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Investigating roles of sustainable intensification practices in Ghana cropping systems using crop modelling approaches

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Abstract

Successful upscaling of sustainable intensification (SI) practices from specific locations to regional scales requires further investigating the suitability of SI, especially under highly spatial and temporal heterogeneity of soil, seasonal climatic characteristics, and local inputs (e.g. fertilisers and residues). Understanding of SI performance across locations could be based on comprehensive field trials which are often lacking in Africa. In such a backdrop, dynamic crop modelling systems incorporating SI practices [e.g. crop residue retention or varied nitrogen (N) and phosphate (P) applications in crop rotation system] theoretically offer opportunities to investigate the effects of those SI practices on crop yield and soil nutrients (including mineral N, soil organic carbon, and total nitrogen). In this study, we used two crop growth models (SIMPLACE <LINTUL5> and APSIM) along with the existing field measured data for the maize-soybean rotation system in northern Ghana. Changes in simulated yield and soil nutrients corresponding with step-wise incremental changes of previous crop residues (0, 25 %, 75 %, and 100 %) as well as applied N (0, 30, 60, and 90 kg N ha^{-1}) and P (0, 15, and 30 kg P_2O_5 ha^{-1}) were evaluated. The calibration of both crop models relied on the biomass and grain yield measurements from the 2010 sole maize crop. Compared to the observed biomass data, bias errors were recorded at 0.314 and 0.328 ton ha^{-1} for LINTUL5 and APSIM, respectively. During validation across different years, both models consistently overestimated biomass and yield in 2011 and 2012, with bias errors around 0.9 ton ha^{-1}, while underestimating grain yield by approximately 0.5 ton ha^{-1} in 2013. The LINTUL5 model successfully captured the positive impact of crop rotation (soybean-maize-soybean-maize) on maize grain yield. Nonetheless, it was noted that the observed increase in maize grain yield after rotation seasons was higher than the simulated yield increment within this model. These findings indicate the necessity of considering the spatial variations in crop residue retention and chemical fertilisation inputs in the farmer fields while upscaling model applications from field to regional scales.

Keywords: Chemical fertiliser, crop models, crop residue, crop rotation, maize-soybean, simulation

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