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Toward a Next Generation of Crop Models

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After a number of years during which crop modeling seemed to have plateaued in terms of interest by agricultural scientists and potential users, we have seen a renewed interest in these scientific tools and new approaches being explored in this field that show promise that there is a for a next generation of models. The purpose of this talk is to reflect back on the history of crop modeling to some extent, but focus more on what our scientific community should consider to overcome some of the limitations in existing models and to increase their applicability and confidence in their use by the broader science and user communities. One perspective is that future cropping systems models need to be able to perform virtual experiments for addressing problems and questions and for evaluating alternative production systems as new genetic and management technologies are considered for any production situation in current and future climate conditions. Current models are already being used in some conditions for these types of purposes, including evaluating adaptation options for climate change and for sustainably increasing food production. However, recent research has also shown that there are a number of limitations in existing cropping systems models that limit their applicability for many very important production situations and that large uncertainties exist among models in simulating responses to potential production situations and anticipated future atmospheric CO_2 concentration levels. These limitations and uncertainties have been shown in research recently carried out by groups of crop modelers collaborating in the AgMIP, MACSUR, and other initiatives through comparisons of multiple crop models with high quality datasets from diverse situations (e.g., more than ten and in some studies more than 30 models). These large variations among crop models were found to occur at the potential production level (e.g., responses to temperature and CO_2), even when all other factors were held at their optimum levels and there were no losses due to yield-limiting factors and under water and N limitations.

The presentation will include some thoughts about key changes needed in the agricultural research environment to enable the development of next generation crop models and examples of new capabilities that are needed. For example, I emphasize the fact that the models need to be developed and evaluated using data from a broad range of production environments and management systems if they are to meet expectations and gain credibility for those uses. Broad datasets need to be accessible and usable for evaluating and improving or developing new models; these data will provide a foundation across all disciplines for next generation crop models. Examples of new capabilities include capitalizing on the wealth of molecular genetics data being generated to model plants that help breeders and decision makers select plant and

management technologies for specific production situations and goals, incorporating capabilities to simulate nutrition quality of yield in addition to biomass, incorporating pest and disease damage, and incorporating practical intensive management technologies, such as drip irrigation, slow-release fertilizers, no-till, and others.

Prospects for developing next generation crop models are promising due to recent scientific progress, trends in interest among various users, and new efforts to create open data resources and to change the culture of researchers to enable them to contribute data for broad uses. I am also encouraged by the regional and global projects like MACSUR and AgMIP that have already had major impacts on science that will contribute to next generation models.