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`EFFECT OF DEFICIT IRRIGATION ON VEGETATIVE GROWTH, YIELD AND QALITY OF TWO POTATO CULTIVARS UNDER SANDY SOIL CONDATIONS

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ABSTRACT

Two field experiments were carried out at the Farm of Environmental Studies and Research Institute ،Sadat City University, during both seasons of 2013 and 2014to determine the effect of deficit of irrigation on vegetative growth characteristics, yield and its components and tubers quality on two potato cultivars *Solanum tuberosum* L (.cvs .Red Sun and Sophie) under sandy soil conditions .In this study ، the experiment included 8 treatments, which were the combination between four levels of irrigations i.e., 100% (734.63 and 698.82 mm/fed 587.7) %80 ،(.and 559.1 mm/fed 477.6) %65 ،(and 454.23 mm/fed (.and 50% (367.32 and 349.41 mm/fed (. and two cultivars of potato (Red Sun, and Sophie (during both seasons 2013 and 2014 respectively .The results showed that ،plant height, number of branches and fresh weight/plant ،average tuber weight and tuber weight plant as well as tubers yield per feddan were significantly increased by using the highest level of irrigation ,while marketable yield % was not significantly affected and the size of tubers also was affected by irrigation levels . In addition ،cv .Red Sun showed significant increasing in the vegetative growth expressed as plant height ،fresh weight/plant ،yield and its components and its quality compared with cv .Sophie .On the other hand cv .Sophie reflected significant increase in number of branches than cv. Red Sun .In this regard ، marketable yield % was not significantly affected result of tested cultivars. The results showed that, the interaction between the cv. Red Sun and the highest level of irrigation resulted in significant increases in plant height, fresh weight/plant ،average tuber weight and tuber weight per plant as well as tubers yield per feddan ، marketable yield % and large tuber than size more than 70 mm in diameter also results indicated that cv .Sophie with the highest level of irrigation significantly increased number of branches / plant than cv .Red Sun .

Keywords: *Evapotranspiration, water use efficiency (WUE), yield and quality parameters, irrigation levels*.

INTRODUCTION

The potato plants are sensitive to water deficiency in soil. Optimum yield is obtained when the utilizable water in soil is not over 30–50%. If it drops below 50% the available utilizable moisture, yield may decrease. While the potato is considerably affected by water deficiency during germination, tuber formation and tuber bulking periods, it is less sensitive to water during

ripening and early vegetative periods. Among potato irrigation methods, furrow, sprinkler and drip irrigation methods are the most common ones. Under some circumstances, sub surface drip irrigation systems may be used. However, furrow and sprinkler irrigation methods are the most common methods. Recently, drip irrigation has become one of the methods that are used in potato irrigation (Onder and Onder 2006) .

Production of potato *(Solanum tuberosum L.)* takes a very important place in world agriculture, with a production potential of about 270 million tons harvested and 12.2million ha. planted area. Potato is one of the main crops in Egypt where the production is about 4.80 million tons harvested from 0.178 million ha.(FAOstat3, 2013).

Several researchers had showed that there was a positive linear relationship between yield and water use, Yuan *et al*. (2003) and Onder *et al*. (2005) evaluated the effects of different irrigation regimes on the potato growth at the drip irrigation. Irrigation water quantity was considered as 125, 100, 75, 50, and 25 percent of evaporation from the water level in a ceramic evaporation pan (0.2 m diameter). Plant height, biomass amount, total yield products, and market-friendly tubers (more than 85 gm) were increased by increasing the irrigation water. Plant height and the total yield product at the treatment of 125 percent evaporation from the evaporation pan were close to the 100 percent one. Increasing the irrigation water not only have the number of tubers increased, but increased the mean weight of the tubers, too. Irrigation water increased the quantity of the tubers but reduced their quality, under drip irrigation method, potato growth, tubers yield, size and specific gravity were increased. Also, tubers number and weight as well as tuber quality were improved. Onder and Onder (2006) found that, the amount of water applied ranged between187-560mm values while the actual evapotranspiration ranged between 190 mm to 754 mm. irrigation requirements of potato ranged between 500 and 700 mm.

Nimah and Bashour (2010) found that irrigating 50 to 75 % of the root zone of potato and pepper gave better yield than the control in a study of potato cv. Spunta and pepper cv. Andalus in Lebanon. Water saving of up to 195 mm for potato and 192 mm for pepper was obtained without reduction in total yield for both crops by limiting water penetration to the top 50 % of the root zone. Irrigating 50 % of the root zone resulted in better WUE amounting to 5.46 kg/m^3 and 6.46 kg/m^3 for potato in 2007 and 2008, respectively.

Ayas (2013) found that the effect of irrigation water level on the yield, tuber height, diameter, weight, dry matter, starch content tuber number per plant and plant height were found to be significant. The highest yield was 36 t ha^{-1}. Crop yield response factor (ky) was found as 1.13. The highest values for water use efficiency (WUE) and irrigation water use efficiency (IWUE) were found to be 4.84 and 4.29 kg $m^{-3}$for the K2cp treatment. Cantorea *et al.(*2014) indicated that water stress significantly affected yield response: as an average of the two years, a marketable yield decrement of 25.9 and 63.6% was observed in I50 and rain fed compared with I100 treatment, respectively. The results confirmed that irrigation is required for early potato cultivation because rainfall is not sufficient to meet crop water needs. In addition, the study indicated that the irrigation regime reduced by 50% of crop

water requirements was able to furnish satisfactory yield, with tuber quality characteristics similar or even better than those obtained under full irrigation. In fact, under rain fed conditions, early potato gives low and highly variable yield, while an irrigation regime reduced by 50% of crop water requirements can be able to provide satisfactory yield results, with a tuber quality similar or even better than that obtained under full irrigation regime.

Arafa (2004)found that in comparative study between two cultivars of potatoes, cv. Hermis compared with cv. Lady Rosetta under three levels of N,P and K are significantly increased the characteristics of vegetative growth, yield and its components as well as chemical composition of plant foliage and tubers.

Alva *et al.(2008)*found that potato production is dependent on irrigation. Generally irrigation is managed to replenish full evapotranspiration (ET). This field study was conducted to evaluate the effects of deficit irrigation on tuber yield and quality of 'Ranger Russet' and 'Umatilla Russet' cultivars grown on a typical sandy soil in the PNW (96% sand) with different rates of pre-plant and in-season nitrogen applications. Total tuber yield significantly decreased (by about 7.5%) with deficit irrigation as compared with irrigation to replenish full (ET). The impact of the above yield reduction associated with only 20% decrease in irrigation following row closure of the plant canopy on the net return needs to be evaluated.

Alva *et al*.(2012) found that, in 2004 season, cv. Ranger Russet only, DI with 20% lower total irrigation for the entire growing period resulted in 28% tuber yield reduction compared to that of plants irrigated to replenishment full evapotranspiration (ET) i.e., full irrigation (FI). A subsequent study in 2006 and 2007 with DI (14% to 17% deficit) resulted in tuber yield reduction of 7% to 10% in both cultivars compared to full (ET) irrigation. Yield reduction in DI was generally attributed to reduction in large weight tubers, >0.227 kg/tuber. Deficit irrigation on Ranger Russet cultivar decreased the numbers of tubers >0.340 kg with concurrent increase in small weight tubers, i.e., those in the 0.113 to 0.227 and 0.227 kg.

Habib *et al*.(2014)indicated that the responses of potato genotypes to different irrigation treatments, results showed that limited irrigation reduced plant tuber yield to17.7% compared with common cultivar. The Clone 97-2 gave the highest tuber yield at 80% irrigation treatment.

In Egypt, countries within a semiarid area with annual rainfall of about (14.2 mm.) from December to May the rainfall reaches 4.73 mm, accounting for 30% of the annual precipitation. Water shortage in this season unsavory agricultural production, since the potato growing two seasons goes from September to June. Therefore, because average rainfall and water resources are limited in this period, research on the relationships among yield, crop water consumption, and crop water stress is of great importance for developing water agricultural practices.(World Meteorological Organization,2015).

The purpose of this work are (1) to determine the effects of four levels of irrigation on two cultivars of potato under sandy loam soil conditions.(2) to build the modeling to predicted the yield of two potato cultivars in two years through the information from plant height, number of branches and fresh

biomass. (3) to study the relation between the yield of potato cultivars and the water requirements through water use efficiency.

MATERIALS AND METHODS

Two field experiments were carried out during the two summer growing seasons of 2013 and 2014 at the Farm of Environmental Studies and Research, Institute, Sadat City University to study the effect of deferent irrigation levels on two potato cultivars,*(Solanum tuberosum* L.*)*cvs. Red Sun and Sophie and their interaction on vegetative growth characteristics, yield and its components and quality of tubers under sandy soil conditions .The soil of the experimental field was sandy loam in texture. The physical and chemical analyses of soil are presented in Table 1 and 2.

Table 1: Mechanical analysis of the soil at the experimental field

Soil depth (cm)	Sand %	Silt %	Clay %	Texture
0-30	72.76	19.35	7.69	Sandy loam

Table 2: Chemical analysis of the soil at the experimental field

	Soluble cations and anions meq/l									
Soil depth (cm) 0- 30	**Ec (ds/m)**	**pH**	**Ca++**	**Mg++**	**Na+**	**K+**	**CO_3**	**HCO_3**	**Cl**	**SO_4**
	1.82	7.39	95	61.5	292	2.5	0	3	438	10
	C% total	**n ppm**	**P ppm**	**K ppm**	**Fe Ppm**	**Mn ppm**	**Zn Ppm**	**Cu ppm**		
	0.22	11.1	6.83	280	14.98	3.01	1.82	1.01		

The experiment included 8 treatments, which were the combination between four levels of irrigations i.e., 100% (734.63 and 698.82 mm), 80% (587.7 and 559.1 mm), 65% (477.6 and 454.23 mm) and 50% (367.32 and 349.41 mm) and two cultivars of potato (Red Sun, and Sophie) during both seasons 2013 and 2014 respectively. Spilt plots in a randomized complete blocks design with three replicates were used. The irrigation levels were situated in the main plots while cultivars in subplots. The sub-plot area was 13.50 m^2which included 3 rows of 5.0 m long and 0.9m width. Tuber seeds from each cvs. Red Sun and Sophie were sown on 16th of January in two investigated seasons and spaced at 25 cm apart. The normal agriculture practices for growing potato plants were applied whenever required.
Table 1 and 2 .Some physical and chemical analyses of the soil

Table 3: Monthly maximum, minimum and average temperature, wind speed, rainfall and average daily evapotranspiration (ET_o) for the experimental site during 2013 and 2014.

Month	T.max (c^o)		T.min (c^o)		T. mean (c^o)		Average wind speed Ws (ms^{-1})		Average rainfall (mm/m^2)		ET_o ($mm.day^{-1}$)	
Season	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Jan -Feb	22.66	20.25	6.73	6.04	13.03	12.48	1.10	0.03	0.21	0.03	3.20	2.90
Feb -Mar	22.29	20.9	8.81	7.63	15.13	13.88	1.53	0.16	0.24	0.16	4.10	4.00
Mar-Apr	25.71	23.9	10.04	9.36	17.45	16.32	1.51	0.02	0.02	0.02	5.80	5.50
Apr- May	30.31	28.65	13.82	12.14	21.78	19.87	1.85	0.09	0.08	0.09	7.70	6.70

Data recorded:

I) Vegetative growth measurements:

Two plants from each treatment were randomly pulled up at 70 days after planting to determine the plant height, number of main stems/ plant as well as fresh weight/plant.

II) Total yield and tuber quality:

After 120 days of planting, tubers from each plot were harvested, weighted, counted and graded for recording the following data-:

Average weight of tuber (g), average yield of tubers/ plant, total yield/ plot and then calculated as ton / feddan, marketable yield % and tuber size graded into four size:-

1- Size (more than 70 mm. in diameter).
2- Size tubers (55 -70 mm. in diameter).
3- Size tubers (35 -55 mm. in diameter).
4-Size tubers (less than 35 mm in diameter). Tubers of each size were weighted and its percentage from the total marketable yield was calculated.

Statistical analysis:-

All recorded data were subjected to ANOVA to identify significant treatments and/or interaction effects by 'F test' using the SAS 2003 ،program)SAS Systems for Windows, release 9 ،1.SAS Institute, Cary, NC .(The treatment means were compered using L-S.D test as described by Gomez and Gomez (1984).

Water requirement for Potato (ET_c):

Water requirement was calculated by meteorology data using Cropwat software Smith.(1992) Reference evapotranspiration calculation was based on FAO ،Allen *et al* .(1998) .Inputs included ten days and monthly temperature data (maximum ،minimum and average ،(relative humidity, sun light and wind speed. Crop water requirement) ETcrop (during growth period was estimated by reference evapotranspiration) ET_o (and crop evaporation rate which is called crop coefficient (Kc ،(based on Doorenbos and Pruitt method) Doorenbos and Pruitt (1977) ،according to fallowing equation . $ETcrop = Kc \times ET_{.0}$According to this equation results are acquired for 100 percent irrigation and considering this value, 80 65 ،and 50 percent of crop requirement are estimated.

Water use efficiency (WUE)

Irrigation water use efficiency (IWUE) is defined as the ratio of the crop yield to irrigation water applied, including rainfall (Al- Jamal *et al*. 2001). IWUE can be increased by practicing deficit irrigation, improving irrigation technology, and irrigation scheduling and improving agronomic practices that lead to yield increase.

Water use efficiency (WUE) relates to how much yield increase is obtained per unit of Applied water (Howell, 2003).

$$WUE_{ag} = \frac{P_c}{W}$$

where : P_c is the crop production and W is the volume of water applied.

Modelling of the yield

The Unscrambler X multivariate data analysis software version 10.2 (CAMO Software AS, Oslo) was used to calibrate and validate partial least square models. Partial Least Square Regression (PLSR) creates orthogonal latent variables across the input variables and relates them to the variables measurements (Elsayed *et al*. 2015). This is a way to cope with redundancy in the input variables. The PLSR searches the sensitive information from different parameters such as the values of plant height and number of branches and fresh weight. For determining model quality one approach of validation were used. In Table 7 a (3 fold) cross validation approach was applied for the PLSR models. Calibration and validation quality of models is presented through adjusted coefficients of determination of calibration (R^2cal) and validation (R^2val), root mean square errors for calibration (RMSEC) and for validation (RMSEV) and the slope of the linear regressions between observed and predicted values of all parametersfrom calibration and validation models with observed data for two measurement dates are shown in Table7.

In fig c a validation approach using fully independent data was used. PLSR models were calibrated using datasets at second year and validated using data from first year in the same or a corresponding field trial. The quality of the validation models is presented through adjusted coefficients of determination and the slope and intercept of the linear regressions between observed and predicted values of the yield.

RESULTS AND DISCUSSION

I- Vegetative growth:

Data recorded in Table 4 show that ،all the studied growth aspects i.e., plant height, number of branches and fresh weight/plant were significantly increased with increasing the irrigation levels applied during both growing seasons . In this respect, the highest values in all the studied growth measurements were recorded in case of using the fourth level of irrigation i.e 3085.45) ،.and 2935.02 m^3/fed (.during seasons 2013 and 2014 respectively .The depressive effect of the lowest level of water supply 1542.72)and 1467.51 m^3/fed) on the fresh weight of potato plants is due to the reduction in the uptake of nutritional element causing distribution in the

physiological and metabolic processes need for plant growth (salter and Goode, 1967), as well as to its inferior effect on the growth characters.

Water stress causes an increase in ABA/ cytokinin ratio, which in turn decrease plant growth (Marchner, 1995) he also showed that, under sufficient water conditions there were decrease in ABA and increase in cytokinin, GA and IAA reflecting good and dry matter content. Moreover, under water stress the synthesis of ABA from carotenoids in root occurs and then transport to different plant parts especially leaves and this turn affected the fresh weight accumulation in leaves and different organs (Lancher, 1993). Similar results were mentioned by El- Banna *et al.* (2001) on potato plants, Al- Esely (2002), Yuan *et al.* (2003), Ayoub (2005) and Onder *et al.* (2005) on potato.

Table 4: Effect of irrigation levels, cultivars and their interaction on some vegetative growth characteristics of potato plant.

Seasons		**2013**			**2014**		
Characteristics / Treatments		**Plant height (cm)**	**No. of branches / plant**	**Fresh weight / plant (g)**	**Plant height (cm)**	**No. of branches / plant**	**Fresh weight / plant (g)**
Irrigation levels	50%	46.16 d	1.83 c	115.16 c	48.61 d	2.36 c	168.05 c
	65%	47.50 c	2.66 b	133.83 b	51.66 c	3.25 b	185.25 b
	80%	51.33 b	3.66 a	137.16 b	52.91 b	4.06 a	187.61 b
	100%	52.50 a	3.66 a	189.83a	54.66 a	4.25 a	240.11 a
L.S.D.at5%		1.11	0.49	13.28	1.09	0.50	14.05
Cultivars	Red Sun	51.25 a	2.08 b	172.50 a	54.44 a	2.88 b	222.66 a
	Sophie	47.50 b	3.83 a	115.50 b	49.48 b	4.08 a	167.85 b
L.S.D.at5%		0.79	0.35	9.39	0.81	0.37	9.99
50%	Red Sun	47.33 d	1.00 e	132.66 c	50.22 d	2.00 e	185.44 c
	Sophie	45.00 e	2.66 d bc	97.66 d	47.00 e	2.72 d bc	150.66 d
65%	Red Sun	50.00 c	2.00 d	175.00 b	57.00 c	2.50 d	225.00 b
	Sophie	45.00 e	3.33 b	92.66 d	46.33 e	4.00 b	145.50 d
80%	Red Sun	52.66 b	2.33d c	180.00 b	53.33 b	3.50 b c	230.00 b
	Sophie	50.00 c	5.00 a	94.33 d	52.50 c	4.62 a	145.22 d
100%	Red Sun	55.00 a	3.00 b c	202.33 a	57.22 a	3.50 d c	250.22 a
	Sophie	50.00 c	4.33a	177.33 b	52.11 c	5.00 a	230.00 b
L.S.D.at5%		1.58	0.70	18.79	1.65	0.79	19.89

It is also evident from, data in Table 4 also that, there were a significant differences in all the studied growth traits. In this concern, the highest values in plant height and fresh weight per plant were recorded in case of cv. Red Sun compared with cv. Sophie, while, number of branches / plant , data indicated that, cv. Sophie recorded the highest values than cv. Red Sun. Such results are true during both seasons of study. In this connection, the differences in morphological aspects between the tested cvs. might be due to the variation in genetic pool between the two tested potato cultivars and variation of climates on growth. Similar results were reported by Arafa (2004) and Ayes (2013).

Concerning, the effect of the interaction between the tested irrigation levels and potato cultivars, the same data in Table 4 show clearly that all the studied vegetative growth characteristics were significantly affected due to the interaction between the tested irrigation levels and potato cultivars. In this connection, the highest values in plant height and fresh weight per plant were noticed in case of using the fourth levels of irrigation in case of cv. Red Sun during both seasons of study while, number of branches / plant, data indicated that, cv. Sophie in combination with the third and fourth levels of irrigation gave the highest values in this respect. These results are in agreement with those reported by Onder *et al*. (2005), Alva *et al*.(2012) and Habib *et al*.(2014).

2 - Yield and its components

Data in Table 5 show that all parameters of yield and its components expressed as average tuber weight, tubers yield/ plant and total yield/ fed ،. except marketable yield % significantly increased with increasing the highest used level of irrigation. The marketable yield % was not significant affected ، in this respect, the highest used level i.e 3085.45) ،.and 2935.02 m^3/fed (during seasons 2013 and 2014 respectively .Reflected the highest yield produced either per plant or feddan .

The response of yield and its components that attributes to raising irrigation level under these condition may be due to increasing the availability of N, P and K were sufficient to growing plants in this soil (Table, 2), increasing yield and its components related with the good effect on vegetative growth parameter (Table, 4) and resulted in accumulation of stored food in tubers. These results are agreeable with those reported by Alva *et al*.(2008) and Cantorea *et al.(*2014) on potato.

As for the effect between the two cultivars ,the same data in Table 5 detect also that, the cv. Red sun significantly reflected the highest values in all parameters of yield and its components, i.e., average tuber weight, tubers yield/ plant and total yield/ fed., while , marketable yield% is not significantly affected in both seasons . Such differences in total produced yield and its components among the tested cultivars are related to the differences in their vegetative growth vigor, (Table, 4). These results are in agreement with those reported by Alva *et al*. (2012).

Concerning, the influence of the interaction, data in Table 5 show that cv. Red sun in combination with fourth level (734.63 and 698.82 mm)of irrigation significantly produced the highest values of total produced yield and its components in both growing seasons. These results are in agreement with those reported by Arafa (2004), Onder *et al*. (2005) and Alva *et al.* (2012).

Table 5: Effect of irrigation levels, cultivars and their interaction on potato tuber yield and its components.

Seasons		2013				2014			
Characteristics / Treatments		Average tuber weight (g)	Aver. tubers yield/ plant (g)	Total tubers yield ton/fed.	Marketable yield %	Average tuber weight (g)	Aver. tubers yield/ plant (g)	Total tubers yield ton/fed.	Marketable yield %
Irrigation levels	50%	86.50 b	652.50 d	17.400 d	97.4 a b	97.36 b	752.50 d	13.350 d	97.9 a
	65%	88.33 b	725.00 c	18.400 c	97.5 b	98.57 b	821.50 c	14.600 c	97.8 b
	80%	90.33 b	837.50 b	20.100 b	97.8 a	101.16 b	888.50 b	15.500 b	97.3 b
	100%	111.83 a	922.50 a	21.300 a	96.4 c	117.38 a	955.00 a	17.000 a	98.6 a
	L.S.D.at5%	10.19	58.97	0.99	1.71	10.44	59.03	0.89	1.33
Cultivars	Red Sun	120.00 a	898.75 a	22.250 a	96.9 b	127.79 a	939.27 a	16.653 a	97.6 b
	Sophie	68.50 b	670.00 b	16.350 b	97.6 a	79.45 b	769.50 b	14.571 b	98.6 a
	L.S.D.at5%	7.21	41.70	0.70	6.22	7.55	49.60	0.65	3.4
50%	Red Sun	116.33 b	770.00 b c	19.600 d	97.4 c	126.50 b	860.00 c	16.363 c	98.0 b
	Sophie	56.66 e	535.00 e	15.200 g	97.5 c	68.22 e	645.00 e	14.337 g f	97.9 a b
65%	Red Sun	105.33 b	790.00 b	21.000 c	97.1 b c	115.44 b	885.00 b	15.250 b	96.9 d
	Sophie	71.33 c d	660.00 d	15.800 g f	97.9 b	81.70 c d	758.00 d	13.950 e f	98.7 a
80%	Red Sun	117.00 b	985.00 a	23.200 b	97.5 d	128.00 b	992.00 a	16.800 a	97.8 c
	Sophie	63.66 e d	690.00 c d	17.000 e f	98.2 a	74.33E e d	785.00 d	14.200 b	98.8 a
100%	Red Sun	141.33 a	1050.00 a	25.200 a	95.9 d	141.22 a	1020.10 a	18.200 d	97.9 a b
	Sophie	82.33 c	795.00 b	17.400 e	96.9 d	93.55 c	890.00 b	15.800 g	98.9 a
	L.S.D.at5%	14.42	83.40	1.40	3.02	15.50	85.01	1.22	2.06

3 - Potato tuber size percentage:-

Influence of irrigation application levels ،data in Table 6 show that, the size percentage of7 >) mm) in diameter of tubers ،size of tubers (55-70) and size of tubers (35-55) in diameter significantly increased with using the third and fourth level of irrigation in both growing seasons .While, the size percentage of35<) mm) in diameter increased with the lowest levels of irrigation .These results are in agreement with those reported by Onder and Onder.(2006)

The differences between the two cultivars, data in Table 6 indicate that, the size percentage of (<7mm) in diameter of tubers, size of tubers (55-70) and size of tubers (35-55) in diameter significantly increased with used cultivars. It is evident to report that cv. Red Sun in both growing season showed the highest values in this respect. While, The cv. sophie showed that, the significant values of the size percentage of (>35mm) in diameter this is true during both seasons of 2013 and 2014. These results are in agreement with those reported by Arafa (2004) on potato.

Table 6: Effect of irrigation levels, cultivars and their interaction on potato tuber size percentage.

Seasons		2013				2014			
Characteristics / Treatments		% of tuber Size >35	% of tuber size 35-55	% of tuber size 55-70	% of tuber size <70	% of tuber size >35	% of tuber size 35-55	% of tuber size 55-70	% of tuber size <70
Irrigation levels	50%	25.2 a	29.3 b	29.6 a	15.9 b	23.4 a	31.8 a	26.9 c	17.9 b
	65%	23.5 b	26.5 b	24.4 a	25.6a b	20.5 b	33.1 a	27.4 b	19. 0 b
	80%	21.6 b	29.1 b	23.3 a	26. 0 a	19.6 b	25.8 b	32.6 b	22. 0 a
	100%	16.5 c	34.9 a	31.3 a	17.3 c	15.9 c	28.3 b	34.5 a	21.3 a
	L.S.D.at5%	7.63	8.45	12.03	11.65	5. 08	7.25	9.99	11.11
Cultivars	Red Sun	10.5 b	28.1 b	31. 0 a	30.4 a	10.9 b	31.5 a	32.2 a	25.4 a
	Sophie	32.9 a	31.9 a	23.2 b	12. 0 b	28.9 a	27.9 b	28.5 b	14.7 b
	L.S.D.at5%	8.53	9.45	13.45	13.02	6.61	12.42	12.66	11.61
50%	Red Sun	10.2 c d	24.1 c	45.3 a	20.4a b	12.7 c	32.4 b	34.4 a	20.5 c
	Sophie	40.1 a	34.6 b	13.8 c	11.5 c d	34.1 a	31.1 b	19.5 c d	15.3 c d
65%	Red Sun	11.3 c d	30.4 ab	22.3 a b	36.0a b	9.8 c d	43.3 a	24.7 a b	22.2 b
	Sophie	35.8 b	22.7 c	26.3 a b	15.2 c d	31.5 b	22.8 b c	30.0 c	15.7 c d
80%	Red Sun	8.7 c d	25.8 c d	24.9 a b	40.6 a	9.8	25.3a b	36.0 a	28.9 a
	Sophie	34.5 a b	32.4 a b	21.7 a b	11.4 d	29.4 b	26.3 b c	29.2 c	15.1 b c
100%	Red Sun	11.9 b d	32.0 a b	31.4 b	24.7a b	11.6 d	24.9 c	33.6 b	29.9 a
	Sophie	21.1 c	37.8 a	31.1 b	10.00 e	20.2 c	31.7 b	35.4 a	12.7 e
	L.S.D.at5%	17.07	18.90	26.90	2.08	15.57	17.85	21.25	3.22

Concerning, the influence of the interaction, data in Table 6 show that, the cv. Red Sun in combination with the third and fourth levels of irrigation in both growing seasons, significantly increased the size percentage of7>) mm) in diameter of tubers , size of tubers (55-70) and size of tubers (35-55) in diameter .While ،cv .Sophie in combination with lowest levels of irrigation significantly recorded the highest values of tuber size percentage of 35<)mm) in diameter, in both growing season. These results are in agreement with those reported by Yuan *et al* (2003) .and Onder *et al*.(2005).

Figures (1) show the average yield production and water use efficiency for potatoes cultivars under different irrigation levels during the seasons of 2013 and 2014 under drip irrigation system. Results show that ،the average values of potatoes cultivars production and water use efficiency during season 2013 was higher than that yield and water use efficiency obtained during the season 2014, with about (16.8 ton /fed.) and (6.39 kg/m^3 (respectively . Moreover, it has been noticed that the maximum value of the potatoes cultivars production were 21.3 and 17 ton/fed .under %100 evapotranspiration, while the minimum value were 17.4 and 13.3 ton/fed . under %50 evapotranspiration during the studied seasons 2013 and 2014 ، respectively. These mean that the higher yield productivity were in treatments with increasing amount of water applied .These results agrees with those obtained by Nimah and Bashour (2010 (on potato.

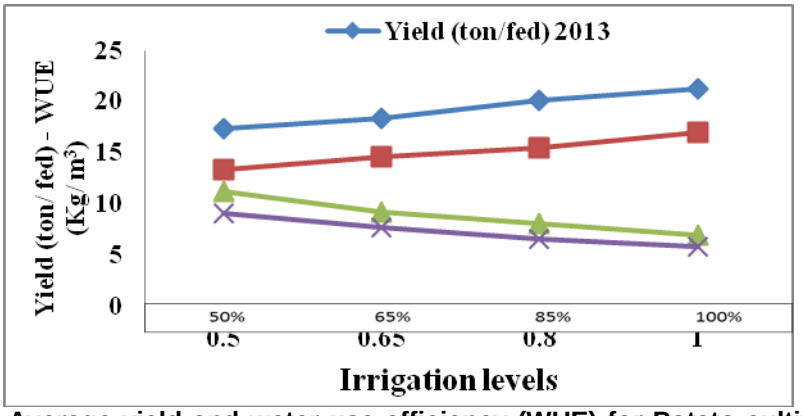

Fig.1.Average yield and water use efficiency (WUE) for Potato cultivars at different levels of water deficit irrigation

It can be concluded that, these point, the average yield production and water use efficiency for potatoes cultivars under different irrigation levels were higher under season 2013 than season 2014, these results due to higher amount of irrigation water under season 2013 than season 2014, these results are in agreement with those reported with Rizhsky *et al*. (2004) in many semi-arid and arid regions where irrigation is obligatory, transient wilting under high temperature and low air humidity is a common phenomenon. Transient stress can result in loss of yield and tuber quality. Although these two a biotic stress factors have been shown to induce distinct defensive responses in Arabidopsis when they occur simultaneously, this joint defensive response remains to be examined in potato.

Figure 2 show the comparison between water use efficiency (WUE) of potatoes cultivars (Red Sun and Sophia) under different levels of evapotranspiration for studied seasons. The results of this comparison showed that 100% of evapotranspiration levels (water requirement) under Sophia cultivar give the lowest values (5.64 and 5.38 kg/m^3) of WUE among the other treatments from the two studied seasons. While 50% of evapotranspiration levels under Red Sun cultivar gives the highest WUE by values (12.7 and 11.5 kg/m^3) for the studied seasons. Moreover, it has been noticed that the maximum values of (WUE) were obtained under Red Sun cultivar when comparing with Sophia cultivar during both seasons 2013 and 2014 respectively.

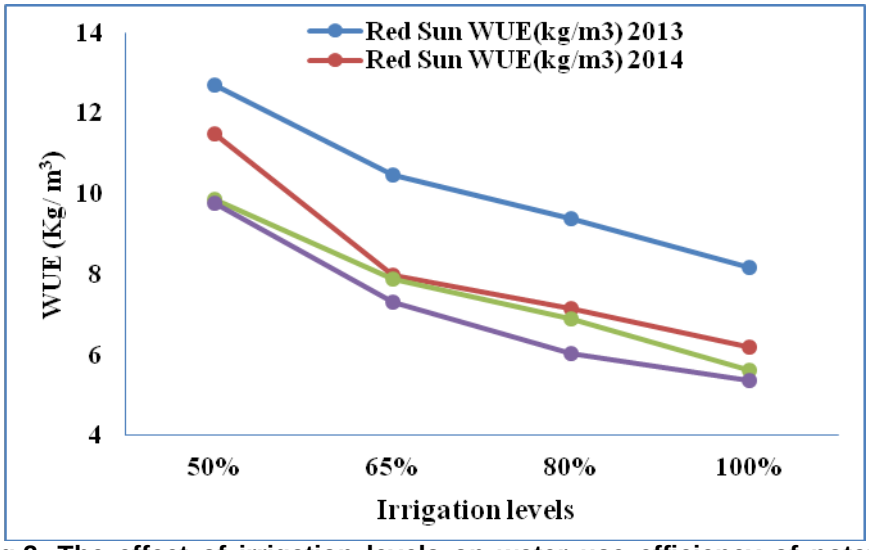

Fig.2. The effect of irrigation levels on water use efficiency of potato cultivars.Modelling of the yield

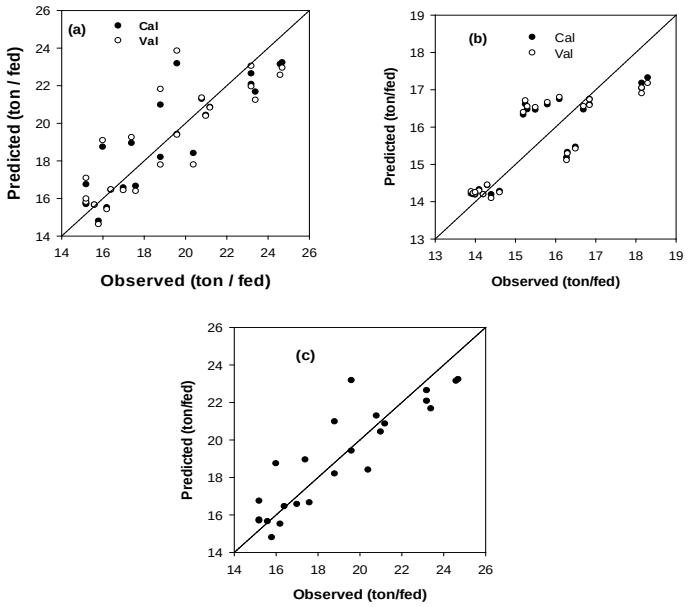

Fig.3 .Relationships between the observed and predicted of) a (the yield at first year) ،b (the yield at second year of potato cultivar for the calibration and validation datasets using a partial least squares model.Predicted values come from partial least square regressions using the values of plant height , number of branches and fresh weight.Statistical information is given in Table .As well as relationships between the observed and predicted of (c) the yield at first year depend on the calibrate data on second year and validate it in first year .

The calibration and validation models of PLRE were strongly related to the yield of potatoes cultivars (Table .(7 The calibration model is more robust during the season 2013 and 2014 through the cross-validation. The calibration yield data from second year can be used to predicted the yield data of first year with the R^2 = 0.80*** and the equation is) y=0.7969x+3.867 .

Table : 7 Calibration (R^2cal ،RMSEC and slope cal ،(and-3 fold cross-validation (R^2val ،RMSEV and slope val (of thestatistics of partial least square regression models of yield at first and second years.

Growth stage	Statistical parameters	[1]PCs	Yield at first year	PCs	Yield at secondyear
	R^2 cal	3	***0.80	1	***0.71
Bulking tuber	R^2val		***0.70		***0.70
	RMSEC		1.4		0.75
	RMSEV		1.72		0.81
	Slope cal		0.8		0.71
	Slope val		0.76		0.68

***Statistically significant at P ≤ 0.001
[1]PCs ،Number of latent variables.Cal, Calibration .Val, Validation.
RMSEC, Root mean square error for calibration
RMSEV ،Root mean square error for validation

These results agree with Sharabian *et al* ،(2014) .who found that strong relationships existed between the predicted and observed values for a validation data set of grain yield (R20.87 =RMSE = 301.

Finally ،it can be concluded that, Red Sun cultivar was the highest production when comparing with Sophia cultivar under the highest of level irrigation and suitable with the Egyptians environmental conditions .

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تأثير نقص ماء الري علي النمو الخضري ، المحصول وجودة درنات صنفين من البطاطس تحت ظروف الاراضي الرملية

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*** قسم التنمية المتواصلة للبيئة وادارة مشروعاتها ـ معهد الدراسات والبحوث البيئية ـ جامعة مدينة السادات –مصر**

**** قسم تقويم الموارد الطبيعية والتخطيط لتنميتها ـ معهد الدراسات والبحوث البيئية ـ جامعة مدينة السادات –مصر**

اجريت تجربتان حقليتان في مزرعة معهد الدراسات والبحوث البيئية – جامعة مدينة السادات خلال موسمي 2013 و2014 لتحديد تأثير النقص في ماء الري علي صفات النمو الخضري ، المحصول ومكوناته وجودة درنات صنفين من البطاطس هما ريد صن وصوفيا تحت ظروف الاراضي الرملية. تمت اضافة مياه الري من خلال نظام الري بالتنقيط واستخدام أربع معدلات اضافة لمياه الرى كنسب مئوية من الاحتياج المائى لمحصول البطاطس والمتمثل فى 100% (734,63 و 698,82 مم / فدان) ، 80% (587,7 و 559,1 مم / فدان) ، 65%(477,6 و 454,23 مم / فدان) و 50% (367,32 و 349,41 مم / فدان) خلال موسمي زراعة التجربة 2013 و 2014 على التوالى .

أوضحت النتائج المتحصل عليها ان طول النبات ، عدد الافرع والوزن الطازج للنبات ، متوسط وزن الدرنة ،متوسط محصول النبات ومحصول الفدان قد زاد معنويا مع استخدام مستوي الري العالي بينما النسبة المئوية للمحصول الصالح للتسويق وحجم الدرنات لم يتأثر تحت تأثير مستويات الري .

تفوق صنف ريد صن علي صنف صوفيا في طول النبات ،والوزن الطازج للنبات ، المحصول ومكوناته وجودة الدرنات ولكن بدرجة اقل في عدد الافرع لكل نبات .

اظهرت النتائج تفوق صنف ريد صن مع اعلي معدل ري في كل الصفات محل الدراسة بينما تفوق صنف صوفيا مع معدل الري المرتفع في عدد الافرع لكل نبات .

وبصفة عامة يمكن التوصية باستخدام (زراعة) صنف ريد صن مع معدل الري (734,63 و 698,82 مم / فدان) للحصول علي أفضل النتائج بالنسبة للنمو الخضري والمحصول ومكوناته وجودة درنات البطاطس .