An Integrated Assessment of Climate Change Impact on Crop Production in the Nioro du Rip Basin of Senegal

I: Crop Modelling

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1. Introduction

•The West African Sub-Saharan region is home to some 300 million people with at least 60% engaged in agricultural activity. In the case of the Nioro basin of Senegal, major crops produced include millet (37%), peanut (53%) and maize (10 %) by area.

•Between 40 to 60% of the GDP derives from agriculture, which is relies largely on natural climate. Climate change and variability pose major threats to agricultural productivity.

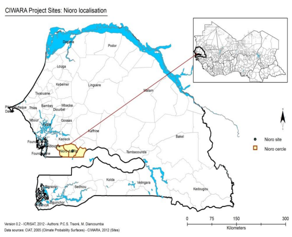

Fig.1 Map of Senegal showing Nioro basin

2. Climate Change impacts on climate variables

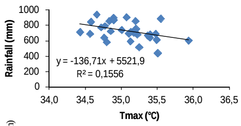

Fig. 2 Average annual rainfall (mm/day) vs. annual mean temperature for baseline

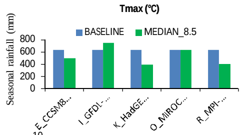

Fig. 3 Nioro Seasonal rainfall for current and future (5 GCMs) climate

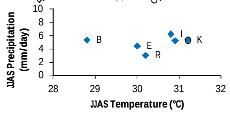

Fig. 4 The five (5) GCM's used for future projections.

3. Problem Statement and Aims

Nioro du Rip has one growing season with an average rainfall of 657 mm. Climate change impacts are already visible tin the current climate (1980 – 2010). Even though both temperature and rainfall show a general increase over time, it is also evident that the warmer years received less rainfall. Hence , it could be conjectured that increased future temperatures might result in lower rainfall. Indeed, climate projections from several General Circulation Models (GCMs) indicate a general increase temperature (Fig. 1) in the near future (2040-2069) and also a decline in rainfall (Fig. 2). The way in which such changes will affect agriculture remains uncertain. Hence, the need for an assessment of crop productivity responses to climate change to support policy formulation and adaptation strategy development to offset any adverse impacts . Due to the multiple factors involved in agricultural production, multidisciplinary approaches including the use of models are more suitable.

The aim of this study is to assess the future productivity of the major crops in the Nioro basin of Senegal using three crop models.

4. Materials and Methods

AgMIP methodology was used to assess climate change impacts on agricultural production. This approach involves the use of multiple crop and climate models to simulate future yields. For the Nioro basin, three crop models (DSSAT and APSIM) were validated using yield, management a data from a survey conducted on 220 farm households carried out in 2007. The crops cultivated were millet, maize and peanut. Weather data were from six stations and soil data from four dominant types. Farms were assigned to the closest weather station and soil types. The validated models were used to simulate yield for the past climatology (1980 to 2010) for each farmer. Thereafter, future yields attainable by each farmer with (changed technology-CT) and without (base technology-BT) adaptation were simulated using future climate projected by 5 GCMs (as indicated in Fig. 3). The adaptation to climate change involved the use of an ideotype that was both heat and drought tolerant. Heat tolerances was achieved by modifying phenology traits while drought tolerance was by modifying root distribution water relations.

5. Results

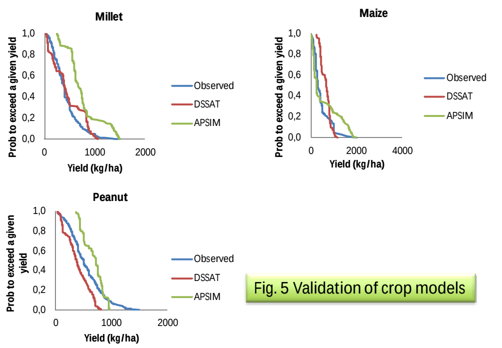

Fig. 5 Validation of crop models

6. Results

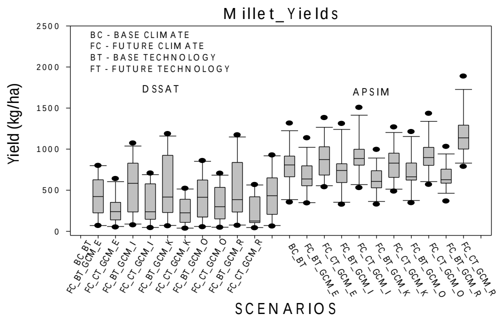

Fig. 6 Simulated millet yields

7. Results

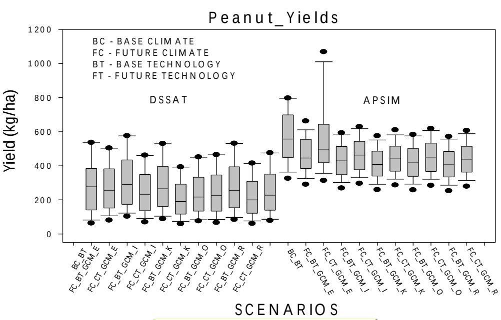

Fig. 7 Simulated peanut yields

8. Discussions

DSSAT and APSIM were able to reasonably simulate the yield data from the household survey for all crops (Fig. 5). Actual matching of simulated to observed could not be done as some of the input data could only be estimated. Despite this challenge the general yield distribution patterns were well captured. Hence the models were considered adequate for assessment of crop response to future climate. Of all the GCMs, R and K gave the lowest future simulated yields. This may partly be attributed to the lower rainfall projection (Fig. 1) Though the GCM E also projected a lower future rainfall, the within season distribution may have been more favourable.

For millet (Fig. 6), simulation by all models show a decrease in future yields using the BT compared with the baseline (22 to 46% and 7 to 22% for DSSAT and APSIM, respectively). DSSAT indicated that yield under four out of the five GCMs using CT (ideotype) will improve future yield even above the baseline of about (1 to 29%). Similar observations can also be made for APSIM with greater increases simulated (3 to 48% %). Comparison of BT with CT indicate almost 80 and 40 % dominance in yield increases of CT for DSSAT and APSIM respectively, under future climate.

9. Discussions

As with millet yields of peanut using all GCMs were also lower than those under the baseline climate (Fig. 7). Future simulations by DSSAT shows a change of -10 to 20%. The corresponding simulated change by APSIM was -22 to 1%. Comparisons between the CT and BT showed a dominance of CT by 16% (DSSAT) and 7% (APSIM).

Conclusions

This study has shown that lower projected future rainfall regimes in Nioro du Rip Basin would adversely affect crop productivity. The use of base technology (i.e. current crop varieties) most often resulted in lower yield under future climate. The introduction of the changed technology (improved variety) will significantly reduce the climate change effect.

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