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Influence of Irrigation Frequency and Lateral Spacing on Drip Irrigated *Kharif* Onion Crop

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Abstract

The aim of this study is to identify the most suitable irrigation frequency and lateral spacing for efficient irrigation management in kharif onion crop. In this study, effect of different spacing between drip lateral (45 cm and 60 cm) and irrigation frequency (One, Two, Three and Four days) on onion crop (*Allium Cepa* L.) under drip irrigation system was studied. Different plant growth and yield parameters were periodically observed. Highest water productivity (10.1 kg m^{-3}) and total bulb yield (169.4 q ha^{-1}) were observed in two days irrigation frequency with 45 cm lateral spacing. Available moisture depth in the root zone (0-60 cm) at 90 DAT, for one day irrigation interval with 45 cm lateral spacing was 11.6 cm at the middle of two laterals which was 9.4% higher than with 60 cm lateral spacing where available moisture was 10.6 cm. In this study, two days irrigation frequency with 45 cm lateral spacing treatment came out to be the most preferable treatment on the basis of water productivity and yield of onion crop.

Keywords: Irrigation frequency, lateral spacing, moisture distribution, soil moisture and trickle irrigation

1. Introduction

India comes just after China in terms of production of vegetables. It is bestowed with favourable climatic conditions and soils which are promising to grow large number of vegetable crops all around the year. Onion (*Allium cepa* L.) is a vegetable crop with great national and international significance with production of 98.89 million Metric Ton (MMT) per annum worldwide (Anonymous, 2018a). In India, it is grown in three seasons that are rabi, kharif and late kharif. Its production is around 23.26 MMT and cultivated in 1.285 mha area (Anonymous, 2017). The five-year average production for the period 2012-2017 during the three seasons is 12.8, 3.0 and 3.9 MMT in rabi, kharif and late kharif season, respectively (Anonymous, 2018 b). The kharif crop plays an important role in fulfilling consumers demand and stabilizing the onion prices in the country in the dearth period between the kharif and rabi crops. There is need to increase kharif crop production and area to tackle the challenges of shortage of supply and price fluctuations. In Haryana, it is grown only in 29.9 thousand ha area and its production is around 7.01 lakh MT (Anonymous, 2018c). Onion have shallow root system and roots are present in top 0.18 to 0.40 m (Greenwood et al., 1982; Metwally, 2011). Being a shallow rooted crop, it requires frequent irrigation to achieve good yields (Drinkwater et al., 1995; Shock et al., 2000). Water requirement of the onion crop is influenced by the variety cultivated, plant density, agro climatic conditions, method of irrigation used etc. Constant soil moisture near surface is important for good root generation in onions (Rajput and Patel, 2006). Water stress can lead to lower productivity and poor yield. Therefore, frequent irrigation in small doses to avoid moisture stress using drip irrigation system have shown better improved yield with increase in bulb size (Renault and Wallender, 2000). Irrigating at frequent frequency has shown to positive impact on yield of different vegetable crops like lettuce, pepper and onion (Hanson et al., 2003; Ismail et al., 2009; Enciso et al., 2009; Muhammad et al., 2011; Bagali et al., 2012). Lateral spacing between drip tapes influence water distribution and important for maintaining proper moisture between the plants (Patel et al., 2014; Satpute et al., 2013; Chouhan, 2015). There is need to identify the most suitable irrigation frequency and design parameter like lateral spacing to develop better irrigation schedules and practices that can be used for efficient irrigation management.

2. Materials and Methods

The experiment was conducted in the field lab of Department of Soil & Water Engineering, College of Agricultural Engineering & Technology, Chaudhary Charan Singh Haryana Agricultural

University, Hisar. The experimental site is located in the north-western part of Haryana at 29° 9' 0.97''N (latitude) and 75° 42' 20.12''E (longitude) with an average elevation of 215.2 m above mean sea level (MSL). Climate in Hisar is characterized as semi-arid, it receives on an average 459 mm of rainfall in a year. South-West Monsoon (June to September) accounts for 75 to 80 % of the annual rainfall received in the district. Average annual temperature of Hisar is 25.1 °C but temperature around the year vary significantly with extremely hot summers and equally cold winters. The micro plots are raised from ground surface to a height of 1.5 m and are 2 m x 2 m (length x width) brick lined isolated chamber with open bottom filled with field soil. An automated drip irrigation system with a provision to schedule irrigation and fertigation has been installed for the micro plots.

In this experiment, seedlings of Agrifound Dark Red variety of onion (*Allium cepa* L.) were transplanted in the micro plots keeping row to row and plant to plant spacing at 15 cm and 10 cm, respectively during kharif season 2018. Field preparation and transplanting was done according to standard package and practises (Anonymous, 2013). The experiment was designed with eight treatments and three replications. Layout of the experiment is given in Figure 1. The treatments considered in the study were two lateral spacing (45 cm and 60 cm) and four irrigation frequencies (One, Two, Three and Four days). A brief summary of different treatment combinations is given in Table 1. Irrigation was done based on 100 % of crop evapotranspiration (ETc) values of crop coefficient was taken according to different growing stages of crop (Allen et al., 1998). The basic physical and chemical properties of initial soil samples of experimental site are given in Table 2.

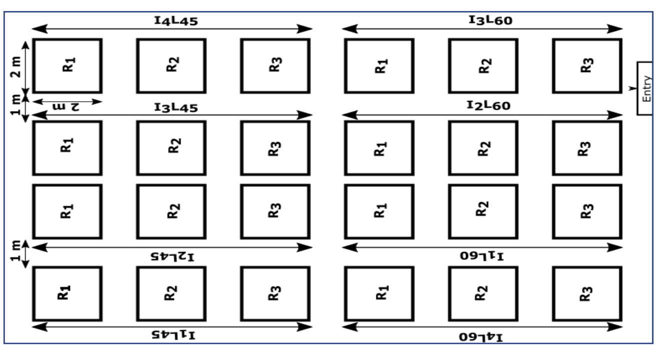

Figure 1: Layout of the experiment

During the experiment different growth and yield parameter were recorded. Soil moisture was determined from samples collected with the help of a tube auger at 0-15, 15-30, 30-45 and 45-60 cm depth below the surface of the soil and at a radial distance 0, 11.25 and 22.5 cm from dripper for lateral spacing 45 cm and at 0, 15 and 30 cm radial distance from dripper for lateral spacing of 60 cm. Also, Volume of water applied (Michael, 2008) and depth of water available in the root zone (Mane et al., 2008) was calculated by standard equation and process.

Table 1: Different treatment combinations and their abbreviation used

Sl. No.	Treatment	Abbreviation
1.	One day irrigation interval with 45 cm spacing between the laterals	I_1L_{45}
2.	Two days irrigation interval with 45 cm spacing between the laterals	I_2L_{45}
3.	Three days irrigation interval with 45 cm spacing between the laterals	I_3L_{45}
4.	Four days irrigation interval with 45 cm spacing between the laterals	I_4L_{45}
5.	One day irrigation interval with 60 cm spacing between the laterals	I_1L_{60}
6.	Two days irrigation interval y with 60 cm spacing between the laterals	I_2L_{60}
7.	Three days irrigation interval with 60 cm spacing between the laterals	I_3L_{60}
8.	Four days irrigation interval with 60 cm spacing between the laterals	I_4L_{60}

Table 2: Physical and chemical properties of the soil of experimental site

Parameters/Properties	Soil depth (cm)			
	0-15	15-30	30-45	45-60
Sand (%)	78.16	78.16	78.16	78.16
Silt (%)	5.72	5.72	5.72	5.72
Clay (%)	16.12	16.12	16.12	16.12
Texture	Sandy loam	Sandy loam	Sandy loam	Sandy loam
Bulk density	1.55	1.54	1.56	1.56
pH	8.02	8.01	8.03	8.04
$EC_{1:2}$	0.23	0.19	0.21	0.23
N (kg ha^{-1})	118.3	116.5	115.3	114.2
P (kg ha^{-1})	15.2	14.6	14.4	13.8
K (kg ha^{-1})	173.3	165.8	146.3	144.5
Organic carbon (%)	0.28	0.26	0.25	0.24
Basic infiltration rate	2.55 cm h^{-1}			

Collected data for different observations was analysed for statistical significance using split plot design (Panse and Sukhatme, 1985) using OPSTAT (Sheoran et al., 1998). Null hypothesis of difference between treatments was tested by using 'F' test at 5% level of significance and standard errors (SEm±) were calculated. Critical Difference at 5% level of probability was computed for significant results.

3. Results and Discussion

Weight of bulbs (kg m^{-2}) in different grades i.e., grade A (>5.0 cm), grade B (4.0-5.0 cm), grade C (3.0-4.0 cm), grade D (<3.0 cm) for different treatments is given in Table 3. It was found to be varying significantly for grade C (3.0-4.0 cm) and Grade D (<3.0 cm) for different irrigation treatments but result was non-significant for different lateral spacing and for interaction effect, for grade B (4.0-5.0 cm) it was significant for different irrigation as well as lateral spacing treatment but not for interaction and for grade A (>5.0 cm) only interaction effects was significant. In grade A, maximum weight of bulb was found in treatment I_4L_{60} (0.665 kg m^{-2}) and least in I_1L_{60} (0.517 kg m^{-2}). For grade B, maximum weight of bulb for different irrigation effect was found in treatment I_2 (0.562 kg m^{-2}) and least in I_4 (0.405 kg m^{-2}) and for different lateral spacing it was 0.52 kg m^{-2} for L_{45} followed by 0.444 kg m^{-2} for L_{60}. In grade C, maximum weight of bulb was found in treatment I_1 (0.392 kg m^{-2}) and minimum in I_4 (0.277 kg m^{-2}) and, for grade D, maximum weight of bulb was found in treatment I_4 (0.153 kg m^{-2}) and minimum in I_1 (0.086 kg m^{-2}).

Table 3: Weight of bulb (kg m^{-2} in different grades for different treatments

	Weight of bulb (kg m^{-2})			
	Grade A	Grade B	Grade C	Grade D
	> 5.0 cm	4.0-5.0 cm	3.0-4.0 cm	<3.0 cm
I_1	0.551	0.513	0.392	0.092
I_2	0.63	0.562	0.377	0.086
I_3	0.578	0.447	0.335	0.119
I_4	0.605	0.405	0.277	0.153
CD (p=0.05)		0.064	0.051	0.023
L_{45}	0.581	0.52	0.342	0.105
L_{60}	0.601	0.444	0.348	0.12
CD (p=0.05)		0.08		
I_1L_{45}	0.585	0.54	0.397	0.086
I_2L_{45}	0.624	0.608	0.393	0.077
I_3L_{45}	0.57	0.489	0.328	0.112
I_4L_{45}	0.545	0.442	0.252	0.146
I_1L_{60}	0.517	0.485	0.387	0.097
I_2L_{60}	0.637	0.516	0.361	0.096
I_3L_{60}	0.585	0.406	0.342	0.127
I_4L_{60}	0.665	0.368	0.301	0.161
CD (p=0.05) (I at same level of L)	0.112			
CD (p=0.05) (L at same level of I)	0.117			

Observed marketable, total bulb yield and water productivity for different treatments is given in Table 4. Marketable yield and total bulb yield were significant for different irrigation frequency, lateral spacing and interaction effect. Highest marketable yield (161.7 q ha^{-1}) was obtained for I_2L_{45} treatment and its minimum value (119.7 q ha^{-1}) was recorded in $I_4L_{60.}$ Total bulb yield (169.4 q ha^{-1}) was highest in I_2L_{45} treatment and its lowest value (135.8 q ha^{-1}) in I_4L_{60} treatment. Water productivity (kg m^{-3}) was significant for different irrigation

Table 4: Marketable yield, total bulb yield and water productivity for different treatments

	Marketable Yield (q ha^{-1})	Total bulb yield (q ha^{-1})	Water productivity (kg m^{-3})
I_1 (One day irrigation interval)	146.2	155.4	9.3
I_2 (Two-day irrigation interval)	156.1	164.7	9.8
I_3 (Three-day irrigation interval)	137.3	149.3	8.9
I_4 (Four-day irrigation interval)	122.7	138.0	8.3
CD (p=0.05)	3.1	2.7	0.158
L_{45} (45 cm lateral spacing)	145.1	155.6	9.3
L_{60} (45 cm lateral spacing)	136.1	148.1	8.9
CD (p=0.05)	4.7	4.8	0.283
I_1L_{45}	153.5	162.1	9.7
I_2L_{45}	161.7	169.4	10.1
I_3L_{45}	139.5	150.7	9.0
I_4L_{45}	125.6	140.2	8.4
I_1L_{60}	138.9	148.7	8.9
I_2L_{60}	150.5	160.1	9.6
I_3L_{60}	135.1	147.8	8.8
I_4L_{60}	119.7	135.8	8.1
CD (p=0.05) (I at same level of L)	5.6	5.1	0.304
CD (p=0.05) (L at same level of I)	5.7	5.4	0.320

frequency, lateral spacing and interaction effect. Water productivity was found maximum (10.1 kg m^{-3}) for I_2L_{45} and its minimum value (8.1 kg m^{-3}) for I_4L_{60}.

Depth of water available in root zone (0-60 cm) at different distances from the dripper for 45 cm lateral spacing at different stages of growth (30 to 90 DAT) calculated is given in Table 5. Maximum variation of available moisture with respect to irrigation interval was observed at 90 days after transplanting in both 45 and 60 cm lateral spacing. At 90 DAT, available moisture for one day irrigation interval with 45 cm lateral spacing just near the dripper, 11.25 cm and 22.5 cm away from dripper was observed 47.2, 37.1 and 52.6%, respectively, higher than four days irrigation interval. Similarly, for 60 cm lateral spacing, available moisture at 90 DAT in one day irrigation interval just near dripper, 15 cm and 30 cm away from dripper was observed 71.3, 65.7 and 89.3 %, higher than four days irrigation interval. At 90 DAT, for one day irrigation interval with 45 cm lateral spacing available moisture depth (11.6 cm) in the root zone (0-60 cm) at the middle of two lateral was observed higher (9.4 %) than with 60 cm lateral spacing where available moisture was 10.6 cm. On comparing the moisture depth at the middle of laterals for other respective irrigation intervals, the available moisture was more in case of 45 cm lateral spacing than 60 cm lateral spacing at different days after transplanting (DAT). This moisture distribution pattern further supports better crop yield in 45 cm lateral spacing than 60 cm lateral spacing.

Table 5: Depth of water available (cm) in the root zone (0-60 cm) for plots with 45 and 60 cm lateral spacing at 30, 60 and 90 days of transplanting (DAT)

Treatments	30 DAT			60 DAT			90 DAT		
	Radial distance (cm)			Radial distance (cm)			Radial distance (cm)		
	0	11.25	22.5	0	11.25	22.5	0	11.25	22.5
I_1L_{45}	11.8	10.6	10.1	11.1	10.1	9.6	13.1	12.2	11.6
I_2L_{45}	10.7	8.8	8.5	10.2	8.7	8.2	12.2	10.6	9.8
I_3L_{45}	7.8	7.2	7.8	7.2	6.9	7.4	8.9	8.7	9.2
I_4L_{45}	7.2	7.4	6.7	7.2	7.2	5.8	8.9	8.9	7.6
I_1L_{60}	12.4	10.4	9.0	11.7	10.0	8.5	13.7	12.1	10.6
I_2L_{60}	10.2	8.7	8.1	9.5	8.9	7.7	11.1	10.7	9.4
I_3L_{60}	8.2	7.0	6.8	7.4	6.7	6.3	9.2	8.8	8.0
I_4L_{60}	7.2	6.5	4.9	7.0	6.2	4.5	8.0	7.3	5.6

4. Conclusion

Higher plant growth parameters for frequent irrigated treatments could be due to better vegetative growth as a result of adequate soil moisture distribution in root zone indicating that irrigation through drip after shorter interval at one day and two days ensures adequate moisture in the crop root zone maintaining optimum soil-water balance. For sandy loam soil, two days irrigation frequency with 45 cm lateral spacing treatment came out to be the most preferable treatment under the given conditions on the basis of water productivity and yield of onion crop.

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