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


1 Universidad Politecnica de Madrid, ETSI Agrónomos, 28040 Madrid, Spain, margarita.ruiz.ramos@upm.es
2 University of Florence, 50144 Florence, Italy
3 IFAPA - Junta de Andalucia, 14004 Córdoba, Spain
4 Environmental Impacts Group, Natural Resources Institute (Luke), 01301 Vantaa, Finland
5 Finnish Environment Institute (SYKE), 00250 Helsinki, Finland
6 Leibniz Centre for Agricultural Landscape Research (ZALF), 15374 Müncheberg, Germany
7 Institute of Agrosystems and Bioclimatology, Mendel University in Brno, Brno 613 00, Czech Republic
8 Global Change Research Centre AS CR, 603 00 Brno, Czech Republic
9 INRES, University of Bonn, 53115 Bonn, Germany
10 Institute of Agrophysics Polish Academy of Sciences, Lublin, Poland
11 INRA, UMR 1114 EMMAH, F-84914 Avignon, France
12 James Hutton Institute, Invergowrie, Dundee, DD2 5DA, Scotland
13 University of Sassari, 07100 Sassari, Italy
14 Université de Liège, 4000 Liège, Belgium
15 University of Copenhagen, 2630 Taastrup, Denmark
16 RIFCON GmbH, 69493 Hirschberg, Germany
17 Rothamsted Research, Harpenden, Herts, ALS 2JQ, UK
18 Wageningen University, 6700AA Wageningen, The Netherlands
19 Consiglio per la ricerca in agricoltura e l’analisi dell’economia agraria (CREA-SCA), 70125 Bari, Italy

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 CO₂ 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.

<table>
<thead>
<tr>
<th>Number of options</th>
<th>Vernalisation</th>
<th>Cycle length*</th>
<th>Sowing date</th>
<th>Irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1+baseline= 2</td>
<td>Yes</td>
<td>+10 %</td>
<td>15 days earlier</td>
<td>40 mm at flowering</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>-10 %</td>
<td>30 days later</td>
<td>Full irrigation</td>
</tr>
<tr>
<td>2+ baseline= 3</td>
<td></td>
<td></td>
<td>2+ baseline= 3</td>
<td>2+baselines 3</td>
</tr>
</tbody>
</table>

*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.

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