Tropentag, September 20-22, 2017, Bonn

"Future Agriculture:
Socio-ecological transitions and bio-cultural shifts"

Yields and Water Use Efficiency of Maize and Sorghum under the Impacts of Climate Change in West Africa

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Abstract

Increasing warming, recurrent dry spells, and land degradation represent serious threats to sustainable development in West Africa. The climate-driven changes in soil water and nutrients will put at risk the resilience of the production systems, but one remains uncertain about the magnitude in this region, including northern Benin. This study examined the responses of maize and sorghum to three soil fertility management options (control, integrated soil-crop management, high mineral fertiliser use) under historic climate (1986–2005) and compared these to the performance of the same options under bias-corrected ensemble predictions (BNU-ESM, CanESM2, and MPI-ESM-MR models) of future climate (2080–2099) for three Representative Concentration Pathways (RCPs, 2.6, 4.5, and 8.5). The climate datasets served as inputs in the previously calibrated and evaluated CERES-Maize and CERES-Sorghum Cropping Systems Models. The ensemble of the climate models predicted seasonal rainfall variability reaching $^{-2}$%±6, -4%±8, and +1%±9 for RCPs 2.6, 4.5, and 8.5, respectively. Changes in temperature depicted increasing warming trends in minimum temperature of +1.0±0.2, +2.0±0.2, +4.7°C±0.4 and maximum temperature of +1.1±0.2, +2.0±0.3, +4.6°C±0.5, for RCPs 2.6, 4.5, and 8.5, respectively. The ensemble simulated a decrease in solar radiation by about -0.4 MJ $m^{-2}d^{-1}$. CERES-Maize predicted a larger increase in the dynamics of aboveground biomass at the season onset but a decrease later in the cropping seasons, with largest changes under RCP8.5. CERES-Sorghum simulated similar patterns, but the decrease in biomass accumulation would occur earlier in the season under RCP2.6 and 4.5 than with RCP8.5. The assumed future climates reduced maize biomass yield by 11–29 %, grain yield by 10–46 %, and water-use efficiency by 17–53 %. CERES-Sorghum predicted decreases by 21–47 % for biomass yield, 22–51 % for grain yield and 23–51 % for water-use efficiency. The largest depressive effects were predicted under RCP 8.5. With an integrated soil-crop management and high mineral fertiliser use, maize response was relatively resilient to climate change under RCP2.6 and 4.5. It is concluded that a stabilisation of the warming below 2°C remains critical for achieving benefits from sustainable intensification efforts in major production systems in West Africa.

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Keywords: Climate scenarios, crop production, CSM-CERES, resource use efficiency, *Sorghum bicolor*, *Zea mays*