EJA Paper of the Month (June 2012)

Rice in cropping systems - Modelling transitions between flooded and non-flooded soil environments by Gaydon, D.S., Probert, M.E., Buresh, R.J., Meinke, H., Suriadi, A.., Dobermann, A., Bouman, B.A.M., Timsina, J., 2012. / European Journal of Agronomy 39, 9-24.

Water shortages in many parts of the rice-growing world, combined with growing global imperatives to increase food production, are driving research into increased water use efficiency and modified agricultural practices in rice-based cropping systems. In many of these regions rice is now grown in rotation with a range of other, non-flooded crops or pastures. Aerobic rice systems and alternative wetting and drying (AWD) techniques are also increasingly practised. To quantitatively evaluate the overall systems productivity of alternative management strategies and/or crops, well-tested cropping systems models that capture interactions between soil water and nutrient dynamics, crop growth, climate and management are required. Many previous successful rice modelling efforts were focussed on agronomic issues within rice crops, not on questions relating to optimal management of rice-based cropping systems, including sequences of varied crops. The APSIM model was designed to simulate diverse crop sequences, residue/tillage practices and specification of field management options. It was previously unable to simulate processes associated with the long-term flooded or saturated soil conditions encountered in rice-based systems, due to its heritage in dryland cropping applications. To address this shortcoming, the rice crop components of the ORYZA2000 rice model were incorporated and modifications were made to the APSIM soil water and nutrient modules to include descriptions of soil carbon and nitrogen dynamics under anaerobic conditions. We established a process for simulating the two-way transition between anaerobic and aerobic soil conditions occurring in crop sequences of flooded rice and other non-flooded crops, pastures and fallows. These transitions are dynamically simulated and driven by modelled hydraulic variables (soil water and floodwater depth). Descriptions of floodwater biological and chemical processes were also added. Our assumptions included a simplified approach to modelling O_2 transport processes in saturated soils. The improved APSIM model was tested against diverse, replicated experimental datasets for rice-based cropping systems, representing a spectrum of geographical locations (Australia, Indonesia and Philippines), soil types, management practices, crop species, varieties and sequences. The model performed equally well in simulating rice grain yield during multi-season crop sequences as the original validation testing reported for the stand-alone ORYZA2000 model simulating single crops (n = 121, R2 = 0.81 with low bias (slope, α = 1.02, intercept, β = −323 kg ha−1), RMSE = 1061 kg ha−1 (cf. SD of measured data = 2160 kg ha−1)). This suggests robustness of the newly developed simulation capabilities. Of particular practical importance is the model's ability to simulate rice in rotation with other crops, responses to applied fertilizers as well as simulating the consequences of bare fallows on resource availability and use. APSIM is now suitable to investigate production responses of potential agronomic and management changes in rice-based cropping systems, particularly in response to future imperatives linked to resource availability, climate change, and food security. The model provides researchers with a reliable tool for examining the risk-return performance of such options. Once parameterised, calibrated, and validated, the model can augment field experiments by providing greater insights into the variability of system performance over a much broader range of seasonal climates than is usually possible from field experimentation. The model also offers researchers a convenient tool for examining climate change impacts and adaptation options in rice based cropping systems. Further testing is required to evaluate the impact of our simplified assumptions on the model's simulation of greenhouse gas emissions in rice-based cropping systems.

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