

## Impact of climate change on sunflower crop production in Egypt

El-Marsafawy Samia, M.

*Water Requirements and Field Irrigation Res. Dept., Soil, Water & Environment  
Res. Institute, Agric. Res. Center, Egypt*

### Abstract

The present investigation was carried out to study the potential impact of climate change on the yield and ETcrop of sunflower oil productivity in the main agricultural regions of Egypt.

OILCROP-SUN model, embedded in the Decision Support system for Agrotechnology Transfer (DSSAT3.5) was used for the crop simulations with current and possible future management practices. Equilibrium doubled CO<sub>2</sub> climate change scenarios were derived from the CCCM and GFD3 general circulation models (GCMs). These scenarios predict consistent increases in air temperature, small increases in solar radiation and precipitation changes that will happen in the future.

The calibration and validation test was carried out in the present study. Simulation of sunflower productivity was carried out for 30 years (for Middle and Upper Egypt) and 26 years (for Delta) under the normal weather conditions and climate change conditions.

The response of sunflower crop production to different sowing dates, irrigation water amounts and skipping one irrigation at different growth stages under climate change conditions were studied. A number of adaptation policies are suggested here.

The results revealed that the two climate change scenarios considered resulted in simulated decrease in sunflower yield at the three sites. The change percent of seed yield in Delta, Middle and Upper Egypt reached about -21, -27 and -38% under climate change conditions compared to their production under current conditions, respectively.

At the same time, water consumptive use will be increased about 5 and 12% in Delta and Middle Egypt respectively, while in Upper Egypt, it will be decreased about 0.5% as a result of high reduction in yield under climate change conditions compared to their current water consumption.

On the other hand, results of adaptation options indicate that sunflower crop have to be sown between the 1<sup>st</sup> of May and 10<sup>th</sup> of May in Delta and Middle Egypt and between the 1<sup>st</sup> of June and 10<sup>th</sup> of June in Upper Egypt to reduce unfavorable effects of climate change on sunflower production under climate future.

Reducing irrigation water amounts by 10% could be recommended as a way to conserve irrigation water without clear reduction in seed yield.

Vegetative growth stage is most sensitive stage to water stress for sunflower plants. At the same time, omitting irrigation at the late seed growth could be practiced.

**Keywords:** sunflower, climate change, CO<sub>2</sub> effects, adaptation, crop simulation.

### Introduction

Sunflower is one of the major crops in Egypt (used as oil crop). The national sunflower and other oil crops production does not meet the current demand for oils, and

each year additional amounts have to be imported. The rapid growth of the country's population, the economic stress of reliance on food imports, and the limited area for agriculture (most of the country is a desert) require Egyptians to find new ways to increase agriculture productivity in general and oil crops in specific. If climate change as projected by atmospheric scientists (IPCC 1992a, 1992b and 1994) adversely affected crop production, Egypt would have to increase its reliance on costly food imports.

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, 1996). The expected impact of climate change on the supply of water (i.e., on the flow of the Nile) is very uncertain (Strzepek et al., 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).

DSSAT software programs assist researchers, decision makers and planners in identifying strategies that are desirable economically and environmentally.

DSSAT model is a multiyear and multicrop daily time-step simulation model. It has been developed to serve as an analytical tool to study the effect of cropping systems management on productivity and the environment. The model simulates the soil, water budget, soil plant nitrogen budget, crop canopy and root growth, dry matter production, grain yield, residue production and decomposition, and erosion. 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 DSSAT3 (1995) and COTTAM (Jackson et al., 1988) models. (Eid et al. 1993a, b; Eid and El-Sergany 1993; Eid 1994; Eid et al. 1994 a, b; Eid et al. 1995a, b; Eid et al. 1996 and Eid et al. 1997 a, b, c, d, El-Shaer et al. 1997). 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 sunflower 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.

## **Materials and Methods**

### **Vulnerability Studies (Simulation Studies)**

Climate change studies were made to estimate the potential impacts on yield and water use of sunflower 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 et al. 1996).

The simulation of climate change effects on agricultural production in Egypt requires coordinated effort 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 sites representative 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.

Climate change scenarios for each site were created by combining the output of two equilibrium 2xCO<sub>2</sub> General Circulation Models (CCCM, GFD3) with the daily climate data for each site. IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations endorse this approach (IPCC, 1994). The two equilibrium general circulation models used in this study to create the climate change scenarios are at the high level end of the IPCC range (1.5 °C to 3.5 °C).

The crop was simulated in three main agroclimatological regions (Delta, Middle and Upper Egypt) to represent the old lands in Egypt (Nile Valley and Delta). Agrometeorological data for each region were obtained from one representative site within each region as follows:

The Delta region was represented by Sakha (Khafra El-Sheikh Governorate; Lat.: 31.07 N, Long.: 30.57 E, Elev.: 20 m); Middle Egypt was represented by Giza (Giza Governorate; Lat.: 30.03 N, Long.: 31.13 E, Elev.: 19 m) and Upper Egypt was represented by Shandaweel (Sohag Governorate Lat.: 26.26 N, Long.: 31.38 E, Elev.: 60 m).

### **Baseline Climate and Climate Change Scenarios**

Daily maximum and minimum temperatures, precipitation, and solar radiation for Sakha (1975 to 2000), Giza (1960 to 1989), and Shandaweel (1965 to 1994) were used (from: Soil, Water & Environment Res. Institute, SWERI, ARC, and Ministry of Agriculture).

Climate change scenarios for each site were created combining output of two equilibrium General Circulation Models (Canadian Climate Change Model "CCCM" and Geophysical Fluid Dynamics Laboratory GFDL R-30 "GFD3") with the daily climate data for each site (see Rosenzweig and Iglesias 1994 for a full description of the

methodology). The recent IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations endorse this approach (IPCC 1994).

### **Crop Models**

Crop yields and water requirements were estimated with the OILCROP-SUN model included in DSSAT3.5 (1998). The DSSAT3.5 crop models include the option of simulating changes in crop photosynthesis and water consumptive use (ET) that result from changes in atmospheric CO<sub>2</sub> (Peart et al., 1989).

### **Management Variables for the Crop Model**

Typical soils at Sakha, Giza and Shandaweel are described elsewhere by (Abdel Wahed 1983; Eid 1994 and Eid et al., 1996 as well as El-Shaer et al. 1997). The description of the soil in the crop model includes texture, albedo, and water-related specific characteristics; nevertheless it does not include salinity and other characteristics that can be limiting for crop production in the simulated sites. A generic soil (Clayey) was selected to represent the soils at all sites. Flood irrigation field schedule was translocated into the mentioned automatic method to avoid crop water stress through simulation. Nitrogen was considered non-limiting at all sites by applying the recommended application at each site.

### **Crop Model Validation**

The OILCROP-SUN model was validated by comparing observed data of flowering date, physiological maturity date, seed yield, seed weight/ head, number of seeds/ m<sup>2</sup>, biomass yield and seed oil % with local agronomic experimental data for two growing seasons (2002 and 2003) at Giza area. Genetic coefficient was generated for the crop.

### **Adaptation Studies**

Studies of adaptation strategy evaluation to climate change were carried out using Dssat3.5 simulation model. To identify appropriate crop management strategies to maximize benefits and minimize risks associated with sunflower production, the following treatments were applied:

#### **I- sowing dates:**

- 1- Base treatment (June 08)
- 2- 1<sup>st</sup> of May
- 3- 10<sup>th</sup> of May
- 4- 20<sup>th</sup> of May
- 5- 1<sup>st</sup> of June
- 6- 10<sup>th</sup> of June

#### **II- Irrigation amounts:**

- 1- Base amount (895 mm/ season)
- 2- Base amount -10%
- 3- Base amount -20%
- 4- Base amount -30%
- 5- Base amount -40%
- 6- Base amount +10%

7- Base amount +20%

### **III- Skipping one irrigation at different growth stages**

- 1- Base treatment (without skipping)
- 2- Skipping the second irrigation (at the 15<sup>th</sup> day after sowing)
- 3- Skipping the third irrigation (at the 23<sup>rd</sup> day after sowing)
- 4- Skipping the fourth irrigation (at the 32<sup>nd</sup> day after sowing)
- 5- Skipping the fifth irrigation (at the 42<sup>nd</sup> day after sowing)
- 6- Skipping the sixth irrigation (at the 52<sup>nd</sup> day after sowing)
- 7- Skipping the seventh irrigation (at the 62<sup>nd</sup> day after sowing)
- 8- Skipping the eighth irrigation (at the 73<sup>rd</sup> day after sowing)

Adaptation strategies through the selection of sowing on the optimum dates, optimum irrigation (date and amount) have to be evaluated to reduce unfavorable effects of climate change on yield.

## **Results and Discussion**

### **Crop model validation**

The results of the validated experiment presented in Table (1) indicated that the observed data of flowering date, physiological maturity date, seed yield, seed weight/ head, number of seeds/ m<sup>2</sup>, and seed oil % were very close to the corresponding simulated values. The predicted total biomass was slightly different from the measured one. According to these results, OILCROP-SUN model was considered validated for the conditions of the study and can be used correctly to simulate the effect of different sowing dates and different irrigation regimes.

Through the calibration / validation experiment, the genetic coefficient for the sunflower cultivar (S53 CV) was created and could be used in different purposes and help in breeding programs for new sunflower cultivars (Table 2).

### **Vulnerability study**

#### **Yield under GCM climate scenarios**

The two climate change scenarios considered resulted in simulated decrease in sunflower yield at the three sites. The change percent of seed yield in Delta, Middle and Upper Egypt reached about -21, -27 and -38% under climate change conditions compared to their production under current conditions, respectively.

### **Adaptation studies**

#### **I. Adaptation under different sowing dates**

##### **I. 1. Effect of simulated sowing dates on sunflower yield**

Studies of sowing dates (as adaptation measures) on the yield were carried out through Dssat3.5 model. It is clear that growing sunflower (S53 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 Figs. (1-2) indicate that planting sunflower in Delta region on the 8<sup>th</sup> of June resulted in decreasing seed yield about 21% under climate change conditions compared to yield under current conditions. The main cause for the yield

decrease is a shortening of the growing period, particularly the seed –filling stage, due to more rapid accumulation of thermal units associated with higher temperatures. On the other hand, sowing sunflower plants under climate change conditions at the same location on the 1<sup>st</sup> of May, 10<sup>th</sup> of May, 20<sup>th</sup> of May, 1<sup>st</sup> of June and 10<sup>th</sup> of June resulted in decreasing seed yield by -0.7, -3.4, -13.0, -15.7 and -21.7 %, respectively as compared with the yield under current conditions (base treatment). It is clear that planting sunflower from the 1<sup>st</sup> of May to the 1<sup>st</sup> of June revealed an increase ranged 5-20% in seed production. It could be concluded that planting in early May is the optimum planting date for sunflower under climate change conditions.

In Middle Egypt, the vulnerability of climate change on sunflower production resulted in reduction yield about 27% compared to current yield (Figs. 3-4). While, planting sunflower on the 1<sup>st</sup> of May, 10<sup>th</sup> of May, 20<sup>th</sup> of May, 1<sup>st</sup> of June and 10<sup>th</sup> of June under future climate change conditions resulted in decreasing seed yield by -9.1, -14.4, -19.3, -23.4 and -25.8%, respectively as compared with the yield under current conditions. It is clear that planting sunflower from the 1<sup>st</sup> of May to the 1<sup>st</sup> of June revealed an increase ranged 1-18% in seed production. Also, planting in early May is the optimum planting date in Middle Egypt.

With respect to Upper Egypt, results as presented in Figs. (5-6) indicate that the sensitivity of sunflower plants to increasing temperature in Upper Egypt was more than Delta or Middle Egypt which resulted in reduction yield about 38% as compared with the current yield. Sowing sunflower on the 1<sup>st</sup> of May, 10<sup>th</sup> of May, 20<sup>th</sup> of May, 1<sup>st</sup> of June and 10<sup>th</sup> of June under future climate caused reduction in yield by -42.3, -43.1, -41.0, -39.9 and -39.2 %, respectively as compared with the yield under current climate. This could be attributed to inappropriate prevailing weather conditions for the sunflower seedling which could in turn affect final yield.

Generally, it can be concluded that weather conditions plays an important role in sunflower 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.

## **I. 2. Effect of simulated sowing dates on ETcrop**

Results as recorded in Figs. (7-8) show that planting sunflower in Delta region on the 8<sup>th</sup> of June caused increase ETcrop about 5% under climate change conditions compared to the current ETcrop. On the other hand, planting sunflower on the 1<sup>st</sup> of May, 10<sup>th</sup> of May, 20<sup>th</sup> of May, 1<sup>st</sup> of June and 10<sup>th</sup> of June resulted in increasing ETcrop by 19.0, 18.1, 11.5, 8.3 and 4%, respectively as compared with the ETcrop under current conditions. It is clear that planting sunflower from the 1<sup>st</sup> of May to the 1<sup>st</sup> of June revealed an increase ranged 4-14 % in ETcrop.

In Middle Egypt, results as shown in Figs. (9-10) indicate that planting sunflower on the 8<sup>th</sup> of June caused increase ETcrop about 12% under climate change conditions compared to the current ETcrop. However, planting sunflower on the 1<sup>st</sup> of May, 10<sup>th</sup> of May, 20<sup>th</sup> of May, 1<sup>st</sup> of June and 10<sup>th</sup> of June resulted in increasing ETcrop by 25.3, 22.3, 19.6, 15.1 and 10.9%, respectively as compared with the current ETcrop. It is clear that planting sunflower from the 1<sup>st</sup> of May to the 1<sup>st</sup> of June revealed an increase ranged 3.0-13.0% in ETcrop.

As to Upper Egypt, planting sunflower on the 8<sup>th</sup> of June caused decrease ETcrop about -0.5% under climate change conditions compared to the current ETcrop (Figs. 11-12). On the other hand, sowing sunflower plants under climate change conditions on the 1<sup>st</sup> of May, 10<sup>th</sup> of May, 20<sup>th</sup> of May and 1<sup>st</sup> of June resulted in increasing ETcrop by 3.8, 1.8, 1.8 and 1.3%, respectively. While, planting sunflower on the 10<sup>th</sup> of June caused an decrease in ETcrop about -1.6%.

The main cause for the ETcrop decrease in Upper Egypt compared to Delta or Middle Egypt due to high reduced crop growth and yield.

## **II. Adaptation under irrigation water amounts**

### **II. 1. Effect of simulated irrigation water amounts on sunflower yield**

Changes in sunflower productivity as a result of different irrigation water amounts were considered as possible adaptation strategies. Results in Figs. (13-14) indicate that under climate change conditions, seed yield in Delta region was decreased by -22.1, -24.8, -30.4 and -43.9% for the base level -10%, base-20%, base-30% and base-40%, respectively. Under excess water supply, base level+10% and base level+20%, increasing seed yield didn't clear (Fig. 16 a, b).

From the results in Figs. (15-16) it is clear that by applying a base level -10%, base-20%, base-30% and base-40% in Middle Egypt under climate change conditions could be directed to decrease seed yield by -27.2, -31.6, -45.0 and -55.7%, respectively as compared with the current yield. While, under the excess of irrigation water, base level +10% and base level +20%, they didn't affect seed yield.

In addition from the results in Figs. (17-18), it is clear that by applying a base level -10%, base-20%, base-30% and base-40% in Upper Egypt under climate change conditions could be directed to reduction yield by -43.0, -53.6, -65.1 and -73.1%, respectively. Increasing water supply did not clearly affect seed yield.

### **II. 2. Effect of simulated irrigation water amounts on ETcrop**

Changes in sunflower productivity as a result of different irrigation water amounts were considered as possible adaptation strategy to overcome the expected yield reduction as a result of temperature raise in the future. Results as recorded in Figs. (19-20) indicate that applying a base level -10%, base-20%, base+10% and base+20% could be directed to increase ETcrop by 3.8, 1.5, 4.6 and 4.7%, respectively compared to current ETcrop. While, applying a base level-30% or base-40% resulted in decreasing ETcrop by -6.5 and -19.7%, respectively. The main cause for the ETcrop decrease under the two treatments of base -30% and base-40% due to high reduced crop growth and yield.

Results as shown in Figs. (21-22) show that ETcrop under the four irrigation regimes of a base level -10%, base-20%, base+10% and base+20% increased by 10.6, 3.1, 11.9 and 11.9%, respectively compared to current ETcrop. While, under the two irrigation regimes of base level -30% and base-40% caused decrease ETcrop by -5.7 and -22.9%, respectively.

As to results in Figs. (23-24), it is clear that applying a base level -10%, base-20%, base-30 and base-40 could be directed to decrease ETcrop by -6.0, -13.9, -23.7 and -35.0%, respectively compared to current ETcrop. However, under the two irrigation regimes of base +5% and base+10% caused an increase in ETcrop by 2.6 and 3.2%, respectively.

Generally, it can be concluded that Sunflower plants (S53 CV) are sensitive to excess or shortage of water supply. Reduction in yield due to decreasing water amounts may be occur as a result of decreasing nutrients absorption, whereas under increasing water amounts the reduction occurs as a result of nutrients leaching from the root zone.

### **III. Adaptation under skipping irrigation at different growth stages**

#### **III. 1. Effect of simulated skipping irrigation at different growth stages on sunflower yield**

Changes in sunflower productivity according to skipping irrigation at different growth stages were considered as possible adaptation strategy to overcome the expected yield reduction as a result of shortage of water in different growth stages. In the same direction, expected the stages are more vulnerable to water deficit. Results are shown in Figs. (25-26) in Delta region clear that skipping irrigation at the 2<sup>nd</sup> irri., 3<sup>rd</sup> irri., 4<sup>th</sup> irri., 5<sup>th</sup> irri., 6<sup>th</sup> irri., 7<sup>th</sup> irri and 8<sup>th</sup> irri. caused reduction of seed sunflower yield about -37.5, -33.3, -28.0, -22.4, -21.0, -21.0 and -21.0%, respectively as compared with the base yield (without skipping) under current conditions. Skipping irrigation at 2<sup>nd</sup> or 3<sup>rd</sup> irri. cause severe yield reduction because it affect plant height, leaf area index, fertilization and consequently number of seeds/ head and weight/ seed.

With respect to results in Figs. (27-28) in Middle Egypt, it is indicate that skipping irrigation at the same respective skipping irrigation treatments caused yield reduction by -37.7, -36.1, -34.9, -31.0, -27.1, -26.8 and -26.6%, compared to current yield. Also, the vegetative growth stage is more sensitive to water stress as compared with the other stages.

As shown in Figs. (29-30), in Upper Egypt, skipping irrigation at the same respective treatments caused yield reduction by -43.6, -44.0, -44.2, -45.4, -45.2, -42.2 and -41.2% compared with the yield under current climate. It is clear that all growth stages are sensitive to water deficit specially at flowering stage and early seed filling period (skipping irrigation at the 5<sup>th</sup> and 6<sup>th</sup> stage).

#### **III. 2. Effect of simulated skipping irrigation at different growth stages on ETcrop**

In addition from the results in Figs. (31-32) it is obvious that skipping irrigation at the 2<sup>nd</sup> irri., 3<sup>rd</sup> irri. and 4<sup>th</sup> irri. could be conserved irrigation water in Delta region by 11.0, 7.5 and 2.4%, respectively as compared with the current ET. On the other hand, ETcrop at the same region was increased under skipping irrigation at 5<sup>th</sup> irri., 6<sup>th</sup> irri., 7<sup>th</sup> irri. and 8<sup>th</sup> irri. about 2.5, 3.1, 2.4 and 1.1% as compared with the Et under current climate.

In Middle Egypt, skipping irrigation at the 2<sup>nd</sup> and 3<sup>rd</sup> irri. could be conserved irrigation water by 2.4 and 0.5%, respectively compared to ETcrop under cuurent climate. While, skipping irrigation at the 4<sup>th</sup>, 5<sup>th</sup> irri., 6<sup>th</sup> irri., 7<sup>th</sup> irri. and 8<sup>th</sup> irri. caused increased ETcrop about 1.6, 5.4, 8.4, 8.6 and 8.4%, respectively compared to current ETcrop (Figs. 33-34).

As to Upper Egypt, all skipping irrigation treatment could be conserved irrigation water. The change percent of ETcrop under climate change conditions reached about -10.1, -10.8, -11.3, -13.0, -11.6, -8.9 and -7.4% for skipping irrigation at the 2<sup>nd</sup> irri., 3<sup>rd</sup> irri., 4<sup>th</sup> irri., 5<sup>th</sup> irri., 6<sup>th</sup> irri., 7<sup>th</sup> irri. and 8<sup>th</sup> irri., respectively compared with the base. The



main cause for the ETcrop decrease in Upper Egypt due to high reduced crop growth and yield (see Fig. 35-36).

Generally, it could be concluded that vegetative growth stage is most sensitive stage to water stress for sunflower plants. At the same time, omitting irrigation at 7<sup>th</sup> irri. or 8<sup>th</sup> irri. during the late seed growth could be recommended under climate change conditions as a way to conserve irrigation water in Delta and Middle Egypt without clear reduction in seed yield.

The general trends detected from the overall averages of simulated sunflower seed yield indicate that sunflower crop have to be sown between the 1<sup>st</sup> of May and 10<sup>th</sup> of May in Delta and Middle Egypt and between the 1<sup>st</sup> of June and 10<sup>th</sup> of June in Upper Egypt to reduce unfavorable effects of climate change on sunflower production under climate future.

Reducing irrigation water amounts by 10% could be recommended as a way to conserve irrigation water without clear reduction in seed yield.

Vegetative growth stage is most sensitive stage to water stress for sunflower plants. At the same time, omitting irrigation at the late seed growth could be practiced.

### References

- Abdel Wahed, A. 1983.** Research Report on Soil Survey. Soil Survey EMCIP Res.Extension Centers. Publication No. 62. Consortium for International Department. ARC, Cairo, May 1983.
- Agricultural Economic Research Institute Bulletins. Volumes No. 1986 : 2003.** Ministry of Agriculture.
- 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.
- DSSAT3.5 1998.** Decision Support System for Agrotechnology Transfer, V 3.5. G. Y. Tsuji, J. W., Jones, G. Uhera, and S. Balas (eds.). IBSNAT. University of Hawaii, Honolulu,
- Eid, H. M. (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, H. M., D. Z. El-Sergany. 1993 .** Impact of climate change on soybean yield and water needs. Proc. First Conference on the Environment. Egypt. p. 313 -316.
- Eid, H. M., D. Z. El-Sergany and W. L. McCuistion. 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, H. M., N. M. Bashir, N. G. Ainer, and M. A. Rady. 1993b.** Climate change crop modeling study on sorghum. *Annals Agricultural Science, Special Issue*, 1, 219-234.
- Eid, H. M., N. A. Anton, and A. M. Tarrad. 1994a.** Comparative study on Egyptian wheat cultivars and their response to high temperatures. *Annals of Agric. Sci. Moshtohor* Vol. 32 (1) 143-154.
- Eid, H. M., D. Z. El-Sergany and W. L. McCuistion. 1994b.** 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, H. M., N. M. El- Mowelhi, M. A. Metwally, N. G. Ainer, F. A. Abbas, and M. Abd El-Ghaffar. 1995a.** 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, H. M., A .A. Rayan., K. A. Mohamed, M. M. A. El-Refaie, M. M. Attia, H. A. Awad, K.M. R. Yousef, and M. M. A. El-Koliey. 1995b.** Impact of climate change on yield and water requirements of some major crops. *On- Farm Irrigation and Agroclimatology. pp.492 - 507.*
- Eid, H. M., S. M. El-Marsafawy, N. G. Ainer, M. A. Ali, M. M. Shahin, N. M. El-Mowelhi and O. El-Kholi. 1996.** "Vulnerability and Adaptation to Climate Change in Egyptian Agriculture". *Country Study Report. (1-53), CSP Washington, D C.*
- Eid, H.M.; Samia M. El- Marsafawy; M. A. Ali; N. G. Ainer; A. A. Rayan and O. El-Koli. 1997a.** Vulnerability and Adaptation to Climate Change in Wheat Crop. *Meteorology & Environmental Cases Confer. 2-6 March, 1997.*
- Eid, H.M.; Samia M. El- Marsafawy; A. Y. Salib and M. A. Ali. 1997b.** Vulnerability of Egyptain Cotton Productivity to Climate Change. *Meteorology & Environmental Cases Confer. 2-6 March, 1997.*
- Eid, H.M.; Samia M. El- Marsafawy; N. G. Ainer; N. M. El- Mowelhi and O. El- Koli. 1997c.** Vulnerability and Adaptation to Climate Change in Maize Crop. *Meteorology & Environmental Cases Confer. 2-6 March, 1997.*
- Eid, H.M.; Samia M. El- Marsafawy; M. M. Shahin; A. N. Khater and I. Abdel Gelil. 1997d.** Adaptation of Egyptian Cotton to Climate Change. *Meteorology & Environmental Cases Confer. 2-6 March, 1997.*
- El-Shaer, M. H., C. Rosenzweig, A. Iglesias H. M. Eid and D. Hellil. 1997.** Impact of climate change on possible scenarios for Egyptian agriculture in the future. *Mitigation and Adaptation Strategies for Global Change* 1: 233- 250.

- IPCC. 1992a. Climate Change 1992. The Supplementary Report to the IPCC Scientific Assessment. In J. T. Houghton, G. J. Jenkins, and J. J. Ephraums (eds). Cambridge University Press. IPCC. 1990. Climate Change. The IPCC Impacts Assessment. In W. J. Mc G. Tegart, G. W. Sheldon and D. C. Griffiths (eds). Intergovernmental Panel on Climate Change. World Meteorological Organization and United Nations Environmental Program. Bracknell, UK.**
- IPCC. 1992b. Climate Change. 1992. The Supplementary Report to the IPCC Scientific Assessment. J. T. Houghton, B. A. Callandar, and S. K. Varney (eds). Cambridge University Press.**
- 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, B. S.; G. F. Arkin, and A.B. Hearn. 1988. The cotton simulation model COTTAM: Fruiting model calibration and testing. Trans. ASAE 31: 846-854.**
- Peart, R. M., J. W. Jones, R. B. Carry, K. Boote and L. H. Allen, Jr. 1989. Impact of climate change on crop yield in the southeastern U. S. A. In Smith, J. B. D. Tirpak (eds). The potential Effects of Global Climate Change on the United States. Report to Congress. EPA -230 -05- 89- 050. U.S. Environmental Protection Agency. Washington DC. Appendix C -1, pp 2-1, 2-54.**
- 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 D. Hillel. 1994. Egyptian Agriculture in the 21st Century. Collaborative Paper CP-94-12. International Institute for Applied Systems Analysis, Luxemburg, Austria.**
- Rosenzweig, C. and M. L. Parry. 1994. Potential impact of climate change on world food supply. Nature 367,133-138.**
- Strzepek, K. M., C. Onyeji, M. Saleh, and D. Yates. 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.**

Table (1): Results of calibration / validation test of sunflower at Giza.

Variable	Predicted	Measured
Flowering date (dap)	54	52
Physiological maturity (dap)	94	90
Seed yield (kg/ ha, dry)	2330	2324
Wt. per ear (g, dry)	0.070	0.070
Grain number (grain/ m <sup>2</sup> )	3000	3286
Biomass at harvest (kg/ ha)	7424	8936
Grain oil (%)	33.8	39.6

Table (2): Created genetic coefficient of sunflower crop (S53).

Genetic Coefficient*	
P1	260.0
P2	3.74
P5	800.0
G2	400.0
G3	3.50
O1	60

\*SUNFLOWER GENOTYPE COEFFICIENTS - SUOIL980 MODEL

P1: Duration of juvenile phase (in degree C.days with a base temperature of 4 C)

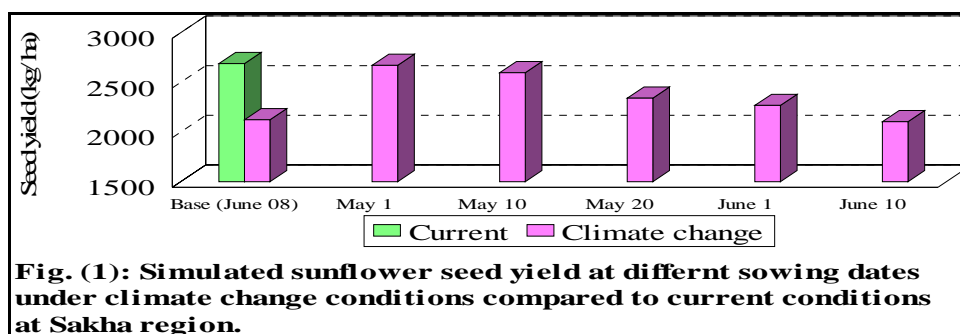
P2: Amount (in days/hour) that development is slowed when crop is grown in photoperiod shorter than the optimum (which is considered to be 15 hours)

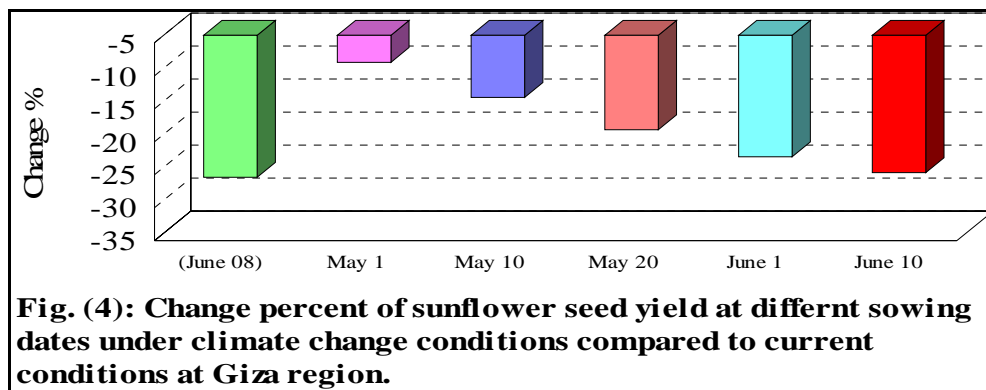
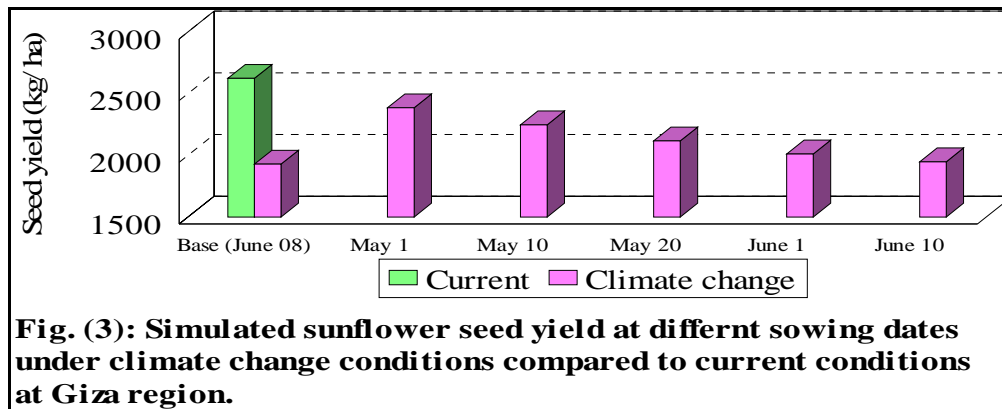
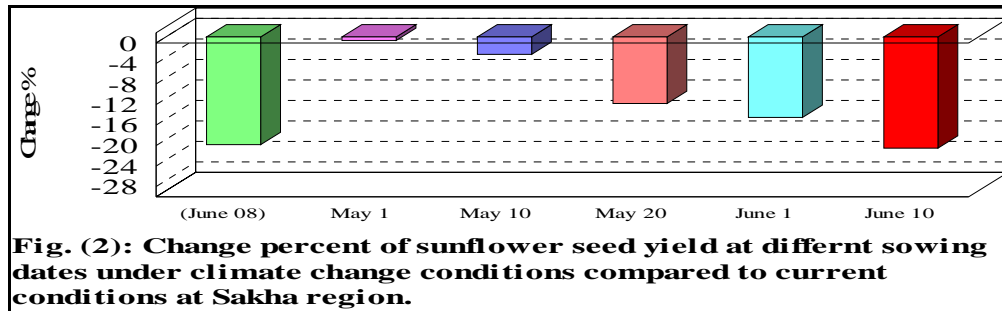
P5: Duration of the first anthesis-physiological maturity stage (in degree days above a base of 4C)

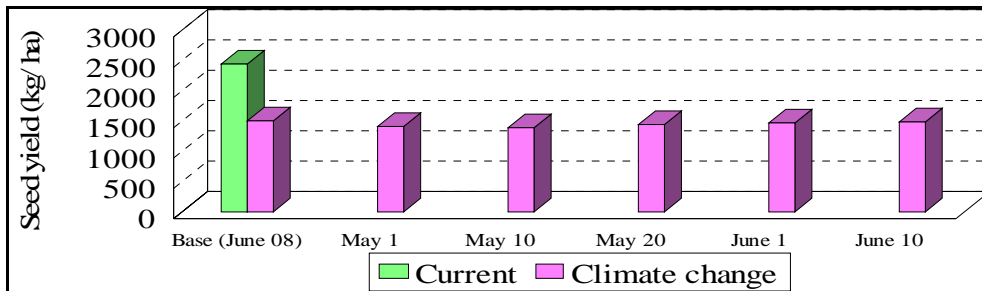
G2: Maximum possible number of grains per head (measured in plants grown under optimum conditions and low plant population density)

G3: Potential kernel growth rate during the linear kernel filling phase (in mg day<sup>-1</sup>, measured in plants grown under optimum conditions and low plant population density).

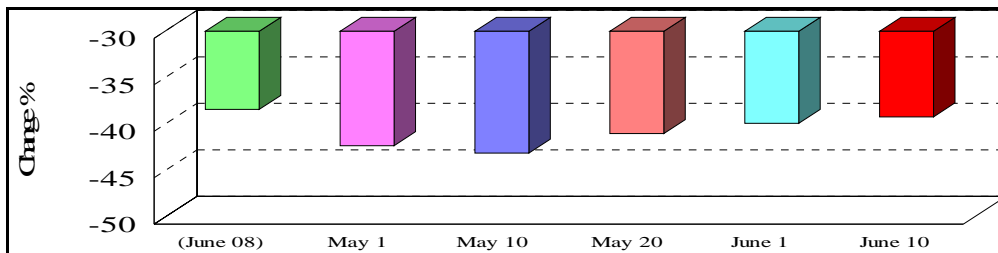
O1: Maximum kernel oil content (%)



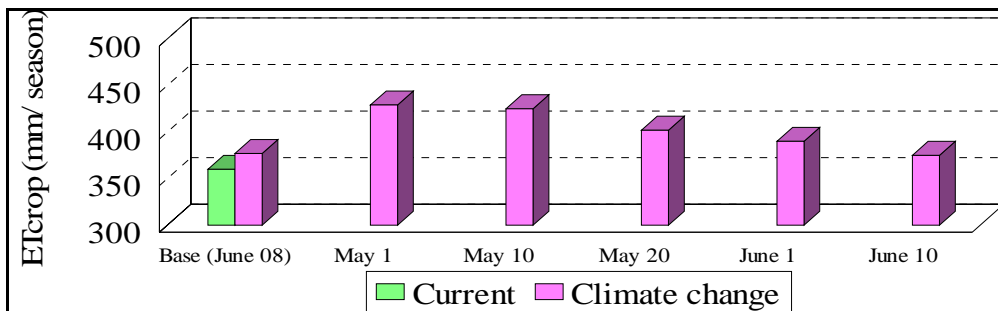




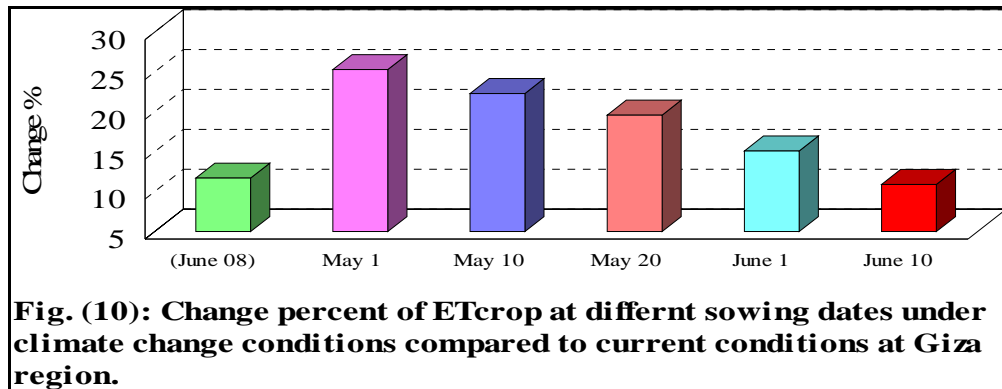
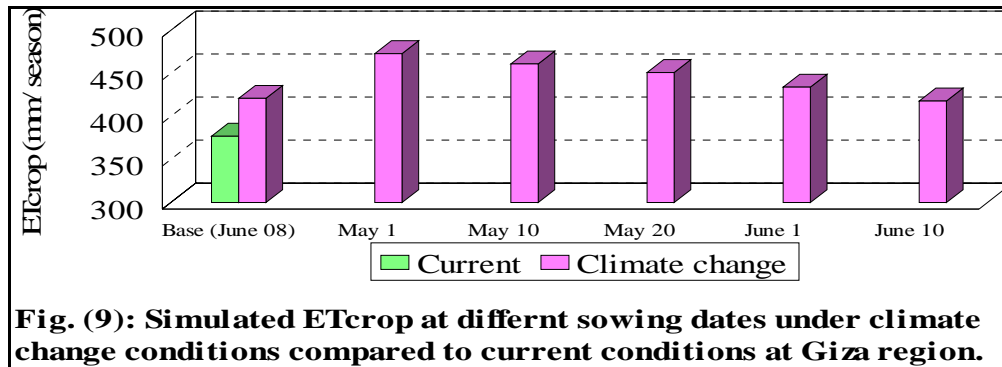
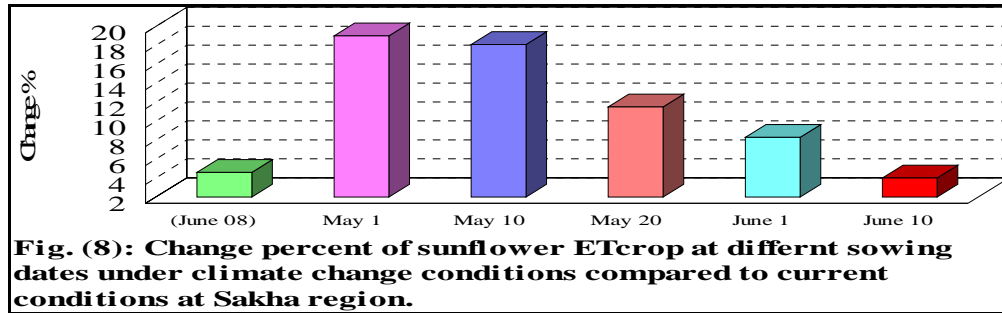
**Fig. (5): Simulated sunflower seed yield at differnt sowing dates under climate change conditions compared to current conditions at Shandaweel region.**

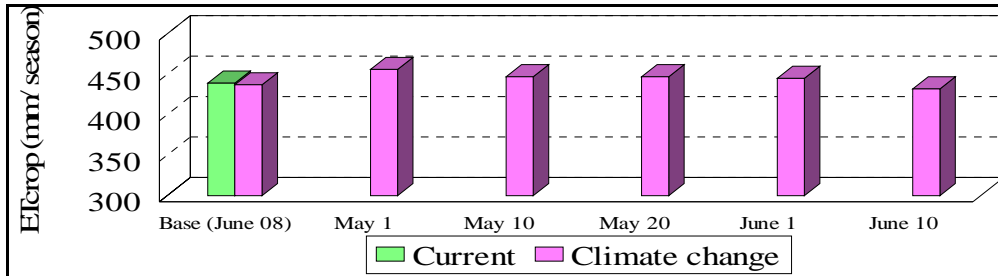


**Fig. (6): Change percent of sunflower seed yield at differnt sowing dates under climate change conditions compared to current conditions at Shandaweel region.**

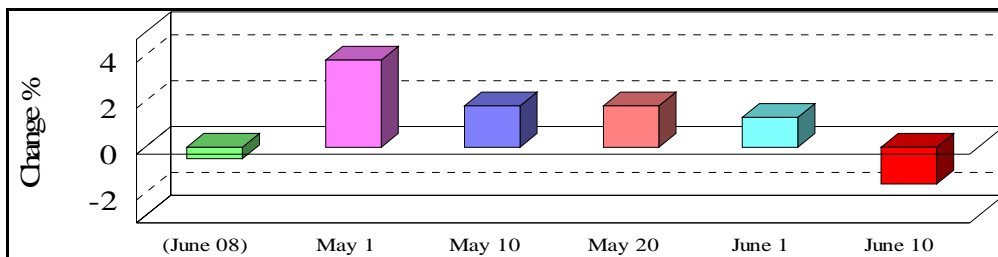


**Fig. (7): Simulated sunflower ETcrop at differnt sowing dates under climate change conditions compared to current conditions at Sakha region.**

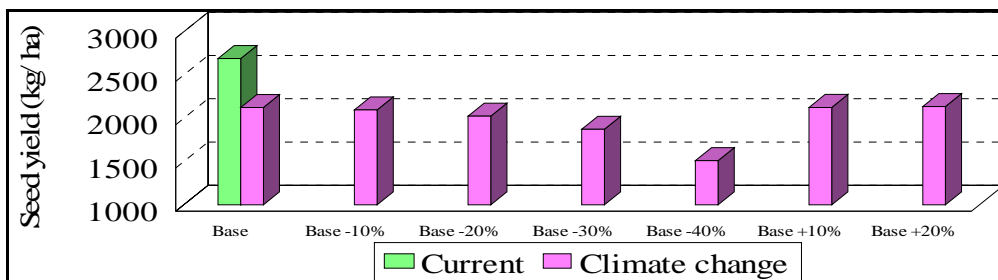




**Fig. (11): Simulated ETcrop at differnt sowing dates under climate change conditions compared to current conditions at Shandaweel region.**

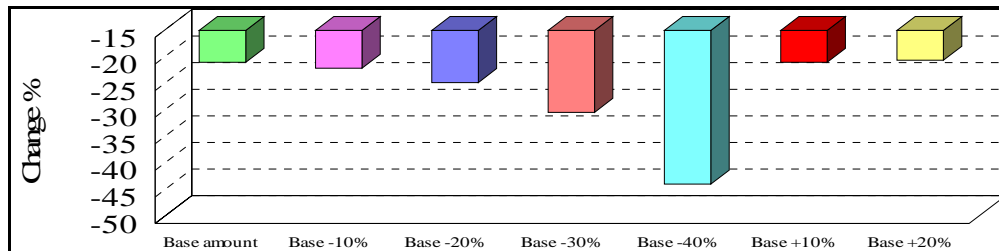


**Fig. (12): Change percent of ETcrop at differnt sowing dates under climate change conditions compared to current conditions at Shandaweel region.**

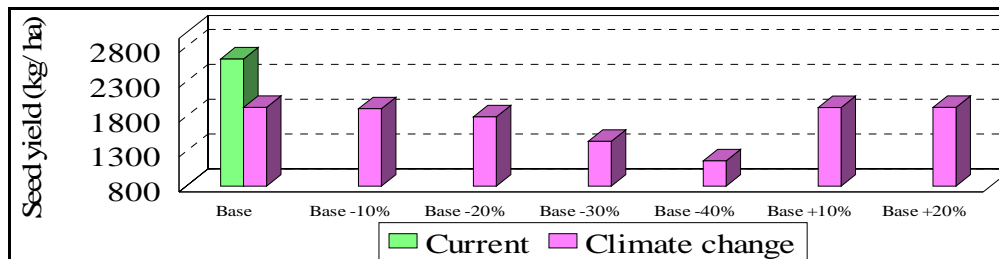


**Fig. (13): Simulated sunflower seed yield at differnt irrigation water amounts under climate change conditions compared to current conditions at Sakha region.**

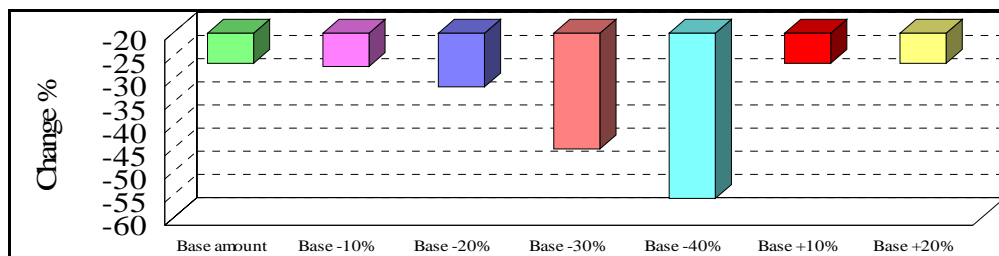




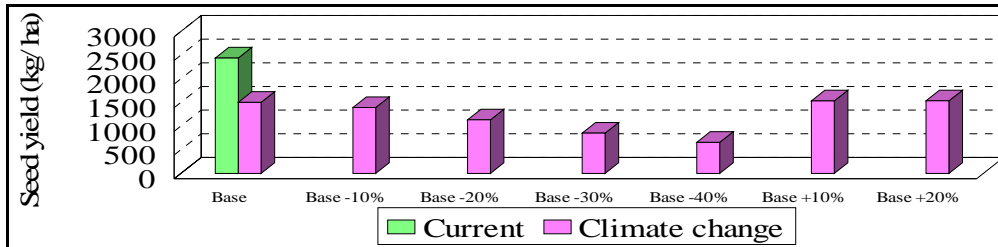
**Fig. (14): Change percent of sunflower seed yield at different irrigation water amounts under climate change conditions compared to current conditions at Sakha region.**



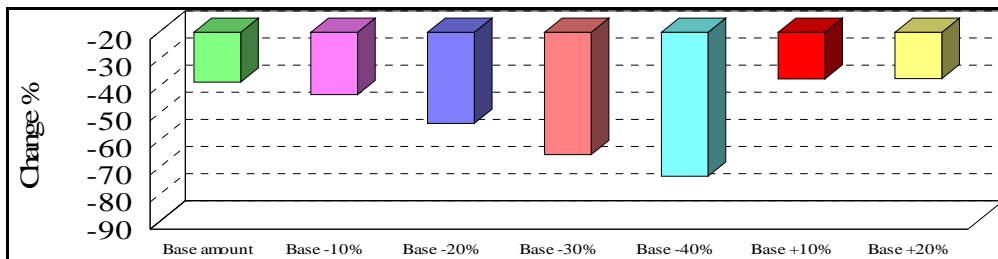
**Fig. (15): Simulation of sunflower seed yield at different irrigation water amounts under climate change conditions compared to current conditions at Giza region.**



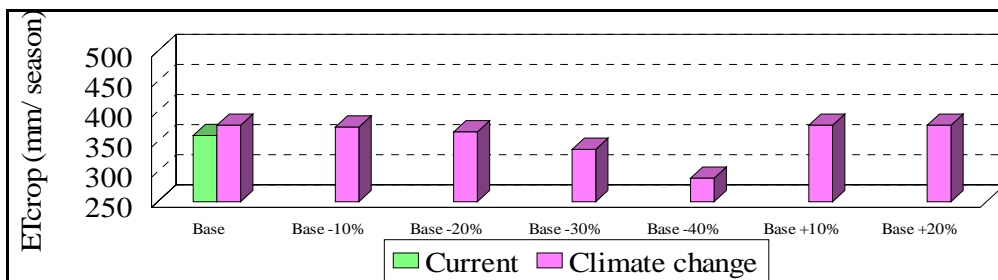
**Fig. (16): Change percent of sunflower seed yield at different irrigation water amounts under climate change conditions compared to current conditions at Giza region.**



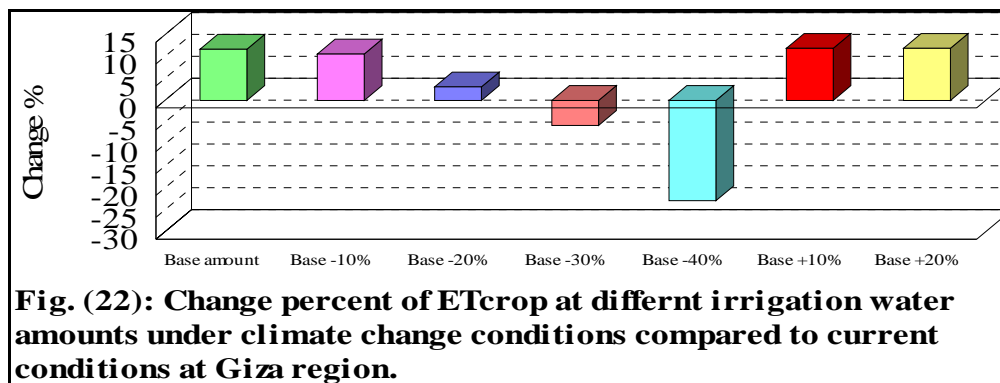
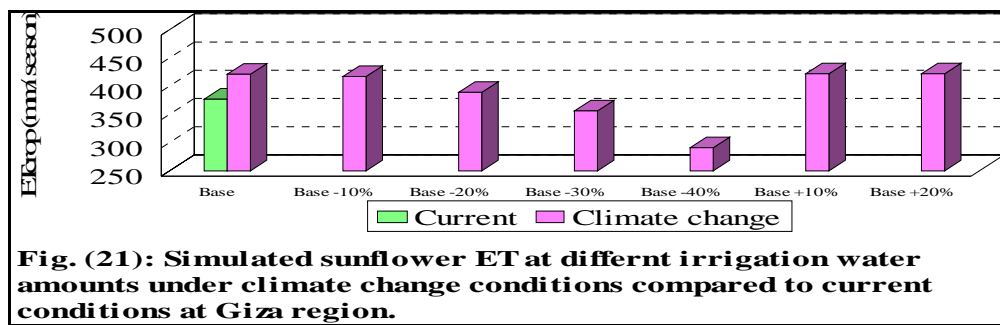
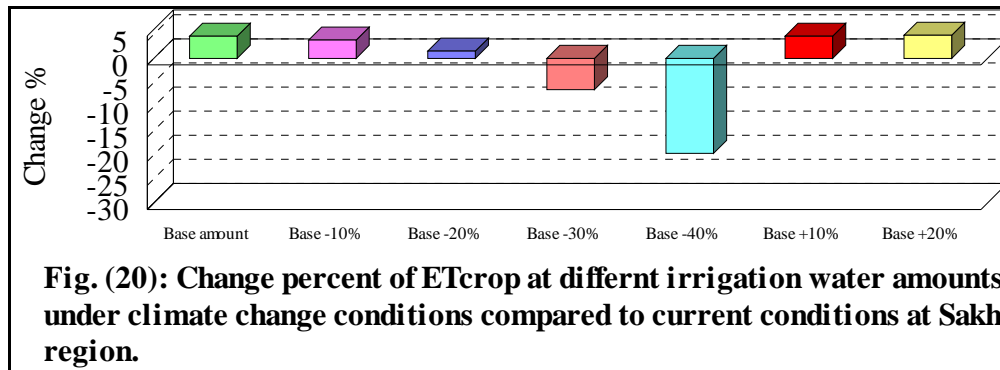
**Fig. (17): Simulated sunflower seed yield at differnt irrigation water amounts under climate change conditions compared to current conditions at Shandaweel region.**

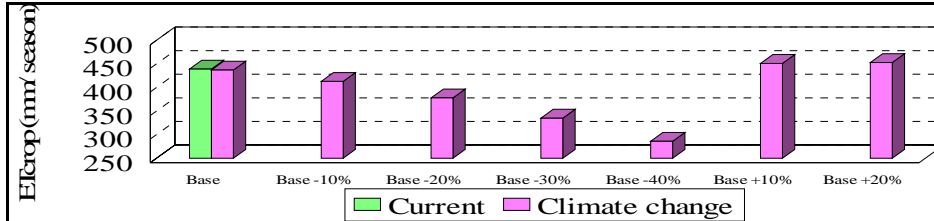


**Fig. (18): Change percent of sunflower seed yield at differnt irrigation water amounts under climate change conditions compared to current conditions at Shandaweel region.**

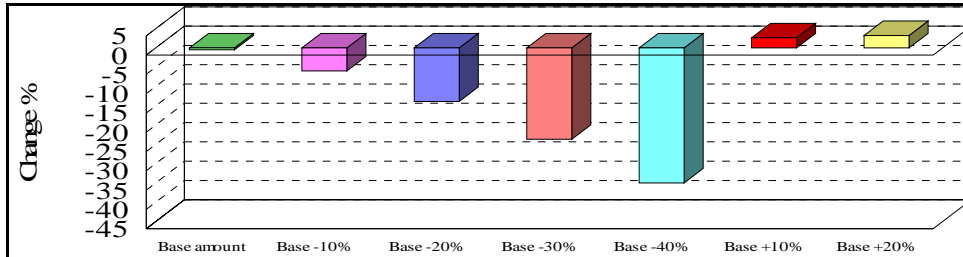


**Fig. (19): Simulation of sunflower ET at differnt irrigation water amounts under climate change conditions compared to current conditions at Sakha region.**

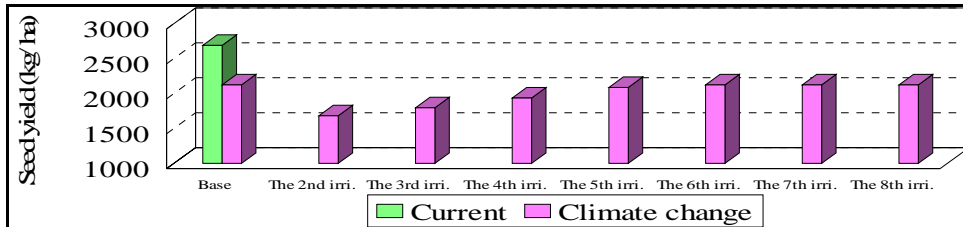




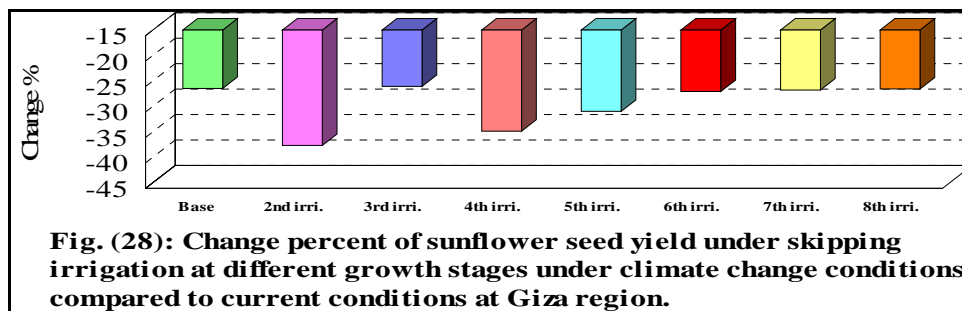
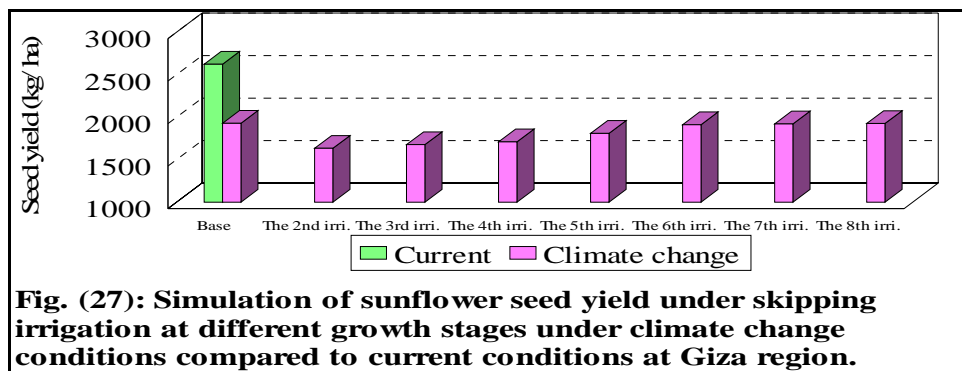
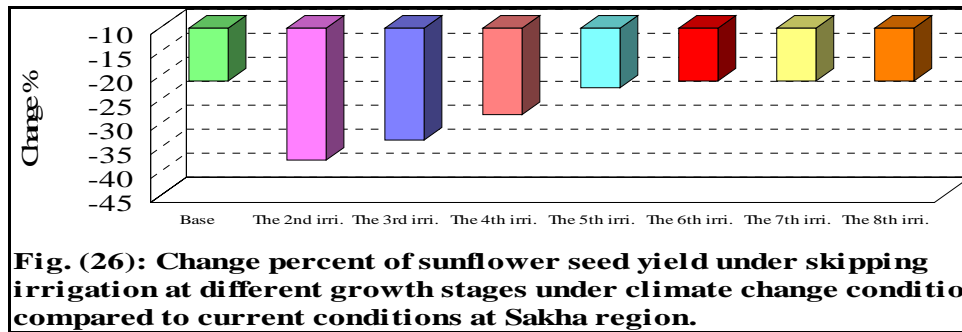
**Fig. (23): Simulation of sunflower ET at differnt irrigation water amounts under climate change conditions compared to current conditions at Shandaweel region.**

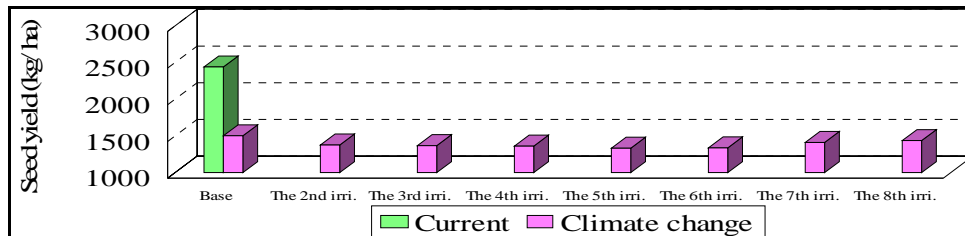


**Fig. (24): Change percent of sunflower ET at differnt irrigation water amounts under climate change conditions compared to current conditions at Shandaweel region.**

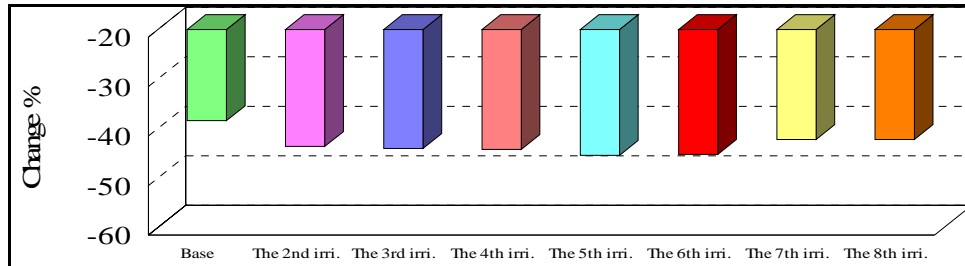


**Fig. (25): Simulation of sunflower seed yield under skipping irrigation at different growth stages under climate change conditions compared to current conditions at Sakha region.**

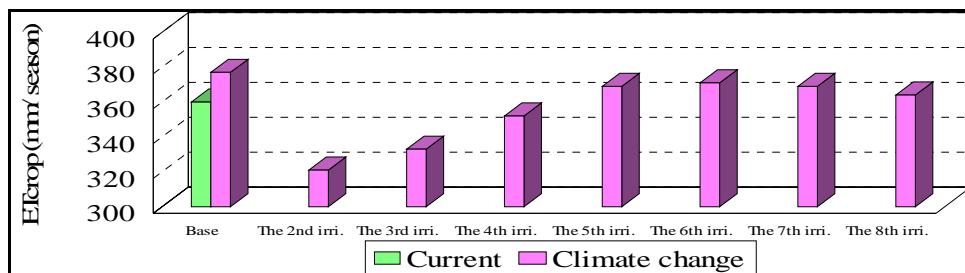




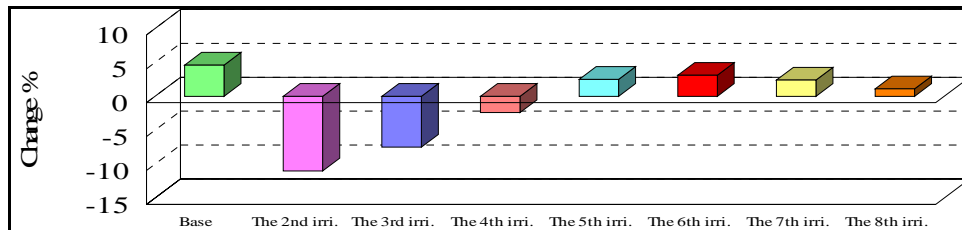
**Fig. (29): Simulation of sunflower seed yield under skipping irrigation at different growth stages under climate change conditions compared to current conditions at Shandaweel region.**



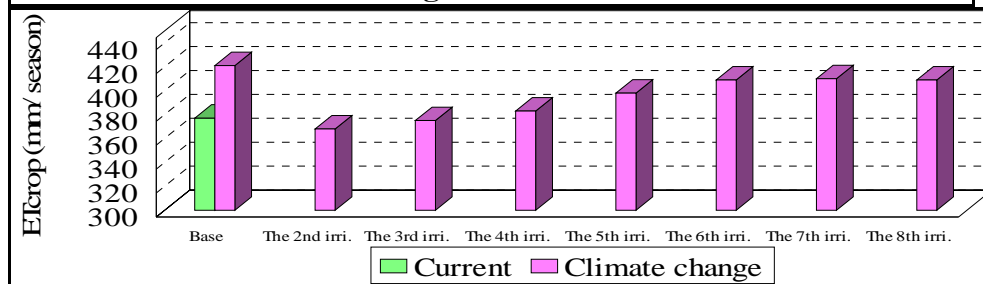
**Fig. (30): Change percent of sunflower seed yield under skipping irrigation at different growth stages under climate change conditions compared to current conditions at Shandaweel region.**



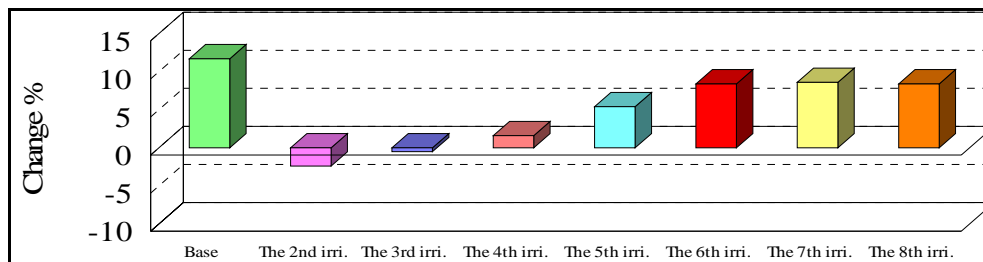
**Fig. (31): Simulation of ETcrop under skipping irrigation at different growth stages under climate change conditions compared to current conditions at Sakha region.**



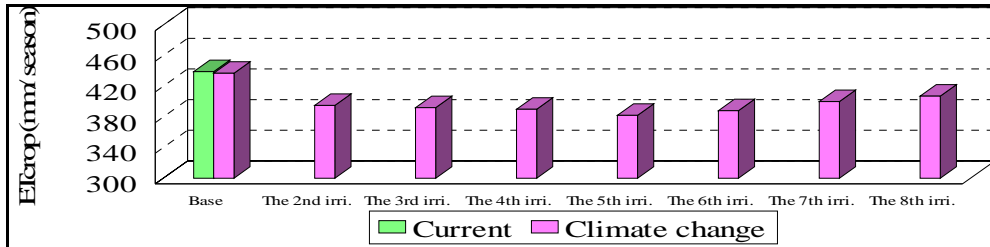
**Fig. (32): Change percent of ETcrop under skipping irrigation at different growth stages under climate change conditions compared to current conditions at Sakha region.**



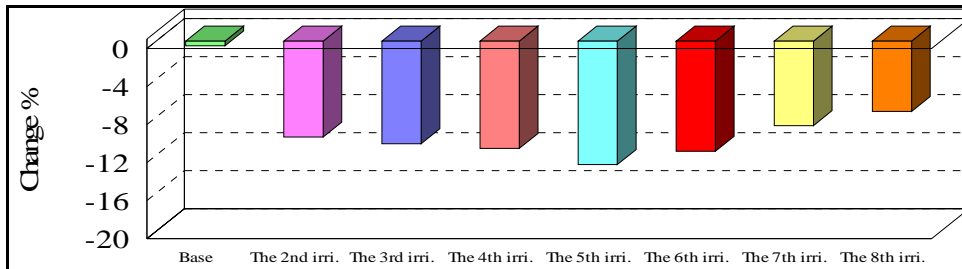
**Fig. (33): Simulation of ETcrop under skipping irrigation at different growth stages under climate change conditions compared to current conditions at Giza region.**



**Fig. (34): Change percent of ETcrop under skipping irrigation at different growth stages under climate change conditions compared to current conditions at Giza region.**



**Fig. (35): Simulation of ETcrop under skipping irrigation at different growth stages under climate change conditions compared to current conditions at Shandaweel region.**



**Fig. (36): Change percent of ETcrop under skipping irrigation at different growth stages under climate change conditions compared to current conditions at Shandaweel region.**



## أثر التغير في المناخ على إنتاجية محصول عباد الشمس في مصر

سامية محمود المرصفاوى

وحدة بحوث الأرصاد الجوية الزراعية والتغير في المناخ- معهد بحوث الاراضى والمياه والبيئة \_ مركز البحوث الزراعية- مصر

أجرى هذا البحث لدراسة التأثير المحتمل للتغيرات المناخية على إنتاجية محصول عباد الشمس والاستهلاك المائي له في مصر. وقد استخدم لهذا الغرض نموذج OILCROP-SUN من خلال برنامج دسات DSSAT3.5 ، وقد استخدم اثنين من السيناريوهات GFD3 & CCCM من خلال نماذج الدورات العامة GCMS ، هذه السيناريوهات تستطيع تغيير الظروف الجوية إلى ما هو متوقع تحت ظروف التغير في المناخ (بجول منتصف هذا القرن).

وقد أجريت اختبارات المعايرة والتأييد لهذا النموذج Validation and calibration tests للتأكد من صلاحية البرنامج للعمل بكفاءة عالية تحت الظروف المصرية. وقد تمت دراسة التأثير المتوقع لمواعيد الزراعة المختلفة & الري بكميات مياه مختلفة & وإسقاط رية في أطوار نمو مختلفة على كل من الإنتاج والاستهلاك المائي لعباد الشمس الزيت في مصر & كما أقترح عدد من سياسات الأقلمة في هذا الشأن.

وتشير نتائج الدراسة إلى أن التغيرات المناخية سوف تسبب نقص في إنتاجية عباد الشمس بنسب تصل إلى -21% ، -27% ، -38% في كل من الدلتا ومصر الوسطى ومصر العليا على الترتيب بالمقارنة بالإنتاجية تحت الظروف الحالية. كما حدث زيادة في الاستهلاك المائي بنسبة 5% ، 12% في كل من الدلتا ومصر الوسطى على الترتيب، بينما انخفض الاستهلاك المائي بنسبة 0.5% في مصر العليا نتيجة للانخفاض الكبير في إنتاجية المحصول تحت ظروف التغيرات المناخية في هذه المنطقة.

ومن حيث نتائج دراسات الأقلمة التي أجريت في هذا الشأن فقد أوضحت النتائج أن أنسب ميعاد لزراعة نبات عباد الشمس هو من 1 مايو إلى 10 مايو في الدلتا ومصر الوسطى، ومن 1 يونيو إلى 10 يونيو في مصر العليا وذلك لتقليل الأثر السلبي للتغيرات المناخية على إنتاجية المحصول.

ومن حيث كمية مياه الري المناسبة للمحصول، تشير النتائج إلى أن إضافة الكمية الأساسية (895 مم / موسم) منقوصا منها 10% (805.5 مم / موسم) لا يسبب نقص واضح في المحصول، كما أن تحريم الري في الفترات المتأخرة من امتلاء البذور لا يؤثر كثيرا على إنتاجية المحصول.

ومن ناحية أخرى فقد أظهرت نتائج دراسات الأفلمة أن فترة النمو الخضري والتزهير من أكثر الفترات حساسية في حياة نبات عباد الشمس حيث أن تأخير الري في هذه الفترات يسبب نقص كبير في المحصول تحت ظروف التغيرات المناخية.