Research Application Summary

Assessment of impacts of climate variability and change on rainfed sorghum productivity in central Tanzania

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Abstract

The central regions of the country stretching from Dodoma to Mwanza account for three-quarters of Tanzania's 500,000 to 800,000 ton annual sorghum harvest. The zone is one of the most sensitive to climate variability and change mainly owing to temperature and rainfall variability. Over the 20th century, both the temperature and the pattern of rainfall in the zone have changed. One of the most dramatic examples of the consequences of the climate variability and change is the increase in prolonged dry spells. In Tanzania, dry spells have led to crop failures especially maize. In this study, an attempt was made to estimate climate change impacts on crop yields in the zone through developing a simulation framework using DSSAT as a tool for assessing the impact of variability and changes in rainfall, temperature and evapo-transpiration.

Key words: Adaptation, climate variability, central zone, impact assessment, sorghum, Tanzania

Résumé

Les régions centrales du pays qui s'étendent de Dodoma à Mwanza comptent pour les trois quarts de la récolte annuelle de sorgho évaluée de 500.000 à 800.000 tonnes en Tanzanie. La zone est l'une des régions les plus sensibles à la variabilité et au changement climatiques suite principalement à la variabilité de la pluviométrie et de la température. Au cours du 20ème siècle, à la fois la température et la répartition des pluies dans la zone ont changé. L'un des exemples les plus dramatiques des conséquences de la variabilité et des changements climatiques est l'augmentation des périodes prolongées de sécheresse. En Tanzanie, les périodes de sécheresse ont conduit à de mauvaises récoltes en particulier du maïs. Dans cette étude, on a tenté d'estimer les impacts du changement climatique sur les rendements des cultures dans la zone à travers l'élaboration d'un cadre de simulation en utilisant DSSAT comme un outil d'évaluation de l'impact de la variabilité et des changements dans les précipitations, la température et l'évapotranspiration.

Mots clés: Adaptation, variabilité climatique,, zone centrale, évaluation de l'impact, sorgho, Tanzanie

Background

IPCC (2007) concludes that climate variability and change in Tanzania will severely compromise agricultural production and access to food, where it is estimated that yields from rain-fed agriculture can be reduced by up to 50% by 2020. Crop simulation models can provide good simulations of crop productivity under the impact of variable weather in a range of soil, water and crop management choices (Cooper *et al*., 2008). Despite the fact that overall millet and sorghum yields are projected to be slightly higher under climate change, probably given their higher tolerance to higher tempera-tures and drought stress; these results need further investigation especially at a lower level of a country or more particularly a zone. In Tanzania, studies using the DSSAT crop model to assess the impact of the future long-term climatic change on agriculture are still few. In particular, very few studies are documented which use CERES-Sorghum, linked with GCMs or RCMs to simulate the change of production in rainfed sorghum under the IPCC SRES scenarios A1B and B1. The projections of two GCMs, driven by two SRES scenarios will be statistically downscaled for multiple locations throughout the region, for the 2020s and 2050s climate.

Literature Summary

IFPRI (2009) indicate that cereal production growth for a range of crops in SSA is projected to decline by a net 3.2% in 2050 as a result of climate change. Both Challinor *et al*. (2009) and Ruane *et al.* (2012) demonstrate the need of using crop growth models in simulating the impacts of climate variability and change on crops. In particular, Ruane *et al*. (2012) show the extent to which a single calibrated model configuration may shed light on many other related farming systems. Moreover, Rosenzweig *et al.* (2012) propose inter-comparison procedures that would scale field-level outputs up to zone or country and regional scales. For example, comparison of the techniques used in GLAM (Challinor *et al*. 2009), DSSAT (IFPRI, 2009) and CLICROP (Arndt *et al*. 2011) may give a direction on how best to undertake simulations at the zone level such as central Tanzania.

Study Description

The central zone of Tanzania (Dodoma and Singida) is located between latitudes 6° and 06°08' S and longitudes 34°30' and 35° 45'E. Soils in this zone are mainly sandy and loamy of low fertility and seasonally waterlogged or flooded clays. The field experiment was conducted at Hombolo Agricultural Research Institute (ARI) located at 05°45'S latitude, 35°57'E longitude. The soil texture in this area ranges from sandy to sandy clay on the surface and loam subsoil. These soils are classified as Typic Ustorthent in the US soil taxonomy and as Dystric Regosol in the FAO classification. The average annual rainfall is 589mm but the distribution is highly variable with high intensities. The average annual temperature is 22.7°C. The main objective of the study was to develop a set of relevant climate change scenarios for the central zone and to apply these scenarios to determine the impacts of current variability and future changes in climate on productivity of rainfed sorghum. For the model, the integrations of two GCMs (CSIRO-MK3.5 and ECHAM5) running under two SRES scenarios (A1B and B1), statistically downscaled using MarkSim-GCM weather generator for six locations throughout the region/zone will be used. Three time periods are being considered as scenarios: 1991–2010 (baseline), 2021–2040 (2030s) and 2041–2060 (2050s) with the ranges of very dry to dry and very wet to wet periods.

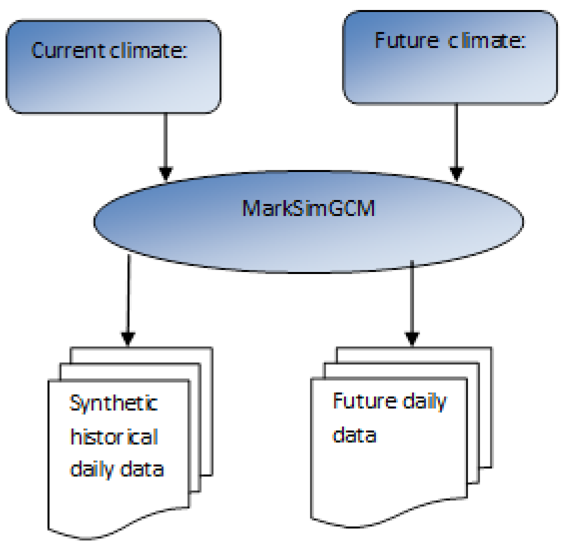

Figure 1. Downscaling of the climate change scenarios for the central zone.

Therefore, a simulation framework is being developed which takes into account the spatial and temporal variability in information on soils, cultivars, sowing dates and crop management. From the simulated yields under variable climate (scenarios), it will be possible to establish if climate change will have a negative or positive impact on sorghum productivity. In the ongoing season the data is compiled for the soil water holding characteristics that define the lower limit of plant-extractable water (LL), drained upper limit (DUL), and saturated soil water content (SAT) from the WISE database and other reports, the genetic coefficients of the three sorghum cultivars (PATO, TEGEMEO and MACIA) are also being determined from the field experimental data.

Research Application

The daily climate projections will be used as the input data in CERES-sorghum crop simulation model of the Decision Support System for Agrotechnology Transfer (DSSAT) to simulate the change in sorghum production in six locations selected in Central Tanzania. The model needs inputs of daily data of rainfall, maximum and minimum temperatures and solar radiation, cultivar-specific coefficients (genetic coefficients) and soil profile characteristics for model execution. Since the model must be calibrated from the field experimental data for the season 2012/2013 the compilation of data is not complete. Some of the data compiled include genetic coefficients (Table 1). When all the data required for the model execution are available the CERES model will be used to simulate the impact of climate variability and change to sorghum yield in six locations in central Tanzania using the output of two GCMs run under two distinct

Table 1. Genetic coefficients determined during the season.

Name	Description	Genetic coefficients		
		Macia	Pato	Tegemeo
P1	Thermal time from seedling emergence to the end of the juvenile phase	426.5	426.5	426.5
P20	Critical photoperiod	12.0	12.0	12.0
P2R	Extent to which phasic development leading to panicle initiation above critical photoperiod	40.5	40.5	40.5
P5	Thermal time from beginning of grain filling to PM	535.0	540.0	540.0
G1	Scaler for relative leaf size.	0	0	0
G2	Scaler for partitioning of assimilates to the panicle (head).	6.0	6.0	6.0
PHINT	Phylochron interval	49	49	49

SRES scenarios for three time periods: 2000s (baseline), 2030s, and 2050s. For each time period, DSSAT will be run ten times under different synthetic weather conditions to adequately take into account climate variability.

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