Cropsyst Simulation and Response of Some Wheat Cultivars to Late Season Drought

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Abstract: *Drought has a significant impact on crop growth and production, especially wheat as one of the world major crops. The objectives of this study were to assess the impact of different irrigation treatments on wheat grain yield and calibrate CropSyst model to simulate wheat under normal and deficit irrigation. The field experiment was carried out during 2010/2011 wheat growing season at El-Beheira, Egypt. Two irrigation treatments were applied: normal (full irrigation) and deficit (late season drought). Results indicated that, the deficit irrigation has a trivial impact on anthesis, while it is significant for both physiological maturity days and their corresponding Growing Degree Days (GDD) for all wheat cultivars. Under the deficit irrigation conditions, the greatest reductions in wheat grain yield were recorded for Sakhs93, Sakha61, and Sakha94 by 63.85, 56.14, and 50.84 % respectively. While, the lowest reductions in wheat grain yield were observed for Gemmiza9, Gemmiza7, Sids1, Gemmiza10 and Giza168 with 37.73, 33.12, 30.55, 26.56 and 24.40 % respectively. It is obvious that, the last cultivars are more tolerant to water deficit than Sakha cultivars. Henceforth, it is highly recommended undergoes to further studies to spread its cultivation under water scarcity conditions. The calibration of CropSyst revealed that, the Model Percentage Error ranged from -0.139 to 0.222 % and 0.282 to 0.068% for normal and deficit irrigation respectively. As well as, the values of Normalized Root Mean Square Error and Normalized Mean Bias were 0.030-0.192 %, and 0.147-0.104 % respectively. Also, the results prove that, the CropSyst gives a reasonable prediction for wheat grain yields under normal and deficit irrigation; it still needs further investigations to be used under current and future conditions in Egypt.*
Keywords: *Normal and deficit irrigations, late-season drought, CropSyst model, wheat cultivars, growing degree-days.*

Riassunto: *La siccità ha un impatto significativo sulla crescita e la produzione delle colture e in particolare sul frumento, una delle principali colture a livello globale. Lo studio ha avuto il duplice obiettivo di valutare l'impatto di diversi trattamenti irrigui sulla resa in granella del frumento e di calibrare il modello CropSyst per la simulazione della produzione in regime di irrigazione completa e deficitaria. L'esperimento è stato condotto durante la stagione 2010/2011 a El-Beheira, in Egitto. Sono stati applicati due trattamenti di irrigazione: normale (irrigazione completa) e deficitaria (simulando una condizione di siccità a fine stagione). I risultati hanno indicato che l'irrigazione deficitaria non ha influenza sull'antesi, mentre ha un impatto significativo sia sul raggiungimento della maturità fisiologica sua sulla corrispondente sommatoria termica (GDD) per tutte le cultivar studiate. In condizioni di irrigazione deficitaria le maggiori riduzioni di resa sono state osservate per Sakhs93, Sakha61 e Sakha94, rispettivamente di 63.85, 56.14 e 50.84%. La minore riduzione è stata invece osservata per Gemmiza9, Gemmiza7, Sids1, Gemmiza10 e Giza168 con un calo del 37.73, 33.12, 30.55, 26.56 e 24.40%, rispettivamente. Sembra chiaro, quindi, che queste ultime cultivar sono più tolleranti al deficit idrico rispetto alle cultivar Sakha. Per questo motivo sarebbe opportuno condurre ulteriori ricerche allo scopo di incrementare l'adozione di tali cultivar in condizioni di scarsità idrica. La calibrazione di CropSyst ha rivelato un errore percentuale del modello tra -0.139 e 0.222% nel caso de l'irrigazione normale, e tra 0.282 e 0.068% nel caso di quella deficitaria. Inoltre, i valori dell'errore quadratico medio normalizzato e del Bias medio normalizzato sono stati rispettivamente 0,030-0,192% e 0,147-0,104%. I risultati dimostrano che il modello CropSyst fornisce una stima ragionevole della resa del frumento, ciononostante ulteriori studi sono auspicabili al fine di poterlo applicare al meglio sia in condizioni climatiche attuali che future in Egitto.*
Parole chiave: *Irrigazione ottimale e deficitaria, siccità di fine stagione, modello CropSyst, cultivar di frumento, sommatorie termiche.*

1. INTRODUCTION

Climate change is observed in the last decades without any doubt, and it is an ongoing process in the 21st century, causing changes in the hydrological cycle by affecting precipitation and evaporation (IPCC, 2013). One of the largest climate change impacts is expected to be on agriculture sector (Piao *et al.*, 2010; Wang *et al.*, 2013; Barros *et al.*, 2014), because its indirect impacts on freshwater resources and availability. In recent years, droughts and water scarcity problems are considered as a limiting factor for agricultural production (Zhang *et al.*, 2015). In addition, drought is a most damaging and widespread climate index that negatively affecting agricultural production, ecosystem function, water resources, and human lives around the globe (Dai, 2011).

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In addition to the potential impact of climate change, also the biological variables, such as the lengths of the crop growth periods and the crop cycle, play and have an important and vital role on crop production. Around the world, agriculture is challenged with an increased frequency of drought periods and reduction of available water, which stagnates and decreases the crop yields (Becker and Schmidhalter, 2017). As well as, 72% of available global fresh water is consumed by agriculture (Geerts and Raes, 2009; Andarzian *et al.*, 2011). In addition, water deficit limits crop growth and yield more than any other environmental stress (Zhu 2002; Wang *et al.*, 2003), especially in arid and semi-arid regions like Egypt. Water stress is the most common environmental stress affecting about 32% of the cultivated wheat in the developing countries (Rajaram, 2000). Drought affects wheat grain yield through shortening most wheat growth stages (Dadbakhsh and YazdanSepas, 2011) and the early grain development stage is more vulnerable to water stress than latter grain development stage (El-Kholy *et al.*, 2005). Where, decreased number of irrigation or increased moisture stress showed accelerated the grain filling rate (GFR) and hastened the grain filling duration (GFD) of bread wheat (Ejaz *et al.*, 2007) and Shortening phenological phases (Roohul *et al.*, 2012). In the same time, it affected the plant water status during the spike formation and flowering stages, resulting in reduced grain yield by 37% and straw yield by 18% (Katerji *et al.*, 2009).

Due to the world increase in population, the world agricultural products and fresh water demand increases every year (Tilman *et al.*, 2011; Godfray, 2014) and it has become a necessity for an increase in food and water production (Kale, 2016). Many studies showed that, one of the encouraging irrigation strategies to increase water productivity might be deficit irrigation (Kipkorir, 2002; Debaek and Aboudrare, 2004; Fereres and Soriano, 2007; Ali and Talukder, 2008; Farre and Faci, 2009; Behera and Panda, 2009; Blum, 2009; Geerts and Raes, 2009; Noreldin *et al.*, 2015). Where, adopting deficit irrigation treatment implies the acceptance of a certain level of reduction in yield level (Hamdy *et al.*, 2005).

In the Mediterranean region, where water resources are limited, the irrigation management must be optimized to maximize economic water use efficiency and reduce waste (Bouazzama *et al.*, 2017). In addition, the irrigation under limited water supply decreases photosynthesis, claws, leaf area, biomass, number of grain per an ear, thousand-kernel weight and grain yield (Zubaer *et al.*, 2007). Egypt as one of these countries is not far from the previous problems as its agriculture sector mainly depends on irrigation system. Since 85% of total available water in Egypt is consumed in agriculture and it should be adequately applied to crops to avoid water waste (Noreldin *et al.*, 2015). In addition, the rainfall provides only 30% of crop water requirements for winter wheat, while the rest 70% comes from irrigation water (Ouda, 2016).

Wheat (*Triticum aestivum L.*) is one of the most world extensive cultivated cereals that is often under abiotic stress (Cossani and Reynolds, 2012) and has a critical role in the world food supplies (Shiferaw *et al.*, 2013), as well as in Egypt.

The investigation of crop response to different irrigation treatments and its optimal time in the field and carried out experiments on different crop management practices is costly, time consuming and laborious (Sen *et al.*, 2017). Where, the irrigation scheduling significantly change depending on sowing date, nitrogen fertilization, and the irrigation system in use (Bouazzama *et al.*, 2017).

The crop simulation models (CSMs) are considering this kind of limitations and represent an effective tool in agricultural research, especially in the decision support systems. It evaluate the effects of water deficits on crop productions, and optimizing the irrigation with the available limited water (Boote *et al.*, 1996; Zairi *et al.*, 2000; Kipkorir *et al.*, 2001; Lobell and Ortiz-Monasterio, 2006; Benli *et al.*, 2007; Heng *et al.*, 2007; Lorite *et al.*, 2007; Pereira *et al.*, 2009; Blum, 2009; Qi *et al.*, 2013). These crop models are offered to investigate the multiple interactions between soil, climate, genotype and crop management (Rizzo *et al.*, 1992), as well as to examining different management scenarios (Zare *et al.*, 2014) and their impact on crop growth and productivity (Lenka and Singh, 2011).

One of the most important CSMs at present that can be used in this regard is CropSyst model (Stöckle *et al.*, 2003; 2014). CropSyst model has validated and widely applied to simulate cereals under different cropping systems (Confalonieri *et al.*, 2004; Wang *et al.*, 2006; Benli *et al.*, 2007; and Singh *et al.*, 2008). CropSyst model was largely used to simulate wheat yield (Pannkuk *et al.*, 1998; Wang *et al.*, 2006; Moriondo *et al.*, 2007; Singh *et al.*, 2008). Under Egyptian conditions, many Egyptian scholars have used the model to simulate wheat yield (Khalil *et al.*, 2009; Ouda *et al.*, 2010; Ouda *et al.*, 2012; Taha, 2012; Ibrahim *et al.*, 2012; Abdrabbo *et al.*, 2013;

Fertilizer Type	Fertilizer Amount (kg / fed)	Date of Application
Mono-super phosphate (15.5% P_2O_5)	22.5	22/11/2010 Before sowing
Potassium sulfate (48% K_2O)	24	22/11/2010 Before sowing
Ammonium sulfate (20.5% N)	20	22/11/2010 Before sowing
	40	23/11/2010 With first irrigation
	40	21/12/2010 With second irrigation

One hectare (ha) = 2.4 feddan (fed)

Tab. 1 - Fertilizer Type, its amount (kg/fed), and the date of application.
Tab. 1 - Tipo di fertilizzante, quantità (kg/fed) e data di somministrazione. 1 ettaro (ha) = 2,4 feddan (fed).

Morsy, 2015; Ouda *et al.*, 2015a). These researches reported that the CropSyst model performed fairly well in wheat biomass production and grain yield simulation. CropSyst model is a perfect sample of simulation model that ever used in the world and one of its significant features is that it can connect to GIS software (Zare *et al.*, 2014). Consequently, the CropSyst model can assist in determining the expected wheat yield losses due to reducing number of applied irrigations.

The present study aims to:
Study the effects of different water irrigation treatments on different wheat cultivars growth stages and the grain yield.
Simulate wheat yield in response to different irrigation supplemental treatments using CropSyst model.

2. MATERIAL AND METHODS

2.1 Field Experiment

The field experiment was carried out at El-Bostan experimental farm with latitude 30.723 °N, longitude 30.279 °E, and elevation 7 meter above sea level. It belongs to Faculty of Agriculture, Damanhour University, Egypt. El-Bostan region is a newly reclaimed area and recently became an important agricultural region in El-Beheira Governorate. The length of the growing season was 149 days with sowing and harvesting dates 23/11/2010 and 20/04/2011 respectively. This region is characterized by average daily maximum, minimum, and mean temperatures 22, 15, and 18.5 ºC respectively, during the experimental season. All agronomy practices, except irrigation, were applied as recommended by agronomists for the experimentation site which shown in (Tab. 1).
The experiment included eight wheat cultivars and its identification and pedigree, as shown in (Tab. 2).
Two different irrigation treatments were applied on the studied wheat cultivars as follow:

a) Normal irrigation, and
b) Withholding irrigation from tillering until full maturity (late season water stress; deficit irrigation).

This experimental was carried out in a split-block system, with four replicates (blocks) for each irrigation treatment, where the average of these four repetitions is calculated and used in this study to obtain on more accurate results. These blocks

ID No.	Name	Pedigree
1	Sakha93	Sakha 92 / TR 810328.
2	Sakha61	Inia / RL4220//7C / Y R"S".
3	Sakha94	Opata / Rayon // Kauz.
4	Gemmeiza9	ALd"S"/Huac"S"//CMH74A. 630/5X.
5	Gemmeiza7	CMH 74 A. 630 /5X // Seri 82 / 3/ Agent.
6	Sids1	HD 2172/ pavon "S" //1158.57/Maya 74 " S".
7	Gemmeiza10	Maya47"S"/On//1160-147/3/Bb/GLL/4/CHAT"S"/5/CROW "S".
8	Giza168	Mil /Buc // Seri.

Tab. 2 - Identification and pedigree of the studied eight-bread wheat.
Tab. 2 - Identificazione e pedigree delle otto cultivar di frumento tenero studiate.

Soil properties	Value
Sand %	92.05
Clay %	4.06
Silt %	3.89
pH (1:2.5, soil : water)	8.15
EC (1:2) dS/m	1.38
Total CO3 %	3.77
Organic matter- C %	0.652
Available nitrogen (µg/g soil)	49.35
Available potassium (µg/g soil)	101
Available phosphorus (µg/g soil)	4.95

Tab. 3 - Soil analysis of El-Bostan experimental site at an average of soil depth 0-60 cm.
Tab. 3 - Caratteristiche del suolo del sito sperimentale di El-Bostan alla profondità di 0-60 cm.

were split into sub blocks; each one consists of six rows with 2-meters long and 30 cm spacing, with seeding rate of 65 kg/Feddan (about 1.038 acres). Each type of wheat was planted within a randomly selected sub-block.
The soil of the site experimentation is characterized by sandy loam with little bit of clay and silt. Soil samples have been collected and analyzed for different locations at an average of soil depth 0-60 cm through the site. Physical and chemical properties of these samples are shown in (Tab. 3). As well as, the applied irrigation treatments are shown in (Tab. 4).

2.2 Weather data

Daily weather data (solar radiation, maximum and minimum temperature, and precipitation) for the study location were used, as one of the CropSyst model simulation requirements for the growing season. These data were collected from NASA Prediction of Worldwide Energy Resources (POWER) project for agro-climatology, with horizontal resolution 1° latitude by 1° longitude (https://power.larc.nasa.gov/cgi-bin/agro.cgi?na).

2.3 CropSyst calibration

The required input weather, soil, crop and management files to run the CropSyst model for wheat simulation were prepared in its compatible format. Some crop parameters input were taken either from the experimental observation (soil properties: description, texture, and hydraulic; spring wheat crop variety and management parameters: growth coefficients, phenology, harvest index and irrigation) or from the CropSyst manual (Stöckle and Nelson, 2000) (other spring wheat crop variety and management parameters: morphology, vernalization, baseline and elevated references atmospheric CO_2 concentration and residue management). For model calibration purpose, the aboveground biomass-transpiration coefficient (kPa kg/m^3) and light to aboveground biomass conversion (g/MJ) parameters were adjusted in the model, to reflect reasonable simulation. To investigate the goodness of fit between the measured and simulated wheat cultivars, different statistical calculations executed (Model Percentage Error (MPE) (Ouda *et al.*, 2015a), Root Mean Square Error (RMSE) and its Normalized (NRMSE %) (Jamieson *et al.*, 1998), and Mean Bias (MBE) (Singh *et al.*, 2013) and its Normalized (NMBE %) (Sayad *et al.*, 2015)). These statistical calculations give a good overall measure of model performance, indicate the model absolute fit to the observed data, and estimate the degree of correspondence between the mean prediction and the mean observation. These statistical equations used in this study represented as follow:

$$\mathrm{MPE} = \frac{X_p - X_o}{X_o} * 100 \qquad (1)$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(X_p - X_o)^2}{n}} \qquad (2)$$

$$NRMSE\% = \frac{RMSE}{\bar{X}_o} * 100 \qquad (3)$$

No. of days from sowing to irrigation	Irrigation No.	Date	Normal irrigation	Late water stress
At sowing	1st	23/11/2010	√	√
29	2nd	21/12/2010	√	√
56	Rain event	17/01/2011	√	√
66	3rd	27/02/2011	√	X
99	4th	01/03/2011	√	X
123	5th	25/03/2011	√	X

√ and X = applied and not applied irrigations respectively.

Tab. 4 - Number and dates of irrigation treatments during the growing season.
Tab. 4 - Numero e date dei trattamenti irrigui effettuati durante la stagione.

$$MBE = \frac{\sum_{i=1}^{n}(X_p - X_o)}{n} \quad (4)$$

$$NMBE\% = \frac{MB}{\bar{X}_o} * 100 \quad (5)$$

Where X_o and X_p represent the observed and simulated values, n represents the number of observations used in comparison and $\overline{X}_o$ is the observed average.

3. RESULTS AND DISCUSSION

3.1 Wheat productivity under different irrigation treatments

Tab. 5 represents the observations of different crop parameters that measured during the field experiment. These were days to anthesis (flowering), days to physiological maturity, and wheat productivity (ton/ha) for each cultivar under the two applied irrigation treatments. In addition to, the Growing Degree Days (GDD) in degree centigrade from planting to anthesis and to physiological maturity for each wheat cultivar are calculated and presented in (Tab. 5) too. Where, GDD is calculated from accumulation of daily average temperature minus base temperature (3 °C for wheat) for each crop growth stage from planting until maturity. GDD can be regarded as an index relates the development of crop with air temperature. In addition, the GDD is an indication of the length of growing season that indirectly reflected on the final yield.

It is obvious from (Tab. 5) that, there are significant differences in days to anthesis, days to physiological maturity, GDD and grain yield for each wheat cultivar under deficit than normal irrigation treatment. Where the difference in days to anthesis for whole cultivars was one or two days and their corresponding GDD were ranged between 11 to 26.7 °C. These differences are small because of the wheat under normal treatment took one more irrigation than the one under deficit. Therefore, this trivial decrease in the anthesis days or GDD would not have a significant impact on the final grain yield. While, the maximum effect appears in the decreased physiological maturity days that ranges from 7 to 15 days with corresponding GDD of 113 to 253 °C. This decrement in the maturity days or its GDD led the wheat grain yields decrease

Crop parameter	Irrigation treatments	Wheat Cultivar (ID)							
		1	2	3	4	5	6	7	8
Days to anthesis	Normal (N)	81	77	85	85	79	85	86	81
	Deficit (D)	79	75	84	83	78	83	84	79
Difference (D-N)		-2	-2	-1	-2	-1	-2	-2	-2
GDD to Anthesis (°C)	Normal (N)	1119	1025	1071	1119	1049	1119	1131	1071
	Deficit (D)	1092	999	1049	1105	1038	1092	1105	1049
Difference (D-N)		-27	-26	-22	-14	-11	-27	-26	-22
Days to maturity	Normal (N)	137	129	136	140	131	139	139	136
	Deficit (D)	122	122	126	128	124	124	126	125
Difference (D-N)		-15	-7	-10	-12	-7	-15	-13	-11
GDD to maturity (°C)	Normal (N)	1912	1743	1877	1860	1783	1931	1912	1860
	Deficit (D)	1659	1630	1630	1690	1659	1724	1690	1674
Difference (D-N)		-253	-113	-247	-170	-124	-207	-222	-186
Grain yield (ton/ha)	Normal (N)	7.11	5.54	6.51	8.72	7.79	7.66	8.36	8.32
	Deficit (D)	2.57	2.43	3.2	5.43	5.21	5.32	6.14	6.29
Difference (D-N)		-4.54	-3.11	-3.31	-3.29	-2.58	-2.34	-2.22	-2.03
* Normalized Difference (%)		-63.85	-56.14	-50.84	-37.73	-33.12	-30.55	-26.56	-24.40

* ((D-N)/N)*100

Tab. 5 - Days to anthesis, physiological maturity, corresponding GDD (°C), wheat productivity (ton/ha) and their differences for each wheat cultivar under the two applied irrigation treatments.
Tab. 5 - Numero di giorni e relativa sommatoria termica (°C) per il raggiungimento delle fasi di antesi e di maturità fisiologica, produttività (ton/ha) e loro differenze per ciascuna cultivar e per ciascun trattamento irriguo.

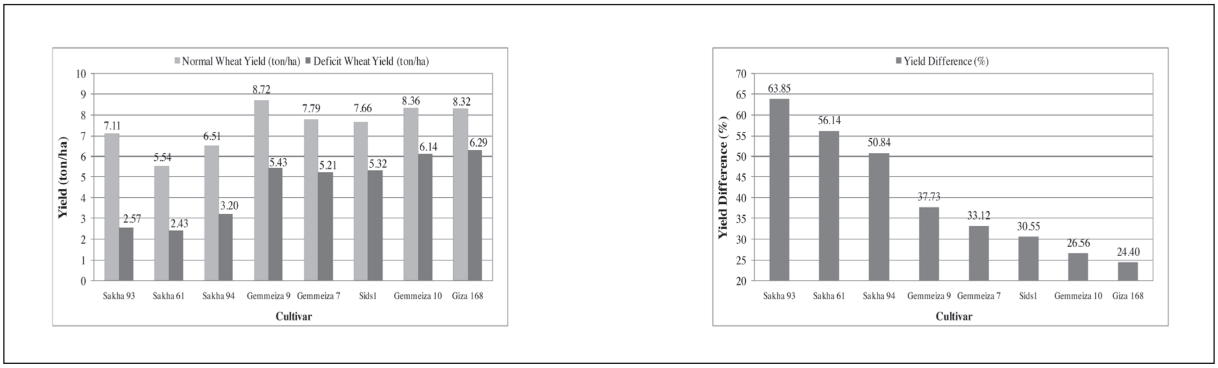

Fig. 1 - Grain yield (ton/ha) to the left and their differences (%) to the right under the normal and deficit irrigation.
Fig. 1 - Produzione di granella (ton/ha) a sinistra e differenza (%) a destra in condizioni di irrigazione normale e deficitaria.

between 2.03 (ton/ha) and 4.54 (ton/ha) with ratios 24.4% and 63.85% respectively. These decreases might be because of the variability of each cultivar to resist heat and water stress.

The wheat cultivars grain yield and their differences under the normal and deficit irrigation are shown in (Fig. 1). It is noticed from (Fig. 1) and (Tab. 5) that, Sakhs93, Sakha61, and Sakha94 cultivars have the highest decrement in grain yield with percentages 63.85, 56.14, and 50.84 respectively under the deficit than normal irrigation. As well as, Sakha cultivars already have a small grain yields under normal conditions. It can be deduced that, Sakha is not resistant to water and environmental stress, i.e. it is not recommended to be cultivated under the water scarcity conditions. While, the percentage decrement of grain yield due deficit irrigation for Gemmiza9, Gemmiza7, Sids1, Gemmiza10, and Giza168 were 37.73, 33.12, 30.55, 26.56, and 24.40 respectively. Therefore, these cultivars are recommended to be cultivated under the water scarcity conditions.

3.2 CropSyst simulation under normal and deficit irrigation

CropSyst model is used to simulate the wheat cultivars at El-Bostan experimental farm. In addition, the selected two irrigation treatments were applied during the simulation. Furthermore,

Wheat Cultivar (ID)	Irrigation Treatments	Yield (Ton/ha)		MPE (%)	NRMSE (%)	NMBE (%)
		Measured	Predicted			
1	Normal	7.110	7.100	-0.139	0.158	-0.147
	Deficit	2.570	2.566	-0.167		
2	Normal	5.540	5.538	-0.030	0.125	-0.107
	Deficit	2.430	2.423	-0.282		
3	Normal	6.510	6.508	-0.029	0.030	-0.029
	Deficit	3.200	3.199	-0.028		
4	Normal	8.720	8.714	-0.068	0.069	-0.016
	Deficit	5.430	5.434	0.068		
5	Normal	7.790	7.807	0.222	0.192	0.104
	Deficit	5.210	5.206	-0.072		
6	Normal	7.660	7.659	-0.007	0.040	0.024
	Deficit	5.320	5.324	0.068		
7	Normal	8.360	8.355	-0.065	0.066	-0.010
	Deficit	6.140	6.144	0.065		
8	Normal	8.320	8.313	-0.087	0.086	-0.084
	Deficit	6.290	6.285	-0.082		

Tab. 6 - Measured and predicted wheat grain yield (ton/ha) under normal and deficit irrigation.
Tab. 6 - resa in granella misurata e simulata (ton/ha) nei trattamenti di irrigazione ottimale e deficitaria.

the simulated wheat cultivars yield was compared with the experimental yield, to investigate the performance of CropSyst model. The MPE, NRMSE, and NMBE between measured and predicted grain yield for wheat cultivars are shown in (Tab. 6).

From (Tab. 6) one may notice that, the MPE ranged from -0.139 to 0.222 % and -0.282 to 0.068% for normal and deficit irrigation treatments respectively. In addition, NRMSE and NMBE were between 0.030 to 0.192 % and -0.147 to 0.104 %. These statistical comparisons gave very small differences between the measured and simulated wheat grain yield using the CropSyst model. Henceforth, it proves a high performance in wheat yield prediction under normal and deficit irrigation conditions with good fit and reasonable results.

Furthermore, the obtained statistical results reveal that the model was successful to reflect the effect of different irrigation treatments on wheat cultivars grain yield. The selected crop parameters from the CropSyst manual are adjusted to obtain a considerable relationship between observed and simulated wheat grain yield. The CropSyst simulation for wheat grain yield was in a good compatibility and agreement with some previous studies (e.g., Ouda *et al.*, 2015b; Noreldin *et al.*, 2016). Where, their results indicated that the model gives a good fit and reasonable wheat simulation under different irrigation treatments. In this study, through the selected field experiment at El-Bostan region, the CropSyst model simulated the selected wheat cultivars grain yield with a significant MPE, NRMSE, and NMBE; but it needs further testing to prove its capability in wheat prediction under current and future conditions in Egypt.

4. CONCLUSIONS

The effect of deficit irrigation (late season water stress) does not have a big effect on the anthesis days and its GDD, but lead to a significant decrement in the required days to physiological maturity and corresponding GDD for all cultivars and consequently the wheat grain yield. These decreases might be because of each cultivar has its resistance to heat and water stress. Sakha cultivars have small grain yield under normal conditions and decreased over 50% under deficit irrigation. While, under deficit irrigation decrement in other cultivars is less 38% than normal one. It may conclude that, the other cultivars could be cultivated under the water scarcity conditions than Sakha.

The CropSyst model is an important tool in agricultural research, to investigate different assumptions before taking cultivation decisions for specific agricultural sites. This will save a lot of time, money, and effort. In addition, the smallest values of MPE, NRMSE, and NMBE between the measured and simulated wheat grain yield, as an initial model testing, proved its capability to be used in wheat grain yield prediction under different irrigation treatments. Therefore, one may conclude that the model needs further investigations for wheat prediction under current and future conditions in Egypt.

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