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Assessing Yield Potential Under Climate Change by Using Crop Ideotypes

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Yield potential can be estimated by three different methods viz. crop model simulation, field experiments, and maximum farmer yield achieved by a sizable sample of farmers. These methods are good for the current conditions, but only crop modelling is applicable for assessing yield potential under future climates. Crop modelling is a powerful tool that can be used to identify key traits for improvement and to quantify potential threats to crops. There are two challenges: large uncertainty in prediction of future climates and lack of information on future cultivars. Local-scale climate scenarios can be generated by using climate projections from global climate models (GCM) that are downscaled using one of the downscaling techniques, e.g. stochastic weather generator. Crop simulation models can be used to design and test in silico crop ideotypes optimised for a wide range of future climates and environments. This provides cultivar parameters optimised to achieve high yields for target climates. A crop ideotype could be defined as a set of cultivar parameters that delivers optimal performance in target environment. To illustrate this approach, we estimated wheat yield potentials under current baseline climate (1980-2010) and in 2050 in the UK and NZ using the Sirius wheat simulation model. Three sites were selected in each country, and ideotypes were designed independently for each site. Climate scenarios were generated by the LARS-WG weather generator and were based on the HadGEM2 projections. Current observed mean farmer yields are very similar in two countries, about 8 t/ha in the UK and about 8.5 t/ha in NZ. Record yields are also similar. In 2017, the record wheat yield of 16.79 t/ha was harvested in Canterbury, NZ using winter wheat variety Oakley. In 2015, the record yield of 16.52 t/ha was harvested in Lincolnshire, UK using winter wheat variety Reflection. Wheat ideotypes were designed for the baseline climate (1980-2010) and future 2050 climate. For baseline, mean yield for ideotypes in the UK was 17.0 t/ha and in NZ was 22.3 t/ha. For 2050 climate, mean yield in the UK was 19.5 t/ha and in NZ, 24.2. Yield potential in NZ is about 5 t/ha greater than in the UK for both baseline and 2050 climates despite of similar mean and record yields for the current conditions. This suggests that cultivars grown in NZ at present are not adapted to utilise all available resources and have large potential for improvement. When optimising ideotypes, cultivar parameters were perturbed independently from each other. This might not be a valid assumption and correlation between parameters might exist. If such correlation is known, then ideotype optimisation can be extended to include dependency between parameters.