*CARIWIG Case Study Report 6*

# The impact of future climate change on sweet potato production

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## Summary

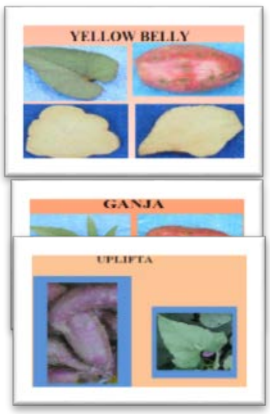
- For some applications such as modelling the impact of climate change within a sector the availability of long series of meteorological data for historical and future periods is quite useful. One of the ways such a long series may be generated is through the use of a weather generator
- In this case study data from the CARIWIG weather generator is used to provide input to the FAO AquaCrop model calibrated on sweet potato to determine the impact of future climate change on field grown sweet potato production.
- High increases in both yield and biomass (up to 40%) are indicated for 2041-2070 relative to 1981-2010 under the A1B (medium emissions) scenario with a decrease in reference evapotranspiration ($ET_o$). This combined effect of higher productivity and reduced $ET_o$ is associated with an increase in water productivity (up to 108%).

## Aim and objectives

The aim of this study is to assess the impact of future climate change on field grown sweet potato production. Jamaica currently accounts for 66% of sweet potato production among all CARICOM states and the crop contributed to the 8% increase in non-traditional agricultural exports in 2012 over 2011. The mandate of the Ministry of Agriculture and Fisheries is to promote food security and food safety and increased sweet potato production is identified as one of the targeted interventions through which these will be achieved. The objective of this study is to determine the percentage change in yield, biomass, evapo-transpiration and water productivity across three varieties of sweet potato for 2041-2070 relative to 1981-2010. The varieties examined are Ganja, Uplifta and Yellow Belly.

## Which tools were used? How and why?

The tools used are the CARIWIG Weather Generator and the FAO AquaCrop Model. The CARIWIG weather generator is used given its ability to generate long series and multiple realization of meteorological data at specific site locations for present and future periods on daily timescales. This is required for input to the AquaCrop model. Daily series of rainfall, maximum and minimum temperature and vapour pressure are obtained from the weather generator for two periods: 1981-2010 and 2041-2070. Data for the 1981-2010 period were generated based on observed rainfall and maximum and minimum temperature data for Worthy Park in Jamaica. Data for the 2041-2070 period were generated under the A1B scenario by perturbing the weather generator with change factors derived from the HadCM3Q0 global climate model. One hundred series were generated for both periods.

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Caribbean Agricultural Research Division, CARDI (Jamaica); Ministry of Agriculture and Fisheries (Jamaica), Meteorological Service of Jamaica, (Jamaica); Christian Potato Growers (Jamaica); College of Agriculture Science and Education, CASE (Jamaica); HEART NTA (Jamaica).

The series were also used to calculate potential evapotranspiration by means of the FAO reference evaporation Calculator which uses the Penmann-Monteith Equation (procedures are explained in Raes (2009)).

The rainfall, temperature, relative humidity, vapour pressure (obtained from the records of temperature using standard procedures) and potential evaporation data were used as input to the AquaCrop Model that had been calibrated for sweet potato. AquaCrop is a crop-water productivity model that simulates yield response to water of herbaceous crops and is particularly suited to address conditions where water is a key limiting factor in crop production. For each run, yearly outputs of yield, biomass, evapotranspiration ($ET_o$) and water productivity were obtained. All one hundred present day (1981-2010) series for all variables were run through AquaCrop while thirty randomly chosen series under A1B were used. An average was calculated across the three varieties for the future and for present day scenarios and the differences between the two scenarios were calculated.

Some characteristics of the site in St. Catherine used for field trials include a mean annual rainfall of 1556 mm, an elevation of 100 m, clay soil properties and is rainfed.

## The findings

Preliminary climate analyses suggest a slight increase in the mean seasonal rainfall amounts by 9.9 mm (+1.5%) but there was much higher inter-annual variability for the period 1981-2010 (284.5 mm) compared to that for 2041-2070 (124.6 mm). Increases were also noted for the maximum temperature, minimum temperature, vapour pressure and relative humidity. See Table 1.

**Table 1. Mean seasonal changes in some key weather variables for 2041-2070 relative to 1981-2010 under the A1B scenario.**

| Rainfall (mm) | | | Maximum Temperature (˚C) | | | Minimum Temperature (˚C) | | | Vapour Pressure | | | Relative Humidity (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Min | Mean | Max | Min | Mean | Max | Min | Mean | Max | Min | Mean | Max | Min | Mean | Max |
| 161.3 | 9.9 | -540.2 | 3.5 | 3.0 | 12.6 | 2.8 | 2.1 | 7.8 | 3.7 | 3.0 | 9.4 | 1.2 | 1.3 | 25.4 |

High increases in both yield (33%) and biomass (range: 32–37%) are indicated for 2041-2070 relative to 1981-2010 under the A1B (medium emissions) scenario, seemingly added by more consistent rainfall. There was a decrease in reference evapotranspiration by about 15%. The combined effect of higher productivity and reduced $ET_o$ is associated with an increase in water productivity. This further underscores the crop's resilience to climate change, its adaptability to varying environmental conditions (Romero and Baigorria 1991; CARDI 2010; Stathers et al. 2013) and importance for food security, given projections for a warmer Caribbean with more variable rainfall. Higher $CO_2$ concentrations in future climates- which are possible given current trajectories- could produce even higher production increases. Table 2 summarizes these results.

**Table 2. Absolute and Percentage seasonal change in future sweet potato production in St. Catherine, Jamaica for 2041-2070 relative to 1981-2010 under the A1B scenario**

| Change | Biomass (t/ha) | | | Yield (t/ha) | | | Evapotranspiration (mm/day) | | | Water Productivity ($kgm^{-2}mm^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Mean | Max | Min | Mean | Max | Min | Mean | Max | Min | Mean | Max |
| Absolute | 4.4 | 4.3 | 4.2 | 2.2 | 2.2 | 2.3 | -88.2 | -89.0 | -95.7 | 0.8 | 0.9 | 1.0 |
| Percentage | 37.0 | 33.9 | 31.6 | 33.9 | 32.5 | 32.0 | -15.5 | -15.3 | -15.9 | 63.9 | 70.1 | 70.9 |

# Implications for policy and planning

The results suggest that sweet potato may be a potential 'climate change' adaptation crop particularly given its moderate drought tolerance, requiring little labour and inorganic fertilizers for development of the tuber. Additionally given that the crop can be grown on marginal lands, is highly adaptable to multiple agro-ecological conditions is not exposed to destructive winds of tropical cyclones (the tubers are underground), it may be viewed as a reliable food source even in times of adverse weather.

The potential to mainstream crop modelling in routine operations of the Agricultural sector in the Caribbean should be pursued. Crop models can be used as strategic planning tools to improve production or as in-season advisories on weather-induced production problems and disease management (Boote, Jones, and Hoogenboom 2008). Crop models are also useful for testing and validating field studies and for experimenting with new planting techniques, nutrient and irrigation treatments and new crop varieties. Models are a powerful tool for extending findings and conclusions to conditions not tested in the field, especially in cases where field experimentation is cost prohibitive (FAO 2002).

# Feedback on the tools

The weather generator provides the ability to produce series of daily data at present and future periods which is quite advantageous to investigating a number of climate scenarios. Additionally the weather generator output showed good skill in representing observed mean climate as well as extremes and year-to-year variability.

There was some challenge working across 100 ensemble members for each scenario. Moreover, data for some missing parameters (such as wind and solar radiation) needed for computing reference evapotranspiration cannot be produced by the weather generator.

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# What more could be done?

Future work could involve the following:

- The effect of $CO_2$ fertilisation could be explored to see how production benefits and to determine the limits at which further increases in $CO_2$ have no net beneficial effects.
- The crop is particularly susceptible to the sweet potato weevil, especially during drought. Modelling the effect of pest and disease on future crop production could be quite useful.
- The application of the weather generator to multiple sites across the Caribbean and for other crops could be investigated contingent on the availability of meteorological and yield datasets.
- The Use of weather generator data that have been obtained in relation to regional climate models under the A1B or other emissions scenarios could be explored. This study involved the use of one global climate model under one emission scenario (A1B).
- An examination of the seasonality of the climate change projections in relation to the sweet potato growing season could be undertaken to better understand what is driving the increases in yield.

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