RESPONSE OF SQUASH TO DEFICIT IRRIGATION AND POTASSIUM FERTILIZATION UNDER SOLAR – POWERED DRIP IRRIGATION

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ABSTRACT

The availability of fresh water and energy resources in remote locations is a major challenge for agricultural crop production in many countries in the Middle East region. Using limited water resources efficiently is crucial to sustain rapidly population growth. This research aimed to investigate the possibility of enhancing productivity and water productivity of squash crop through deficit irrigation technique. Two field studies were carried out to investigate the response of squash crop to deficit irrigation (DI) technique and potassium fertilization (K) over the spring and fall seasons of 2018. The irrigation treatments were based on the reference evapotranspiration (ETo). The results showed that the optimum squash seed yield could be obtained with K fertilizer level of 250 kg K_2O ha^{-1} and irrigation with amount of water equals 75% of ETo using DI with laterals placed at 0.15m from crop row or 50% of ETo in the last stage using RDI techniques. Fully irrigated (1.0 ETo) treatments had the highest values of yield and yield components of squash and there were no significant differences with RDI and DI with 0.75 ETo. The application of RDI can save more than 20% of applied water with no significant reductions in squash yield. Potassium rates enhanced squash yield and water productivity with the greatest value at 250 kg K_2O_5 ha^{-1}.

Key words: *squash, deficit irrigation, applied, water, solar, pumping, potassium fertilization.*

1. INTRODUCTION

Many regions of the world suffer shortage of traditional energy sources in remote locations while having abundant renewable energy sources (solar and wind energy) particularly in African countries. Solar power offer huge opportunities to improve the energy access in many areas of the developing worldwide by providing a huge source of clean and cost-effective source of energy.

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Solar – powered pumping systems are likely to be a promising alternative for irrigating agricultural crops in the remote locations. In Egypt more than 95% of cultivated landmass is under irrigation and most of the newly reclaimed areas have no grid connection and subsequently solar – powered pumps can be a reliable way to enhance crop production in these locations. Previous studies documented the effectiveness of PV pumping systems for irrigating agricultural crops (**Burney et al., 2010 and Abu-Aligah, 2011**). It is therefore obvious that solar energy captured by PV solar cells can be a robust way to operate drip irrigation systems since they are comparable and cost effective to diesel powered pumps (**Odeh et al., 2010**). **Hossain et al., (2015)** reported that solar powered pump systems are profitable more than diesel powered pumps.

One of the main challenges facing humanity is how to use limited and scarce natural resources in a sustainable way. According to **Seckler, (1999)** scarcity of water is now the single greatest threat to the global food supply. Widespread, agriculture is the main consumer of water. More than 85 % of the allocated water budget to Egypt is used for irrigation purposes and thus water availability has a direct impact on national food security. Therefore, the proper irrigation management and scheduling has become a determinant factor in crop production in these regions (**Kang and Zhang, 2004**). Moreover, worldwide water scarcity and predicted climate change have demanded emphasis on utilizing available water resources more efficiently via assessing critical plant water status factors for accurate and reliable irrigation water management (**Anderson et al., 2008**).

Introducing new irrigation techniques (i.e. PRD and RDI) that are suitable and successful to conserve the scare irrigation water resources would be important. These techniques can be reliable to reduce the demand for water at the farm level, and control the negative effects of over-irrigation (**Pereira et al. 2002**).

This challenge has promoted research into irrigation systems techniques and strategies to enhance yield productivity and thus water use efficiency (WUE). PRD is among water saving techniques in which half of the root system is exposing to alternate drying and wetting cycles. Basically, well watered side of the soil maintains a well plant status while dehydration of the other side encourages the synthesis of the abscisic acid and therefore decrease stomata conductance (**Giuliani et al., 2017**). Among various irrigation techniques PRD has the potential of increasing water use efficiency and sustain yield of different crops (**Hu et al., 2009; Nardella et al., 2012; Yactayo et al., 2013; Marjanovic et al., 2015; Wei et al. 2016 and Gomaa et al., 2018 Qi et al., 2019**).

DI irrigation has been shown as an effective irrigation strategy to save water while maintaining yield reductions at the minimum and increase WUE (**Nangare et al., 2016 and Mele 2019**). RDI is among the most reliable irrigation techniques which designed to save water while having little negative effect on yield (**Naor, 2006**). This technique can be achieved by applying deficit irrigation at certain growth stage when the crop is relatively tolerant to moisture stress (non critical times). RDI was used successfully in reducing irrigation rate while having similar yields (**Romero et al., 2004**). Generally, the main aim of RDI is to increase WUE via either decreasing the amount of irrigation water of the number of irrigations (**Kirda, 2002**).

Attention should also be considered to potassium fertilization (K) when cultivating vegetable crops since it is the most absorbed micronutrients by most of these crops (**Fernandes et al., 2016**). Fertilization plays an important role in the absorption of macronutrients in various plant organs and formation of the yield. **Haytova (2013**) concluded that squash is a vegetable crop responsive to fertilization as a result of rapid accumulation of vegetative mass in a relatively short period of time. The overall aim of this research was to assess the potential of RDI and potassium fertilization on enhancing yield and water productivity of squash crop under solar-powered drip irrigation system.

2. MATERIALS AND METHODS

Experimental Site and Design

Field experiments were conducted at a private farm in Nubaria region (30^o 4' 12" N and 30^o 19' 48" E) during the spring and fall seasons of 2018. Disturbed and non-disturbed soil samples were collected at two depths of the soil profile (0-30, and 30-60 cm) to determine some main physical and chemical characteristics. The experimental soil was classified as loamy sand in texture, with an EC of 1.32 dS m^{-1}. Table (1) shows the details of the chemical analysis of the experimental soil. Squash was sown during the first week of March and last week of July and the growing season lasted to around 105 days after planting. The hydro physical properties of the experimental soil were also determined including field capacity, welting point and available water (Table 2). Nitrogen fertilization in the form of ammonium nitrate was added with the recommended rate (285 kg N ha^{-1}) in three equal doses at 30, 45 and 60 days after planting.

Table (1): Some chemical analysis of the experimental soil at different soil depths

Soil depth, cm	EC, dS/m^{-1}	pH	Cations, meq/L				Anions, meq/L			
			Mg^{++}	Ca^{++}	K^{+}	Na^{+}	Co_3^{---}	HCo_3^{--}	Cl^{-}	So_4^{--}
0-30	1.32	7.39	3.2	3.21	1.28	4.77	0.0	2.71	7.18	2.54
30-60	1.17	7.21	3.33	3.34	1.37	4.61	0.0	2.77	7.36	2.51

Table (2): Mechanical analysis and some soil physical properties

Depth, cm	ρ_b, gcm^{-3}	FC, %	WP, %	AW, %	Particle size			Texture
					Sand	Silt	clay	
0-30	1.40	16.9	9.34	7.56	87.3	6.36	6.34	Loamy sand
30-60	1.56	15.13	8.35	6.78	86.3	7.52	6.18	Loamy sand

FC, field capacity; WP, wilting point; AW, available water; $\boldsymbol{\rho_b}$, bulk density

Solar – powered pumping and irrigation systems

The solar – powered pumping system consisted of 40 solar modules (JKM 250P-60) comprised of two groups 20 modules each connected in series then both groups connected together parallelly (Fig 1). Each solar cell had the dimensions of 165 cm length, 99.2 cm width and 4 cm thickness. Both solar cell groups were oriented facing south direction. The 40 PV cells (250 W) produced enough energy to operate the pump that was able to supply the required amount of water for the whole farm. This solar powered pumping system was designed to irrigate a 20 feddan farm comprising citrus and vegetable crops. The solar irradiance varied from month to another with the maximum and the minimum of 7.1 and 3.8 kWh m^{-2} recorded in June and December, respectively. A 10 kW maximum power controller (PS9K2) was linked to the solar modules with an efficiency of 98%. A 7.5 kW PUC-SJ30-7 submersible pump was used to deliver water to drip irrigation network. The solar system worked from sunrise to sunset producing the maximum discharge rate at noon.

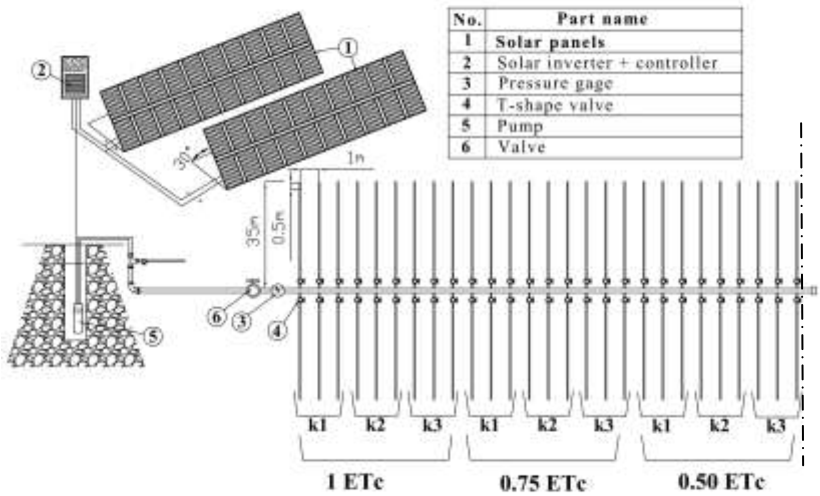

Fig. (1): A schematic diagram showing the solar – powered system connected with the drip irrigation network; ETc –crop water requirements and k_1, k_2, k_3 – potassium fertilization rates

A drip irrigation network was employed for irrigating the experimental plots. 16 mm polyethylene lateral lines were spaced at 1.0 m with dripper of 4 L h^{-1} discharge rate spaced at 0.5 m. A pressure differential tank was used for the application of fertilizers. A split-plot experimental design with three replicates was used with an experimental unit consisting of nine 35- m long lateral lines with built-in emitters of 4 L h^{-1} discharge rate. Irrigation treatments were randomly assigned to the main plots and K rates were assigned to the sub-mains. The amount of irrigation water was based on ETo that was determined using Class A pan evaporation data. The experimental design included 6 irrigation combinations (1 ET_o, 0.75 ET_o, 0.50 ET_o, DI_3 – 0.75 ETo and laterals spaced at 0.15 m from

crop row, DI_4 – 0.50 ETo and laterals spaced at 0.15 m from crop row and RDI) and three doses of K (150, 200 and 250 kg K_2O_5 ha^{-1}). RDI**:** 100% ETo throughout the growing season, and only 50% ETo at the seeding and maturation growth stage (regulated deficit irrigation). Potassium fertilization was applied ten times (weekly) starting from two weeks after planting and the applied amount of K was differed according to each treatment. The irrigation techniques were as follows:
To ensure high germination ratio all treatments were fully irrigated for 21 days and then various treatments were applied.

Applied Irrigation Water:
Reference evapotranspiration (ET_o) based on the Class A pan evaporation method (**Doorenbos and Kassam, 1986**) was identified according to the following equation:

$$ETo = Epan \times Kpan$$

Where: ETo- reference evapotranspiration (mm d^{-1}), Epan-daily measured pan evaporation (mm d^{-1}), Kpan-pan coefficient. 0.75 was taken for the experimental site according to the local climatic condition (**FAO, 1970**). The amount of applied water was calculated according to **Vermeiren and Jopling (1984)** as follows:

$$AIW = \frac{ETo\,.\,Kr\,.\,I}{Ea}$$

where: AIW - the depth of applied water, mm; ETo - reference evapotranspiration, mm day^{-1}; K_r is the reduction factor that depends on ground cover and according to **James (1988)**, it was assumed to be 1.0 since the spacing between drip lines was less than 1.8 m; E_a is the drip irrigation system efficiency which was assumed to be on average 0.8 and I - irrigation interval, days.

Irrigation time was identified before an irrigation event according to **Ismail (2002)** as follows:

$$T = \left(\frac{AIW \times A}{q}\right)$$

Where: T - irrigation time, h; A – the wetted area by each emitter, m^2 and q - emitter discharge rate, L h^{-1}

Water Use Efficiency

Water use efficiency (kg of squash seeds per m^3 of water applied) was calculated as follows:

$$WUE = \frac{squash\ seed\ \ yield\ (kg\ ha^{-1})}{applied\ irrigation\ water\ (m^{3}\ ha^{-1})}$$

Potassium Use Efficiency (KUE)

Potassium use efficiency was calculated as follows:

$$KUE = \frac{Y}{K}$$

Where: KUE is the potassium use efficiency, kg of squash seeds (kg $K_2O_5)^{-1}$

Y is the squash yield in kg ha^{-1} in a certain treatment; K is the added amount of K_2O_5 to the same treatment

Statistical Analysis:

SAS software package was run to subject experimental data to statistical analysis. Least significant difference (LSD) at 5% significance level was used to compare the means of various treatments.

3. RESULTS AND DISCUSSION

Solar – powered irrigation pumping system productivity

The energy produced from the pumping system ranged from a minimum of 33 kWh in December to a maximum of 56 kWh in the period of June and July (Fig. 2). From May to August, the system produced roughly the same amount of energy**.** The average daily produced energy over the whole year was 48 kWh. The experimental site is sunny most of the year with a few cloudy days during the winter months (December to February). The water discharge rate of the system varied throughout the year based on the energy produced every month since the energy is a function of sunlight hours. The greatest daily water discharge rate of 279 m^3 $day^{-1}$was recorded in June followed by July (274 m^3 day^{-1}) and the minimum record of discharge rate was recorded in December (158 m^3

day^{-1}). From May to August, similar trend like produced energy the solar powered pumping system produced was roughly the same as the water discharge rate (less than 5 % increase). Fig. 3 illustrates the average daily water discharge rate in different months throughout the year. The system was designed to convey water directly to the drip irrigation network or to the water reservoir to use it over night when the solar system stops working.

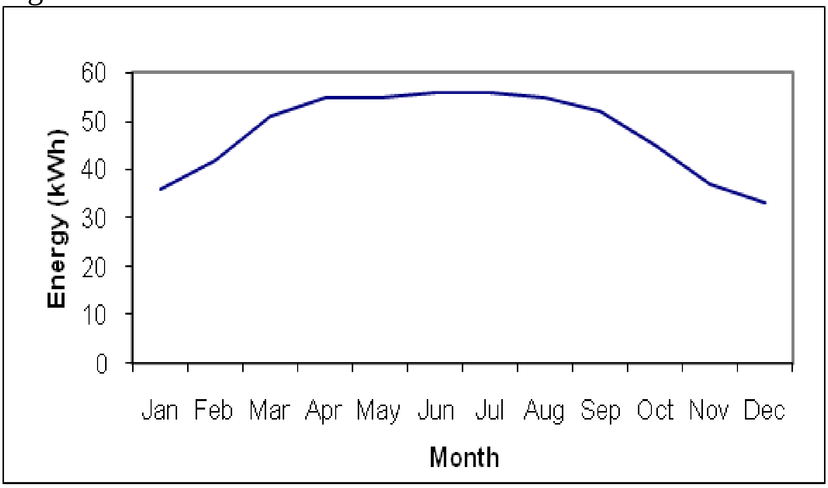

Fig. (2): Average daily energy (kWh) produced by the solar – powered pumping system used througout the year

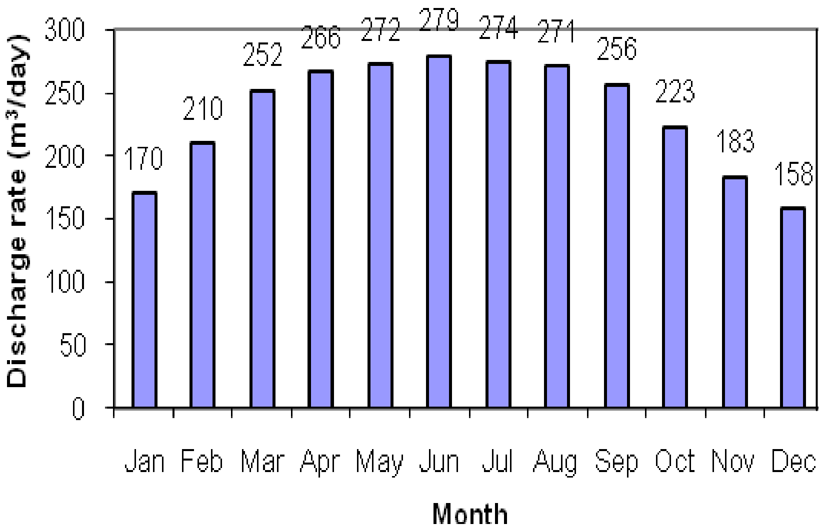

Fig. (3): Average daily discharge rate (m^3 day^{-1}) of the solar – powered pumping system used over the year

Effects of irrigation treatments and potassium fertilization on squash seed yield

The results detailed in Table 3 demonstrate the effect of irrigation techniques and potassium fertilization on squash seed yield. There were significant effects of investigated parameters on squash seed yield in both spring and fall growing seasons. No significant reductions were observed between fully irrigated treatments and those irrigated by DI_3 and RDI since the reductions were 8.9 and 10.4% in spring season and 9.4 and 6.5% in fall season, respectively. The results further demonstrated that applying DI_4 with 50% ETc produced 19.8 and 23.5% higher yield compared with DI_1 (50% ETc normal) in spring and fall seasons, respectively. In this context, applying mild stress via RDI and DI can save water by at least 20% without significant reductions in squash seed yield and this is crucial in cases of water scarcity in arid and semi arid regions. Data also showed that increasing applied K rate remarkably increased the yield of squash. The maximum squash yield values of 1110.2 and 1077.2 kg ha^{-1} were obtained from the treatments served by the combination 1.0 ETc and 250 kg K_2O_5 ha^{-1} in spring and fall seasons respectively. For a given irrigation technique, squash seed yield showed significant difference among K_2O_5 fertilization rates. Great rates of K_2O_5 may reduce the water stress effect due to the dominant role of K in controlling stomata opening, which regulates the transpiration of water**.** Low squash yields obtained from the smallest dose of K showed its vital necessity for photosynthesis since in case of K deficiency reductions in photosynthesis rate occurs and so decreasing the accumulation of carbohydrates. Another effect of the lack of K for plants is that the stomata do not open regularly that result in reduced carbon dioxide and subsequently lower photosynthesis intensity and ending up with lesser yield.

From the above mentioned results it can be concluded that choosing the proper K rate coupled with the RDI and DI irrigation techniques for growing squash crop can result in saving at least 20% of the applied irrigation water required for full irrigation due to reduced root size distribution. The results obtained in this research regarding the AIW are similar to those reported by **Topcu et al. (2007)**.

Table (3): Effect of irrigation treatment and K rates on squash seed yield (kg ha^{-1}) in both investigated seasons

Season	Irrigation treatment	K Fertilization, kg ha^{-1}			Mean
		150	200	250	
Spring 2018	1.0 ETc	812.3	989.3	1110.2	970.6 a
	0.75 ETc	466.5	756.7	968.6	730.6 c
	0.50 ETc	522.1	558.4	778.4	619.6 d
	RDI	712.4	908.3	986.3	869.0 ab
	DI_3	685.4	880.6	1089.2	885.1 ab
	DI_4	588.8	756.7	972.6	772.7 bc
Mean		631.3	808.3	984.2	
Fall 2018	1.0 ETc	810.7	968.9	1077.2	952.3 a
	0.75 ETc	466.1	502.1	952.0	640.1 bc
	0.50 ETc	515.5	530.8	605.1	550.4 c
	RDI	813.3	891.6	965.3	890.1 a
	DI_3	731.0	818.7	1036.9	862.2 a
	DI_4	516.5	790.4	854.0	720.3 b
Mean		642.2	750.4	915.1	

Applied Irrigation Water:

Table 4 details the amounts of applied water to various irrigation techniques in both investigated seasons of squash crop over different growth stages. The results revealed that the amount of applied water was less over the vegetative growth period in spring and fall seasons and reached its peak during fruits formation stage and then decreased again over seeding and maturation growth stage. The highest amounts of applied water were associated with the fruits formation and flowering growth stages recording 134.66, 102.5 and 111.43, 89.96 mm for spring and fall seasons, respectively. Same amounts of applied water were added to all treatments for the 1^{st} growth stage (vegetative stage) to ensure high percentage of germination. The application of DI_3 treatment saved water by 21 % with little yield reductions compared with fully irrigated treatments. It is therefore obvious that the RDI and DI irrigation would be efficient systems to apply less water to tolerant crops while having similar grain yields.

Table (4): Applied irrigation water (AIW) in mm for squash at various growth stages with different irrigation treatments in spring and fall seasons

Season	Growth stage	Irrigation treatments and regimes 1.0 ETc	0.75 ETc	0.5 ETc	RDI	DI_3	DI_4
Spring 2018	Vegetative	53.9	53.9	53.9	53.9	53.9	53.9
	Flowering	102.5	76.78	51.25	102.5	76.87	51.25
	Fruits	134.66	100.99	67.33	134.66	100.99	67.33
	Seeding	78.75	59.06	39.38	39.38	59.06	39.38
	Total	**369.81**	**290.82**	**211.86**	**330.44**	**290.82**	**211.86**
Fall 2018	Vegetative	45.98	45.98	45.98	45.98	45.98	45.98
	Flowering	89.96	67.47	44.98	89.96	67.47	44.98
	Fruits	111.43	83.57	55.72	111.43	83.57	55.72
	Seeding	61.72	46.29	30.86	30.86	46.29	30.86
	Total	**309.09**	**243.31**	**177.54**	**278.23**	**243.31**	**177.54**

Water Use Efficiency of squash (WUE)

The effects of irrigation management and K-fertilization rate on water use efficiency (WUE) for both tested seasons are detailed in Table 5. The results demonstrated that WUE values were higher in the treatments that received the combination of DI_3 and DI_4 with the highest rate of K fertilization. It is obvious that applying less water to squash with deficit irrigation with laterals placed at 0.15 m produced higher seed yield in comparison to normal deficit treatments having the same amount of applied water. The greatest WUE records were obtained with DI_3 and DI_4 in all treatments at all rates of potassium fertilization rates. RDI technique produced more or less the same seed yield like fully irrigated treatments while saving at least 20% of water applied in both spring and fall growing seasons. The greatest WUE of 0.459 and 0.481 kg ha^{-1} were obtained from the combination of DI_4 and 250 kg K_2O_5 ha^{-1} in spring and fall seasons, respectively. As seen from Tables 5 and 4 there was no significant difference between squash yield of the fully irrigated, DI_3, and RDI techniques. It could be concluded that applying DI_3 technique can save more than 20% of the applied water. The results obtained in this research agreed with those reported by **Amer (2011)** who showed that DI produced greater WUE more than fully irrigated treatments.

Table (5): The effects of irrigation treatments and potassium fertilization rates on WUE of squash in both spring and fall seasons.

Season	Irrigation treatment	K Fertilization rate, kg ha^{-1} 150	200	250	Mean
Spring 2018	1.0 ETc	0.219	0.267	0.300	0.262
	0.75 ETc	0.160	0.260	0.333	0.251
	0.50 ETc	0.247	0.263	0.367	0.292
	RDI	0.216	0.274	0.298	0.263
	DI_3	0.236	0.303	0.374	0.304
	DI_4	0.279	0.357	0.459	0.365
Mean		0.226	0.287	0.355	
Fall 2018	1.0 ETc	0.262	0.313	0.349	0.308
	0.75 ETc	0.192	0.206	0.391	0.263
	0.50 ETc	0.290	0.299	0.341	0.310
	RDI	0.292	0.320	0.347	0.320
	DI_3	0.300	0.336	0.426	0.354
	DI_4	0.291	0.445	0.481	0.406
Mean		0.271	0.320	0.389	

Potassium Use Efficiency of squash (KUE)

As detailed in Table 6, KUE was negatively affected by the amount of K_2O_5 regardless the irrigation treatment used since the greatest KUE value was recorded with the combination of 150 kg K_2O_5 and various irrigation treatments in comparison to other two greater K rates. In both seasons, the highest KUE values of 5.42 and 5.40 kg squash seeds (kg $K_2O_5)^{-1}$were recorded with the treatments received 150 kg K_2O_5 ha^{-1}. Interestingly in both tested seasons, DI_3 and DI_4 produced higher KUE values in comparison to 0.75 and 0.5ETc which had the same amount of applied water. This may have been a result of smaller root size. As noticed from the results, RDI enhanced KUE since DI_4 with 75% ETc and RDI produced high KUE while saving at least 20% of irrigation water applied. The lowest average values of KUE were obtained from the combinations of 50% ETc and 250 kg K_2O_5.

Table (6): The effects of irrigation treatments and potassium fertilization rates on KUE (kg squash seeds/kg K_2O_5) in spring and fall seasons of 2018.

Season	Irrigation treatment	K Fertilization rate, kg ha^{-1}			Mean
		150	200	250	
Spring 2018	1.0 ETc	5.42	4.95	4.44	4.93
	0.75 ETc	3.11	3.78	3.87	3.59
	0.50 ETc	3.48	2.79	3.11	3.13
	RDI	4.75	4.54	3.95	4.41
	DI_3	4.57	4.40	4.36	4.44
	DI_4	3.93	3.78	3.89	3.87
Mean		4.21	4.04	3.94	
Fall 2018	1.0 ETc	5.40	4.84	4.31	4.85
	0.75 ETc	3.11	2.51	3.81	3.14
	0.50 ETc	3.44	2.65	2.42	2.84
	RDI	5.42	4.46	3.86	4.58
	DI_3	4.87	4.09	4.15	4.37
	DI_4	3.44	3.95	3.42	3.60
Mean		4.28	3.75	3.66	

CONCLUSION

This research aimed to investigate the potential of deficit irrigation to enhance water use efficiency, yield of squash under various rates of potassium fertilization in regions suffering from shortage of fresh water resources such as Nubaria region. In calcareous soils of Nubaria region, the yield and yield components of squash can be optimized to maximize the final income through better management of water and energy. Full irrigation regime can produce higher yield with less water use efficiency. The results further showed that deficit irrigation can be a reliable irrigation strategy for saving irrigation water in areas suffering from water scarcity since it can save water by more 20% and resultantly help to increase cultivated area in newly reclaimed regions. Solar – powered pumping drip irrigation systems would be a promising tool for producing agricultural crops in regions with no connection to traditional energy sources.

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الملخص العربى

استجابة الكوسة للرى المنقوص والتسميد البوتاسى تحت الرى بالتنقيط المشغل بالطاقة الشمسية

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ان محدودية المياه والطاقة فى العديد من المناطق فى الشرق الاوسط تعتبر من المعوقات الاساسية لانتاج المحاصيل الزراعية . وتعتبر مصر من الدول التى تقع فى الحزام الشمسى وبالتالى يمكن الاستفادة من هذه الطاقة المتجددة فى المناطق التى تعانى عدم وجود مصدر للطاقة التقليدية وكذلك مصدر لمياه نهر النيل. ويعتبر نظام ضخ مياه الرى بالطاقة الشمسية من البدائل الجيدة للتغلب على هذه المشاكل. ان استخدام موارد المياه المتاحة فى هذة المناطق بكفاءة عالية يعتبر من التحديات التى تواجه التنمية المستدامة وذلك للمحافظة على مخزون المياه الجوفية ولذلك اجريت تجربتين حقليتين فى مزرعة خاصة بمنطقة النوبارية لدراسة تأثير كل من نظام الرى المنقوص بمعدلات رى مختلفة ومعدل التسميد البوتاسى على انتاجية الكوسة – انتاجية المياه وكفاءة استخدام البوتاسيوم باستخدام نظام الرى بالتنقيط المشغل بالطاقة الشمسية وكانت عوامل الدرسة كالتالى:

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معدل الرى : ١٠٠% ، ٧٥% و ٥٠% من الاحتياجات المائية للمحصول
معدل التسميد البوتاسى : ١٥٠ ، ٢٠٠ و ٢٥٠ كجم هكتار-١ وكانت أهم النتائج مايلى:

- نظام ضخ مياه الرى باستخدام الطاقة الشمسية يمكن استخدامه بكفاءة فى المناطق التى تعانى عدم وجود مصدر للطاقة التقليدية وقد أعطى أعلى معدل للطاقة وتصرف المياه فى شهر يونيو بمعدل ٥٦ كيلوات ساعة ، ٢٧٦ م٣/يوم على الترتيب.
- أظهرت النتائج أن أعلى انتاجية لمحصول الكوسة كانت مع معاملة الرى ١٠٠% ومعدل تسميد بوتاسى ٢٥٠ كجم للهكتار بينما كانت أقل انتاجية مع معاملة الرى المنقوص (٥٠%) ومعدل تسميد بوتاسى ١٥٠ كجم للهكتار.
- المعاملات التى احتوت على رى منقوص بمسافة ١٥ سم عن خط النبات اعطت انتاجية وانتاجية مياه اعلى من مثيلاتها فى معاملات الرى المنقوص العادية (٥٠ و ٧٥%) مع ثبات معدل اضافة المياه.
- أوضحت الدراسة ايضا ان استخدام نظام الرى المنقوص عند مرحلة معينة فقط يمكن ان يعطى تقريبا نفس الانتاجية مع توفير مياه الرى.

وبناءا عليه أوضحت هذه الدراسة ان استخدام نظام ضخ المياه بالطاقة الشمسية كمصدر للرى يعتبر مستقبل الزراعة فى مصر وأن نظام الرى المنقوص تحت نظام الرى بالتنقيط من التقنيات التى تساعد فى توفير ما لا يقل عن ٢٠ % من كمية مياه الرى اللازمة للمحصول.