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Soil-crop long-term feedback matters to assess climate change impact on maize yield in Sub-Saharan Africa

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Sub-Saharan Africa (SSA) faces significant food security risks, primarily due to low soil fertility leading to low crop yields. Climate change is expected to worsen food security issues in SSA due to a combined negative impact on crop yield and soil fertility. A common omission from climate change impact studies in SSA is the interaction between change in soil fertility and crop yield. Integrated soil fertility management (ISFM), which includes the combined use of mineral and organic fertilizers, is expected to increase crop yield but it is uncertain how this advantage is maintained with climate change.

We explored the impact of scenarios of change in soil fertility and climate variables (temperature, rainfall, and CO_2) on rainfed maize yield in four representative sites in SSA with no input and ISFM management. To do so, we used an ensemble of 15 calibrated soil-crop models. Reset and continuous simulations were performed to assess the impact of soil fertility vs climate change on crop yield. In reset simulations, SOC, soil N and soil water were reinitialized each year with the same initial conditions. In continuous simulations, SOC, soil N and soil water values of a given year were obtained from the simulation of the previous year, allowing cumulative effects on SOC and crop yields.

Most models agreed that with current baseline (no input) management, yield changed by a much larger order of magnitude when considering declining soil fertility with baseline climate (-39%), compared with considering constant soil fertility but changes in temperature, rainfall and CO_2 (from -12% to +5% depending on the climate variable considered). The interaction between change in soil fertility and climate variables only marginally influenced maize yield (high agreement between models). The model ensemble indicated that when accounting for soil fertility change, the benefits of ISFM systems over no-input systems increased over time (+190%). This increase in ISFM benefits was greater in sites with low initial soil fertility. We advocate for the urgent need to account for soil-crop long-term feedback in climate change studies to avoid large underestimations of climate change and ISFM impact on food production in SSA.

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