#7488 SIMULATION OF CASSAVA YIELD UNDER DIFFERENT CLIMATIC SCENARIOS IN KILEMBWE, SOUTH-KIVU PROVINCE EASTERN DR CONGO

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ABSTRACT

Climate variability and change are projected to significantly impact agricultural production across Africa. This study assessed the effects of climate variability and change on cassava yield in Kilembwe, South-Kivu province Eastern DR Congo. The assessment relies on the DSSAT crop model simulation of cassava under current and future climate. The period 1980–2010 was used to represent the baseline, while future projection covers three periods including the near future (2010–2039), mid-century (2040–2069), and end-century (2070-2099). Climate, soil, and crop yield and field management data were collected for Kilembwe in the South-Kivu Province. Results show both Tmin and Tmax are projected to increase over time up to 1.9°C and 1.8°C (RCP 4.5) and up to 3.91°C and 3.57°C (RCP 8.5) at the End of the Century. Rainfall is also projected to increase up 10.36 and 9.27%; respectively under RCP 4.5 and RCP 8.5 at the end of the Century. The projected climate is likely to increase cassava yields between 35.63 to 50.67% for RCP 4.5 and between 30.92 up to 50.16% for RCP 8.5 in Kilembwe. Rainfall increase and temperature changes are determining factors of yield increase. Climate variability and change will continue to affect positively cassava production in Kilembwe. Farmers are therefore encouraged to increase growing cassava to increase their resilience to climate variability and change.

Keywords: cassava, climate variability and change, DSSAT, Kilembwe

INTRODUCTION

Root crops, cassava (*Manihot esculenta Crantz*) included are important in the African diet (Chandrasekara and Kumar 2016). It is estimated that 60% more food will be required by 2050 (compared to 2005) to meet human nutrition needs in Africa (Msowoya and Madani 2016). Root crops' contribution to global and regional food security is diverse. Cassava is the world's fourth most important source of food energy (carbohydrates) as well as fourth among staple crops in the tropics after rice, sugar, and maize. Its global production is estimated at 183 million tons per year (FAO STAT, 2014). Worldwide, 800 million people depend on cassava as their primary staple food. It is estimated that two-thirds or more of its production is used for human food and one third or less used feeding animal and industrial purpose (Ferraro et al., 2016). Africa is the continent that depends most on root and tuber crops in feeding its population. In the humid and sub-humid areas of tropical Africa, it is either a primary staple food or a secondary co-staple. Cassava is the main staple crop and food in the Democratic Republic of Congo and second staple crop and food after rice in Kilembwe, Fizi Territory. Across the current cassava producing situation, predicting future cassava yields relies on understanding how climate change will affect cassava growth and development remain relevant (Sanginga & Mbabu, 2015). In order to provide the interactions between climate and crop production under future climate scenarios, crop models are important tools as used by (Jones et al., 2003; Zinyengere et al., 2015, Muhindo et al. 2016 and Oumarou, 2017) to predict the impacts of climate variability and change on agriculture production. These studies have deployed outputs from global climate models "GCM" datasets associated with the AgMIP protocol under different climate scenarios (Moore et al. 2012). The Decision Support System for Agrotechnology Transfer (DSSAT) Version 4.7.5 is a software application program that comprises crop simulation models for over 32 crops (Hoogenboom et al., 2010). Studies (Sonwa et al., 2014; Fotso-Nguemo et al., 2018; Nonki et al., 2020; Sonkoué et al., 2018) in Central Africa including in DR Congo have shown that rainfall variability and temperature will be on the rise with significant impact on crop production. However, future cassava under different climate scenarios was still unknown despite it being the main staple food in the DR Congo.

MATERIALS AND METHODS

This study was conducted in Kilembwe located at 0.55°S and 31.53°E in the high altitude of 1232m of Fizi territory, in the South-Kivu Province, Eastern part of the Democratic Republic of Congo. The climate in Kilembwe is tropical with annual average rainfall of 1500mm and the mean temperature varies between 24 and 28°C. The data collected during the survey included the major crops grown, their yield, prices, management practices, labor cost, inputs cost, adaptation measures used, planting and harvesting period, the quantity of harvest sold, and consumed by the household. Besides, crop yields per household were estimated in the field and their prices asked in the local market, due to lack of meteorological stations climate data were downloaded from the AgMERRA portal (https://data.giss.nasa.gov/impacts/agmipcf/agmerra/). Focus group discussion "FDGs" were organized at the community level. The assessment of the effects of climate variability and change on cassava yield was done using DSSAT. DSSAT 4.5.7 to simulate historical and future cassava yields. Historical cassava yield was compared to the future cassava yield under different scenarios using the T-test. Historical data on Cassava yields were generated for the period (1980-2010). Man Kendall and linear regression were all used for determining the trend of historical rainfall, temperature (Tmax and Tmin), and cassava yield (Salmi et al., 2002; Pohlert, 2020). The cultivar used to simulate cassava yields was a local variety called "*Sawasawa*". For the projection of future cassava yield, three future climate projection periods namely NC (near-century/future 2010-2039), MC (mid-century 2040-2069), and EC (End-Century 2070-2099), and two Representative Concentration Pathways (RCP 4.5 and 8.5) were considered.

RESULTS AND DISCUSSION

Historical Temperature, Rainfall, and Cassava Yield Trends

Figure 1 shows the trend of historical annual rainfall, average annual temperature (Tmax and Tmin) and cassava yield. Both average annual Tmax and Tmin tended to increase with time. The gradient for average annual Tmin varied from 0.03°C to 0.06°C and the gradient for average annual Tmax varied from 0.02°C to 0.06°C. Both Tmin and Tmax varied significantly ($p=0.01$) overtime. The peak (1650mm) of the annual rainfall was observed between 2000 and the minimum (920mm) annual rainfall was observed in 1992. Cassava yield tended to decline as indicated in the linear regression and Sen's slope was -84.789 Kg/ha.

Projected Change in Temperature and Rainfall for all Periods and RCPs 4.5 and 8.5

Projected climate change for the three periods and the two RCPs are presented in Table 1. Results show that the change in average annual maximum and minimum temperature is likely to increase in all periods. In the Near-Term the increase in maximum and minimum temperature ranged between 0.71°C and 0.73°C and 0.92°C and 0.98°C for RCP 4.5 and RCP 8.5 respectively. In the Mid-Century, there is an increase of 1.50°C and 1.53°C for maximum and minimum temperature for RCP 4.5 and 2.10°C and 2.34°C respectively maximum and minimum temperature for RCP 8.5. lastly, for the End-Century there was an increase of 1.80°C and 1.90°C and 3.57°C and 3.91°C for maximum and minimum temperature for RCP 4.5 and RCP 8.5 respectively. The average rainfall was projected to increase by 4.37%, 1.81%, 6.76%, 8.16%, 10.36%, and 9.27% in the Near-Term, Mid, and End-Centuries of RCP 4.5 and 8.5 respectively. Both Tmin and Tmax as well as rainfall are likely to increase over time and the end-century is likely to have the highest increment in Temperature and rainfall ($p<0.05$) while Near Future projected the lowest ($p<0.05$). The results of this study are showing an increasing trend in temperature and rainfall which corroborates with the findings of Muhindo et al. (2016) for Kavumu and Luberizi in the South-Kivu Province, Democratic Republic of Congo. The increase in temperature can be linked to the global temperature increase induced by greenhouse gas concentration into the atmosphere that has passed the 400 parts per million (ppm) caused by agricultural activities, deforestation, mining activities, and other anthropogenic activities.

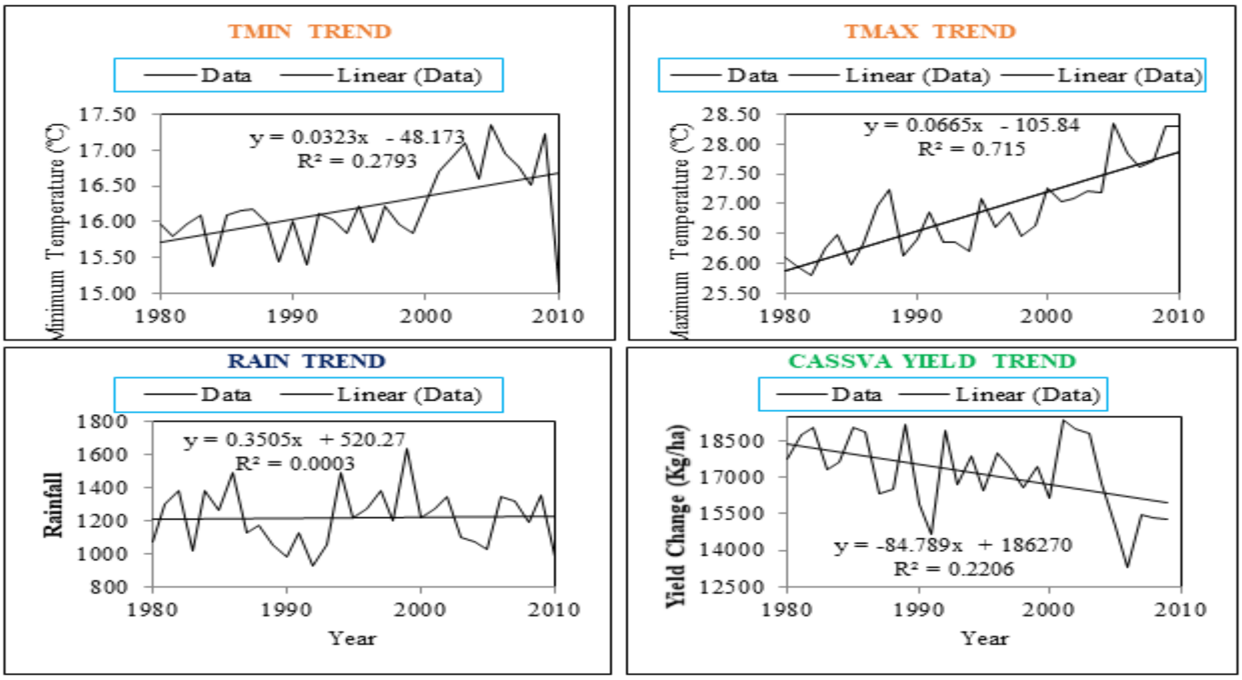

Figure 1. Historical trend in temperature, rainfall, and cassava yield in Kilembwe

Table 1. Future changes in rainfall, minimum and maximum temperatures for Kilembwe

Period	RCP 4.5			RCP 8.5		
	ΔTmax	ΔTmin	Relative change in Rainfall	ΔTmax	ΔTmin	Relative change in Rainfall
	(°C)	(°C)	(%)	(°C)	(°C)	(%)
Near-Term	0.71	0.73	4.37	0.92	0.98	1.81
Mid-century	1.53	1.53	6.76	2.10	2.34	8.16
End-century	1.80	1.90	10.36	3.57	3.91	9.27

Projected Increase in Cassava Yield Under Different Climate Regimes

The projected yield changes are shown in Figure 2. All selected five GCMs and RCPs projected an increase in cassava yield for all periods under different climate regimes. The projected increase in yield ranged from 35.63% to 50.67% and from 30.92% to 50.16% for RCP 4.5 and RCP 8.5; respectively ($p<0.05$). The extent in the yield increase was higher in Hot/Wet for both RCP 4.5 ($p<0.05$) and RCP 8.5 not significant ($p=0.07$) than the rest of the climate regimes while Hot/Dry for RCP 4.5($p<0.05$) and Cool/Dry for RCP 8.5 ($p=0.01$) projected a lower increase. The increase in cassava yield in the tropic was also found by Tenge et al. (2012) and Bashaasha et al. (2012) who found an increase about 60 and 80% in Rwanda and Uganda; respectively. The increase in cassava yield can be attributed to temperature and rainfall changes which are within the range of the required value for optimum cassava growth (25 to 29° C) while rainfall for the last decade was also within the range required rainfall (1000 to 1500 mm) for cassava growth.

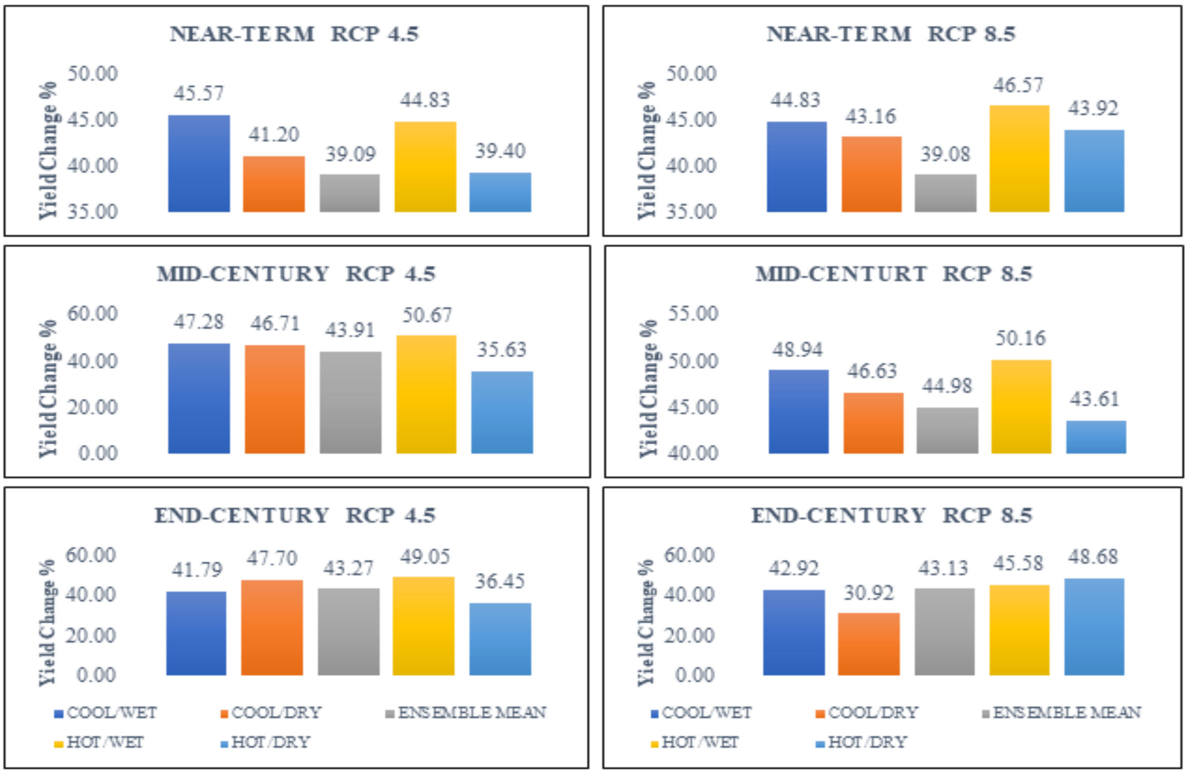

Figure 2. Impact of climate change on Cassava yield in NT, MC, EC under RCP 4.5 and RCP 8.5

CONCLUSIONS AND RECOMMENDATIONS

We observed that both Tmin and Tmax are projected to increase over time up to 0.98°C, 0.92°C for the near future; for the Mid-century 2.34°C, 2.1°C and 3.91°C, 3.57°C for the End-Century. Rainfall will increase by 10.36% (RCP 4.5) and 9.27% (RCP 8.5) in the End-century. These observed patterns in rainfall and temperature will lead to an increase in cassava production by 50.67% and 50.16% RCP 4.5 and 8.5; respectively. We encourage farmers to adopt cassava as a crop because of its responsiveness to climate, this could help the farmer to be food secure despite the projected climate variability and change.

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