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Application and Evaluation of DSSAT V.4.6.1 Program for Simulation of Wheat and Soybean yields in Egypt

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ABSTRACT

Adoption of conservation agriculture (CA) is increasingly being promoted as a way of adapting agricultural systems to increasing climate variability, especially for areas such as Africa where rainfall is projected to decrease. The DSSAT (Decision Support System for Agro Technology) crop simulation models can be a valuable tool in evaluating the effects of CA, which are viable both economically and environmentally. Our objectives were to evaluate the ability of DSSAT to predict the combined effect of tillage system and fertilizer rates through wheat/soybean rotation on crop yield. DSSAT v.4.6.1 (CERES-wheat and CROPGRO-soybean) was utilized for the study to simulate crop yield. Observed field data revealed that, the effect of tillage systems during the summer season of 2013 did not differ significantly due to studied Soybean traits. Related to, winter season of 2013/2014, the results revealed that, CA tillage system increased significantly all studied wheat traits as compared with the other tillage systems. Referring to, the summer season of 2014, CA system scored the significant high values for the studied Soybean traits. As for the effect of studied NPK fertilizer levels, results showed that, 100% of the recommended doses of NPK favored the values of the studied soybean and wheat traits significantly during summer 2013 and winter 2013/2014, as compared by 50% of the recommended dose of it, in addition, there are no-significant difference between the two fertilizer levels for soybean traits in the third season (summer, 2014). Regarding, the interaction effect between the tested factors, results of the three trial seasons revealed that, growing soybean or wheat under the condition of conservation agriculture (CA) and fed by 100% or 50% of the recommended dose of NPK fertilizers scored the greatest values for most of soybean and wheat traits. On contrast, the lowest value was resulted under the condition of conventional tillage (CT) and fed by the 50% of the recommended dose of NPK fertilizers. The DSSAT– CERES-wheat and CROPGRO-soybean models also reflected this trend. These results indicated that, The DSSAT program exposed powerful for stimulation for grain yield/fed., harvest index as affected by interaction effect between tillage systems and fertilizer rats, which there RMSE ranged between good and excellent, RMSE = (12.44, 12.29) and (7.92, 1.76) and (1.68, 16.24) for summer 2013, winter 2013/2014 and summer 2014 seasons respectively, through (soybean→ wheat→ soybean) crop sequence.

***Key words**: CERES model; no tillage; CROPGRO model; simulation; RMSE*

I. INTRODUCTION

Heavy and continuous conventional agriculture can cause loss of soil organic carbon, as well as increase soil erosion and deterioration of soil structure [18]. In the last few years, the search for practices that improve soil fertility and productivity and agricultural sustainability has increased. Interest in conservation agriculture technique (such as reduce and no tillage) is growing be. Because these practices reduce soil erosion, therefore preserving soil structure and fertility [25]. Improve in the soil structure and increase its productivity by applying conservation agriculture technique has been reported in numerous studies [32]. This technique is based on enhancing natural biological processes above and below the ground. Itis a farming system based on three principles: 1) minimum soil disturbance, 2) permanent soil cover with crop residuals and/ or cover crops; and 3) crop rotations with different plant species, which include legumes [4]. Conservation Agriculture (CA) is increasingly promoted in Africa as an alternative for coping with the need to increase food production on the basis of more sustainable farming practices. Also, CA is specifically seen as a way to address the problems of soil degradation resulting from agricultural practices that deplete the organic matter and nutrient content of the soil. It aims at higher crop yields and lower production costs. Yet, success with adopting CA on farms in Africa has been limited [14]. Diagram (1), shows CA adoption in selected countries of Africa

The crop simulation models could be used to evaluate various tillage-rotation combinations and explore management scenarios. The Decision Support System for Agro technology Transfer (DSSAT) [11]. Provides a suite of crop models and tools suitable for this task. DSSAT simulated crop yield using a defined data set on crop management, minimum weather data and soil profile parameters. Some of the crop management data required to simulate DSSAT included crop, cultivar, planting date, row and plant spacing, fertilizer levels, tillage practices and organic amendments [13]. In Egypt north Delta area, intensive farming of Nile valley land through the prevailing crop composition in those areas during summer and winter season that permeates from the previous service operations of farming, especially the process of stirring the soil by plowing that led to the degradation of the soil structure and decrease its fertility as a result of the rapid and continuous decomposition of the compound humus which led to increases the over consumption of soil nutrients that needs over use of fertilizers to compensate lack of fertility.

Therefore, the study aims to - Try to control soil service operation by using a modern agriculture technique known by conservation agriculture (CA) in addition, evaluate the ability of DSSATv.4.5-CERES and CROPGRO models to predict yield and its components traits of some Egyptian soybean and wheat varieties grown in clay soil under different tillage systems as well as fertilizer rats through (soybean→ wheat→ soybean) cropping system.

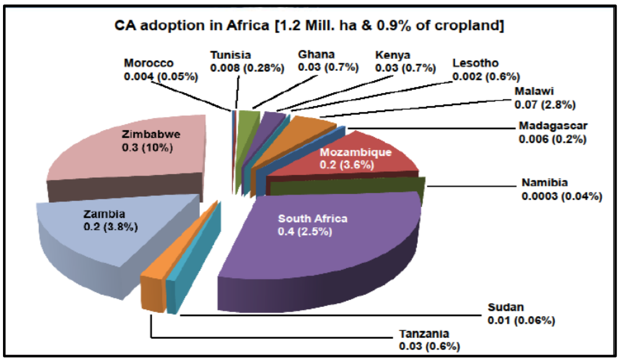


Diagram (1), shows CA adoption in selected countries of Africa

II. *MATERIALS AND METHODS*

1. Field experiment

The field experiment started in summer 2013 and continued for 3 seasons in Gemmieza agricultural experimental research station, Egyptian Agricultural Research Center (ARC)

1.1. The studied experimental treatments:

1.1.1. Tillage systems treatments: (TS)

☒ **Conventional agriculture (CT)**

In this system, the normal conventional agricultural practises of growing crop were done such as tillage

☒ **Conservation agriculture (CA)**

Under the conditions of this system, the soil was left without any land preparation and the previous crop residuals was hammered and left on soil surface and the seed was growing by hand drilled around hills

☒ **Semi-conservation agriculture (SCA)**

This method as the same conservation agriculture method without hand drilled around hills.

1.1.2. Fertilizer treatments:

✓ The recommended fertilizer (NPK)

✓ Half of the recommended fertilizer (1/2 NPK)

Table (1): shows the recommended nitrogen, phosphorous, potassium fertilizer rates, and seeding rates for the studied crops variety

Fertilizer crops	Crop variety	Nitrogen Kg N/fed.)	P_2O_5 15% (kg/fed.) fore planting	K_2SO_4 kg/fed.)	Seeding rate Kg/fed.)
Wheat	emmeiza-9	75	100	50	75
Soybean	Giza-111	15	150	50	40

The phosphorus and potassium fertilizer rate of each crop were applied as, single calcium super phosphate (15.5% P2o5) and potassium sulphate (48% K2O) during soil preparation for (CT) tillage treatments while that fertilizers were added broadcasting through (SCA) and (CA) tillage systems.

Regarding to, nitrogen fertilizer rate for each crop as shown before in table (5) were applied in the form of urea (46%N) before water irrigation as follow.

As for wheat, the nitrogen fertilizer was added in five equal portions as follow:

- At emergence stage just before the first irrigation at plant age of 20 days from sowing date
- At tillering stage before the second irrigation at plant age of 40 days from sowing date.
- At elongation stage before the third irrigation
- At booting stage before the fourth irrigation
- At grain filling stage before the fifth irrigation.

In reference to Soybean, success inoculation for its seed was done by *Rhizobium jabonicum* and the nitrogen fertilization take place before Mohayah irrigation at the rate of 15 kg N /fed.

Referring to, Giza-111 Soybean variety, 2-3 seed was sown in hills, at 15 cm apart using hand afire method on the 5,7th April in 2013 and 2014 seasons and harvested on the 16, 20th August 2013 and 2014 respectively. In addition, Gemmeiza-9 wheat variety was hand afire planted on the 20th October 2012 and 2013 seasons and harvested on the 26th March 2013 and 2014

Experimental design:

In the three studied seasons, each field experiment included six treatments, which were the combination of three systems of tillage practice, and two levels of NPK fertilizer, the treatments were arranged in a split plot design with three replicates. The main plots were randomly devoted to the three systems of tillage practice (CT, SCA and CA) at the area of 403 m^2 (31 m x 13 m) while the area of sub-plots were randomly assigned to the two levels of fertilizer (100% of the recommended of NPK and half NPK), the area of each was 16 m^2 (4 m. length and 4 m. width), which were separated from each other by 1 m alleys. All plots were irrigated by surface irrigation system every 10 day for soybean crop and 20 days' intervals for wheat crop according to region conditions.

Statistical analysis:

All data were exposed to the proper statistical analysis according to [7]. The mean values were compared at 5% level of significance using least significant differences (L.S.D) test.

Studied attributes:

Wheat crop:

• Number of spikes per m2, it was determined from random samples of one m2 taken from each plot

• Biological yield (kg) per Fed., It was determined by weighting all the plants of each plot, then converted to kg/fed.

• Grain yield (kg) per Fed., It was determined by weighting the total grain yield of each plot, then converted to kg/fed.

• Harvest index (HI) was calculated according to the following formula:

HI = Grain yield (kg/fed.)/ Total biological yield (kg/fed.)

Soybean crop:

• Plant height (cm) which was determined from the average of five random plants samples taken from each plot.

• Biological yield (kg/fed): whole plants of each plot were harvested then weighted and transformed to biological yield per fed., according the plot area.

• Seed yield (kg/fed) which was calculated according to the total seed yield per each plot area.

• Harvest index (HI) was calculated according to the following formula:

HI = Seed yield (kg/fed.)/ Total biological yield (kg/fed.)

2. Crop simulation methods

2.1. Model description:

The crop simulation model DSSAT (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. More than 18 different crops simulated with CSM, including Soybean, wheat, rice, barley, sorghum, millet, Soybean, peanut, dry bean, chickpea, cowpea, faba bean, velvet bean, potato, tomato, bell pepper, cabbage, Bahia and brachiaria and bare fallow. We used DSSAT version 4.6.1, which includes the new tillage model based on the improved CROPGRO and CERES-Till [2]. A model used to predict the influence of crop residue cover and tillage on soil surface properties and plant development. CROPGRO and CERES-Till has been tested for wheat and Soybean and has demonstrated the ability to simulate differences in soil properties and wheat, Soybean yield under several tillage systems.

Input files for DSSAT v.4.6.1 program requires an experimental details file, a weather data file, a soil data file and a genotype data file shown as follow:

Experimental details file

such as, field characteristics, soil analysis data, initial soil water, irrigation and water management, fertilizer management, tillage operations, environmental modifications, harvest management and simulation controls. Details of irrigation events for all the experiments.

Weather data file

The model requires daily weather data for the duration of the growing season. The minimum data required for above two models are solar radiation, minimum and maximum air temperature and rainfall. [22].

Soil data file

The data related to soil profile, soil water, soil nitrogen and root growth characteristics, soil taxonomic classification, soil texture and other descriptive data of the experimental site were used to develop the soil file for the experimental station.

Genotype data file

Farmers can change cultivars in order to maximize yield. The DSSAT crop models also have the ability to take that source of variability into account. For each model the cultivars are characterized by a specific set of genetic coefficients. These coefficients express the genetic potential of each genotype independently of all environmental constraints: soil; weather, etc. by simulating the yield of different cultivars in different conditions, it is possible to select the one (s) that best explore the available resources.

2.2. 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 and CROPGRO model are related to photoperiod sensitivity, duration of grain filling, conversion of mass to grain number, grain-filling rates, Maximum weight per seed (g), Time between first flowers and first pod, vernalization requirement, stem size and cold harden. The genetic coefficients used in two models characterize the growth and development of crop varieties differing in maturity as fallowing table (2 and 3).

Table (2): Genetic coefficients used in CSM-CERES-model characterize the growth and development of wheat variety after Model calibration and validation

Coefficients	***Definition***	***Gemmeiza-9***
P1V	Days at optimum vernalizing temperature required to complete vernalization.	**25.00**
P1D	Percentage reduction in development rate in a photoperiod 10 hour shorter than the threshold relative to that at the threshold.	**80.00**
P5	Grain filling (excluding lag) phase duration (°C.d).	**600.00**
G1	Kernel number per unit canopy weight at anthesis (#/g).	**27.00**
G2	Standard kernel size under optimum conditions (mg).	**80.00**
G3	Standard, non-stressed dry weight (total, including grain) of a single tiller at maturity (g).	**6.00**
PHINT	Phylochron interval, the interval in thermal time (degree-days) between successive leaf tip appearances.	**88.00**

Table (3): Genetic coefficients used in CROPGRO-model characterize the growth and development of soybean variety which was obtained from Model calibration

Coefficients	***Definition***	***Giza-111***
EM-FL	Time between plant emergence and flower appearance (R) photo thermal days	**16.25**
FL-SH	Time between first flower and first pod (R3) (photo thermal days)	**10.00**
FL-SD	Time between first flower and first seed (R5) (photo thermal days)	**14.00**
SD-PM	Time between first seed (R5) and physiological maturity (R7) photo thermal days	**33.35**
FL-LF	Time between first flower (R1) and end of leaf expansion photo thermal days	**18.00**
LFMAX	Maximum leaf photosynthesis rate at 30 C, 350 vpm CO2, and high light mg CO2/m2	**1.05**
SLAVR	Specific leaf area of cultivar under standard growth conditions cm2/g	**350.00**
SIZLF	Maximum size of full leaf (three leaflets) (cm2)	**185.00**
XFRT	Maximum fraction of daily growth that is partitioned to seed + shell	**1.00**
WTPSD	Maximum weight per seed (g)	**0.176**
SFDUR	Seed filling duration for pod cohort at standard growth conditions photo thermal days	**42.50**
SDPDV	Average seed per pod under standard growing conditions (#/pod)	**2.07**
PODUR	Time required for cultivar to reach final pod load under optimal conditions (photo thermal days)	**10.00**
THRSH	The maximum ratio of (seed/ (seed+ shell)) at maturity	**78.00**
SDPRO	Fraction protein in seeds (g (protein)/g (seed))	**0.40**

2.3. Crop model validation:

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

➢ ***Evaluation of applying CERES and CROPGRO model:***

The two models were evaluated through three methods:

- **First method:**

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

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

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).

- **Second method:**

The Index of agreement (*d*) 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.

- **Third method:**

The correlation coefficient (R^2) between observed and predicted data was calculated to show the trend in observed and predicted data. Correlation coefficient: the measure of liner relationship between two variables x and y.

➢ **Characteristics studied by CERES and CROPGRO models:**

At the end of that study, comparison study between the observed and predicted data for the seed or grain yield (Kg/ha) and the harvest index of each studied crop according to the crop simulation program of DSSAT v.4.6.1 program (CERES-Cereal model and CROPGRO-Legumes model) because that traits is the best parameter to observe about the treatment crop effort done under the condition of thread heeds of conservation agriculture triangle (No tillage, permanent soil cover with crop residuals and crop rotations with different plant species)

III. RESULTS AND DISCUSSION

A). Soybean after wheat (summer 2013): -

Results presented in Table (4) shows the effect of tillage systems, NPK fertilizer levels as well as the interaction between them on studied traits of soybean during summer 2013 season through (soybean→ wheat→ soybean) crop sequence. It is worthy to mention that, non-significant differences had been achieved between conventional tillage(CT), semi-conservation agriculture(SCA) and conservation agriculture (CA) for the studied soybean traits.

As for, the effect of studied NPK fertilizer levels, results of the studied soybean characters in summer 2013 indicate that, 100% of the recommended doses of NPK significantly favored soybean plant height (cm), biological yield (kg/fed.), and seed yield (kg/fed.) as compared by 50% of the recommended dose of NPK fertilizers there were enhanced by 23.91 %, 144.35%, and 43.52 % respectively. On the other side, the results indicated that, 50% of the recommended dose of NPK significantly increased harvest index as compared by the 100% of the recommended dose of NPK by 69.65%.

Table (4): Effect of tillage system and fertilizer levels on yield and yield component of Soybean under some crop system (Soybean→ wheat→ Soybean) in season, 2013

Treatments		**plant height (cm)**	**Biological yield (kg/fed.)**	**Seed yield (kg/fed.)**	**Harvest index**
Tillage systems	**Fertilizer level**				
Conventional tillage (CT)	**100 % NPK**	116.33	5244.00	1233.00	0.235
	50% NPK	85.33	2037.00	710.00	0.349
Mean		**100.83**	**3640.50**	**971.50**	**0.292**
Semi-conservation agriculture (SCA)	**100 % NPK**	117.67	5297.00	1235.00	0.233
	50% NPK	99.33	2260.00	957.00	0.423
Mean		**108.50**	**3778.50**	**1096.00**	**0.328**
Conservation agriculture (CA)	**100 % NPK**	116.67	5389.00	1262.00	0.234
	50% NPK	98.33	2221.00	932.00	0.420
Mean		**107.50**	**3805.00**	**1097.00**	**0.327**
	Mean NPK fertilizer				
	100 % NPK	**116.89**	**5310.00**	**1243.33**	**0.234**
	50% NPK	**94.33**	**2172.67**	**866.33**	**0.397**
	LSD at 5%				
	Tillage systems (TS) =	**NS**	**NS**	**NS**	**NS**
	Fertilizer (F) =	**12.06**	**484.00**	**326.00**	**0.011**
	TS x F =	**22.45**	**997.00**	**396.00**	**0.030**

Regarding to, the interaction effect between studied treatments, results revealed that, it had significant effect on the studied traits, Table (4) clarified that, the application of conservation agriculture (CA) and fed by the 100% of the recommended dose of NPK fertilizers scored the greatest value for soybean biological yield and seed yield (kg/fed..) as compared with the other treatments. on contrast, the lowest values for soybean plant height, biological yield and seed yield were resulted under the condition of conventional tillage (CT) and fed by the 50% of the recommended dose of NPK fertilizers being (85.33 cm), (2037 kg/fed.), and (710 kg/fed.) respectively**.**

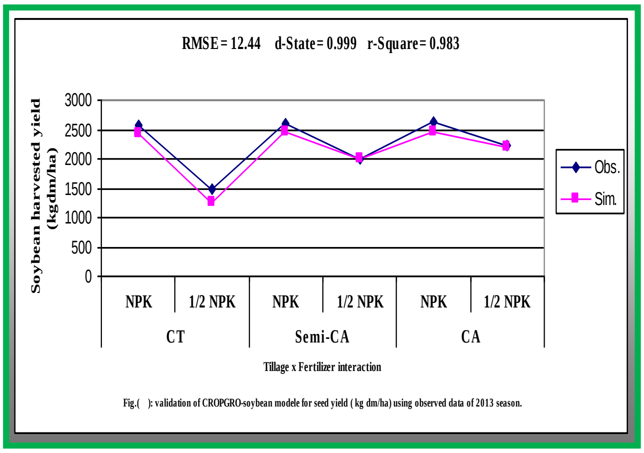
Validation data by CROPGRO -Soybean model (predicted data)

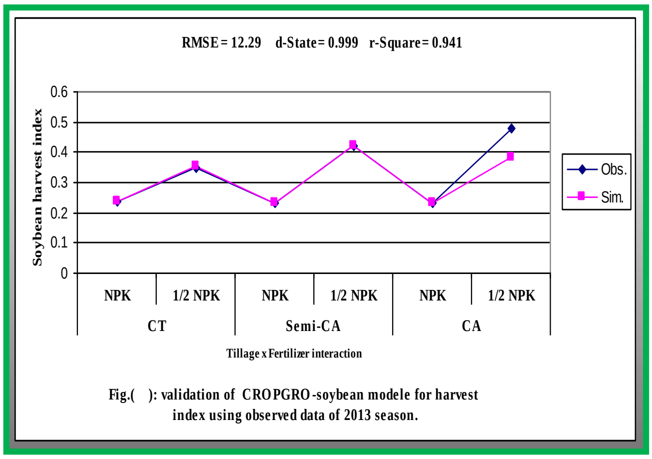
Validation data revealed that, the output data from the CROPGRO-soybean model for soybean seed yield (kg/ha) and harvest index for summer 2013 season, were good coincided with the observed data as affected by tillage system, fertilizer levels and the interaction between them RMSE=12.44 and 12.29 respectively, and its D-state were 0.999 and 0.999 respectively. As for the correlation between observed and predicted data, the correlation coefficient between them was strong 0.980 and 0.941 respectively. These results are similar to [16]. Who concluded that, the model CROPGRO-soybean model can be used to predict soybean yield in different environments as determined by season, optimum-sowing date, inter and intra spacing, management practices, prevailing weather parameters and moisture.

Table (5): the coincided between observed and predicted data of seed yield (kg dm/ha) and harvest index of Soybean as affected by the interaction between tillage system and fertilizer levels through (Soybean-Wheat-Soybean) crop sequences

Crop sequence		***Summer, 2013, Soybean crop***			
		Seed yield (kg dm/ha)		***Harvest index***	
Treatments		***Observed***	***Simulated***	***Observed***	***Simulated***
CT	100 % NPK	2583	2440	0.235	0.236
	50% NPK	1487	1250	0.349	0.351
Semi-CA	100 % NPK	2587	2468	0.233	0.23
	50% NPK	2004	2010	0.423	0.423
CA	100 % NPK	2642	2465	0.234	0.233
	50% NPK	2217	2200	0.477	0.38
Validation CROPGRO-Model					
RMSE=		12.44		12.29	
d-State=		0.999		0.999	
r -Square		0.980		0.941	
Coincided degree		Good		Good	

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





Figs (1 and 2): the coincided between observed and predicted data of harvested yield (kg dm/ha) and harvest index of Soybean as affected by the interaction between tillage system and fertilizer levels through (Soybean-Wheat-Soybean)

B). Wheat after Soybean (2013/2014).

Data in Table (6) illustrated the effect of tillage systems, NPK fertilizer level and the interaction effect between them through (soybean- wheat- soybean) crop sequence in winter 2013/2014 season. From the results, it could be notice that, conservation agriculture (CA) significantly pronounced it superiority reflect on increase wheat no. of spikes/m^2 by (18.51%, 59.41%), biological yield/fed. by (8.73%, 48.91%), and grain yield/fed. by (10.42%, 27.65%) as compared by semi-conservation agriculture (SCA) and conventional tillage (CT) respectively. As for harvest, index results showed that, conventional tillage (CT) significantly increased wheat harvest index by 18.82 and 16.87 % as compare by (SCA) and (CA) respectively. With the respect of, fertilizer levels, results in the previous Table showed that, 100% of the recommended doses of NPK significantly favored wheat biological yield(kg/fed.) and grain yield (kg/fed) as compared by 50% of the recommended dose of NPK fertilizers by 15.79% and 17.33 % respectively. On the other hand, insignificance effect had been achieved for the studied NPK fertilizer doses on no. of spikes/m^2 and harvest index. Regarding to, the interaction effect between studied treatments, results recorded in Table (6) clarified that, growing wheat plants under the condition of conservation agriculture (CA) and fed by the 100% of the recommended dose of NPK fertilizers scored the greatest value for no. of spikes/m^2 (520.33), biological yield (13132 kg/fed), and grain yield (3200 kg/fed.). On the contrary, the lowest value for above mentioned traits were resulted under the condition of conventional tillage (CT) and fed by the half recommended dose of NPK fertilizers (264.67), (7060 kg/fed.), and (2015 kg/fed.) respectively. As for harvest index, results revealed that the application of conventional tillage (CT) + 100% of the recommended dose or 1/2 dose of NPK gave the greatest value for that trait and the differences between them did not reach the significant level. Confirm similar results obtained by, [23]. who stated that, wheat yield when cropped under no-till system presents higher productivity combined with crop rotation than under continuous cropping; lower productivity tends to occur under conventional tillage and the difference in productivity under no-till using crop rotation and continuous cropping is 450 kg/ha for wheat. In addition, these results are in agreement with those of, [21], who found that, zero tillage straw retained (ZTsr) produced highest no. spikes/m2 and 1000-grain weight, at 200 kg N/ha and produced higher soil organic matter (SOM) at 200-250 kg N ha at the end of 2yr cropping. Thus, ZTsr with 200 kg N/ ha may be an optimum and sustainable approach to enhance wheat yield and soil quality. In addition, [31], they concluded that, higher grain yield and straw biomass of wheat were obtained from wheat produced on minimum tillage following faba bean with recommended N-P fertilizer application as compared to barley and continuous wheat. In addition, [15], found that grain yield of wheat following soybean was greater than wheat following grain sorghum. Mean grain yield of wheat following barley was equal or less than continuous planted under minimum and conventional tillage system.

Table (6): Effect of tillage system and fertilizer levels on yield and yield component of wheat under some crop system (Soybean → wheat→ Soybean) in season, 2013/2014.

Treatments: Tillage systems	Treatments: Fertilizer level	No. of spikes/m2	Biological yield (kg/fed.)	Grain yield (kg/fed.)	Harvest index
Conventional tillage (CT)	**100 % NPK**	371.00	10390	2933	0.282
	50% NPK	264.67	7060	2015	0.285
Mean		**317.84**	**8725**	**2474**	**0.284**
Semi-conservation agriculture (SCA)	**100 % NPK**	437.00	12600	3037	0.241
	50% NPK	418.00	11298	2683	0.238
Mean		**427.50**	**11949**	**2860**	**0.240**
Conservation agriculture (CA)	**100 % NPK**	520.33	13132	3200	0.244
	50% NPK	493.00	12852	3117	0.243
Mean		**506.67**	**12992**	**3159**	**0.244**
Mean of NPK fertilizer	100 % NPK	442.78	12041	3057	0.256
	50% NPK	391.89	10403	2605	0.255
LSD at 5%					
Tillage systems (TS) =		**25.90**	**571**	**221**	**0.026**
Fertilizer (F) =		**NS**	**1137**	**450**	**NS**
TS x F =		**180.65**	**2166**	**749**	**NS**

- **Validation data by CERES-wheat model (predicted data)**

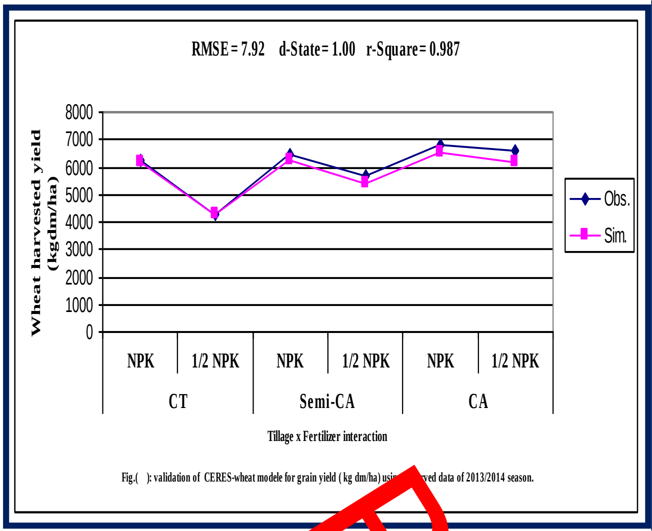
The results indicated that the output data from the CERES-wheat model (predicted data) for wheat grain yield (kg/ha) and harvest index for winter 2013/2014 season reached to be excellent coincided (RMSE=7.92 and 1.76) and its D-state were (1.00 and 1.00), respectively, as compared with observed data affected by the interaction between tillage system and fertilizer rates while the correlation coefficient between them was 0.987 and 0.975 respectively.

This result is incongruent with [9]. In Egypt, indicated that, by comparing results obtained from CERES-Wheat model and actual observations in the field enabled us to reach very good calibration and validation of the model for predicting phonological stages as well as grain yield at different locations. In addition to, [5], who found that, the calibrated and validated of CERES-Wheat model can be successfully used for the prediction of wheat growth and yield under conditions appropriate to Western Europe. In addition, confirm similar results obtained by [27], who found that, the RMSE of final grain yield was 0.7 t ha^{-1} for calibration and testing. This study showed that DSSAT might be used to predict the growth and yields of wheat genotypes in Algeria. In addition, [33], who reported that, CERES-wheat model can act as a useful tool for winter wheat yield forecast in Beijing. Moreover, [30]. Reported that, the CERES-Wheat predicted the anthesis and maturity dates quite well (normalized RMSE = 4–5%; D-index = 0.94–0.99), and over eight sets for grain and two sets for biomass yield. The model predicted them also reasonably well (RMSE = 10–16%; D-index = 0.86–0.97).

Table (7): the coincided between observed and predicted data of seed yield (kg dm/ha) and harvest index of wheat as affected by the interaction between tillage system and fertilizer levels through (Soybean-Wheat-Soybean) crop sequences

Crop sequence		*Winter, 2013/2014, Wheat crop*			
		Grain yield (kg dm/ha)		*Harvest index*	
Treatments		*Observed*	*Simulated*	*Observed*	*Simulated*
CT	**100% NPK**	6213	6199	0.282	0.283
	50% NPK	4268	4270	0.285	0.285
Semi-CA	**100% NPK**	6432	6235	0.241	0.240
	50% NPK	5684	5400	0.238	0.237
CA	**100% NPK**	6778	6550	0.244	0.247
	50% NPK	6602	6160	0.243	0.230
Validation CERES-Model	RMSE=	7.92		1.76	
	d-State=	1.000		1.000	
	r -Square	0.987		0.975	
Coincided degree		Excellent		Excellent	

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



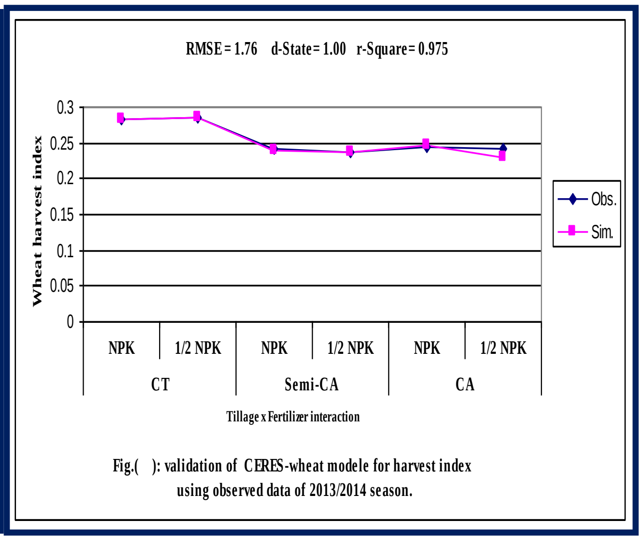


Fig (3 and 4): the coincided between observed and predicted data of harvested yield (kg dm/ha) and harvest index of wheat as affected by the interaction between tillage system and fertilizer levels through (Soybean-Wheat-Soybean**)**

C). Soybean after wheat (summer 2014):

Results presented in Table (8) showed that, soybean plant height (cm), biological yield (kg/fed.), seed yield (kg/fed.) and harvest index as affected by tillage systems, NPK fertilizer level and the interaction effect between them through (soybean→ wheat→ soybean) crop sequence in 2014 season.

Results concluded that, conservation agriculture (CA) significantly pronounced its superiority reflected on increase soybean plant height by (25.76%, 10.73%), biological yield/fed. by (32.02%, 21.20 %), and seed yield/fed. by (37.29 %, 17.25%) as compared with either of conventional tillage (CT) or semi-CA respectively. As for harvest index results revealed that, semi-CA significantly showed its superiority reflected on increase soybean harvest index by (3.70 %, 6.21%) as compared with either of conservation agriculture (CA) or conventional tillage (CT) respectively.

With respect to fertilizer levels, results evident that, there is no significant difference between the recommended doses of NPK and the half dose of it for soybean plant height (cm), biological yield/fed., seed yield/fed. and harvest index

Regarding to, the effect of first order interaction between tillage system and fertilizer levels, results clarified that, growing soybean plants under the condition of conservation agriculture (CA) and fed by 100% of the recommended dose or half dose of NPK fertilizers exposed the greatest values for plant height (138.33-136.67 cm), biological yield (6265 - 4825 kg/fed.), and seed yield (1638- 1602 kg/fed.) respectively.

These previous results were similar to the findings concluded by [23]. who indicated that, soybean yield when cropped under no-till system present higher productivity combined with crop rotation than under continuous cropping; lower productivity tends to occur under conventional tillage and the difference in productivity under no-till using crop rotation and continuous cropping is 500 kg/ha for soybean. [3]. who reported that, soybean yield increased by 56 %, while fertilizer inputs for these crops were cut back by 50%, confirmed similar results. In addition to, (1) found that, Legumes in CA rotations provide increased, availability of nitrogen, thus diminishing the need for large amounts of applied nitrogenous fertilizers.

Table (8): Effect of tillage system and fertilizer levels on yield and yield component of Soybean under some crop system (Soybean→ wheat→ Soybean) in season, 2014

Treatments		**plant height (cm)**	**Biological yield (kg/fed.)**	**Seed yield (kg/fed.)**	**Harvest index**
Tillage system	**Fertilizer level**				
Conventional tillage (CT)	100% NPK	110.33	5300	1360	0.257
	50% NPK	108.33	3100	1000	0.323
Mean		**109.33**	**4200**	**1180**	**0.290**
Semi-conservation agriculture (SCA)	100% NPK	125.00	5450	1510	0.277
	50% NPK	123.33	3700	1253	0.339
Mean		**124.17**	**4575**	**1382**	**0.308**
Conservation agriculture (CA)	100% NPK	138.33	6265	1638	0.262
	50% NPK	136.67	4825	1602	0.332
Mean		**137.50**	**5545**	**1620**	**0.297**
Mean of NPK fertilizer					
	100% NPK	**124.55**	**5672**	**1503**	**0.265**
	50% NPK	**122.78**	**3875**	**1285**	**0.331**
LSD at 5%					
	Tillage systems (TS) =	**8.5**	**498**	**119**	**0.010**
	Fertilizer (F) =	**NS**	**NS**	**NS**	**NS**
	TS x F =	**28.69**	**1970**	**590**	**0.050**

- **Validation data by CROPGRO-soybean model (predicted data)**

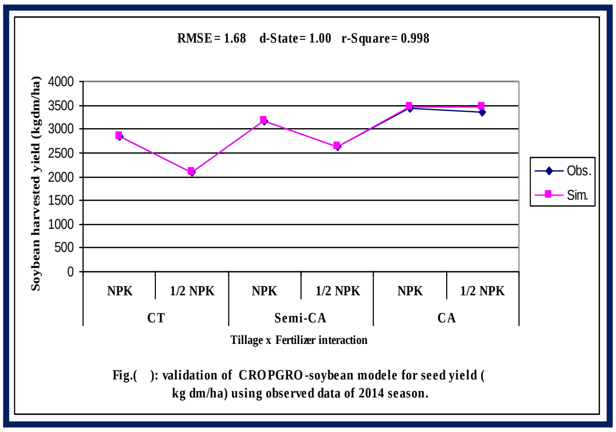
The validation of data for first order interaction effect (tillage x fertilizer) is presented in Tables (9) and figure (5 and 6), The results revealed that the output data from the CROPGRO-soybean model for seed yield (kg/ha) and harvest index for summer 2014 season reached to the excellent and good harmony with the observed data (RMSE=1.68 and 16.24) and its D-state were (1.00 and 0.999), respectively.

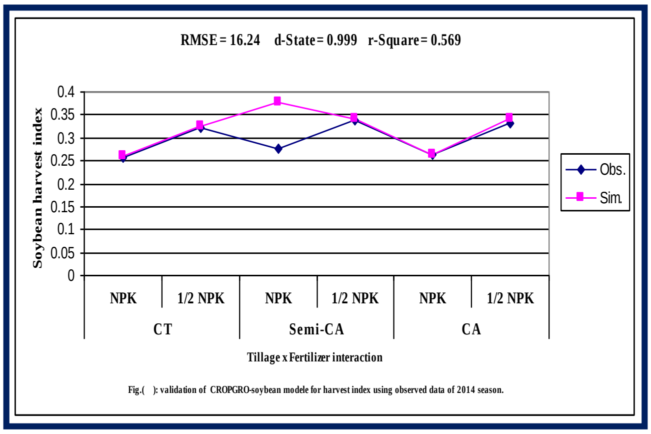
Regarding to the correlation coefficient between them for the two previous traits was 0.998 and 0.569 respectively. This trend is in harmony with previous results reported by [24], who concluded that the modified parameters improved the accuracy of the CROPGRO-Soybean model for the calibration year but did not significantly improve prediction for the three independent years

Table (9): the coincided between observed and predicted data of seed yield (kg dm/ha) and harvest index of Soybean as affected by the interaction between tillage system and fertilizer levels through (Soybean-Wheat-Soybean) crop sequences

Crop sequence		**Summer, /2014, Soybean crop**			
		Seed yield (kg dm/ha)		**Harvest index**	
Treatments		**Observed**	**Simulated**	**Observed**	**Simulated**
CT	**100%NPK**	2848	2844	0.257	0.259
	50% NPK	2094	2090	0.323	0.325
Semi-CA	**100%NPK**	3163	3165	0.277	0.378
	50% NPK	2625	2622	0.339	0.340
CA	**100%NPK**	3431	3465	0.262	0.265
	50% NPK	3355	3450	0.332	0.340
Validation CROPGRO-Model					
RMSE=		1.68		16.24	
d-State=		1.000		0.999	
r -Square		0.998		0.569	
Coincided degree		Excellent		Good	

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





Figs (5 and 6): the coincided between observed and predicted data of harvested yield (kg dm/ha) and harvest index of Soybean as affected by tillage system and fertilizer levels through (Soybean-Wheat-Soybean)

IV. DISCUSION

As explained before, in Egypt our agricultural farming systems involving extensive tillage and removal or in site burning of crop residuals which lead to soil erosion and degradation [32]. Confirmed that, which reflected on increasing the production coast through the intensive consumption of chemical fertilizer for improving the soil productivity to gain profit. Conservation agriculture (CA) is approving approach to save food production and mix possible benefits to smallholder farmers, consumers and rural national economies especially in dry regions like Egypt. The innovation of conservation agriculture is to avoid plowing of the soil, which saves time, energy and labor while conserving water and nutrients in the soil to support crop production, as shown from the results of the researches that, conservation agriculture gives at least the same yield as conservational tillage, often more, with less time and energy input and better environmental sustainability.

The results of our research confirmed almost the benefit of fallow conservation agriculture as compared with the conventional tillage (CT). The results revealed that, by applying the conservation agriculture instructions (1. Mi nimum soil disturbance, 2- permanent soil cover with crop residuals or cover crops and 3. crop rotation with different plant species which include legumes) starting from summer season 2013 with soybean crop through winter season 2013/2014 with wheat and ended by summer season of 2014 with soybean in the same site, results recorded gradually improvement of the productivity, started from non-significant differences between the three tested tillage systems on soybean studied traits until at the end of the crop sequence. That agrees with that documented by International Center for Agriculture Research in the dry areas [12], who reported that CA gives at least the same yields as conservational tillage, which may be due to increasing nodulations and biological nitrogen fixation under CA as reported by [19]. Through winter 2013/2014 season with wheat, started CA or SCA (semi-CA) pronounced their superiority reflecting on increase wheat No. of spike/m2, biological yield/fed, grain yield/fed and harvest index. These results probably were attributed to the role of the residual organic nitrogen as constructive element come from planting soybean before.

After harvesting wheat and applying the three tillage systems and cultivate soybean, also CA or SCA tillage system led to more positive effect on the studied soybean traits, these may be attributed to the accumulate effect of nutrients in the soil appositive effect of CA or SCA compared by (CT) system.

As for, the results of first order interaction effect between tillage system and fertilizer NPK rate through the crop sequences soybean→ wheat → soybean for each crop, it is very interest to approve that, CA or SCA led to save half dose of NPK fertilizer rate for each crop and that gained by p
the greatest values of studied traits for soybean, wheat and soybean through 2013, 2013/2014 and 2014.

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