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Potential individual versus simultaneous climate change effects on soybean (C_3) and maize (C_4) crops: An agrotechnology model based study

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Abstract

Landuse/landcover change induced effects on regional weather and climate patterns and the associated plant response or agricultural productivity are coupled processes. Some of the basic responses to climate change can be detected via changes in radiation (R), precipitation (P), and temperature (T). Past studies indicate that each of these three variables can affect LCLUC response and the agricultural productivity. This study seeks to address the following question: What is the effect of individual versus simultaneous changes in R, P, and T on plant response such as crop yields in a C_3 and a C_4 plant? This question is addressed by conducting model experiments for soybean (C_3) and maize (C_4) crops using the DSSAT: Decision Support System for Agrotechnology Transfer, CROPGRO (soybean), and CERES-Maize (maize) models. These models were configured over an agricultural experiment station in Clayton, NC [35.65°N, 78.5°W]. Observed weather and field conditions corresponding to 1998 were used as the control. In the first set of experiments, the CROPGRO (soybean) and CERES-Maize (maize) responses to individual changes in R and P (25%, 50%, 75%, 150%) and T (±1, ±2 °C) with respect to control were studied. In the second set, R, P, and T were simultaneously changed by 50%, 150%, and ±2 °C, and the interactions and direct effects of individual versus simultaneous variable changes were analyzed. For the model setting and the prescribed environmental changes, results from the first set of experiments indicate: (i) precipitation changes were most sensitive and directly affected yield and water loss due to evapotranspiration; (ii) radiation changes had a non-linear effect and were not as prominent as precipitation changes; (iii) temperature had a limited impact and the response was non-linear; (iv) soybeans and maize responded differently for R, P, and T, with maize being more sensitive. The results from the second set of experiments indicate that simultaneous change analyses do not necessarily agree with those from individual changes, particularly for temperature changes. Our analysis indicates that for the changing climate, precipitation (hydrological), temperature, and radiative feedbacks show a non-linear effect on yield. Study results also indicate that for studying the feedback between the land surface and the atmospheric changes, (i) there is a need for performing simultaneous parameter changes in the response assessment of cropping patterns and crop yield based on ensembles of projected climate change, and (ii) C_3 crops are generally considered more sensitive than C_4; however, the temperature–radiation related changes shown in this study also effected significant changes in C_4 crops. Future studies assessing LCLUC impacts, including

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