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Integrating an agro-system model and remote sensing information to simulate maize and potato yields in smallholder intercropping systems on the Jos plateau, Nigeria

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Abstract

Smallholder agriculture is responsible for more than half of the global food yield, predominantly thrives in low- to middle-income regions of Africa, Asia, and Latin America. However, owing to the dynamic nature and diversity inherent in smallholder agriculture, accurate estimates of their production pose a formidable challenge. The use of simulation models for crop growth and yield prediction in smallholder systems is often hampered by the lack of experimental data for calibration, the capability to represent mixed cropping systems and of data for large-area assessments. We integrated remote sensing data from the Sentinel 2 mission to generate leaf area time series for model calibration. Then, we simulated yields across sole- and intercropped fields using the MONICA agroecosystem model. The results of the spatial simulations revealed the impacts of annual weather conditions and their interaction with local conditions on annual attainable yields. Potato yields between 4,200 – 7500 kg ha^{-1} were simulated as attainable across different spatio-temporal windows and for different sowing dates. In the same manner, attainable grain maize yields were simulated in a range between 2,000 – 4,500 kg ha^{-1}. Our results further revealed higher yields for potato under mid and late sowing options. The current practice on the Jos plateau is, however, early sowing to avoid the severe impacts of diseases, and potatoes are harvested at the onset of diseases to avoid tuber decay. We therefore suggest the establishment of early warning systems to inform farmers about the best windows for sowing. The integration with remotely sensed crop type information provides a comprehensive spatial yield estimate for the Jos Plateau, revealing supplementary yields of 11 % to 89 % ha^{-1} where intercropping is practised, depending on the soil, climate, site, and management conditions of the intercropped field. Interestingly, results also implies that higher individual maize and potato yields are achieved within the intercropped fields. The overall potential mean annual maize and potato yields on the Jos Plateau is estimated to be 989,321 and 327,317 tons, respectively. Our results presents the first comprehensive yield estimated for Nigeria. Through this integrated approach, valuable insights was provided into optimising yield monitoring and food planning in SSA.

Keywords: Climate change, intercropping, mono cropping, sub-Sahara Africa

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