



Management of Irrigation Water for Cucumber Crop by Using Drip Irrigation Systems under Greenhouse

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Abstract: This study aimed to examine the consequences of three regimes for irrigation on cucumber crops and their growth indication, production, and water productivity under greenhouse cultivation. Cucumber seedlings were planted in May 2018 under a greenhouse condition. Three regimes of drip irrigation were examined, first 100%, 80%, and 50% of ET_c namely T1, T2, and T3, respectively. Second regime was systems of drip irrigation (surface and sub-surface irrigation), finally the third is drippers discharge which used (2 l/h and 4 l/h). Results indicated clearly that the best production was under 80% ET_c regime by 2 l/h dripper for surface and subsurface that was 10.1 and 11.2 ton/greenhouse respectively with IR 172 m³/season and the best regime by using 4 l/h was 50% ET_c for surface and sub-surface respectively which was 11 and 11.5 ton/greenhouse with IR 216 m³/season which saved about half a quantity of irrigation water. On the other hand, the very best water productivity value (WP) was under 80% ET_c was 58.7 and 65.4 kg/m³ under surface (S) and sub-surface (SS) drip irrigation respectively by 2 l/h dripper flow rate.

1 Introduction

Water-saving in the agricultural sector is a very important factor for Egypt's water scarcity to serve the growing population with the limited resources. Recently, cultivating vegetables under greenhouses in Egypt has been expanding rapidly. The number of greenhouses reached about twenty thousand, where about 12000 (60%) are used for cucumber production (EL-Aidy et al 2007).

Under greenhouses cucumber crop is one of the most popular and best vegetables grown in the Arab Republic of Egypt. Irrigation scheduling has a significant effect on growing cucumber crops by irrigation water volume which adding during un-

der different growth stages (Mao et al 2003). It gives more production under greenhouse cultivation than the open field (Maklad et al 2012).

Usually, drip irrigation systems used under greenhouse Cause of saving water with increasing fruit yield and improved WP due to consumption of less water (Berihun et al 2011), any degree of water deficits may produce deleterious effects on the growth and yield of the crop (Saifet et al 2003).

Water scheduling application is an effective way on drip irrigation system efficiency, by reducing irrigation amount, while the causes of water stress are the inadequate irrigation. (Deng et al 2006, Zaman et al 2001).

This study aimed to search out technologies for water-saving by maximizing production by employing the drip irrigation regimes for irrigating cucumber crops under greenhouse conditions.

2 Materials and Methods

2.1 Materials

2.1.1 Soil and water characteristics

The soil of the experimental greenhouse is assessed as silty clay texture by mechanical analysis of homogeneous soil of the experiment at 40 cm depth which is suitable for cucumber growing roots details showed in **Table 1**. The irrigation well was 40 m depth with 10 m diameter and irrigation groundwater characteristics are detailed in **Table 2**.

2.1.2 Climate data

The climatic data were obtained from a meteorological station located next to the field of experiment and accustomed estimate the ETo data because the microclimate may be a major think about this study, these following data were recorded at Central Laboratory for Agriculture Climate (CLAC 2018) during growth season showed in **Table 3**.

2.1.3 The greenhouse experiment

A field study was at an experimental greenhouse of Agriculture Research Centre, located at Dokii, Egypt, (Latitude 30°N and longitude 30°N). The water source was groundwater from a well situated within the experimental area, an arch there is not any heating and air ventilation inside the chosen greenhouse, manufactured from wooden frames covered with transparent plastic roof polyethylene (PE) 120µm thickness plastic film protected with meshes of 20 x 10 threads/cm². The greenhouse used for this experiment was classified as low technology greenhouse, each of 3.2 m high, 40 m long, and 16 m wide 640 m² area showed in **Fig 1**.

2.1.4 Drip irrigation system

The components of the system are described below:

- 1- Control head: It was at the water supplement source, a centrifugal pump 4"/3", driven by an electric engine 15 HP. The pump discharge is

35 m³/h and 30 m lift, at width 1900 rpm screen filter 3" (120 mesh), backflow prevention device, pressure gauges, pressure regulator, control valves to control the desired pressure at different part of the system, flowmeter, and chemical injection.

- 2- Fertilizer unit for injecting fertilizers into the irrigation system.
- 3- Main line: 75 mm diameter PVC pipes, and sub-main line: PVC pipes of 50 mm diameter.
- 4- Laterals: PE tubes 16 mm in diameter at the spacing of 50 cm distance, built-in 16 mm PE surface and sub-surface drip line with 2 l/h and 4 l/h emitter discharge at 1 bar operating pressure. The spacing was 50 cm. The irrigation network is described in **Fig 2**.

2.1.5 Cucumber plant

Seedling's cultivation for cucumber (*Cucumis sativus* L.) was transplanted in May 2018 and harvested on August 2018 end as a summer cycle, with distance (0.5 m) between each cucumber seed, the length of season was 14 weeks. Cucumber (*Cucumis sativus* L.), Joyance variety at 10 days with stalk length 7-10 cm, were planted at a rate of 960 saplings per 640 square meters, Treatments had the identical recommended amount of fertilizers.

2.2 Methods

2.2.1 Experimental design

The greenhouse designed in a splits plot with three replications where irrigation regimes (T1:100%, T2:80% and T3:50%) of estimated evapotranspiration, the greenhouse divided into 6 plots of 2 m × 40 m area with 0.5 m spacing between them this description showed in **Fig 3**. Each plot has two built-in SDI (surface drip irrigation) and SSDI (sub-surface drip irrigation) with two different emitters, 2 l/h and 4 l/h to exam every irrigation regime which the best as showed in **Fig 4**. Irrigation was scheduled based on a water balance, calculated by (El-Gindy 2007).

2.2.2 Evapotranspiration

ETc, estimated from the potential evapotranspiration (ETo), and using the crop coefficient (Kc) proposed this equation,

$$ETc = ETo * Kc \quad \dots\dots\dots (1)$$

ETc: crop evapotranspiration localized irrigation system, mm/day,

Eto: reference crop evapotranspiration, mm/day and Kc: crop coefficient.

Table 1. Physical properties of homogeneous soil of the experiment analyzed before cultivation

Depth	Soil particle size distribution %			Texture	F.C% At 33 KPa	P.W.P At 1500KPa
	Sand	Clay	Silt			
(0-50) cm	8.1 sand	48.8 clay	43.1 silt	Silty clay	36	17

Where: F.C: field capacity % and P.W.P: permanent wilting point were determined as percentage in weight %.

Table 2. Irrigation water's chemical analysis

pH	EC ppm	Soluble anions and cations (meq/l)							
		Ca ⁺⁺	Mg ⁺⁺	Na ⁺⁺	K ⁺	CO ₃ ⁻	HCO ₃ ⁻	SO ₄ ⁻	Cl ⁻
7.30	500	1.2	0.1	3.31	0.41	0.00	0.5	1.4	3.12

Table 3. Average rooting depth and crop coefficient for cucumber crop (FAO 2011)

Growth stage	Days no.	Kc	Date
Initial Stage	8	0.45	2 May :10 May 2018
Development Stage	40	0.70	11 May: 20 June 2018
Mid-Season	30	0.90	21 June: 20 July 2018
Late-Season	25	0.75	21 July: 15 August 2018

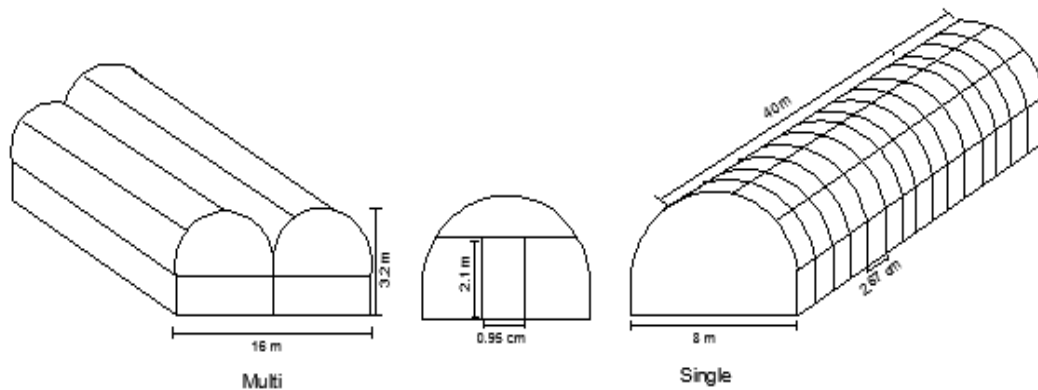


Fig 1. Greenhouse dimensions

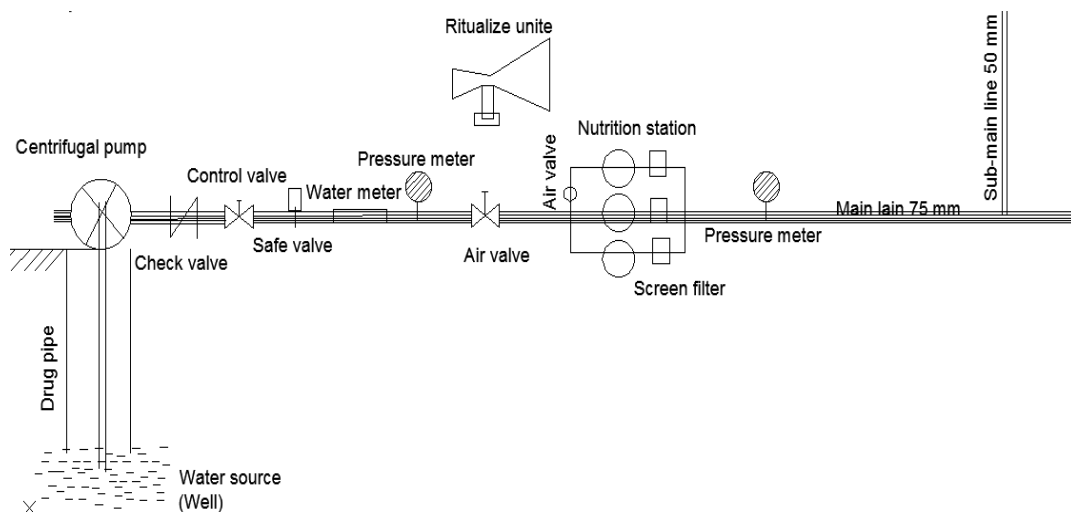


Fig 2. The layout of drip irrigation system component

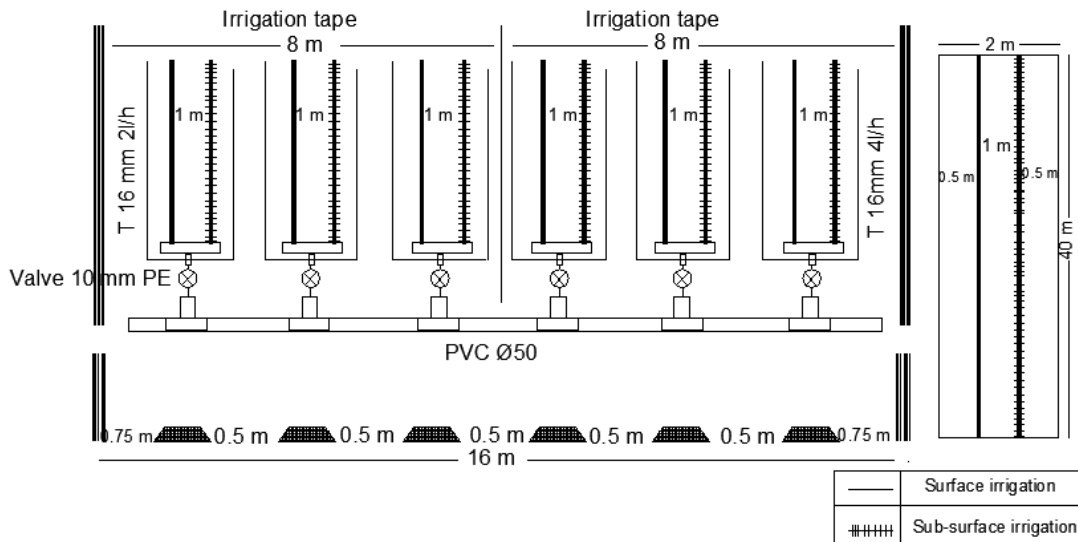


Fig 3. The layout of growing beds

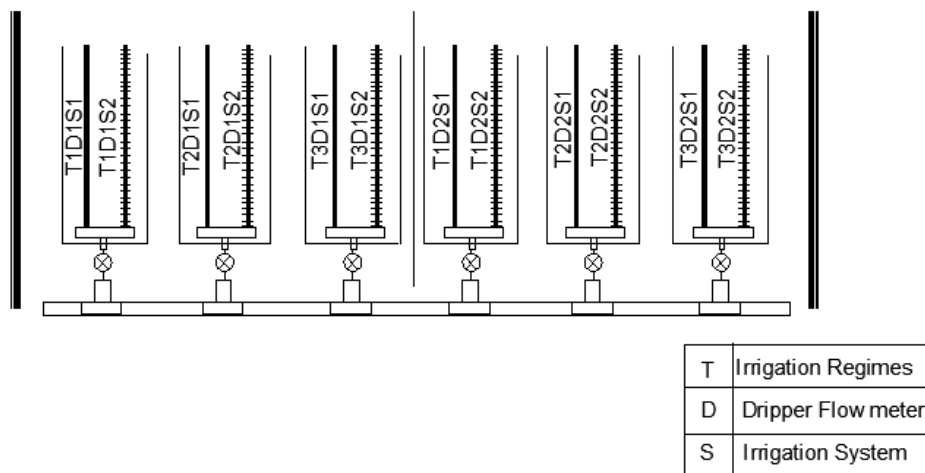


Fig 4. Irrigation treatments under greenhouse

2.2.3 Irrigation requirement

The water applied quantity for each treatment was calculated by the following equation (Howell 2003)

$$IR = \frac{E_{to} \cdot K_c \cdot A}{\Sigma a} * 0.7 \dots\dots\dots (2)$$

Where:

IR: irrigation requirement (l/greenhouse/day);
ET_o: reference crop evapotranspiration (mm/day);
K_c: crop coefficient; A: greenhouse area (m²) and
Σa: water application efficiency (Clark et al
2007).

By using the followed equation, total irrigation requirements m^3/season under cultivating greenhouse could be estimated as showed in **Table 4**.

Calculating the amount of irrigation water which already added to cultivating greenhouse by following equation

$$T = \frac{IR \cdot A}{\rho} * 60 \dots\dots\dots (3)$$

T: time of irrigation (minute); IR: irrigation requirements for the plot (mm); A: the area of the plot (m²); Q: discharge of lateral in the greenhouse (l/h)

Table 5 showed the quantity of water which already applied under different irrigation treatments under greenhouse cultivation.

2.2.4 Water productivity (WP)

By authors describing, is the ratio of crop yield or crop value, to a selected measure of water consumed, applied, or evaporated in the process of growing a crop. according to the following equation (Moldn et al 2010, Zwart et al 2004).

$$WP = \frac{\text{crop yield (ton/ha)}}{\text{Applied water (m}^3\text{/ha)}} \dots\dots\dots (4)$$

Table 4. Estimated irrigation requirement for greenhouse/season

Growing stage	Days	Month	ETo mm/day	Kc	Σa	IR m³/growing stage		
						100%	80%	50%
Initial. Stage (8 days)	8	May	4.5	0.45	95%	9.4	7.2	4.6
Development. (40 days)	30	June	5	0.70		80	64	40
	10	July	5.1					
Mid-Season (30 days)	20	July	5.1	0.90		76	60	38
	10	August	4.6					
Late-Season (25 days)	20	August	4.6	0.75		48	38	22
	5	September	3.6					
Σ days	103	IR m³/season				213.4	168	104.6

Table 5. Applied water irrigation requirement for irrigation treatment under greenhouse

Growing stage	Month	Irrigation Time	Line flow rate (m ³ /h)		IR m ³ /growing stage					
					100%		80%		50%	
			2l/h	4l/h	2	4	2	4	2	4
Initial Stage	May	40 mint.	0.16	0.32	17	34	13.6	26	8.4	17
Development Stage	June				84	168	66	132	42	84
	July				64	128	50	102	32	64
Mid-Season	August				52	104	40	80	26	52
Late-Season	September				216	432	172	344	108	216
Total Irrigation										

2.2.5 Soil and plant measurements

There are numerous techniques for evaluating soil moisture. (Digital Mini Moisture) the meter was used for estimating soil moisture at 15 –50 cm profile soil depth at least that of the root penetration.

The data of growing plants were measured during the cucumber crop growth period to evaluate the whole yield, the height of the plant by using the meter to measure the height from the beging of the stalk to its end, and the fruit number harvested per plant.

3 Results and Discussion

3.1 Irrigation requirements

Results showed adding irrigation water requirements by using 2 l/h dripper discharge equal the estimating quantity of irrigation water requirement which supported by climatic factors approximately. Water applied under 50% ET_c treatment by 4 l/h dripper discharge equal the

same quantity of water which applied under 100% ET_c treatment by 2 l/h dripper discharge, as showed in **Table 4**. The results of irrigation regimes estimation agree with (Howell 2003). So, it is often used 2 l/h dripper rather than 4 l/h under 100% ET_c irrigation or using 4 l/h dripper under 50% ET_c irrigation level which saved 50% from total irrigation water.

3.2 Soil moisture

The average soil moisture content at (0-50) within the profile, the values as percentage in weight under different irrigation treatments for two sort of irrigation systems SDI and SSDI with 2 l/h and 4l/h dripper flow. Water content for the soil was readings between two consecutive irrigations, the typical readings for every growing stage for the transplanted crop (initial stage, development, midseason, and harvest stage of cucumber).

Moisture within the profile initially showed the higher moisture altogether the treatments because of the quantity of applied water before transplanting to replenish the profile to field capacity and the treatments at different growth stages receive different

quantities of water by different dripper 2 and 4 l/h which were 100%, 80%, and 50% of ETc as irrigation water levels after transplanting.

Under 2 l/h, after irrigation the soil moisture in the root zone area was lower than field capacity (F.C) but it didn't reach to (PWP) value under 50% irrigation regime. But under others regimes the soil moisture was equal field capacity (F.C) value then reached to (PWP) value after 48 hours from irrigation as showed in **Fig 5**.

Under 4 l/h, it was equal the field capacity (F.C) then lowered to reach to the (PWP) under 50% irrigation regime but under other regimes the soil moisture was higher than field capacity (F.C) then reached to be lower than P.W.P shown in **Fig 6**.

Soil moisture content under 100% ETc and 80% ETc had the same results by 2 l/h and 4 l/h.

The results proved that using 2 l/h dripper discharge to irrigate the greenhouse under 80% ETc treatment had significant differences with other treatments on the soil moisture content under sub-surface irrigated lines. Sub-surface drip irrigation (SSDI) had the highest value of soil moisture content under all irrigation regimes.

3.3 Cucumber total production

Yield was depending directly on the length of the harvest period. Yields range from about 1 to 3 Kg per plant per week during the highest harvest period. A stand harvest period of 14 weeks within the managed crop can yield a complete of 20 to 25 Kg per plant. Most cultivar trials show similar but somewhat lower yields from mini cucumber when put next to strength forward showed in **Figs 7 and 8**.

The 80% ETc irrigation level had the very best yield production was in comparison with other levels of irrigation under 2 l/h discharge of dripper, but under using 4 l/h 50% ETc was the best. The rate of reduction was 0.05% between 4 l/h and 2 l/h dripper discharge under sub-surface drip irrigation.

3.4 Water productivity

The differences in WP under irrigation treatments cause of the quantity of crop yield. Results proved that the yield was preserved under 80% ETc irrigation requirement. Although T1 had higher WP than that under 50% ETc. These results indicators in agreement with (Condon et al 2002, Hashem et al 2011).

There was clear interaction between irrigation type and irrigation water level treatments for WP. The WP values ranged from 34.2 Kg m⁻³ to 65.4 Kg m⁻³ depending on the interaction treatments, dripper flow rate and irrigation system. The very best WP value 65.4 Kg m⁻³ for SSDI under (80% ETc) irrigation level by using 2l/h dripper discharge. Generally, WP increase with SSDI and 2 l/h drippers compared to SDI system irrigation water applied as showed in **Fig 9**.

3.5 Growth indicators

Plant height (m)

The irrigation regime's effect on the height of plant, it compared statistically within treatments as **Fig 10**. showed that which achieved higher height under 100% ETc and 80% ETc regime compared with 50% ETc. Finally, 80% ETc obtained the highest height of plants under using 2 l/h dripper flow rate under sub-surface irrigation (SSDI). So, the idea about adding irrigation water quantity that was over or low had a relation with plant height cucumber crop.

These Results agree with (Hashem et al 2011, Ngouajio et al 2007) stated that the cucumber vegetative parameters were increased with the irrigation level of 80% ETc followed by 100% and 50% irrigation levels during Spring-Summer seasons, the increasing of vegetative parameters under 100% ETc irrigation level were attributed to the suitable irrigation quantity especially in the early stages of crop growth which enhanced a deeper and more extensive root system.

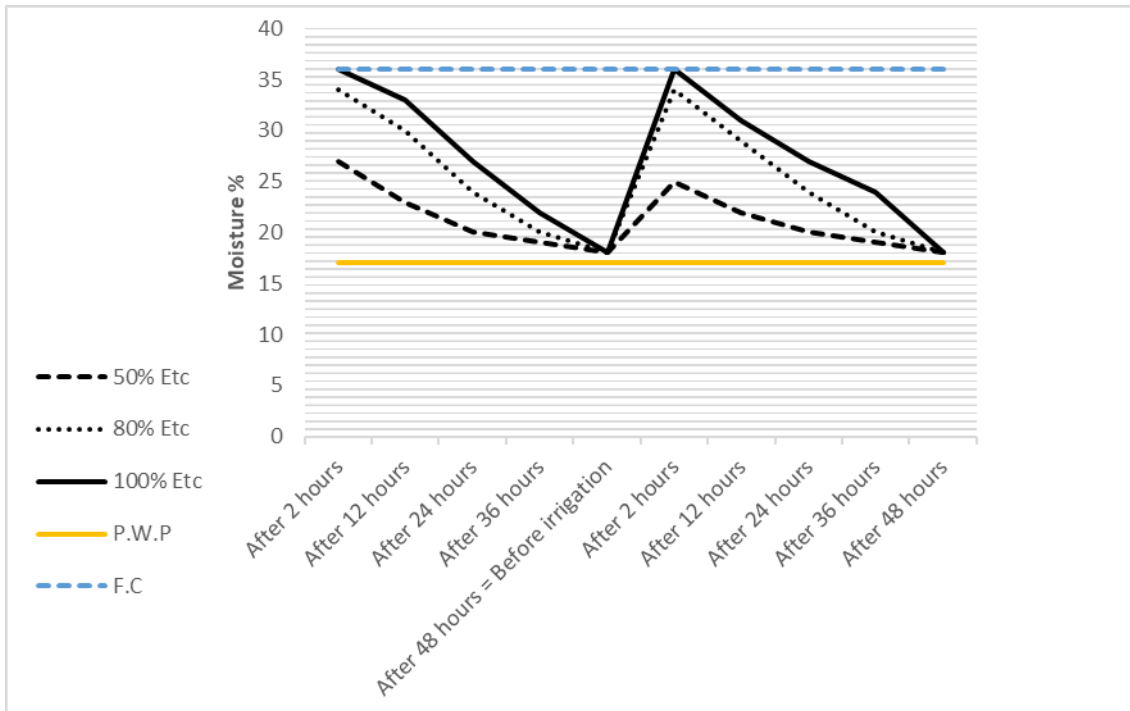


Fig 5. Average soil moisture content values as percentage in weight under three irrigation regimes for 2l/h flow rate dripper during the growth stage of cucumber crop

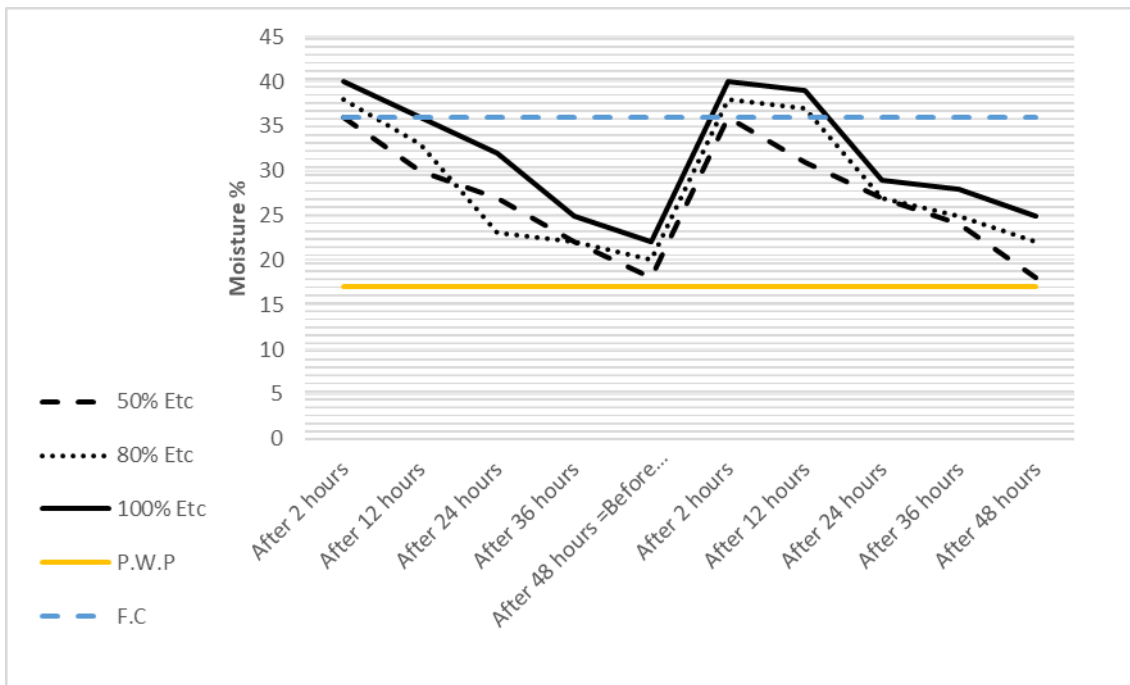


Fig 6. Average soil moisture content values as percentage in weight under three irrigation regimes for 4l/h flow rate dripper during the growth stage of cucumber crop

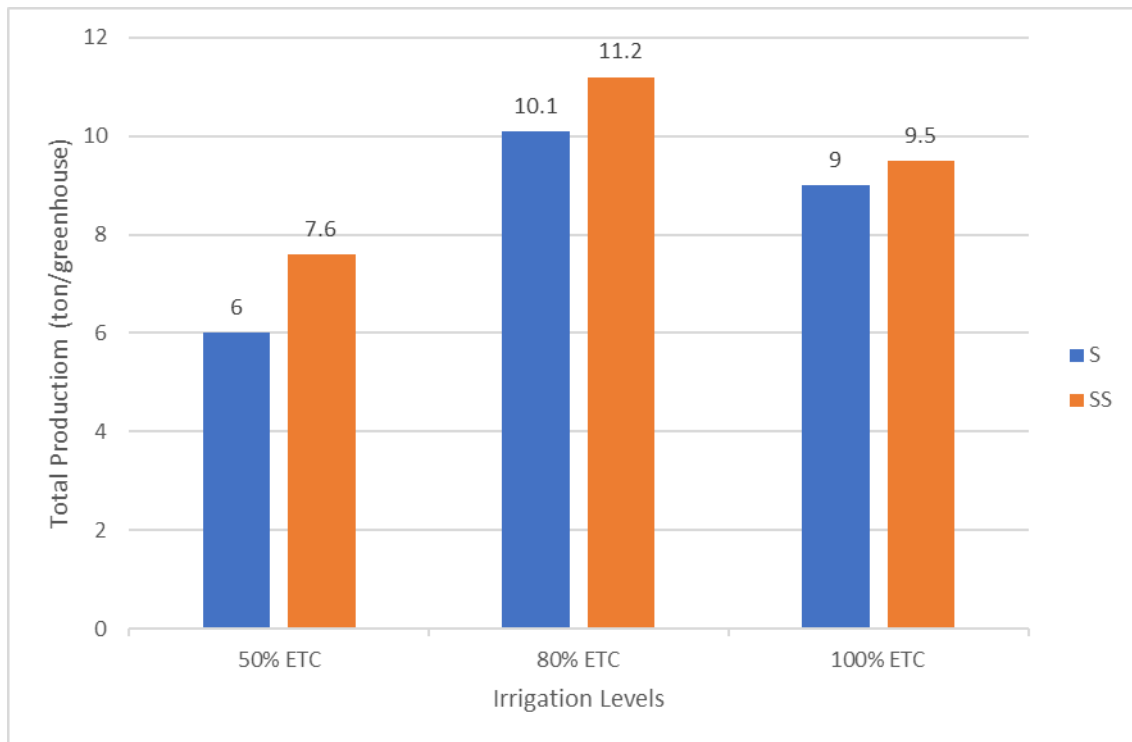


Fig 7. Total cucumber production under three irrigation levels for surface (S) and sub-surface (SS) drip irrigation system by using 2 l/h dripper

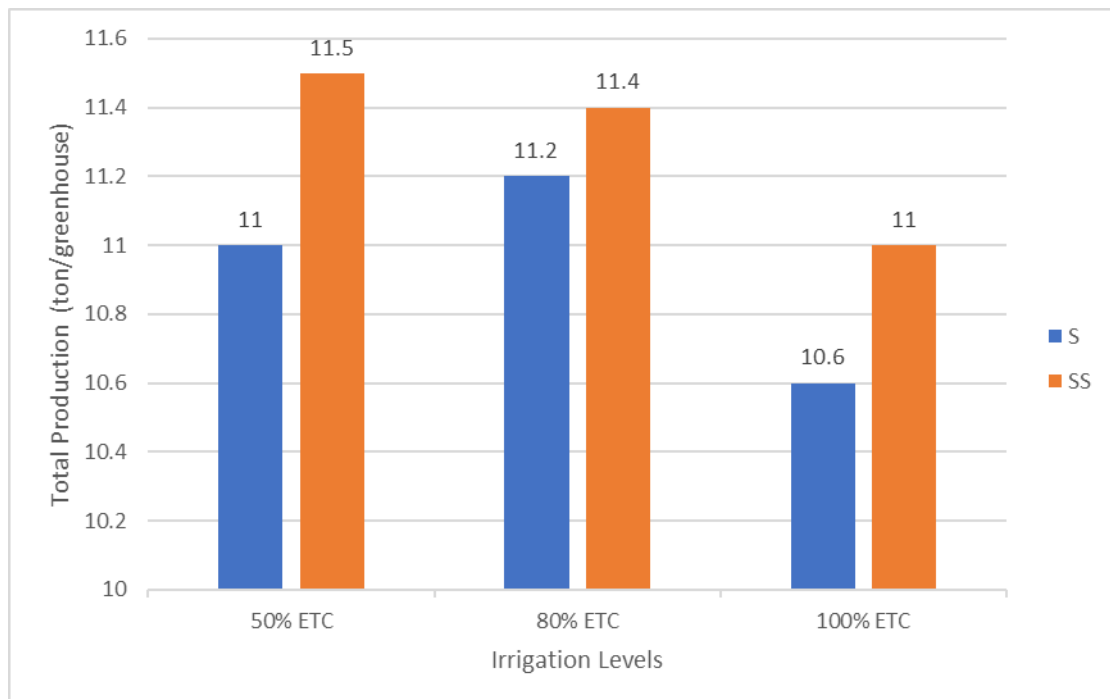


Fig 8. Total cucumber production under three irrigation levels for surface (S) and sub-surface (SS) drip irrigation system by using 4 l/h dripper

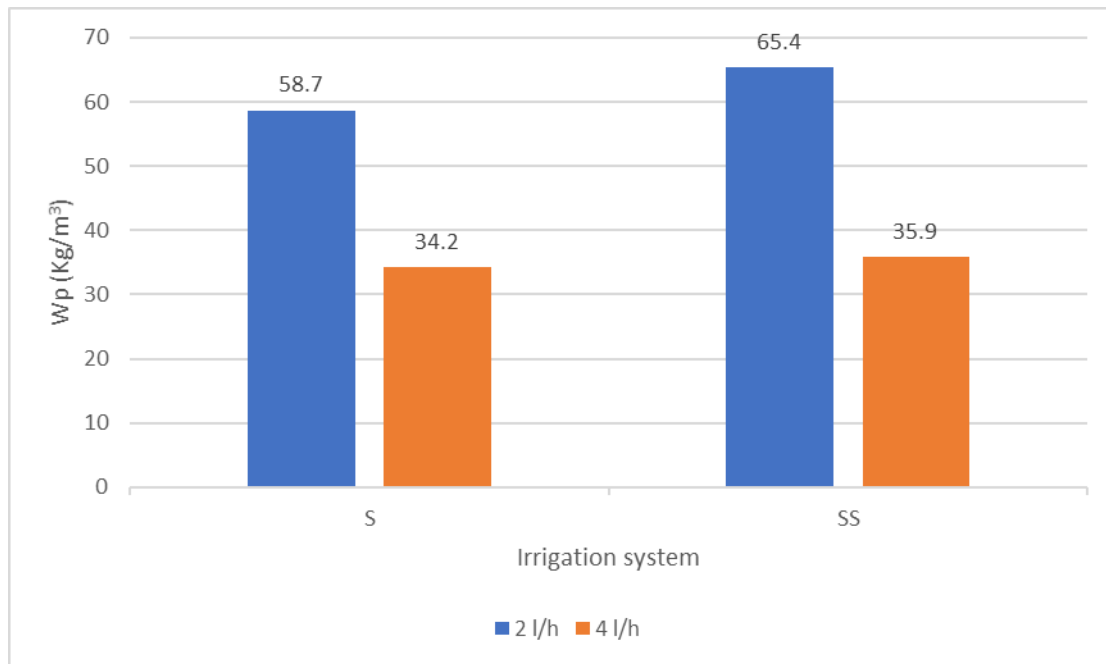


Fig 9. Water productivity (WP) under 80% ETC irrigation level with using 2 l/h and 4l/h flow meter under surface (S) and subsurface (SS) drip irrigation

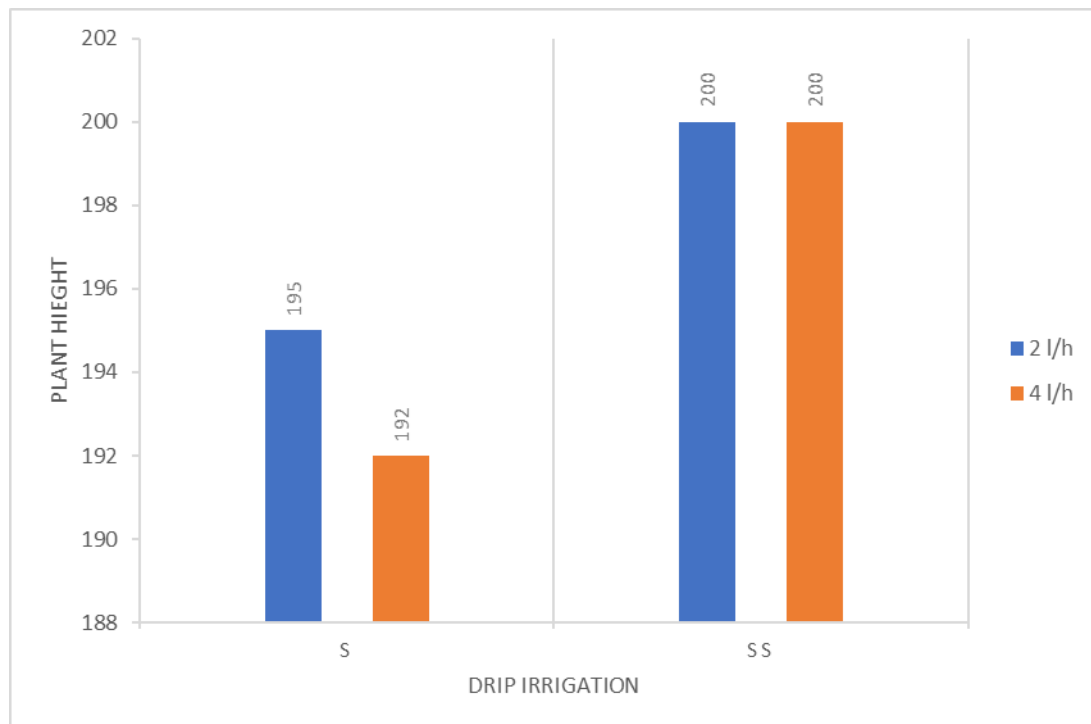


Table 10. The effect of drip discharge under surface (S), sub-surface (SS) irrigation on plant height (cm) for 80% ETC irrigation level

4 Conclusion

It concluded that under conditions of the greenhouses, could be use 80% ET_c irrigation regime which had the highest cucumber yield and water productivity. 2l/h drip emitter discharge at 100% irrigation level gives the same quantity of water which gives with 4l/h drip emitter discharge at 50 % irrigation level. The research recommended using 2l/h emitter discharge than 4 l/h. On another side, the sub-surface drip system reduced the yield production of cucumber by 44%. Study results demonstrated that the growth parameters (plant height, fruit number per plant) were increased by using 80% ET_c throughout the cultivation season, which stimulated and encouraged the best growth for the plant.

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