An ensemble of projections of wheat adaptation to climate change in europe analyzed with impact response surfaces

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Introduction

Adaptation of crops to climate change (CC) requires reliable climate projections with low uncertainty at regional level. When these are not available, approaches can be used to manage the uncertainties involved, e.g. by exploring the potential changes in climate and their impacts. Here we use an ensemble of crop models applied to rainfed winter wheat at Lleida (NE Spain) and analyze the results by constructing impact response surfaces (IRSs).

Materials and Methods

The methodology is adapted from Pirttioja et al., (2015). The modelling experiment is a sensitivity analysis of an ensemble of crop models to changes in baseline (1981-2010) temperature (T) and precipitation (P), perturbed with a delta change approach and with changes in the seasonal patterns. Three levels of CO_2 are simulated, representing conditions until 2050. Two actual soil profiles of the Lleida site are considered. Crop models were calibrated with field data (Abeledo et al., 2008; Gabrielle et al., 2006). A pilot simulation stage conducted with the models DSSAT4.5 and SiriusQuality v.2

served as basis for selecting the adaptation options to be simulated by the whole ensemble of crop models (18 members and 11 models).

Results and Discussion

The specific adaptation options (Table 1) were identified based on the outcome from preliminary simulations. A total of 54 adaptation combinations were defined resulting in more than 450.000 runs per crop model.

Table 1. Adaptation options to be simulated by the ensemble of crop models.

Options	Vernalisation	Cycle length*	Sowing date	Irrigation
	Yes	+10 %	15 days earlier	40 mm at flowering
	No	-10 %	30 days later	Full irrigation
Number of options	1+baseline= 2	2+ baseline= 3	2+ baseline= 3	2+baseline= 3

*Maintaining pre-post-anthesis ratio

Maximum RMSE for calibrated variables was set at 20 %. The models were then considered trustworthy for reproducing crop development and growth and were used for constructing IRSs. One example of preliminary results are presented in Figure 1, that shows how yield is affected by changes in T, P and CO_2 and that adaptation strategies may help to reduce detrimental effects of CC.

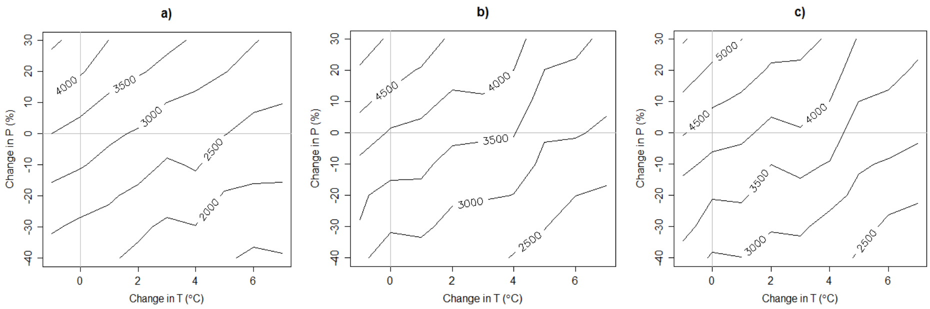

Figure 1. IRSs for wheat yield in Lleida (kg/ha) built with SiriusQuality v.2 for a) baseline CO_2, cultivar and management, b) 447 ppm of CO_2 and 1-month delay in sowing date, and c) as b) but for 522 ppm of CO_2

Conclusions

Our study exemplifies the challenge of conducting adaptation under highly uncertain future conditions, attributable here to the high natural climate variability, the complex topography, the water-limited environment and the limited set of available field data.

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References

Abeledo, L.G., R. Savin and G.A. Slafer (2008). European Journal of Agronomy 28:541-550.
Cartelle, J., A. Pedró, R. Savin, G.A. Slafer (2006) European Journal of Agronomy 25:365-371.
Pirttioja, N., T.R. Carter, S. Fronzek, et al., (2015). Climate Research, in press.