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DSSAT PROGRAM AND PREDICTION OF WHEAT PRODUCTIVITY UNDER RAINFED AND SUPPLEMENTARY IRRIGATION CONDITIONS

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ABSTRACT

Crop simulation models have improved steadily over the past three decades aided by the rapid improvement of computer technology. Some of these crop models are currently used to study the impact of climatic change on crop productivity under different environment conditions . One of these models is DSSAT (Decision Support System for Agrotechnology Transfer) which used to evaluate and predict the yield of several crops (One of these crops is wheat) under various environmental conditions such as weather, soil , irrigation and fertilizers. Also select crop cultivar(s) through the simulation procedure for different environments . This could be helping the decision-makers to put the agricultural strategies with different scenarios. In this study, climate data for current conditions and for two future scenarios, in the form of monthly and daily values, were used to evaluate crop growth using DSSAT, for 2040. These same climate data were then manipulated by changing their standard deviations to produce increased or decreased climate variability scenarios. The potential impact of climatic change on wheat production was evaluated by simulation the predicted data under the current condition and the predicted data by the year 2040. Starting with the assumption of global climate change by 2040, this research concentrates on assessing how agriculture in the North West Coast of Egypt will adapt to such climate change. Eleven wheat varieities were evaluated under rainfed condition at different growth stages (at Maryot Experimental Station , North West Coast of Egypt) and analyzed by DSSAT model to get the predicted yield. The actual field experiments data showed that there were significantly differences between the wheat varieties in most of the morpho-physiological characteristics, yield and yield components. The current results showed that the grain yield per hectare of Gemiza 7 cultivar out-weighed significantly those of the other cultivars followed by Giza 164 . Whereas , Sakha 93 produced the highest value of the predicted grain yield by the year 2040 . Results were evaluated across eleven different wheat varieties and climate scenarios (control or current conditions, mean changes, variance changes, mean and variance changes) . While the overall mean increases by the year 2040 result in increased yields due to the positive effect of duplication in CO_2 and it s effect on the wheat crop as a C3 plant. The framework of this study therefore attempts to fill the gaps of knowledge and methodology between production of climate forecasts and their practical application to improve decision making by the agricultural sector.
Keywords: Wheat , Varieties, Climate change, Rainfed, DSSAT , Crop model

INTRODUCTION

Achievement of self-sufficient level or reduce the vast gap between production and consumption of wheat in Egypt will not realized unless researchers can get the opportunity to make and better use of resources and transfer the new technology. Researchers can change wheat cultivars, fertilizer levels, irrigation regime and agricultural practices to maximize wheat crop yield under the current conditions. The breeder usually records data and makes his selection on the basis of large number of agronomic characters among which significant positive and negative correlation may exist (Johnson and Schmidt , 1968 and Lee and Kaltsikes , 1973) . Under climatic change conditions researchers need to use a crop model to predict the wheat production. DSSAT (Decision Support System for Agrotechnology Transfer) is a crop model that has the ability to take that source of variability into account. Cultivars characterized by a specific set of genetic coefficients that express the genetic potential of each genotype independently of all environmental constraint soil, weather, fertilizer, etc. It can be select one(s) of the best explores available genotypes by simulating the wheat cultivars yield of different cultivars. The CERES (Crop Estimation through Resource and Environment Synthesis) models (Godwin et al., 1989), CERES-Wheat is a yield simulation model that was originally developed under the auspices of the USDA-ARS Wheat Yield .The model is also one of the main models that have been incorporated in DSSAT (Hoogenboom *et al.*, 1994 and Hoogenboom *et al.*, 1999) . The CERES-Wheat model simulates the impacts of the main environmental factors, such as weather, soil type, and major soil characteristics, and crop management on wheat growth, development, and yield (Ritchie *et al.*, 1998). Input requirements for CERES-Wheat include weather and soil conditions, plant characteristics, and crop management (Hunt *et al.*, 2001). The minimum weather input requirements of the model are daily solar radiation, maximum and minimum air temperature, and precipitation. Soil inputs include drainage and runoff coefficients, first-stage evaporation and soil albedo, water-holding characteristics for each individual soil layer. The model also requires saturated soil water content and initial soil water content for the first day of simulation. Required crop genetic inputs are coefficients related to photoperiod sensitivity, duration of grain filling, conversion of mass to grain number, grain-filling rates, vernalization requirements, stem size, and cold hardiness (Hunt *et al.*, 1993). If the crop is irrigated, the date of application and amount is required. Latitude is required for calculating daylength. The model can use different weather, soils, genetic, and management information within a growing season or for different seasons in a single model execution. The model simulates phenological development; biomass accumulation and partitioning; leaf area index (LAI); grain growth; and the soil and plant water and N balance from planting until harvest maturity based on daily time steps (Godwin and Singh, 1998; Ritchie, 1998; Ritchie *et al.*, 1998). Using of a crop model for any application, one first has to estimate the cultivar characteristics if they have not been previously determined. Weather data, soil analysis, genetic coefficients and crop data are sufficient for crop modeling study .The characterization and selection of morpho-physiological traits play an important role in identifying stress tolerant genotypes for dry areas. Understanding the impacts of weather on crop production by applying simulation models provides a credible basis for a quantitative estimate of the range of yields farmers can expect for a given set of management conditions (Arkin and Dugas, 1981, Hammer *et al.*, 1996; Tsuji *et al.*, 1998). At the North West Coast of Egypt, Sabry *et al.* (1994), studied the effect of one irrigation at planting time on wheat yield.

They reported that significant differences in grain yield display between wheat cultivars varied in mean grain yield under rainfed with or without an irrigation after sowing date. In West Asia North Africa (WANA) region, amount of rainfall is low and generally poorly distributed, so periods of water deficit occur during the grain-filling stage of wheat almost every year (Oweis *et al.*, 1992). As a result, crop yield and water use efficiency (WUE) are generally low and variable. The production of 1 kg of wheat (*T. aestivum L.*) grain under fully irrigated conditions requires about 1 to 2 m^3 of irrigation (Perrier and Salkini, 1991); in rainfed areas it requires from 1 to 3 m^3 of rainwater (Cooper *et al.*, 1987 a) . Since water is the major limiting factor for agriculture in the WANA region, improving WUE is vital for meeting the increasing food demand (Cooper *et al.*, 1987b). Supplemental irrigation (SI) is defined as the application of a limited amount of water to rainfed crops when precipitation fails to provide the essential moisture for normal plant growth. This practice has shown potential in alleviating the adverse effects of unfavorable rain patterns and thus improving and stabilizing crop yields (Perrier and Salkini,1991; Oweis *et al.*, 1998; Zhang and Oweis,1999). Supplemental irrigation is widely practiced in Syria, and in southern and eastern Mediterranean countries. However, excessive use of water in supplementry irrigation because of low irrigation cost and attractive gains from increased yields has resulted in a decline of aquifers and deterioration of water quality in many areas (Ward and Smith, 1994). The objective of this study was to determine if the DSSAT program could be used to forecast final grain yield for environmental and management under rainfed and supplementary irrigation conditions at the North Coast of Egypt

MATERIALS AND METHODS

Eleven wheat varieties were cultivated under rainfed conditions during two successive seasons, 2000/01 and 2001/02 at Maryot Experimental Station (North West Coast of Egypt) . Soil sample was periodically analyzed according to Piper (1950) and Jackson (1967) and the average of the main properties are illustrated in Table (1) . Meteorological data, average temperature, Evapotranspiration (ET), wind speed (WS) total rainfall and relative humidity (RH) during the grown seasons are present in table (2 . Each of the two experiments was set in randomized complete block design with four replications . The experimental plot size was 3x4 m^2 and grains were planting in rows at a rate of 60 kg/ha on 20^{th} November . All agricultural practices were done as recommended . Supplementry irrigation were added according to the climate conditions in each growing season . Growth characteristics were recorded on 10 individual plants in four stages i.e. tillering , botting , heading and milk ripe stages . Yield and yield attributes measurements were recorded after one week of the physiological maturity stage for the eleven wheat varieties. The field obtained data were subjected to the proper statistical analysis of variance according to Snedecor and Cochran (1967) . The combined analysis for the results of the two seasons were applied according to Steel and Torrie (1960) .

Table (1) Chemical and physical properties of the soil

Chemical properties	Determination
EC (m mhos/cm)	3.3
Sp	3.9
pH paste	7.8
Ca CO3 %	32.0
Soluble cations (meq./L)	
Ca^{+2}	8.9
Mg^{+2}	2.7
Na^{+}	19.0
K^{+}	0.40
Soluble anions (meq./L)	
$CO^{-}3$	-
$HCO^{-}3$	0.6
CL^{-}	23.0
SO- 4	7.5
C.E.C (meq./L)	20.8
Physical properties Texture class	
Clay %	28.4
Silt %	31.9
Sand %	39.8
Field capacity	19.0

Table (2) Meteorological of the current data at Maryot Experimental Station Location of 2000/01 and 2001/02 growing seasons

Month	Avg temp C^0		*Total Slr W/m^2		ET mm		Avg WS km/ha		Total Rain /mm		Avg RH %	
	2000/2001	2001/2002	2000/2001	2001/2002	2000/2001	2001/2002	2000/2001	2001/2002	2000/2001	2001/2002	2000/2001	2001/2002
Nov	Germination											
	19.18	19.82	0.16	0.16	2.52	2.07	5.96	3.22	15.59	25.18	73.47	67.34
Dec	Jointing											
	14.47	14.27	0.14	0.11	1.89	1.40	5.72	27.88	59.94	72.39	71.69	75.80
Jan	Tillering											
	14.10	12.40	0.11	0.11	1.92	1.42	2.66	17.57	28.70	82.55	77.38	77.53
Feb	Max vegetative											
	13.85	14.90	0.18	0.17	2.64	2.01	4.06	8.22	8.38	22.35	66.88	78.99
Mar	Reproductive											
	17.42	16.48	0.21	0.21	2.99	2.86	3.87	7.04	0.76	3.81	74.89	73.34
Apr	Reproductive											
	19.41	18.57	0.25	0.25	3.56	3.63	4.38	7.35	0.00	4.60	66.85	66.79
Total				143.4				210.9				

* W/m^2 = Wat / meter square

The treatment means were compared by using Duncan's multiple range test (Waller and Duncan, 1969). Decision Support System for Agrotechnology Transfer program (DSSAT) was used to estimate and predict the productivity of wheat varieities under climatic change. Crop model validation used to compare the observed and the predicted data with three steps i.e. retire data (converting data to cures IBSINT), valid data (comparing between predicted and observed data) and run the model . Wheat simulation model used is CESRES-wheat model . Hestorical meteorological data and soil type were calculated by the Project of "An Integrated Crop Management Information System" (ICMIS) , Central Laboratory for Agricultural Climate , and used to feed back and run DSSAT model . The model simulates crop response to climate change , management variables , soils and different levels of CO_2 in the atmosphere . The software used to run programs was developed by DSSAT and includes database management, crop models and application programs (Tsujj *et al.* 1998) . Potential changes in wheat morpho-physiological responses and yield were estimated by using the CERES-wheat model under different climates scenarios . The model simulates (water balance ,phenology and growth throughout the season) on a daily basis of the major climate factors (daily solar radiation maximum and minimum temperature and precipitation), soil and management (cultivars, plant data , plant population , row spacing and sowing depth) . Climate change scenarios for sit were created combining outputs of three equilibrium general circulation models (GISS , GFDL , UKMO) with daily climate data site (Rosenzweig and Iglesias, 1994).

Data presented in Table (2) Show the meteorological data, average temperature, evapotranspiration (ET), total solar radiation (W/m^2), wind speed (WS), total rainfall and relative humidity (RH) during the two growing seasons . These area are characterized by the low rainfall rate , which is not enough to face wheat crop water requirment . Under such conditions adding supplementry irrigation is very important to alleviate moisture stress specially at the end of the season . In this respect Oweis *et al.*, 1992 reported that in West Asia North Africa (WANA) region, amount of rainfall is low and generally poorly distributed, so periods of water deficit occur during the grain-filling stage of wheat almost every year . As a result, crop yield and water use efficiency (WUE) are generally low and variable.

RESULTS AND DISCUSSIONS

1. Growth characteristics:

Results preseneted in Table (3) showed that there were significant differences between wheat varieties in plant height, number of tillers, leaves area/plant and fresh weight characteristics at tillering stage. Where, Gemiza 7 variety surpassed significantly the others in plant height . While Sakha 61 variety had the higest significant value of the number of tillers/plant . Meantime, Giza 164 recorded the higest significant value of leaves area/plant . The highest value of fresh weight/plant were recorded by Sakha 61 and Giza 164 varieties compared with the others. On the other hand there were no significant differences among the varieties in the dry weight/plant.

Table (3): Growth characteristics of wheat varieties at tillering stage under rainfed and supplementry irrigation conditions (Combined data of 2000/01 and 2001/02 growing seasons)

Wheat Varieties	Plant height (cm)	No. Tillers/ plant	Leaves area/plant (cm^2)	Fresh Weight/ Plant (g)	Dry weight/ Plant (g)
Sakha 69	49.3 abc	1.1 bc	13.1 abc	4.17 ab	1.44 a
Sakha 8	49.3 abc	1.5b c	17.3 ab	6.06 ab	2.14 a
Sakha 93	42.9 cd	1.3b c	10.1 c	4.31 ab	1.44 a
Gemiza 9	49.3 abc	1.0 c	17.1 abc	5.18 ab	1.81 a
Giza 186	46.4 bcd	1.1 bc	12.4 abc	4.07 ab	1.39 a
Gemiza 7	55.3 a	1.0 c	15.6 abc	4.96 ab	1.39 a
Baneswif 1	40.7 d	1.0 c	10.3 bc	3.15 b	1.08 a
Sakha 61	43.6 cd	2.3 a	16.5 abc	7.01 a	2.46 a
Gemiza 5	48.6 abc	1.2 bc	13.5 abc	4.95 ab	1.63 a
Seds 1	53.1 ab	1.0 c	15.5 abc	5.53 ab	2.15 a
Giza 164	50.3 abc	1.6 b	18.9 a	6.58 a	2.15 a

Data in Table (4) show that, at booting stage, the eleven wheat varieties differed siginicantly only in plant heihgt and leaves area/plant characterestics. Where Sids1 surpassed significantly the other varieties in plant height . While Gemiza 7 produced the highest significant value of leaves area/plant. On the other hand, there were no significant differences between wheat varieties in the other growth characteristics tested at booting stage . Regarding this , Shalaby *et al.* 1993 and Abo-Warda , 1997 evaluated several wheat varieties and found that there were significant variations in growth characters among wheat genotypes

Table(4):Growth characteristics of wheat varieties at booting stage under rainfed and supplementry irrigation conditions(Combined data of 2000/01 and 2001/02 growing seasons) .

Wheat Varieties	Plant height (cm)	No. Tillers /plant	No. Leaves/ plant	Leaves area/plant (cm^2)	Fresh Weight/ Steams (g)	Dry weight/ steams (g)	Fresh Weight/blades (g)	Dry weight/ blades (g)
Sakha 69	61.4 abc	1.0 a	5.1 a	21.8 ab	2.25 a	0.79 a	2.06 a	0.47 a
Sakha 8	57.9 abc	1.5 a	7.0 a	19.2 bc	2.47 a	0.76 a	2.14 a	0.53 a
Sakha 93	54.5 abc	1.1 a	5.1 a	20.6 bc	1.95 a	0.76 a	2.27 a	0.44 a
Gemiza 9	51.3 bc	1.0 a	5.9 a	22.6 ab	1.78 a	0.69 a	2.20 a	0.53 a
Giza 186	58.4 abc	1.4 a	6.8 a	17.4 bc	2.33 a	0.81 a	1.78 a	0.49 a
Gemiza 7	67.4 ab	1.0 a	5.4 a	28.7 a	3.26 a	0.93 a	2.63 a	0.57 a
Baneswif1	49.9 c	1.6 a	5.8 a	13.4 c	1.88 a	0.67 a	1.42 a	0.50 a
Sakha 61	55.4 abc	1.2 a	5.6 a	16.9 bc	2.07 a	0.76 a	2.10 a	0.46 a
Gemiza 5	62.8 abc	1.1 a	4.9 a	23.3 ab	2.07 a	0.77 a	1.56 a	0.45 a
Seds 1	68.1 a	1.0 a	4.8 a	18.8 bc	1.81 a	0.72a	1.45 a	0.41 a
Giza 164	58.1 abc	1.4 a	7.3 a	24.6 ab	2.58 a	0.85 a	2.57 a	0.57 a

Data presented in Table (5) shwo the varietal differences in some morpho-physiological characteristics between wheat varieties at heading stage . The significant differencs between the eleven wheat varieties were only in the plant height, leaves area/plant and the days to heading. Where Seds1 and Gemiza 7 recorded the highest significant value of plant height character. Giza 164 and Gemiza 9 produced the highest significant value of leaves area/plant character compared with the other wheat varieties. Concerning the days to heading Sakha 8 was the latest variety followed by Sakha 69 and Gemiza 9 varieties. While Gemiza 7 was the earler variety followed by Gemiza 5 variety. On the other hand the differences between the eleven wheat varieties in the other growth characters tested at heading stage did not reach the significant at 5%. In this respect Stapper and Lilley, 2001 reported that differences of a few days in flowering can have a large effect on yield of dryland crops within and between sowing dates. Moreover, Abd EL-Gawad et al. (1998 b) found a clear genetic variation in the morpho-physiological traits of six wheat cultivars tested at heading stage under rainfed conditions. They added that such variation enable breeders to select the most suitable cultivar(s) for rainfed conditions.

Table (5): Growth characteristics of wheat varieties at heading stage under rainfed and supplementry irrigation conditions (Combined data of 2000/01 and 2001/02 growing seasons).

Wheat Varieties	Plant height (cm)	No. Tillers/plant	No. Leaves/plant	Leaves area/plant (cm^2)	Fresh Weigh/ Steams (g)	Dry weight/ steams (g)	Fresh Weight/blades (g)	Dry weight/ blades (g)	Days to heading
Sakha 69	78.3 ab	1.1 a	5.7 a	18.7 ab	3.90 a	1.29 a	1.16 a	0.66 a	93.0 b
Sakha 8	62.7 c	1.4 a	5.5 a	15.3 b	3.19 a	1.21 a	0.87 a	0.53 a	96.0 a
Sakha 93	72.6 abc	1.3 a	5.0 a	20.3 ab	3.61 a	1.21 a	1.31 a	0.61 a	88.0 d
Gemiza 9	63.5 c	1.1 a	5.9 a	26.5 a	3.16 a	1.29 a	2.45 a	0.86 a	91.7 bc
Giza 186	81.1 ab	1.3 a	5.3 a	20.2 ab	2.96 a	1.29 a	1.69 a	0.75 a	84.7 e
Gemiza 7	84.1 a	1.1a	5.5 a	25.4 ab	4.74 a	1.73 a	1.51 a	0.81 a	80.6 f
Baneswif 1	73.0 abc	1.3 a	5.9 a	19.1 ab	3.97 a	1.71 a	1.90 a	0.87 a	90.3 c
Sakha 61	67.1 bc	1.3 a	5.8 a	19.3 ab	3.23 a	1.36 a	1.32 a	0.72 a	83.0 e
Gemiza 5	79.1 ab	1.2 a	5.3 a	20.0 ab	3.35 a	1.28 a	1.51 a	0.71 a	81.0 f
Seds 1	83.3 a	1.1 a	5.6 a	24.8 ab	3.64 a	1.25 a	1.60 a	0.81 a	84.0 e
Giza 164	74.3 abc	1.3 a	6.7 a	27.9 a	3.71 a	1.47 a	2.43 a	0.91 a	83.3 e

Results presented in Table (6) show that the eleven wheat varieties differed significantly in all the morpho-physiological characteristics tested at milk-ripe stage. Where Sakha 69 variety recorded the highest significant value of plant height.

Table (6): Growth characteristics of wheat varieties at milk ripe stage under rainfed and supplementry irrigation conditions (Combined data of 2000/01 and 2001/02 growing seasons).

Wheat Varieties	Plant height (cm)	No. Tillers/ plant	No. Leave/ plant	Leaves area/ plant (cm^2)	Fresh Weight/ Steams (g)	Dry weight/ steams (g)	Fresh Weight /blades (g)	Dry weight/ blades (g)	Days to physio-logical maturity
Sakha69	102.8a	1.0 c	5.0 ef	14.8cde	3.62 ab	1.11 b	1.18 d	0.61 c	140.3 a
Sakha8	97.33ab	1.6 a	6.6 bc	10.1 e	4.62 ab	1.60 ab	1.96 bcd	0.80 abc	144.0 a
Sakha93	87.80cd	1.0 c	5.0 ef	34.8 a	3.65 ab	1.08 b	1.55 cd	0.76 bc	140.7 a
Gemiza9	97.00ab	1.3 abc	5.5 def	24.7 b	5.14 ab	1.49 ab	1.82 bcd	0.79 abc	141.7 a
Giza186	93.27bc	1.53 ab	7.1 ab	15.9 cde	4.79 ab	1.71 ab	2.36 abc	0.91 ab	135.7 b
Gemiza7	84.47de	1.26 abc	6.0 cde	16.5 cde	4.33 ab	1.66 ab	2.44 abc	0.90 ab	134.7 b
Baneswif1	81.00de	1.13 bc	4.8 f	12.6 de	3.363 b	1.32 ab	1.74 bcd	0.70 bc	128.7 c
Sakha61	76.67e	1.60 a	6.6 bc	15.4 cde	5.60 a	2.00 a	2.61 ab	1.00 a	128.0 c
Gemiza5	97.33ab	1.20 abc	6.4 bcd	19.2 bcd	3.45 ab	1.25 ab	2.48 abc	0.86 ab	129.3 c
Seds1	100.9ab	1.60 a	7.8 a	20.0 bc	5.38 ab	1.83 ab	2.97 a	1.03 a	131.0 c
Giza164	99.67ab	1.20 abc	5.33 ef	18.6 bcd	5.01 ab	1.52 ab	1.96 bcd	0.68 bc	140.3 a

Whereas, Sakha 61 variety had the lowest value . Concerning number of tillers/plant, Sakha 8 , Sakha 61 and Seds 1 recorded high significant values compared with the other varieties . While, Sakha 69 and Sakha 93 produced low significant values of number of tillers. Regarding number of leaves/plant character, Seds 1 produced the high significant value, while Baneswif 1 .ecorded the lower significant value . with respect of leaves area/plant character, Sakha 93 variety had the highest significant value followed by Gemiza 9 variety compared with the other wheat varieties . Whereas, Sakha 8 recorded the lowest significant value . Concerning fresh and dry weight of steam trait, data in Table (6) show that Sakha 61 surpassed significantly the other varieties . Meantime Seds1 produced the highest significant values of fresh and dry weight/blades . This may be due to the high number of tillers of Sakha 61 and Seds 1 compared with the other varieties. Results exhibited that the wheat varieties significantly differed in the days to physio-logical maturity, where Sakha 8, Gemiza 9, Giza 186, Sakha 69 and Giza 164 recorded longer period significant followed by Giza 186 and Gemiza 7. While Sakha 61, Baneswif 1, Gemiza 5 and Seds recorded the shorter significant values of days to physio-logical maturity . These differences in growth characteristics of the wheat cultivars at different growth stages can be attributed to their genetical background . In this respect, Whan *et al.* (1989) found that there were significant differences among wheat lines for tillers/m^2 , heads/m^2 and survival rate .

1. Yield and yield attributes:

Results presented in Table (7) show that the eleven wheat cultivars studied significantly differed in the yield and yield attributes except the number of grains/spike. The grain yield per hectare of Gemiza 7 cultivar followed by Giza 164 out-weighed significantly those of the other cultivars. Whereas , there were no significant difference between the other wheat cultivars in grain yield . The increase of grain yield of Gemiza 7 may be due to it's superiority in spike length, spike weight, grain weight and 1000 grain weight . Meantime the superiority of Giza 164 cultivar may be due to the root system of Giza genotypes as shown by Abd el-Gawad et al. (1985) . They pointed out that Giza 155 which has longer, bigger volume and dray weight for roots than Sakha 8 and Sakha 69 cultivars may enable it to grow well under high soil moisture stress conditions . In this respect, Entz and Fowler (1990), found that there was a differential response of winter wheat cultivars to the moisture stress . Moreover, Ghanem *et al.* (1994) reported that there were significant differences ($P<0.05$) between fourteen bread and durum wheat cultivars in grain yield under rainfed condition at the Northwest Coast of Egypt . The wheat varieties tested remarkably differed in the harvest index where Baneswif 1 cultivar recorded the highest value followed by Sakha 93 . Whereas the lowest value of the harvest index was recorded by Seds 1 cultivar . Under low rainfall (170 mm) condition at the same location Abd EL-Gawad et al. (1998 a) found that there were varietail differences between six wheat cultivars in yield and yield components . Moreover , Abd El-Ghany (1997) evaluated thirty four wheat genotypes including 5 commercial Egyptian varieties i.e Giza 163, 164, 157, Sakha 69 and Gemmieza 1. He found that genotypes markedly varied in yield and yield components. El-Kalla *et al.* (1994) under adding two supplemental irrigations in addition to the rainfall conditions with wheat varieties, i.e. Sakha 69, Gemmieza 1 and Giza 163 found that the tested wheat cultivars, showed significant variations in all the studied traits . They added that Gemmieza 1 surpassed the other two cultivars in most of the measured characteristics, while Sakha 69 gave the lowest means.

Table (7): Yield and yield attributes of some wheat varieties under rainfed and supplementry irrigation conditions (Combined data of 2000/01 and 2001/02 growing seasons).

Wheat Varieties	No. Spikes/m^2	Spike length (cm)	No. grains/ spike	Spike weight (g)	Grain weight/ spike (g)	1000-grain weight (g)	Biological yield ton/ha	Grain yield ton/ha	Harvest Index
Sakha 69	511.5 a	7.217 bc	25.12 a	1.427 bc	0.930 bc	37.67 ab	14.19 ab	3.787 ab	26.7
Sakha 8	405.8ab	9.320 ab	35.33 a	1.970 abc	1.303 abc	37.07 ab	11.51 ab	2.543 ab	22.1
Sakha 93	445.5 ab	9.457 ab	35.00 a	2.113 ab	1.220 abc	34.43 ab	9.573 ab	3.487 ab	36.4
Gemiza 9	360.6 b	9.170 ab	36.00 a	2.257 ab	1.530 ab	41.87 ab	14.97 ab	3.403 ab	22.7
Giza 186	410.8 ab	7.613 bc	25.78 a	1.067 - c	0.850 c	31.30 b	9.487 ab	3.120 ab	32.9
Gemiza 7	395.6 ab	11.54 a	35.47 a	2.597 a	1.603 a	45.17 a	15.25 a	3.933 a	25.8
Baneswif 1	454.1 ab	5.837 c	27.33 a	2.157 ab	1.267 abc	45.43 a	5.667 b	2.737 ab	48.3
Sakha 61	455.9 ab	8.963 b	30.35 a	1.980 abc	1.177 abc	37.93 ab	9.220 ab	3.007 ab	32.6
Gemiza 5	435.1 ab	7.800 bc	33.34 a	2.057 ab	1.373 abc	40.67 ab	9.087 ab	2.310 b	25.4
Seds 1	464.4 ab	9.060 ab	31.89 a	1.957 abc	1.097 abc	33.83 ab	12.29 ab	2.620 ab	21.3
Giza 164	409.4 ab	8.447 b	27.67 a	1.790 abc	1.013 abc	37.33 ab	15.94 a	3.853 a	24.2

2. Cimate change scenarios

Data presented in Table (8) show the current and the predicted (by the year 2040) of some climate parameters i.e. temperature (C°), precipitation (mm/day) and solar radiation in w/m^2. Selecting of the year 2040 was due to the doubled of CO_2 concentration at this year . This climate variability leads to very significant yield variability and this study also assesses the impact of such changes in variability on the agricultural producers.

Table (8): Temperature , precipitation and solar radiation for the current (CO_2 = 300ppm) and the expected change situation (CO_2 = 600 ppm) by the year 2040

Month	Temperature c°			Precipitation (mm/day)			Solar (w/m^2)		
	1xCO_2 0.03%	2xCO_2 0.06%	Ratio	1xCO_2 0.03%	2xCO_2 0.06%	Ratio	1xCO_2 0.03%	2xCO_2 0.06%	Ratio
January	11.9	14.8	24.37	0.7	0.5	28.57	155	159	2.58
February	13.1	17.9	36.64	0.5	0.4	20.00	198	199	0.51
March	17.2	21	22.08	0.9	0.7	22.22	259	262	1.16
April	21.5	26.9	25.12	0.3	0.2	33.33	318	315	0.94
May	26.3	32.3	22.81	0.2	0.4	100.0	341	338	0.88
June	32	35.9	12.19	0.2	0.5	150.0	350	341	2.57
July	33.8	37.5	10.95	0.3	1.2	300.0	346	327	5.49
August	33.7	35.8	6.23	0.3	1.9	533.33	317	302	4.73
September	29.2	33.5	14.73	0.8	1.2	50.0	275	268	2.55
October	23.2	26.9	15.95	0.9	1.1	22.22	222	222	0
November	16.2	21.3	31.48	0.5	0.5	0.0	175	174	0.57
December	12.7	16.9	33.07	0.5	0.9	80.0	151	146	3.31

This is done by identifying risk management strategies for producers to enable decision-makers to deal successfully with the new and different risk parameters. Results revealed that temperature will be increased, the increasing in temperature will be in the range of about 2-5 C° during different months of the year. While the opposite trend will be remarkable regarding precipitation except for few months i.e. September, October and December. Regarding solar radiation, a slight difference between the present status and the predicted by the year 2040 .

Effect of the climate change by the year 2040 on the grain yield of some wheat cultivars under rainfed conditions

The measured and the simulated grain yield of the wheat cultivars are shown in Table (9) Results showed that there was a little difference in the grain yield between the eleven wheat cultivars . The simulated grain yield increased compared with the measured grain yield and ranged from 0.81% by Gemiza 5 to 2.23% by Sakha 8 cultivar . In this respect, Stapper and Lilley 2001, reported that in days to anthesis simulation with SIMTAG for 15 genotypes varied between 3 2 and 11.5 days for all data and between 2 0 and 5.7 days for only standard sowings.

Table (9): Measured and simulated grain yield of the wheat varieties .

Wheat cultivar	Grain yield		
	Measured Kg/ha	Simulated Kg/ha	Overall increasing as %
Sakha 69	3.787	3.866	2.09
Sakha 8	2 543	2 687	2 23
Sakha 93	3.487	3.560	2.10
Gemiza 9	3.403	3 431	0.83
Giza 186	3 120	3.171	1.62
Gemiza 7	3.933	3.971	0.96
Baneswif 1	2.737	2.780	1.20
Sakha 61	3 007	3 030	0.78
Gemiza 5	2.310	2.329	0.81
Seds 1	2 620	2 648	1.06
Giza 164	3 853	3 925	1.88

Validation of DSSAT program shown is in Table (10) . The potential impact of climate change in wheat production was evaluated by simulating wheat cultivars production under climate change by the year 2040 compared to that simulated under current conditions. Grain yield of wheat genotypes differed in response to climate change. The general trend is that the predicted grain yield in year 2040 will be increase more than the current yield simulated from 5% to 20.2% according to wheat variety . Results obtained showed that Sakha 93 cultivar had the highest overall grain yield increase (20.2%) followed by Sakha 69 and Seds 1 cultivars (18.4% and 16.3% respectivily) . On the other hand Gemiza 7 cultivar had the lowest value (5.0%) followed by Baneswif 1 and Gemiza 5 cultivars (6.5% and 6.6%). These results indicate that Sakha 93 cultivar has the major opportunity in the grain yield increase when the climate change by the year 2040 . The increase of the predicted grain yield may be due to the positive effect of duplication in CO_2 and it's effect on the wheat crop as a C3 plant . Craufurd *et al* 2001 pointed out that the increase in mean seasonal temperatures of 2-4°C expected towards the end of the next century will greatly modify the global production of annual crops. Within temperate regions, annual crops will mature earlier, and yields are expected to decline in response to warmer temperatures. Nevertheless, studies of the impact of these warmer temperatures when combined with elevated concentrations of CO_2 usually predict that these negative effects of warmer temperatures on crop yield are approximately balanced by the increased rate of growth at elevated CO_2 concentration.

Table (10): Effect of the climate change by the year 2040 on the grain yield of some wheat cultivars under rainfed and supplementary irrigation conditions .

Wheat cultivar	Grain yield		
	Simulated 1xCO_2 (Kg/ha)	Prediction by the year 2040 2xCO_2 (Kg/ha)	The overall increase as %
Sakha 69	3.866	4.964	18.4
Sakha 8	2.687	3.267	11.6
Sakha 93	3.560	4.635	20.2
Gemiza 9	3.431	4.073	8.7
Giza 186	3.171	3.808	10.1
Gemiza 7	3.971	4.567	5.0
Baneswif 1	2.780	3.239	6.5
Sakha 61	3.030	3.709	12.4
Gemiza 5	2.329	2.716	6.6
Seds 1	2.648	3.344	16.3
Giza 164	3.925	4.663	8.8

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برنامج نظم دعم القرار الزراعي (DSSAT) و التنبّؤ بإنتاجية القمح تحت الظروف المطرية والري التكميلي

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تهدف هذه الدراسة إلى الوقوف علي أداء بعض أصناف القمح تحت الظروف المطرية والري التكميلي ومدي إمكانية استخدام أحد برامج التنبؤ (برنامج نظم دعم القرار الزراعي DSSAT) بإنتاج المحاصيل خاصة القمح عند حدوث تغيرات مناخية متوقعة في السنوات القادمة . تم إجراء تجربة حقلية خلال موسمين متتالين ٢٠٠٠/٢٠٠١ ، ٢٠٠١/٢٠٠٢ بمحطة بحوث مريوط بالساحل الشمالي الغربي وذلك بزراعة إحدى عشر صنف من أصناف القمح تحت الظروف المطرية والري التكميلي . كما تم إجراء الدراسات الخاصة ببرنامج التنبؤ باستخدام البيانات المتحصل عليها . ويمكن تلخيص أهم النتائج فيما يلي :

- وجد أن هناك اختلافات معنوية بين أصناف القمح في بعض صفات النمو خلال مراحل النمو (التفريع – الإخصاب – طرد السنابل) بينما في المرحلة المتأخرة للنمو (الطور اللبني) اختلفت الأصناف فيما بينها اختلافا معنويا في كل صفات النمو المدروسة تحت الظروف المطرية والري التكميلي
- أظهرت النتائج أن هناك اختلاف معنوي بين أصناف القمح في المحصول ومكوناته حيث تفوق الصنف جميزة ٧ تفوق معنوي في صفة محصول الحبوب علي باقي الأصناف تلاه الصنف جيزة ١٦٤ في كمية المحصول . بينما لم يكن هناك اختلاف معنوي بين بقية الأصناف في صفة محصول الحبوب . كما ابدي الصنف جميزة ٧ تفوقا معنويا في صفات طول السنبلة ووزن السنبلة ووزن الألف حبة .
- توضح التغيرات المناخية المتوقعة في عام ٢٠٤٠ والتي يتضاعف عندها تركيز ك ا٢ سوف يكون لها تأثير علي إنتاجية محصول القمح تحت الظروف المطرية والري التكميلي بمنطقة الدراسة . وتظهر نتائج التنبؤ باستخدام برنامج نظم دعم القرار الزراعي أن هناك زيادة تراوحت من ٥% –٢٠,٢% في محصول الحبوب تبعا لصنف القمح مقارنة بالمحصول الحالي والذي قد يرجع إلى التأثير الموجب لزيادة تركيز ك ا٢ علي محصول القمح كأحد المحاصيل ثلاثية الكربون .
- تفوق الصنف سخا ٩٣ في محصول الحبوب عند التغير في الظروف المناخية المتوقعة في عام ٢٠٤٠ يليه صنفي سخا ٦٩ و سدس ١ علي التوالي . بينما كان الصنف جميزه ٧ اقل الأصناف استجابة لتلك التغيرات المناخية يليه صنفي بني سويف ١ وجميزه ٥ .