FACCE-MACSUR

Applying adaptation response surfaces for managing wheat under perturbed climate and elevated CO_2 in a Mediterranean environment

M. Ruiz-Ramos[a*], R. Ferrise[b], A. Rodríguez[a], I.J. Lorite[c], M. Bindi[b], T.R. Carter[d], S. Fronzek[d], T. Palosuo[e],N. Pirttioja[d], P. Baranowski [f], S. Buis[g], D. Cammarano[h], Y. Chen[e], B. Dumont[i], F. Ewert[j], T. Gaiser [j],P. Hlavinka[k,l], H. Hoffmann[j], J.G. Höhn[e], F. Jurecka[k,l], K.C. Kersebaum[m], J. Krzyszczak[f], M. Lana[m], A. Mechiche-Alami[n], J.Minet[o], M. Montesino[p], C. Nendel[m], J.R. Porter[p], F. Ruget[h], M.A. Semenov[q], Z. Steinmetz[r], P. Stratonovitch[q], I. Supit[s], F. Tao[e], M. Trnka[k,l], A. de Wit[s], R.P. Rötter[t]

[a] Universidad Politécnica de Madrid, ETSIAAB, 28040 Madrid, Spain
[b] University of Florence, 50144 Florence, Italy
[c] IFAPA Junta de Andalucía, 14004 Córdoba, Spain
[d] Finnish Environment Institute (SYKE), 00250 Helsinki, Finland
[e] Natural Resources Institute Finland (Luke), 00790 Helsinki, Finland
[f] Institute of Agrophysics, Polish Academy of Sciences, Doświadczalna 4, 20-290 Lublin, Poland
[g] INRA, UMR 1114 EMMAH, F-84914 Avignon, France
[h] James Hutton Institute, Invergowrie, Dundee DD2 5DA, Scotland, United Kingdom
[i] Dpt. AgroBioChem & Terra, Crop Science Unit, ULgGembloux Agro-Bio Tech, 5030 Gembloux, Belgium
[j] INRES, University of Bonn, 53115 Bonn, Germany
[k] Institute of Agrosystems and Bioclimatology, Mendel University in Brno, Brno 613 00, Czech Republic
[l] Global Change Research Institute CAS, 603 00 Brno, Czech Republic
[m] Institute of Landscape Systems Analysis, Leibniz Centre for Agricultural Landscape Research (ZALF), 15374 Müncheberg, Germany
[n] Department of Physical Geography and Ecosystem Science, Lund University, 223 62 Lund, Sweden
[o] Université de Liège, Arlon Campus Environnement, 6700 Arlon, Belgium
[p] University of Copenhagen, 2630 Taastrup, Denmark

i

Instrument:	Joint Programming Initiative
Topic:	Agriculture, Food Security, and Climate Change
Project:	Modelling European Agriculture with Climate Change for Food Security (FACCE-MACSUR)
Start date of project:	1 June 2015
Duration:	24 months
Theme, Work Package:	CropM
Deliverable reference num.:	D-C4.4
Deliverable lead partner:	p24, U Politécnica de Madrid
Due date of deliverable:	month 24 (MACSUR2)
Submission date:	Available online 25 January 2017
Confidential till:	Public

Revision	Changes	Date
1.0	First public release	2017-06-04

[q] Rothamsted Research, Harpenden, Herts AL5 2JQ, UK
[r] RIFCON GmbH, 69493 Hirschberg, Germany
[s] Wageningen University, 6700AA Wageningen, The Netherlands
[t] TROPAGS, Department of Crop Sciences, Georg-August-Universität Göttingen, Grisebachstr. 6, 37077 Göttingen, Germany

*margarita.ruiz.ramos@upm.es

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.

Table of Contents

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 (IRSs, 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 andmanagement 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 (sI), 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 sI 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 haveproved 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.

Acknowledgements

This work was financially supported by the Spanish National Institute for Agricultural and Food Research and Technology (INIA, MACSUR01-UPM), the Italian Ministry of Agriculture and Forestry and the Finnish Ministry of Agriculture and Forestry (D.M. 24064/7303/15) through FACCE MACSUR − Modelling European Agriculture with Climate Change for Food Security, a FACCE JPI knowledge hub; MULCLIVAR, fromthe SpanishMinisterio de Economía y Competitividad (MINECO, CGL2012-38923-C02-02); the Academy of Finland (decisions: 277276 and 277403), the EU FP7 IMPRESSIONS project (grant agreement no. 603416), the NORFASYS project (decision nos. 268277 and 292944) and PLUMES project (decision nos. 277403 and 292836); project IGA AF MENDELU no. 7/2015 with the support of the Specific University Research Grant provided by the Ministry of Education, Youth Sports of the Czech Republic; theMinistry of Education, Youth Sports of the Czech Republic within the National Sustainability Programme I (NPU I), grant number LO1415 NAZV QJ1310123 the Polish National Centre for Research and Development in frame of the projects: LCAgri, contract number BIOSTRATEG1/271322/3/NCBR/2015 and GyroScan, **contract number** BIOSTRATEG2/298782/11/NCBR/2016.

References

Abeledo, L.G., Savin, R., Slafer, G.A., 2008. Wheat productivity in the Mediterranean Ebro Valley: analyzing the gap between attainable and potential yield with a simulation model. Eur. J. Agron. 28, 541–550.

Acutis, M., Ventrella, D., 2015. L'acqua, l'agricoltura e il clima che cambia. In: Mastrorilli, M. (Ed.), L'acqua in agricoltura. Gestione sostenibile della pratica irrigua, Edagricole, pp. 43–60.

Cartelle, J., Pedro, A., Savin, R., Slafer, G.A., 2006. Grain weight responses to post-anthesis spikelet-trimming in an old and a modern wheat under Mediterranean conditions. Eur. J. Agron. 25, 365–371.

IPCC, 2013. Annex I: Atlas of Global and Regional Climate Projections Supplementary Material RCP8.5 [van Oldenborgh, G.J., Collins, M., Arblaster, J., Christensen, J.H., Marotzke, J., Power, S.B., Rummukainen, M., Zhou, T. (eds.)]. In: Stocker, T.F., et al.(Eds.), Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Available from. www.climatechange2013.org. www.ipcc.ch.

Lorite, I.J., Garcia-Vila, M., Carmona, M.A., Santos, C., Soriano, M.A., 2012. Assessment of the irrigation advisory services' recommendations and farmers' irrigation management: a case study in southern Spain. Water Resour. Manag. 26, 2397–2419.

Pirttioja, N., Carter, T.R., Fronzek, S., Bindi, M., Hoffmann, H., Palosuo, T., Ruiz-Ramos, M., Tao, F., Trnka, M., Acutis, M., Asseng, S., Baranowski, P., Basso, B., Bodin, P., Buis, S., Cammarano, D., Deligios, P., Destain, M.F., Dumont, B., Ewert, F., Ferrise, R., François, L., Gaiser, T., Hlavinka, P., Jacquemin, I., Kersebaum, K.C., Kollas, C., Krzyszczak, J., Lorite, I.J., Minet, J., Minguez, M.I., Montesino, M., Moriondo, M., Müller, C., Nendel, C., .ztürk, I., Perego, A., Rodríguez, A., Ruane, A.C., Ruget, F., Sanna, M., Semenov, M.A., Slawinski, C., Stratonovitch, P., Supit, I., Waha, K., Wang, E., Wu, L., Zhao, Z.,

Rötter, R.P., 2015. Temperature and precipitation effects on wheat yield across a European transect: a crop model ensemble analysis using impact response surfaces. Clim. Res. 65, 87–105.

Reidsma, P., Wolf, J., Kanellopoulos, A., Schaap, B.F., Mandryk, M., Verhagen, J., van Ittersum, M.K., 2015. Climate change impact and adaptation research requires integrated assessment and farming systems analysis: a case study in the Netherlands. Environ. Res. Lett. 10, 12.