Designing new cereal cultivars as an adaptation measure using crop model ensembles

Reimund Rötter[1], Taru Palosuo[1], Mikhail Semenov[2], Margarita Ruiz-Ramos[3], Fulu Tao[1], Stefan Fronzek[4], Ni na Pirttioja[4], Marco Bindi[5], Timothy Carter[4], Holger Hoffmann[6], Jukka Höhn[1], Christian Kersebaum[7], Inés Mín guez-Tudela[3], Roberto Ferrise[5], Mirek Trnka[8]

[1]*Plant Production Research, MTT Agrifood Research Finland, FI, reimund.rotter@mtt.fi, taru.palosuo@mtt.fi, fulu.tao@mtt.fi, jukka.hohn@mtt.fi*
[2]*Computation and Systems Biology Department, Rothamsted Research, GB, mikhail.semenov@rothamsted.ac.uk*
[3]*Research Centre for the Management of Agricultural and Environmental Risks CEIGRAM-AgSystems, Technical University of Madrid, ES, margarita.ruiz.ramos@upm.es, ines.minguez@upm.es*
[4]*Climate Change Programme, Finnish Environment Institute (SYKE), FI, stefan.fronzek@ymparisto.fi, nina.pirttioja@ymparisto.fi, tim.carter@ymparisto.fi*
[5]*Department of Agri-food Production and Environmental Sciences, University of Florence, IT, marco.bindi@unifi.it, roberto.ferrise@unifi.it*
[6]*Institute of Crop Science and Resource Conservation (INRES), University of Bonn, DE, hhoffmann@uni-bonn.de*
[7]*Leibniz-Centre for Agricultural Landscape Research (ZALF), DE, ckersebaum@zalf.de*
[8]*Department of Agrosystems and Bioclimatology, Mendel University in Brno, and Global Change Research Centre, Czech Academy of Sciences, CZ, mirek_trnka@yahoo.com*

To date, crop models have been little used for characterising the types of cultivars suited to a changed climate, though simulations of altered management (e.g. sowing) are often reported. However, in neither case are model uncertainties evaluated at the same time.

Ensemble modelling can provide information on uncertainty in model outputs. Here, a probabilistic approach using multi-model ensembles is presented for evaluating the effectiveness of new crop cultivars under climate change. It comprises a unique combination of crop ensemble modelling with three other methodological elements illustrated for wheat: (i) ideotyping of wheat cultivars for future climates based on an agroclimatic indicator approach used for identifying shifts in risks to be avoided, (ii) impact response surface (IRS) analysis of current and new wheat cultivars under different CO_2 concentrations, and (iii) overlay of resultant IRSs for different time periods with joint probabilities of projected temperature and precipitation to evaluate changing risk.

This novel approach applies a subset of results from a systematic climate sensitivity analysis based on a large ensemble of over twenty wheat models (IRS1), and on agroclimatic indicator analyses with recently refined critical thresholds that suggest severe impacts of future climate change on yields of current wheat cultivars in Europe.

Applying the approach for different soil conditions and projected 2050s climate shows the potential of new cultivars with adjusted management to reduce risks of future climate-

induced crop stress. Results also underline the need for crop model improvements, new experimental data and co-innovation with stakeholders, to better evaluate adaptation options.