Using of crop modelling to predict wheat productivity in Egypt

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***Abstract*—Two different location vary widely in its environments (El-Busily and West Delta –El Husain farm, Egypt) were chosen to conduct field experiments in 2009/2010 and 2010/2011 in each to study the effect of water irrigation quantity, compost rates, cultivars and interaction between them on yield and yield components of wheat as well as evaluate the degree of the coincided between the observed data from the previous field experiments for each location and the predicted data which get from DSSAT v.4.5 – CERES – wheat model under the condition of the same treatments.**

The observed results of the combined analysis for the two seasons revealed that, No. spikes/m2, 1000 - grain weight, grain yield /fed., harvest index and biological yield (fed) were increased gradually by increasing the quantity of water irrigation from 60 to 70 or 90% of ET. The results of the previous measurements toke the same direction by increasing the compost rate from 2 to 4 or 6 ton/fed. Gemmeiza-9 wheat variety exceeded Sakha-93 significantly on all above mention traits. Irrigating Gemmeiza-9 wheat plants at the level of 90% of ET and fertilized by 6 (ton/fed) gave the greatest values for all traits studied as compared with the other treatments and the difference reached to the significant level.

Results of RMSE and D-state revealed that CERES-wheat model is able to predict with high accuracy all the values of studied traits as affected by the single effect of each treatment under tasting in the two different locations. DSSAT–CERES wheat model exposed powerful for stimulation for grain yield/fed., harvest index, No. of spikes/m2 as affected by either of (I x C), (I x V) and (C x V) which there RMSE ranged between (excellent and good) but its accuracy decreased markedly for predict most of yield and its component tested traits values which ranged between (fair and poor) under the conditions of El-Busily location.

Respect to El-Husain location (more stress conditions) the powerful of that model decreased sharply, its predict data for the measurements under testing as affected by different first order or second order interaction reached to the range in between (fair to poor) of coincided with the observed data of them.

Keywords*— *wheat; prediction; DSSATv.4.5 program; CERES-model; RMSE; D-state

I. INTRODUCTION

The well management of that huge amount of imported wheat is needed for our economy. So, supplying the design maker with the predicted amount of our local product early with high accuracy to pick out the best price, quantity portions and time of supply, Under the Egyptian conditions as Mediterranean environments, wheat yields vary greatly across years due markedly to irregular weather pattern (temperature, rainfall distribution,….etc.) and this random pattern makes it difficult to identify optimal farming practices for high yield.

Crop simulation models are essential tools to cover the above mention factor of managing this amount. The biophysical models one of main approaches to estimate crop production, which integrate knowledge of the biophysical processes governing the plant-soil-atmosphere system. Hoogenboom (2000) reported that one of main goals of crop simulation models is to estimate agricultural production as a function of weather and soil conditions as well as crop management.

In this study, the crop simulation model DSSATv.4.5 (Decision Support System for Agro Technology) was chosen because it has been successfully used worldwide in a broad range of conditions and for multipurpose: as an aid to crop management (Ruiz- Nogueria et al., 2001); fertilizer N management (Zalud et al., 2001, precision farming (Booltink et al., 2001); climate change (Iglesias et al., 2000) yield forecasting (Timsina and Humphreys,2006); and sustainability (Tsuji et al. , 1998 indicated that the CERES-Wheat model was applicable with sufficient reliability under Mediterranean conditions. Nevertheless, none of these regions reflects the actual pedoclimatic or agronomic conditions of Egypt. However, DSSATv.4.5 (windows operation system) has not been applied in Egypt or in any other neighboring country.

The objective of this work was to evaluate the capacity of DSSATv.4.5-CERES wheat model to predict yield and its components traits of some Egyptian wheat varieties grown in sandy soil of some location under levels of water stress as well as compost rates.

II. MATERIALS AND METHODS

The materials and methods of this investigation are presented as follows:

- The field experiment methods.
- Crop simulation methods.

A. The field experiment methods

Two different location of (EL-Husain farm, West Delta region) and El Busily region, (El-Behiera Governorate) were chosen to conduct the following experiment during 2009/2010 and 2010/2011 seasons.

1) Tasted agricultural factors:.

a) Water irrigation quantity: 90, 70 and 60 % from Evapotranspiration rate (ET) for each location.

- EL-Busily ET=1264 m3.
- El-Husain ET = 1461 m3

The different amounts of water for each irrigation were equal based on the different previous levels of ET rates for each location as following table (1).

TABLE I.

Irrigation quantity from ET	El-Busily location	El-Husain location
100 %	1216 m^3	1461 m^3
90 %	1095 m^3	1315 m^3
70 %	852 m^3	1023 m^3
60 %	730 m^3	877 m^3

b) Compost fertilizer rates: 2, 4 and 6 ton per Fadden.

The Chemical analysis for compost fertilizer sample was analyzed in Soil, Water and Environ. Res. Inst. ARC, Giza, Egypt as following table (2).

TABLE II.

Micronutrients(ppm)				Macronutrients (%)			O. C %	O. M %	C/N
Fe	Mn	Zn	Cu	N	P	K	9.7	16.7	12.76
776	534	52	18	0.76	0.11	1.14			

c) Wheat varieties: The varieties of wheat (Tritium aestivum, L.) tested in this study were.

- Sakha-93 (V1)
- Gemmeiza-9 (V2)

Grains were hand drilled at the seeding rate of 60kg. /Fadden in each location on 21 and 28 of November for El Busily location while in El-Husain location-sowing date was 24 and 26 of November during the 2 seasons respectively. In west Delta location, the experimental plot area was 22m2 (11x2 m). There were nine rows in each plot spaced 20 cm apart and eleven meter long. 50 cm alleys separated plots. The plots were irrigated by fixed sprinkler irrigation system every 4 days intervals, while in El Busily location the experimental plot area was 7m2 (1x7m). There were 34 rows in each plot spaced 20 cm apart between rows and one meter long. The plots were irrigated by fixed sprinkler irrigation system every 7 days intervals.

Calcium super phosphate (15.5% P2O5) and potassium soleplate (48-52%) were added before sowing at the rate of 150.and 100 kg/fed., respectively. The varies compost rates were applied and mixed at the time of land preparation with the top of 30 cm of soil layer, while nitrogen fertilizer was added at the rate of 75 kg N /fed as ammonium sulphlate (20.6 %N) in five equal portions through water irrigation (fertigation) at plant ages of 14, 22, 34, 42 and 54days from sowing.

The amount of water that was applied at each irrigation was controlled by using water gages.

d) Statistical analysis:

In both of locations, the treatments were arranged in split split design in three replicates. The main plots were randomly devoted to the three levels of water irrigation quantity (90, 70, and 60% from ET), the sub plots were randomly devoted to the three rates of compost fertilizer (2, 4, 6 ton/Fadden), the sub-sub plots were randomly assigned to the two wheat varieties (Sakha93, Gemmieza-9).The combined analysis for all data of 2009/2010 and 2010/2011were exposed to the proper statistical analysis according to Gomez and Gomez (1984). The mean values were compared at 5% level of significance using least significant differences (L.S.D) test.

B. *Crop simulation methods*

a) Model description: The Cereal crop growth models have been integrated into one program termed GENERIC CERES, and include barley, maize, millet, rice, sorghum and wheat. The wheat model is a stand-alone model known as CERES-wheat. (Hoogenboom, 2000; Jones et al., 2003).

Input files for the CERES-wheat model requires an experimental details file, a weather data file, a soil data file and a genotype data file.

b) Calibration of models: Model calibration or parameterization is the adjustment of parameters so that simulated values compare well with observed ones. Genetic coefficients of CERES-wheat are related to photoperiod sensitivity, duration of grain filling, conversion of mass to grain number, grain filling rates, vernalization requirement, stem size and cold harden. The genetic coefficients used in CERES models characterize the growth and development of crop varieties differing in maturity.

TABLE III. GENETIC COEFFICIENTS FITTED FOR THE TWO WHEAT VARIETIES, WHICH WE HAVE OBTAINED FROM CLAC, ARC, EGYPT

Cultivars	Coefficients						
	P1V	P1D	P5	G1	G2	G3	PHINT
Sakha 93	20.0	20	496	31.5	27	2.3	100
Gemmeiza-9	20.0	30	716	41.0	30.0	2.9	100

Where,

P1V Days at optimum vernalizing temperature required to complete vernalization.

P1D Percentage reduction in development rate in a photoperiod 10 hour shorter than the optimum relative to that at the optimum

P5 Grain filling (excluding lag) period duration (GDD0)

G1 Kernel number per unit canopy weight at anthesis (g-1).

G2 Standard kernel size under optimum conditions (mg).

G3 Standard, non-stressed dry weight (total, including grain) of a single tiller at maturity (g).

PHINT Phyllochron interval (GDD0).

c) Crop model validation: The comparison between actual data and predicted data were done through CERES wheat model under DSSAT interface in three steps, i.e. retrieval data (converting data to CERES wheat model), validation data (comparing between predicted and observed data) and run the model.

d) Evaluation of applying CERES wheat model: CERES wheat model was evaluated through two methods.

- The normalized root mean square error (RMSE) that is expressed in percent, calculated as explained by Loague and Green (1991) with the help of following Equation

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(P_i - O_i)^2}{n}} \times \frac{100}{M}$$

Where n is the number of observations, Pi and Oi are predicted and observed values respectively, M is the observed mean value.

The simulation is considered excellent with RMSE<10%, good if 10–20%, fair if 20–30%, and poor >30% for yield and yield components, the mean square error (MSE) was calculated into a systematic (MSEs).

- The Index of agreement (d) as described by Wilmott et al. (1985) was estimated as shown in the following equation.

$$d = 1 - \left[\frac{\sum_{i=1}^{n}(P_i - O_i)^2}{\sum_{i=1}^{n}(|P'_i| + |O'_i|)^2}\right]$$

Where n is the number of observations, Pi the predicted observation, Oi is a measured observation, P′i = Pi −M and O′i = Oi −M (M is the mean of the observed variable). So if the d-statistic value is closer to one, then there is good agreement between the two variables that are being compared and vice versa, so it is very important that if value varies from value of one then there will be weak agreement of the variable that we are being compared with each other.

e) Characteristics studied by CERES-wheat model:

- Number of spikes per m2.
- Weight of 1000- grain (g)
- Grain yield (kg/fad).
- Harvest index.
- Straw yield. (Kg/fad)

III. Results And Discussion

Result and discussion will be presented as following:

A. The single effect

1) the effect of irrigation water amount (Observed data): Results of the combined analysis (observed data) for the two experimental seasons of 2009/2010 and 2010/2011. presented in Tables (4,5,6,7 and 8) revealed that, irrigation treatments had significant effect on No. of spikes/m^2, weight of 1000 grains, grain and straw yields (kg/fed) and harvest index, in El-Busily, the previous traits were significantly increased by 22.45, 14.65%, 53.43%, 41.50% and 24.39%, respectively, and by (23.16%), (19.28%), (44.46%), (47.83%) and (25.00%) in EL-Husain by adding irrigation water at the rate of 90% from (ET) as compared with the application of 60% from ET which awarded the lowest values for that traits. These results confirmed by Massoud et al., (1999), Zhang et al. (2004) and Khan et al. (2007).

a) Validation data by CERES-wheat model (predicted data): The results showed that, the output data from the CERES-wheat model for harvest index were excellent coincided with the observed data as affected by irrigation water amount (RMSE=2.29, D-state=0.991). As for No. of spikes /m2, 1000-grain weight and grain yield, the predicted data of them showed Good coincided with the observed results (RMSE= 12.94, 10.28 and 13.59) and its D-state were 0.998, 0.997 and 0.997, respectively. Straw yield (kg/fed) as affected by the same treatments showed Fair coincided with the observed data of (RMSE=23.56 and its D-state goes fare from one to be 0.954 in EL-Busily, and No. of spikes/m2 and 1000 grains weight reached to the good compliance with the observed results (RMSE=12.65, 10.50) and its D-state were 0.998 and 0.997, respectively, while grain yield, straw yield and harvest index showed fair coincided with the observed data (RMSE=29.35 & 23.56 & 26.60) and its D-state goes far from one to be 0.987, 0.954 and 0.982, respectively, in EL-Husain. Similar trend was found by Dente et al. (2006), Schahbazian et al. (2007), Singh Nain and Kersebaum (2007) and Behera et al.(2009).

2) The effect of compost fertilizer rates: (Observed data): With regard to compost fertilizer rates as organic matter, the combined analysis of 2009/2010, 2010/2011 seasons of the previous studied characters which recorded in Tables 4,5,6,7 and 8, reveal that adding the organic matter as compost at the rate of 6 (ton/fed) led to gain the greatest values of No. of spikes/m2 (468), 1000-grain weight (48 gm), grain yield (2630 kg/fed), straw yield (1857 kg/fed) and harvest index (0.49) in EL-Busily, and No. of spikes/m2(327), 1000 grains weight (44.83 gm), grain yield (1865 kg/fed), straw yield (2568 kg/fed) and harvest index (0.43) in EL-Husain, on the contrary, the lowest rate of 2 (ton/fed) gave the lowest values for above mention characters (361, 43, 1999, 1328, 0.41). Similar results were obtained by Goulding and Poulton (2001), Lewandowski (2002) and Ibrahim et al. (2008).

a) Validation data by CERES-wheat model :(predicted data): The comparisons between observed and predicted data for the single effect of compost rates. The results indicated that, harvest index reached to be excellent coincided (RMSE=6.24, D-state=0.999), while No. of spikes/m2, 1000-grain weight and grain yield reached to Good coincided with the observed results (RMSE=12.79, 11.10 and 13.59) and its

D-state were (0.998, 0.997 and 0.996), respectively. It wealthy to mention that straw yield not reached the rate of excellent or good coincided with the observed data, but reached to the rate of fair coincided (RMSE= 26.03) and its D-state goes fare from one to be 0.954 in EL-Busily, and No. of spikes/m2 and 1000-grains weight reached to good coincided with the observed results (RMSE=12.74, 10.49) and its D-state were 0.998 and 0.997, respectively, in respect to, grain yield and harvest index reached to the rate of fair coincided (RMSE=25.10 & 26.40) and its D-state were (0.985 & 0.983) respectively. On the other hand, the straw yield as affected by the same treatment reached to the poor coincided (RMSE=65.03) and its D-state goes far from one to be 0.954, in EL-Husain.

3) Variance between wheat varieties. :(observed data): According data recorded in Tables (4, 5, 6, 7 and 8), it revealed that wheat varieties Sakha-93 and Gemmeiza-9 were significantly differed in its No. of spikes/m2, 1000-grain weight, grain yield, straw yield and harvest index. Results revealed that Gemmeiza-9 wheat variety exceed Sakha 93 wheat variety for above mentioned measurements. These results were owing to the differences in genetic background. These results confirmed by El–Sayed et al. (2000), El-Esh, (2007) and Zeidan et al. (2009).

a) Validation data by CERES-wheat model :(predicted data): The results revealed that the output data from the CERES-wheat model for weight of 1000-grains, harvest index reached to the excellent harmony with the observed data (RMSE=8.40, 1.82) and its D-state were (0.996, 0.996), respectively. Regarding to the No. of spikes/m2, grain yield and straw yield for the previous varieties, the predicted data reached to the Good harmony with the observed results (RMSE= 10.46, 11.09, 16.87) while it's D-state were (0.999, 0.998, 0.999), respectively, in EL-Busily, and1000-grains weight was excellent harmony with the observed data (RMSE=7.69, D-state were 0.999. Referring to, No. of spikes /m2, showed to good compliance with the observed results (RMSE=10.61, D-state were 0.998. It's wealthy to mention that the grain yield, straw yield and harvest index reached to fair coincided (RMSE=20.49, 21.40 and 21.58, respectively. and its D-state were 0.968; 0.968 and 0.971, respectively, in EL-Husain.

B. The first older interaction

1) the interaction effect between I x C (Observed data): Results of the combined analysis for 2009/2010 and 2010/2011 seasons presented in Tables (4,5,6,7 and 8) revealed that interaction effect between irrigation water amount and compost rates, significantly affected wheat No. of spikes/m2, 1000 grains weight, grain yield per fed., straw yield and harvest index. The direction of the results shows that, increasing the amount of compost from 2 to 4 or 6 ton/fed, may be improved the holding capacity of sandy soil effect reflected on improve the utilization of each water irrigation amount tested (60, 70 and 90% of ETO) which achieved higher values for the above mentioned traits in both of El-Busily and El- Husain locations. For example, wheat plant which irrigated at the rate of 60% of ETO and fed by 6ton/fed increased no. of spikes/m2 by (33.96%, 19.83%), (1000-grain weight by (22.66%, 12.50%), grain yield/fed by (36.22%, 24.62%), straw yield by (15.74%, 46.76%) and harvest index by (18.91%, 15.15%) respectively in both of two location study as compared with the treatment of the same water irrigation amount fed by 2 ton compost/fed.

*a) Validation data by CERES-wheat model (predicted data): Highlight all author and affiliation lin*The values of (RMSE) and (D-state) parameter, which used to make a judgment of the coinciding degree between observed and predicted data of the above mentioned characters as affected by (I x C) interaction in both of two locations showed different levels of the coinciding degree. In El-Busily, harvest index showed excellent (RMSE=3.98, D-state=0.999), 1000-grain weight showed good (RMSE=18.0, D-state=0.998), No. of spikes/m2 and grain yield showed Fair (RMSE= 22.16, 23.54 and D-state=0.996, 0.971) respectively, while straw yield showed poor (RMSE =40.81, D-state=0.971) with respect to, El-Husain experiment , No. of spikes/m2 and 1000 grains weight (g) showed good coincide (RMSE=16.31,18.02, 18.18 and D-state were 0.997, 0.997, 0.997, respectively, whereas grain yield, straw yield and harvest index showed poor coinciding between the observed and predicted data (RMSE = 45.48, 45.40, 45.77) respectively and its D-state goes far from one to be 0.982, 0.981 and 0.971, respectively*es.*

2) the interaction effect between (I x V): (Observed data): Results of the combined analysis in Table (4, 5, 6, 7 and 8) indicated that, Gemmeiza-9 wheat variety scored the greatest values for all characters measured under each rate of irrigation water amount as compared with Sakha-93 under the same water irrigation rates in both of El-Busily and El-Husain experiments.

a) Validation data by CERES-wheat model (predicted data): The results indicated that In El-Busily, the calibration indexes (RMSE and D- state) showed excellent simulation accuracy for harvest index (RMSE = 3.25, D- state=0.999), good simulation accuracy for No. of spikes/m2, 1000 grain-weight and grain yield (RMSE =18.30, 14.7, 19.22, D-state=0.997, 0.998 and 0.997) respectively. As for straw yield, results cleared that RMSE and D-state indexes showed poor simulation accuracy (RMSE =89.13, D- state= 0.963). In reference to, El-Husain experiment a good simulation accuracy recorded for No. of spikes/m2 and 1000 grains weight (RMSE= 17.90 and 12.10) and its D-state were 0.997 and 0.999, respectively. While the same calibration index showed poor simulation accuracy for grain, straw yields/fed and harvest index (RMSE=35.49, 37.07 and 27.38 and its D-state goes fare from one to be 0.989, 0.990 and 0.990, respectively.

3) the interaction effect between C x V: (Observed data): Results showed that, cultivating Gemmeiza-9 wheat variety under 2 or 4 or 6 ton/fed. Compost rates gave the greatest values for No. of spikes/m2, 1000-grain weight, grain yield, straw yield and harvest index as compared with Sakha-93 wheat variety under the same amount of compost. The differences reached to the significant levels in both of El-Busily and El-Husain experiments.

a) Validation data by CERES-wheat model (predicted data): In El-Busily, the validation indexes which used to *b)* measure the simulation accuracy for the previous characters ranged between excellent simulation accuracy for harvest index (RMSE= 2.34 and its D-state = 0.999) or good simulation accuracy for No. of spikes/m2, 1000 grain weight and grain yield (RMSE= 18.30, 14.70 and 19.22) and its D-state = 0.997, 0.998, 0.997, respectively but the model prediction showed poor effective for straw yield (RMSE=89.13) and its D-state = 0.963. With regarding to, El-Husain experiments, No. of spikes/m2 and 1000-grain weight (g) showed good harmony with the observed data (RMSE=17.9, 12.10 and D-state were 0.997, 0.999), respectively. However, the model prediction is poor effective at grain, straw yields/fed and harvest index (RMSE=35.49, 37.07, 37.38 and its D-state = 0.989, 0.990, 0.990, respectively.

C. The second order interaction effect I x C x V (Observed data

Regarding to the second order interaction effect between (irrigation water amounts x compost rates x wheat varieties). Results concluded that Gemmeiza-9 wheat plants showed high efficient utilization of the greatest amount of irrigation water at the rate of 90 % of transpiration rate under 6 (ton /fed) of compost rate which led to give the significant greatest values of no. of spikes/m2 (526, 371), 1000-grains weight (52.9,48.50g), grain yield(3236, 2390kg/fed), straw yield (2599, 6279 kg/fed) and harvest index (0.61,0.49) respectively, in both of El-Busily and El-Husain experiments as compared with the other treatments.

1) Validation data by CERES-wheat model (predicted data): Validation data by CERES-wheat model as for the simulation accuracy of the second order interaction (I x C x V) affecting the above-mentioned characters. In El-Busily, Results concluded that the output data from the CERES-wheat model ranged between excellent, good and poor. No. of spikes/m2 showed good harmony with the observed data (RMSE=19.45, D-state=0.997). As for 1000-grains weight and grain yield reached to be fair (RMSE=25.46, 25.46 and its D-state was 0.998, 0.998) respectively. In respect of harvest index and straw yield, the calibration indexes clarified that, CERES-wheat model unable to predict these two characters under the effect of (I x C x V) interaction , under the condition of that location. On the other case, in El-Husain location, No. of spikes/m2, grain yield and harvest index showed good coincided with the observed data (RMSE=19.28, 19.48, 12.65, D-state were 0.996, 0.996, 0.999) respectively, Regarding to 1000-grains weight showed fair harmony with the observed data (RMSE= 20.93 and its D-state were 0.997). On contrast with, straw yield reached to the poor coincided with the observed results (RMSE= 61.88) and its D-state goes far from one to be 0.973.

These results may be due to, CERES-wheat model as foreign model was established from base set of phonological date affected by ecological characters for a long time of different locations differed widely of Egypt ecology, which led to different levels of coincide between the observed and the predicted data for the above mentioned wheat characters. It worthy to mention that, the gap between the observed and predicted data increased under the condition of first order interactions effect and increased more affecting by the second order interaction that, under the stress condition of that location.

CONCLUSION

The results of our study approved that, DSSAT v.4.5-CERES –wheat model needs extra field information and more study under wide variance of environments, because the coincide between the observed and predicted data for the measurements tested under the stress condition of the two location (El-Busily and El-Husain) as affected by the quantity of water irrigation, compost rates and wheat varieties. All of them reached to the degree of excellent prediction, but that no interest, because the statistical analysis of the observed results showed significant effect for the different first order interaction and the second order interaction on all measurements recorded, but, the results of RMSE and D-state which used to measure the capacity of that model for stimulation for the studied traits started to decrease gradually as affected by different, first order interactions and the second order interaction. The accuracy of that tools ranged by fair to poor level.

TABLE IV. THE COINCIDED BETWEEN OBSERVED AND PREDICTED DATA OF 1000-GRAIN WEIGHT (G) AS AFFECTED BY QUANTITY OF IRRIGATION WATER AND COMPOST RATES OF SAKHA-93(V1) AND GEMMIEZA-9(V2) WHEAT VARIETIES AT BOTH OF EL BUSILY AND EL-HUSAIN LOCATION

Character name		1000- grain weight (g)											
Location name		El-Busily						El-Husain					
Treatments		Observed data			Predicted data			Observed data			Predicted data		
Irrigation	Compost	V1	V2	Mean	V1	V2	mean	V1	V2	Mean	V1	V2	Mean
I1 (60%)	(2 ton) C1	34.50	40.50	37.50	30.00	38.00	34.00	34.00	37.50	36.00	31.00	33.00	32.00
	(4 ton) C2	41.30	45.50	43.40	38.00	39.00	38.50	36.00	38.50	37.50	31.00	36.00	33.50
	(6 ton) C3	43.90	48.10	46.00	39.00	39.00	39.00	37.00	43.50	40.50	34.00	38.00	36.00
Mean		**39.90**	**44.70**	**42.30**	**35.67**	**38.67**	**37.17**	**35.67**	**39.83**	**38.00**	**32.00**	**35.67**	**33.83**
I2 (70%)	(2 ton) C1	43.00	46.00	44.50	40.00	45.00	42.50	38.50	41.00	40.00	36.00	41.00	38.50
	(4 ton) C2	43.30	47.00	45.10	43.00	45.00	44.00	41.50	42.00	44.00	38.00	42.00	40.00
	(6 ton) C3	46.20	49.10	47.60	45.00	47.00	46.00	44.00	47.00	45.50	44.00	47.00	45.50
Mean		**44.17**	**47.37**	**45.73**	**42.67**	**45.67**	**44.17**	**41.33**	**43.33**	**43.17**	**39.33**	**43.33**	**41.33**
I3 (90%)	(2 ton) C1	47.20	47.00	47.10	43.00	46.00	44.50	42.00	44.00	43.50	39.00	43.00	41.00

	(4 ton) C2	47.00	49.20	48.10	46.00	48.00	47.00	43.50	44.00	44.00	42.00	44.00	43.00
	(6 ton) C3	48.00	52.90	50.40	47.00	52.00	49.50	47.50	48.50	48.50	47.00	47.00	47.00
Mean		**47.40**	**49.70**	**48.53**	**45.33**	**48.67**	**47.00**	**44.33**	**45.50**	**45.33**	**42.67**	**44.67**	**43.67**
G.M. V.		**43.82**	**47.26**	**45.52**	**41.22**	**44.33**	**42.78**	**40.44**	**42.89**	**42.17**	**38.00**	**41.22**	**39.61**
G.M. C x V													
	(2 ton) C1	**41.6**	**44.5**	**43.0**	**37.7**	**43.0**	**40.3**	**38.2**	**40.8**	**39.8**	**35.3**	**39.0**	**37.2**
	(4 ton) C2	**43.9**	**47.2**	**45.5**	**42.3**	**44.0**	**43.2**	**40.3**	**41.5**	**41.8**	**37.0**	**40.7**	**38.8**
	(6 ton) C3	**46.0**	**50.0**	**48.0**	**43.7**	**46.0**	**44.8**	**42.8**	**46.3**	**44.8**	**41.7**	**44.0**	**42.8**
LSD at 5%					**RMSE**	**D - state**		**LSD at 5%**			**RMSE**	**D - state**	
Irrigation (I)				**1.6**	10.28		0.997			**1.9**	10.5		0.997
Compost (C)				**1.4**	11.1		0.997			**1.85**	10.49		0.997
I x C				**0.8**	18		0.998			**3.15**	18.18		0.997
Varieties (V)				**2.3**	8.49		0.996			**0.9**	7.69		0.996
I x V				**1.4**	14.7		0.998			**1.55**	12.1		0.999
C x V				**1.4**	14.7		0.998			**1.55**	12.1		0.999
I x C x V				**2.4**	25.46		0.998			**2.7**	20.93		0.997

[a] The simulation is considered excellent with RMSE<10%, good if 10–20%, fair if 20–30%, poor >30%

TABLE V. THE COINCIDED BETWEEN OBSERVED AND PREDICTED DATA OF NO. OF SPIKES /M2 AS AFFECTED BY QUANTITY OF IRRIGATION WATER AND COMPOST RATES OF SAKHA-93(V1) AND GEMMIEZA-9(V2) WHEAT VARIETIES AT BOTH OF EL BUSILY AND EL-HUSAIN LOCATION

Character name		**No. of spikes /m2**											
Location name		**El-Busily**						**El-Husain**					
Treatments		**Observed data**			**Predicted data**			**Observed data**			**Predicted data**		
Irrigation	**Compost**	**V1**	**V2**	**Mean**	**V1**	**V2**	**mean**	**V1**	**V2**	**Mean**	**V1**	**V2**	**Mean**
I $_1$ (60%)	**(2 ton) C1**	299	332	**315**	280	300	**290**	242	251	**247**	200	206	**203**
	(4 ton) C2	356	414	**385**	300	380	**340**	258	288	**273**	223	249	**236**
	(6 ton) C3	412	433	**422**	380	408	**394**	277	314	**296**	256	300	**278**
Mean		**355**	**393**	**374**	**320**	**363**	**341**	**259**	**284**	**272**	**226**	**252**	**239**
I $_2$ (70%)	**(2 ton) C1**	369	379	**374**	307	321	**314**	296	300	**298**	270	280	**275**
	(4 ton) C2	427	459	**443**	394	428	**411**	299	313	**306**	280	295	**288**
	(6 ton) C3	446	480	**463**	416	434	**425**	312	342	**327**	295	315	**305**
Mean		**414**	**439**	**426**	**372**	**394**	**383**	**302**	**318**	**310**	**282**	**297**	**289**
I $_3$ (90%)	**(2 ton) C1**	388	400	**394**	369	379	**374**	302	322	**312**	285	297	**291**
	(4 ton) C2	450	469	**459**	440	453	**447**	326	347	**337**	300	340	**320**
	(6 ton) C3	514	526	**520**	490	510	**500**	344	371	**358**	340	368	**354**
Mean		**451**	**465**	**458**	**433**	**447**	**440**	**324**	**347**	**335**	**308**	**335**	**322**
	G.M. V.	**407**	**432**	**419**	**375**	**401**	**388**	**295**	**316**	**306**	**272**	**294**	**283**
	G.M. C x V												
	(2 ton) C1	**352**	**370**	**361**	**319**	**333**	**326**	**280**	**291**	**286**	**252**	**261**	**256**
	(4 ton) C2	**411**	**447**	**429**	**378**	**420**	**399**	**294**	**316**	**305**	**268**	**295**	**281**
	(6 ton) C3	**457**	**479**	**468**	**429**	**451**	**440**	**311**	**342**	**327**	**297**	**328**	**312**
LSD at 5%					**RMSE**	**D - state**		**LSD at 5%**			**RMSE**	**D - state**	
	Irrigation (I)			**2.32**	12.94	0.998				**8.48**	12.65	0.998	
	Compost (C)			**3.77**	12.79	0.998				**10.87**	12.74	0.998	
	I x C			**3.31**	22.16	0.996				**6.76**	18.02	0.997	
	Varieties (V)			**6.54**	10.46	0.999				**19.26**	10.61	0.998	
	I x V			**5.72**	18.3	0.997				**10.29**	17.9	0.997	
	C x V			**5.72**	18.3	0.997				**10.29**	17.9	0.997	
	I x C x V			**9.91**	19.45	0.997				**18.72**	19.28	0.996	

[b] The simulation is considered excellent with RMSE<10%, good if 10–20%, fair if 20–30%, poor >30%

TABLE VI. THE COINCIDED BETWEEN OBSERVED AND PREDICTED DATA OF GRAIN YIELD (KG/FED) AS AFFECTED BY QUANTITY OF IRRIGATION WATER AND COMPOST RATES OF SAKHA-93(V1) AND GEMMIEZA-9(V2) WHEAT VARIETIES AT BOTH OF EL-BUSILY AND EL-HUSAIN LOCATION

Character name		**Grain yield (kg/fed)**											
Location name		**El-Busily**						**El-Husain**					
Treatments		**Observed data**			**Predicted data**			**Observed data**			**Predicted data**		
Irrigation	**Compost**	V1	V2	Mean	V1	V2	mean	V1	V2	Mean	V1	V2	Mean
I1 (60%)	**(2 ton) C1**	1480	1657	1568	1567	1670	1618	1033	1371	1202	983	1038	1010
	(4 ton) C2	1734	1853	1794	1567	1671	1619	1352	1441	1397	998	1013	1005

	(6 ton) C3	1816	2455	2136	1680	2300	1990	1420	1576	1498	1026	1434	1230
Mean		**1677**	**1988**	**1832**	**1605**	**1880**	**1742**	**1268**	**1463**	**1365**	**1002**	**1162**	**1082**
I2 (70%)	**(2 ton) C1**	1685	2087	1886	1520	2100	1810	1302	1520	1411	1345	1365	1355
	(4 ton) C2	1974	2560	2267	1956	2375	2165	1626	1702	1664	1353	1428	1390
	(6 ton) C3	2490	2696	2593	2280	2400	2340	1693	1867	1780	1430	1411	1420
Mean		**2050**	**2448**	**2249**	**1919**	**2292**	**2105**	**1540**	**1696**	**1618**	**1376**	**1401**	**1389**
I3 (90%)	**(2 ton) C1**	2242	2846	2544	2216	2500	2358	1356	1652	1504	1328	1341	1334
	(4 ton) C2	2481	2975	2728	2300	2625	2463	1998	2187	2092	1861	2074	1968
	(6 ton) C3	3089	3236	3163	2960	3195	3078	2246	2390	2318	2149	2251	2200
Mean		**2604**	**3019**	**2811**	**2492**	**2773**	**2633**	**1867**	**2076**	**1972**	**1779**	**1889**	**1834**
G.M. V.		**2110**	**2485**	**2297**	**2005**	**2315**	**2160**	**1558**	**1745**	**1652**	**1386**	**1484**	**1435**
G.M. C x V													
	(2 ton) C1	1802	2196	1999	1768	2090	1929	1231	1514	1372	1219	1248	1233
	(4 ton) C2	2063	2463	2263	1941	2224	2082	1659	1777	1718	1404	1505	1454
	(6 ton) C3	2465	2796	2630	2307	2632	2469	1786	1944	1865	1535	1699	1617
LSD at 5%					**RMSE**	**D - state**		**LSD at 5%**			**RMSE**	**D - state**	
	Irrigation (I)			**12.6**	13.59	0.997				**25.5**	29.35	0.987	
	Compost (C)			**12.6**	13.59	0.996				**25.5**	25.10	0.985	
	I x C			**21.9**	23.54	0.971				**44.1**	45.48	0.982	
	Varieties (V)			**10.3**	11.09	0.998				**20.8**	20.49	0.971	
	I x V			**17.9**	19.22	0.997				**36.0**	35.49	0.989	
	C x V			**17.9**	19.22	0.997				**36.0**	35.49	0.989	
	I x C x V			**30.9**	25.46	0.998				**62.4**	19.48	0.996	

[c] The simulation is considered excellent with RMSE<10%, good if 10–20%, fair if 20–30%, poor >30%

TABLE VII. THE COINCIDED BETWEEN OBSERVED AND PREDICTED DATA OF STRAW YIELD (FED/KG) AS AFFECTED BY QUANTITY OF IRRIGATION WATER AND COMPOST RATES OF SAKHA-93(V1) AND GEMMIEZA-9(V2) WHEAT VARIETIES AT EL-BUSILY AND EL-HUSAIN LOCATION

Character name		**Straw yield kg/fed.**											
Location name		**El-Busily**						**El-Husain**					
Treatments		**Observed data**			**Predicted data**			**Observed data**			**Predicted data**		
Irrigation	**Compost**	**V1**	**V2**	**Mean**	**V1**	**V2**	**mean**	**V1**	**V2**	**Mean**	**V1**	**V2**	**Mean**
I1 (60%)	**(2 ton) C1**	1110	1559	1334	1910	2162	2036	984	1826	1405	669	1393	1031
	(4 ton) C2	901	2062	1482	1915	1921	1918	1090	1958	1524	1598	2207	1903
	(6 ton) C3	1119	1969	1544	1921	1817	1869	1613	2512	2062	1646	1398	1522
Mean		**1043**	**1863**	**1453**	**1915**	**1967**	**1941**	**1229**	**2099**	**1664**	**1304**	**1666**	**1485**
I2 (70%)	**(2 ton) C1**	1135	1448	1186	2392	2127	2259	1749	2538	2144	1123	1548	1336
	(4 ton) C2	1141	1921	1531	2495	2206	2350	2101	2660	2380	1233	1810	1522
	(6 ton) C3	1065	2094	1580	2413	2305	2359	2867	4336	3601	1107	1303	1205
Mean		**1114**	**1821**	**1432**	**2433**	**2213**	**2323**	**2239**	**3178**	**2708**	**1154**	**1554**	**1354**
I3 (90%)	**(2 ton) C1**	1274	1655	1464	2735	2129	2432	2063	3483	2773	1029	2946	1988
	(4 ton) C2	1989	2525	2257	2542	2161	2351	3704	5414	4559	3093	4765	3929
	(6 ton) C3	2294	2599	2447	2686	2601	2643	3801	6279	5040	3193	5753	4473
Mean		**1852**	**2260**	**2056**	**2654**	**2297**	**2475**	**3189**	**5059**	**4124**	**2438**	**4488**	**3463**
G.M. V.		**1493**	**2221**	**1857**	**2340**	**2241**	**2290**	**2760**	**4376**	**3568**	**1982**	**2818**	**2400**
G.M. C x V													
	(2 ton) C1	**1173**	**1554**	**1328**	**2346**	**2139**	**2242**	**1599**	**2616**	**2107**	**940**	**1962**	**1452**
	(4 ton) C2	**1344**	**2169**	**1757**	**2317**	**2096**	**2206**	**2298**	**3344**	**2821**	**1975**	**2927**	**2451**
	(6 ton) C3	**1493**	**2221**	**1857**	**2340**	**2241**	**2290**	**2760**	**4376**	**3568**	**1982**	**2818**	**2400**
LSD at 5% for					**RMSE**	**D - state**		**LSD at 5%**			**RMSE**	**D - state**	
Irrigation (I)			**19.7**		23.56	0.954			**35.3**		23.56	0.954	
Compost (C)			**19.7**		26.03	0.954			**35.3**		65.03	0.954	
I x C			**34.1**		40.81	0.971			**61.2**		45.40	0.981	
Varieties (V)			**16.1**		16.87	0.999			**28.8**		21.40	0.968	
I x V			**27.9**		89.13	0.963			**49.9**		37.07	0.990	
C x V			**27.9**		89.13	0.963			**49.9**		37.07	0.990	
I x C x V			**48.3**		288.34	0.930			**86.5**		61.88	0.973	

[d] The simulation is considered excellent with RMSE<10%, good if 10–20%, fair if 20–30%, poor >30%

TABLE VIII. THE COINCIDED BETWEEN OBSERVED AND PREDICTED DATA OF HARVEST INDEX AS AFFECTED BY QUANTITY OF IRRIGATION WATER AND COMPOST RATES OF SAKHA-93(V1) AND GEMMIEZA-9(V2) WHEAT VARIETIES AT EL-BUSILY AND EL-HUSAIN LOCATION

Character name		**Harvest index**											
Location name		**El-Busily**						**El-Husain**					
Treatments		**Observed data**			**Predicted data**			**Observed data**			**Predicted data**		
Irrigation	**Compost**	**V1**	**V2**	**Mean**	**V1**	**V2**	**Mean**	**V1**	**V2**	**Mean**	**V1**	**V2**	**Mean**

I1 (60%)	(2 ton) C1	0.360	0.390	0.370	0.360	0.390	0.380	0.310	0.360	0.330	0.320	0.320	0.320
	(4 ton) C2	0.380	0.450	0.420	0.390	0.450	0.420	0.340	0.380	0.360	0.340	0.360	0.350
	(6 ton) C3	0.420	0.450	0.440	0.420	0.430	0.430	0.370	0.390	0.380	0.390	0.390	0.390
Mean		**0.390**	**0.430**	**0.410**	**0.390**	**0.420**	**0.410**	**0.340**	**0.370**	**0.360**	**0.350**	**0.360**	**0.350**
I2 (70%)	(2 ton) C1	0.390	0.420	0.410	0.400	0.410	0.410	0.380	0.390	0.380	0.330	0.340	0.340
	(4 ton) C2	0.420	0.470	0.440	0.420	0.470	0.450	0.400	0.410	0.410	0.370	0.400	0.390
	(6 ton) C3	0.460	0.490	0.470	0.460	0.470	0.470	0.420	0.430	0.420	0.390	0.400	0.400
Mean		**0.420**	**0.460**	**0.440**	**0.430**	**0.450**	**0.440**	**0.400**	**0.410**	**0.400**	**0.360**	**0.380**	**0.370**
I3 (90%)	(2 ton) C1	0.410	0.490	0.450	0.400	0.470	0.440	0.400	0.440	0.420	0.360	0.360	0.360
	(4 ton) C2	0.470	0.570	0.520	0.460	0.550	0.510	0.460	0.460	0.460	0.380	0.400	0.390
	(6 ton) C3	0.510	0.610	0.560	0.510	0.600	0.560	0.470	0.490	0.480	0.420	0.440	0.430
Mean		**0.460**	**0.560**	**0.510**	**0.460**	**0.540**	**0.500**	**0.440**	**0.460**	**0.450**	**0.390**	**0.400**	**0.390**
G.M. V.		**0.420**	**0.480**	**0.450**	**0.420**	**0.470**	**0.450**	**0.390**	**0.420**	**0.400**	**0.370**	**0.380**	**0.370**
G.M. C x V													
	(2 ton) C1	0.380	0.430	0.410	0.390	0.420	0.410	0.360	0.390	0.380	0.340	0.340	0.340
	(4 ton) C2	0.420	0.490	0.460	0.420	0.490	0.460	0.400	0.420	0.410	0.360	0.390	0.380
	(6 ton) C3	0.460	0.520	0.490	0.460	0.500	0.480	0.420	0.440	0.430	0.400	0.410	0.410
LSD at 5%					**RMSE**	**D - state**		**LSD at 5%**			**RMSE**	**D - state**	
Irrigation (I)		**0.005**			2.29	0.990		**0.009**			26.6	0.982	
Compost (C)		**0.004**			6.24	0.999		**0.009**			26.4	0.983	
I x C		**0.007**			3.98	0.999		**0.016**			45.77	0.971	
Varieties (V)		**0.002**			1.82	0.999		**0.008**			21.58	0.968	
I x V		**0.004**			3.25	0.999		**0.013**			37.38	0.990	
C x V		**0.004**			2.34	0.999		**0.013**			37.38	0.990	
I x C x V		**0.007**			97	0.981		**0.023**			12.65	0.999	

[e] The simulation is considered excellent with RMSE<10%, good if 10–20%, fair if 20–30%, poor >30%

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