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Forecasting climate extremes impacting sorghum production in senegal: evidence from apsim model simulations

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Abstract

Sorghum is a vital staple crop for food security in Senegal's semi-arid regions, including Bambey, Nioro, and Velingara, where it supports millions of smallholder farmers. However, increasing climate extremes threaten sorghum productivity, necessitating robust assessments of future climate risks. This study employs the Agricultural Production Systems Simulator (APSIM) alongside an ensemble of CMIP6 from five contrasting Global Climate Models (ACCESS-CM2, CNRM-ESM2–1, HadGEM3-GC31-LL, MPI-ESM1–2-HR, and UKESM1–0-LL) to evaluate historical (1985–2014) and projected (2040–2069) under SSP2–4.5 and SSP5–8.5 scenarios for selected sorghum cultivars. We analysed key climate indices relevant to sorghum growth, including growing season onset, cessation, length, extreme rainfall events (Rx1day, CWD), heat stress indicators (TXx, TNx, GDD), and drought metrics (CDD, MDD). Our results indicate region-specific impacts: under the high-emission SSP5–8.5 scenario, the growing season is projected to shorten by approximately 11 days in Velingara, with smaller reductions in Bambey and Nioro. Growing season onset is delayed by up to 9 days in Velingara and 2.5 days in Nioro. Heat extremes intensify, with maximum daily temperatures during the growing season rising by over 2°C in Bambey and Nioro, while Velingara experiences minimal change. Consecutive dry days increase notably in Bambey and Velingara, signalling elevated drought risk, whereas Nioro shows a slight decrease. Despite inter-model variability, consistent trends of warming and altered rainfall extremes emerge. These findings underscore the vulnerability of sorghum production to climate extremes in Senegal and highlight the urgent need for adaptive strategies. Approaches such as adjusting sowing dates, adopting heat- and drought-tolerant varieties, and improving agronomic practices are critical to enhancing sorghum resilience. This study contributes to the growing body of evidence that climate change poses significant challenges to cereal crop production in West Africa, reinforcing the importance of integrated climate risk management for sustaining food security.

Keywords: Climate extremes, Drought risk, Growing season, sorghum

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