Crop yields, soil organic carbon and soil nitrogen content change under climate change

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Introduction

It has been demonstrated that model ensembles is an efficient way to reduce the uncertainty associated with climate change impact on crop growth. (Asseng et al., 2015). Using such this approach, wheat and maize grain yields response to temperature increase were simulated by Asseng et al., 2015 and Bassu et al., 2014 using annually re-initialized soil conditions (soil water and nitrogen). Basso et al., 2015, showed that by running models in a continuous mode, yield results differed from the annual reinitialized runs. In this study, we present the results of continuous model run of the AgMIP wheat- and maize-pilot under temperature and CO_2 changes and different management practices.

Materials and Methods

Five maize models and seven wheat models were run using a continuous mode under conventional tillage and no-till using the same factorials temperature, CO_2, rain and nitrogen fertilization levels of the AgMIP pilots (Asseng et al., 2015 and Bassu et al., 2014). We evaluate the range of response provided by the different models soil organic carbon (SOC) dynamic, soil nitrogen ($N\text{-}NO_3^-$) and water dynamics under the maize-fallow and wheat-fallow crop rotations.

Results and Discussion

Under continuous running mode, models agreed in the direction of the changes for soil $N\text{-}NO_3^-$ and SOC under the different temperature treatments. Furthermore, soil $N\text{-}NO_3^-$ was found to increase and SOC was found to decrease with temperature increases. Consequently, important differences on simulated yields were observed between reinitialized and continuous run of the model. Fig. 1 compares the average model results under different CO_2 treatments and soil management practices for the continuous run. Whatever the temperature, yields were overall higher when CO_2 increased and lower when practicing no-till. Soil $N\text{-}NO_3^-$ was lower under higher CO_2 concentration and was found to increase with temperature.

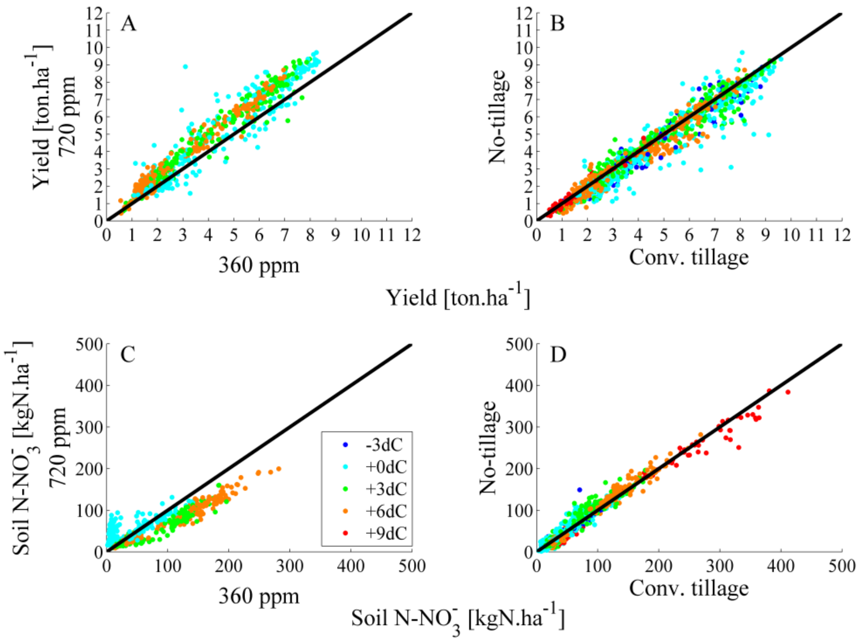

Figure 1. Wheat yield (A-B) and soil $N\text{-}NO_3^-$ (C-D) content under different temperature (-3 to +9°C) treatments. Impact of CO_2 concentration (A-C) and tillage practice (B-D).

Conclusions

Continuous running mode of crop models appeared as a promising way to better understand the interactions between soil, climate and crop management. Such an approach is a promising mean to conceive crop and soil management strategies able to mitigate adverse climate change impacts.

References

Asseng, S., Ewert, F., Martre, P. et al., (2015). Nature Clim. Change 5: 143-147.
Bassu, S., Brisson, N., Durand, JL., Boote, K. et al., (2014). Global Change Biology 20: 2301-2320.
Basso B. et al., (2015). Plos One 10(6): e0127333.