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An investigation on the effects of elevated CO_2 and temperature on Chickpea yield in Zanjan

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Abstract
Climate change is one of the most important concerns throughout the world.Because the entire world will be affected by this phenomenon, much more attentions have paid to eliminate or alleviate its detrimental effects. To assess the effects of this phenomenon, different models and scenarios have been developed and applied. To assess the effects of changing temperature and carbon dioxide concentration as the main consequences of climate change on chickpea yield in Zanjan distinct, Iran, the SSM model (Soltani and Sinclair, 2011) was applied and 8 different scenarios were used. The scenarios were as: 1) current situation without any change in temperature or carbon dioxide concentration; 2-4): 2, 4 and 6 °C change in temperature without carbon dioxide change and 5-8) 2, 4 and 6 °C change in temperature along with doubled CO_2 concentration. Our results indicated that increasing temperature did not changed mean yield, while increased maximum observed yield in studied region (changed from 14 to 35%). But, when temperature increased in parallel to doubled CO_2, Mean yield also increased considerably, with 36 to 41.3 % increasing in comparison with Scenario 1). The Scenario 4 (4°C increasing temperature and doubled CO_2) was selected as the superior scenario with the higher increase in mean yield, and reasonable increase in both minimum and maximum yields.

Keywords: Chickpea, climate change, elevatedCO_2, Increased temperature, Iran.

Introduction

Climate change is one of the most important concerns which the world has faced by it during current decades. Because the entire world will be affected by this phenomenon, much more attentions have paid to eliminate or alleviate its detrimental effects. To assess the effects of this phenomenon, different models and scenarios have been developed and applied. Crop simulation models also have been used widely along with other tools to quantify o predictive climate change effects. For example, CSM-CERES-Maize (Ritchie *et al.*, 1998; Jones *et al.*, 2003) model of DSSAT family simulates daily crop growth from sowing to maturity by using soil, weather and crop management parameters. Scientists had been used this model for decision making in crop production under variety of environment. Zalud and Dubrovsky, (2002) and Cedron *et al.* (2005) used this model for climate change risk management studies. DSSAT model facilitates researchers in decision making through seasonal, spatial and rotational analysis drivers to improve the efficiency and profitability of cropping systems.

Rosenzweig (1990) used CERES-Wheat and CERES-Maize models to simulate the effects of climate change under doubled CO2 conditions on yields of wheat and maize grown in the Southern Great Plains of the United States.

Jones *et al.* (1995) reported that two wheat models have been used to simulate climate-change effects on wheat production in Europe.

The WOFOST model (van Diepen *et al.*, 1989) simulates daily increments of crop growth using daily weather data. It simulates potential production based on weather variables alone, and can also simulate effects of water-limitation on production. Wolf (1993) used WOFOST with weather and soil data for 201 locations across Europe and three GCM scenarios to simulate the effects of climate change on yields of winter wheat. He modified the model to simulate CO2 effects on photosynthesis, transpiration, and specific leaf area and found that water-limited yields of winter wheat increased under all scenarios (by 1 to 2.3 t ha-1) when the direct effects of CO2 were included.

Mera *et al.* (2006) studied the effect of individual versus simultaneous changes in radiation (R), precipitation (P), and temperature (T) on plant response such as crop yields in a C3 and a C4 plant by using the DSSAT: including CROPGRO (soybean), and CERES-Maize (maize) models. The use of simulation models to predict the likely effects of climate change on crop production is, of necessity, an evolving science. As both general circulation models and crop simulation models become more sophisticated, as more high quality historical weather data for a larger number of sites become available, and as better physiological data become available to model maize responses to climate change variables, predictions will become more accurate.This study was aimed to assess the effects of elevated CO_2 and temperature on Chickpea yield by SSM model (Soltani and Sinclair, 2011).

Material and Methods

To assess the effects of changing temperature and carbon dioxide concentration as the main consequences of climate change on chickpea yield in Zanjan distinct, Iran, the SSM model (Soltani and Sinclair, 2011) was applied and 8 different scenarios were used. SSM model (Soltani and Sinclair, 2011) is a crop simulation model which simulates phonological development, leaf development and senescence, mass partitioning, plant nitrogen balance, yield formation and soil water balance and works using daily weather data. The model has been successfully tested against data from field experiments (Soltani and Sinclair, 2011).

The scenarios were as: 1) current situation without any change in temperature or carbon dioxide concentration; 2-4): 2, 4 and 6 °C change in temperature without carbon dioxide change and 5-8) 2, 4 and 6 °C change in temperature along with doubled CO_2 concentration. Descriptive statistics procedure also was used to determine the range and mean of variations in

Results and Discussion

Our results indicated that increasing temperature did not changed mean yield (changed from 680.4 to 710.5 Kg), while increased maximum observed yield in studied region (changed from 14 to 35%). But, when temperature increased in parallel to doubled CO_2, Mean yield also increased considerably (changed from 930.28 to 980.3 kg ha-1, with 36 to 41.3 % increasing in comparison with Scenario 1). The Scenario 4 (4°C increasing temperature and doubled CO_2) was selected as the superior scenario with the higher increase in mean yield, and reasonable increase in both minimum and maximum yields. These results indicated that simultaneous increasing of temperature and CO_2 can resulted in higher grain yield in chickpea fields of study area. Also, increased temperature (6 °C) reduced minimum obtainable yield, while increased mean yield. It seems that synergistic effects of both temperature increasing and elevated CO2 can enhance chickpea yield in the study area.

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