be evaluated with models.

AquaCrop, the crop water productivity model of FAO is widely applicable for a broad range of crops and geographical locations, and aims for accuracy, robustness and simplicity (Raes et al., 2009; Steduto et al., 2009). In the model, crop transpiration and crop water productivity responses to elevated [CO_2] are simulated through a downward adjustment of the crop transpiration coefficient and an upward adjustment of the water productivity parameter (WP). Evidence for both effects was obtained via a meta-analysis of primary literature on FACE (free air CO_2 enrichment) experiments. The procedure to consider the effect of CO_2 was recently adjusted because the existing procedure for adjustment of WP (Steduto et al., 2007) resulted in a strong overestimation of the crop response when compared to FACE experiments. The lower response in the field can be due to suboptimal fertility management that does not consider the increased nitrogen demand under elevated [CO_2], crops’ limited sink capacity, and carbon leakage processes.

With the updated procedure, users are now allowed to specify their preference to simulate the CO_2 effect to be closer to the lower ‘field’ effect or the higher ‘theoretical’ effect as derived by Steduto et al. (2007). This feature permits to differentiate between crops with different sink capacities (e.g., potato with a higher sink capacity than wheat) or to follow trends in breeding (e.g., improved varieties might exhibit a more optimal response to CO_2 in the future). Further, the updated procedure treats C3 and C4 crops differently as the positive CO_2 effect on C4 crops is mainly confined to decreased crop transpiration.

AquaCrop can be run with weather data projected for the future as generated by (stochastic) weather generators in combination with projected [CO_2] levels for different climate scenarios to assess crop production and the soil water balance under future climatic conditions. A number of simulation studies have demonstrated that the ‘CO_2 fertilization effect’ can temper the detrimental effects of changed climatic factors in certain locations or improve the agricultural production in other places. For a case study in Tunis (Tunisia), simulated yield of wheat decreased for the period 2046-2065 compared to the baseline period if only the effect of climatic changes (rainfall, ETo and temperature) were considered while yield increased if also the effect of elevated CO_2 was considered. For another study in Mekelle (Ethiopia), simulated yield of tef increased modestly under changed climatic conditions for the period 2046-2065 compared to the baseline period without consideration of elevated [CO_2]. If the ‘CO_2 fertilization effect’ was considered, the yield increase was even much stronger. The simulation results confirm the need for quantification of the CO_2 effect on crops in addition to the effect of altered air temperatures, rainfall patterns and evaporative demand to assess the agricultural productivity in the future.

References

Raes, D., Steduto, P., Hsiao, T.C., Fereres, E., 2009. Agron. J. 101, 438-447.

Steduto, P., Hsiao, T. C., Raes, D., Fereres, E., 2009. Agron. J. 101, 426-437.

Steduto, P., Hsiao, T.C., Fereres, E., 2007. Irrig. Sci. 25, 189-207.