Efficacy of Drip Irrigation System for Some Vegetables: Assessments of Yield and Water Productivity

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Abstract

Vegetables are well responded to no-water stress conditions in rooting zone. In present study, yield and some yield components as well as water use efficiency, WUE, were examined by use of worldwide results of previous studies relevant to drip irrigation performance on some vegetables. The results showed that drip irrigation has produced better crop yield, and water productivity by proper water management. In general, subsurface drip irrigation, SSD, was more efficient over surface drip irrigation, SD. In such Irrigation system, program based on less soil water depletion, SWD, e.g. 20-30%, has led to maximum yield. The findings revealed that vegetables are best yielded by drip irrigation system with full irrigation.

Key Words: Drip irrigation, vegetables, yield, water saving, soil water depletion

Introduction

As we know that plenty food and row materials have been obtained from irrigated agriculture. The top freshwater consumer sector is agriculture with rate of 70% followed by industry as 20% and residential utilization as 10% worldwide. In that regard, water saving should be started at irrigation practices firstly. Modern irrigation technologies e.g. drip irrigation is increasing popularity due to resulting better yield, and water and energy productivities under proper management e.g. energy consumption at drip irrigation system reported as only 25% of sprinkler irrigation system (Campos, 2014; Yavuz *et al.,* 2015 a,b; Yavuz *et al.,* 2016; Patel *et al.,* 2017; Futo and Bencze, 2018; Velasco-Munoz *et al.*, 2018; Yavuz *et al.,* 2019).

Narayanamoorty *et al.* (2018) stated that water saving as 40% and electricity use as about 1554 kwh/ha under drip irrigation at vegetable production areas of Brinjal, Tamil Nadu, India. Beside those, It resulted reductions in some vegetable production costs e.g. fertilizer as 31% by enhancing crop yield as 52%, consequently 54% more income. In other study performed by Narayanamoorty and Dewika, (2017), water and electric savings, reduction of cultivation cost, and yield increase under drip-irrigated okra plants were 47%, 15%, and 49%, respectively.

Water saving is the backbone of the sustainable agro-production particularly for water poor regions. One of the practical solutions for improvement crop yield or economical incomes is usage of surface or subsurface drip irrigation systems. Drip irrigation can be defined as ‘application of light and frequent water to crops by emitters being on or in laterals under low operation pressure (Shaw *et al.,* 2018). Campos (2014) suggested followings particularly for water-limited environments; replacement from conventional irrigation systems to pressurized irrigation systems, lining water delivery canals, and accurate soil moisture monitoring. Beside those, for those climates, following strategies can be recommended; preference of drought tolerant crop varieties (Seymen *et al.*, (2019) and application of around 25% deficit irrigation by drip irrigation system (Acar *et al.*, 2014).

In this current study, yield and water use efficiencies for different drip-irrigated vegetable plants were comparatively analyzed by using data relevant to water-yield responses of drip-irrigated some vegetables.

Material and Methods

In current study, worldwide findings from previous studies relevant to yield responses of vegetables to different irrigation regimes were assessed for comparatively analysis of drip irrigation system performance. For that purpose, detailed literature reviews were performed and procedures about how to improve yield and WUE of drip-irrigated vegetables were presented by the lights of our detailed evaluations.

Results and Discussion

Jha *et al.* (2017) compared performance of drip and furrow irrigation methods for some vegetables such as tomato, potato, cauliflower, French bean, and pea at Saraitoli village, Ranchi district, India under Sandy-Loam or Loam soil. They involved 20 famers (10 of them use drip and 10 of them use furrow method) to their surveys. Full irrigation treatment was used for both irrigation systems. Irrigation intervals for drip and furrow experiments were 1-day and 7-day, respectively.

In accordance of their research, drip irrigation system was more efficient in accordance of yield (Table 1). The maximum yield increase was obtained from pea as about 66% followed by tomato as 59% and cauliflower as 58%. The yields of tomato under drip and furrow methods were 250 t/ha and 158 t/ha, respectively. The pea productions for drip and furrow methods were as about 54 t/ha and 32 t/ha, respectively. Average of yield increase for those five vegetables was around 50%.

WUE under drip irrigation treatment was greater than furrow method. The higher crop yield as well as WUE under drip irrigation system could be associated from minimum nutrients losses to lower parts of root systems, and presence of no-water stress condition due to the light and frequent water application. In result, vegetables are well suited to no-water stress condition in soil so drip irrigation is very suitable technique in vegetable production.

Table 1. Yield and WUE for some drip and furrow-irrigated vegetables (Jha *et al.*, 2017)

Vegetables	Yield (t/ha) Drip	Yield (t/ha) Furrow	Yield increment over furrow irrigation (%)	WUE (kg/m^3) Drip	WUE (kg/m^3) Furrow
Tomato	250	158	59	13.7	2.86
Potato	186	135	38	7.94	1.17
Cauliflower	199	126	58	8.90	1.28
French bean	71	51	39	3.0	0.83
Pea	54	32	66	0.97	0.42

Ahmed *et al.* (2017) studied about two squash plant responses to surface (SD) and subsurface drip (SSD) irrigation systems in Silt-Loam soil under full irrigation treatment at Egypt. In addition, they examined fertilizers applications intensity; tree, six, nine and twelve intervals.

According to their results, FAD cultivar produced better yield under both SD and SSD system over ESK variety (Table 2).

Table 2. Yield and some yield components with WUE of squash varieties under SD and SSD (Ahmed *et al.*, 2017)

Treatments		Fruit Yield				
Cultivar	Irrigation system	fruit/plot	kg/fruit	Plant fresh weight (t/ha)	Yield (t/ha)	WUE (kg/m^3)
FAD	SD	94	0.111	95	24	3.47
	SSD	147	0.145	140	49	7.00
ESK	SD	54	0.097	81	13	1.88
	SSD	87	0.131	112	26	3.73

In such study, maximum and minimum plant fresh weights as 140 t/ha and as 81 t/ha were obtained from FAD under SSD and ESK at SD, respectively. Similarly, the greatest WUE as 7 kg/m^3 was calculated from FAD at SSD. In examined yield per hectare, SSD produced as about 100% increase over SD for FAD and ESK cultivars, respectively. In the other word, it is possible to obtain two-fold squash fruit yield in same cultivar from replacement SD to SSD. In addition, fertilizer application with frequently e.g. 12 doses led to maximum yield as well as WUE. By this way, WUE values for FAD and ESK were calculated as 6.6 and 5 kg/m^3, respectively. They recommended fertilizer application by SSD with 9 or 12 doses for obtaining desired yield consequently high economical returns.

Patil and Tiwari (2018) studied irrigation regimes and N levels affect on yield performance of okra (F1 Hybrid; The Miss Okra-18) plants under SSD and furrow irrigation for soil of Sandy-Loam (SL) with bulk density of 1.63 g/cm^3 at Kharagpur, West Bengal, India. They considered full irrigation treatment for both irrigation systems. In SSD, three different irrigation regimes as 20%, 35% and 50% soil water depletion, SWD, from the field capacity soil moisture content were researched. In SSD, laterals with 0.30 m emitter space, 4 L/h emitter discharge and 97.2% Emission Uniformity were placed at 1.0 m below surface by servicing two plant rows. The top width, depth, length, and slope of furrows were 0.60 m, 0.15 m, 13 m and 0.3%, respectively. The seeds were sown with density of 0.6 m x 0.30 m and harvested 102-day after sowing.

In general, there were little differences between plant heights among treatments (Table 3). The highest plant heights were obtained from SSD with 20% SWD followed by furrow method for examined years. The maximum green fruit yield was at SSD with 20% SWD. Those were 11, 10.6 and 10.8 t/ha for 2015, 2016, and 2017, respectively in such treatment. The lowest values were obtained from furrow treatment as 7.0, 6.7 and 7.0 t/ha, respectively for same years. In the light of those findings, like the most vegetables okra plant is best suited at frequent irrigation intervals with full irrigation under SSD.

Table 3. Plant height and green bud yield of okra plant (Patil and Tiwari, 2018)

Irrigation Treatments	Plant height (cm)			Green fruit yield (t/ha)		
	2015	2016	2017	2015	2016	2017
SSD 20% SWD	85.6	83.9	84.5	11.0	10.6	10.8
SSD 35% SWD	80.2	80.7	82.8	10.1	9.4	9.8
SSD 50% SWD	80.3	78.7	79.9	9.2	9.0	9.2
Furrow	83.5	82.2	83.5	7.0	6.7	7.0

The maximum ETc values were obtained from furrow treatment (Table 4). Those were 462 mm, 513 mm, and 506 mm for 2015, 2016, and 2017, respectively at in that irrigation method. Among SSD treatments, the highest ETc was at 20% with SWD for all growing years. The maximum WUE was at SSD with 20% SWD in all treatments.

In accordance of their research, it is possible for us to say that SSD 20% with SWD is highly preferable for maximal fruit yield or WUE consequently high economic incomes.

Table 4. Plant height and green bud yield of okra plant (Patil and Tiwari, 2018)

Irrigation Treatments	ETc (mm)			WUE (kg/ha/mm)		
	2015	2016	2017	2015	2016	2017
SSD 20% SWD	455	496	490	24.2	21.5	22.1
SSD 35% SWD	444	487	480	22.7	19.4	20.3
SSD 50% SWD	434	477	470	21.3	18.9	19.5
Furrow	462	513	506	15.2	13.2	13.8

Amoo *et al.* (2019) performed fieldwork to determine yield, ETc, and WUE for drip-irrigated okra (Hibiscus esculentus) at Ekili State, Nigeria under clay soil with bulk density of 1.38 g/cm^3. They reported ETc values for growing periods of Oct., Nov., Dec., and Jan., were found as 132 mm, 145.5 mm, 187.5 mm, and 159.5, respectively with total of 637 mm/ season. In such study, total applied water was 596 mm. Green bud yield was as 17.28 t/ha and finding obtained present study is much more greater than report of Patil and Tiwari (2018).

The differences could be associated from plant cultivars, quality of cultural practices, ecologies and water management in both study regions. Drip irrigation is applicable practice to obtain more economical returns from okra production and should be used in places especially where the water shortage is very big limitation for agro-production. That irrigation system can produce savings at time, energy, labor, water and so on under correct management.

Abdelraouf *et al.* (2020) researched different geometry of laterals affect on yield and WUE of drip irrigated potato plant under sandy soil condition at El-Nubaria, Norhern Egypt. They examined three lateral designs; 1- accordance of local practice, 2- same direction with manifold, and 3- opposite side of the manifold (new design).

In that study, they calculated emission uniformity, EU, between 73% and 99.6% depending on lateral designs. In results, they obtained maximum yield from design-3 as known new design for both growing season e.g. it was 37.4 t/ha for 2015-2016 growing season (Table 5). The minimum one was found under design-1. The WUE value was maximum at design-3. The application efficiencies for design-1, design-2 and design-3 were averages of 92%, and 94%, and 98%, respectively for both growing season. In the light of those findings, design-3 can be highly recommended for better yield and water saving.

Table 5. Tuber yield and WUE of drip-irrigated potato plant (Abdelraouf *et al.,* 2020)

Lateral Designs	Tuber Yield, t/ha		WUE, Kg $_{potato}$/m^3 water	
	2015-2016	2016-2017	2015-2016	2016-2017
1	24.2	24.00	4.21	4.0
2	27.1	25.00	4.71	4.2
3 (New Design)	34.4	34.4	6.5	5.7

Conclusion

Drip irrigation can be used successfully for irrigation of vegetables such as tomato, potato, okra, and squash. It is also very beneficial technique for savings water and energy, very important inputs in crop production costs especially in Turkey, and is possible to obtain around 50% yield increase replacement of surface irrigation to drip irrigation system in vegetable farming. SSD is more efficient than SD so it can be preferred for vegetable irrigation after comparing their economical returns.

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