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Integrated Soil Health Assessment bridging Local Knowledge and Soil Science in Conservation Agriculture

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Climate change challenges across sub-Saharan Africa require more resilient food production systems. To improve agricultural resilience, the Climate Smart Agriculture (CSA) framework has been proposed including Conservation Agriculture (CA). CA has three key principles; 1) minimum soil disturbance, 2) crop residue cover, 3) crop diversification. Current soil health studies assessing CA's impact have focused on 'scientific measurements', paying no attention to local knowledge. Local knowledge however influences farmers' land decision making and their evaluation of CA. In this study, a participatory approach to evaluate CA's soil health impacts is developed and implemented using farmers' observations and soil measurements on farm trials in two Malawian communities. The on-farm trials compared conventional ridge and furrow systems (CP), with CA maize only (CAM) and CA maize-legume intercrop systems (CAML). This approach contextualizes the CA soil health outcomes and contributes to understanding how an integrated approach can explain farmer decision-making.

Based on a stepwise integrated soil assessment framework, firstly farmers' soil health indicators were identified as crop performance, soil consistency, moisture content, erosion, colour and structure. These local indicators were consistent with conventional soil health indicators for quantitative measurements. Soil measurements and observations show that CA leads to soil structural change. Both soil moisture (Mwansambo: 7.54%-38.15% lower for CP; Lemu 1.57%-47.39% lower for CP) and infiltration improve under CA (Lemu CAM/CAML 0.15 cms^{-1}, CP 0.09 cms^{-1}; Mwansambo CP/CAM 0.14 cms^{-1}, CAML 0.18 cms^{-1}). Farmers perceive ridges as positive due to aeration, nutrient release and infiltration, which corresponds with higher exchangeable ammonium (Lemu CP 76.0 $mgkg^{-1}$, CAM 49.4 $mgkg^{-1}$, CAML 51.7 $mgkg^{-1}$), and nitrate/nitrite (Mwansambo CP 200.7 $mgkg^{-1}$, CAM 171.9 $mgkg^{-1}$, CAML 103.3 $mgkg^{-1}$). This perspective still contributes to the popularity of ridges, despite the higher yield and total nitrogen measurements under CA. The perceived carbon benefits of residues, and ridge advantages have encouraged farmers to bury residues in ridges.

This work shows that an integrated approach provides more nuanced and localized information about land management. The stepwise integrated soil assessment framework developed in this study can be used to understand the role of soil health in farmers' land management decision-

making. Thereby supporting a two-way learning process for scaling agricultural innovations and broadening the evidence base for sustainable agricultural innovations.