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Same Climate, Different Soil: Simulating Maize Yield and Water Use for Smallholder Systems with Different Soil Datasets in the Lowveld Region of Limpopo Province, South Africa

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Abstract

Maize is the main staple crop in southern African drylands, but smallholder farmers are far from achieving potential yields. Climate change projections indicate that low and variable yields will be exacerbated, making maize farming riskier without adaptation. The assessment of management interventions through Crop Simulation Models (CSM) such as Agricultural Production System sIMulator (APSIM) can help understand these systems and design improvements, but they usually rely on good quality and site-specific soil data. While site-specific soil sampling can be resource-demanding, global soil databases could be a reliable source of information. However, the efficiency and accuracy of such databases in terms of simulated crop yield has not been extensively researched.

Using the Limpopo province South Africa as a case study, manually sampled soil data collected across two contrasting villages, Gabaza (fertile soil, high rainfall) and Selwane (marginal soil, low rainfall), were compared with digital soil data from the iSDAsoil database. The CSM APSIM was used to examine the extent to which digital soil data can replace physical soil sampling through its ability to simulate maize yield performance over a 20-year period (1999–2019). Soil parameters used across the two datasheets (observed and gridded data) include the C: N ratio, soil texture and rooting depth.

Findings from our analysis revealed that soil parameters from the iSDAsoil map were significantly different ($p < 0.05$) from sampled (observed)data for the fertile site (Gabaza) but not for the marginal soil in Selwane. Simulated maize yield results mirrored these differences. Using a Status quo management scenario (no fertiliser or irrigation, locally recommended plant density of 2.7 plants m^{-2}) showed that average maize yields for Gabaza were 1.7 vs. 1.1 t ha^{-1} (observed vs. iSDA) and for Selwane 0.8 vs. 0.9 t ha^{-1} (observed vs. iSDA). Overall, our study showed that the iSDAsoil map could be used with high confidence to simulate smallholder maize performance only for marginal soils in the study area. Discrepancies for the fertile soils necessitate further investigations.

Keywords: APSIM, Digital vs. observed soil data, smallholder maize systems, Sustainable adaptation

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