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EFFECT USE OF PULSED DEFICIT DRIP IRRIGATION FOR TOMATO CROP IN GREENHOUSE POWERED BY SOLAR ENERGY

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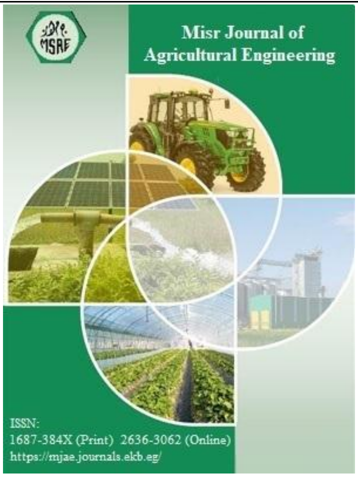

Keywords:
Pulsed-deficit drip irrigation, solar energy, tomato.

ABSTRACT

The presented study aims to investigate the effect of using two effective irrigation techniques; the pulse-deficit drip irrigation and the deficit irrigation powered by solar energy in a greenhouse. This work studied impact of these factors a tomato soilless productivity, water productivity and of these techniques solar energy productivity. The experimental study was carried out at Tractors and Farm Machinery Research and Test Station, Alexandria Governorate. The results showed that, the pulsed-full drip irrigation at 100% of ETc (FP100) gave the highest yield of 35.8 ton/fed., but the continuous- deficit drip irrigation at 50% of ETc (DC50) gave the lowest yield of 20.4 ton/feddan. The highest water productivity (WP) was 37.1 kg/m^3 when using the treatment of (DP50), on the other hand the Continuous-Full drip irrigation at 100% of ETc (FC100) (control treatment) represents the lowest WP of 27.9 kg/m^3. Application of pulse-deficit irrigation (DP50) saved 50% of the water irrigation requirements and decreased the total tomato yield per feddan by 34%, but the water productivity increased by 33% compared with continuous-full irrigation (FC100) as control. Treatment of pulse-deficit irrigation (DP50) saved 50% of solar energy consumption and increase energy productivity (908 kg/kWh) by 33% compared to continuous-full irrigation (FC100) as control. The results showed that pulse-deficit drip irrigation technique, decrease tomato yield but increase WP in all treatments. This study recommend apply, pulse-deficit irrigation (DP75) technique results in reducing tomato yield by 3% and increasing water and energy productivity by 29.3 and 29.4% respectively.

1. INTRODUCTION

The country lies within the semi-arid regions with limited water resources and this need to find effective irrigation techniques to rationalize and save irrigation water aim to sustainable agricultural irrigation. Tomato is one of the vegetable crops of worldwide demand because of its various purposes including nutritional, economic and medicinal values (**Savić et al., 2008**). It is also an important constituent of daily diet worldwide. Tomato considered as vegetables being sensitive to water deficit. Availability of water can considerably influence crop yield and quality **(Salokhe et al., 2005).**

Deficit irrigation (DI) considered worldwide as a way of maximizing water productivity (WP). It eliminating irrigations that have little impact on yield, while save water and improve fruit quality (**English, 1990; English and Raja, 1996; Kirda et al., 1999; Karam, et al., 2007**). Moreover**, Kirnak et al. (2002)** pointed out that yield loss that may result from deficit irrigation is offset by the benefits of reduced water use. Deficit irrigation (DI) can cause some problems as water stress and limit crop transpiration, but many studies have found that moderate water stress can improve water productivity (WP) (**Tognetti et al., 2004**; **Chen et al., 2013; Qiu et al., 2015; Dijkstra et al., 2016; Khapte, et al., 2019**). Also, it is found that deficit irrigation with partial root zone drying as 85% of the water requirement of the plant was the best method for hydroponic cultivation of tomato **(Hooshmand, et al., 2019**). A lot of benefits of deficit irrigation in terms of improved quality and water productivity while sustaining fruit yield could be achieved with regulated DI at 0.8xETc and DI at 0.6xETc during vegetative stage followed by flowering **(Nangare, et al., 2016)**. **Silveira, et al., (2020)** found that deficit irrigation management at 50 % ETc is a better water saving strategy**. Al-Ghobari & Dewidar, 2018; Yu, et al.,** (**2020**) studies demonstrated that deficit irrigation is a promising practice, the regional environment and proper deficit irrigation methods should be carefully considered.

Pulse drip irrigation is an experimental irrigation technique primarily used for maintaining a high level of soil moisture for seeds germination. Pulsed drip irrigation refer to the practice of irrigating for a short period then waiting for another short period, and repeating this on-off cycle until the entire irrigation water is applied (**Eric et al., 2004**). Pulse drip irrigation is used in a lot of arid and semi-arid regions, largely to reduce water losses and to improve crop yields and water productivity. Applying pulse drip irrigation technique lead to increase in water movement in horizontal direction more than vertical direction thus increasing in water soil volume **(Li, et al., 2004; Bakeer, et al., 2009; Skaggs et al.,2010; Abdel tawab, 2015**). **Ismail, et al., (2014)** and **Abd-elhakim (2019)** reported that the advantage of pulse flow, for reducing the deep percolation of water under the crop root zone, while obtaining a wide horizontal spread of wetting. This enables using a highly discharge emitter with the same amount of water.

Solar irrigation has become a life saver for farmers struggling to water crops amidst rising electricity costs in rural areas around the world. Where, it's in Mediterranean areas, as its climate is characterized by a high number of sunlight hours. Therefore, an irrigation photovoltaic energy system is increasingly gaining interest. Solar powered irrigation technology can be utilized by independent farmers in small-scale remote rural farms in Sub-Saharan Africa **(Wazed, et al., 2017)**. Also, micro-irrigation system integrated with low cost solar based pumping system was designed to suit small holders whereas, Adoption of such system would help in conservation of energy and mitigate the climate change (**Kumar, et al., 2015**). Solar-powered agricultural irrigation is an attractive application of renewable energy due to the rise in Oil prices and the upscaling in commercialisation of PV technology. However, to be practical it must be both technically and economically feasible. especially as it reaches more competitive levels with other energy sources in terms of cost, may serve to sustain the lives of millions of under privileged people in developing countries. Furthermore, solar energy devices can benefit the environment and economy of developing countries (**Kelley et al., 2010; Devabhaktuni et**

al., 2013). Based on the literature the most effective PV system is presented for the irrigation of a small scare remote rural farm with respect to the cost, pumping capacity and system efficiency (**Wazed et al., 2018).**

The study aim effect of using two irrigation techniques; the pulse-deficit drip irrigation powered by solar energy in greenhouse and study their impact on the Tomato soilless productivity, water productivity and solar energy productivity.

2. MATERIAL & METHODS

1. Field experiment description and treatments

The field experiments were carried out in buckets for tomato culture 'Super Marmande variety' in a polyethylene greenhouse (dimensions: length of 12 m, width of 4m, and height in the range of 2-3m). It has the planting area of 32 m^2. The greenhouse situated at Tractors and Farm Machinery Research and Test Station, Alexandria Governorate (Latitude 31.24 N, and Longitude 29.98 E) during one season 2019-2020 from 20 October to the end of February. Weather data for experimental site was taken from El-Nouzha airport station, Alexandria Governorate, Egypt that include daily observations for temperature (° C), humidity (%), wind speed (mph), and precipitation (mm). Weather data inside greenhouse were measured using Environment Meter apparatus (EM9300SD). It is Environment instrument, multi-function, and four in one. The experimental field was divided into six treatments. The treatment was divided into 4 replicates. Each replicate was specified as bucket (bucket scale 0.25X 0.25 m width X length with 0.40m depth), each bucket is planted two seedlings. Growth media in bucket was shown in table (1), distance between buckets was 50 cm, the drip irrigation system used lateral lines contained in-line GR emitters of 4 l/hr discharge, where each bucket used one emitter. The irrigation techniques are pulsed drip irrigation at cycle ratio equal 0.5 for cycle time (30minutes). The pulse-deficit and deficit drip irrigation was at 50, 75, and 100% of tomato crop water requirements, ETc. ETo was calculated using Pan evaporation method. Pan evaporation, Ep data was get from site of Central Laboratory for agricultural Climate as an average of six years (1999-2005). Pan factor, kp was 0.85. ETo in greenhouse was equal 70% multiple ETo in open field (**Khalil, 1998**). Values of crop coefficient, Kc were get from tables and reduction factor for drip irrigation, kr (**Ismail, 2002**). Hence, it was calculated ETc. Fertilizer program for tomato crop during drip irrigation follows prescribed doses in technical bulletin **Zaki, et al., (2010).** Drip irrigation system powered by solar photovoltaic with DC pump used to study the effect of Pulsed-Deficit drip irrigation technique on solar energy consumption rate. Components of Solar pumping system were the solar panel (0.40 * 0.55 m), the charging unit (10) Amp, 12 volts was delivers a signal to charges battery, the battery sealed lead acid battery 12V - 9 Amp, and D.C. pump 12 Volts 15 Watt, flow 4.5 LPM and press 6.8 bar. Experimental site description was shown in Fig. (1). The statistical analysis were carried out based on completely randomized design (CRD). The obtained data analyzed by (Minitab) software package (version16). The mean values of the six treatments were compared using L.S.D. test at a significance level of 0.05 as follows:

1. Continuous-Full drip irrigation technique at 100% ETc (FC100).
2. Continuous- Deficit drip irrigation technique at 75% ETc (DC75).
3. Continuous- Deficit drip irrigation technique at 50% ETc (DC50).
4. Pulsed-Full drip irrigation technique at 100% ETc (FP100).

5. Pulsed- Deficit drip irrigation technique at 75% ETc (DP75).
6. Pulsed- Deficit drip irrigation technique at 50% ETc (DP50).

Measurements and calculations

1. Soil analysis for growth media: texture and chemical analysis for the used soil was carried out in Soil Salinity Laboratory- agricultural research center as shown in Tables (1 through 3).

Table (1): The growth media texture and physical properties**.**

Soil Depth	Clay (%)	Silt (%)	Sand (%)	Soil texture	Organic matter (%)	Bulk density (g/cm3)
0-40 cm	21.55	30.14	47.11	Loam	1.2	1.22 -1.33

Table (2): Chemical analysis for Growth media in bucket.

Soil Depth	PH	EC	Cations, meq/l				Anions, meq/l		
		mmhos/	Ca	Mg	Na	K	HCO3 -	Cl -	SO4 --
0-40	6.8	1.6	6.5	12.5	25	0.1	8.1	28.9	5

Table (3): Fertilizers elements for growth media in bucket.

Soil Depth	Micronutrients				Macronutrients		
	Fe	Mn	Zn	Cu	N	P	K
0-40 cm	3.62	1.47	1.32	0.42	30	6.23	310

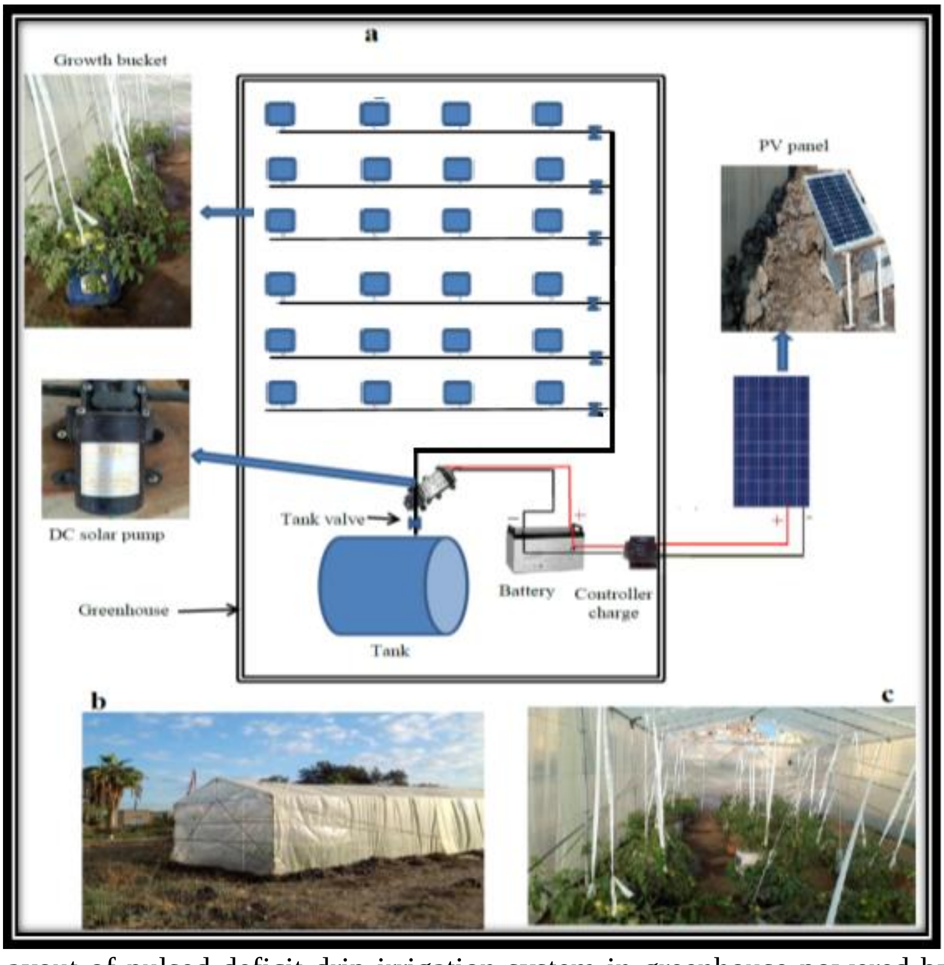

Fig. (1): Layout of pulsed deficit drip irrigation system in greenhouse powered by PV solar energy for cultivated tomato in bucket: a) Diagram of experiment components; b) Outside greenhouse; and c) Inside greenhouse.

2. Moisture content for growth media: Soil samples were taken to determine the water content in the growth media in buckets by auger from the soil profile after 12 hours irrigation on distances of 10 cm from emitter and depth of (0-15cm) and (15-30cm) from the emitter. Soil moisture content was determined by the gravimetric methods.

3. Tomato yield and quality parameters: Harvesting tomato was started within 102 and 130 days after transplanting for one season. The tomato yield was determined for each bucket and that represented treatment. The tomatoes were hand harvested and weighted using a sensitive scale 0.01gm with a capacity of 2 kg and adjusted to tomato yield in ton/fed. Total fruit yield; T Yield, marketable yield; M Yield (the non-marketable yield included yellow fruits and fruits having blossom end rot; BER), the number of fruit per plant; FN/plant and the average weight of the fruit per plant; FW were determined.

4. Water productivity: Water productivity was calculated according to **James (1988)** as follows: -

$$\mathrm{WP} = \frac{\mathrm{y}}{\mathrm{w_a}} \text{ -- (1)}$$

Where, WP is Water productivity, kg/m^3, y is Total crop yield, kg/fed, and w_a is Total applied water, m^3/fed. Total applied water was calculated assist the relations and equations from references (Khalil, 1998 and Ismail, 2002).

5. Required PV solar energy: Required solar energy for irrigation relies on several parameters including pump head, suction head, pipes length, and volumetric flow rate. Equation (2) shows the solar energy as a function of some important parameters (Kelley et al., 2010):

$$E_{pvs} = \frac{r \times g \times Q \times h \times t \times n}{E_p \times E_{pv} \times 3600} \text{ -------------------------------------- (2)}$$

Where, Epvs is PV system energy (kWh/season), r is water density (1000 kg/m^3), g is gravitational acceleration (9.81 m/s^2), Q is volumetric flow rate (m^3/h), h is pumping head (m), t is daily operating time (hr), n is number of days during season, Ep is DC-pump efficiency (90%), and Epv is PV cell efficiency (74%), respectively.

6. Solar energy productivity: The solar energy productivity for pumping irrigation water during the tomato growth season was calculated as follows:-

$$\mathrm{SEP} = \frac{\mathrm{y}}{\mathrm{Epvs}} \text{ -- (3)}$$

Where, SEP is solar energy productivity, kg/kWh, y is Total crop yield, kg/fed, and E_{pvs} is PV consumption solar energy for pumping irrigation water during the tomato growth season (kWh/season).

3. RESULTS & DISCUSSIONS

1. Meteorology conditions

Ambient weather data (air temperature, dew point, relative humidity and wind speed at 2 m height) were daily recorded during growth season from 22 October up to the end of February. Air temperature in experiment site was ranged from 10.9 to 25.3 ^{o}C with an average of 17.3 ^{o}C as shown in Fig. (2), where the optimum temperature in the greenhouse for tomato growth is ranged from 21 to 29 ^{o}C as mentioned by **Zaki, et al., (2010)**. Therefore, the daily mean air temperature in the greenhouse was 24.8 ^{o}C during growth season. Air temperature at dew point outside greenhouse was ranged from 3.5 to 19.8 ^{o}C) with an average of 11.2 ^{o}C as shown in Fig. (2). The daily mean air temperature at dew point inside greenhouse was 13 ^{o}C. Relative humidity in study site was ranged between (50.5 -85.6%) with an average of 69 % as shown in Fig. (3). The optimum range of relative humidity for growth tomato is ranged from 60 to 70% which conforms to **(Zaki, et al., 2010)**. Therefore, the daily mean relative humidity inside the greenhouse was 66% during growth season.

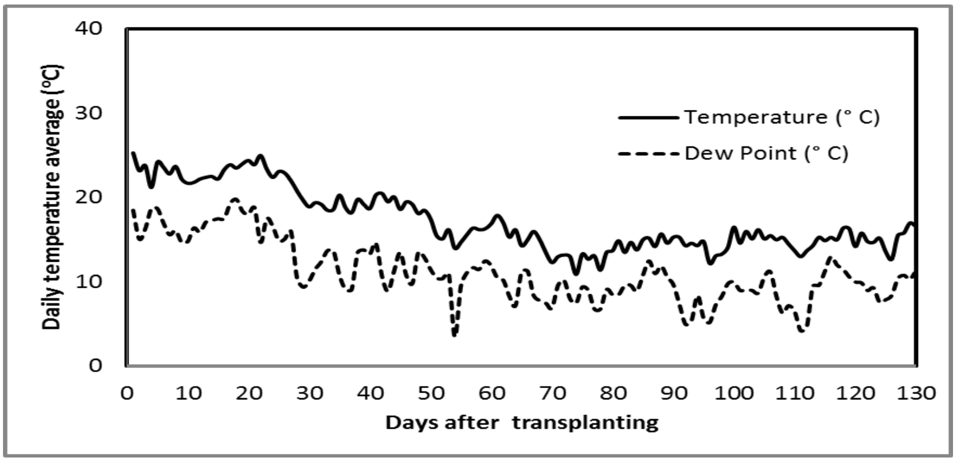

Fig.(2): Average daily temperature (ºC) for experiment site during tomato growth season from 22 October up to the end of February

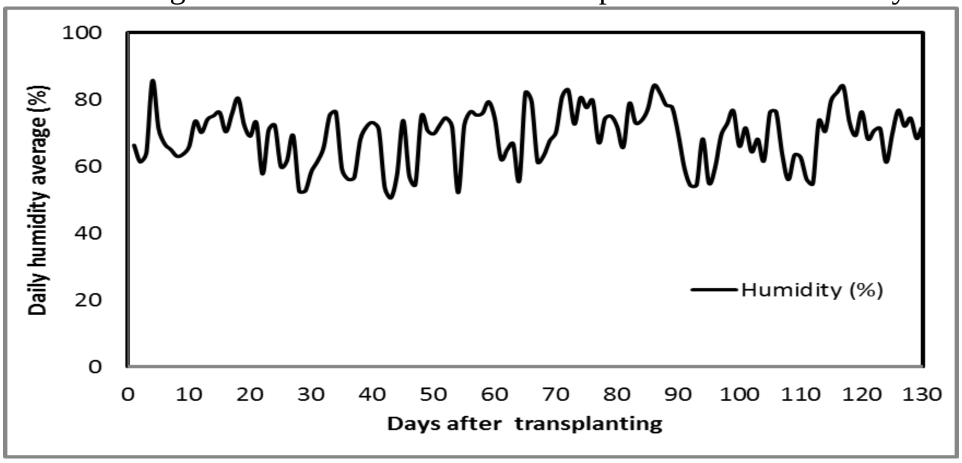

Fig. (3): Average daily air humidity (%) for experiment site during tomato growth season from 22 October up to the end of February.

2. Moisture content; MC

Through measurements it was noticed that, the averaged moisture content for tomato growth media after one day irrigation in Buckets increased largely using Pulsed-Deficit drip irrigation techniques compared to deficit irrigation techniques only as shown in Fig. (4). which was reflected in reduce water losses and the increase of tomato crop yield and irrigation water productivity, in addition to increase in moisture content percent which conforms to **(Ismail, et al., (2014) and Abd-elhakim, 2019).**

3. Tomatoes yield and quality parameters:

<u>a. The number of fruits per plant; FN/plant</u>

The average numbers of tomato fruits per plant (FN/plant) were (31, 30, 29, 29, 25, and 25 fruits/plant) for FP100, FC100, DP75, DC75, DP50 and DC50 treatments respectively as shown in Fig. (5). The highest number of tomato fruits per plant were 31 fruits/plant in the treatment of FP100 despite it was exposed to water stress for using deficit irrigation techniques. It can be noted that there were no significant difference in the average number of tomato fruits per plant as result of applying pulse-deficit drip irrigation techniques especially at level 75% of irrigation water requirements. The statistical analysis showed that, there were significant effects at the 0.01 probability level due to irrigation treatments on number of fruits per plant as shown in table (4).

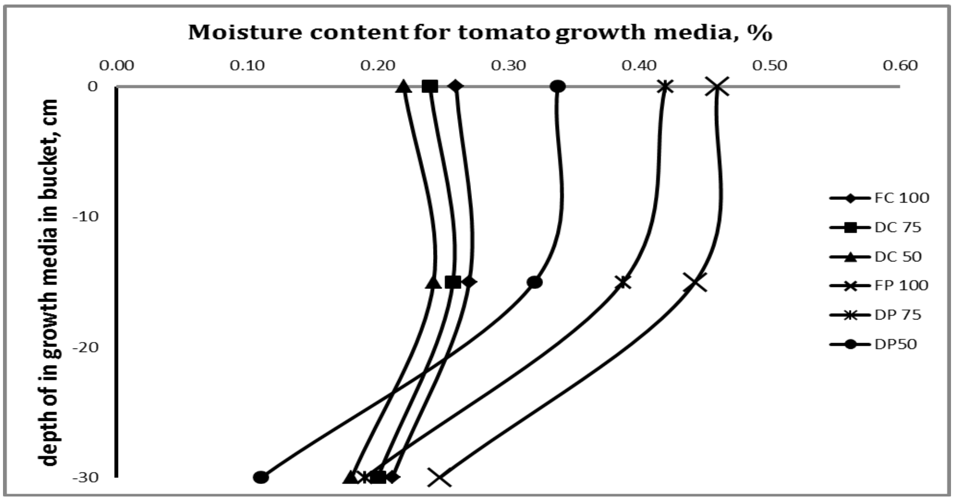

Fig. (4): The average moisture content for tomato growth media after one day of irrigation.

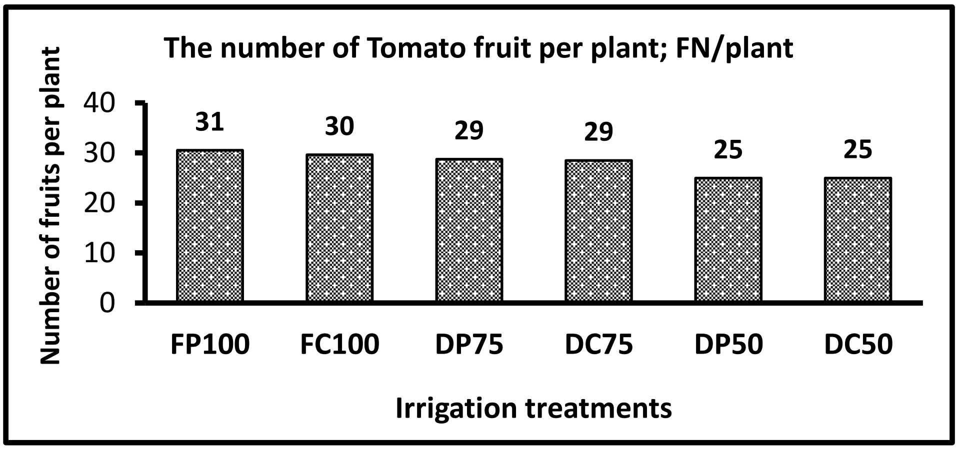

Fig. (5): The number of tomato fruits per plant under different irrigation treatments.

b. The average weight of the fruit per plant; FW

The average weight of tomato fruit per plant (FW) were (69.7, 66.9, 66.9, 64.4, 54, and 45.6 g/fruit per plant) for FP100, FC100, DP75, DC75, DP50 and DC50 for treatments respectively as shown in Fig. (6). Results showed that the average weight of the fruit per plant was the highest in the pulse-deficit drip irrigation more than continuous-deficit irrigation techniques. The highest weight of tomato fruit per plant were in the treatment of FP100 (69.7 g/fruit) but, the lowest weight of tomato fruit per plant were in the treatment of DC50 (45.6 g/fruit). It can be noted there were no significant difference in the average weight of tomato fruits per plant. These were results of applying pulse-deficit drip irrigation techniques at levels of 100, 75% irrigation water requirements compared to continuous-deficit techniques, but there was reducing clear in at level of 50% irrigation water requirements. The statistical analysis showed that, there were significant effects at the 0.01 probability level due to irrigation treatments on the average weight of fruit per plant as shown in table (4).

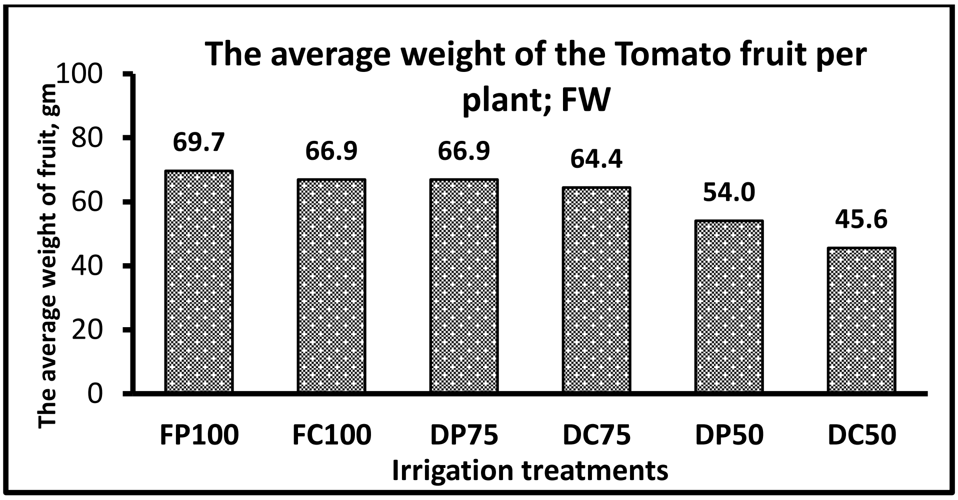

Fig. (6): The average weight of the fruit per plant; FW under different irrigation treatments.

c. Tomato yield per plant

The tomato yield per plant (FY) was (2.1, 2, 1.9, 1.8, 1.3, and 1.2 kg/plant) for FP100, FC100, DP75, DC75, DP50 and DC50 for treatments respective as shown in Fig. (7). Results showed that the tomato yield per plant (FY) was the highest in the pulse-deficit drip irrigation as compared with the continuous-deficit irrigation techniques. The highest yield per plant were in the treatment of FP100 (2.1 kg/plant) but, the lowest yield per plant were in the treatment of DC50 (1.2 kg/plant). It can be noted there were significant difference in the yield per plant as result of applying pulse-deficit drip irrigation techniques led to increase the yield per plant compared to continuous-deficit techniques, but there was reducing clear in yield at using only deficit irrigation technique. The statistical analysis showed that, there were significant effects at the 0.01 probability level due to irrigation treatments on the tomato yield per plant as shown in table (4).

d. Total Tomato yield; T Yield,

The total tomato yield per feddan (TYield) were (35.8, 33.3, 32.3, 30.9, 22.1 and 20.4 ton/fed) for FP100, FC100, DP75, DC75, DP50 and DC50 for treatments respective as shown in Fig. (8). Results showed that the total tomato yield per feddan (TYield) was the highest in the pulse-deficit drip irrigation more than continuous-deficit irrigation techniques by (7, 4, and 8%) for levels of (100, 75, and 50%) respectively. The highest total tomato yield per feddan was in the treatment of FP100 (35.8 ton/fed) but, the lowest yield per plant were in the treatment of DC50 (20.4 ton/fed). It can be noted there were clear significant difference in the total tomato yield per feddan as result of applying pulse-deficit drip irrigation techniques led to increase the total yield compared to continuous-deficit techniques, but there was reducing clear in yield at using only deficit irrigation technique. The statistical analysis showed that, there were significant effects at the 0.01 probability level due to irrigation treatments on the total tomato yield per feddan as shown in Table (4).

e. Water productivity; WP

The recorded data of Water productivity (WP) were (30, 27.9, 36.1, 34.6, 37.1 and 34.1 kg/m^3) for treatments of FP100, FC100, DP75, DC75, DP50 and DC50 respectively as shown in Fig. (9). Total applied water were (1192, 1192, 894, 894, 596, and 596 m^3/fed) for FP100, FC100, DP75, DC75, DP50 and DC50 treatments respectively. Pulse-deficit drip irrigation techniques were positively reflected on the increase of water productivity (WP). It was found that the highest water productivity was in the treatment of DP50 (37.1 kg/m^3) and that was better water saving strategy which conforms to **(Silveira, et al., 2020).** The lowest WP was in the treatment of FC100 (27.9 kg/m^3). Also, result of use deficit irrigation techniques only was the highest WP at DC75 (34.6 kg/m^3) which conforms to **(Nangare, et al., 2016)**. The statistical analysis showed that, there were significant effects at the 0.01 probability level due to irrigation treatments on water productivity as shown in table (4).

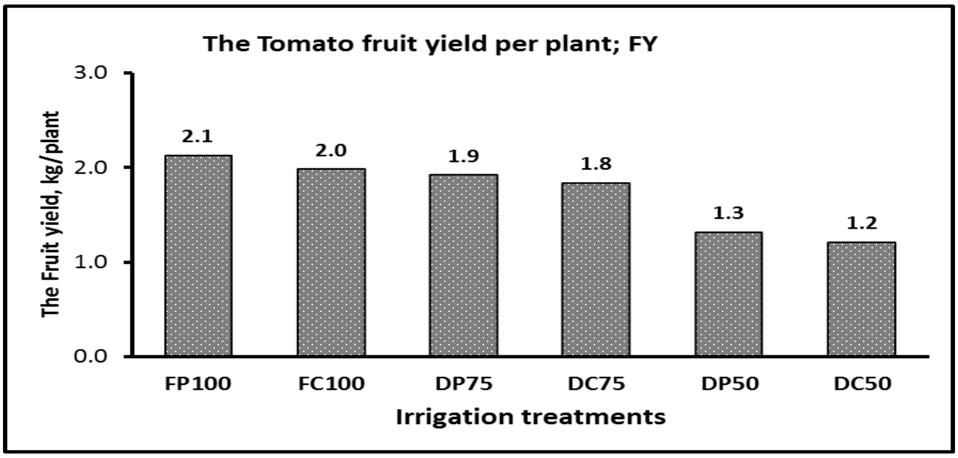

Fig. (7): The tomato yield per plant under different irrigation treatments.

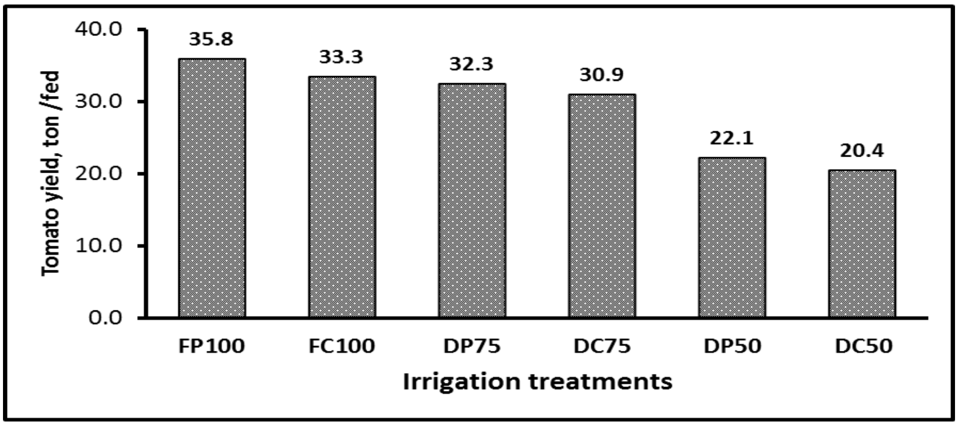

Fig. (8): The tomato yield per feddan under different irrigation treatments in greenhouse.

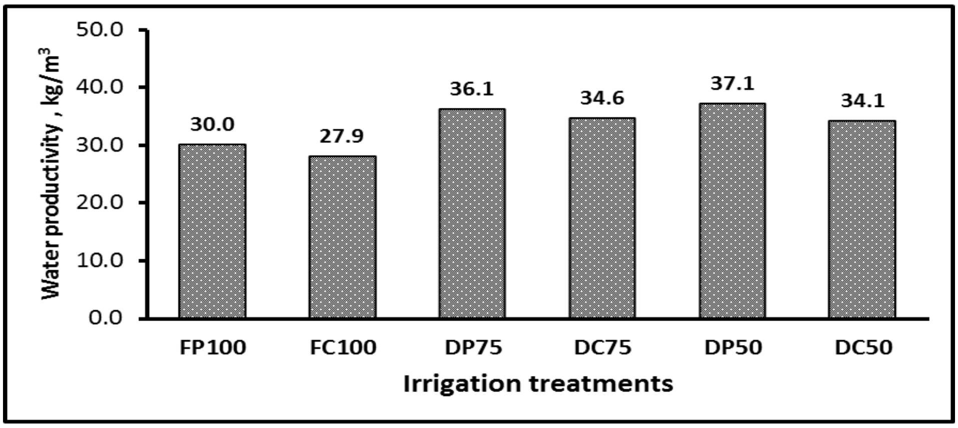

Fig. (9): Water productivity for irrigating tomato crop in greenhouse**.**

Table (4): Statistical analysis of some growth and productivity parameters of Tomato under different treatments.

Treatments	TY (ton/fed)	WP (kg/m^3)	FN (fruits/ plant)	FW (g/fruit)	FY (kg/plant)
FP100	35.772 a	30.007bc	30.5 a	69.678 a	2.1293 a
FC100	33.299 a	27.932 c	29.6 a	66.932 a	1.9821 a
DP75	32.302 a	36.128 ab	28.8 ab	66.911 a	1.9227 a
DC75	30.899 a	34.559 ab	28.5 ab	64.448 a	1.8392 a
DP50	22.127 b	37.122 a	25.0 b	54.036 b	1.3171 b
DC50	20.354 b	34.147 abc	25.0 ab	45.602 c	1.2115 b
P-value	0.000	0.001	0.005	0.000	000
Significance level	**	**	**	**	**

*: Significance at the 0.05 probability level, and **: significance at the 0.01 probability level.

4. Solar Irrigation parameters

a. Solar energy consumption; SEC

Results showed saving in the solar energy consumption for irrigating tomato crop during growth season at applying the pulse-deficit and deficit drip irrigation techniques at levels of 75%, and 50% ETc compared with full continuous and pulsed irrigation techniques at level of 100% ETc. The calculated data of SEC based on water requirements for Tomato crop during growth season were (48.7, 48.7, 36.6, 36.6, 24.4 and 24.4 kWh/season) for treatments of FP100, FC100, DP75, DC75, DP50 and DC50 respectively as shown in Fig. (10). Operating times were (48, 48, 36, 36, 24, and 24 minutes) for FP100, FC100, DP75, DC75, DP50 and DC50 treatments respectively.

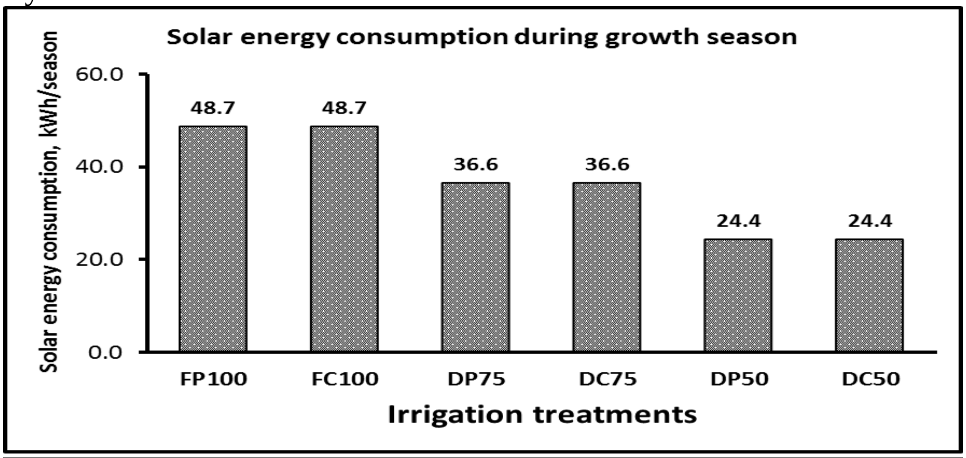

Fig. (10): Solar energy consumption for irrigating tomato crop in greenhouse.

b. Solar energy productivity; SEP

Solar energy productivity (SEP) is an effective indicator for maximizing the use of the solar energy for irrigating tomato crop in greenhouse during growth season. The recorded data of SEP were (734, 683, 884, 845, 908 and 835 kg/kWh) for treatments of FP100, FC100, DP75, DC75, DP50 and DC50 respectively as shown in Fig. (11). Results showed that the use of pulse-deficit drip irrigation techniques was positively reflected on the increase of solar energy productivity (SEP). It is found that the highest SEP was in the treatment of DP50 (908 kg/kWh) but, the lowest SEP were in the treatment of FC100 (683 kg/kWh). Also, result of use deficit irrigation techniques was the highest SEP only at DC75 (845 kg/kWh).

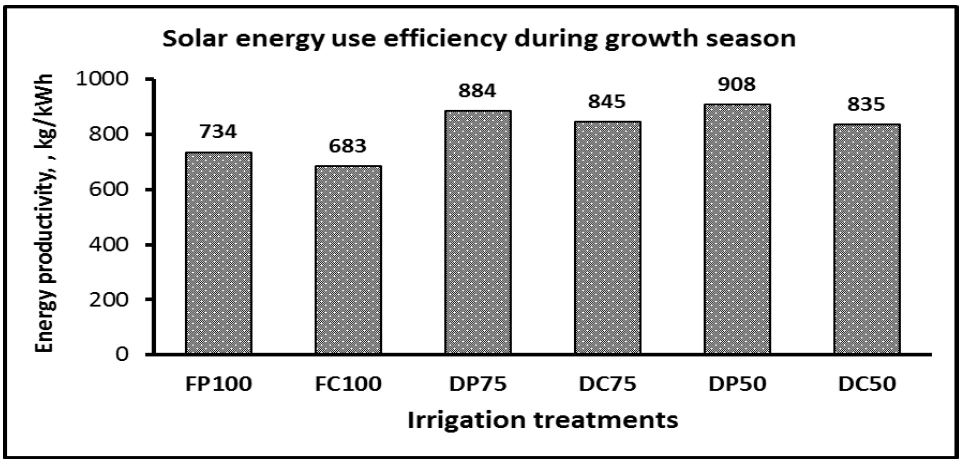

Fig. (11): Solar energy productivity for tomato crop product in greenhouse**.**

4. CONCLUSION

Field experiments were conducted to study the effect of using two effective irrigation techniques together such as the pulse-deficit irrigation powered by solar energy in greenhouse to investigate their impact on the Tomato productivity in buckets, water productivity and solar energy productivity. It was found that, the moisture content for tomato growth media after irrigation in Buckets increased largely under Pulsed-Deficit drip irrigation techniques compared to deficit irrigation techniques only. It can be noted that, there were no significant difference in both of the average number of tomato fruits and the average weight of tomato fruits per plant as a result of applying pulse-deficit drip irrigation techniques at levels of 100 and 75% irrigation water requirements compared with the continuous-deficit techniques. But there was reduction at level of 50% irrigation water requirements. The highest tomato yield in the pulse-deficit drip irrigation was more than continuous-deficit irrigation techniques by (7, 4, and 8%) for levels of (100, 75, and 50%) respectively. The highest total tomato yield per feddan was achieved under the treatment of (FP100) was 35.8 ton/fed but, the lowest yield per plant in the treatment of DC50 was 20.4 ton/fed. The highest water productivity (WP) was 37.1 kg/m^3 when applying of (DP50). On the other hand the treatment of (FC100) gave the lowest WP of 27.9 kg/m^3. The WP in treatment of (DP50) increased by 33% while, total tomato yield per feddan decreased by 34% where it exposed to water stress 50% of irrigation water requirements compared with continuous-full irrigation (FC100) a control. Application of pulse-deficit irrigation (DP50) saved 50% of solar energy consumption and increase EUE (908 kg/kWh) by 33% as compared with (FC100). The statistical analysis was highly significant for the irrigation treatments on tomato productivity, (WP), and plant morphological characteristics. Irrigation with using pulse-deficit drip irrigation technique would enable a decrease in tomato yield because of using deficit irrigation technique, which exposed to water stress but increase in WP in all treatments. Therefore, we recommend using pulse-deficit irrigation (DP75) technique (water stress 25% of the needed irrigation water requirements) because it reduce tomato yield by 3% and increase water and energy productivity by 29.3 and 29.4% respectively.

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تأثير استخدام الري بالتنقيط الناقص النبضي على محصول الطماطم فى الصوب الزراعية تعمل بالطاقة الشمسية

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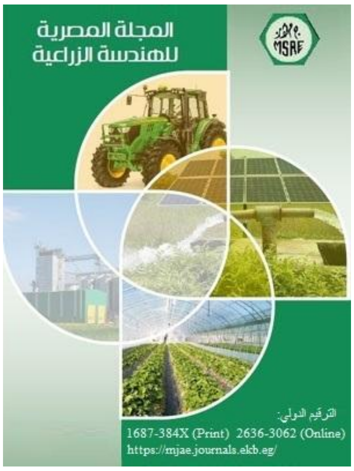

الكلمات المفتاحية:
الري بالتنقيط الناقص النبضي، الطاقة الشمسية، الطماطم.

الملخص العربي

العمل المقدم اقترح دراسة تأثير استخدام طريقتين فعالتين للري معًا مثل الري بالتنقيط الناقص النبضي والري الناقص فقط والذي يدار بالطاقة الشمسية في البيوت المحمية لدراسة تأثيرها على إنتاجية الطماطم و المياه و الطاقة. لذلك، أجريت التجارب بمحطة اختبار وابحاث الجرارات والآلات الزراعية بمحافظة الإسكندرية لموسم زراعة (٢٠١٩-٢٠٢٠). أظهرت النتائج التالي:

أن أعلى انتاجية لمحصول الطماطم عند المعاملة (FP100) للري النبضي فقط بلغت ٣٥,٨ طن/فدان، ولكن أقل انتاجية عند المعاملة (DC50) كانت ٢٠,٤ طن/فدان.

أعلى انتاجية للمياه عند المعاملة (DP50) حيث بلغت ٣٧,١ كجم/م٣ ولكن أقل انتاجية للمياه عند المعاملة FC100 كانت ٢٧,٩ كجم/م^{٣} (Control).

أدى استخدام أسلوب الري الناقص النبضي في المعاملة (DP50) إلى توفير ٥٠٪ من متطلبات استهلاك مياه الري و الطاقة الشمسية وتقليل إنتاجية محصول الطماطم للفدان بنسبة ٣٤٪، وزيادة انتاجية المياه و الطاقة بنسبة ٣٣٪ مقارنة بأسلوب الري المستمر الكامل (FC100) كمعاملة مرجعية.

اظهر التحليل الإحصائي تأثير معنوي عالي لمعاملات الري على انتاجية محصول الطماطم و انتاجية المياه.

في هذا البحث ، نجد أن استخدام أسلوب الري بالتنقيط الناقص النبضي أدى إلى انخفاضً في انتاجية محصول الطماطم بسبب أسلوب الري الناقص والذى يتعرض فيه المحصول لنقص فى الاحتياجات المائية اللازمة ولكن أدى إلى زيادة في كفاءة استخدام المياه في جميع المعاملات ، لذلك نوصي بتطبيق أسلوب الري بالتنقيط الناقص النبضي للمعاملة (DP75)) والذى يتعرض فيه محصول الطماطم لنقص فى الاحتياجات المائية بنسبة ٢٥٪ من احتياجات مياه الري اللازمة لأنها كانت تقلل من إنتاجية الطماطم بنسبة قليلة ٣٪ وتزيد من كفاءة استخدام المياه والطاقة بنسبة ٢٩,٣ و ٢٩,٤٪ على التوالي.