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Short Communication

A simple SSM model for predicting the performance of maize crop in Khash region

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ABSTRACT:

Models are being used to figure out the response of plants to possible changes in plant characteristics. The experiment was conducted at the Khash region in 2016. For the coefficient estimate and to evaluate the SSM model, the field trial data for corn single cross 704 was used. Corn seed varieties used include single cross 704 with 120 to 135 day growing period in agro-industrial company located in Mashhad Kaveh. In order to simulate the growth and yield of corn with SSM model in the field, climate data was used for comparison. The experimental design was a randomized complete block with four replications. After measuring the leaf area and the number of leaves on the main stem, in order to measure the dry weight of each sample (10 days) green and yellow leaves were shed, stems and seeds were dried at 70 ° C to achieve constant weight in the oven. Then dry weight was measured. Leaf area was determined using a leaf area meter Delta T. In the model, correlation coefficient was 0.99 to simulate the leaf dry weight, ear dry weight and leaf area index, which indicates good accuracy of the model to simulate all the characteristics.

Keywords:
Corn, Crop models, Simulations, SSM Models.

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INTRODUCTION

Cereal plants are monocotyledons that crops a year, meaning their life cycle in is one growing season. Corn (*Zea mays*) is a annual crop and uses C_4 photosynthetic pathway. Due to drought stress 40 to 60 percent of the world's agricultural land is affected (Sankar *et al.,* 2007). In between environmental stresses, drought is having adverse effects on crop production. Plants can be at risk of water stress in the arid and semi-dry conditions (Burghardt and Riederer, 2003). Plants also have numerous morphological and physiological mechanisms that allow them to adapt to water stress (Karkanis *et al*., 2011). Drought stress is the most important stress factor limiting the growth and yield of grain crops, including corn (Debaeke and Aboudrare, 2004). Depending on the season drought stress can lead to serious loss of product. In arid and semi-arid regions, plants during their growth period face dehydration and they should be able withstand it (Emam and Niknejad, 2004).

In Iran, corn is used in animal feed and for industrial purposes. Nitrogen is one of the main plant nutrients and is the fourth constituent element of dry matter and a component of many important molecules such as proteins, nucleic acids, hormones, chlorophyll and other primary and secondary metabolites (Hopkins, 2000). Nitrogen is one of the main element that affects grain yield, when the amount of soil nitrogen supply is limiting potential yield, nitrogen application significantly increased grain yield (Bly and Woodard, 2002). Increased use of nitrogen can have a significant effect on seed weight, which therefore increase the green area of plant and prolonging the flowering stage. This leads to an increase in (longer period) effective filling of grains (Abdel and Otman, 2010).

MATERIALS AND METHODS

The experiment was conducted at the Khash region in 2016 which is situated between 27° North and 61° East. For the coefficient estimate and to evaluate the SSM model the field trial data for corn single cross 704 was used. Composite soil sampling was made in the trial area before the imposition of treatments and was analyzed for physical and chemical characteristics. Soil organic matter was measured following Rowell and Coetzee (2003). For the determination of the total nitrogen, Kjeldahl method was applied. Corn seed varieties used include single cross 704 with 120 to 135 day growing period in agro-industrial company located in Mashhad Kaveh.

In order to simulate the growth and yield corn with SSM model in the field, climate data was used for comparison. The experimental design was a randomized complete block with four replications. Each plot has a four-row, each with a length of three meters and to reach a different density at 15, 20, 25, 30 and 35 cm on the row, and the distance between rows was 60 cm in the main plot. Plots in a row at an equal planting distance and distance between each iteration of a three-row planting was considered. Seeds were planted by hand. The characteristics of leaf area, number of green leaves and yellow leaves and the received radiation, phenological stage, the dry weight of the different organs *viz*, stem, spikes, seeds, plant height and yield measurement were calculated.

For phenological studies, plants were taken into considerations during the growing season. After measuring the leaf area and the number of leaves on the main stem, in order to measure the dry weight of each sample (10 days old) green and yellow leaves were shed, stems and seeds were dried at 70° C to achieve constant weight in the oven. Then dry weight was measured. Leaf area was determined using a leaf area meter Delta T (Delta T). AccuPAR device was used to measure radiation (AccuPAR model LP 80) as per the recommendations of Wilhelm *et al.* (2007). This was done in each plot for three times and the average radiation levels above and below the canopy of the plot was used. To determine the performance, area equivalent to two

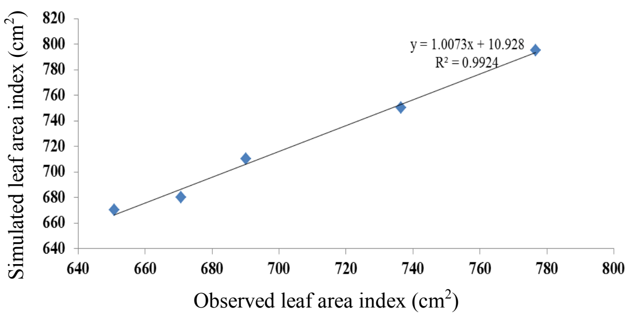

Figure 1. The observed and simulated of leaf area index

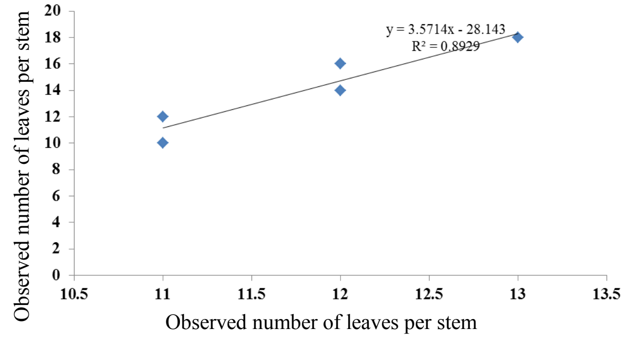

Figure 2. The observed and simulated of number of leaves per stem

square meters per plot at the stage of maturity that has reached 95% of the clusters, were taken. After transferring the samples to the laboratory, number of kernels per ear, seed weight and seed yield per unit area were determined.

In this study, a model similar to the model proposed by Soltani and Sinclair (2012) was designed. The ability to simulate the phenology, growth and leaf senescence, the distribution of dry matter, nitrogen balance of plant, soil water balance its form and functions were all seen. Reply of plant processes to environmental factors such as solar radiation, photoperiod, temperature, nitrogen and water availability were also considered in the model. Important weather variables that influence plant growth and yield, such as of solar radiation, temperature and precipitation (amount of dispersion), relative humidity and wind speed were taken into consideration for analysis.

The two-piece SSM model contains two lines which crossover the slope of the line in the first piece representing an increase in the number of leaves and the horizontal line represents the maximum number of leaves per stem.

$y = a + bx \quad \text{if} \quad x < x_0$

$y = a + bx_0 \quad \text{if} \quad x \geq x_0$

where 'y' number of leaves, 'x' time (cumulative growing degree days after planting), 'a' junction of the curve with the vertical axis (x = 0), 'b' speed linear increase in the number of leaves (leaf per unit increase in temperature units), 'x_0' the end of a linear increase in the number of leaves and 'a + bx_0' maximum number of leaves per shoot. There was no significant differences in the density equation at 95%.

RESULTS AND DISCUSSION

Figure 1 shows the simulated maximum leaf area index using the SSM. In the model, the correlation

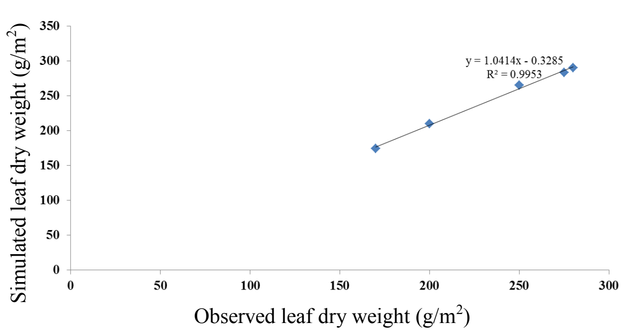

Figure 3. The amount of observed and simulated of leaf dry weight

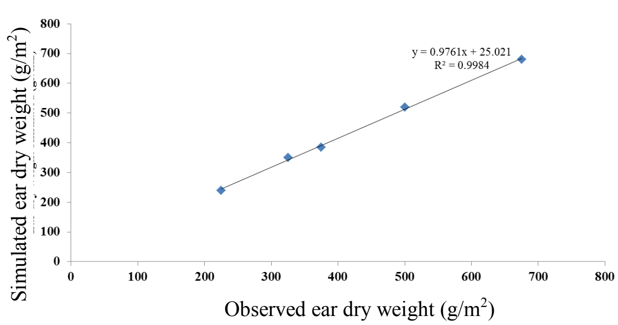

Figure 4. The amount of observed and simulated ear dry weight

coefficient was 0.99 to simulate the leaf area index, which indicates good accuracy of the model to simulate the leaf area index.

Figure 2 shows the simulated maximum number of leaves per stem using the SSM. In the model, the correlation coefficient was 0.89 to simulate the number of leaves per stem, which indicates good accuracy of the model to simulate the number of leaves per stem. Figure 3 shows the simulated maximum leaf dry weight using the SSM. In the model correlation coefficient was 0.99 to simulate the leaf dry weight, which indicates good accuracy of the model to simulate the leaf dry weight. Figure 4 shows the simulated ear dry weight using the SSM. In the model correlation coefficient was 0.99 to simulate the ear dry weight, which indicates good accuracy of the model to simulate the ear dry weight.

Plant simulation models are mathematical representations of crop development processes as influenced by interplay among genotype, plant management and environment. They have become an indispensable tool for supporting scientific research, plant management, and politics analysis (Hansen, 2002). Different methods have been used for simulating corn (*Zea mays* L.) growth and development. Generic plant models portray the processes of respiration, assimilation, growth and development, without regard to plant species, and are then fine-tuned to simulate the physiological and phenological traits of specific plants such as corn, potatoes or rice (Brisson *et al*., 2003). Maize-specific simulation models vary extremely from generic models in both theoretical frame and treatment of key processes that drive development and growth (Lindquist, 2001).

CONCLUSION

In this research, we determined that in the model correlation coefficient was 0.99 to simulate the leaf dry weight, ear dry weight and leaf area index, which indicates good accuracy of the model to simulate the all characteristics.

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