Global Journal of Scientific Researches
Available online at gjsr.blue-ap.org
©2014 GJSR Journal. Vol. 2(6), pp. 179-187, 31 March, 2014
E-ISSN: 2311-732X

Evaluation of the impacts, vulnerability and adaptation of wheat productivity to climate change at north delta region in Egypt

AM Saad* **and Marwa GM**

Agriculture Research Center; Soil, Water and Environment Research Institute, Egypt
Corresponding Author: A.M. Saad

Received: 25 May, 2014 *Accepted: 10 June, 2014* *Published: 30 June, 2014*

ABSTRACT

In this study, the impact, vulnerability and adaptation of climate change on wheat production and water requirements in North delta of Egypt were analyzed. Empirical models were used to predict wheat productivity under current temperature and with a raise in temperature by 1.5° C and by 3.6° C. CERES-wheat model embedded in the Decision Support System for Agrotechnology Transfer (DSSAT4.5) model was used for the crop simulation with current and possible future management practices. Impacts on crop productivity were assessed according to future conditions derived from GCMs/MAGICC/SCENGEN scenarios. The calibration and validation test was carried out in this study. Simulation of wheat productivity was carried out for thirty years in North delta under normal weather and climate change conditions. The response of wheat crop production to different sowing dates, crop varieties and irrigation amounts under climate change conditions were studied. The results revealed that, the two climate change scenarios considered resulted in simulated decrease in wheat yield. At the same time, water consumptive use increased as a result of increasing temperature compared to the current water consumptive use. On the other hand, results of adaptation options indicate that, planting Giza-168 cultivar and sowing between 10th to 20th of December in North delta(Sakha) to reduce unfavorable effects of climate change on wheat production under climate future. Also, adding 400 mm/season as irrigation water quantity could be recommended as away to conserve irrigation water without clear reduction in wheat yield.

Keywords: *adaptation, simulation models, vulnerability, warming.*

INTRODUCTION

In the recent years, visible changes in temperature and rainfall in both the global and regional aspects were known as climate change phenomenon in terms of amount and time of occurrence and consequently have exerted different impacts on the inputs and agricultural production (Wolf, 2002). Researchers of the related sciences have disagreements in the area of causes and nature of climate changes, but it seems that in the past decades the climate change impacts and especially its ecological consequences have been so apparent that many of these contradictions have been resolved. The main factor in increasing the greenhouse effect, is the increase in the concentration of gases CO_2, CH_4 and N_2O and types of Halo-Carbons (like CFC) due to the human activities; these gases have an essential role in absorbing the solar radiation that the climate system is also affected by this issue (Tubiello, 2000).

Our planet is figuratively ‹on fire ›. The increase in global temperature is evident (Fig.1). The reports of the Intergovernmental Panel on Climate Change (IPCC) clearly indicate that the temperature has increased and it is anticipated to increase further in the future unless measures and adaptation options are taken (El-Beltagy and Madkour,2012). Agriculture in Egypt is the main utilize of land and the principal water-consuming sector (Iglesias .,2003).

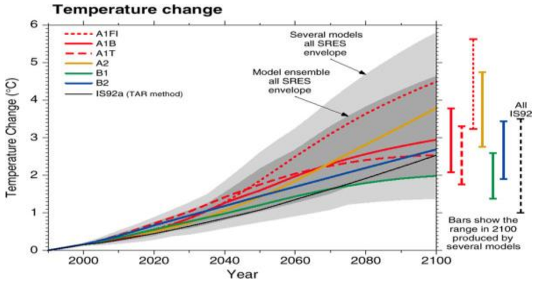

Figure 1. Projected increase in global temperature until 2100 under different scenarios of climate change

Under semi arid and arid regions the pressures of agricultural sector on the water and land resources intensify, these pressures due to the increased irrigation water and fertilizers demands. In addition to the agricultural activities affecting negatively on quality of water resources that decreases due to the bad management of irrigation, fertilizers and pesticides. Moreover, soil fertility decreases due to the same previous activities.

Egypt is considered as developing country, which is highly vulnerable to climate change impacts, this is due to its arid climate, and if climate change makes this region, climate drier or warmer, pressure on agriculture sector would intensify. The hazard effects of climate change are perceived to be associated with agricultural activities, leading to conflicts over the use of resources with other sectors. Egypt has a very large proportion of irrigated land (almost 95 % of the crop land). Water demand for irrigation is expected to increase in Egypt. Therefore, it is important to evaluate the effects of climate change on agricultural sector and its water demands. Also, studying the vulnerability of food production system in Egypt is a vital point.

And according to the impacts and the vulnerability of agriculture system adaptation strategies have to be defined to take into account the allowed deficit of water for irrigation in the future (Eid .,1996; Strzepek .,1995; Iglesias .,2003). Vulnerability could be defined as ‹ the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity› (IPCC,2001).

The adaptation science agenda should have two primary goals. One is to generate and provide scientific knowledge, working in partnership with decision –makers and other stakeholders that can be used to decide and implement vulnerability reducing adaptations. The second goal is to build capacity and partnerships for generating, evaluating, integrating, communicating and applying knowledge for adaptation (Anonymous,2004).

Adaptation to climate change in Egypt is a major issue from the prospective of food production, rural population stabilization, and distribution of water resources. Previous studies have addressed adaptation in a top-down approach, testing theoretical options with little relation to current agricultural management (Abdel Hafez ., 2003; Eid,1994; Eid .,1993,1995,1996,2001). There is a need to incorporate the value of the management knowledge for formulating adaptation measures for agriculture in a bottom –up approach.

Egypt's adaptation capacity to climate change is challenged in particular, as it comes in conjunction with high development pressure, increasing populations, water management that is already regulating most of available water resources, and agricultural systems that are often not adopted to local conditions. In Egypt expected climate change, population increase, urbanization and industrial development as well as irrigation intensification constantly increase water demand and can intensify the vulnerability of agriculture.

Analysis of the impacts of climate change suggests that agro-ecological systems are the most vulnerable sectors. The future of agriculture in Egypt is thus hard to project even assuming the continuation of current climate conditions. The task is made all the more difficult by the possibility of a significant warming expected to result from the enhanced greenhouse effect (IPCC, 1994). The expected impact of climate change on the supply of water (i.e., on the flow of the Nile) is very uncertain (Strzepek, 1995). Egypt appears to be particularly vulnerable to climate change, because of its dependence on the Nile River as the primary water source, its large traditional agricultural base, and its long coastline, already undergoing both intensifying development and erosion (Rosenzweig, 1995; Rosenzweig and Hillel, 1994). Any attempt to assess the future of Egyptian agriculture must consider the complex interactions among the factors which determine the use of land, the choice of cropping systems and the socio-economic characteristics and limitations (see Rosenzweig and Hillel, 1994). identifying strategies that are desirable economically and environmentally.

The Decision Support System for Agrotechnology Transfer (DSSAT) Version 4.5 is a software application program that comprises crop simulation models for over 28 crops. For DSSAT v4.5 to be functional it is supported by data base management programs for soil, weather, and crop management and experimental data, and by utilities and application programs. The crop simulation models simulate growth, development and yield as a function of the soil-plant-atmosphere dynamics. DSSAT and its crop simulation models have been used for many applications ranging from on-farm and precision management to regional assessments of the impact of climate variability and climate change. It has been in use for more than 20 years by researchers, educators, consultants, extension agents, growers, and policy and decision makers in over 100 countries worldwide. The management options include: cultivar selection, crop rotation, irrigation, nitrogen fertilization, tillage operations, and residue management.

In this connection, the potential impact of climate change on some field crops production and ET in Egypt was studied through DSSAT 3 (1995) and COTTAM (Jackson ., 1988) models,(Eid . 1993a, b; Eid and El-Sergany, 1993). Based on the mentioned previous simulation studies, climate change could decrease national production of many crops (ranging from -11% for rice to -28% for soybean) by the year of 2050 compared to their production under current conditions. Yield of cotton would be increased in comparison with current climate conditions. At the same time, water needs for summer crops will be increased up to 8% for maize and up to 16 % for rice by the year 2050 compared to their current water needs.

The purpose of the present study was to investigate the impacts of climate change on productivity and water requirements for wheat crop and how to mitigate the potential effects of climate change on this crop through analysis and evaluation of adaptation strategies and determining the effective ones to reduce the adverse impacts and improve opportunities of the expected climate change on the agriculture sector. The study was the assessment of strategy and policy measures for adaptation to climate change in Egyptian agriculture.

2. Materials and Methods

2.1. Vulnerability Studies (Simulation Studies)

Climate change studies were made to estimate the potential impacts on yield and water use of wheat crop in the agricultural system at each region. Crop models are now available for most of the major crops grown in Egypt to accomplish this task. Crop models are also useful for testing potential adaptations to climate change such as changes in planting dates and shifts in cultivars or crops (Rosenzweig and Parry 1994 and Eid . 1996).The simulation of climate change effects on agricultural production in Egypt requires coordinated effect in which data, computer software, and expertise from various disciplines and institutions are integrated. The first step is to calibrate and validate the model with local agronomic experimental data for a set of representative site of major Egyptian agricultural regions. Next, simulations with observed climate provide a baseline. Then, crop model simulations were run with a suite of climate change scenarios. Finally, farm-level adaptations were tested to characterize possible adjustments to climate change. The impacts on crop productivity in the command area were evaluated according to the future conditions derived from MAGICC/SCENGEN software, with input data from HADCM3, GCM and A1 and B2 SRES scenarios experiments. DSSAT (Decision Support System for Agrotechnology Transfer) simulation model was the main tool for analysis of climate change impacts on wheat crop production.

2.2. Case study selection

One case study, Sakha region,(Kafr El-Sheikh Governorate, Egypt; Lat.:31.07 N, Long.: 30.57 E, Elev.: 20 m)was selected to study the effect and vulnerability of wheat to climate change, as well as assessing the adaptation strategies in a range of climate, agricultural and socioeconomic systems found in Egypt (Fig.2). The study analyzed wheat crop production as a very important cereal crop in the world. Also, irrigated systems were evaluated to understand the interactions between climate, especially drought, its effects and the vulnerability of the system. Irrigation systems were studied to assess the demand of water under climate change conditions and to determine the value of additional irrigation as an alternative adaptation method to climate change.

Figure 2. Map show the study area at North delta region , Sakha, Egypt

2.3. Baseline Climate and Climate Change Scenarios

Daily maximum and minimum temperatures, precipitation, and solar radiation for Sakha (1980-2010) were used from Soil, Water and Environment Res. Institute, SWERI; ARC; and Ministry of Agriculture.

2.4. Crop agricultural models and decision support systems:

Crop yield and demand for irrigation water were estimated with the CERES-wheat model included in DSSAT 4.5 (Hoogenboom ., 2010 and Jones .,2003) developed by the International Benchmark Sites Network for Agro technology Transfer.

Typical soils at Sakha (clay loam soils) are montomorillonitic, thermic, slightly calcareous and deep(Abdel-Wahed,1983).Wheat is grown using flood irrigation. Data of one experiment at Sakha were used for the simulations, the field schedule irrigation option was chosen to supply the crop with water as field schedule; the model includes an option that simulates flooding.

2.5. Crop Model Validation

The CERES model was validated by comparing observed data of flowering, physiological maturity, grain yield and biomass with local agronomic experimental data for two growing seasons (2012 and 2013) at Sakha area.

2.6. Regression analysis

Empirical models are defined as models directly describing observational data, while containing no information beyond the original data (Thornley and Johnson,1990). One form of empirical model is prediction equation resulted from regression analysis. Regression analysis(Drapper and Smith,1987) is a technique utilized to fit a line through a set of observations, and test how a single dependent variable is affected by the value of one or more independent variables. As a result, a prediction equation is developed and used to predict the performance of the dependent variables. The aim of use of models in this case is to predict wheat productivity under current temperature and with a raise in temperature by 1.5° C and by 3.6 ° C.

Data for mean temperature and wheat productivity were collected for thirty years (1980-2010) for Sakha, Kafr El-Sheikh Governorate, Egypt (Delta region). The sowing was assumed to be done at November,20. Mean temperature was used to predict wheat productivity, where straight line was fitted to yield of wheat as a function of temperature. This assumption was examined by testing for lack of fit. The developed equation was used to assess the impact of high temperature by predicting wheat yield (kg ha^{-1}) under current temperature, current temperature + 1.5° C, and current temperature + 3.6° C. The impact of high temperature on wheat yield in that case is the reduction percent in yield. The developed equation can be stated as follows:

(1) Y` = 14205.25 – 610.85 * M temp; Mean=4673+/-229.1

Predicted yield using equation (1) was graphed with measured yield. For graphing purposes and to reduce yield inter-annual variation, data was customized and then graphed with predicted yield. To overcome the adverse effect of high temperature on yield and reduce vulnerability, different adaptation techniques were examined e.g. delay sowing, and altering irrigation amounts. Three sowing dates (November, 30; December, 10; December, 20), and four irrigation amounts (300, 350, 400, 450 mm/season) were included in the prediction and new prediction equations were developed. The percent of yield quantity improvement as a result of these adaptation techniques is then determined.

* Effect of sowing date. Prediction equations that include different sowing dates could be stated as follows:

- Sowing at November, 20: (2) Y` = 13856.32 - 588.32 * M temp
- Sowing at December, 10: (3) Y` = 14565.38 - 647.06 * M temp
- Sowing at December, 20: (4) Y` = 14620.89 - 658.04 * M temp

* Effect of irrigation amounts. Prediction equation that includes different irrigation amounts (Irr) could be stated as follows:

(5) Y` = 14043.10 - 611.55 * M temp +0.86 * Irr (irrigation amounts)

2.7. Adaptation Studies

Studies of adaptation strategy evaluation to climate change were carried out using Dssat4.5 simulation model. To identify appropriate crop management strategies to maximize benefits and minimize risks associated with wheat production, the following treatments were applied:

I- sowing dates:
    1- November,20
    2- November, 30
    3- December, 10
    4- December, 20
II- Wheat cultivars:
    1- Sakha-8
    2- Giza-168
    3- Sakha69
III- Irrigation amounts:
    1- 300 mm/season
    2- 350 mm/season
    3- 400 mm/season
    4- 450 mm/season

.

RESULTS AND DISCUSSION

3.1.Using regression models to evaluate the effect of adaptation strategies

3.1.1. Effect of sowing date

Although delay sowing reduces season length and consequently reduces yield, it could be useful to overcome the impact of high temperature on wheat yield, and reduce vulnerability. As it shown in Table 2, wheat yield was predicted using equations (2), (3), and (4). The differences in yield as a result of a raise in temperature were found to be decreasing, when sowing was delayed. Results in Table 3 showed that sowing wheat at December, 20 reduced vulnerability by 1.61,1.64 % under a raise in temperature by 1.5° C and 3.6° C, respectively.

Table 2. Predicted wheat yield using different sowing dates under current temperature, and with a raise in temperature.

Sowing date	Predicted yield under current temperature(kg/ha)	Predicted yield under current temperature +1.5◌̊C		Predicted yield under current temperature +3.6◌̊C	
		Yield	Yield current-yield+1.5◌̊C	Yield	Yield current-yield+3.6◌̊C
Nov,20	6129.8	5213.5	- 916.3	3930.8	-2199.0
Nov,30	6078.7	5196.2	-882.5	3915.7	-2163.0
Dec,10	6011.3	5170.1	-841.2	3940.7	-2070.6
Dec,20	5921.6	5132.0	-789.6	3894.8	-2027.4

Table 3. Effect of delay sowing on wheat yield and vulnerability to high temperature

Sowing dates	Current temperature + 1.5° C			Current temperature + 3.6° C		
	Impact	Adaptation	Vulnerability	Impact	Adaptation	Vulnerability
November, 20	-14.95	0	-14.95	-35.87	0	-35.87
November, 30	-14.95	+0.43	-14.52	-35.87	+0.29	-35.58
December, 10	-14.95	+0.96	-13.99	-35.87	+1.42	-34.45
December, 20	-14.95	+1.61	-13.34	-35.87	+1.64	-34.23

3.1.2.Effect of irrigation amounts

As a result of heat stress, the atmospheric demand increases, which in turn, increases evapotanspiration Gardner .(1985). Therefore, increasing irrigation amounts could reduce the impact of heat stress. Wheat yield was predicted using equation (5). The differences in wheat yield as a result of a raise in temperature were found to be decreasing with the increase of irrigation amount per season Table 4. Results in Table 5 show that increasing irrigation amount could serve as a relief factor to overcome heat stress. Irrigation with 450 mm/season reduced wheat yield vulnerability by 3.51 and 3.46 % when a raise in temperature by +1.5° C and 3.6° C occurs, respectively.

Table 4. Predicted wheat yield using different irrigation amounts under current temperature and with temperature increase

Irrigation amounts	Predicted yield under current temperature(kg/ha)	Predicted yield under current temperature +1.5◌̊C		Predicted yield under current temperature +3.6◌̊C	
		Yield	Yield current-yield+1.5◌̊C	Yield	Yield current-yield+3.6◌̊C
300 mm/season	6129.81	5299.08	-830.73	4014.82	-2114.99
350 mm/season	6078.73	5342.08	-736.65	4057.82	-2020.91
400 mm/season	6011.25	5385.08	-626.17	4100.82	-1910.43
450 mm/season	5921.60	5428.08	-493.52	4143.82	-1777.78

Table 5. Effect of irrigation amounts on wheat yield and vulnerability to increased temperature

Irrigation amounts	Current temperature + 1.5° C			Current temperature + 3.6° C		
	Impact	Adaptation	Vulnerability	Impact	Adaptation	Vulnerability
300 mm/season	-14.95	+0.92	-14.03	-35.87	+1.37	-34.50
350 mm/season	-14.95	+2.01	-12.85	-35.87	+2.05	-33.82
400 mm/season	-14.95	+2.81	-12.14	-35.87	+2.77	-33.10
450 mm/season	-14.95	+3.51	-11.44	-35.87	+3.46	-32.41

3.1.3.Interaction between sowing dates and irrigation amounts

Both the effect of delay sowing and increasing irrigation amounts were included in the prediction to reduce vulnerability of wheat yield to heat stress (Tables 6 and 7). Results in Table 6 show that under the condition of temperature increased by + 1.5° C, planting wheat at December, 20 reduced yield vulnerability was by 2.2, 2.7, 3.3, 3.8 %, when the four irrigation amounts were used, respectively.

Furthermore, results in Table 7 show that under the condition of temperature increased by + 3.6° C, planting wheat at December, 20 reduced yield vulnerability was by 1.1, 1.6, 3.1, 3.6 %, when the four irrigation amounts were used, respectively.

Table 6. Effect on wheat yield of the interaction between the delay in sowing date and irrigation amounts under current temperature and + 1.5° C temperature increase

Sowing date	300 mm/ season			350 mm/ season			400 mm/ season			450 mm/ season		
	I	A	V	I	A	V	I	A	V	I	A	V
Nov, 20	-15.0	+1.4	13.6	-15.0	+2.1	-13	-15.0	+2.9	-12.1	-15.0	+3.6	-11.4
Nov, 30	-14.5	+1.4	13.1	-14.5	+2.0	-12	-14.5	+2.6	-11.9	-14.5	+3.2	-11.3
Dec, 10	-14.0	+1.1	12.9	-14.0	+1.9	-12	-14.0	+2.7	-11.3	-14.0	+3.5	-10.5
Dec, 20	-13.3	+2.2	11.1	-13.3	+2.7	-10	-13.3	+3.3	-10.0	-13.3	+3.8	-9.5

I = impact A = adaptation V = vulnerability

Table 7. Effect on wheat yield of the interaction between the delay in sowing date and irrigation amounts under current temperature and + 3.6° C temperature increase

Sowing date	300 mm/ season			350 mm/ season			400 mm/ season			450 mm/ season		
	I	A	V	I	A	V	I	A	V	I	A	V
Nov, 20	-35.9	+1.4	-34.5	-35.9	+2.1	-33	-35.9	+2.8	-33.1	-35.9	+2.5	-32.4
Nov, 30	-35.5	+1.7	-33.8	-35.5	+2.2	-33	-35.5	+2.8	-32.7	-35.5	+3.4	-32.1
Dec, 10	-34.5	+1.1	-33.4	-34.5	+1.9	-32	-34.5	+2.7	-31.8	-34.5	+3.5	-31.0
Dec, 20	-34.2	+1.1	-33.1	-34.2	+1.6	-32	-34.2	+3.1	-31.1	-34.2	+3.6	-30.6

I = impact A = adaptation V = vulnerability

3.2. Process-based crop agricultural models and decision support systems

CERES-Wheat model was validated by comparing observed data on biomass, yield, and maturity date to simulated values (Table 8). The results of the validation experiment indicated that CERES-Wheat crop model can be used successfully at the selected site in Egypt. The observed data on grain yield and season length were very close to the corresponding simulated values. The observed total biomass was slightly smaller than the simulated one. According to these results, the model was considered validated for the conditions of the study.

Table 8. Calibration and validation test for wheat (Sakha-8 CV) at Sakha region

Variable	Measured	Predicted
Flowering date (dap)	125	121
Physiological maturity (dap)	170	162
Grain yield (kg/ha; dry)	4770	4755
Wt. per grain(g; dry)	0.03	0.037
Grain number(grain/m^2)	12440	12229
Maximum LAI (m^2/m^2)	5.7	5.02
Biomass (kg/ha) at harvesting	1440	16944

3.3.Adaptation to Climate Variability and change

3.3.1.Adaptation using different wheat cultivars:

Studies of different cultivars (as adaptation measures) on wheat yield were carried out through DSSAT 4.5 model. Options of adaptation to climate under climate change (GCMs/MAGICC/ SCEN GEN) are shown in Fig. 3.

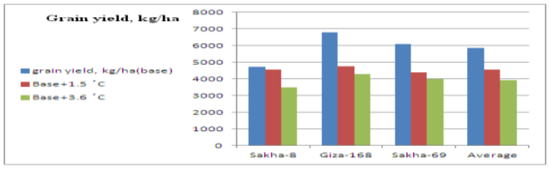

Figure 3. simulation of grain yield for some wheat cultivars under current (base) and climate change conditions

Results as recorded in Fig.3. indicate that under current conditions, Giza-168 cultivar gave the highest wheat yield 6780 kg/ha as compared to other cultivars. Also, under future conditions and with increasing temperature by 1.5°C and 3.6°C, Giza-168 cultivar achieved the highest yield in comparison with sakha-69 and sakha-8 (Rosenzweig and Parry 1994 and Eid . 1996).

3.3.2. Adaptation using different amounts of irrigation water

Changes in wheat productivity as a result of using different amounts of irrigation water were considered as possible adaptation strategies. Results in Fig.4 show that increasing amount of irrigation water led to reducing the adverse impact of high temperature on decreasing wheat yield. The highest yield of wheat was noticed under irrigation with 450 mm/season as compared to other treatments. But, adding 400 mm/season gave acceptable yield and the yield reduction wasn't clear.

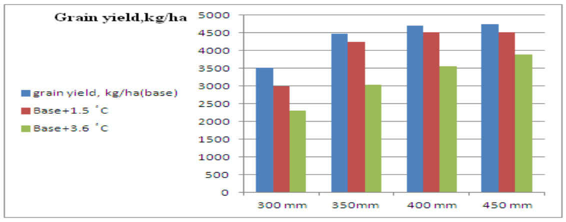

Figure 4. simulation of grain yield under different water amounts for wheat crop (Sakha-8 CV) under climate change conditions

3.3.3. Adaptation using different sowing dates

Studies of sowing dates (as adaptation measures) on wheat yield were carried out through DSSAT 4.5 model. It is clear that growing wheat (Sakha-8 cultivar) at the most suitable agroclimatological region and optimum sowing date will increase crop production and this will reduce the adverse impact of the expected climate change on crop production.

Results as recorded in Fig.5 indicate that, planting wheat in delta region on the 20th of November resulted in decreasing yield about 5.28% and 35.09% under climate change conditions for 1.5°C and 3.6°C increase in temperature respectively as compared to yield under current conditions. To avoid such effect of climate change on wheat yield, different planting dates were used, where planting on the 01th of December gave the highest yield under increasing temperature with 1.5°C. While, under 3.6°C increase in temperature, the highest yield 3400 kg/ha was obtained by sowing on the 20th of December. It could be concluded that, planting on 20th of December is the optimum planting date under climate change conditions. Generally, it can be concluded that weather conditions plays an important role in wheat crop productivity. The optimum growth temperature frequently corresponds to the optimum temperature for photosynthesis. Higher temperature affects the rate of plant development (vegetative growth) and hence speed annual crop through the developmental process.

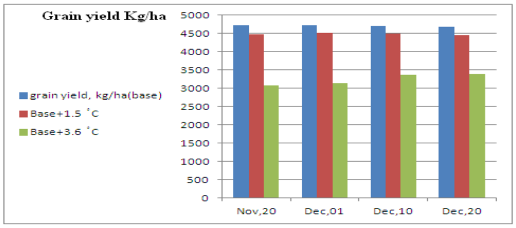

Figure 5. simulation of grain yield under different growing dates for wheat crop (Sakha-8 CV) under climate change conditions

3.3.4. Simulation of ET crop under some wheat cultivars

From the results in Fig.6, it is clear that increasing temperature led to increasing crop evapotranspiration. Crop ET increased by 3.6 % and 22.5% for both 1.5°C and 3.6°C increase in temperature respectively. Data also show that Sakha-8 cultivar is the best variety under climate change conditions, where, it consumed the lowest quantity of water 498 mm/season under 3.6°C increase in temperature.

3.3.5.Simulation of crop ET under different amounts of irrigation water

As a result of heat stress, the atmospheric demand increases, that in turn, increases evapotranspiration (Gardner .,1995). Data in Fig.7 show that simulated values of crop ET increased with increasing the amount of irrigation water applied.

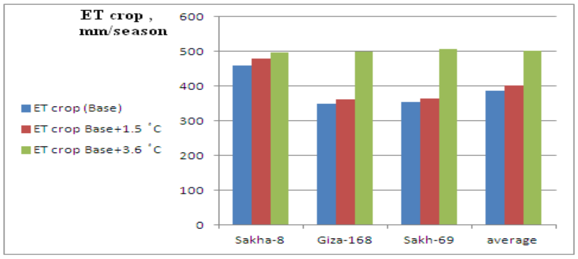

Figure 6. Simulation of Et (mm) for some wheat cultivars under climate change conditions

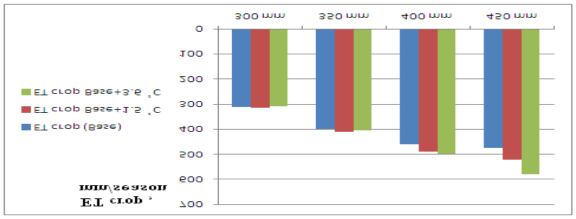

Figure 7. Simulation of Et (mm) under different water amounts for wheat crop (Sakha-8 CV) under climate change conditions

3.3.6. Simulation of crop ET under different sowing dates

Data in Fig.8 clear that planting on 10th of December is the best planting date could be used to overcome the adverse impact of climate change. Planting on December,10 decreased the ET crop and gave the lowest value of ET crop 490 and 497 mm/season for both 1.5°C and 3.6°C increase in temperature respectively.

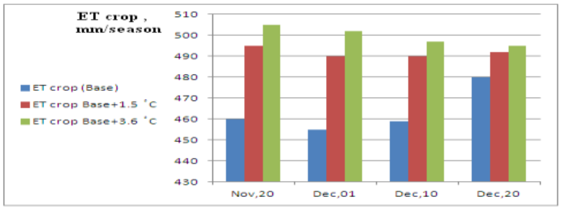

Figure 8. Simulation of Et (mm) under different sowing dates for wheat crop (Sakha-8 CV) under climate change conditions

4. Conclusion

Two climate change scenarios were studied, under current climate plus 1.5°C , the variety of Giza-168 is more tolerance to high temperature as compared with Giza-168 and Sakha-69. Regarding to water amount, the treatment of 400 mm/season is the most efficient as compared with 300, 350 and 450 mm/ season. At the same time, sowing on 1st to 10th of Dec. is more suitable to wheat cultivation at Sakha region, which gave maximum yield and minimum ET under climate change conditions as compared with the others. With respect to water consumptive use (ET), it was increased by 5.4, 0.85 and 1.7% for Sakha-8, Giza-168 and Sakha-69, respectively as compared with those under current conditions. While, under climate change plus 3.6° C , the reduction of grain yield reached about 26.3 % and 36.9 % for Sakha-8 and Giza- 168, respectively, as compared with the yield of these varieties under current conditions.

Regarding to sowing dates, the change percent reached about -35, -33.5, -28.6 and -27.4% for Nov. 20, Dec.01, Dec. 10 and Dec. 20, respectively as compared with the current conditions. Increasing water amount under climate change will decrease the adverse impacts on yield. The change percent of grain yield for different water amounts under climate change compared to current conditions was -34, -32, -24 and -17% for 300, 350, 400 and 450 mm/season, respectively. Finally, Giza-168 is more tolerance to high temperature (+3.7°C) as compared with other cultivars. The most suitable date for wheat cultivation at Sakha region under climate change from 10th to 20th Dec., which gave maximum yield and minimum ET.

Acknowledgments

This research has been undertaken with the support and collaboration from a wide range of individuals and institutions. I would like to express my sincere tanks to especially to Prof.Dr. Gerrit Hoogenboom (University of Hawaii) the essential member of DSSAT 4.5 preparing team , who supported me with many updated information of this model. Research funded by Agriculture Research Center, Egypt and carried out in North Delta region (Kafr El-Sheikh Governorate), Egypt.

REFERENCES

Abdel Hafez SA, Ainer NG and Eid HM. 2003. Climate Change Impacts on Delta Crop Productivity, water and agricultural land. J. Agric.Sci. Mansoura Univ. Special Issue, Scientific Symposium on “Problems of Soils and Water in Dakahlia and Damietta Governorates”. ISSN 1110-0346 Pp. 15-26.

Abdel Wahed A. 1983. Research Report on Soil Survey. Soil Survey EMCIP Res. Extension Centers. Publication No. 62. Consortium for International Department. ARC, Cairo.

Anonymous. 2004. Science in Support of Adaptation to Climate Change, Recommendations for an Adaptation Science Agenda and a Collection of Papers Presented, Side Event of the 10th Session of the Conference of the Parties to the UNFCC, Buenos Aires, Argentina.

Drapper NR and Smith H. 1987. Applied Regression Analysis. John Wiley and Sons, Inc. NewYork. pp. 397 - 402.

DSSAT3. 1995. Decision Support System for Agrotechnology Transfer, V 3.0.Three Volumes. Y. Tsuji, J. W., Jones, G. Uhera, and S. Balas (eds).IBSNAT. University of Hawaii, Honolulu, Hawaii.

Eid HM. 1994. Impact of Climate Change on Simulated Wheat and Maize Yields in Egypt, In C. Rosenzweig and Iglesias (eds). Implications of Climate Change for International Agriculture: Crop Modeling Study. US Environmental Protection Agency. Washington D.C.

Eid HM, Bashi NM, Ainer NG and Rady MA. 1993. Climate Change Crop Modeling Study on Sorghum, Annals Agricultural Science, Special Issue,1, 219-234.

Eid HM, El- Mowelhi NM, Metwally MA, Ainer NG, Abbas FA and Abd El-Ghaffar MA. 1995. Climate Change and its Expected Impacts on Yield and Water Needs of Some Major Crops, Second ARC Field Irrigation and Agroclimatology Conference. Paper No.17 January 1995.

Eid HM, El-Marsafawy SM, Ainer NG, Ali MA, Shahin MM, El-Mowelhi NM and El-Kholi O. 1996. Vulnerability and Adaptation to Climate Change in Egyptian Agriculture,Country Study Report. (1-53), CSP Washington, D C.

Eid HM, El-Sergany DZ and McCuistion WL. 1993a. Simulated soybean yield and water requirements in relation to selected agronomic characters in Egypt. Proc. 6th Conf. Agron., Al-Azhar Univ. Vol. II: 471- 489.

Eid HM, Bashir NM, Ainer NG and Rady MA. 1993b. Climate change crop modeling study on sorghum. Annals Agricultural Science, Special Issue, 1, 219-234.

Eid HM and El-Sergany DZ. 1993 . Impact of climate change on soybean yield and water needs. Proc. First Conference on the Environment. Egypt. p. 313 -316.

Eid, H.M.; El- Marsafawy, S, M., Ainer,N. G. 2001. Using MAGICC and SCENGEN Climate Scenarios Generator Models in vulnerability and Adaptation Assessments, Meteorology and Environmental Issues. Conf. March, 2001 Egypt.

El-Beltagy,A., Madkour,M.2012. Impact of climate change on arid lands agriculture Agriculture & Food Security , 1:3 doi:10.1186/2048-7010-1-3.

Gardner, F. P., Pearce,R. B., Mitchell,R. L. 1985. Physiology of Crop Plants. Iowa State University Press. Ames. pp .76 – 97.

Hoogenboom, G., Jones, J.W., Wilkens, P.W., Porter, C.H., Boote, K.J., Hunt, L.A., Singh, U., Lizaso, J.L., White, J.W., Uryasev, O., Royce, F.S., Ogoshi, R., Gijsman,A.J., Tsuji,G.Y. 2010. Decision Support System for Agrotechnology Transfer (DSSAT) Version 4.5 (CD-ROM). University of Hawaii, Honolulu, Hawaii.

Iglesias, A., Ward, N.M., Menendez, M., Rosenzweig, C. 2003. Water Availability for Agriculture:Understanding Adaptation Strategies to Climate in the Mediterranean. XI World Water Congress, WATER RESOURCES MANAGEMENT IN THE 21st CENTURY, 5-9 October, Madrid.

IPCC. 2001. Impact, Adaptation and Vulnerability, Third Assessment Report (TAR), Cambridge Univ.Press, Cambridge. UK.

IPCC. 1994. IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations. T. R. Carter, M. L. Parry, H. Harasawa, and S. Nishioka. WMO and UNEP. Center for Global Environmental Research, University College of London,UK.

Jackson BS, Arkin GF and Hearn AB. 1988. The cotton simulation model COTTAM: Fruiting model calibration and testing. Trans. ASAE 31: 846-854.

Jones JW, Hoogenboom G, Porter CH, Boote KJ, Batchelor WD, Hunt LA, Wilkens PW, Singh U, Gijsman AJ and Ritchie JT. 2003. DSSAT Cropping System Model. European Journal of Agronomy 18:235-265.

Rosenzweig C. 1995. In: Strzepek, K. M. And Smith, J. B. (eds). As Climate Changes: International Impacts and Implications. Cambridge University Press, Cambridge.

Rosenzweig C and Hillel D. 1994. Egyptian Agriculture in the 21st Century. Collaborative Paper CP-94-12. International Institute for Applied Systems Analysis, Luxemburg, Austria.

Rosenzweig C and Parry ML. 1994. Potential impact of climate change on world food supply. Nature 367,133-138.

Strzepek KM, Onyeji C, Saleh M and Yates D. 1995. An Assessment of Integrated Climate Change Impacts on Egypt. In (Eds. Strzepek and Smith) As Climate Changes: International Impacts and Implications .Cambridge University press. Cambridge, England.

Thornley JHM and Johnson IR. 1990. Plant and Crop Modeling: A Mathematical approach to plant and crop physiology. Clarendon Press. Oxford. pp. 3 – 44.

Tubiello FJ, Donatelli M, Rosenzweig C and Stockle CO. 2000. Effects of climate change and elevated CO2 on cropping systems:model predictions at two Italian locations. European Journal of Agronomy 13, 179–189.

Wolf J. 2002. Comparison of two potato simulation models under climate change. I. Model calibration and sensitivity analyses.Climate Research 21, 173–186.