Rice Model Inter-comparison Activities in Asia

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Keywords: AgMIP, Climate change, International collaboration, Uncertainties

Rice (*Oryza sativa*) is the staple food in Asia, where more than 90 % of the world's rice production is produced. Demand for rice has increased dramatically for the past 50 years and is projected to rise further by about 30 % by 2050 [1]. There are concerns that the current rates of yield increase will not be sufficient to meet the increasing demand for the future [2]. Climate change, in particular more frequent occurrences of extreme events, poses another concern for the future food security (Intergovernmental Panel on Climate Change, IPCC [3]). Accurate projection of rice production in the future is thus essential for future food policy and technology development.

Crop growth models play a pivotal role in the projection. Up to present, a number of crop models have been developed in different countries and institutions for major crops such as wheat, maize and rice (see a list of world crop models in Asseng et al.[4] for wheat; Bassu et al.[5] for maize, and Li et al. [6] for rice). They differ in objectives, structures and time-spatial resolutions, but have often been used for predicting yields under future climatic conditions predicted by various climate models. Comprehensive reviews reported in the previous IPCC reports demonstrated that, in general, increasing temperatures are projected to have a negative effect on yield, but that elevated [CO_2] will attenuate the reduction by promoting photosynthesis and biomass production [7][8]. In their analyses, the magnitude of the overall effects depends on the regions varying from low to mid- to high latitudes; more negative effects are often observed in lower latitudes. The simulation results also contain significant uncertainties arising from a number of difference sources. Their analyses, however, were based on various independent simulations with different assumptions, climate, management and cultivars. With these datasets, sources of uncertainties could not be identified.

Since early 1990's, systematic use of a multiple number of models or ensemble has become a common practice among the climate projection communities [9], the results are often presented as the uncertainties due to climatic projections or greenhouse gas emission scenarios. On the other hand, other sources of uncertainties, in particular, those arising from crop model projections, however, have rarely been evaluated. Agricultural Model Intercomparsion and Improvement Project (AgMIP) [10] was launched in 2010 and one of the important missions of AgMIP is to evaluate crop model uncertainties. The AgMIP Rice team has started in 2011 and 16 rice models are currently involved in inter-comparison and improvement activities in order to identify 1) magnitude of the uncertainties, 2) sources of uncertainties, 3) weaknesses of the current models and 4) methodologies for further improvements.

In this report, I show results of intercomparisons of 13 rice models against multi-year experimental data [6]. Simulations were made for irrigated paddy conditions as this system produces 75% of the total rice production. All models were evaluated against field experiments and regional yield records at four sentinel sites in different ecological zones in Asia; Ludhiana, India; Los Banos, Philippines; Nanjing, China and Shizukuishi, Japan, because rice is grown in widely different environments, and the responses to environment could be largely different [11]. We then examined whether different modelling approaches on major physiological processes attribute to the uncertainties of prediction to field measured yields and to the uncertainties of sensitivity to changes in temperature and CO_2. We also tested weather a use of an ensemble of crop models can reduce the uncertainties. Individual models did not consistently reproduce both experimental and regional yields well, and uncertainty was larger at the warmest and coolest sites.

The variation in yield projections was larger among crop models than variation resulting from 16 climate scenarios. However, the mean of predictions of all models reproduced experimental data, with an uncertainty of less than 10% of measured yields. Using an ensemble of eight models calibrated only for phenology or five models calibrated in detail resulted in the uncertainty equivalent to that of the measured yield in well-controlled agronomic field experiments. Sensitivity analysis indicates the necessity to improve the accuracy in predicting both biomass and harvest index in response to increasing [CO_2] and temperature. Currently, an effort is underway to test and improve the modelling of [CO_2] and temperature sensitivity by collaborating with previous and ongoing FACE and chamber studies.

Acknowledgement

I thank all the members of AgMIP rice team and those who provided the field data indicated Li et al [6].

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