THE EFFICACY OF SUBSURFACE DRIP IRRIGATION FOR CUCUMBER (*Cucumis sativus* L.) IN PROTECTED AGRICULTURE

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ABSTRACT

The agriculture sustainability depends on conservation and appropriate use and management of scarce water resources in Iraq. The objective of this study was to evaluate the efficiency of subsurface drip irrigation technique compare with surface drip irrigation to produce cucumber (*Cucumis sativus* L.) crop and determining water productivity under protected agriculture. Greenhouse study was conducted at Hactria and Sharia district in Abu_Ghraib project during 2013 growing seasons using complete randomized block design with three replicates. Treatments were subsurface drip irrigation (SDI) and surface drip irrigation (DI) with four irrigation intervals. The results of the study indicated that SDI treatments excelled all other treatments in yield and water productivity (WP), where its yield was 15.48 kg/m^2 compared with 12.16 kg/m^2 for surface drip irrigation. The highest WP was recorded under SDI method and 5 day irrigation interval (67.88 kg/m^3) followed with 56.00 kg/m^3 in DI method at same intervals. SDI treatment gave the highest leaf area and plant length. The dry root weight didn't record a significant difference between the two methods used.

INTRODUCTION

Water scarcity is a major constraint to crop production in some parts of the world. The increased competition for water between agricultural, industrial and urban demands creates the need for continuous improvement in irrigation practices in commercial crop production. This need is compelling in some parts of the world where water scarcity is predicted to be severe due to climate change impact increasing competition for water resources together with changes in temperature, precipitation and runoff continue to impact agricultural productivity and food security (7). However, the vegetable production in Iraq relies heavily on surface irrigation resulting in low irrigation efficiencies and an increase in salinity problem. Irrigation efficiency can be improved considerably by adaptation of surface drip (DI) or subsurface drip irrigation (SDI) methods. The water use efficiency increased by reduced evaporation loss in SDI method (7). While (9) reported that placement of drip line at 15 cm depth decreased the evaporation to 40 % of that in surface drip irrigation. SDI also reduced the incidence of diseases contributing to greater yields and better quality products as compared to those under DI methods (11). SDI method is potentially efficient because it provides water directly to the root zone, minimizing evaporative loss, especially in arid land (6,15,16). Cucumber (*Cucumis sativus* L.) is one of the important vegetable crops in Iraq (4, 1). Annual production of cucumber in Iraq is about 192525 metric tons (14). Cucumber is grown in open fields in spring and autumn seasons and in tunnels and greenhouses in winter and early spring. Furrow irrigation is the most common method for cucumber production. Cucumber accounted for 95% of protected agriculture despite a lot of limitations for protected agriculture, most important being water scarcity. Cucumber is highly susceptible to water stress.

Directorate of Agric. Res. –Ministry of Agric.- Baghdad, Iraq.**Adequate water availability during growing season is critical to support high yields and quality. Yields has been decreased when reduction in water supply (13).**

Optimal irrigation scheduling is very critical to attain efficient use of irrigation water by avoiding the soil water content to fall below the management allowed deficit (MAD) limit (2). In water limiting growing conditions, the aim should be maximizing water productivity (WP), i.e. yield per unit water used, as compared to attaining maximum yields per unit land area. Research on increasing water productivity is extremely limited in Iraq.

Therefore, the aim of this study was to evaluate the water productivity for cucumber under Subsurface drip (SDI) and Surface drip (DI) irrigation methods.

MATERIALS AND METHODS

A greenhouse plot experiment was conducted in January to May 2013 using a randomized complete block design (RCBD) with 3 replication in Hactria and Sharia district (latitude: 331537 N; longitude: 4408448 E) at Abu-Ghraib project, 20 km west of Baghdad.

The soil in the greenhouse was a silty loam with a mean electrical conductivity was 4.8 $dS.m^{-1}$ at 30 cm depth. The soil pH was 8.0. The experiment was irrigated by Abu-Ghraib river water with salinity of 1.1 $dS.m^{-1}$ and the pH of 7.9.

One half of the greenhouse was irrigated by SDI method, while the other by DI method. Double row bed was used spaced at 40 cm with row spacing of 40 cm on the bed. The subsurface laterals pipe was buried at 12-15 cm depth, with 40 cm in line emitter spacing on the lateral line. Each irrigation method had four sub treatments, i.e., daily irrigation, and irrigations at 3, 4, or 5 days interval. Volume of irrigation water applied was measured by a flow meter, the same amounts of irrigation water were used for each method, the amount applied depends on local experience of farmers .Cucumber seedlings (var. Naseem F1) were transplanted on 26 Jan, 2013 and last harvesting was done on 7 May, 2013. A single cucumber seedling planted by hand . Fertilizer applications were based on soil analysis recommendation. All treatment plots received 180 $kg.ha^{-1}$ triple superphosphate, 240 $kg.ha^{-1}$ urea (46% N) and 120 $kg.ha^{-1}$ K_2SO_4 before plowing. Liquid fertilizer (Al-Ruya 8-8-8, N-P-K with Trace elements) was applied with irrigation water after each fruits harvesting at 0.5 ml/plant.

Recommended pest control sprays were done during the growing period. The harvesting area in each plot was $1m^2$. Plant height, dry root weight was measured at final harvest, leaf area measured by traditional weight method . Yield was harvested by hand depending on physiological maturity stage and weighted in each harvesting to calculate the total yield. Water productivity (WP) was calculated by dividing total yield on the amount of irrigation water used.

RESULTS AND DISCUSSIONS

Fruit yield

Fruit yield was significantly greater in SDI (15.48 kg/m^2) as compared to that in DI (12.16kg/m^2) treatment (Table1). Irrigation interval effect was non-significant. This may be due to the use of SDI method reduces the loss of irrigation water applied as a result of evaporation, therefore means the availability of sufficient quantity in the root area, The highest yield in SDI treatment is attributed to placement of water and nutrients closer to the root system for efficient crop uptake and reduced loss of fertilizer by volatilization and water loss by evaporation. These results were in agreement with that reported by 8, 12 and 10. Since the irrigation frequency effects were non-significant, low frequent irrigation can be beneficial to save water without any negative effects on yield. However, the interaction between irrigation methods and irrigation intervals had statistical significance in two irrigation methods used and these results needs more investigation. These results were agree with (2), who found that use of

deficit irrigation had a significant effect on cucumber fruit weight which cultivated in greenhouse and irrigated by surface drip irrigation methods.

Table 1: Effects of Irrigation methods and irrigation Interval on cucumber yield (kg/m2).

Irrigation methods	Interval of Irrigation (Day)				Mean
	Control (daily)	3	4	5	
Surface Drip	11.55	13.03	12.18	11.88	12.16
Subsurface Drip	17.22	14.75	15.56	14.39	15.48
LSD (p = 0.05)	Interaction = 1.050				LSD (p = 0.05) = 0.525 irrigation methods
Mean	14.39	13.89	13.87	13.14	
LSD (p = 0.05) irrigation Interval	NS				

Leaf area

Leaf area was significantly greater in SDI as compared to that in DI treatment (Table 2). That may be attributed to higher efficient of SDI method to delivering irrigation water and nutrients directly to the root zoon and this allows to maintaining a uniform water distribution resulting in greater control of the irrigation water and nutrients (5). Irrigation interval and interactions between irrigation methods and irrigation interval treatments effects were non-significant.

Use of SDI method led to improve the water use-efficiency of cucumber by minimizing the evaporative loss from soil surface, and meet the actual requirements of plants for water and nutrients , compared with DI method when the evaporation will start as soon as the irrigation water application to soil surface.

Table 2: Effects of Irrigation methods and irrigation Interval on cucumber leaf area (cm^2)

Irrigation Methods	Interval of Irrigation				Mean
	Control (daily)	3 Day	4 Day	5 Day	
Surface drip	33.15	31.17	31.08	24.44	29.96
Subsurface drip	44.12	42.78	44.84	38.57	42.58
L.S.D (p = 0.05)	Interaction= N.S				LSD (p = 0.05)= 2.997 Irrigation Methods
Mean	36.98 38.63		37.96	31.5	
L.S.D (p = 0.05) Irrigation Interval	N.S				

Plant height

The plant height was significantly greater with SDI method as compared to that with DI method (Table 3). Plant height decreased significantly when the irrigation interval increased to 4 and 5 days as compared to that with irrigation daily or 3 days interval. There were no significant interactions between the irrigation methods and interval. Increasing of irrigation interval in control treatment (daily) with use of SDI and DI methods led to reduce the plant height compared with 3 day interval although the development of cucumber plant increased with the increasing in soil water contain (2). This phenomenon may be attributable as consequence of soil saturation condition which led to reduce the soil air continually.

Table 3: Effects of Irrigation methods and irrigation Interval on cucumber plant height (cm)

Irrigation Method	Interval of Irrigation				Mean
	Control (daily)	3 Day	4 Day	5 Day	
Surface drip (DI)	268.7	289.7	234.3	233.0	256.4
Subsurface drip (SDI)	362.3	363.7	296.3	272.7	323.8
L.S.D (p = 0.05)Interaction	N.S				L.S.D(p = 0.05)= 17.25 Irrigation Method
Mean	315.5	326.7	265.3	252.8	
L.S.D (p = 0.05) Interval	24.39				

Dry roots weight

The results in table 4 indicated that no significant differences in dry root weight between SDI and DI methods used (2.065 and 2.020 g / plant) respectively. The effect of irrigation intervals on dry roots weight were observed that no differences between irrigation intervals of 4 and 5 days. But these treatments were differ than daily irrigation intervals (Control) and 3 days, the highest dry root weight obtained when used of 4 days irrigation interval. The results were showed that the dry roots weight is relatively more stable for SDI than those in DI with a slight exception of 4 day irrigation interval in interaction treatments.

These results reflects that SDI is more efficient than DI methods used because of SDI systems are capable of applying of water directly to the plant root zone, and can be applied frequently to maintain favorable root zone moisture conditions and there was greater increase in volumetric of roots and Improvements in yield and quality.

Table 4: Effect of Irrigation methods and irrigation Interval on cucumber dry root weight (g/plant)

Irrigation Methods	Interval of Irrigation				Mean
	Control (daily)	3 Day	4 Day	5 Day	
Surface drip (DI)	1.564	1.529	2.466	2.702	2.065
Subsurface drip (SDI)	1.853	1.869	2.406	1.951	2.020
L.S.D (p = 0.05) Interaction	0.1952				N.S Irrigation Method
Mean	1.708	1.699	2.436	2.326	
L.S.D (p = 0.05) Interval	0.1381				

Water productivity (WP)

Increasing intervals between the irrigations increased the WP in each irrigation methods. In the same time the treatments with the higher yield had the higher WP. The highest values were recorded when use of SDI method and 5 day irrigation water interval (67.88 kg/m^3) followed by 56.00 kg/m^3 in DI method at same interval. In fact, it increased about 21% compared with DI methods. This increasing in WP as consequence of uniform delivery of irrigation water and nutrients directly to the plant roots zone by use of SDI method. These results consistent those found by 3, 12, 17 and 18who found that a significantly increased yield and WUE in all crops when use of SDI methods. The treatments of water productivity was tracked the follow sequence from high to low

67.88 >58.28> 42.75> 32.43 kg/m^3 for SDI and 56> 45.61> 37.76 > 21.75 kg/m^3 for DI with irrigation intervals of 5, 4, 3 days and control , respectively (Fig 1). These results clearly indicated that the best way to obtained the highest water productivity and save more irrigation water by use of SDI with irrigation interval of 5 days. It can be concluded that the use of subsurface drip irrigation method to be more efficient of irrigation water applied even if long irrigation interval was used.

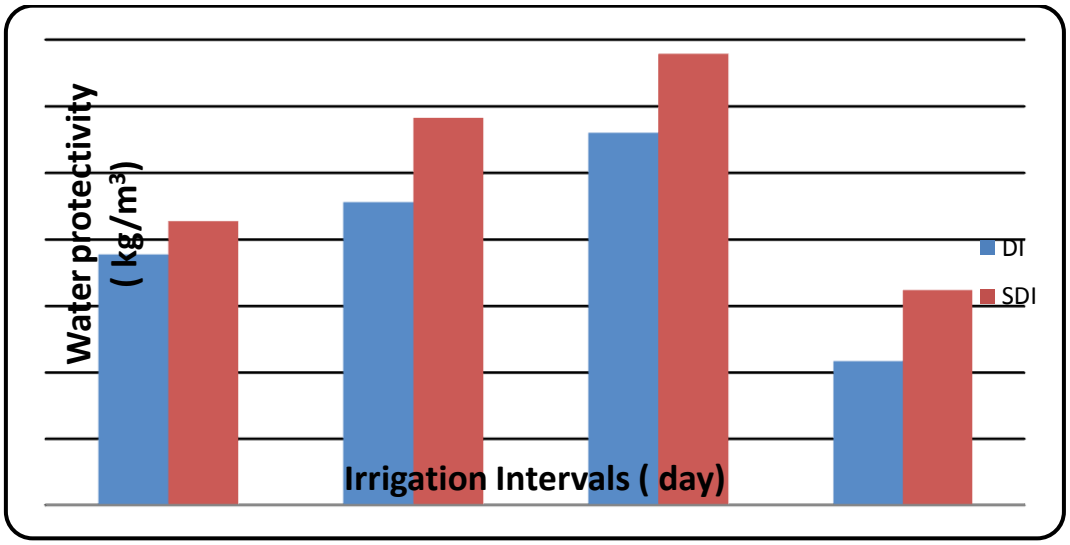

Fig 1: Effect of Irrigation methods and irrigation Interval on water productivity (kg/m^3) for cucumber yields

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REFERENCES

1- Arnaot, M.A. (1998)."Herbs, medicinal plants, food and medicine". Egyptian Lebanese House.
2- Ayas, S. and C. Demirtas (2009). "Deficit irrigation effects on cucumber (*Cucumis sativus* L.) yield in unheated greenhouse condition". Journal of Food, Agriculture & Environment, Vol. 7, No.3&4: 645–649.
3- Ayars J.E.; C.J. Phene; R.B. Hutmacher; K.R. Davis; R.A. Schoneman; S.S. Vail and R.M. Mead (1999). "Subsurface drip irrigation of row crops: A review of 15 years of research at the Water Management Research Laboratory", Agriculture Water Management, Vol.42,: 1–27.
4- Chakravarty, H.L. (1966). "Monograph of the cucurbitaceae of Iraq". Ministry of Agriculture, Baghdad, Iraq.
5- Camp, C.R.; F.R. Lamm; R.G. Evans and C.J. Phene (2000). "Subsurface drip irrigation past, present and future". In National Irrigation Symposium, November 14–16, Phoenix, Arizona, pp. 363–372, ASAE, St. Joseph, MI, USA.
6- Camp C.R. (1998). "Subsurface Drip Irrigation".A Review,Transactions of the ASABE, Vol. 41, No. 5: 1353-1367.
7- Douh, B. and A. Boujelben (2011). "Improving Water Use Efficiency for a

Sustainable Productivity of Agricultural Systems Using Subsurface Drip Irrigation". Department of Genius of Horticultural Systems and Environment, High Institute of Agronomy, Chott Meriem, BP 47, Sousse 4042, Tunisia.

8- Douh B.A.; S. Boujelben Khila; and A. Bel Haj Mguidiche (2013). "Effect of subsurface drip Irrigation system depth on soil water content distribution at different depths and different times after irrigation". Tunisia,University of Sousse, Larhyss Journal: 7-16.

9- EI-Awady, M N.; M.F. Ahd El-Salam; M.M. EI-Nawawy; and M.A. EI-Farrah (2003). "Surface and subsurface irrigation effects on Spinach and sorghum". The IIth Annual Conference of Misr Society of Agr. Eng.: 118-130.

10- Hassan, A.A. (1988). "The Basics of Vegetable Production Technology of Open Fields and Protected Agriculture (greenhouses)". Arab House for publication and distribution. Egypt.

11- Hochmuth, G.J. (1994). "Current status of drip irrigation for vegetables in Southeastern and mid-Atlantic United States". Hort Technology, Vol. 4: 390- 393.

12- Lamm, F.R. and C.R. Camp (2007). "Subsurface drip irrigation". Elsevier. Vol.13.: 473– 551. Amsterdam. The Netherlands. In: F.R. Lamm, J.E. Ayars and F.S. Nakayama (eds.), Micro irrigation for crop production: Design, operation, and Management, Elsevier, Amsterdam, the Netherlands.

13- Matlob, A.N.; A.S. Mohammed and K. S. Abduol (1989). "Vegetable Production". Part II, 2th revised edition.

14- Ministry of Planning, Central Bureau of Statistics (NBS) (2011). Agricultural Statistics Department, Statistical Abstract , Baghdad, Iraq.

15- Suarez-Rey, E.; Y.P. Choi C; M. Waller; and D. M. Kopec (2000)."Comparison of subsurface drip irrigation and sprinkler irrigation for Bermuda grass turf in Arizona". Transactions of the ASABE. Vol. 43, No.3,: 631-640.

16- Suarez-Rey, E.; C.Y. Choi; B. William and M.K. David (2006). "Effects of chemicals on root intrusion into subsurface drip emitters". Irrigation and Drain. Vol.55: 501–509.

17- Wichelns, D. (2007). "Economic implications of micro irrigation".: 221–259 In: F.R. Lamm Ayars, and F. S. Nakayama (eds.), "Microirrigation for Crop production, Design, operation, and management", Elsevier, Amsterdam, The Netherlands.

18- Zhenying, W.; L. Zuoxin and L. Zhang (2009)."Subsurface drip irrigation scheduling for cucumber (*Cucumis sativus* L.) grown in solar greenhouse based on 20 cm standard pan evaporation in Northeast China". Scientia Horticulturae – Sci.Hort- Amsterdam, Vol. 123, No.1: 51-57.

كفاءة طريقة الري بالتنقيط تحت السطحي (*Cucumis sativus* L.) لمحصول الخيار في الزراعة المحمية

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الملخص

تعتمد الزراعة المستدامة على الإستخدام الأمثل والإدارة الملائمة للموارد المياه وخاصة في الدول التي تواجه شحة في وارداتها المائية كما هو الحال في العراق. تهدف هذه الدراسة الى تقويم كفاءة طريقة الري بالتنقيط تحت السطحي مقارنة مع الري بالتنقيط السطحي لإنتاج محصول الخيار (*Cucumis sativus* L.) في الزراعة المحمية وتقدير إنتاجية المياه باستخدام الطريقتين المذكورتين آنفاً.

أجريت دراسة في احد البيوت الزجاجية في مقاطعة هاكتريا والشعار ضمن مشروع أبو غريب للموسم الشتوي لعام 2013 باستخدام تصميم البلوكات العشوائي الكاملة وبثلاثة مكررات.

المعاملات المستخدمة في التجربة هي طريقة الري بالتنقيط تحت السطحي والري بالتنقيط السطحي إذ تم الري باستخدام اربع مدد زمنية لكل من طريقتي الري المستخدمة.

أظهرت نتائج الدراسة أن طريقة الري بالتنقيط تحت السطحي تفوقت على طريقة الري بالتنقيط السطحي لكل مدد الري المستخدمة في الحاصل وإنتاجية المياه. إذ بلغ الحاصل في طريقة الري بالتنقيط تحت السطحي 15.48 كغم/م^2 مقارنة بطريقة الري بالتنقيط السطحي 12.16 كغم/م^2، في حين سجلت أعلى انتاجية للمياه عند استخدام طريقة الري بالتنقيط تحت السطحي مع مدة ري كل 5 ايام حيث بلغت 67.88 كغم/م^3 وتبعها 56.00 كغم/م^3 في طريقة الري بالتنقيط السطحي ولمدة الري نفسها. كما اظهرت النتائج بان استخدام طريقة الري تحت السطحي اعطت اعلى مساحة سطحية للاوراق وارتفاع النبات، بينما لم تظهر فروق معنوية لاوزان الجذور بطريقتي الري المستخدمة.

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