Journal of AgriSearch, 8 (1): 26-29
An Open Access International Peer Reviewed Quarterly

ISSN : 2348-8808 (Print), 2348-8867 (Online)
https://doi.org/10.21921/jas.v8i01.19559

Performance of Tomato under Subsurface Drip Irrigation Laterals placed at various Depths in Inceptisols

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ABSTRACT

Tomato is one of the important vegetable crops for nutrition security. The vegetables respond very well to proper irrigation water management towards increasing yield. A study on response of tomato under subsurface drip irrigation (SDI) with laterals placed at 5 cm, 10 cm and 15 cm depth below soil surface was carried out in inceptisols at ICAR- Indian Institute of Vegetable Research, Varanasi. It was found that soil water content variation was less and more favorable within top 30 cm depth of soil profile under SDI with lateral placed at 10 cm depth below soil surface. The maximum yield of tomato 52.85 t/ha was realized under SDI with lateral placed at 10 cm depth below soil surface followed by yield under 15 cm and 5 cm depth of lateral placement. It was 14.67% higher than the surface drip irrigation. The lowest yield of tomato was recorded 46.09 t/ha with surface drip irrigation. Maximum water use efficiency 1.968 t/ha-cm was obtained with SDI lateral placed at 10 cm depth below soil surface. To realize maximum yield and water use efficiency of tomato, SDI laterals could be placed at 10 cm depth below soil surface.

KEYWORDS

Tomato, Subsurface drip irrigation, Lateral placement depth, Yield, Water use efficiency

ARTICLE INFO

Received on	:	27/11/2020
Accepted on	:	28/02/2020
Published online	:	19/03/2021

INTRODUCTION

Vegetables play vital role in nutritional security of India. Presently, vegetable cultivation occupies more than 10 million ha area with production of about 191.7 million tons. The minimum vegetables requirement for ever increasing population necessitates enhanced vegetable production which is to be raised to 225 million tons by 2025. It can be achieved either by bringing more area under cultivation or enhancing productivity using improved production techniques including irrigation water management. But, rapid urbanization, and industrialization impose constraints of decreased arable land as well as share of water to agriculture year after year. Therefore, agriculture in the future has to produce ever increasing quantities of food with decreasing quantities of water available for irrigation. Water is vital for realizing the full potential of the agricultural sector for food self-sufficiency and security. Therefore, optimum and efficient utilization of water in agriculture for irrigation assumes great significance. Surface irrigation methods used in about 90% irrigated area in country have low field level application efficiency of only 40-50%. Whereas, drip irrigation may achieve field level application efficiency of 80-90% (Heerman *et al.*, 1990 and Postel, 2000). Thus, the drip irrigation may allow more crops per unit water. Moisture availability to crop with drip irrigation remain near the field capacity which enables plants to uptake soil water with least stress and results higher yield and of quality produce.

Drip irrigation has advantages of low water delivery rate, precise placement of water and minimum losses resulting less weed growth and improved crop yields, water saving and water use efficiency. Application of chemicals and fertilizers could be used efficiently with drip along with irrigation water to increase crop yield and economic benefit (Singh *et al.*, 2012 (a and b); Singh *et al.*, 2013 (a)). The drip irrigation system with the lateral lines laid on the soil surface is the most popular application method in our country. It has net potential area estimated to be 21.27 mha for the country (Narayana moorthy, 2004). The drip irrigation can be made more applicable for irrigating a wide range of crops by installing the laterals below the soil surface, *i.e.* subsurface placement of the laterals called subsurface drip irrigation (SDI) system. SDI is defined as application of water below the soil surface through the emitters, with discharge rates generally in the same range as surface drip irrigation (ASAE Std., 1999).

SDI has many advantages over the surface drip and other irrigation methods such as; reduced evaporation loss and precise placement and management of water, nutrient and pesticides leading to more efficient water use, greater water application uniformity, enhanced plant growth, crop yield and quality (Camp, 1998). The other advantages include less interference with cultural operations and improved cultural practices; allows field operations even during irrigation; less nutrient and chemical leaching and deep percolation; reduced weed germination and their growth; reduced pest and diseases damage due to drier and less humid crop canopies; warmer soils; reduced exposure of irrigation equipment to damage; no soil crusting due to irrigation; and well suited to widely spaced crops (Phene, 2000).

Many vegetables and fruit crops have been produced

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successfully using same SDI system (Camp *et al.,* 1993; Camp *et al.*, 1997 and Toderich, *et al.,* 2004). SDI system were found beneficial in increasing crop yield, saving of water and enhancing water use efficiency in various soils and crops with good irrigation system performance (Singh, 2004; Singh *et al.*, 2006; Luthra and Pandey, 2007; Patel and Rajput, 2007; Singh *et al.*, 2007; Singh *et al*., 2010 and Singh, *et al*., 2011). The depth of lateral placement of SDI plays important role towards its efficacy. It should be sufficient to avoid damage from tillage equipments but shallow enough to wet the root zone. In general, the depths of placement of laterals range from 2 to 70 cm for many crops (Camp, 1998). However, more specific information will be required to determine lateral placement depths for specific soil and crop combinations. Tomato being one of the most important and popular vegetables, a study on performance of tomato under subsurface drip irrigation laterals placed at various depths was conducted in *inceptisols* of ICAR-Indian Institute of Vegetable Research, Varanasi.

MATERIALS AND METHODs

Irrigation system

The study was carried out in inceptisols at research farm of ICAR-Indian Institute of Vegetable Research, Varanasi during 2012-13 and 2013-14. The soil of the area was silt loam. The SDI consisted of main, submain and lateral pipes. The diameter of sub main and main pipe existed in the experiment was 75 mm diameter. The main and sub main pipes were placed at 45 cm depth below soil surface. The lateral pipe line with clog resistant inbuilt emitters of 2 Lph discharge rate spaced at 50 cm apart had diameter of 16 cm and length 50 m. The laterals were spaced 60 cm apart on the sub main pipe. Trenches of 20 cm width were dug to place various laterals at desired depths. The lateral pipe was placed in trenches with emitter openings facing upwards and trenches were filled with the soil and compacted little bit to make it like surrounding soil. The drip laterals were placed at 0 cm depth i.e. on the soil surface, 5 cm, 10 cm and 15 cm depths below the soil surface.

Layout of experiment

The *Kashi Vishesh* variety of tomato was taken up for the study. Tomato seedlings were transplanted at 50 cm plant to plant spacing near and above the drip laterals. The experiment consisted of four treatments and four replications. Treatment T1 consisted of lateral placed at 0 cm i.e. on the soil surface, T2: lateral placed at 5 cm depth below soil surface, T3: lateral placed at 10 cm depth below soil surface, T4: lateral placed at 15 cm depth below the soil surface. The schematic of layout of experiment is shown in Fig. 1.

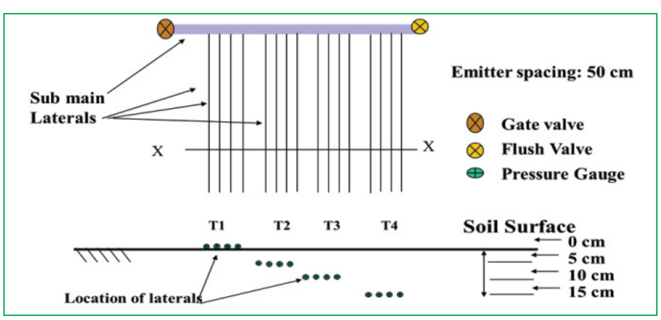

Fig. 1: layout of experiment

Irrigation and fertigation scheduling

Daily irrigation water requirement of tomato was calculated based on crop evapotranspiration (ET_c), efficiency of irrigation system and shaded area of the plant. ET_c was calculated as $ET_c = K_c\, ET_o$, where, K_c is crop coefficient and ET_0 is reference evapotranspiration (Allen *et al.*, 1998). K_c incorporates crop characteristics and varies with various growth stages of crop i.e. initial, development, mid season and late season. Plants were irrigated daily as well as alternate day. Recommended dose of fertilizer applied in tomato crop was 120: 60: 60 kg NPK. Out of this, 25% N and 50% PK was applied as basal dose. The remaining fertilizer i.e. 75% N and 50% PK was applied through drip fertigation using urea and water-soluble fertilizer on weekly basis. The observations on soil water content, crop growth and yield of tomato were taken during the study period.

RESULTS AND DISCUSSION

Soil water content

Soil water content was determined using gravimetric method by collecting soil samples up to 60 cm depth from 5 cm, 10 cm, 20 cm and 30 cm distance away from emitter location for drip irrigation with laterals placed at surface, 5 cm, 10 cm and 15 cm depths below soil surface. The soil water content in terms of volume percent at location 5 cm away from emitter up to 60 cm depths below soil surface for SDI with laterals placed at 10 cm depth has been depicted in Fig. 2. It may be observed that the variation in soil water content within top 30 cm soil depth was less as compared to that within 30-60 cm soil depth.

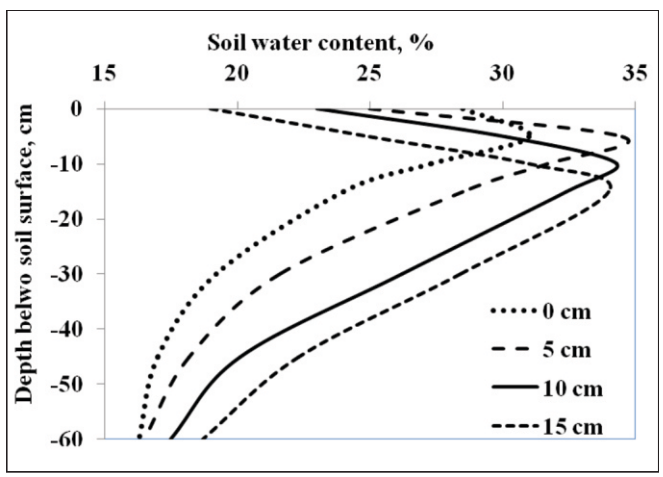

Fig. 2: Soil water content in top 60 cm soil profile at 5 cm distance from emitter location under various placement depths of SDI laterals

The Variation of soil water content within top 30 cm soil profile has been presented in Table 1. It may be observed that variation in soil water content with SDI lateral placed at 10 cm depth below soil surface was less (more near to field capacity and favorable) as compared to soil water content under subsurface drip lateral placed at surface, 5 cm and 15 cm depth below soil surface. It created better water availability for plant growth and yield than other SDI laterals placement depths and surface drip.

Table 1: Variation of soil water content within top 30 cm soil profile

SDI lateral placement depth (cm)	Range of soil water content (Volume %)
0	19.2 -31.0
5	2 1.6 -34.5
10	23.0 -34.3
15	19.0 -34.0

Yield of tomato

The tomato yield with SDI laterals placed at soil surface, 5 cm, 10 cm and 15 cm depths below soil surface i.e. T1, T2, T3 and T4 has been depicted in Table 2. It may be observed that the yield of tomato increased due to SDI with lateral placed at various depths (Singh *et al*., 2011 (a & b). The highest yield of tomato was observed under T3 which was significantly superior than T1 and T2 but statistically at par with T4 during first and second year of study. However, the pooled mean of yield indicated that T3 was superior over all the treatments and 14.67% higher than T1. The maximum mean yield of tomato 52.85 t/ha was recorded under SDI with lateral placed at 10 cm depth below soil surface. It was followed by yield under 15 cm and 5 cm depth of lateral placement.

Table 2: Tomato yield under different treatment of lateral placement depth of SDI

Treatment: Lateral placement depth of SDI (cm)	Tomato yield (t/ha)					
	I-Year (t/ha)	II-Year (t/ha)	I-Year (t/ha-cm)	II-Year (t/ha-cm)	Mean (t/ha-cm)	Increase over T1 (%)
T1: 0	47.96	44.21	1.831	1.602	1.716	0
T2: 5	52.03	47.04	1.986	1.704	1.845	7.51
T3: 10	54.80	50.90	2.092	1.844	1.968	14.68
T4: 15	53.28	49.37	2.033	1.789	1.911	11.36
CD (P:=0.05)	1.82	1.93	0.07	0.07	0.045	

The lowest yield of tomato was recorded 46.09 t/ha with surface drip irrigation. The improved yields from SDI are most likely due to more water being available to the plants, as compared to surface drip (Evett *et al*., 1995). Total depth of irrigation water provided to tomato during first year and second year was 26.2 cm and 27.6 cm, respectively. Maximum water use efficiency 1.968 t/ha-cm was obtained with SDI lateral placed at 10 cm depth below soil surface followed by 15 cm, 5 cm and lateral placed at soil surface (Table 2).

Water use efficiency

The water use efficiency for T3 was significantly superior over T1 and T2 but statistically at par with T4. Water use efficiency under T3 and T4 were 14.68 and 11.36% higher as compared with T1. Higher yield of tomato with 10 cm depth of lateral placement could be due to uniform soil water content (Singh *et al*, 2008) within top 30 cm soil depth, the zone of most active root growth (Table 3).

Table 3: Tomato Water use efficiency under different treatment of lateral placement depth of SDI

Treatment: Lateral placement depth of SDI (cm)	Water use efficiency			
	I-Year (t/ha-cm)	II-Year (t/ha-cm)	Mean (t/ha-cm)	Increase over T1 (%)
T1: 0	1.831	1.602	1.716	0
T2: 5	1.986	1.704	1.845	7.51
T3: 10	2.092	1.844	1.968	14.68
T4: 15	2.033	1.789	1.911	11.36
CD (P=0.05)	0.07	0.07	0.045	

CONCLUSIONS

Tomato crop was irrigated using drip irrigation with laterals placed at surface, 5 cm, 10 cm and 15 cm depth below soil surface. The soil water content variation was found less and more favorable within 30 cm depth under SDI with lateral placed at 10 cm depth below soil surface. The maximum yield of tomato was realized under SDI with laterals placed at 10 cm depth below soil surface followed by yield under 15 cm and 5 cm depth of lateral placement. It was 14.67% higher than the yield under drip irrigation with lateral placed at soil surface which recorded lowest yield. Maximum water use efficiency 1.968 t/ha-cm was realized with SDI lateral placed at 10 cm depth below soil surface. To realize maximum yield and water use efficiency of tomato, SDI laterals could be placed at 10 cm depth below the soil surface.

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Citation:

Singh DK, Bahadur A, Chaurasia SNS and Singh S.2021. Performance of tomato under subsurface drip irrigation laterals placed at various depths in Inceptisols. *Journal of AgriSearch* **8**(1): 26-29