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MODELLING THE ADAPTATION CAPABILITIES OF SUNFLOWER AND WINTER WHEAT TO CROP ROTATION AND POSSIBLE CLIMATIC CHANGE IN THRACE

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Abstract
In agriculture, most changes in atmospheric conditions are uncontrolled factors caused by climate change or variability that could have effects on different sectors. Globally, major important sector is agriculture by means of supplying food on Earth. Determination of the positive and negative effects of climate change to make provision for possible future conditions could be executed using Crop-Climate models. Developed by the Food and Agriculture Organization (FAO), the AquaCrop is an explanatory Crop-Climate model, which could be used to analyze such relationships between climate change and food productivity. In this research, variations in the growth and yield parameters associated with rotation between the sunflower and winter wheat were investigated using AquaCrop between the periods of 2014 and 2016 in Kırklareli and Edirne cities which have specific climates and soil types in the Thrace Region. Moreover, main yield-related outputs of the model will been validated after model AquaCrop will simulate sunflower and winter wheat crop rotation until 2099 for Thrace Region to expand our future perspective.

Keywords: AquaCrop, simulation, crop rotation, Turkey.

Introduction
Atmospheric conditions are the uncontrollable processes in nature and have positive or negative impacts on most sectors. Agriculture is one of these sectors. Climate is a primary environmental factor that effect life of the living beings. Researches about different environmental and other factors on crop growth and yield are not only cheap but also long process (Şaylan, 1994). For this reason, answers about any crops whether or grow in our country conditions are found in many years of study. AquaCrop, crop growth simulation model, has become popular in recent years, which is developed by Food and Agriculture Organization of the United Nations (FAO). Researchers in different countries have intensively tested the AquaCrop model and wanted to expand their perspective how effects crop development, yield and etc. by agricultural drought in different climates, irrigation schedules, agricultural practices (Andarzian et al., 2011; Araya et al., 2010; Vanuytrecht et al., 2014; Voloudakis et al., 2015). According to Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5), Mediterranean Basin is negatively affected by climate change. Rain accumulation will decrease and air temperature will significantly increase. Turkey is located in Mediterranean Basin and it is expected that different region in Turkey will be affected differently by climate change. The Northwestern part of Turkey which includes Thrace Region plays an important role on sunflower and winter wheat cultivation. Percentage of sunflower and winter wheat production are 75% and 35%, respectively. This research was pursued at Atatürk Soil Water and Agricultural Meteorology Research Institute to analyze between modelled and observed sunflower and winter wheat yield.

Material and methods
This research is conducted at two different cities, which are Kırklareli (40°43'42.43"N latitude, 26°26'42.69"E longitude) and Edirne (41°41'55.34"N latitude, 27°12'38.71"E longitude), in Thrace

Region. Beeline distance between these two locations is 126.2 km (Figure 1). Soil types of Kırklareli and Edirne are sandy loam and clay, respectively. These two locations represent Kırklareli and Edirne.

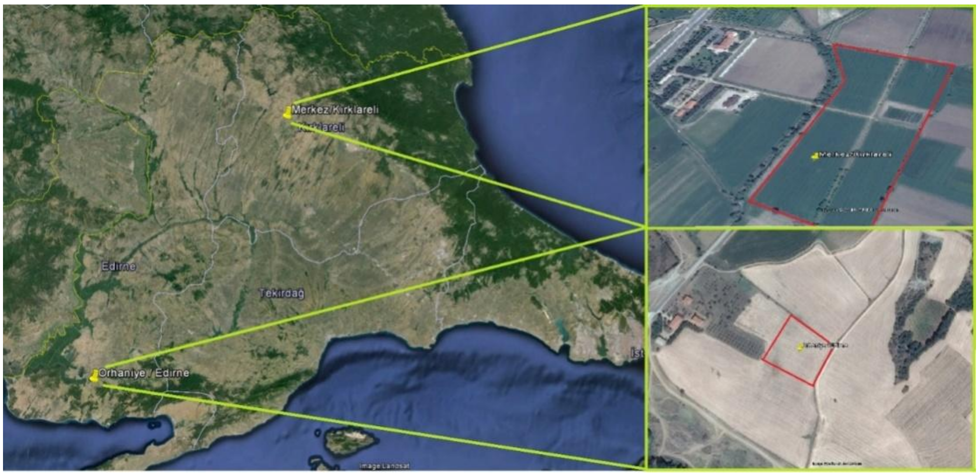

Figure 1. Location of Study Area

Two Meteorological stations were installed at research fields. Each station includes data logger (CR1000, Campbell Sci.), pyranometer (CMP6, KippZonen), temperature and relative humidity (Rotronic and Vaisala), wind speed and direction (NRG), soil water content (CS616, Campbell Sci.) at 3 different (0-30, 30-60, 60-90 cm) depths. These sensors measure 30 sec. time interval and log data 10, 30, 60 min and 24 hour. In order to estimate sunflower and winter wheat crop yield and other crop parameters, AquaCrop developed by FAO were performed. The flowchart of AquaCrop can be found in Figure 2.

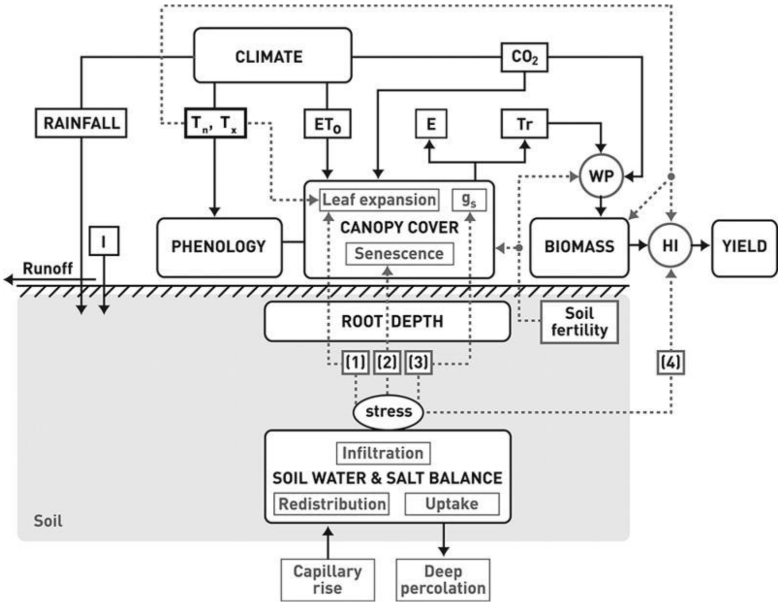

Figure 2. The Flowchart of AquaCrop Model (Raes et al., 2009)

General calculation of the AquaCrop model depends on the soil-water balance method with a daily time step. Partitioning of biomass into yield given the simulated above ground biomass (B), crop yield is obtained with the help of the Harvest Index (HI). In response to water and/or temperature stresses, HI is continuously adjusted during yield formation. Reference Evapotranspiration (ET_0) is calculated by FAO Penman-Monteith method (Eq. 1) with measured meteorological factors at two different research locations.

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T+273}u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \quad (1)$$

where; ET_0 reference evapotranspiration (mm/day); Δ, slope vapour pressure curve (kPa/°C); R_n, net radiation (MJ/m^{2}day); G, soil heat flux density (MJ/m^{2}day); γ, psychrometric constant (kPa/°C); T, air temperature at 2 m height (°C); u_2, wind speed at 2 m height (m/s); e_s, saturation vapour pressure (kPa); e_a, actual vapour pressure.

Results and discussion

Meteorological variables and crop biomass of two locations were simultaneously measured. Sunflower and winter wheat simulations of the AquaCrop model were performed and can be seen in Figure 3, 4, and 5. Sunflower simulations for Edirne and Kırklareli, measurements from meteorological stations and crop phenological observations became input values for AquaCrop model. Calculation of soil water content in AquaCrop was done from initial soil water content and using soil water balance method. For sunflower simulations in Kırklareli, 2014 and 2015 growing season predictions were overestimated in comparison with in-situ measurements. Sunflower yields in 2014 and 2015 growing season are 250 kg/da and 202 kg/da, respectively. On the other hand, AquaCrop simulations for these growing seasons were 443 kg/da and 279 kg/da, respectively (Figure 3).

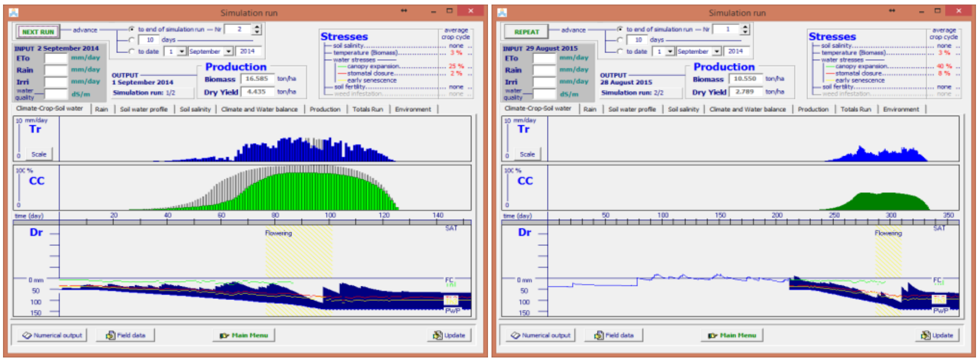

Figure 3. Sunflower Simulations for 2014 and 2015 Growing Season for Kırklareli

For sunflower simulations in Edirne, 2014 and 2015 growing season predictions were again overestimated. Sunflower yields in 2014 and 2015 growing season are 300 kg/da and 164 kg/da, respectively. On the other hand, AquaCrop simulations for these growing seasons were 314 kg/da and 288 kg/da, respectively (Figure 4).

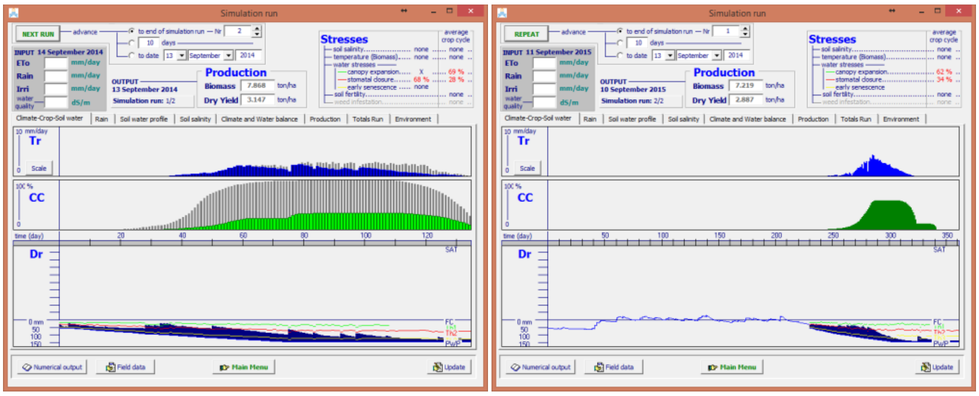

Figure 4. Sunflower Simulations for 2014 and 2015 Growing Season for Edirne

Moreover, winter wheat simulations for Kırklareli and Edirne were performed for 2015-2016 growing season. While winter wheat simulation for Kırklareli was underestimated, simulation for Edirne was overestimated for yield. This difference could come from soil texture and the capacity of available water in root zone. But, locations, estimation and measurement biomass values are not considerably different. Simulations for winter wheat yield in 2015-2016 growing season in Edirne and Kırklareli 417 kg/da and 532 kg/da, respectively (Figure 5). In-situ measurements of winter wheat yield 444 kg/da in Kırklareli and 478 kg/da in Edirne.

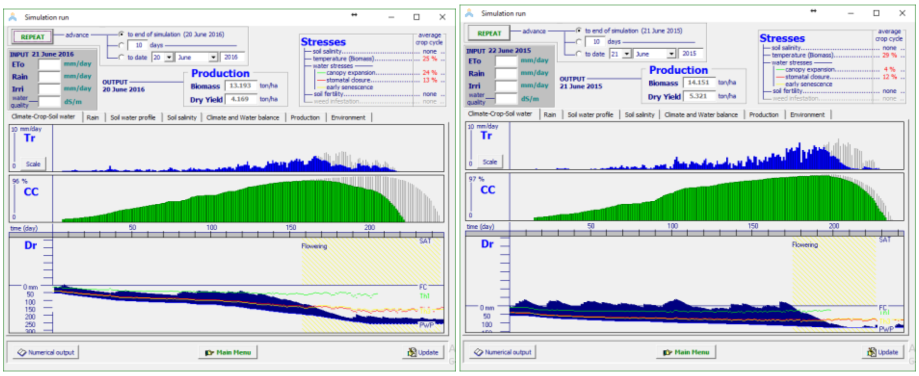

Figure 5. Winter Wheat Simulations for 2015-2016 Growing Season for Kırklareli and Edirne locations

Measurements and modelled biomass time series can be found in Figure 6. According to sunflower simulations, modelled biomass values are underestimated for two locations. However, yield performance of AquaCrop was overestimated. In winter wheat simulations, AquaCrop performance is relatively higher than sunflower simulations.

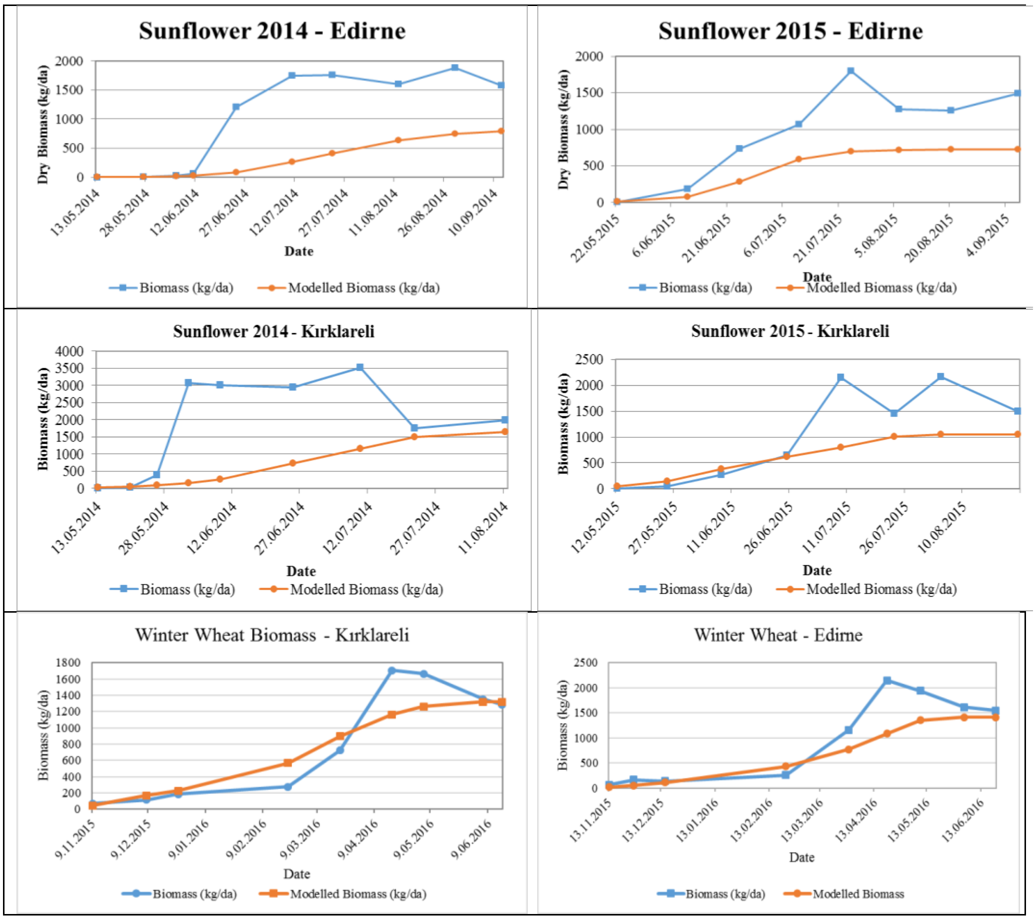

Figure 6. Measurements and Modelled Biomass of Simulations

AquaCrop simulates crop development, soil water content, crop water requirements, soil water profile, evapotranspiration etc. according to the soil water balance method. It is also user-friendly and preferred by among researchers. Simulations for different crops and locations help us to understand how climate affect crop development, biomass, and yield etc. Our simulations cover two consecutive sunflower growing periods and a winter wheat growing period in two locations. These locations do not have the same soil type and climate features. Therefore, water content in different soil type affect crop development. In addition, sunflower is more sensitive to soil water content than winter wheat. Especially in flowering phenological stage for sunflower is considerably important for yield formation. Because, this phenological stage period is in the middle of the summer. In drought years, crop development may be critical circumstances. In next years, sensitivity analysis of sunflower and winter wheat will be performed. Moreover, climate projections data until 2099 for these two locations will be obtained. After model calibration, AquaCrop will simulate sunflower and winter wheat crop rotation until 2099 for Thrace Region to expand our future perspective.

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