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RESPONSE OF EGGPLANT (*Solanum melongena* L.) TO SUBSURFACE DRIP IRRIGATION METHOD IN COMPARISON WITH SURFACE DRIP AND FURROW IRRIGATION METHODS UNDER CONVENTIONAL AGRICULTURE

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ABSTRACT

In order to study and assess the use of subsurface drip irrigation (SDI), Surface Drip Irrigation (SD) and Furrow Irrigation (FI) methods and their effect on growth and yield components of Eggplant, field experiment was designed with three main treatments representing the irrigation methods and the different irrigation intervals (1, 3 and 5 day) with irrigation water quantity of 1.72, 1.28 and 1.06 m^3/m^2 respectively. Those treatments were applied in a factorial experiment according to randomized complete block design with three replications. Growth parameters and yield data were collected during the experimental period. Based on the results of this work, application of SDI caused better condition for Eggplant growth parameters, in comparison with surface drip irrigation (DI) and FI methods. Furthermore, application of SDI produced highest yield and, therefore, highest water-use efficiency in comparison with the other two methods - DI, furrow irrigation. The saving percentages in quantity of irrigation water used at 5 days interval, for SDI method about 21% and 62% compared with irrigation at 3 and 1 day interval, respectively.

INTRODUCTION

Eggplant is an important summer vegetable crop in Iraq. Farmers' conventional irrigation practice uses huge quantities of water by furrow irrigation method leading to high water demand, consumption and wastage.

Currently, world Eggplant production is 35.3 million tons from 1-9 million ha according to the data of 2009 of which 93% of the production takes place in Asia FAO (7).

The total production of Eggplant in Iraq is 387000 tons using open field and greenhouse cultivation system FAO (7). The Iraqi agricultural economy is essentially dependent upon the water supplied by the Tigris and Euphrates Rivers. But Iraq is lately facing a shortage in the quantity of water due to new dams developed in neighboring countries such as Syria and Turkey. One of issues in irrigated agriculture in Iraq is the low water productivity and the use of inefficient irrigation methods such as surface flood and furrow.

In Iraq, vegetable farms are usually irrigated by short, deep and wide furrows, causing loss of irrigation water and low water productivity. Poor water management is the most influential factor on the crops production in the agricultural sector and that gives opportunity to improve water use efficiency FAO (7).

Currently, new irrigation methods called subsurface drip irrigation (SDI) are being used to save more irrigation water without reducing productivity of croplands Boujelben(3).

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Subsurface drip irrigation (SDI) method means the application of water below the soil surface using emitters, with discharge rate generally in the same range as surface drip irrigation ASAE (1). Subsurface drip irrigation (SDI) is regularly used to provide water and nutrients to plants while maintaining a dry soil surface. Subsurface drip irrigation (SDI) also contributes to alleviation of health hazards, odor, contamination of groundwater Trooien et al.(12).

Boujeben (3) conducted study to evaluate the surface drip irrigation and subsurface drip irrigation application effects on Eggplant crop performance in Tunisia, the study indicated an increase in yield of Eggplant when used of SDI method compared with DI method. Camp,(4) indicated that the horticultural crop yields for subsurface drip irrigation were equal to or greater than those for other irrigation system. Yield of tomatoes for subsurface drip method were 20% more than furrow in Texas Bogle et al. (2) and California Rose et al.(10). El-Gindy and El-Araby (6) found that the yield of tomato and cucumber were more in subsurface drip-irrigated plots when compared with surface drip method in Egypt. Potato yield with SDI was greater than for sprinkler in California DeTar et al.(5).

Najafi (9) concluded that SDI has advantages including improved water, nutrient-use efficiencies, potential for improved yields and crop quality, greater control over applied water resulting in less water and nutrient loss through deep percolation and reduced total water requirements.

The objective of this study is to determine and compare the effects of subsurface drip irrigation SDI, surface drip irrigation (DI) and furrow irrigation (FI) methods under different irrigation intervals (1, 3 and 5 day) on the Eggplant yield at open field conditions, and to calculate the saving in irrigation water used.

MATERIALS AND METHODS

The field experiment was carried out during summer season, March – July of 2012, at Abu-Ghraib (Akarkoof district), 20 km west of Baghdad. The study area is located near Baghdad and lies between latitudes 33° 06‘ and 33° 50‘ N and longitudes 43° 50’ and 44° 25’ E. The chemical and physical properties of soil are presented in Table 1 and the chemical properties of irrigation water are presented in Table 2.

Table 1: Some physical and chemical properties of soil.

Depth m	ECe $dS.m^{-1}$	pH	Soluble cations and anions $meq.l^{-1}$								P.S.D.* $g.kg^{-1}$		
			Na	Ca	Mg	K	Cl	SO4	HCO^{-}_{3}	CO_3	Sand	Silt	Clay
0-0.3	4.18	7.5	9.89	32.0	12.0	0.53	14.5	27.4	2.4	0	188	448	364
											Silt clay loam		

*** Particle size distribution**

Table 2: Chemical properties of irrigation water used

Location	ECe $dS.m^{-1}$	pH	Cations and anions $meq.l^{-1}$							
			Na	Ca	Mg	K	Cl	SO_4	HCO_3	CO_3
Abu-Ghraib Canal	0.94	7.15	30.7	3.1	28.0	0.16	3.1	5.2	1.3	0.2

The field was divided into three blocks, each block was irrigated in one of irrigation methods which are subsurface drip irrigation (SDI), surface drip Irrigation (DI) and Furrow Irrigation (FI). Each irrigation method had three plots for irrigation Interval which were 1, 3 and 5 days with total irrigation water quantity of 1.72, 1.28 and 1.06 m^3/m^2 respectively. Each plot consisted of three rows with 25m long and 0.75m width each. Those treatments were applied in a factorial experiment according to randomized complete block design with three replications. The same quantities of irrigation water were applied in each time according to treatments appointed and measured by water meters.

Seedlings of the Eggplant were transplanted at 0.25 x 0.75m spacing on 14 March, 2012. One square meter contained 5 plants. The 200 $kg.ha^{-1}$ of triple superphosphate and 355 $kg.ha^{-1}$ of urea (46% N) was applied before plowing. The soluble fertilizer (Al-Ruya 8-8-8+, N-P-K +Trace element) of 0.5 ml/plant was applied with irrigation water after each fruit harvest.

Agricultural pest control was used during growing period, biometric bservations (dry shoot and root weight, plant height , Number of branches) and fruit yield were recorded by using standard methods.

RESULTS AND DISCUSSIONS

Fruits yield

Table 3 shows that there were significant differences in yield based on the irrigation method in unit area (kg/m^2), where the SDI method has more effective in increasing the yield (12.09 kg/m^2) when compared with FI and DI methods, which were 10.38, 8.79 kg/m^2 respectively, implying that the yield decreased by 14% and 27 % in FI and DI methods, respectively. The significant decreasing in yield when use of DI method (8.94 and 5.18 kg/m^2) compared with FI method (10.60 and 13.26 kg/m^2) practically in irrigation interval of 3 and 5day respectively, due to that part of the irrigation water applied by DI method was evaporate before it percolation into the soil as a result of the slow water applied and high temperature of season.

Table 3: Effect of Interval of Irrigation period and method of irrigation on Eggplant fruits yield (kg/m^2)

Irrigation method	Interval of Irrigation (day)			Mean
	1	3	5	
Furrow	7.28	10.60	13.26	10.38
Subsurface Drip	10.60	12.94	12.74	12.09
Surface Drip	12.26	8.94	5.18	8.79
L.S.D 0.05	1.54 Interaction			0.89 (Irrigation method)
Mean	10.05	10.83	10.39	
L.S.D 0.05 (Interval)	NS			

The results also showed that there is a significant effect of interaction between irrigation methods and interval irrigation period on yield, the highest yield (13.26 kg/m^2) was obtain by 5 day interval and use of FI method, but this value was not differ significantly on the value of the treatments of 3 and 5 days

irrigation interval with SDI method used , and that is mean saving in irrigation water used. This result was agreed with Najafi and Tabatabaei (8) who indicated that the application of SDI at depth of 15 cm for the Eggplant significantly increased water-use efficiency as a result of decreasing surface evaporation with SDI in comparison to furrow irrigation and surface drip irrigation.

While the irrigation interval used had no significant effect on yield for the three irrigation methods (SDI, DI and FI), the use of SDI method gave highest fruit yield (12.94 kg.m^2) for 3 days irrigation interval. Similarly, the use of SDI method with 5 days interval yield was not different significantly when compared with 3 days irrigation interval. This means saving in irrigation water equivalent to 0.22m^3/m^2 when use of 5 days interval.

The saving percentage in quantity of irrigation water when used of 5 days interval with SDI method were about 21% and 62% compared with using 3 and 1 day interval, respectively

Plant height

Table shows the comparison of irrigation methods and irrigation intervals on plant height of eggplant. The results showed that the method of irrigation and irrigation intervals had a significant effect on the plant height. The highest mean value recorded was 77.13 cm when using SDI method and the plant height reduced with increase in interval irrigation from 1 to 5 days. The most elevated height is in the case of SDI method for three interval 1, 3 and 5 day intervals but the plant height did not have a big different when compared with the use of FI method. The highest mean value of plant height recorded was 72.71 cm when irrigated with 1 day interval. The lowest value of plant height was observed for

Table 4: Effect of Interval of Irrigation periods and methods of irrigation on Eggplant plants height (cm).

Irrigation method	Interval of Irrigation (day)			Mean
	1	3	5	
	Plant height (cm)			
Furrow	76.70	75.57	70.70	74.32
Subsurface Drip	78.83	77.77	74.80	77.13
Surface Drip	62.60	61.53	61.10	61.74
L.S.D 0.05	N.S. Interaction			2.17 (Irrigation method)
Mean	72.71	71.62	68.87	
L.S.D 0.05 (Interval)	2.17			

the DI method (62.60, 61.53, 61.10 cm) for three treatments of interval 1, 3, and 5 days when compared with other irrigation methods for the same interval.

Dry shoot weight

Table 5 shows that the irrigation methods had significantly effect on the dry shoot weight which is expressed by the shoot weight (g/plant) where the SDI method gave highest shoot weight (323.3 g/plant), while the highest mean shoot weight was achieved under 1 day interval irrigation period, although the mean highest fruit yield was recorded in the treatment of 5 days interval (Table 3). These results were very reasonable because the increase of irrigation water

means increase in shoot weight and decrease in flowering development and it is related to physiological capacity. This phenomenon was used by the farmers by making the plants under water stress to get more flowering.

Table 5: Effect of Interval of Irrigation periods and methods of irrigation on Eggplant Dry shoot weight (g/plant).

Irrigation method	Interval of Irrigation (day)			Mean
	1	3	5	
Furrow	284.0	186.0	188.3	219.4
Subsurface Drip	401.0	307.7	261.3	323.3
Surface Drip	174.7	172.3	135.7	160.9
L.S.D 0.05	8.64 Interaction			4.99 (Irrigation method)
Mean	286.6	222.8	195.1	
L.S.D 0.05 (Interval)	4.99			

Number of branches / plant

The results in Table 6 indicate that the methods of irrigation had significant effect on the number of branches/plant. The SDI method gave the highest number of branches (6.7 branches/plant) compared with 5 and 4 branches/plant for DI and FI method, respectively. The irrigation interval of 3 days gave the highest number of branches (5.4 branches/plant), whereas the lowest value was 5.0 branches/plant.

Table 6: Effect of Irrigation Interval periods and methods of irrigation on eggplant number of branches (branch/plant).

Irrigation method	Interval of Irrigation (day)			Mean
	1	3	5	
Furrow	3.2	4.4	4.4	4.0
Subsurface Drip	6.7	6.9	6.5	6.7
Surface Drip	5.2	4.8	5.0	5.0
L.S.D 0.05	N.S. Interaction			0.32 (irrigation method)
Mean	5.0	5.4	5.3	
L.S.D 0.05 (interval)	0.32			

Dry roots weight

The results in Table 7 indicated that there was a significant effect of irrigation method on the dry root weight (gm/plant). The method of SDI had highest roots weight of Eggplant (62.11 gm/plant). The results also indicated a significant effect of irrigation intervals, where the highest value of dry roots weight was 47.18 gm/plant when irrigated at 5 days. Longer intervals between irrigations means saving in irrigation water quantity at farm- and district-level. There was no significant effect of interaction treatments of irrigation method and irrigation interval on the root weight of eggplant.

The increase of root weight was reflected an increase in yield of eggplant (Table 3) when using SDI method and with 3-5 interval irrigation period, although there wasn't difference in yield between these two treatments.

The use of SDI method was efficient in utilization of the available irrigation water as well as the uptake of soluble nutrient in larger quantities without loss and increased the yields. These results coincide with the conclusions by Tiwari et al. (11,13) which report that the DI and SDI methods of irrigation are the most effective methods to convey directly water and nutrients to plants and it save water and increases yields of vegetable crops.

Table 7: Effect of Irrigation Intervals and methods of irrigation on Eggplant dry root weight (gm/plant).

Irrigation method	Interval of Irrigation (day)			Mean
	1	3	5	
Furrow	43.27	43.47	45.17	43.97
Subsurface Drip	62.57	61.47	62.30	62.11
Surface Drip	35.20	33.00	37.07	34.09
L.S.D 0.05	N.S. Interaction			0.99 (Irrigation method)
Mean	47.01	45.98	47.18	
L.S.D 0.05 (Interval)	0.99			

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استجابة محصول الباذنجان لطريقة الري بالتنقيط تحت السطحي بالمقارنة مع الري بالتنقيط السطحي والمروز تحت ظروف الزراعة التقليدية

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الملخص

بهدف دراسة وتقييم طريقة الري بالتنقيط تحت السطحي مقارنة مع طريقة الري بالتنقيط السطحي والري التقليدي بالمروز وتأثيرها في نمو ومكونات حاصل الباذنجان، فقد صممت تجربة حقلية بثلاث معاملات متمثلة بطرق الري المختلفة وبثلاث مدد ري (1 و 3 و 5 أيام بين رية واخرى) وبكمية مياه ري كلية مضافة مقدرها 1.72 ، 1.28 و 1.06 م^3/م^2 على التوالي. صممت التجربة كتجربة عاملية ضمن تصميم القطعات الكاملة المعشاة RCBD وبثلاثة مكررات. تم جمع البيانات لمؤشرات النمو والحاصل اثناء مدة التجربة . لقد اظهرت النتائج ان استخدام طريقة الري بالتنقيط تحت السطحي كان افضل مقارنة بطريقتي الري بالتنقيط السطحي والري بالمروز لمؤشرات النمو والحاصل الكلي للباذنجان. فضلاً عن ذلك فان استخدام طريقة الري بالتنقيط تحت السطحي سبب زيادة في الحاصل الكلي للباذنجان، وبالنتيجة الحصول على اعلى كفاءة لاستخدام المياه مقارنة بطريقتي الري الاخرتين. كما اظهرت النتائج انه باستخدام طريقة الري بالتنقيط تحت السطحي ولمدة ري قدرها 5 ايام بين رية واخرى قد وفر كمية من المياه المستخدمة مقدارها 21% و 62% مقارنة مع مدتي ري من 3 و1 يوم على التوالي.

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