Central Laboratory for Agricultural Climate

Assessment of the impact of climate change and adaptation on potato production

Dr. Mahmoud Medany

Agricultural Research Center,
Ministry of Agriculture and Land Reclamation, Egypt

Final Report
2006

Table of Contents

Summary

This work was conducted in order to assess the impact of climate change on potato yield and to investigate the possible options for overcoming the negative impacts. A field experiment was carried out at El-Beheira Governorate in season 2005/2006; and included three levels of irrigation (80, 100 and 120 %) from the potential evapotranspiration. The DSSAT (Decision Support System for Agrotechnology Transfer) model was run with weather data, soil data and experimental data in order to predict potato tuber yield. Predicted and measured yields were compared and the results showed a non-significant deference between them. In conclusion, DSSAT was able to simulate potato crop parameters under current conditions with a difference from 0.01 to 0.08 % compared to the actual yield. The potential impact of climate change on potato production was evaluated by simulating different planting dates in Second cultivation (January 1st; January 15th and January 30th) and first cultivation (September 30th October15th and October 30th), irrigation levels (80, 100 and 120 %) on potato production with climate change scenarios by the years 2025s, 2050s, 2075s and 2100s compared with that predicted under the current conditions of 2005. Using the future climate data a yield loss of -3.98, -1.41, 0.16, 0.75 % was projected for second cultivation, while a yield increase of 17.0, 35.9, 44.6, 45.5 % was projected for the first cultivation at time series of 2025s, 2050s, 2075s and 2100s, respectively. The negative impact was decreased when planting date of second cultivation was changed from January 15th to January 1st (from -10.5, -7.2, -5.9, -4.9 to 5.6, 9.9, 13.2, 15.0 for the time series 2025s, 2050s, 2075s and 2100s, respectively). A tuber fresh yield under climate change scenarios (A1, A2, B1, and B2) was increased in different planting dates, irrigation levels in first cultivation. Water level of 100% from potential evapotranspiration gave the highest tuber yield at difference planting dates with climate change Scenarios. Water level of 80% irrigation level treatment had the highest water use efficiency with different planting dates in both cultivations.

The difficulties associated with this assessment are mainly related to the limited utilization of other crop models rather than DSSAT. In addition, reliable data for validation are rather limited and further work is required to cover major strategic crops in relation to limited irrigation water.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the major crops in Egypt. The national potato crop production does meet both the current local demand, and the export market. The rapid growth of the country population, the economic stress of reliance on food imports, and the limited area for agriculture require Egyptians to find new ways to increase agriculture productivity in general and food crops in specific. Potato is a major industrial crop in Egypt and is one of the main food crops grown mainly in delta, and middle Egypt. The production of potato is concentrated in Beheira, Menufia, Gharbia, Giza, Dakahlia and Minia. The selection of high yielding, the optimization of water levels, sowing dates to improve potato crop production under current and future climate change have to be evaluated. The choice of the best ones can conserve the agricultural Resources by sowing dates potato crop in the best time for sustainable agriculture in Egypt. In this connection, the best sowing time can improve productivity. **Sinha et al. (1988)** in India found that the best sowing date for screening cultivars against wilt would be around June 20 as maximum. Disease incidence is likely in the crop sown during this period. **Garcia (1987)** in Cuba grew sweet potato in January, and July. He found delaying from January to July reduced that yield. Early sowing Potato growers believe that early sowing produces a good yield before blight defoliation begins. There is evidence that foliar blight increases in later crops as compared to early ones. However, early sowing cannot be relied upon for blight control in years with early monsoons (**Maung et al. 2001).**

Wolfe et al (1982) in field trials on deep yolo loam soils, found that seasonal evapotranspiration of potato ranged from 31.6 to 61.0 cm for Kennebee cv and from 33.1 to 63.0 for White Rose cv. Water stress reduced yield production due to reduced leaf area and leaf formation duration. **Yamaguchi et al. (1964)** found that yield, specific gravity and starch content of Russet Burbank cv and White Rose cv tubers were higher, and the sugar content lower when grown at soil temperatures between 15 and 24°C, than when grown at higher temperatures. The DSSAT family of models was used extensively to simulate potato growth and yield **(Tsuji et al., 1994).**

Sepp and Tooming (1991) show that potato productivity is most sensitive to changes in spring water storage in soils, shifts in potato sowing time, and growth of precipitation. The key problem of mankind's response to climate change is the adaptation of agriculture to the changed agroclimatic conditions and resources. **Tooming (1988**) recommend that plant cultivation be established according to the principle of maximum plant productivity**.** Generally speaking, plant cultivation in accordance with the principle of maximum plant productivity will utilize natural resources i.e. soil and climate not only with maximal productivity in the existing environment but also with maximal efficiency. Natural plants and plant communities are systems that have adapted to the existing climate and all environmental conditions during a long evolutionary process. Their structure and functions are harmonically related and well adapted to the climate and environmental conditions. Field crops have been developed by human activity over a long period of time. Accordance of plant demands with the given climatic and environmental conditions for agricultural crops is the most important precondition for high productivity if climatic changes as projected by atmospheric scientists **(IPCC, 2001)** adversely affected crop production, Egypt would have to increase its reliance on costly food imports. The rising trend of the global atmospheric carbon dioxide concentration (CO2) is well established. Estimates of future increases range from 45% to 115 % above the pre- industrial levels (near 280 ppm) by the year 2040 **(Pearman, 1988).** This increase of CO2 is expected to induce a change in climate, which its magnitude is still uncertain **(Bolin, et al., 1986; IPCC, 2001)**. Assessments of the impact of CO2 induced change on agricultural productivity are needed for both scientific and policy making purposes. The complexity of climate – crop production interaction makes simulation a useful and probably, the only practical approach available for making the needed assessments **(Claudio, et al., 1992).** In Egypt MAGICC and SCENGEN Climate Scenarios Generator Models was used to create climate change data in vulnerability and adaptation assessments **Eid et al. (2001)**. Water demand for irrigation is expected to increase in all countries of North Africa and it is important to define adaptation strategies that take into account the possible deficit of water for irrigation in the future **(Eid et al., 1995; Iglesias et al., 2003).** The present study aimed to assess the impact of climate change on potato yield and to investigate the possible option for overcoming the possible negative impacts.

Work procedure:

1. Current experiment studies

Field experiment was carried out at El-Bossily region, El- Beheira Governorate, Egypt, during growing seasons of 2005/2006 to study the effect of water levels on potato yield (*Solanum tuberosum* L.) Valour cultivar.. In addition, validation predicted yield by DSSAT (SUBSTOR-Potato model) was compared with actual data and impact of climate change scenarios on production and water needs of potato under different planting dates. The treatments comprised of three water levels (80, 100 and 120 % of the amount of water calculated according to class A pan equation). Date of plating was October 15, 2005. All other agriculture practices of cultivation were performed as recommended by Ministry of Agriculture. Chemical and physical properties of the soil of the experiment were analyzed before cultivation; the results are tabulated in Table (1). The permanent wilting point (PWP) and field capacity (FC) of the trial soil were determined according to **Israelsen and Hansen (1962).** Plot area was 150 m2 (15 m length x 10 m width). Plant distances were 30 cm apart. A distance of 2 m was left between each two irrigation treatments. The total amount of irrigation water was calculated by class A Pan equation. The normal agro-meteorological data of class A Pan evaporation for El-Bosaily region was obtained and expressed as mm/day. Drip irrigation was used the cultivation season. The total amount of drip irrigation was applied by water flow-meter for each treatment (EC of water irrigation 0.8 dS/m). Irrigation treatments were named low, medium and high respectively. The EC of the irrigation ranged from 0.7 to 0.9 dS/m.

Potato tubers were harvested during February, and total yield per feddan was estimated for each treatments.

Water Use Efficiency (WUE) was calculated according to the following equation:

$$\text{WUE}\ [\text{kg/m}^3] = \frac{\text{Total yield [kg/fed]}}{\text{Total applied water } [\text{m}^3/\text{fed}]}$$

Table (1) Chemical and physical properties of the soil of the experiment analyzed before cultivation.

Chemical properties							
Ec m/moh	pH	Ca++ meq/l	Mg++ meq/l	Na+ meq/l	K+ meq/l	HCO3- meq/l	Cl - meq/l
3.00	7.89	30	10	14.26	1.66	2.5	12.6
Physical properties							
Sand %	Clay %	Silt %	Texture	FC %	PWP %	Bulk density g/cm3	
95.31	4.29	0.36	Sandy	16.77	5.65	1.435	

2. Crop model validation for current climate

Field data was used by SUBSTOR-Potato through DSSAT model to simulate and predict potato yield. The experiment data were prepared on the basis of **IBSNAT data set (1988).** The required climatic data for El- Beheira Governorate (Latitude 31.24, Longitude 30.24) were obtained from the Central Laboratory for Agricultural Climate, A.R.C. Egypt. The physical properties of the soil of the experiment of site ;tuber yield potato (kg/hectare) were recorded**.**

Genetic coefficients allow a single potato crop growth model to predict differences in development, growth, and yield among cultivars when planted in the certain environment. The genetic coefficients can be divided into those relate to development and both vegetative and reproductive growth. Definitions of the coefficients. Genetic coefficients were calculated by run The SUBSTOR-Potato model with weather data and experimental data for valour varietiy to calculate the genetic coefficient by using sub model (GENCALC) in order to predict potato growth and yield

The comparison between actual data and predicted data was done through SUBSTOR-Potato model under DSSAT interface in three steps, i.e. retrieval data (converting data to SUBSTOR-Potato model), validation data (comparing between predicted and observed data) and run the model DSSAT provides validation of the crop models that allows users to compare simulated outcomes with observed results. Necessary files were prepared as required. Evaluation of applying SUBSTOR-Potato model: Calculating the difference percentage between predicted and observed data, Correlation coefficient and Paired T-test.

3. Climate data for future (time series 2025s, 2050s, 2075s and 2100s)

Climate change scenarios for site were assessed according to future conditions derived from MAGICC/SCENGEN software of the University of East Anglia (UK). In this the study four scenarios of climatec data were used i.e. A1, A2, B1 and B2. The principle of MAGICC/SCENGEN is to allow the user to explore the consequences of a medium range of future emissions scenarios. The user selects two such scenarios from a library of possibilities. The reason for two scenarios is, primarily, to be able to compare a no action scenario with an action or policy scenario. Thus, in MAGICC/SCENGEN, the two emissions scenarios are referred to as a 'reference' scenario and a 'policy' scenario **(Wigley et al., 2000).** The data which generated from MAGICC/SCENGEN are represented in 4 Scenarios (A1, A2, B1, and B2). These scenarios are described by **IPCC 2001** as follows: The A1 scenario describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies; The A2 scenario describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. There are increasing in population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other scenarios; The B1 scenario describes an approximate world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives; The B2 scenario describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. Increasing global population is at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

4. Crop simulation

The potato simulation model that used was the SUBSTOR-Potato model. The model simulates crop responses to changes in climate, management variables, soils and different levels of CO_2 in the atmosphere. The software used to run the programs, which was developed by the DSSAT and includes database management, crop model and application programs **(Tsuji, et al, 1994)**. Potential changes in potato physiological responses (yield) were estimated using the SUBSTOR-Potato model under different climate scenarios. The model simulates physiological crop responses (water balance, phonology and growth throughout the season) on a daily basis to the major climate factors (daily solar radiation, maximum and minimum temperature and precipitation), edaphic factors and management (cultivar, planting date, plant population, row spacing and sowing depth).

5. Options to mitigation negative impacts in production

Studies on simuilation of different sowing dates and water levels carried out using the following method with DSSAT model. Simulation runs on different sowing dates and water levels through DSSAT model on potato at El- Beheira governorate were carried out. The simulation study was carried for the validation test as well as planting dates at 15 day intervals in Second cultivation (January 1st; 15 January and 30th January 2005) and first cultivation (September 30th, October15th, and October 30th 2005) in order to valdiate applying model under deferance planting date with recommendation tepmerature (the optimum potato planting date can be determined depended on the ongoing weather data minimum temperature for 8-12°C ongoing days). Studies on simuilation of different sowing dates (Second cultivation and first cultivation) in order to impact of climate change on production planting dates and water.

Results of the assessment:

1. Current experiment studies:

The effect of different irrigation levels on potato tuber yield illustrated in Table (2). Regarding the effect of different irrigation treatments, data show that using 100% irrigation level increased potato yield followed by 80 % treatment. The lowest yield was obtained by 120% irrigation level treatment.

Relevant to the effect of different irrigation levels on water use efficiency, data in Table (2) also show that increasing irrigation quantity led to decrease water use efficiency for all irrigation treatments. The highest water use efficiency (WUE) obtained when 80% irrigation levels was used.

The results of this study generally agreed with the observations that increase in water level above 100% irrigation level led to decrease WUE **Norwood (2000), Shani and Dudley (2001) and Erdem et al, (2006).**

2. Crop model validation for current climate:

The comparison between observed and predicted data for tuber fresh yield (kg/ha) in the three water levels at El-bossily region, El- Beheira Governorate is presented in Table (2). It was noticed that the output data from the SUBSTOR-Potato model (predicted data) were in harmony with the observed data for fresh tuber yield. Regarding the effect of different irrigation treatments, data showed that using 100% irrigation level increased potato tuber fresh yield significantly followed by 80 % treatment. The lowest yield was obtained by 120% irrigation level treatment. The same data were obtained from predicted model, Differences in tuber fresh yield (kg/ha) due to water levels in both results from observed and predicted data, 100% irrigation level gave the highest value for yield production as compared with other water levels in observed (24623 kg/ha) and predicted data (24800 kg/ha). The difference percentage between observed and predicted data was from -0.02 to -0.08 % , the average of difference percentage was -0.036%.

Value of correlation coefficient was significant (p-value 0.000); this means the same trend was found in predicted and observed data. Paired T-test value was not significant (p-value 0.135); this means no difference between observed and predicted data. Results of the validation experment indicat that the SUBSTOR- Potato crop model can be used successful in Egypt.

Table (2): Effect of different water application on water use efficiency as well as actual and estimated potato yield.

Water treatments		WUE Kg/m3 water	Tuber fresh yield (kg/ha)		
			Actual	Estimated	Yield Change %
80%	3295	6.61	21352	21770	-0.02
100%	4119	6.02	24623	24800	-0.01
120%	4943	3.8	17340	18760	-0.08
Mean	4119	5.32	21105	21105	-0.036

Correlation coefficient = 0.998
T-value = -1.76
P-value = 0.135

3. Effect of sowing dates and water levels on simulated potato tuber yield

Simulation results of tuber fresh yield (kg/ha) as affected by different sowing dates and water levels are shown in Table (3). Results show that; delaying sowing date from September 30th to October 30th reduced gradually tuber fresh yield in first cultivation ; delaying sowing date from January 15th to January 30th reduced tuber fresh yield in Second cultivation . These results are in agreement with **Ali (1993).** The general trends detected from the overall avarages of simulated tuber yield indicate that potato crop have to be sown in September 30th in first cultivation and January 15th in Second cultivation to obtain the maximum tuber yield and saving irrigation water at the same time. This results is in agreement with that obtained by **Ainer et al. (1993) and Ali (1993).**

Relevant to the effect of different irrigation levels on water use efficiency (WUE), data in Table (3) showed that increasing irrigation quantity led to decrease water use efficiency for all irrigation treatments. The highest WUE obtained by 80% irrigation levels.

The highest WUE obtained by 80% irrigation level followed by 100% irrigation level. The lowest tuber yield was obtained by 120% irrigation level. The results of this study general agreed with the observations that increase water level above 100% irrigation level led to decrease WUE **Norwood (2000), Shani and Dudley (2001) and Erdem et al, (2006**). In general, 80% irrigation level was the best aimed at maximum WUE in this study. This recommendation is slightly different in irrigation from our recommendation aiming at optimum tuber yield obtained by 100% irrigation level. The adoption of 80 % irrigation level will be superior to 100% irrigation level.

Table (3): Effect of different sowing dates on potato production and WUE under current climate conditions.

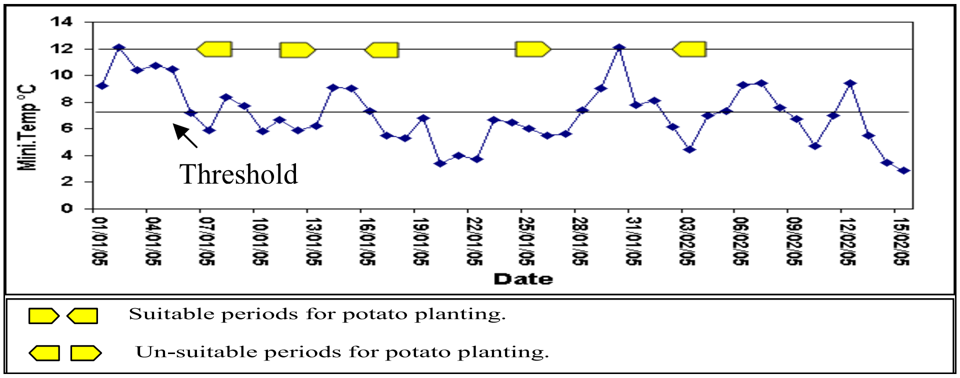
Planting dates		Water treatments	water consumption m3/ha	WUE Kg/m3 water	Tuber fresh yield kg/ha) Current	Mean
First cultivation	September 30th, 2005	80%	3564	9.46	33730	32133
		100%	4455	7.37	32810	
		120%	5346	5.59	29860	
	October 15th, 2005	80%	3295	6.61	21770	21777
		100%	4119	6.02	24800	
		120%	4943	3.80	18760	
	October 30th, 2005	80%	2868	6.90	19800	18743
		100%	3585	5.35	19180	
		120%	4302	4.01	17250	
Second cultivation	January 1st, 2005	80%	3234	7.68	24830	25703
		100%	4042	6.28	25390	
		120%	4850	5.54	26890	
	January 15th, 2005	80%	3684	6.86	25280	25750
		100%	4605	5.63	25940	
		120%	5526	4.71	26030	
	January 30th, 2005	80%	4278	5.63	24080	24653
		100%	5348	4.65	24860	
		120%	6417	3.90	25020	
Water treatments		80%	3487	7.19	24915	24793
		100%	4359	5.88	25497	
		120%	5231	4.59	23968	
Mean			4359	5.89	24793	

4. Potato planting prediction

Potato is cultivated during three seasons: fall, winter and spring/summer **(El-Bedewy R. and A. Sharara, 1990)**. The main problem in potato production during Second cultivation (local multiplication potato seeds in Egypt) is the germination decline percentage. The minimum temperature after planting is the major factor for successes germination. The weather analysis results indicated that, the potato planting threshold is between 7.5-8 °C as minimum temperature under the Egyptian weather conditions. **Riha et. al., (1996)** found that the suitable minimum temperature for success germination is 7-10°C.

The above mentioned analysis indicate that, the optimum planting dates in the study region (Bosaily, north Egypt) are 1st to 4th January 2005, 11th to 16th January 2005 and 27th January 2005 to 3rd February 2005, In this connection, the best sowing time can improve productivity. The observed and simulated fresh tuber yield value was closed with planting prediction results. Generally, it could be concluded that SUBSTOR-Potato model could be used predict tuber yield of potato under North Egypt conditions in future to make different strategy.

Figure (1): Minimum air temperature during the groing season in comparison with recommended and minmum temperature threshold planting dates



5. Effects of Climate Change and water levels on potato Production

5.1 Potato Second cultivation

The potential impact of climatic changes on tuber fresh yield potato was evaluated by simulating different planting dates (Second cultivation), irrigation requements level on simulated potato production with climate change Scenarios (A1, A2, B1, and B2) medium refer to aerosol levels by the year 2025, 2050, 2075 and 2100 compared with that predicted under the current conditions 2005 (Table 4 and 5). The tuber fresh yield potato differed according to water levels, planting dates and climate change Scenarios. The difference percentage between current predicted (2005) and predicted under climate change senirios was from -16.1 to 26.5 % , the average of difference percentage was -3.98, -1.41, 0.16 and 0.75 % by the year 2025, 2050, 2075 and 2100 Respectively. The predicted temperature increases affected crop production negatively. The B1 scenario resulted in simulated tuber yield reductions from 0.1% to -4.2 % less than that predicted under the current conditions. By studying the decreasing effect of the climatic changes on the crop using some alternative ways include changing of planting date. The results show that early planting date (January 1st) tends to positively increase yield compared with the current conditions and under the changed climatic conditions.

Potato adaptation would do little to counterbalance the negative temperature effects seen in our simulations. Current Egyptian potato production is limited to cultivars that need a period of cold weather for tuber initiation. The only viable strategy to reduce yield losses would be a change in planting dates, to allow for increased storage of carbohydrates and sufficient time for leaf area development prior to tuber initiation. These results are in agreement with **Medany (2001)** he found that the Change of planting dates under changed climatic conditions improved simulated yield on maize.

Table (4): Interaction of the effect of different planting dates (Second cultivation), irrigation requirements level on simulated potato production with climate change Scenarios (A1, A2, B1, and B2) for the years 2025s, 2050s, 2075s and 2100s.

Water Req.	Tuber fresh yield (kg/ha)								
	2005	2025s A1		2050sA1		2075s A1		2100sA1	
	Current	Estimated	difference %	Estimated	difference %	Estimated	difference %	Estimated	difference %
80%	24830	27320	10	28590	15.1	29350	18.2	29130	17.3
100%	26890	27450	2.1	28850	7.3	29520	9.8	29710	10.5
120%	25390	27050	6.5	28190	11	29170	14.9	29350	15.6
80%	25280	23160	-8.4	23780	-5.9	24140	-4.5	24120	-1.6
100%	26030	23350	-10.3	24620	-5.4	24940	-4.2	24880	-7.3
120%	25940	22380	-13.7	23330	-10.1	23710	-8.6	23970	-7.6
80%	24080	20430	-15.2	20480	-15	20350	-15.5	20210	-16.1
100%	25020	24710	-1.2	24610	-1.6	24900	-0.5	24790	-0.9
120%	24860	23770	-4.4	23870	-4	23840	-4.1	23210	-6.6
		2025s A2		2050s A2		2075s A2		2100s A2	
80%	24830	27270	9.8	28590	15.1	29970	20.7	31410	26.5
100%	26890	27240	1.3	28850	7.3	29770	10.7	30950	15.1
120%	25390	26980	6.3	28190	11	29570	16.5	30040	18.3
80%	25280	23340	-7.7	23780	-5.9	24920	-1.4	25420	0.6
100%	26030	23140	-11.1	24620	-5.4	24260	-6.8	24480	-6
120%	25940	23080	-11	23330	-10.1	24630	-5.1	24860	-4.2
80%	24080	20410	-15.2	20480	-15	20240	-15.9	19610	-18.6
100%	25020	24610	-1.6	24610	-1.6	24860	-0.6	24270	-3
120%	24860	23740	-4.5	23870	-4	23050	-7.3	22430	-9.8
	2005	2025s B1		2050s B1		2075s B1		2100s B1	
80%	24830	27030	8.9	27920	12.4	28800	16	29040	17
100%	26890	27030	0.5	28080	4.4	28550	6.2	28620	6.4
120%	25390	26770	5.4	27620	8.8	28190	11	28690	13
80%	25280	23290	-7.9	23500	-7	24730	-2.2	25060	-0.9
100%	26030	23160	-11	24250	-6.8	23700	-9	23980	-7.9
120%	25940	22730	-12.4	22880	-11.8	23440	-9.6	23790	-8.3
80%	24080	20390	-15.3	20600	-14.5	20800	-13.6	21350	-11.3
100%	25020	24670	-1.4	24400	-2.5	24500	-2.1	24840	-0.7
120%	24860	23700	-4.7	23790	-4.3	23830	-4.1	23370	-6
		2025s B2		2050s B2		2075s B2		2100s B2	
80%	24830	27130	9.3	27680	11.5	28710	6.8	28950	18.4
100%	26890	27110	0.8	28060	4.4	28910	16.4	29400	7.7
120%	25390	26840	5.7	28060	10.5	28310	11.5	29080	14.5
80%	25280	23000	-9	24020	-5	23830	-8.5	24180	-0.7
100%	26030	23210	-10.8	24770	-4.8	24970	-1.2	25100	-7.1
120%	25940	22740	-12.3	23760	-8.4	23540	-9.3	23760	-8.4
80%	24080	20320	-15.6	20460	-15	20740	-13.9	20830	-13.5
100%	25020	24710	-1.2	24640	-1.5	24760	-1	24730	-1.2
120%	24860	23710	-4.6	23830	-4.1	23850	-4.1	23290	-6.3
Mean	25369	24360	-3.98	24329	-1.41	25426	0.16	25581	0.75

Table (5): Single effect of different planting dates (Second cultivation), irrigation requirements level on simulated potato production with climate change Scenarios (A1, A2, B1, and B2) for the years 2025s, 2050s, 2075s and 2100s.

Treatments		Tuber fresh yield (kg/ha)								
		2005	2025s		2050s		2075s		2100s	
		Current	Estimated	Difference %	Estimated	difference %	Estimated	difference %	Estimated	Difference %
Irrigation	80%	24730	23591	-4.7	24157	-2.4	24715	-1.2	24943	1.4
	100%	25980	25033	-3.7	25863	-0.5	26137	1.5	26313	0.5
	120%	25397	24458	-3.6	25060	-1.3	25428	0.1	25487	0.4
Planting dates	January 1st	25703	27102	5.6	28223	9.9	29068	13.2	29531	15
	January 15th	25750	23048	-10.5	23887	-7.2	24234	-5.9	24467	-4.9
	January 30th	24653	22931	-7.1	22970	-6.9	22977	-6.9	22744	-7.8
Climate change scenarios	A1	25369	24402	-3.8	25147	-0.9	25547	0.6	25486	0.4
	A2	25369	24423	-3.8	25147	-0.9	25697	1.2	25941	2.1
	B1	25369	24308	-4.2	24782	-2.4	25171	-0.8	25416	0.1
	B2	25369	24308	-4.2	25031	-1.4	25291	-0.4	25480	0.4
Mean		25369	24360	-3.98	25027	-1.41	25426	0.16	25581	0.75

5.2 Potato First cultivation

The potential impact of climatic changes on tuber fresh yield potato was evaluated by simulating different planting dates (first cultivation), irrigation requements level on simulated potato production with climate change Scenarios (A1, A2, B1, and B2) medium refer to aerosol levels by the year 2025, 2050, 2075 and 2100 compared with that predicted under the current conditions 2005 (Table 6 and 7). The results indicated that the Climate change Scenarios (A1, A2, B1, and B2) increased tuber fresh yield in different planting dates (first cultivation), irrigation levele on simulated potato production by the year 2025, 2050, 2075 and 2100 compared with that predicted under the current conditions 2005. The predicted temperature increases affected crop production positively in first cultivation potato. The A1 scenario resulted in simulated yield increased from 18.6 to 47.5 % by the year 2025 and 2100 Respectively. Results show that; delaying sowing date from September 30th to October 30th reduced gradually tuber fresh yield in first cultivation 2005 and difference under climate change. The sowing date in september 1st gave the highest tuber yield. Relevant to the effect of different irrigation levels on tuber yield the results showed that the water level 100% gave the highest tuber yield at diferance planting dates with climate change Scenarios (A1, A2, B1, and B2) by the year 2025, 2050, 2075 and 2100 compared with that predicted under the current conditions 2005.

These results are in agreement with **Karing et al. (1999**) they found that the potato yields under climate change senirios (HADCM2 and ECHAM3TR) increased by about 6 to 8%. The yield increase was larger (from 10 to 16%) on coastal islands and in North Estonia.

Table (6): Interaction of the effect of different planting dates (first cultivation), irrigation requements level on simulated potato production with climate change Scenarios (A1, A2, B1, and B2) for the years 2025s, 2050s, 2075s and 2100s

Planting dates	Water Req.	Tuber fresh yield (kg/ha)								
		2005	2025s A1		2050s A1		2075s A1		2100s A1	
		Current	Estimated	difference %	Estimated	difference %	Estimated	difference %	Estimated	difference %
	80%	32810	39170	23.4	41480	35	43640	40.3	44630	40
	100%	33730	40480	16.1	44280	23	46040	29.4	45950	32.3
30 Sep.	120%	29860	35780	19.8	38470	28.8	40790	36.6	41430	38.7
	80%	21770	29840	37.1	31460	44.5	34850	65	30900	41.9
	100%	24800	30230	21.9	33640	35.6	35930	40.5	35980	45.1
15 Oct.	120%	18760	24690	31.6	28030	49.4	30060	60.2	31130	65.9
	80%	19180	24050	21.5	27150	37.1	29260	47.8	29140	47.2
	100%	19800	24720	28.9	27990	45.9	30020	56.5	30870	60.9
30 Oct.	120%	17250	21820	26.5	25200	46.1	26530	53.8	26770	55.2
		2005	2025s A2		2050s A2		2075s A2		2100s A2	
	80%	32810	40140	22.3	41480	35	43020	31.1	48360	47.4
30 Sep.	100%	33730	38830	15.1	44280	23	44820	32.9	47300	40.2
	120%	29860	35500	18.9	38470	28.8	41680	39.6	44370	48.6
	80%	21770	29510	35.6	31460	54.5	37250	71.1	39500	81.4
	100%	24800	30140	21.5	33640	26.9	35440	42.9	36180	45.9
15 Oct.	120%	18760	24380	30	28030	49.4	31210	66.4	32450	73
	80%	19180	23560	22.8	27990	45.9	31200	62.7	32730	70.6
	100%	19800	23720	19.8	27150	37.1	30560	54.3	31830	60.8
30 Oct.	120%	17250	21480	24.5	25200	46.1	27270	58.1	28630	66
			2025s B1		2050s B1		2075s B1		2100s B1	
	80%	32810	39530	20.5	40420	29	44220	34.8	43950	34
	100%	33730	38140	13.1	42330	19.8	41480	23	42490	26
30 Sep.	120%	29860	35200	17.9	37780	26.5	38760	29.8	39880	33.6
	80%	21770	28860	32.6	29580	46.7	33420	53.5	33960	56
	100%	24800	29920	20.6	31930	19.3	32780	32.2	33920	36.8
15 Oct.	120%	18760	23950	27.7	26420	40.8	27800	48.2	29000	54.6
	80%	19180	23930	24.8	25240	36.1	27840	45.2	28760	49.9
	100%	19800	23240	17.4	26100	27.5	26700	34.8	27150	37.1
30 Oct.	120%	17250	21090	22.3	23240	34.7	25180	46	26060	51.1
			2025s B2		2050s B2		2075s B2		2100s B2	
	80%	32810	38580	21.6	40700	32.8	42000	24.5	4350	36.7
	100%	33730	39910	14.4	43580	20.7	44760	36.4	44850	-87.1
30 Sep.	120%	29860	35670	19.5	37820	26.7	39120	31	40820	36.7
	80%	21770	29260	34.4	30870	51.8	34130	56.8	34950	60.5
	100%	24800	30120	21.5	33050	24.5	33360	34.5	34940	40.9
15 Oct.	120%	18760	24170	28.8	27340	45.7	28450	51.7	29740	58.5
	80%	19180	23580	26.5	26280	41.4	28430	48.2	29780	55.3
	100%	19800	24270	19.1	27120	32.7	27250	37.6	28240	42.6
30 Oct.	120%	17250	21440	24.3	24520	42.1	25330	46.8	26480	53.5
Mean		25369	29692	17	32492	35.9	34461	44.6	34374	45.5

Table (7): Single effect of different planting dates (first cultivation), irrigation requements level on simulated potato production with climate change Scenarios (A1, A2, B1, and B2) for the years 2025s, 2050s, 2075s and 2100s.

Treatments		Tuber fresh yield (kg/ha)								
		2005	2025s		2050s		2075s		2100s	
		Current	Estimated	difference %	Estimated	difference %	Estimated	difference %	Estimated	difference %
Irrigation	80%	24587	30834	25.4	32843	40.8	35772	48.4	33418	51.8
	100%	26110	31143	19.3	34591	28	35762	37.9	36642	31.8
	120%	21957	27098	23.4	30043	38.8	31848	47.3	33063	52.9
Planting dates	30-Sep	32133	38078	18.5	40924	27.4	42528	32.4	40698	27.3
	15-Oct	21777	27923	28.2	30454	40.8	32890	51.9	33554	55
	30-Oct	18743	23075	23.1	26098	39.4	27964	49.3	28870	54.2
Climate change scenario	A1	25369	30087	18.6	33078	30.4	35236	38.9	35200	47.5
	A2	25369	29696	17.1	33078	30.4	35828	41.2	37928	42.8
	B1	25369	29318	15.6	31449	24.0	33131	30.6	33908	46.9
	B2	25369	29667	16.9	32364	27.6	33648	32.6	30461	44.6
Mean		25369	29692	17	32492	35.9	34461	44.6	34374	45.5

CONCLUSIONS

For the overall results, it could be concluded that DSSAT can be used successfully to prediect potato tuber yield in Egypt. Using the future climate data a yield reduction from -1.41 to -3.98% was projected for the second cultivation that starts in Egypt in January 1st for the years till 2100. A yield increase was projected for the first cultivation that starts in Egypt in September 30th. The negative impact of yield reduction was decreased when planting date of second cultivation was changed from January 15th to January 1st. Water level 100% gave the highest tuber yield at difference planting dates with all climate change Scenarios. Water level 80% irrigation level gave the highest water use efficiency with the different planting dates in first and second cultivation followed by 100% irrigation level.

REFERENCES

Ainer, N. G. ; R. A. El-Bedewy and A. N. Khater (1993) Comparison of sprinkler, furrow and drip irrigation systems for potato yield and quaility on vertissols. Zagazig J. Agric. Res. pp. 1663-1671.

Ali, M. A. (1993). Physiological studies on water requirments of potato plant. PhD thesis. Fac. Agric. Moshtohor, Zagazig Univ.

Bolin, B; B. R.. Doos; J. Jager and R. A., Warrick (eds), (1986) The Greenhouse Effect: Climatic Changes and Ecosystems. John Wiley and Sons, New York, pp.363-92.

Claudio O; J. Stockle; R. Williams, Norman J.R. and C.Allan Jones(1992)A method for estimating and climatic effects of rising atmospheric carbon dioxide on growth and yield of crops:part 1-modification of the EPIC model for climate change analysis. Agricultural systems pp 225-238.

Eid, H.M., A .A. Rayan., K. A. Mohamed, M. M. A. El-Refaie, M. M. Attia, H. A. Awad, K.M. R. Yousef, and M. M. A. El-Koliey. (1995). Impact of climate change on yield and water requirements of some major crops. On- Farm Irrigation and Agroclimatology. pp.492 - 507.

Eid, H.M.; Samia M. El- Marsafawy, and N. G. Ainer (2001) Using MAGICC and SCENGEN Climate Scenarios Generator Models in vulnerability and Adaptation Assessments. Meteorology and Environmental Issues. Conf. March, Egypt.

El-Bedewy R. and A. Sharara, (1990) Potato production in Egypt. CIHEAM-CIP Potato Workshop of the Mediterranean Region 10–13 September 1990., Zaragoza, Spain. 7 p.

Erdem Y.; S. Seshril, T. Erdem and D. Kenar. (2006) Determination of crop water stress index for irrigation scheduling of bean (Phaseolus vulgaris L.). . Turk J Agric. 30: 195-202.

Garcia, E, G. (1987) Effect of duration of cultivation , planting date and depth of soil preparation on yields of sweet potato. Documentos- De- Cienias Agropecuarias de la Habana, San Jose De Las Lajas, Havaan, Cuba.

IBSNAT (International Benchmark Sites Network for Agrotechnology Transfer, 1988). Experimental design and data collection procedures for IBSNAT. The minimum data set for systems analysis and crop simulation. Third Ed. Technical Rep.1 Honolulu, HI, USA; IBSNAT. 74 pp.

Iglesias, A; M.N. Ward; M. Menendez, and C. Rosenzweig. (2003) Water Availability for Agriculture Under Climate Change: Understanding Adaptation Strategies in the Mediterranean. In: C. Giupponi, an M. Shechter (eds.). Climate Change and the Mediterranean: Socioeconomic Perspectives of Impacts, Vulnerability and Adaptation. Edward Elgar Publishers.

IPCC (Intergovernmental Panel on Climate Change) (2001). The Third Assessment Report (TAR): Climate Change 2001 The Scientific Basis. Cambridge University Press for the Intergovernmental Panel on Climate Change.

Israelsen, O. W. and V. E. Hansen .1962. Irrigation Principles and Practices, third edition, John Wiley and Sons, Inc New York..

Karing, Peeter, Ain Kallis, and Heino Tooming. 1999. "Adaptation principles of agriculture to climate change," Climate Research, Vol. 12, No. 2-3, pp. 175-183.

Maung M. M., Thein Su and San Thein. (2001). Effects of sowing time, mound burning, practice and timing of fungicide applications in the management of potato late blight in Myanmar. Journal of Agricultural University of Hebei, China Vol. 24 (2): 25–31. Proceedings of the GILB East and Southest Asia Linkage Group workshop on late blight, 16–20 August, Baoding Hebei, China.

Medany, M. A. (2001). The Impact of climate change on production of differerent cultivars of maize (Zea mays L.). Meteor. Res. Bull. Vol 16. 194-209.

Norwood, C.A. (2000) Water use and yield of limited-irrigated and dryland corn. Soil Sci. Soc. Am. J. 64:365–370.

Pearman, G. I., 1988. Greenhouse gases: Evidence for atmospheric changes and anthropogenic cases. In planning for climate change, ed. G.I.pearman. CSIRO, Div. Atmospheric Research. E. J. Brill, New York.

Riha S. J; Wilks, D. S, Simoens P. (1996) Impact of temperature and precipitation variability on crop model predictions. Clim. Change 32:293–311

Sepp J. V and Tooming H. G (1991) Productivity resources of potato. Gidrometeoizdat, Leningrad (in Russian)

Shani, U. and Dudley, L. M. (2001). Field Studies of Crop Response to Water and Salt Stress . Soil Sci. Soc. Am. J. 65:1522–1528.

Sinha, S. K., Rai, K., and Ahsan, M. M. (1988). Effect of date of sowing on the incidence of potato wilt at ranchi. Bacterial- Wilt- Newsletter, ACIAR.

Tooming H (1988) Principle of maximum plant productivity. In: Kull K, Tiivel T (eds) Lectures in theoretical biology. Acad Sci Estonia, Tartu, p 129–137

Tsuji, G. Y.; J. W. Jone; G. Uehara and S., Balas, (1994). Decision Support Systems for Agro-Technology Transfer. Version 3 vol .2. IBSNAT.

Wigley, T.M.L.; S.C.B. Raper; M. Hulme and S.J. Smith (2000). The Magicc/Scengen Climate Scenario Generator Version 2.4: Technical Manual. C.F: http://www.cru.uea.ac.uk.

Wolfe, D. W., Freses, S., Voss, R. E. and Timm H. (1982). Growth and yield response of two potato cultivars levels of applied water. American potato journal (10) 490 (En) California Univ., Davis, CA 95616, USA. (Field Crop Abs. 1983: 36 (6) 4854).

Yamaguchi, M., H. Timm, and A.R. Spurr. (1964) Effects of soil temperature on growth and nutrition of potato plants and tuberization, composition, and periderm structure of Tubers. Proc. Am. Soc. Hortic. Sci. 84:412-423.