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Applying adaptation response surfaces for managing wheat under perturbed climate and elevated CO₂ in a Mediterranean environment

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Abstract/Executive summary

This study developed Adaptation Response Surfaces and applied them to a study case in North East Spain on winter crops adaptation, using rainfed winter wheat as reference crop. Crop responses to perturbed temperature, precipitation and CO₂ were simulated by an ensemble of crop models. A set of combined changes on cultivars (on vernalisation requirements and phenology) and management (on sowing date and irrigation) were considered as adaptation options and simulated by the crop model ensemble. The discussion focused on two main issues: 1) the recommended adaptation options for different soil types and perturbation levels, and 2) the need of applying our current knowledge (AOCK) when building a crop model ensemble. The study has been published Agricultural Systems (Available online 25 January 2017, <https://doi.org/10.1016/j.agsy.2017.01.009>), and the text below consists on extracts from that paper.

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Introduction

Adaptation of crops to climate change has to be addressed locally due to the variability of soil, climate and the specific socio-economic settings influencing farm management decisions. Adaptation of rainfed cropping systems in the Mediterranean is especially challenging due to the projected decline in precipitation in the coming decades, which will increase the risk of droughts (IPCC, 2013).

Methods

Methods that can help explore uncertainties in climate projections and crop modelling, such as impact response surfaces (IRs, Pirttioja et al., 2015) and ensemble modelling, can then be valuable for identifying effective adaptations. Here, an ensemble of 17 crop models was used to simulate a total of 54 adaptation options for rainfed winter wheat (*Triticum aestivum*) at Lleida (NE Spain), calibrated with field data from Cartelle et al. (2006) and Abeledo et al. (2008). To support the ensemble building, an ex post quality check of model simulations based on several criteria was performed. Those criteria were based on the “According to Our Current Knowledge” (AOCK) concept, which has been formalized here. Adaptations were based on changes in cultivars and management regarding phenology, vernalization, sowing date and irrigation. The effects of adaptation options under changed precipitation (P), temperature (T), [CO₂] and soil type were analysed by constructing response surfaces, which we termed, in accordance with their specific purpose, adaptation response surfaces (ARSs). These were created to assess the effect of adaptations through a range of plausible P, T and [CO₂] perturbations

Results

The results indicated that impacts of altered climate were predominantly negative. No single adaptation was capable of overcoming the detrimental effect of the complex interactions imposed by the P, T and [CO₂] perturbations except for supplementary irrigation (sl), which reduced the potential impacts under most of the perturbations. Yet, a combination of adaptations for dealing with climate change demonstrated that effective adaptation is possible at Lleida. Combinations based on a cultivar without vernalization requirements showed good and wide adaptation potential. Few combined adaptation options performed well under rainfed conditions. However, a single sl was sufficient to develop a high adaptation potential, including options mainly based on spring wheat, current cycle duration and early sowing date.

Discussion

Three novelties were presented in this paper: 1) the use of an ensemble of crop models for supporting adaptation; 2) ARSs, which have proved to be a useful tool for planning adaptations under highly uncertain conditions; and 3) the formalization of the AOCK concept, which should be a driver for comprehensively interpreting model results in all modelling studies. Based on these, we conclude that effective adaptation at Lleida is possible. When locally addressed (Reidsma et al., 2015) the scope for adaptation widens and several solutions might arise depending on the availability of irrigation (Lorite et al., 2012; Acutis and Ventrella, 2015). Depending on local environment (e.g. soil type), many of the adaptations proposed here can maintain current yield levels under moderate changes in T and P, and some also under strong changes. We conclude that ARSs can offer a useful tool for supporting planning of field level adaptation under conditions of high uncertainty.

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