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Application of DSSAT crop simulation model to identify the changes of rice growth and yield in Nilwala river basin for mid-centuries under changing climatic conditions

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Abstract

Changes of climate will be one of the deciding factors that affect for future food production in the world because crop growth is highly sensitive to any changes of climatic conditions. As the rice is staple food of Sri Lankans, it is essential to identify the impacts of climate changes on country's rice production. This study was conducted to identify the yield and growth changes of most popular two rice varieties (At362 and Bg357) cultivated in Nilwala river basin at *Yala* season under the global climate change scenario Representative Concentrate Pathway (RCP) 8.5. The Decision Support System for Agro technology Transfer (DSSAT) software is used to forecast the rice yield for *Yala* season in mid-centuries. To simulate the rice yield DSSAT requires data sets of crop growth and management, daily weather data and soil data. Crop management data were obtained from an experiment which was conducted in Palatuwa area at Nilwala downstream in Matara district. Daily weather data were collected from Mapalana weather station and soil data were collected from wet zone soil classification. Model was calibrated using experimental data for *Yala* season 2014 and model was validated using collected data in *Yala* season 2013. Future yield was predicted using forecasted weather data under climate change scenario RCP 8.5 for Mapalana area. The results show that increasing temperature and solar radiation and decreasing rainfall in mid-centuries affects both yield and growth of rice. Grain yield in mid-centuries shows decreasing trend in both varieties by 25% to 35% than the yield at 2014 and growth period will be shorter than the present conditions.

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Keywords: Climate change; DSSAT; rice yield

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1. Introduction

Impacts of climate change on Agriculture will be one of the major deciding factors influencing the future food security of mankind on earth. Since rice is the staple food of Sri Lanka, it is essential to identify the impacts of climate change on rice yield to increase the country's rice production. Climatic factors such as temperature, rainfall, atmospheric CO_2 and solar radiation are important parameters to rice production[1].

The average daily maximum temperature and rainfall pattern will be changed as a result of increasing concentrations of CO_2 and other greenhouse gases in atmosphere. These changes have become the most important considerations for Sri Lankan rice production[2]. Increasing trend of daily maximum temperature may decrease the rice spikelet fertility, which affects for reduction of the yield while the increasing trend of atmospheric CO_2 concentration could increase the rice yield[3].

Matara district is one of the rice cultivation districts in Sri Lanka and have a good potential for rice cultivation in both *Maha* and *Yala* season. Nilwala river is the major water source for rice cultivation in this area. Most of the farmers in this area cultivate improved rice varieties but their yield is always lower than the potential yield due to the different level of management practices and the variation of climatic conditions. Yield gap can be increased in the future due to climate change especially if current agricultural practices are continued[4]. Conducting the field experiments for identify impacts of climate change on rice cultivation will take long time period.

DSSAT is a popular crop model that is used worldwide for modeling growth and yield of 30 different crops including rice under given soil and daily weather conditions. For future yield prediction it is required to calibrate and validate the DSSAT model with adjusting the cultivar genetic coefficients. For rice there were 8 genetic coefficients and they describe the genotype and environmental interactions[5].

Validated DSSAT model can be used to predict the future rice yields with future weather conditions and find the suitable adaptation measures for increase the yield[5].Therefore this study was conducted to identify the changes of rice yield and growth in Nilwala river basin under changing climate in mid-centuries using DSSAT model.

2. Materials and Methodology

2.1. Selection of Rice varieties

Two improved rice varieties namely At362 and Bg357 which are most commonly grown in the study area were selected for yield simulation. Both are medium duration and high yielding varieties.

2.2. Data collection

Technical reports of DSSAT software were used as a guide for data collection. Data sets were obtained from sample analysis, observations and use of existing data.

As Daily weather data Daily maximum and minimum air temperatures, precipitation and solar radiation from planting date to harvesting date were collected from Mapalana weather station. As Soil data Soil class, texture, Bulk density, Organic Carbon%, Sand%, Silt%, Clay%, pH and Cation Exchange Capacity in Surface layer (0-20 cm) and subsurface layer (20-50 cm) were obtained from Palatuwa series wet zone soil classification. The crop management data were collected from ongoing field trials in Palatuwa area in *Yala* season 2014.Planting method, planting date , plant density, row spacing, amount of fertilizer application, irrigation data, panicle initiation date, panicle maturity date, harvesting date, harvesting method, grain yield/m^2, and leaf area index in 5 growth stages were collected.

2.3. Model calibration, validation and future yield simulations

Three input files were created to run the DSSAT model using collected data.

- Weather file: Weatherman program in DSSAT and collected weather data
- Soil file: SBuild program in DSSAT and soil data
- Experimental data file: XBuild program in DSSAT and crop management data