Impact of climate change on water requirements for some major field crops in Egypt

Namait Allah Yesif Osman Mokhtar

This study was curried out as a part of global studied established in many countries allover the world to study the impact of climate change on several sector and activities. The objective of the worldwide study is to establish national plans in the participating countries for implementation of some selected options and adaptation policies capable of reducing the expected negative impact of climate change. Also to maximize the positive effects of climate change. Egypt is rich agricultural country, which more than 84 % of current water budget consumed by irrigation purpose and plan to increase land area by about 18% in future. Therefore, the current investigation focuses to assess the potential impact of climate change on crop water requirement and their production in Egypt.The study concerns two parts as following: Part 1: field experiment studyPart 2: Simulation model studyPart 1: Field experiment studyTwo field experiments were carried out at Giza Agricultural Research Station, ARC, Egypt, during 2004/2005 and 2005/2006 growing seasons to study the effect of irrigation scheduling using evaporation pan coefficient and applied nitrogen rate on water relation, yield and yield components for three wheat cultivars grown in middle Egypt. Potential evapotranspiration ETO was estimated using three ET formulas, i.e. Modified Penman, Penman Monteith and Doorenbos-Pruittformulas, then compared with actual ET to evaluate the most efficient of these formulas in calculating ETO for wheat crop grown under Giza reign conditions in Middle Egypt.The experiment was laid out in the rEndomized complete block, factorial design with three replicates. The plot area was 15.0 m2 (3 x 5 m).The experimental factors and treatments were as follows: Factor A: irrigation regime (evaporation pan coefficient ”EPC”:Il- 1.25 EPC.12-1.00 EPC.13-0.75 EPC. Factor B: wheat cultivars:1-Sakha 692-Sakha93.3-Giza 168 Factor C :fertilizer nitrogen levels:1-60 kg N/ fed (about 144 kg N/ha)2-75 kg N/ fed. (about 180 kg N/ha)3-90 kg N / fed. (about 216 kg N/ha)Sowing dates were 8th Dec.2004 and 0 Dec. 2005 for the first and second seasons, respectively. Plants were harvested on 41 May 2005 and 21-111- May 2006 for each season respectively. The preceding crop to wheat was sunflower ir both seasons.Irrigation was practiced according to the cumulative values of the daily evaporation records from class A panSummary -189-establish in Giza Agro- climatological Station for the different irrigation treatments. The fertilizer nitrogen was applied in the form of ammonium nitrate (33.5%N) in two equal portions; the first portion was applied immediately before the life irrigation (El- Mohayah irrigation) and the second one after 21 days from the first one. All other practices were applied as adopted in the area and region of the study. First: Studied parameters for the field experiment:A. Water relations :1.Actual water consumptive use (CU).1-1.seasonal water consumptive use (Eta) 1-2.monthly water consumptive use2.Water use efficiency (WUE).3.Potential evapotranspiration estimated by some ET formulae (ETO).4.Comparison ETO with the actual ETa.B. Yield and yield components: 1- Plant height.2-grain weight /spike3-grain weight /m24-1000-grain weight5-Number of spike /m2.6-Biomes yield7-Grain yieldSecond: Results of this the field experiment study can be summarized as follows:I- Water relations:1.Seasonal water consumptive use (ETa) for wheat crop as a function of evaporation pan coefficient (EPC), nitrogen fertilizer levels and wheat cultivars together were 329.0 and 341.0 mm in 2004/2005 and 2005/2006 growing seasons , respectively.2.Number of applied irrigations and seasonal water consumptive use (ETa)) were increased as the value of EPC increased and 1.25 EPC treatment obtaend the highest values of Eta

for the two growing seasons.3.Seasonal water consumptive use (ETa) was increased gradually with increasing nitrogen levels, which plants treated with 90 kg N/fed consumed more water than other tested N-levels. Also Eta values differed due to wheat cultivars and Giza 168 cultivar was more malleable to consume water more than the other tested cultivars.4.Monthly ETa values were highest with irrigating at 1.25 EPC treatment, during all months when they compared with other irrigation treatments.5.Monthly Eta value was increased with increasing N-levels up to 90 kg N/fed (N3) during the all months of the season and Giza 168 cultivars recorded the highest monthly Eta more than the other tested cultivars.6.Monthly ETa started low when plants were in the seedling stage and increased gradually with increasing plant age toreach maximum value during the flowering stage (March) and then decreased again at late season till harvest.7.The highest Water Use Efficiency (WUE) was recorded under 0.75 EPC, comparable to 1.00 or 1.25 EPC values, also values of WUE differed due to nitrogen fertilizer levels and 60 kg N/fed recorded lowest (WUE) while 75 kg N/fed obtained highest value in two growing seasons.8.Giza 168 cultivar was superior in water utilization than other tested cultivars in two growing seasons.9.The most efficient method in calculating ETc of wheat crop under Giza region condition was Penman-Monteith Method.II. Plant growth, yield and yield components parameters:1.The plant height, grain weight/spike, grain weight/m2 and 1000-grain weight significantly influenced due to the adapted irrigation regimes, and generally tended to increase as the coefficient of pan evaporation was increased.2.Grain and straw yields seemed to increase with increasing the value of EPC. The highest grain yield was obtained as irrigation was practiced according to 1.25 EPC and tended to reduce under the other assessed EPC treatments. This finding was true with straw yield and it was found in two growingseasons.3.All of agronomic yield and its component were significantly increased as the nitrogen fertilizer levels increased, where 90 kg N/ fed treatment recorded the maximum values than theother tested N-levels.4.The plant height, grain weight/spike, grain weight/m2 and 1000-grain weight were significantly increased with Giza 168 cultivar, while Sakha 69 cultivar showed minimum values in both growing seasons.5.All interaction between tested variable of yield and its component were positively increased as the adapted irrigation regimes interacted with the nitrogen fertilizer levels and the maximum value was recorded with combination of1.25 EPC x 90 kg N/ fed. This tended was found for three wheat cultivars and at two growing seasons. Part 2: Crop simulation model studies: First: Description of the models:Two simulation models were used. The first is (DSSAT 3.0) model developed by International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT) Project. Hawaii State University, and the second is (CROPSYST) model developed by Claudio 0. Stckle Washington State University, BiologicalSystems Engineering Department. These models were used to simulate and predict wheat and maize water requirement and yield by using data of field experiment and region weather data under current and climate change scenarios conditions. The experimental data and site database were used as describe in materials and methods part to run simulation by the two selectedmodels.Second: Results of this simulation studies can be summarized as follows:A: Crop model validation results:1.Validation results for both crop simulation models (DSSAT 3.0) and (CROPSYST) showed high response and is acceptable in predicting wheat and maize crop production and water requirement with high degree of accuracy under middle Egypt environmental conditions, (Giza region) .2.The (CROPSYST) simulation model was superior in predicting crops water requirement and productivity compared with (DSSAT 3.0) model under conditions of the study.3.Validation results indicate that cultivar (Gizal 68) was superior in matching with the two models used for simulation compared with the other tested wheat cultivars.B: Current climate condition results:1.Results of running the simulation models showed slight differences between measured and predicted water consumptive (Eta) grain and biomes yield values under current climate condition.2.Predicted values for the tested variable were increased with increasing EPC treatments and 1.25 EPC treatment obtained the highest values at the two growing seasons but these increases were less than those obtained by filed experiment.3.Predicted values for grain and biomass yields were increased with increasing N-level up to 216 kg/ha , while the effect of nitrogen fertilizer level was slight regarding to prediction of water consumptive (Eta),4. The two simulation models recorded optimum predicted values of the tested variables with Giza 168 cultivar in the two growing seasons.C: Climate change condition results:1.Both DSSAT 3.0 and CROPSYST

models recorded maximum expected increase in water consumptive and decrease in grain and biomes yields for maize crop compared with wheat crop.2.Effect of irrigation treatments was slight on predicting water consumptive (Etc); grain and biomes yields with regard to wheat crop under (DSSAT 3.0) model, while the effect was clear for maize crop.3.Effect of nitrogen fertilizer levels was slight on predicting water consumptive (Eta); grain and biomes yield for wheat and maize crops under both (DSSAT 3.0 and CROPSYST) models.4.Scheduling irrigation treatments at 1.00 E?C minimizes both increase percentage in ETc and decrease percentage in yield for wheat crop under CROPSYST models.5.Scheduling irrigation treatments at 1.25 EPC minimize both increase percentage in ETc and decrease percentage in yield for maize crop under both (DSSAT 3.0 and CROPSYST) models.6.Wheat cultivar Giza 168 was more tolerance to water and heat stress compared to the other tested wheat cultivars under the two climate scenarios.7.HadCM3 B2 climate change scenario recorded the maximum increase percentage in wheat and maize consumptive use (ETc) when compared with HadCM3 A2 climate change scenario.8.HadCM3 A2 climate change scenario recorded the maximum decrease percentage in wheat and maize grain and biomass yields when compared with HadCM3 B2 climate change scenario.9.The expected average increase percentage in Etc for wheat tend to be 1.8 and 4.3 % for A2 and B2, respectively, while corresponding values for maize crop being 6.8 and 12.4 % for A2 and B2 scenario.10.The expected average decrease in grain yield for wheat amounted to 25.5 and 13.3 % for A2 and B2, respectively, while corresponding values for maize crop would reach to 48.0 and 34.5 % for A2 and B2 scenario.11 The expected average decrease percentage in biomass yield for wheat will be 15.8 and 12.2 % for A2 and B2, respectively, while corresponding values for maize crop were 45.0 and 30.8 % for A2 and B2.In general, the impact of climate change on water requirement and yield of crops was negative and high especially for summer crops such as maize. Efficient management in agriculture adopting practices and breeding new tolerant cultivars more especially to heat stress may reduce this impact. However future research should be done to evaluate the models for a wider use and different conditions and regions particularly in the long term cropping system and climate change strategy.