BIOMASS AND YIELD RESPONSES TO CLIMATE VARIABILITIES FOR RICE AND MAIZE - A MODELING IN AN GIANG PROVINCE, VIETNAM

Dissertation

LE HUU PHUOC

1931618001

FACULTY OF AGRICULTURE

ANDALAS UNIVERSITY

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As one of the requirements to obtain Doctorate Degree
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This Dissertation has been tested and defended in front of the Open Examination Committee of the Agricultural Science at the Doctoral Study Program of Agriculture Science, Faculty of Agriculture, University of Andalas, was declared to have passed on March 13, 2024

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STATEMENT

I, the undersigned, Le Huu Phuoc, residing Long Xuyen City, Vietnam, hereby declare that in this dissertation, there is no work submitted by any other person to obtain an academic degree at a tertiary institution. To the best of my knowledge, there are no works or opinions written or published by others except those presented in the manuscript and cited in the bibliography.

Padang, 2024

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SUMMARY

This research focused on crop modeling “SIMPLECrop model” for rice and maize crops in An Giang, Vietnam, under open-field and climate variabilities (increased temperature and CO_2). The study also involved developing a spatiotemporal crop advisory user program. The study gathered data on rice and maize spanning a decade (2010-2019) to analyze trends in temperature, CO_2 levels, solar radiation, rainfall, as well as the validation the modeling. The experiments have been conducted to obtain observed data during 2020-2021. Experimental trials spanned crops' open-field and greenhouse conditions across two growing seasons Autumn-Winter (AW) and Winter-Spring (WS). The results showed that increasing temperature resulted in a shortened growth duration and decreased yield, which had an impact on biomass.

The study successfully validated the crop model's proficiency in simulating rice and maize growth dynamics under the field and varying temperature and CO_2 scenarios. Effective performance was observed in greenhouse and field conditions, with accurate crop biomass and yield predictions indicated by low Relative Root Mean Square Error (RRMSE) and high Nash-Sutcliffe efficiency coefficient (NSE). Evaluation results demonstrated NSE values fell within the range of 0.87 to 0.93, while RRMSE varied from 4.2% to 6.3% under open-field conditions. In contrast, within greenhouse conditions, RRMSE ranged from 1.4% to 15.1%, with NSE values spanning from 0.75 to 0.89. Despite the positive effects of CO_2 fertilization on biomass and yield, escalating temperatures counteracted these benefits, illustrating the complex climate-crop dynamic. Furthermore, a user-friendly crop user interface, available in both R-flatform and browser-based versions (Chrome, Safari, Firefox, Edge, CocCoc, Opera), was also developed. This practical tool was utilized as a source of information for researchers, companies, agricultural cooperative, provincial agricultural deparment.

In summary, simulating a 5°C temperature increase for rice and maize led to significant reductions in biomass and yield, with varying impacts across seasons. Rice experienced reductions of 7.2% to 7.7% in straw biomass and 8.5% to 7.0% in yield in WS and AW seasons, respectively. Maize saw reductions of 5.2% to 19.3% in stover biomass and 11.3% to 27.0% in yield. Conversely, increasing CO_2 concentration alone resulted in increased biomass and yield, most markedly at a 250 ppm increase. Rice saw increases of 15.3% to 19.9% in biomass and 16.3% to 20.0% in yield, while maize experienced a 2.5% increase in biomass and 7.7% to 9.1% in yield. However, under severe heat stress, the beneficial effects of elevated CO_2 were reduced to approximately 3-5%. These findings highlight the need to consider temperature and CO_2 interactions in predicting crop responses.