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Evaluation and prediction of some wheat cultivars productivity in relation to different sowing dates under North Sinai region conditions

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Abstract Two open-field experiments were conducted during 2011/2012 and 2012/2013 seasons at the experimental farm, Faculty of Environ. Agric. Sciences, EL-Arish, Suez Canal University (31° 08′ 04.3″ N, 33° 49′ 37.2″ E). This work was aimed to evaluate the performance of four bread wheat (*Triticum aestivum* L.) cultivars *i.e.*; Misr-1, Sakha-93, Giza-168 and Gemmeiza-9 sown at three sowing dates (15th October, 15th November, 15th December) under the metrological conditions of North Sinai. Results obtained from experimental field studies were used as indicators to test the performance of DSSAT-CSM (Cropping System Model) Ver. 4.5.1.023. Necessary files were prepared as required. Calibration and validation of applying CERES-Wheat model was done through using d-Stat index of agreement between simulated and observed values. Field experiment results indicated that under North Sinai environmental conditions, the significantly highest values of spike length, one thousand kernel weight and radiation use efficiency % were recorded by Gemmeiza-9 cultivar under early sowing date (October, 15). However, the highest values of spike weight, grain yield and dry biological yield were obtained when the same cultivar cultivated under mediate sowing date (mid-November). The output data from the CERES-Wheat model showed that Gemmeiza-9 cultivar recorded the highest observed grain yield in the 1st and 2nd seasons (5352 and 5928 kg ha^{-1}, respectively) and highest predicted grain yield (3957 and 4619 kg ha^{-1}, respectively) in mediate sowing date (mid-November) as compared to other wheat cultivars Misr-1, Sakha-93 and Giza-168. Generally, Gemmeiza-9 under mediate sowing date (November, 15) is recommended treatment to maximized bread wheat grain yield under North Sinai environmental conditions and all similarity regions.

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Introduction

Wheat (*Triticum* ssp.) is the most important food crops in the world and tops the list of cereal crops in terms of area and production. Wheat can be grown under many different topographic and soil situations and is adaptable to extreme weather conditions. Total area planted wheat in the world about 218 million hectares during the 2011/2012 season and is produced about 700 million tons (3.24 ton/ha.) (USDA, 2013) which will control the future of food security of world, especially under the existence of large gap between wheat production and consumption. For that reason, more research for adaptation strategies should be explored to reduce the problem of such increasable gap especially under the predicted future climatical changes. Hassanein et al. (2012) pointed out that predicted the rise in the Earth's surface temperature will adversely affect the productivity of many crops in addition to the increasing demand for water requirements. Under Egyptian conditions, wheat productivity will be reduced by 12% with each 1.5 °C increase, while this decrease will reach 27% if the increase in temperature is 3.5 °C. Unfortunately, only four percent of 287 thousand feddans reclaimed lands in Egypt with water resources and infrastructures are available in the Sinai and eastern Suez Canal (Hanna and Moustapha, 1995) and consequently adaptable to wheat production. However, the great challenge for the coming decades will therefore be the task of increasing food production with less water, especially in arid and semi-arid regions (Abouzeid, 1992; FAO, 2003). Due to reduction in tillering period and increased risk of hot weather during grain filling, late planting results in linear reduction in wheat grain yield. Therefore sowing date plays vital role in yield potential of wheat production. The influences of two sowing dates (November, 21th and December, 21th), bread wheat genotype and their interaction on grain yield and yield component characters were investigated by Refay (2011). Results indicated that delayed sowing is associated with substantial losses in grain yield estimated by 7.98% as compared with early and affected number of days to flowering, maturity and grain filling period. Superiority of Gemmeiza-9 cultivar with regard to yield and yield components was investigated by many authors (El-Shami et al., 2000; Hefnawy and wahba, 2003; El-Gizawy, 2005) However, there were differential responses among wheat genotypes to planting dates. In this respect and under North Sinai, Egypt conditions El-Sarag-Eman and Ismaeil (2013) found that the 2nd sowing date (1st December) gave superiority of wheat grain yield and most of its components and Sakha-93 was the potent cultivar in this respect. Meanwhile, Baloch et al. (2010) concluded that sowing wheat on October-25 and November-10 produced the highest number of tillers, spike length, plant height, 1000-grain weight and the grain yield, which subsequently decreased with successive sowing dates. The Decision Support System for Agro-technology Transfer (DSSAT) is a software application program integrating the effects of soil, crop phenotype, weather and management options that allows users to comprise crop simulation models for over 28 crops, as of Version 4.5 (DSSAT.net, 2011). CERES-Wheat model (Godwin et al., 1981; Ritchie and Otter, 1985) is a simulation model for wheat in the DSSAT package that describes daily phenological development and growth in response to environmental factors (soils, weather and management). Simulation study using the CERES-Wheat model by Ouda et al. (2005) recommended to plant wheat between 15th of November, and 1st of December, to attain the highest yield. The objectives of this study are to evaluate the performance of some wheat cultivars in relation to meteorological parameters of different sowing dates under El-Arish-North Sinai conditions. Investigation was also extended to evaluate the application of DSSAT-CERES-Wheat model for prediction of growth and yield of wheat under such environmental conditions.

Materials and methods

Field experiments

Two field experiments were conducted at the experimental farm, Faculty of Environ. Agric. Sciences, EL-Arish, Suez Canal University, North Sinai (31° 08′ 04.3″ N, 33° 49′ 37.2″ E) during two seasons of 2011/2012 and 2012/2013. This investigation aimed to evaluate the performance of four bread wheat (*Triticum aestivum* L.) cultivars *i.e.*; Misr-1, Sakha-93, Giza-168 and Gemmeiza-9 under three sowing dates (15th October, 15th November and 15th December). The climatic data of the field experiments, during the growing season of wheat plants in 2011/2012 and 2012/2013 were obtained from El-Arish Agro-meteorological station, Central Laboratory for Agriculture Climate (CLAC, Egypt) and presented in Table 1.

Surface supplementary irrigation during wheat growth period was added as needed. Treatments were arranged in randomized complete block design (RCBD) with four replicates. Sowing dates occupied main plots whereas wheat cultivars were arranged in the sub-plots. Rows spacing were 15 cm apart. Experimental unit area was 10 m^2 and seeding rate was 121.19 kg ha^{-1}. Fertilization and all other agricultural practices were carried out as recommended for wheat growing under the conditions of North Sinai as a semi-arid land. Harvesting dates and accumulated heat units for each sowing dates are shown in Table 2.

Recorded data

(1) Vegetative growth; plant height (cm) and number of tillers/plant.
(2) Yield and its components; spike length (cm), spike weight (g), spike kernel weight (g), 1000-kernel weight (g), number of kernel/spike, dry biological yield (kg/m^2) and grain yield (kg ha^{-1}).
(3) Solar radiation use efficiency (RUE) %.

$$\frac{\textit{Chemical energy of dry biomass}}{\text{Solar radiation energy utilized in photosynthesis}} \times 100$$

(Moursi and Fayed, 1979)

Chemical energy of biomass was estimated in gram calories from dry weight of biomass in gram × 3.7 × 1000. Solar radiation utilized by wheat plants was calculated from total solar radiation along the effective growing period of wheat plant in gram calories × 4200 × 100 × 100. Calculated effective growing period values were different according to sowing dates and wheat cultivars as presented in Table 3.