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MODIFICATION OF MICROCLIMATE CONDITIONS FOR IMPROVING TOMATO PLANT GROWTH COMPONENTS AND WATER USE EFFICIENCY

W. M. A. Ismail[1&*], M. M. Hegazy[2], K. F. El-Bagoury[2], W. M. Sultan[3], M. M. Mohamed[4]

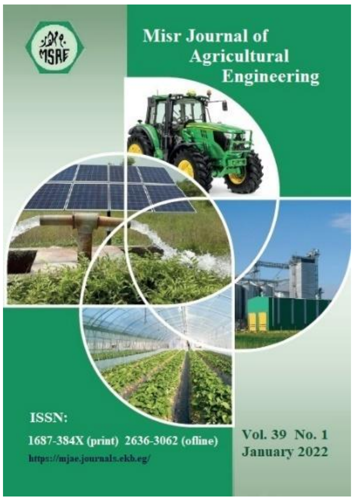
[1] Ph.D. Student, Ag. Eng. Dept., Fac. of Ag., Ain Shams U., Egypt.

[2] Prof. of Ag. Eng., Ag. Eng. Dept., Fac. of Ag., Ain Shams U., Egypt.

[3] Head of Res., Field Irrigation Eng. Dept., Ag. Eng. Res. Inst., Ag. Res. Center, Egypt.

[4] Prof. of Soil Science, Soil and Water Science Dept., Fac. of Ag., Ain Shams U., Egypt.

* E-mail: wafaa.mahmoud1990@gmail.com



Keywords:

Drip irrigation; Mulching; Plant height; Plant stem diameter; Yield.

ABSTRACT

Climate change is one of humanity's most pressing problems. So, the aim of study was to improve tomato (Solanum lycopersicum L. cv. Elisa) healthy unit area productivity (Quality and Quantity) under surface and sub-surface drip irrigation systems. Field experiment was conducted within the time of Dec. 2019 to May 2020, in the Horticulture Department, Faculty of Agriculture, Ain Shams University in Shoubra El Kheima, Kalyubia Governorate, Egypt. Experimental farm is located at (latitude 30°, 12'N and longitude 31°, 24'E; mean altitude, 26 m above sea level). The experimental design was a split plot design with three replicates comprising two irrigation systems [surface drip irrigation (T1) and sub-surface drip irrigation (T2)] in main plots involving drip irrigation [built-in dripper, normal flow rates were 8 l/h/m (dripper spacing 0.5m)]. Tunnel heights 75 cm, three plastic tunnels of low thicknesses [40 micron (P1), 50 micron (P2) and 60 micron (P3)] in subplots. Data analysis revealed under surface and sub-surface drip irrigation at was treatment plastic thickness 60 micron at a plant height of 135.6 cm and 141.5 cm. Plant stem diameter under surface and sub-surface drip irrigation 33.8 mm and 34.5 mm, it increased by 10.4% and 11.6% more than control with mulching. Yield was 22.94 ton/fed and 24.45 ton/fed under surface and sub-surface drip irrigation increase ratio 54.1% and 45.8% more than control with mulching. Water use efficiency was 16.46 kg/m^3 and 20.38 kg/m^3 under surface and sub-surface drip irrigation increase ratio 58.1% and 55.5% more than control with mulching.

1. INTRODUCTION

Greenhouse technology allows farmers to grow many kinds of crops in regions and seasons of adverse climatic conditions which bring high profit. The popularity of greenhouse farming techniques increased the crop production for the whole world and contributed to the reduction of world hunger problems. However, the success of greenhouse crop productions relies on the capacity to carefully regulate the microclimate inside the greenhouse in order to meet the requirement for crop production and quality. Low tunnels are similar to high tunnels but are relatively unexplored as an environmental protection tool for strawberries. In the low tunnel system, strawberries are grown on raised beds with plastic mulch (Anderson, et al., 2019). The structure protects the crop from wind damage. It also helps to retain the heat. Crops inside the row cover mature early and produce a reasonable yield having a higher market price (Sindhu and Chatterjee, 2019). Mulch is a protective cover placed over the soil, primarily to modify the effects of local climate. It is a well-established technology in vegetable cultivation, but the success of mulching depends on the selection of the right mulching material. Various factors affect mulch selection, but the most important are the season of cultivation (Rai and Dinmani, 2018). They added that the low tunnel technology is mainly suitable for the off-season cultivation of cucurbits like muskmelons, round melons, long melons, bitter grand, bottle gourds, summer squash, etc. The micro-climate inside the poly-house can be changed. In one example, certain insects require ultraviolet (UV) light for vision purposes. The opaque UV covering of the poly house helps to keep the insects from entering the house. Consequently, there is a minimal use of insecticides (Kumar et al., 2017). The soil temperature under the mulch treatment was higher than that of the control because the plastic preserves the soil temperature as compared to unmatched soil (Kwambe et al., 2015). The highest solar radiation was observed in H3 (low tunnel heights 75cm) and I5 (single row planting) treatments in the tunnel height and irrigation treatments respectively. (Lodhi, et al., 2013). The variation in the transmissivity coefficients was at most 10% within six months of experimental field test. (Vox, G., and Schettini, E., 2013). The low plastic tunnel has a direct effect on the air temperature and the relative humidity and an indirect effect on the soil temperature and the soil moisture inside the tunnel. In addition, mulching is used to maximize water use and growth improvements in plants. Mulching could be used to increase or decrease soil temperature and creates a favorable soil-water-plant relationship (Singh et al., 2012). The tomato (Lycopersicon esculentum Mill.) is one of the most important vegetables worldwide. Global tomato production in 2001 was about 105 million tons of fresh fruit from an estimated 3.9 million hectares (ha). As it is a relatively short duration crop and gives a high yield, it is economically attractive, and the area under cultivation is increasing daily (Dam, 2005). Increased irrigation water use efficiency (IWUE) by using the drip irrigation system in the case of tomatoes (Ngouajioa et al., 2007). The aim of study was to improve tomato (Solanum lycopersicum L. cv. Elisa) healthy unit area productivity (Quality and Quantity) under surface and sub-surface drip irrigation systems.

2. MATERIALS AND METHODS

Field experiment was conducted from Dec. 2019 to May 2020 growing winter seasons. The location of the experiment at sit, which belongs to Horticulture Department, Faculty of Agriculture, Ain Shams University that located in Shoubra El Kheima, Kalyubia Governorate, Egypt (latitude 30^o, 12' N, and longitude 31^o, 24'E, and mean altitude 26 m above sea level). The soil texture of the experimental area is clay loam. However that cultivated with tomato plants (Solanum lycopersicum L. cv. Elisa).

2.1 Soil analysis: Laboratory experiments were carried out at Soil and Water Unit- Central Laboratory, Faculty of Agriculture, Ain Shams University at Shoubra El-Kheima, Kalyubia

Governorate, Egypt, show the mechanical and chemical analyses of the soil samples had been summarized in tables (1 and 2).

Table (1): Mean physical analysis of the experimental soil

Soil depth (cm)	Particle size (%) Sand	Silt	Clay	Texture class	B.D., (g/cm^3)	F.C., (%)	P.W.P., (%)
0-30	24	36	40	Clay loam	1.32	31.05	14.81
30-60	27	32	41	Clay loam	1.34	32.71	17.52
60-90	23	33	44	Clay loam	1.40	35.02	17.68

F.C. = Field Capacity, P.W.P. = Permanent Wilting Point, were determined as percentage in weight, B.D. = Bulk Density

Table (2): Mean chemical analysis of the experimental soil

Soil depth (cm)	pH	EC (dS/m)	Soluble cations (meq l^{-1})				Soluble anions (meq l^{-1})			CaCO$_3$ (%)	Organic matter (%)
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{2-}		
0-30	7.91	1.05	2.02	1.55	6.5	0.43	1.60	7.20	1.70	1.80	1.64
30-60	7.61	0.66	1.20	1.11	3.50	0.80	0.71	5.49	0.41	1.41	0.82
60-90	7.54	0.77	1.31	0.78	4.90	0.75	1.50	5.30	0.90	0.76	0.12

2.2 Meteorological data: Climatic data was obtained from weather station which belongs to Central Laboratory for Agricultural Climate (CLAC), ARC, Egypt (2019, 2020). Daily variation of reference evapotranspiration (ET_o) for winter seasons calculated by the FAO Penman Monteith using ET_o Calculator program as shown in tables (3).

Table (3): Climatic data during the studied growing season

Month	**T-Mean (°C)**	**T-max (°C)**	**T-min (°C)**	**RH- Mean (%)**	**Radiation (W/m^2)**	**ET_o (mm/day)**
Dec-2019	16.4	21.9	12.0	60.5	62.4	1.86
Jan-2020	13.6	19.1	9.2	63.5	75.8	1.97
Feb-2020	15.2	21.7	10.3	65.4	100.4	2.57
Mar-2020	18.2	25.4	12.5	61.9	146.5	4.1
Apr-2020	21.5	29.1	15.5	55.1	176.4	5.19
May-2020	26.3	34.6	19.4	46.1	197.4	6.21

2.3 Irrigation systems, experimental design and treatment:

The drip irrigation network consists of a water source from the Nile, control unit, main ball valve and built-in dripper, actual flow rates were 8 l/h/m (dripper spacing 0.5m); emission uniformity (EU) was 95.21% (Excellent) with CV of 3.51% (Excellent), lateral length is eight meters long and the distance between lines is one meter.

The main plots were irrigated through surface drip irrigation and subsurface drip irrigation (T1, T2), tunnel heights 75 cm, and the sub-subplots had plastic thicknesses (P) of [40 micron (P1), 50 micron (P2) and 60 micron (P3)]. For sub-surface drip irrigation, the irrigation hose is buried at a depth of 15 cm. The experiments had four control treatments with and without mulching under both systems of drip irrigation; the layout of the experimental design is shown in (Fig. 1).

<u>2.4 Tunnels:</u> The tunnels were made with 6 mm thick steel (iron) rods and a parabolic shape with the given base and desired height (Lodhi, et al., 2013). Base lengths were kept at 3.0 m for the insertion of frames into the soil, and inner loops were provided on both sides of the frame for support in addition to that provided by low tunnel height, in which tunnel heights was 75 cm and tunnel width was one meter. Tunnel length is eight meters long, the distance between the first arc and the next arc and the last and before it is one meter and the distance between the arc and the next arc is two meters.

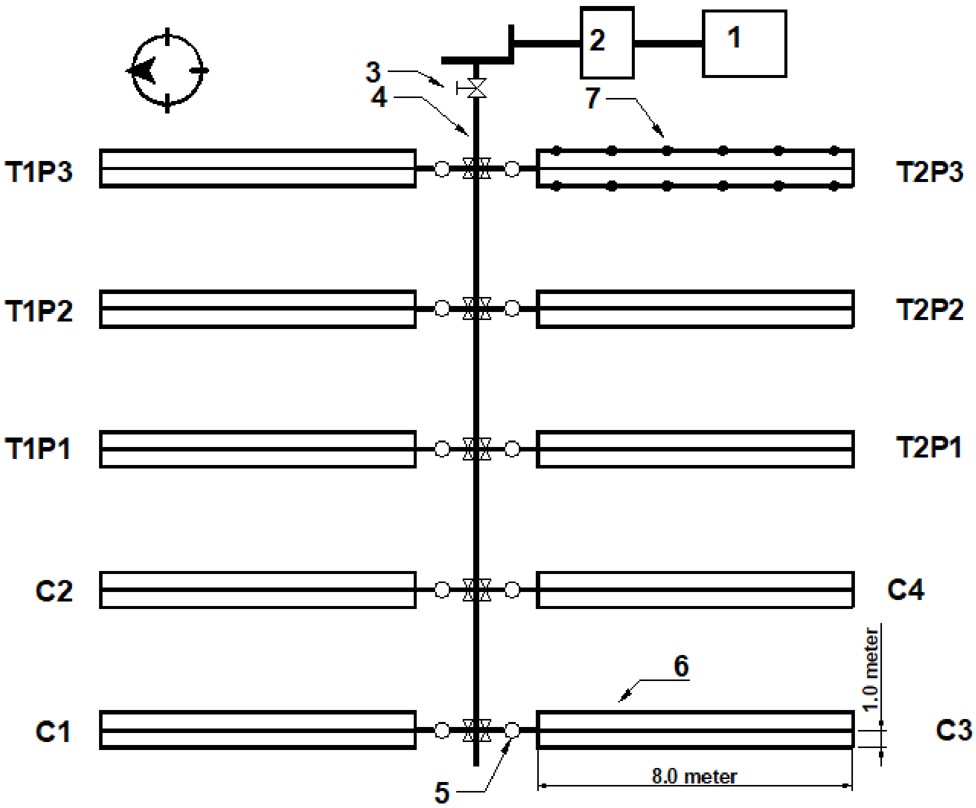


Fig. (1): Layout of irrigation systems with control and treatments distribution

1- Water source and pumping, 2- Control head, 3- Manual valve,
4- Mainline (Pipe diameter ϕ32 mm), 5- Flow meter. 6- Lateral line ϕ16 mm,
7- Dripper,

C1 : Control without mulch under surface drip irrigation systems.
C2 : Control with mulch under surface drip irrigation systems.
C3 : Control without mulch under sub-surface drip irrigation systems.
C4 : Control with mulch under sub-surface drip irrigation systems.
T1P1 : Surface drip irrigation systems, plastic thickness 40 micron and with mulch.

T1P2 : Surface drip irrigation systems, plastic thickness 50 micron and with mulch.
T1P3 : Surface drip irrigation systems, plastic thickness 60 micron and with mulch.
T2P1 : Sub-surface drip irrigation systems, plastic thickness 40 micron and with mulch.
T2P2 : Sub -surface drip irrigation systems, plastic thickness 50 micron and with mulch.
T2P3 : Sub -surface drip irrigation systems, plastic thickness 60 micron and with mulch.

2.5 Tomato crop: The Elisa variety was cultivated in field on December 28, 2019. Irrigation was applied, as per the treatments. In the single furrow, the row-to-row spacing was 1.0 m, and the plant-to-plant spacing was 50 cm. In accordance with the recommendations of the Ministry of Agriculture's 'Package of Practices for Vegetable Crops' (source), complete plant protection measures were adopted during the growth period to ensure disease- and weed-free crops.

- After crop transplantation, the plants were covered with plastic sheet that were 40, 50, and 60 micron thick as well as 240 cm wide. The plastic sheet covered tunnel frame heights of 75 cm to protect the crops from frost and other types of damage. The tunnel frames were installed at the beginning and at the end of a single row, and the distance between successive frames was kept at 2.50 m. The ventilation system was a natural, with the plastic cover lifted only on sunny days to remove excess heat or relative humidity from the tunnel and to aid helpful insects in pollination throughout the flowering period.

Measurements:

a. Climatic parameters: the data was measured the above-mentioned by devices at 2:30 p.m.;
b. Vegetative measurements on tomato yield: the data on plant height and the plant stem diameter at harvest time was recorded;
c. Fruits characteristics: plants' data was recorded per plant, as fruit weight (g), fruit length (cm) and fruit diameter (mm);

2.3 Methods of calculation:

2.3.1 Tomato irrigation water requirements per growth stage time had been calculated according to period: Crop evapotranspiration (ET_c) are calculated for the normal time process by comparing evapotranspiration (ET_o) in combination with the tomato crop coefficient (K_c). (Allen, et al., 1998) (Table 4). Calculation of total applied water for controls and treatment within different growth stages under surface and sub-surface drip irrigation shown at tables (5 and 6).

$$\boldsymbol{ET_C = ET_o \times K_c}$$

Table (4): Crop coefficient (K_c) for tomato per season growth periods (Allen et al., 1998)

Growth stages of tomato		No. of days/ stage	Crop coefficient, K_c
Initial stage	Dec. - Jan.	25	0.6
Developmental stage	Jan. - Feb.	35	0.88
Middle growth stage	Feb. - March - April	65	1.15
Late stage	May	30	0.9

Table (5): Total applied water for controls and treatment within different growth stages under surface drip irrigation

Growth stages of tomato	Months	No. of days/ stage	C1	C3	T1P1	T1P2	T1P3
Initial stage	**Dec. - Jan.**	**25**	**288.75**	**210.00**	**204.75**	**199.5**	**212.625**
Developmental stage	**Jan. - Feb.**	**35**	**446.25**	**315.00**	**254.625**	**249.375**	**262.50**
Middle growth stage	**Feb. - March - April**	**65**	**971.25**	**918.75**	**732.375**	**729.75**	**735.00**
Late stage	**May**	**30**	**341.25**	**278.25**	**204.75**	**199.50**	**183.75**

Table (6): Total applied water for controls and treatment within different growth stages under sub-surface drip irrigation

Growth stages of tomato	Months	No. of days/ stage	C2	C4	T2P1	T2P2	T2P3
Initial stage	**Dec. - Jan.**	**25**	**236.25**	**220.5**	**160.125**	**178.5**	**162.75**
Developmental stage	**Jan. - Feb.**	**35**	**288.75**	**270.375**	**212.625**	**231**	**215.25**
Middle growth stage	**Feb. - March – April**	**65**	**763.875**	**748.125**	**682.5**	**703.5**	**687.75**
Late stage	**May**	**30**	**236.25**	**220.5**	**133.875**	**149.625**	**133.875**

2.3.2 Yield and Irrigation Water Use Efficiency (IWUE):- Jensen (1983) is used and expressed as a mass of marketable crops per unit water volume (kg/m3) per unit water volume and is determined by the following equation:

$$\boldsymbol{IWUE}, \quad \boldsymbol{kg/m^3} = \left({}^{\boldsymbol{Y}}/_{\boldsymbol{TAW}}\right)$$

Where, IWUE= Irrigation Water Use Efficiency, (kg/m^3); Y = yield, (kg/fed), TAW= total applied water, (m^3/fed).

3. RESULTS AND DISCUSSION

3.1 Climatic parameters:

3.1.1 Air Temperature:

The measured data of air temperatures had been presented that thermal conditions based on the height of the tunnel and the irrigation systems as shown in figs. (2 and 3). At 2:30 p.m., the air temperature (°C) in the tunnel coverage with plastic thicknesses of 60 microns 21.5ºC to 26.5ºC, at surface drip irrigation systems below tunnel height of 75 cm, respectively, compared to open field temperatures ranging from 17.5°C to 22.7°C. The findings above were very similar to those of Wolfe et al., (1989), who stated a 5°C to 20°C daytime air temperature rise under row covers as compared to open field. According to Lodhi, et al., (2013), stated air temperature under low tunnel differs between 3.25°C and 3.71°C at 7:30 a.m., while at 2:30 pm it differs between 6.38°C and 9.3°C as compared to open field. They additional that differences in temperature between low tunnel treatments may be due to factors including initial air and soil temperature in the tunnel.

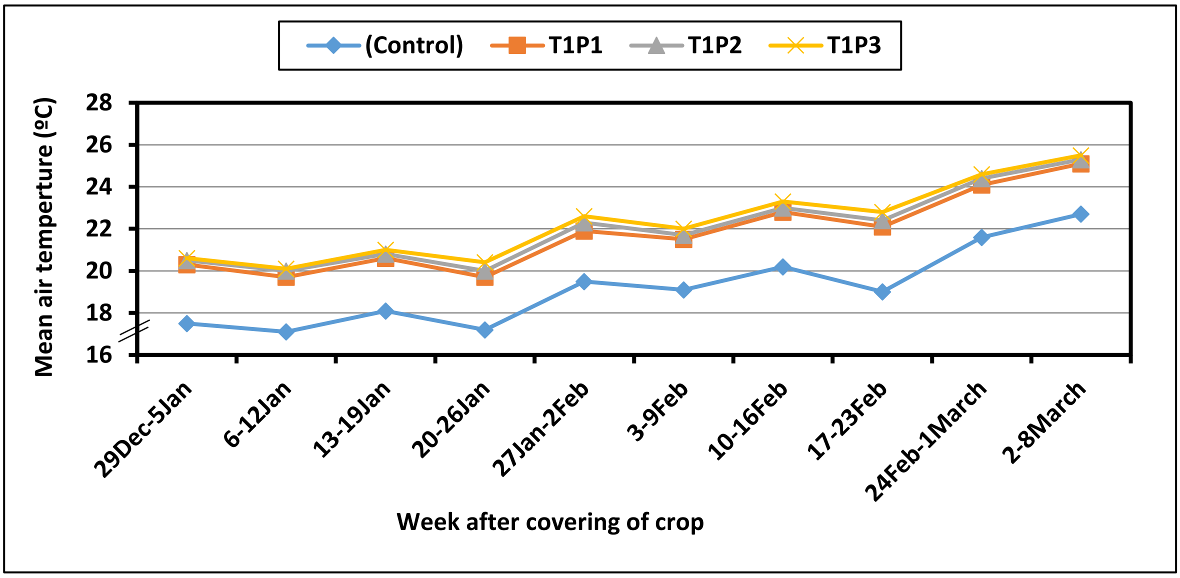


Fig. (2): Mean air temperature (°C) at surface drip irrigation systems

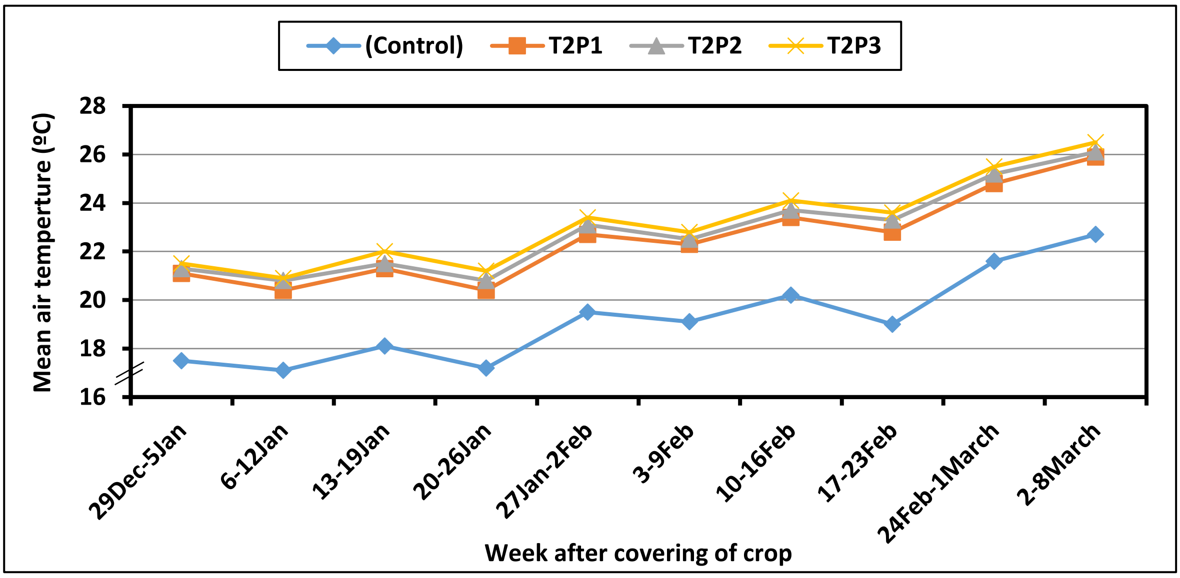


Fig. (3): Mean air temperature (°C) at sub-surface drip irrigation systems

3.1.2 Relative humidity

Relative humidity reported presented as shown in fig. (4 and 5). At 2:30 p.m., relative humidity (%), in the tunnel coverage with plastic thicknesses of 60 microns 53.9% to 52.6%, at surface drip irrigation systems below tunnel height of 75 cm, respectively, compared to open field temperatures ranging from 30.3% to 27.1%. The data also reveal that the low tunnel effect decreases relative humidity in the morning but in the daytime, it increases relative humidity to provide favorable conditions for plant growth. The findings above were very similar to those of Chaugule, et al., (1990) and Lodhi, et al., (2013).

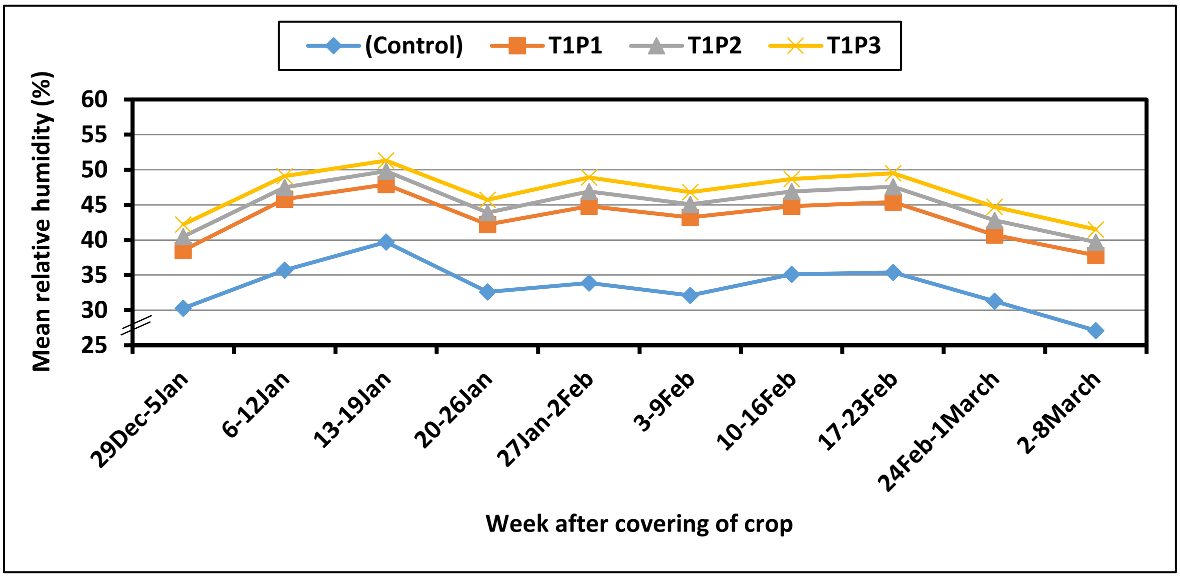


Fig. (4): Mean relative humidity (%) at surface drip irrigation systems

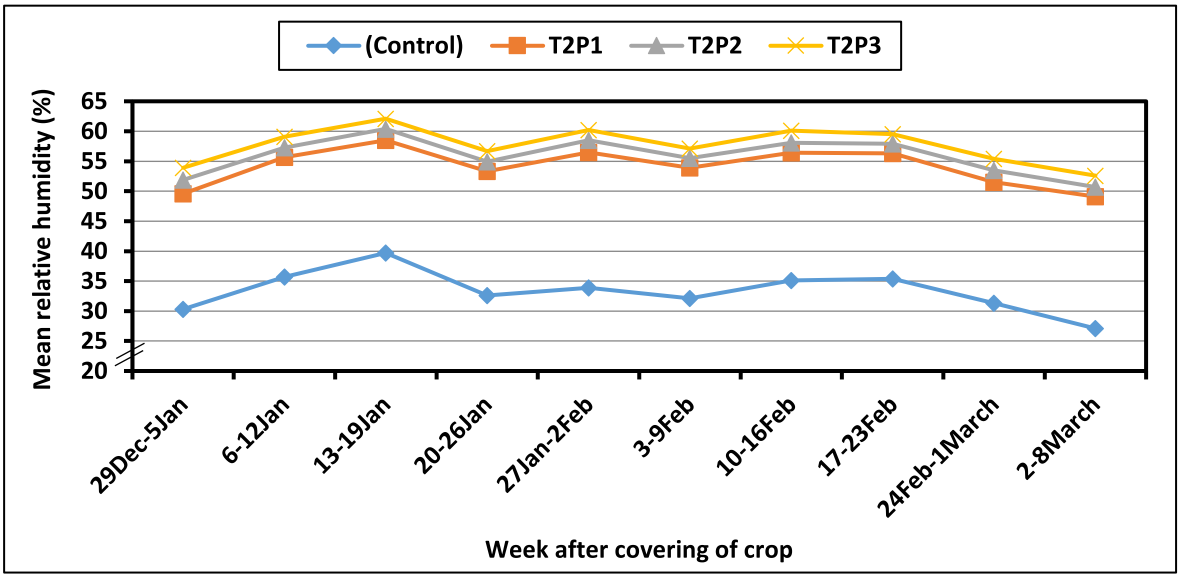


Fig. (5): Mean relative humidity (%) at sub-surface drip irrigation systems

3.1.3 Solar radiation

The measurement of solar radiation depends on tunnel height and the type of irrigation methods as shown in fig. (6 and 7). Around 2:30 p.m., solar radiation below tunnel height of 75 cm varied from 207.6 W/m^2 to 317.7 W/m^2, in comparison with open field from 275.1 W/m^2 to 391.1 W/m^2.

Solar radiation below tunnel height of 75 cm varied from 67.9 W/m^2 to 103.88 W/m^2, in comparison with open field from 275.1 W/m^2 to 391.1 W/m^2. The variations in solar radiation between low tunnels treatments may be due to different surface areas of the tunnels. These findings are also consistent with those of Lodhi, et al., (2013), who reported that row cover elevated mean solar radiation 16.6% to 37.4% and encouraged plant growth relative to bare soil.

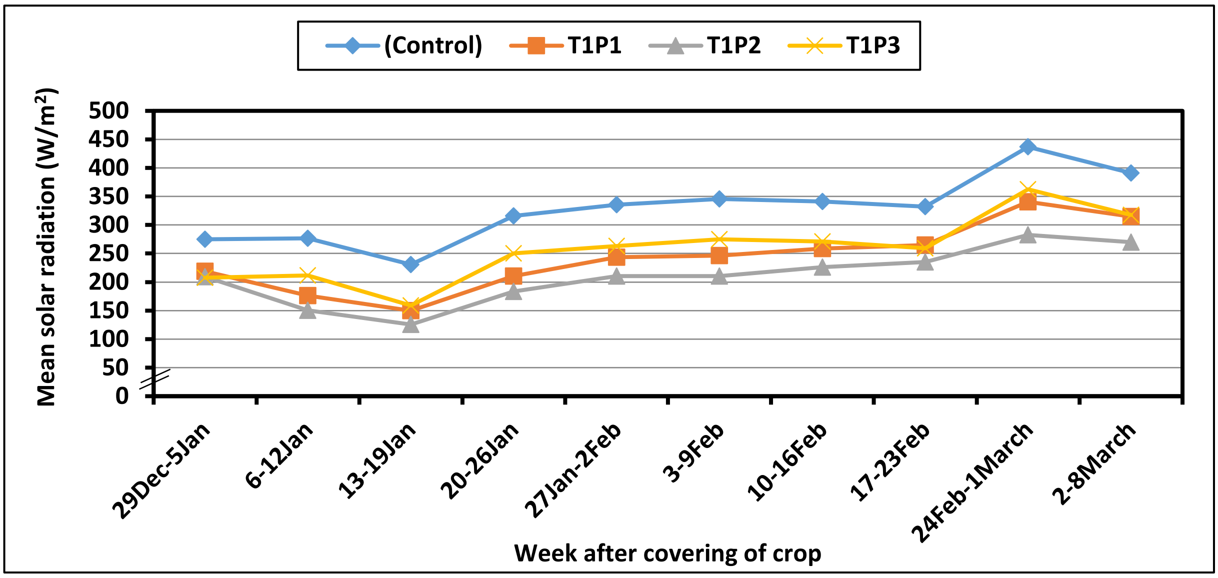


Fig. (6): Mean solar radiation (W/m^2) at surface drip irrigation systems

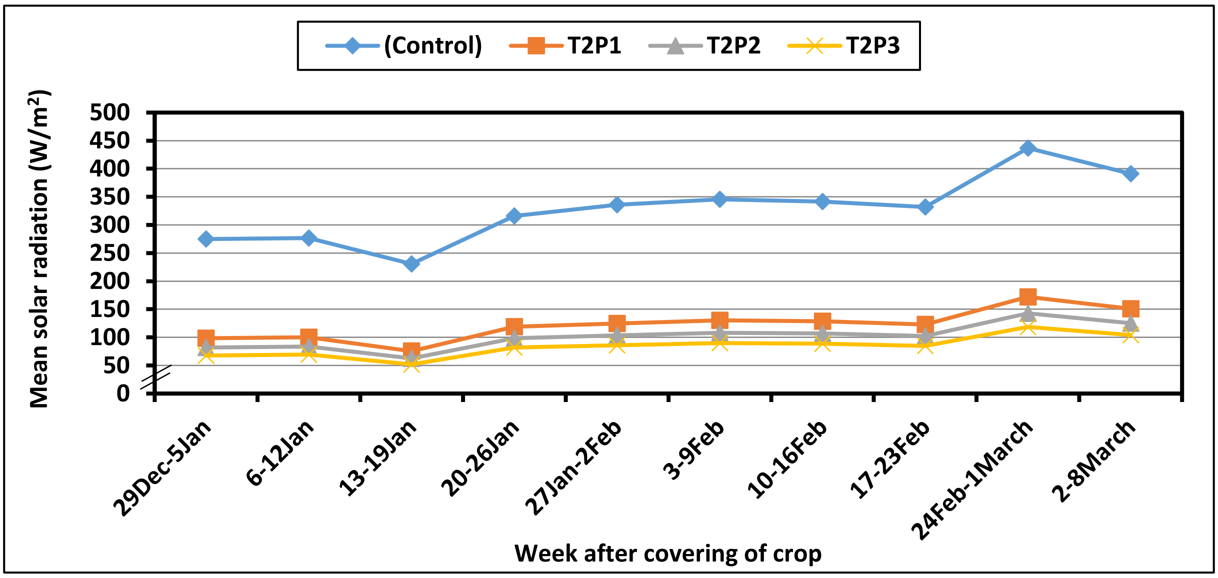


Fig. (7): Mean solar radiation (W/m^2) at sub-surface drip irrigation systems

3.1.4 Soil temperature

The reported soil temperature measure showed that the thermal state focuses on the height of the tunnel and the method of irrigation applied, as shown in fig. (8 and 9). At 2:30 p.m., the soil temperature (°C) in the tunnel coverage with plastic thicknesses of 60 microns 25.6ºC to 25.8ºC, at surface drip irrigation systems below tunnel height of and 75 cm, respectively, compared to open field temperatures ranging from 20.2°C to 22.1°C.

The above results were similar to those of Hemphill (1986), who reported that row covers increased daily mean soil temperature over bare soil by 1 to 4°C and Lodhi, et al., (2013), who described that low tunnel raised mean soil temperature from 1.3°C to 4.76°C and stimulated plant growth compared to bare soil.

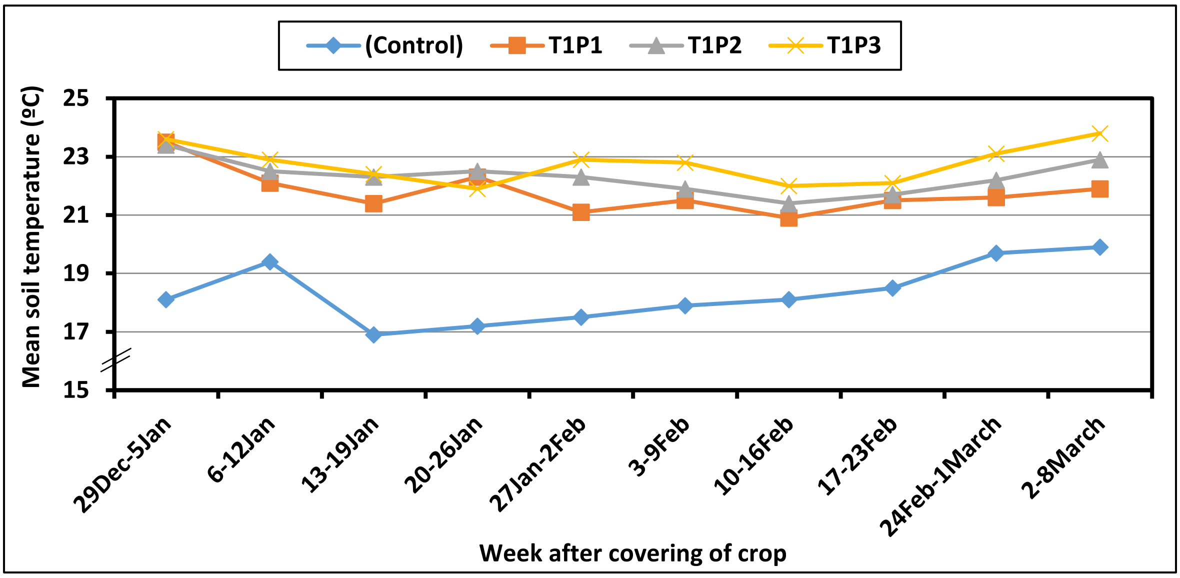


Fig. (8): Mean soil temperature (ºC) at surface drip irrigation systems

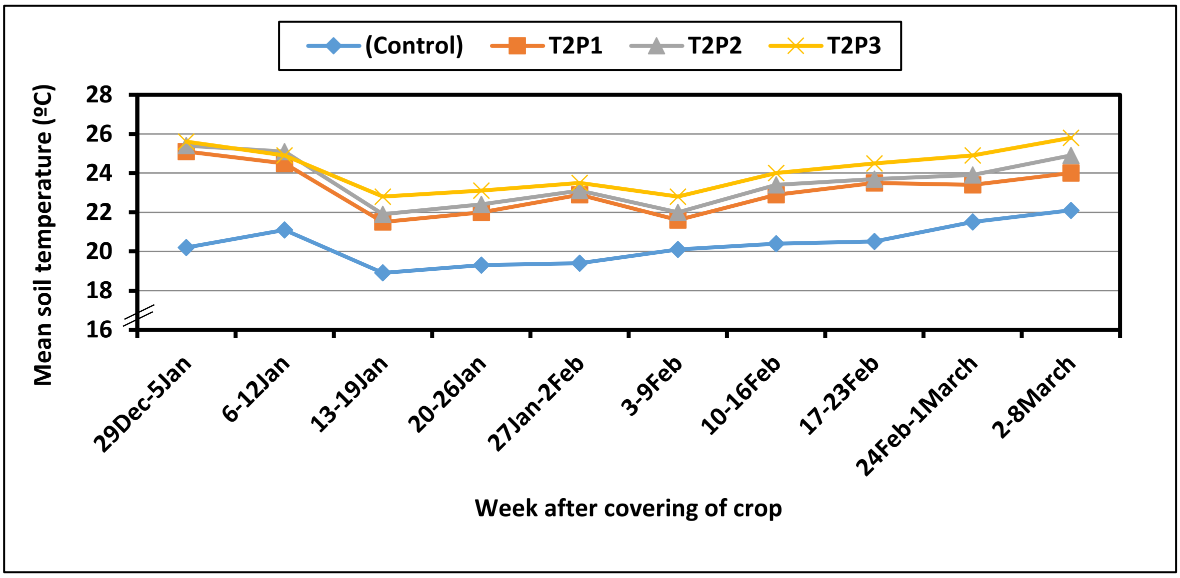


Fig. (9): Mean soil Temperature (ºC) at sub-surface drip irrigation systems

a. <u>Vegetative components measurements and tomato yield:</u>

Data in figs. (10 and 11), Show the effect of tunnel and mulch applications on plant height and plant stem diameter. The following can be observed: Compared to control without mulch, which was 100.56 cm and 30.01 mm, and control with mulch, which was 100.9 cm and 30.3 mm, the best value at plastic thickness 60 micron for plant height and stem diameter respectively at plastic thickness 60 micron was 135.6 cm and 33.8 mm, respectively at surface drip irrigation. While sub- surface drip irrigation at the same plastic thickness was 141.5 cm and 34.5 mm for plant height and plant stem diameter, respectively. This finding is in agreement with other researcher (Chernet et al., 2014) who obtained tomato with plant height in the range of 36.80 to 139.0 cm. In accordance with the researchers (Arin, L., and Ankara, S., 2001), this result was also obtained in the range of 30.01 to 34.60 mm tomatoes with plant stem diameter.

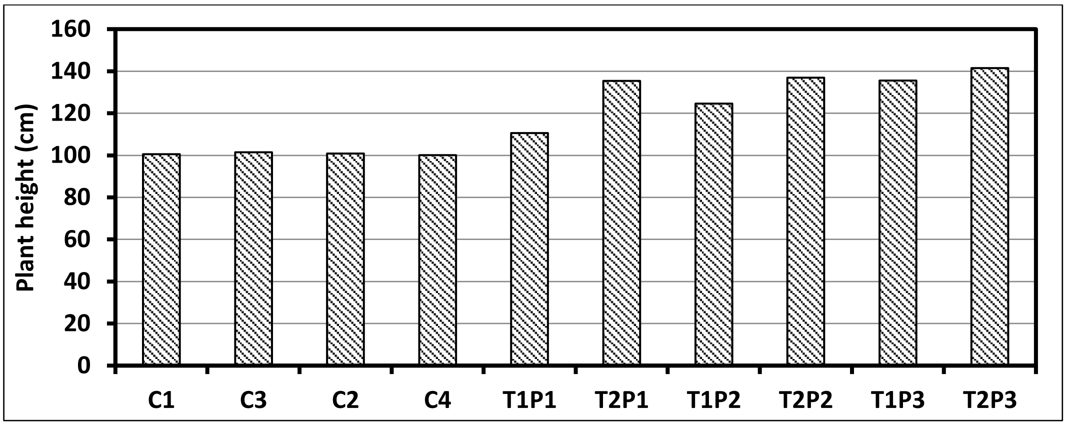


Fig. (10): the effect of tunnel and mulch applications on plant height (cm)

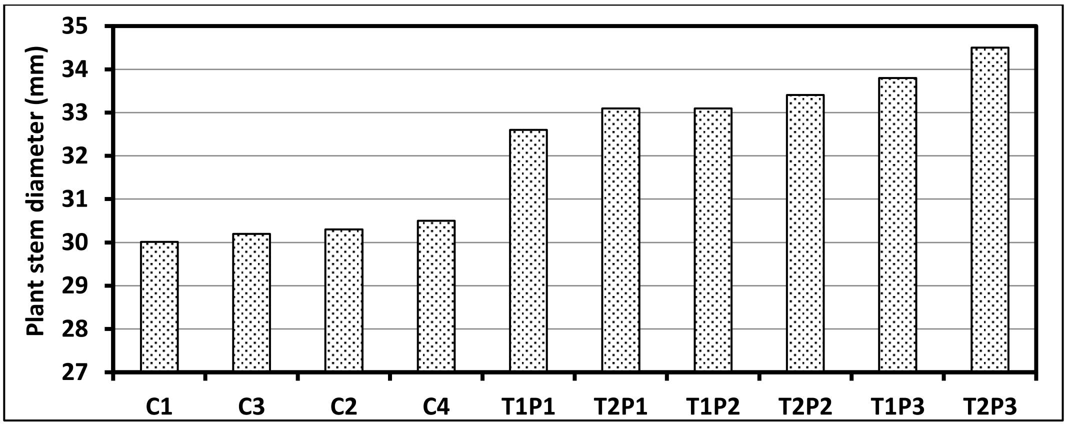


Fig. (11): the effect of tunnel and mulch applications on plant stem diameter (mm)

b. <u>Fruits characteristics:</u>

Data are shown in tables (7), the best value for Fruit weight, fruit length, and fruit diameter under surface drip irrigation systems at plastic thickness 60 micron was 175.6 g, 60 cm, and 59 cm respectively, compared to Control without mulch, which was 33.5 g, 35 cm, and 37 cm and Control with mulch, which was 44.9 g, 45 cm, and 40 cm respectively.

Under sub-surface drip irrigation systems at plastic thickness 60 micron, the best value was 193.5 g, 85 cm and 83 cm for fruit weight, fruit length and fruit diameter, respectively, compared to control without mulch, 50.6 g, 46 cm and 43 cm and Control with mulch, respectively, 55.6 g, 47 cm and 45 cm.

Table (7): the effect of tunnel and mulch applications on fruit weight, fruit length and fruit diameter under surface and sub-surface drip irrigation systems

Fruits characteristics	Control/ Treatment									
	C1	C3	C2	C4	T1P1	T2P1	T1P2	T2P2	T1P3	T2P3
Fruit weight (g)	33.5	50.6	44.9	55.6	109.9	110.5	150.8	180.1	175.6	193.5
Fruit length (mm)	35	46	45	47	49	57	59	67	60	85
Fruit diameter (mm)	37	43	40	45	45	55	56	65	59	83

c. <u>Yield and Irrigation Water Use Efficiency:</u>

Data in table (8) indicate irrigation of the surface drip: the control WUE without mulch and with mulch was 4.6 kg/m^3 and 7.71 kg/m^3 and 94.272 ton/fed and 11.760 ton/fed, respectively. At plastic thickness 60 micron, the highest value was 18.17 kg/m^3 and output 22.944.0 ton/fed, but at plastic thickness 40 micron the lowest value was 10.04 kg/m^3 and output 14.016.0 ton/fed, respectively. While sub-surface drip irrigation: 6.11 and 9.08 kg/m^3 and 10.521.6 ton/fed/season and 13.248.0 ton/fed were WUE in control without mulch and with mulch. At plastic thickness 60 micron, the highest value was 20.38 kg/m^3, 24.4480 ton/fed, but at plastic thickness 40 micron, the lowest value was 11.25 kg/m^3, 15.504 ton/fed/season. The above findings were similar to those of Ngouajioa et al., (2007) and Palada et al., (2003), who reported increased irrigation water use efficiency (IWUE) by using the drip irrigation system in combination with plastic mulch in case of tomatoes.

Table (8): relationships between total applied water, yield crop and water use efficiency under surface and sub-surface drip irrigation

IWUE&Yield	Control/ Treatment									
	C1	C3	C2	C4	T1P1	T2P1	T1P2	T2P2	T1P3	T2P3
TAW (m^3/fed)	2047.5	1722	1525.1	1459.5	1396.5	1189.1	1378.1	1262.6	1393.9	1199.6
Yield (ton/fed)	94.27	11.76	10.52	13.25	14.02	15.50	14.98	18.29	22.94	24.45
IWUE (kg/m^3)	4.60	7.71	6.11	9.08	10.04	11.25	10.74	15.38	18.17	20.38

4. SUMMARY AND CONCLUSIONS

There results showed that actual flow rates were 8 L/h/m and emission uniformity (EU) was 95.21% (Excellent) with CV of 3.51% (Excellent). This study showed additional benefits of using low tunnels in vegetable crops with the potential to increase sustainability. Low tunnels modified the micro-environment by increasing air temperatures and soil temperatures in comparison to the open field about vegetative growth and yield of tomato compared with the open field. After crop transplantation, the plants were covered with plastic sheet that were 40, 50, and 60 micron thickness. The plastic sheet covered tunnel frame heights of 75 cm and plastic thickness 60 micron with plastic mulch (50 micron) to protect the crops from frost and other types of damage. The plants were completely covered with low-thickness tunnels up to March 8, 2020, after which these tunnels were removed. All the treatments were replicated thrice to assess the level of significance. A set of observations on microclimate parameters representing the middle of each subplot and outside on the adjoining open field. We recommended using plastic sheet plastic thickness 60 micron with plastic mulch (50 micron) under sub-surface drip irrigation systems.

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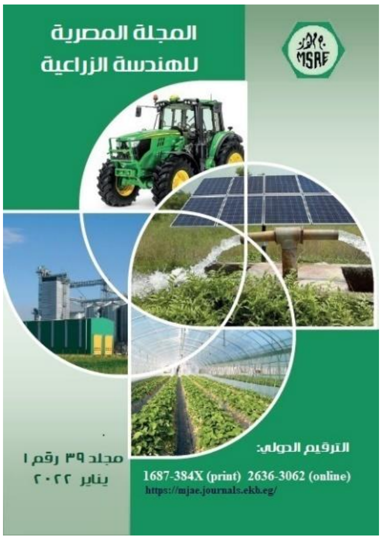
تعديل ظروف المناخ الدقيق لتحسين مكونات نمو نبات الطماطم وكفاءة استخدام وحدة المياه

م. وفاء محمود عبد الباري إسماعيل[1]، أ.د. محمود محمد حجازي[2]، أ.د. خالد فران طاهر الباجوري[2]،
أ.د. وائل محمود مختار سلطان[3] و أ.د. منال مبارك محمد[4]

[1] طالبة دراسات عليا - كلية الزراعة - جامعة عين شمس - مصر.
[2] أستاذ الهندسة الزراعية - كلية الزراعة - جامعة عين شمس - مصر.
[3] رئيس بحوث بمعهد بحوث الهندسة الزراعية - قسم هندسة الري الحقلي - مركز البحوث الزراعية - مصر.
[4] أستاذ بقسم علوم الأراضي - كلية الزراعة - جامعة عين شمس - مصر.



الملخص العربي

يعتبر تغير المناخ من أكبر التحديات التي تواجه البشرية، الهدف من الدراسة هو تعظيم إنتاج محصول الطماطم (Solanum lycopersicum L. cv. Elisa) وكفاءة استخدام وحدة المياه تحت نظامي الري بالتنقيط (السطحي والتحت سطحي). أجريت زراعة التجربة الحقلية في الحقول المكشوفة خلال موسم الشتاء ديسمبر ٢٠١٩ حتى مايو ٢٠٢٠ في (شبرا الخيمة - محافظة القليوبية - مصر) بكلية الزراعة جامعة عين شمس (خط عرض ٣٠ درجة، ١٢ درجة شمالاً وخط طول ٣١ درجة، ٢٤ درجة شرقاً؛ متوسط الارتفاع ٢٦ م فوق مستوى سطح البحر)، في تربة طينية طميية. تم وضع التجربة في القطع المنشقة مرة واحدة تحت نظامي الري بالتنقيط [نقاط داخلي ذو تصرف ٨ لتر/ساعة/متر (المسافة بين النقاطات ٠,٥ متر)] كان طول خط التنقيط ٨ متر والمسافة بين الخط والذي يليه ١ متر. القطع الرئيسية هي الري بالتنقيط السطحي والري بالتنقيط تحت السطحي (T1 وT2) مع ارتفاع النفق (٧٥ سم) والقطع الفرعية سمك البلاستيك (٤٠، ٥٠ و٦٠ ميكرون) مع أربعة تحكم اثنين منهم تحت بلاستيك الملش ٥٠ ميكرون (تغطية التربة) تحت كلا نظامي الري بالتنقيط على التوالي ويعمل ذلك على زيادة الإنتاج وتحسين نوعيته والإقلال من استخدام المبيدات.

كانت قيم الري بالتنقيط السطحي وتحت السطحي عند استخدام سمك بلاستيك ٦٠ ميكرون لارتفاع النبات ١٣٥,٦ سم و١٤١,٥ سم، حيث زادت بنسبة ٢٥,٦٪ و٢٩,٣٪ الأرض المكشوفة المغطى ببلاستيك الملش على الترتيب. قطر ساق النبات للري بالتنقيط السطحي والري بالتنقيط تحت السطحي ٣٣,٨ مم و٣٤,٥ مم، زاد بنسبة ١٠,٤٪ و١١,٦٪ أكثر من الأرض المكشوفة المغطى ببلاستيك الملش على الترتيب. بلغ المحصول ٢٢,٩٤ طن/فدان و٢٤,٤٥ طن/فدان للري بالتنقيط السطحي والتحت السطحي بنسبة 54.1٪ و٤٥,٨٪ أكثر من الأرض المكشوفة المغطى ببلاستيك الملش على الترتيب. بلغت كفاءة استخدام مياه الري ١٦,٤٦كجم/م^{٣} و٢٠,٣٨ كجم/م^{٣} للري بالتنقيط السطحي والتحت سطحي بنسبة ٥٨,١٪ و٥٥,٥٪ أكثر من الأرض المكشوفة المغطى ببلاستيك الملش علي الترتيب.

الكلمات المفتاحية:
الري بالتنقيط؛ تغطية التربة؛ طول النبات؛ قطر ساق النبات؛ الإنتاجية.