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Evaluating sustainable maize intensification strategies in smallholder farming systems in northern Ghana

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Abstract

Context-specific management practices supporting sustainability are crucial for maintaining maize productivity in smallholder farming systems, particularly in northern Ghana in the face of declining soil fertility, sub-optimal use of inputs and the increasing erratic weather. This study employed the Agricultural Production Systems simulator (APSIM) to assess the performance of sustainable intensification practices; sole application of inorganic fertiliser or manure, combination of both, different maturity duration maize varieties (Obatanpa and Abontem), and different planting dates across three districts – Tolon, Savelugu, and Mion in Northern Ghana. Calibration and evaluation relied on on-station (Nyankpala) and farm-level experiments (19 farmer fields from Dimabi and Langa). Grain and biomass yield were adequately simulated with Relative Root Mean Squared Error (RRMSE) below 14 %. RMSE for days to anthesis and maturity were 2.1 and 1.7 days, respectively. Combined use of manure and inorganic fertiliser generally produced the highest grain yields for both cultivars across all locations, with yield gains ranging from 55–67 % compared to the control (no fertiliser or manure is applied) based on simulation results using multi-year climate data (1984 – 2024). Tolon (with the lowest soil Organic Carbon (OC%)) recorded the lowest grain yield, while Mion (highest OC%) produced the highest yield across all treatments. Yield variability (CV) under the fertility treatments was generally lowest for Mion (12), while Tolon recorded the highest average variability of 18.4. The sustainability of yield (SYI) was highest for treatments that combined inorganic fertiliser and manure for both cultivars. Across sites, Mion had the highest SYI with values from 0.65 – 0.87 for Obatanpa and 0.71 – 0.84 for Abontem. Interannual standard deviation (INST) was highest for Tolon and least for Mion. INST indices generally decreased with increasing SYI at all locations. Doubling inorganic fertiliser from 30 to 60 kg N/ha increased grain yield across all locations and varieties by 11–16 %. Late sowing windows yielded more grain with higher SYI than early sowings. These findings offer practical guidance for extension services and policy to promote locally appropriate sustainable intensification in smallholder farming systems needed to enhance food security and the resilience of agri-food systems in northern Ghana.

Keywords: Crop modelling, low-input systems, maturity duration, site-specific, yield stability

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