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Evaluating Ceres-Maize Model under Different Irrigation and Nitrogen Fertilizer Rate in Medial Egypt

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ABSTRACT.

Increasing water productivity with improving and enhancing agriculture practices becoming biggest target of worldwide country especially in developing country i.e. Egypt .Simulation models, such as the DSSAT (Decision Support System for Agrotechnology Transfer) Crop System Models are often used to characterize, develop and assess field crop production practices. In this study, one of the DSSAT Cropping System Model; CERES-Maize was employed to characterize maize (Zea mays) yield, water use and nitrogen uptake at Sids, Beni Swief Governorate condition in Middle Egypt (Lat. 29º 04' N, Long. 31º 06' E and 30.40 m above the mean sea level). A field experiment was conducted including three water regimes (irrigating at 100%, 85% and 70% of reference evapotranspiration (ETo) and three nitrogen levels (216, 288 and 360 kg N/ha).After success model calibration with data collected from two distinct growing seasons (summer 2013-2014) ,the model was used to predict the grain yield, ET crop and N uptake. Then, validation was done and, results showed high correlation between simulated versus observed data with values of correlation coefficient (R^2) ranged between 0.92 and 0.99. Running simulation showed that increasing soil water content increased simulated grain yield and ET crop while N uptake was not effected by increasing soil water. Yield was positively affected by increased N-level and maximum simulated values were obtained at 336 kg N/ha but the ET crop increase was limited due to increase N levels. These outcomes indicate that such model can be used to improve our understanding of the effects of irrigation and N fertilizer management practices on maize yield especially if the long-term irrigation and fertilizer management practices strategy have been adopted under study region conditions.

Keywords: irrigation water- mineral nitrogen fertilizer, maize productivity- CERES-Maize simulation model

INTRODUCTION

Water scarcity is becoming an biggest problem increasingly resource worldwide. Therefore, shortage the water coupled with rapidly increasing population growth especially in developing country i.e. Egypt (arid climate condition and limited resource of water) necessitates protocols to enhance water productivity in agriculture [Pereira, L.S., 2006], and governorate and the farmer's goal should be maximize net income per unit water used rather than per land unit. . In field crops, a well- designed deficit irrigation regime can optimize water productivity over an area when full irrigation is not possible (Fereres and Soriano, 2007). Maize crop (Zea mays) is ranked the third important crop after wheat and rice in worldwide countries. It is the most popular crop due to its high yielding per unit area and low cost of production. The grains contains 65 % carbohydrates, 10-12 % protein and 4-8 % fat (Iken and Amusa, 2004). (FAO Statistical Yearbook, 2014), stated that total sowing area was more than 180 million ha which produced 1,016,431,783 ton of maize grains yield with an average of 5.52 metric ton ha^{-1}. In Egypt , Corn is desired for its multiple purposes as human food, animal feed, and pharmaceutical and industrial manufacturing with cultivated area in 2013 was 703,921 ha with an average productivity equals 7.72 ton ha^{-1} under surface irrigation (Zohry and Ouda, 2015 and Abdullah et al., 2015). the local production does not meet the consumption. Therefore, the main goal in agriculture production in the coming decades focused mostly on the increasing of yield and production (Ulusoy, 2001 and Amanullah et al., 2014). This goal could be achieved by growing more productive cultivars and enhancing the agronomic factors e.g. efficient irrigation management as well as fertilization, especially Maize (Zea mays L.) growth and yield are most sensitive to nitrogen applications under moisture stress condition

Nitrogen fertilizer is very important for all plants; it promotes the vegetative growth and increases the protein content in cereals. The imbalance fertilizer application can significantly reduce fertilizer use efficiency with 20-50%. Only the whole "package" of agronomic practices will result in the highest effectiveness of fertilizers in food production (FAO, 1980).

Computer simulation models, which are able to capture the short or long-term effects of weather fluctuations , various soil properties and management practices on the soil water balance, nutrient dynamics, and crop growth and final yield production could contribute to further our understanding of cropping systems performance under different environmental. Its almost are used to study the interactive effects of various management strategies, and could simulate scenarios under different conditions of soil, atmosphere, irrigation strategies, and agricultural management (Kloss et al.2012; Homayounfar et al. 2014; Singh 2014). Such models should improve the efficacy of decision making for fertilizer and water management. The DSSAT CERES-maize model is a maize growth simulation model that describes daily phonological development in response to environmental factors. The CERES-maize model is cultivar-specific and site-specific and operates on a daily time step. It dynamically simulates the development of roots and shoots, the growth and senescence of leaves and stems, biomass accumulation, and the growth of maize grain yield as a function of soil and weather conditions, crop management practices, and cultivar characteristics. It employed commonly over ward (Eid *et al* (1997), Sowalim *et al.* (2003) Ma *et al.* (2006) ,López-Cedrón *et al.* (2005), Liu *et al.* (2011) and De Jonge *et al.* (2012)

In anticipation of future applications of the CERES-maize model in the region, the objective of this study is to evaluate its ability to simulate growth, yield, water and nitrogen use of a Maize cultivar grown under different water and N regimes in Middle Egypt at the Sids Research Station of Agriculture Research Center of Egypt.

MATERIALS AND METHODS

The field experiments data

The field data used for model calibration/ validation were obtained from two field experiments carried out at Sids Agricultural Research Station (Lat. 29º 04' N, Long. 31º 06' E and 30.40 m above the mean sea level), during 2013 and 2014 growing season under Beni Swief region condition in Middle Egypt. The treatments were laid out in a split-plot experimental design with four replicates. Plot area was 5X7 m2 in both growing seasons. Sowing dates were 20^{th} and 25^{th} of May for the first and second seasons, respectively. Plants were harvested on 23^{th} and 25^{th} of September for the same two respective seasons. The preceding crop was wheat in the two seasons. Irrigation was practiced according to values of the daily reference evapotranspiration (ETo) computed using the Penman-Monteith equation (Allen et al. 1998) for the different irrigation treatments. Application of irrigation regime treatments was practiced and started from the second irrigation and corresponded to ETo value. Treatment was as follows: (I1) 100% ETo; (I2) 85% ETo and (I3) 70% ETo. Water consumptive use (CU) was determined via soil samples from the sub plots just before each irrigation and 48 hrs later as well as at harvest. Sampling depths were 15-cm successive layers down 60-cm depth of the soil profile. The CU was calculated according to Israelsen and Hansen (1962) as follows:

$$CU = D \times Bd \times Q2 - Q1 / 100$$

Where:

CU= actual evapotranspiration (in mm).

D = effective root depth (in mm).

Bd = bulk density of soil in (g/cm3).

Q2= soil moisture percentage two days after irrigation (w/w).

Q1=soil moisture percentage before next irrigation (w/w).

The fertilizer nitrogen treatments were as follows: (N1) 216; (N2) 288 kg and (N3) 360 kg N/ha in the forms of ammonium sulphate (20.6 %N), respectively. Application was done in two equal splits; the first portion was applied before the life irrigation (El- Mohayah irrigation) and the second one after 21 days from the first one. All other practices were applied as adopted in the area. At harvest, the plants of each entire sub-plot were harvested in order to determine component yield and grain yield at 15.5% seed moisture content

Modeling Procedure

CERES-Maize Model Description

The DSSAT CERES-maize model is a maize growth simulation model that describes daily phenological development in response to environmental factors. The model is cultivar-specific and site-specific which operates on a daily time step. It dynamically simulates the development of the growth and senescence of leaves and stems, biomass accumulation, and the growth of maize grain yield as a function of soil and weather conditions, crop management practices and cultivar characteristics. It also predicts the temporal changes in crop growth, nutrient uptake, water use, final yield as well as other plant traits and outputs. By including nitrogen and water balance in the model it is possible to optimally use fertilizers to realize nutrition and water storage in the plant.

Model parameter requirements (input data)

Simulation files contain information allowing the user to build simulation conditions from a database of existing location, soil, crop, and management files. Simulation files also contain information regarding the period of simulation and initial values for variables, which require initialization (Jones *et al.* 2003).

1- Climatic Data

Location file includes latitude, longitude and sea levels, storms evapotranspiration, wind for the study site. Weather database file includes Precipitation, maximum and minimum temperatures, sunshine and solar radiation were collected on a daily basis in each growing season and formatted for model input using WeatherMan software (Pickering et al. 1994; Wilkens 2004). The summarized as monthly weather data are shown in Table1.

2- Soils Data

The soil data measured in 2013-2014 growing season were used as the initial soil parameters required to run the CENTURY-based soil module. The soil profile data included the soil texture, soil organic carbon content (wt.%), pH value measured in water, various soil water contents; soil profile data are shown in Table 2 and Table 3.In addition, the field slope, evaporation limit, color, runoff curve number are required for the soil file (data not shown).

Table 1. Some meteorological data at Sids Agric. Res. Station2013 and 2014 seasons

Season	2013					2014				
Month	T max	T min	RF	SS	SR	T max	T min	RF	SS	SR
May	35.1	19.7	0.0	7.0	268	33.6	19.2	0.0	7.0	268
June	36.0	22.4	0.0	7.0	280	36.0	22.1	0.0	7.0	280
July	35.2	22.5	0.0	7.9	353	36.4	23.3	0.0	7.9	353
August	37.2	23.7	0.0	8.6	441	37.2	23.8	0.0	8.6	441
September	34.8	21.8	0.0	9.6	519	34.7	22.1	0.0	9.6	519
October	30.1	21.2	0.0	10.8	585	30.9	18.5	0.0	10.8	585
Average	34.7	21.9	0.0	8.5	408	34.8	21.5	0.0	8.5	408

T max and T min = maximum and minimum temperatures, °C ; RF = rain fall, mm ; SS = actual sun shine, hr ; SR = solar radiation, $cal/cm^2/day$

Table 2. Soil moisture constants (% by weight) and bulk density (g/cm^3) of soil site of Sids Agricultural Research Station.

Seasons	Soil layer depth (cm)	Field capacity (%, w/w)*	Wilting point(%, w/w)*	Available water (%, w/w)*	Bulk density (gc m^{-3})*
2013	00 – 15	45.08	21.58	23.50	1.13
	15 – 30	37.95	18.04	19.91	1.24
	30 – 45	35.95	17.32	18.63	1.28
	45 – 60	33.14	16.04	17.10	1.32
2014	00 – 15	44.56	22.17	22.39	1.17
	15 – 30	37.09	17.66	19.43	1.29
	30 – 45	35.55	16.92	18.63	1.35
	45 – 60	33.19	15.80	17.39	1.37

Table 3. Some physical and chemical properties of the soil at experimental site.

Particle-size distribution Soil fraction	**Content %**		
Growing season	2013	2013	
sand	16.35	16.35	
Silt	33.45	33.47	
Clay	50.20	50.18	
Textural class	Clay	Clay	
Soil chemical **properties****			
Organic matter	1,55	1.70	%
Available N (KCl-extract)	34.0	32.8 (ppm)	
Available P (Na - bicarbonate extract)	11.20	11.75 (ppm)	
Available K (NH4 - a acetate extract)	213.90	224.31 (ppm)	
pH (1:2.5, soil: water suspension)	7.85	7.9	
EC dSm-1 (1:5)	0.55	0.60	

4 - Crop Variables:

Daily crop growth, expressed of biomass increase per unit area, is calculated every 2 weeks on the basis of the minimum of four limiting factors; light, temperature, water and nitrogen , crop cultivar characteristics are required to crop file. (Jones and Kiniry 1986; Jones *et al*.2003).

5 - Management Variables :

Management variable file include: cultivar selection (, crop rotation (including fallow years), irrigation, nitrogen fertilization, tillage operations and residue management as follows:

1. Planting and harvesting date
2. 50% flowering date and grain falling data .
3. Grain yield kg/ ha.
4. Water management: date, amount and irrigation system.
5. Fertilizers management: date, amount, forms and method of application.
6. Pre-planting practices (type, date, and times of application).
7. Previous crop residue: quantity and depth.

Crop model calibration

For the model calibration, the following are experimental data, which were used as input data for crop management file in simulation module: (the irrigation and nitrogen application were schedule as study treatments).

Soil type : clay.
Cultivar : Single- Cross 10(SC10)
Planting date : 20/05/2013 and 25/05/2014.
Row spacing : 70 cm.
Plant population : 6.2 plant/m^2.

Initial soil water (depth cm, water content %): (5 & 18) (15 & 26) (15 &21) (15& 21) (15&21) (30&17) (30&11) (30& 11) .

Irrigation dates (Julian calendar) and amounts: (schedule (I_1=100% ETo) (I_2=85% ETo) (I_3=70% ETo) for etch irrigation intervals

N-fertilization dates and amounts: (schedule (N1) 216 kg/ha; (N2) 288 kg and (N3) 360 kg N/ha.

The CERES MAIZE model which is used for maize, makes use of five genetic coefficients that summarize various aspects of the performance of a particular genotype. These coefficients are:

Genotype variable	ID	Range of Values	Usual
Juvenile phase coefficient	P1	100- 400	315
Photoperiod sensitivity coefficient	P2	000- 001	0.71
Grain filling duration coefficient	P5	600-1000	870
Growth Aspects			
Kernel number coefficient	G2	350-1000	750
Kernel weight coefficient	G3	5.0 -12.0	8.40

Genetic coefficients of the Egyptian cultivars were created through the model in the calibration/validation tests.

Data for the experiment file were collected and used together with weather data, soil and genetic coefficients in the running the simulation. Only the recommended treatment of =100% ETo and 288 kg N/ha was used to validate the model.

Crop model validation

The model was validated by comparing observed experimental field results for a normal treatment (irrigation at 100 ETo with 288 kg N/ha) with simulated values obtained from the same treatment inputs including the fluctuation of growing season duration, grain yield and cumulative evapotranspiration (Etc) in both growing seasons.

RESULTS AND DISCUSSION

Crop model Calibration/ Validation:

Calibration of crop input parameters allowed the CERES MAIZE Crop model to perform satisfactorily in mimicking the changes throughout the growing season. Also, grain yield, ET, and N uptake at harvest for all treatment combinations were simulated reasonably well. After calibration, the model was validated using the measured data of yield and consumptive use to test the goodness of fit between the measured and predicted data, percent difference (pd) between measured and predicted values for each growing season were calculated .Validation results indicate that the observed and the simulated values are comparable for the maize crop under the experiment condition. Change percentage ranged from 0.95 to 4.96 % (Table 4), and the most similar ones were growing season duration, Et crop , N uptake while grain yield values were rather different. This trend was true in both growing seasons. Crop phonology was predicted closely to the observed values for emergence day, begin flowering day, grain filling for the two growing seasons. Simulated maturity date was 6 days later than observed in 2013 season. In general, validation results were acceptable for the purpose of the study, which indicates that the (CERES MAIZE Crop Models under DSSAT) is valid for predicting maize crop production, water use, growing season duration and N uptake under middle Egypt (Sids) environmental condition.

Table 4 . calibration/validation test regarding various parameters for maize crop during 2013 and 2014 seasons

Tested Variable	2013 growing season			2014 growing season		
	observed	Predicted	P d %	observed	Predicted	P d %
Actual ET mm/seas.*	664	678	2.00	669	671	0.34
Grain yield kg/ha	7999	8330	4.13	8371	8685	3.75
Max plant N cont. at flowering kg/kg	0.0071	0.00731	2.96	0.0084	0.0087	3.57
Min plant N cont. at harvest	0.0414	0.0421	1.69	0.0463	0.048	3.67
Planting date	141	141	0.00	146	146	0.00
Emergence Day	148	150	1.35	153	155	1.31
Begin flower	206	210	1.94	211	213	0.95
Harvest Day	262	268	2.29	265	267	1.89
Crop Season Duration in day	121	127	4.96	119	124	4.20

Pd% = percent difference between measured and predicted values

Crop simulated results

Simulated grain yield, cumulative ET crop and growing season duration at harvest are presented in table 5. The simulated treatments followed closely the 1:1 line when plotted against the experimental data (Figures 1a-b, 2a-b and 3a-b).The statistical analysis confirmed that the CERES MAIZE model predicted the tested variable reasonably well. The results as recorded in table 6 indicate that ETc values followed closely the 1:1 line when plotted against the observed data and R^2 values of 0.0.93 and 0.92 for season 1 and 2, respectively (Figures 2:a, -b), while root mean error square RMES were 26.7 and 29.1 mm for the same respective seasons. On the other hand, ET values varied due to irrigation treatment, predicted ETc values increased positively with increases reached to 28.2 and 30.4 % with (I_1) 100% ETo compared to I_3 70% ETo for season 1 and 2, respectively (Table 6), but ET crop values showed diminutive effect due to N levels. This may be due to the model's phonology strongly depends to soil response to N uptake by plant and possible variations with low level of nitrogen. Regarding grain yield, the same trend was true in both growing seasons with R^2 values being 0.99, 0.99 and RMES were 117.5 and 120.2 kg/h (Figures 1: a, b). Simulated grain yield recorded high response to irrigation treatments and N application levels with most positive response to irrigation at 100 % Etc and 360 kg N/ha N_3. Maximum grain yield was obtained by I_1 x N_3 in the first and second seasons, respectively. Crop phonology was predicted closely to the observed values for a thesis, grain filling and physiological maturity for 2013 and 2014 seasons (Figures 3: a, b). The statistical analysis indicate that growing season duration was predicted very closely to the actual values with R^2 value of 0.99 and RMES values of 1.85 and 3.45 for season 1 and 2, respectively. Simulated maturity date was 6 day later than observed in 2013 season. However, although over estimation occurred in the upper end of the N uptake range, predicted values of response to N level were increased with increased N application levels. N use efficiency as pointed in table 7, showed very high response to the model with value between 0.95 and 0.99 %. All other simulated details are recorded in tables 6 and 7 as a sample of daily output files.

Table 5. Statistical summary comparing simulated vs. observed data

Variable	Data from	Obs. mean	Sim. Mean	R^2	Slope	Const	RMES	d c %
Grain Yield kg /ha	Fig. 1a	7189	7510	0.992	1.186	1018	117.5	104.5
Actual ETc. mm/season	Fig. 2a	556.1	574.1	0.933	0.987	4.52	26.65	97.8
Crop Seas. Length .day	Fig. 3a	121	127	0.997	1.023	0.460	3.447	105.0
Grain Yield kg /ha	Fig. 1b	7540	7910	0.992	1.158	822.5	120.2	104.9
Actual ETc. mm/season	Fig. 2b	577.0	559.1	0.916	0.905	36.96	29.09	96.9
Crop Seas. Length .day	Fig. 3b	120	125	0.999	1.026	2.0633	1.853	104.2

Table 6. Summary simulated values at harvest for maize crop as effected by water and nitrogen regime during 2013 and 2214 seasons.

Treatment	Emergence Day	Begin flowering Flowering	Harvest Day	ET act. mm	Yield Kg/ha	Total N applied kg /h nitrogen uptake Kg N/ha	Total N uptake applied Kg /ha	N use efficiency %	Description
100% ETp*216 N	150	210	268	638.4	7281.6	235.6	231.2	0.981	Maize (winter
100% ETp*288 N	150	210	268	678	8330	307.6	301.4	0.980	Maize
100% ETp*360 N	150	210	268	748.5	9734.4	379.6	370.5	0.976	Maize
85% ETp*216 N	150	210	268	521.8	6744	235.6	231.8	0.984	Maize
85% ETp*288 N	150	210	268	553.9	7920	307.6	302.6	0.984	Maize
85% ETp*360 N	150	210	268	584.2	8928	379.6	369.8	0.974	Maize
70% ETp*216 N	150	210	268	448.0	5011.2	235.6	230.6	0.979	Maize
70% ETp*288 N	150	210	268	469.7	6043.2	307.6	297.1	0.966	Maize
70% ETp*360 N	150	210	268	524.9	7600.8	379.6	361.6	0.953	Maize
100% ETp*216 N	155	213	270	7360.8	7632	234.5	230.2	0.982	Maize
100% ETp*288 N	155	213	270	8371	8685	306.5	302.5	0.987	Maize
100% ETp*360 N	155	213	270	9552	10344	378.5	371.3	0.981	Maize
85% ETp*216 N	155	213	270	6770.4	7202.4	234.5	229.9	0.980	Maize
85% ETp*288 N	155	213	270	7622.4	8184	306.5	298.5	0.974	Maize
85% ETp*360 N	155	213	270	8786.4	9336	378.5	368.1	0.973	Maize
70% ETp*216 N	155	213	270	5510.4	5544	234.5	226.1	0.964	Maize
70% ETp*288 N	155	213	270	6434.4	6592.8	306.5	294.6	0.961	Maize
70% ETp*360 N	155	213	270	7452	7672.8	378.5	358.5	0.947	Maize

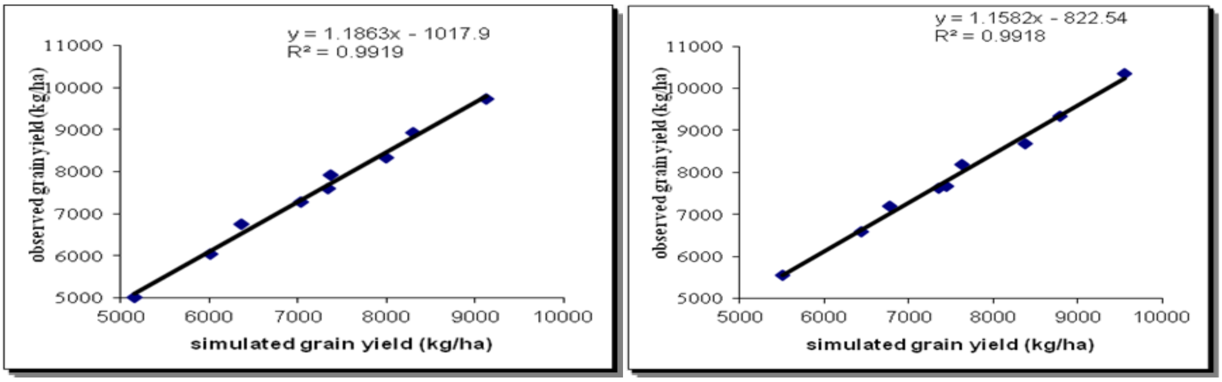

Fig. 1 a,b. Simulated grain kg/h as related to observed data for 2013 and 2014 seasons

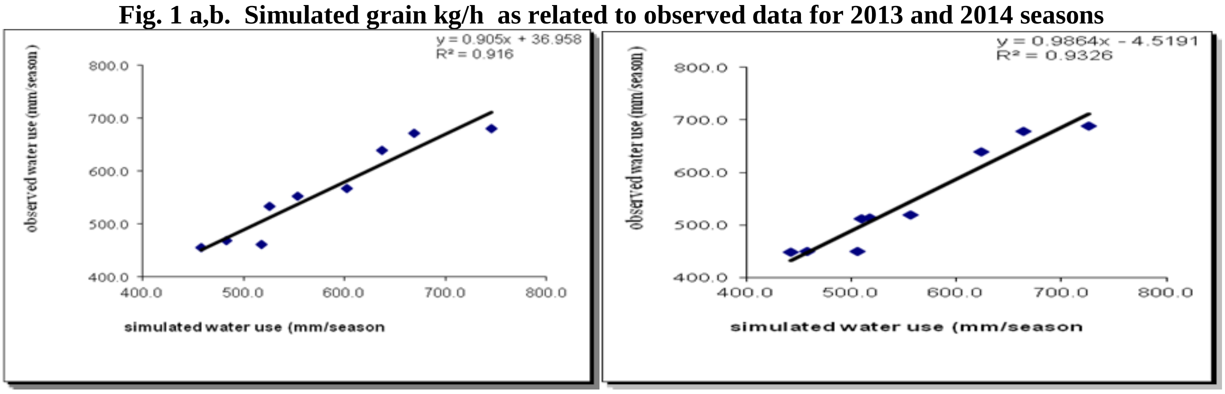

Fig . 2 a,b. Simulated crop water use(Etc mm/season) as related to observed data for 2013 and 2014 seasons

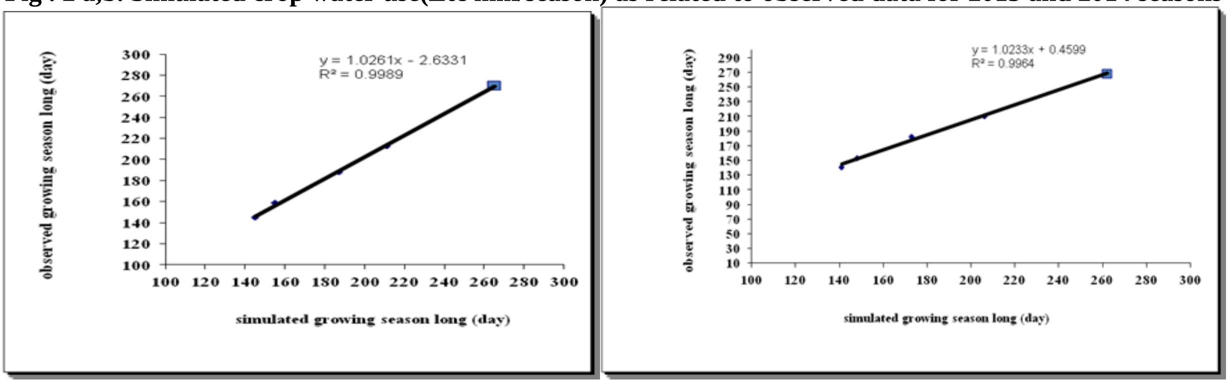

Fig. 3a,b. Simulated growing season long(day) as related to observed data for 2013 and 2014 seasons

CONCLUSIONS

The study showed that CERCS -Maize is able to adequately simulate crop phonology, grain, and water use, as well as the soil N dynamics in the study environment. Therefore, the model can be used for scenario analysis to explore management options and crop production under other regions and crops to be extrapolated in time (long-term responses) after proper calibration and validation.

REFERENCES

Abdullah K., K. Hayrettin, Ö. Mehmet, and B. Gamze. (2015). The effect of different irrigation water levels on grain yield, yield components and some quality parameters of silage Maize (Zea mays indentata Sturt.) in Marmara Region of Turkey. Not Bot Horti Agrobo, (1):138-145.

Allen RG, LS. Pereira, D. Raes, M. Smith (1998) Crop evapotranspiration - guidelines for computing crop water requirements. Irrigation and Drainage Paper No. 56. FAO, Rome

Amanullah, k. ; M. K. Khair, K. Azam , K. Imran , S. Zahir and Z. Hussain (2014). Growth and yield response of maize (Zea mays L.) to foliar NPK-fertilizers under moisture stress condition. Soil Environ. 33(2): 116-123.

DeJong, K., J. Ascough, , A. Andales, , N. Hansen, L. Garcia and M. Arabi (2012).Improving evapotranspiration simulations in the CERES-Maize model under limited irrigation. Agricultural Water Management, 115-.103-92.

Doorenbos, J. and W. O. Pruitt .(1992). Crop water requirements.FAO Irrigation and Drainage. Paper, No. 24, FAO, Rome, 144 pp.

DSSAT3.0. (1995). Decision Support System for Agrotechnology Transfer, V 3.0. Three Volumes. Y. Tsuji, J. W., Jones, G. Uhera, and S. Balas (eds). IBSNAT. University of Hawaii, Honolulu, Hawaii.

Eid, H. M, N. G. Ainer, N. M. El-Mowelhi and O. El-Kholi .(1997). Vulnerability and adaptation to climate change in maize crop. Meteorology & Environmental Cases Conference 2-6 March.

El-Marsafawy, S. M., M. K. Hassanein , H. El-Ramady and Nemait Allah, Y. O.Mokhtar.(2012). Climatic Changes and Their Impact on theBehaviour of Some Maize Varieties in Egypt. New York Science Journal.5:(11); 83-99.

FAO Statistical Yearbook,(2014),http ://faostat.fao.org.

FAO. (1980). *Yield response to water by Doorenbos, J. and A. Kassam. FAO Irrigation and Drainage Paper No. 33, Rome, Italy.*

Homayounfar M, Lai SH, Zomorodian M, Sepaskhah AR, Ganji A (2014) Optimal crop water allocation in case of drought occurrence, is imposing deficit irrigation with proportional cutback constraint. Water Resour Manag 28:3207–3225C rossRef

Iken, J.E. and Amusa, N.A., (2004). Maize research and production in Nigeria. African J. Biotech. 3, 302-307.

Israelsen, O. W. and, V. E. Hansen (1962). Irrigation Principles and Practices, 3rd edit. John Wiley and Sons, Inc., New York, USA.

Je´ go, G., S nchez-Pe´ rez, J. M. and Justes, E. (2012). Predicting soil water and mineral nitrogen contents with the Stics model for estimating nitrate leaching under agricultural fields. Agric.Water Manage. 107:54.65

Jones, J. W. and Kiniry, J. R. (1986). CERES-maize: a simulation model of maize growth and development. Texas A & M University Press, College Station, TX.

Jones, J. W., Hoogenboom, G., Porter, C. H., Boote, K. J،. Batchelor, W. D., Hunt, L. A., Wilkens, P. W., Singh, U،. Gijsman, A. J. and Ritchie, J. T. (2003). The DSSAT cropping system model. Eur. J. Agron. 18: 235.265

Kloss S, Pushpalatha R, Kamoyo KJ, Schütze N (2012) Evaluation of crop models for simulating and optimizing deficit irrigation systems in arid and semi-arid countries under climate variability. Water Resour Manag 26:997–1014CrossRef

Klute, A. (1986). Methods of Soil Analysis. Part 1. 2nd ed. ASA and SSSA. Madison, Wisconsin, USA

Liu HL, Yang JY, Drury CF, Reynolds WD, Tan CS, Bai YL, He P, Jin J, Hoogenboom G (2011) Using the DSSAT-CERES-Maize model to simulate crop yield andnitrogen cycling in fields under long-term continuous maize production. Nutr Cycl Agroecosyst 89:313–328CrossRef

López-Cedrón FX, Boote KJ, Ruíz-Nogueira B, Sal F (2005) Testing CERES-Maize versions to estimate maize production in a cool environment. Eur J Agron 23:89–102CrossRef

Ma L, Hoogenboom G, Ahuja LR, Ascough JC II, Saseendran SA (2006) Evaluation of the RZWQM-CERES-Maize hybrid model for maize production. Agric Syst 87:274–295CrossRef

Mokhtar, N . Y. O. (2009). Impact of climate change on water requirements and productivity of some major field crops in Egypt. Ph.D. thesis Fac., of Agric., Moshtohor, Benha Univ. Egypt

Page, A. L.; R. H. Miller and D. R. Keeny (1982). Methods of Soil Analysis. Part II. Chemical and Microbiological Properties 2nd ed. Amer. Soc. Agron. Inc. Soil Sci. Sco. Amer. Inc. Madison, Wisconsin, USA.

Pereira, L.S., (2006). Irrigated Agriculture: Facing environmental and water scarcity challenges. International Symposium on Water and Land management for sustainable Irrigated Agriculture, Cukurova University April 4-8, Turkey

Pereira, L.S., (2006). Irrigated Agriculture: Facing environmental and water scarcity challenges. International Symposium on Water and Land management for sustainable Irrigated Agriculture, Cukurova University April 4-8, Turkey.

Pickering, N. B., Hansen, J. W., Jones, J. W., Wells, C. M.,Chan, V. K. and Godwin, D. C. (1994). WeatherMan: a utility for managing and generating daily weather data. Agron. J. 86:332-337.

Singh A (2014) Irrigation planning and management through optimization modelling. Water Resour Manag 28:1–14CrossRef

Sowalim, S. M., S. M. El-Marsafay and S. A.. Ouda. (2003). Simulating the effect of irrigation skipping on maize yield and its attributes. Annals of Agric. Sci. Moshtohor. 41(4)1449-1457.

Ulusoy, E. (2001). Objectives of agricultural techniques in changing conditions and conceptions in 2000 years. In 20 National Agricultural Mechanization Congress. Sanliurfa, Turkey.

Wilkens, P. W. (2004). Chaper 4-DSSAT v4 weather data editing program (WeatherMan). In G. Hoogenboom, J. W. Jones, C. H. Porter, P. W. Wilkens, K. J. Boote, W. D. Batchelor, L. A. Hunt, and G. Y. Tsuji, eds. Decision support system for agrotechnology transfer version 4.0. Volume 2,

Zohry, A and . S . Ouda (2015). Facing Water Scarcity in Egypt by Intercropping: Maximizing Maize Production to Reduce its Gap under Changing Climate. LAP LAMBERT Academic publishing. IS: 978-3-659-806285.

استخدام برنامج المحاكاة CERES MAIZE للتنبؤ بمحصول الذرة الشامية تحت معاملات مختلفة من الري والتسميد تحت الظروف البيئية لمصر الوسطى (منطقة سدس-محافظة بنى سويف)

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أقيمت تجربة حقلية بمحطة البحوث الزراعيةبسدس –بنى سويف خلال موسمي 2013 و 2014 لاستخدام نتائجها في تقيم مقدرة برنامج المحاكاة CERES MAIZE (نموذجَ محاكاة للنمو و المحصولِ متعدّدِ المحصولَ متعدّدَ السَنَواتَ،) على تَقليد و التنبؤ بالمحصول والاستهلاك المائي لمحصول الذرة ا صنف (هجين فردى 10) النامي تحت الظروف البيئية لمنطقة مصر الوسطى(بنى سويف) حيث تم جدولة ا لرى باستخدام ثلاث معاملات كنسبة من البخر نتح المرجعى (100% & 80 % & 70 % من ETo) و أضافه ثلاث مستويات متزايدة من التسميد النيتروجيني هي (216 ؛ 288 و 360 كجم /هكتار) . بعد تعديل بيانات البرنامج بالبيانات الحقلية تم إجراء اختبار التأكد والصلاحية بمقارنة القيم الفعلية والمتنبأ بها و كما تم حساب مربع انحرافات الخطأ التجريبي ومعامل التوافق وقد اظهر البرنامج كفاءة عالية للتنبؤ عند مقارنة القيم . كما أن التحليل الإحصائي أظهر قيما عالية لمعامل الارتباط تراوحت بين 0.92 و 0.99 وقد أظهرت نتائج المحاكاة بعد تشغيل البرنامج أن زيادة مستوى الماء الميسر لامتصاص النبات في التربة أدى إلى زيادة محصول الحبوب وكذا الاستهلاك المائي للنبات حيث سجل معامل بجر الوعاء ETo 100% أعلى القيم. كما أظهرت النتائج أيضا زيادة في المحصول بزيادة مستويات النيتروجين المضاف حيث سجلت أعلى القيم مع 360 كجم ن/هكتار إلا إن الاستهلاك المائي زاد زيادة طفيفة فقط مع زيادة مستويات النيتروجين تحت كل معاملات الرى . من ناحية اخرى اظهر البرنامج قدرة عالية على التنبؤ بالنيتروجين الممتص بواسطة النبات وكذا الفقد فى التربة وعند قياس كفاءة استهلاك النيتروجبن بواسطة النبات كانت القيم الاعلى تحت مستويات النتروجين المنخفضة . وعلى ذلك يمكن التوصية باستخدام برنامج CERES MAIZE في التنبؤ بالمحاصيل على نطاق أوسع وتحت ظروف مناخية مختلفة خاصة في مشاريع التنمية المستدامة و أيضا في الدراسات المستقبلية للتغير في المناخ