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Developing climate-adaptative crop decision-making frameworks for smallholders in Senegal: an in-silico approach

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Abstract.

The present study showcases a framework to evaluate crop potential and adaptability in different environments and climate conditions via an in-silico approach. This framework was applied in Senegal, and APSIM software was employed to perform the simulations. The findings aimed to aid smallholders in the decision-making process.

Keywords.
Senegal, crop modeling, climate adaptation, millet, sorghum, peanut,mungbean

Exploring crop suitability in Senegal across global warming scenarios: an in-silico approach

Introduction

Food production systems in Africa are vulnerable to climate change. In this context, rising temperatures are one of the primary causes of the anticipated negative climate change impacts on crop yields. Future yield reductions pose a challenge for smallholders in reaching self-sufficiency. Still, there are opportunities for handling risks via management strategies directed toward adapting and mitigating the adverse effects of climate change. Therefore, the aims of this study were to: i) quantify the impact of management strategies (crop type, sowing date, plant density, and N fertilization) on food production across crops, sites, weather, and global warming levels; and ii) develop climate-adaptative decision-making frameworks based on crop stability to different environments, seasonal precipitation and temperatures, and global warming.

Materials and Methods

the Agricultural Production Systems sIMulator (APSIM) crop growth model was employed to evaluate yield responses of four crops (sorghum, pearl millet, mungbean, and peanut) across five sites in Senegal during 33 years of historical weather data and three global warming scenarios (+2.5oC). Yield was converted into calories, glucose equivalent, and profit. For each year, mean cumulative precipitation and daily mean temperature were accounted for and employed to classify each year according to their position relative to the dataset median (higher or lower) for each site, independently obtaining four weather classifications. The best crop for each site x weather classification was selected, considering higher adaptability (high slope values) in high-yielding scenarios and high stability (lower slope values) in low-yielding scenarios.

Results

Figure 1 shows peanuts as an efficient option to provide more calories and for smallholders to attain self-sufficiency while maintaining adequate economic performance in most environments. Meanwhile, pearl millet exhibited better performance in drier environments. Under warming scenarios, pearl millet expanded its presence as a more stable and productive option in low-yielding environments. In contrast, peanuts increased in prominence in high-yielding environments. There was no environment where planting mungbean was more convenient. The conditions where sorghum is more productive will be restrained under warming conditions.

Conclusions

This study marks a milestone in the journey towards more informed agricultural decision-making in the face of climate change in Senegal. The insights gained have direct implications for smallholders in their quest for self-sufficiency, aligning with broader efforts to promote crop diversification and sustainable agricultural practices. However, the dynamic nature of this process underscores the need for continuous research on farming adaptation.

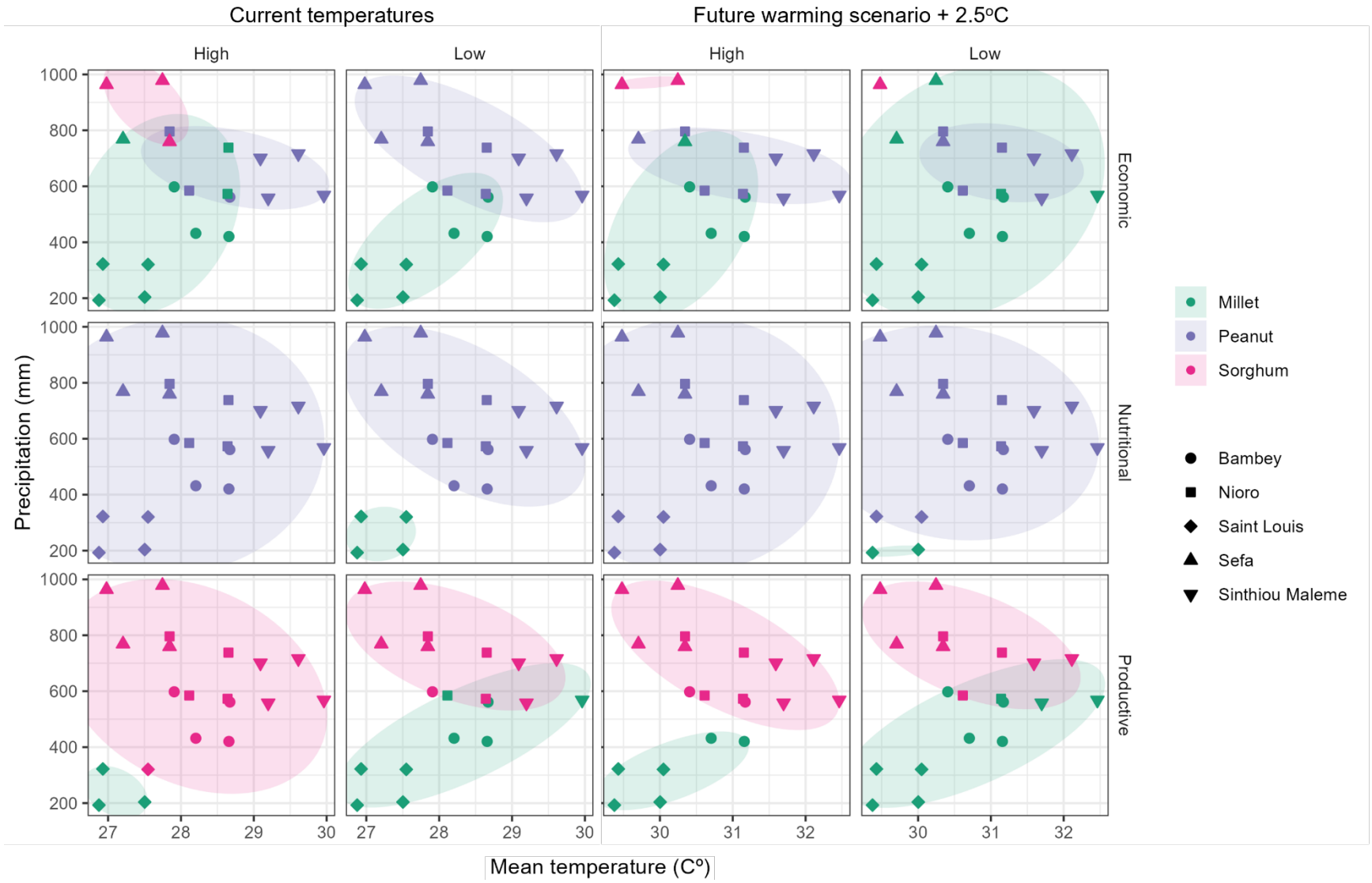

Figure 1. Crop distribution across weather conditions (precipitations and temperature) and yield quality (high yielding environments and low yielding environments) evaluated from an economic (profit), nutritional (calories), and productive (glucose equivalent) standpoint under current temperatures and under the global warming scenario + 2.5 oC. Each site (same shape) has four points, corresponding to one of the weather classifications. Different colors stand for different crops. Shapes stand for different sites. Adapted from Carcedo et al. (under review).