RESEARCH ARTICLE

EFFECT OF DRIP GEOMETRY ON SOIL MOISTURE DISTRIBUTION IN DRIP IRRIGATED ONION

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Abstract: An experiment was conducted, during (Jan-May) 2018, to study the soil water dynamics in drip irrigated onion crop, subjected to treatments comprises of lateral spacing (two levels viz. 45 cm and 60 cm) and lateral placement depth (two levels viz. surface and subsurface) arranged in split-plot-design. With each treatment replicated thrice, the experiment laid in 12 micro plots, already filled with sandy loam soil. Periodic field observations were made to study the soil moisture distribution. During the study, it was observed that soil moisture content tended to decrease with increase in radial distance from the drip lateral at all soil depths and tended to decrease with increase in soil depth at all the radial distances, during whole crop period, in all treatments, irrespective of the lateral spacing and lateral placement depth. It may be concluded from the study that for cultivation of drip irrigated onion in sandy loam soils, closer lateral spacing (45 cm) offers better soil moisture distribution, as compared to wider lateral spacing (60 cm) where as shallow lateral placement depth (5 cm) didn't much affect the soil moisture distribution.

Keyword: Lateral spacing, Lateral placement depth

INTRODUCTION

Conservation and appropriate management of scarce water resources, especially in arid and semi-arid areas where irrigation is required for the production of crops, is key to the sustainability of agriculture production. Drip irrigation is a recent concept which allows accurate control of water supplied in small quantities directly to the root zone, forming partially wetted soil (Kumar *et al*. 2015). Uniform moisture distribution is an important factor for the plant growth and development. Moreover, matching application rates with crop water requirement ensure efficient water utilization while reducing deep percolation losses of water and nutrients (Souza et al. 2009). Application of uniform and sufficient water to each and every crop plant throughout the growing period is one of the most challenging issues of drip irrigation, especially in close growing crops like onion, where one lateral is used to irrigate multiple rows. Water availability for crop, in drip irrigation, depends on water movement from the emitting source to the plant roots (Douh and Boujelben, 2013). A good understanding of soil water distribution and its patterns under the influence of drip geometry has become increasingly important in order to develop modern and environmentally friendly practices involving drip irrigation. Thus in planning and managing a drip irrigation system, selection of appropriate lateral spacing and depth is an important aspect from soil moisture distribution point of view.

The purpose of this study was to determine and evaluate the effect of the different drip geometry (lateral spacing and depth) on the soil moisture dynamics. The findings from this research may be useful in selection of appropriate drip geometry at which irrigation is best carried out in most close growing vegetable crop with shallow rooting pattern for optimum crop performance.

MATERIALS AND METHODS

The present study was conducted in the field lab of the Department of Soil and Water Engineering, College of Agricultural Engineering and Technology, Chaudhary Charan Singh Haryana Agricultural University, Hisar during *rabi* 2018, from January to May. The experimental site is located in the north-western part of Haryana at 29^0 9′ 0.97″N (latitude) and 75^0 42′ 20.12″E (longitude) with an average elevation of 215.2 m above mean sea level (MSL). The experimental site is susceptible to shallow and saline groundwater level during rainy season. Therefore, the present study was conducted in specifically constructed raised micro plots. These micro plots are raised from ground surface to a height of 1.5 m and are brick lined isolated chamber with open bottom. The micro plots are filled with sandy loam soil.

Layout and design of field experiments

The total 12 micro-plots were used for the experimentation. The experiment was laid out following the split plot design with four treatment combinations (2 lateral spacing and two lateral placement depth) and three replications (R1, R2 and R3) of each treatment combination. The detail of treatments, their combinations and abbreviation used, are presented in Table 1.

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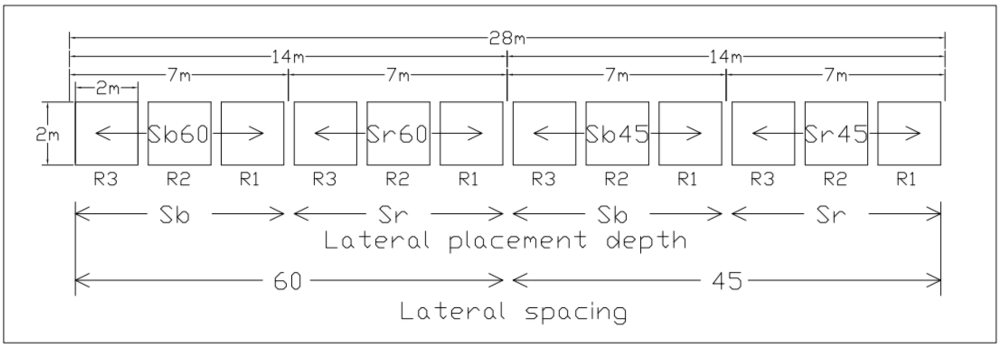
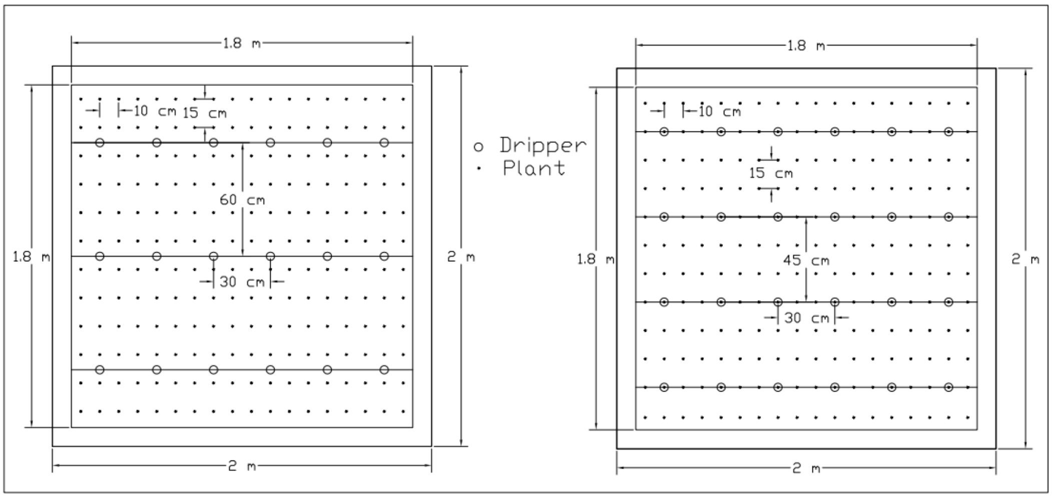
Table 1. Details of treatments

	Treatment		
S. No.	**Lateral Placement Depth**	**Lateral Spacing**	**Abbreviation**
1	**Surface**	**45 cm**	**Sr45**
2		**60 cm**	**Sr60**
3	**Subsurface (5 cm depth)**	**45 cm**	**Sb45**
4		**60 cm**	**Sb60**

The experimental plot layout exhibiting different treatments with replications and micro-plot layout exhibiting crop and drip geometry for 60 and 45 cm lateral spacing, are shown in Fig. 1(a), (b) and (c).



a



b **c**

Fig. 1: The experimental plot layout (a) and micro-plot layouts for 60 (b) and 45 cm (c) lateral spacing.

Description of irrigation system

An automated drip irrigation system, with a provision to schedule irrigation and fertigation, had been installed for the experimental plots. Drip laterals of 16 mm diameter, with pressure compensating in-line drippers spaced 30 cm along the line, were used. Rated discharge of one dripper, at an operating pressure of 1.5 kg/cm^2, was 2.3 LPH. Drip lateral were laid at specified spacing and depth in micro plots, as per experimental layout and treatment combination requirements [Figs. 1(a), (b) and (c)].

Cultural practices and field management

The experimental plots were thoroughly ploughed, two to three times, before transplanting the seedlings. Plots were then flooded thrice for leaching of the salts already present in the soil as the same field was being used previously for study, on use of saline water. FYM @ 20 t/acre, 50 % of Nitrogen (@ 50 kg/acre), 100 % of Phosphorus (@ 20 kg/acre) and 100 % of Potash (@ 10 kg/acre), according to recommended package practices CCS HAU Hisar, were applied before transplanting of the onion seedlings. Field was leveled, after proper mixing of FYM and chemical fertilizers in the soil. Remaining 50 % of Nitrogen was applied in five split doses through fertigation at a fourteen days interval. The source used for NPK was urea, DAP and MoP, respectively.

Transplanting of onion seedlings

Seedlings (45-50 days old) of the onion (variety Hisar Onion 4) were transplanted at spacing of 15 cm (row to row) and 10 cm (plant to plant), with a plant density of 216 plants/plot (net area 3.24 m^2 per plot), on 8th Jan 2018. After transplanting, first irrigation of canal water was applied same day in all the treatments, through drip irrigation, for duration sufficient enough to ensure proper moisture distribution in the entire micro plot, for proper establishment of crop

Soil moisture distribution

Soil samples were collected and analysed periodically [prior to transplanting, 30, 60 and 90 days after transplanting (DAT)] to determine the spatial and temporal distribution of soil moisture.

Soil samples were collected with the help of a tube auger, for 0-15, 15-30, 30-45 and 45-60 cm depth below the soil surface, in vertical planes located at a radial distance 0, 11.25 and 22.5 cm from dripper, perpendicular to lateral, for lateral spacing 45 cm and at 0, 15 and 30 cm radial distance from dripper, perpendicular to lateral, for lateral spacing of 60 cm. Gravimetric method was used for soil moisture determination in which samples were dried in oven for 24 hour at 105^0C. Soil moisture content was computed as under.

$$\theta_w (\%) = \frac{W_1 - W_2}{W_2} \times 100 \quad (2.1)$$

Where, θ_w = Moisture Content (%)
W_1 = Weight of soil sample before drying (g)
W_2 = Weight of soil sample after drying (g)

RESULTS AND DISCUSSION

Soil water dynamics

The spatio-temporal distribution of observed soil moisture content was analysed plotting contour maps considering, radial distance from the drip lateral on x-axis and soil depth on y-axis. The Contour maps, drawn for soil moisture data obtained on 30, 60 and 90 DAT for each treatment are presented in Figure 2. Wetting patterns, obtained as contour maps, were investigated as function of vertical and radial distance from the dripper.

The analysis of soil moisture data presented in contour maps (Fig. 2) exhibited that, in general, the observed soil moisture content tended to decrease with increase in radial distance from the drip lateral at all soil depths and tended to decrease with increase in soil depth at all the radial distances, throughout the soil profile, during whole crop period, in all the treatments, irrespective of the lateral spacing and lateral placement depth.

Effect of lateral spacing on soil moisture distribution

The analysis of soil moisture data presented in Figure 2, revealed that, for a given DAT and soil depth, the soil moisture content at the midpoint between the adjacent laterals was on higher side, in treatments with 45 cm lateral spacing, as compared to corresponding treatments with 60 cm lateral spacing. This distribution of soil moisture content may be attributed to the fact that in 45 cm lateral spacing, the mid-point between the adjacent laterals exist 22.5 cm away from the dripper, which is quite small as compared to the mid-point distance in 60 cm lateral spacing *i.e.* 30 cm. Due to smaller mid-point distance, effective overlapping of soil moisture fronts, from adjacent lateral, occurred in 45 cm lateral spacing, as compared to 60 cm lateral spacing. This resulted in to occurrence of higher moisture contents at mid-points between the adjacent lateral with 45 cm lateral spacing as compared to 60 cm lateral spacing. On the other hand, for a given DAT and soil depth, the moisture content just below the dripper was higher in all the treatments with 60 cm lateral spacing as compared to corresponding treatments with 45 cm lateral spacing. Similarly depth of water stored in root zone (0-60 cm), for a given DAT, just below the dripper, was also higher in all the treatments with 60 cm lateral spacing, as compared to corresponding treatments with 45 cm lateral spacing. This happened due to the fact that to ensure application of equal amount of water to each plot, the time of operation of irrigation system, in treatment with 60 cm lateral spacing (number of lateral per plot only three) was kept proportionally higher as compared to treatments with 45 cm lateral spacing (number of laterals per plot only four). This higher time of operation led to accumulation of higher moisture content just below the dripper (dripper discharge being same) in treatments with 60 cm lateral spacing as compared to treatments with 45 cm lateral spacing.

This type of distribution indicates that for close growing crops like onion (where multiple crop rows are irrigated with one lateral), the sufficient availability of soil moisture to extreme marginal crop rows (at the midpoint of the distance between adjacent lateral), will be less likely to exist, at wider lateral spacing, especially in light soils.

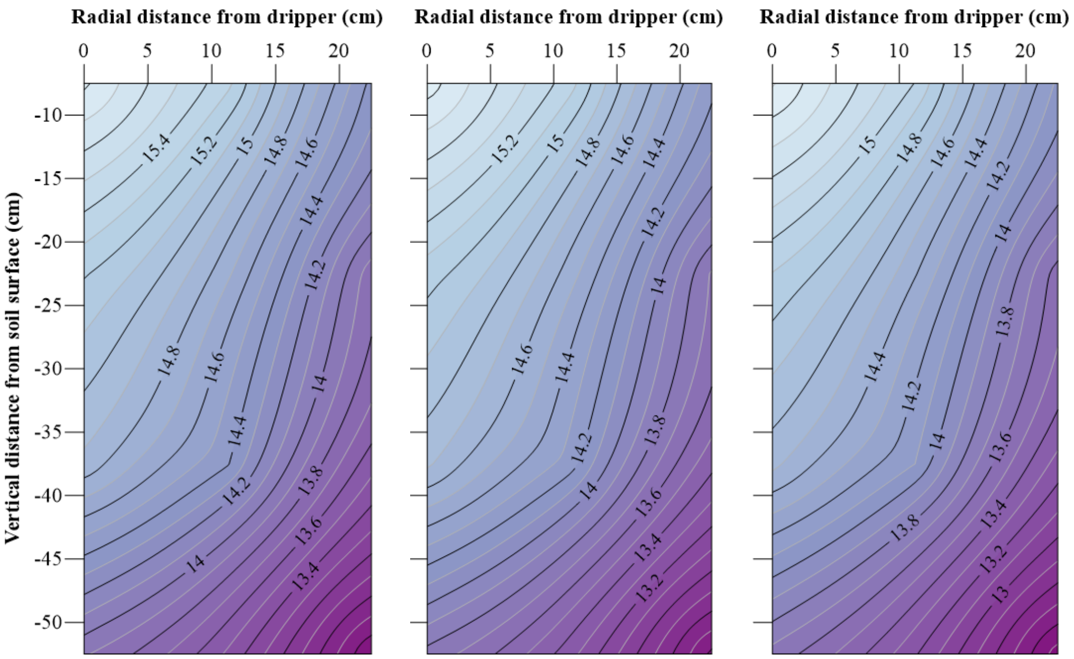
Effect of lateral placement depth on soil moisture distribution

The analysis of soil moisture data presented in Figure 2, revealed that, the moisture content, in treatments with subsurface lateral placement (depth of placement ≈ 5 cm), was on higher side for a given DAT, radial distance and soil depth as compared to moisture content, in corresponding treatments with surface lateral placement, for respective DAT, radial distance and soil depth, except the top layer (0-15 cm depth), where the soil moisture content was on higher side in treatments with surface lateral placement as compared to treatments with subsurface lateral placement. Similar pattern were observed in both years *i.e.* 2018 and 2019. This might have happened due to the fact that in subsurface lateral placement, gravity works against the upward movement of soil moisture and aids the downward movement of soil moisture.

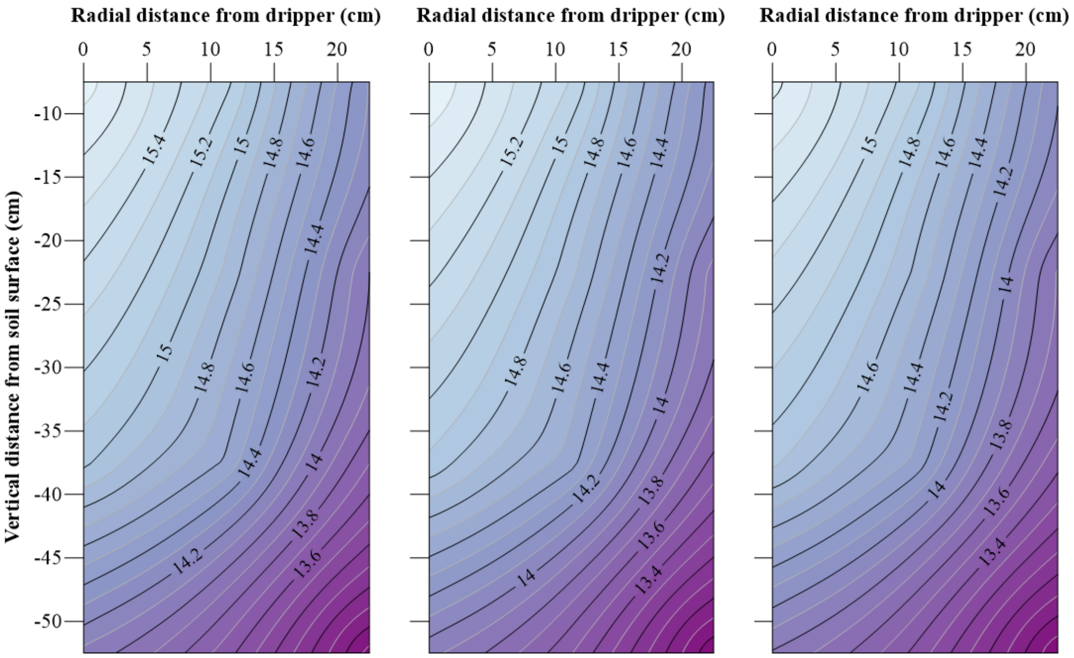
This indicates better moisture availability for crop production in subsurface lateral placement provided, the same volume of water was applied both in surface and subsurface lateral placements.

CONCLUSIONS

It may be concluded from the study that for cultivation of drip irrigated onion in sandy loam soils, closer lateral spacing (45 cm) offers better soil moisture distribution, as compared to wider lateral spacing (60 cm) where as shallow lateral placement depth (5 cm) didn't much affect the soil moisture distribution.



(a) 30 DAT 60 DAT 90 DAT



(b) 30 DAT 60 DAT 90 DAT

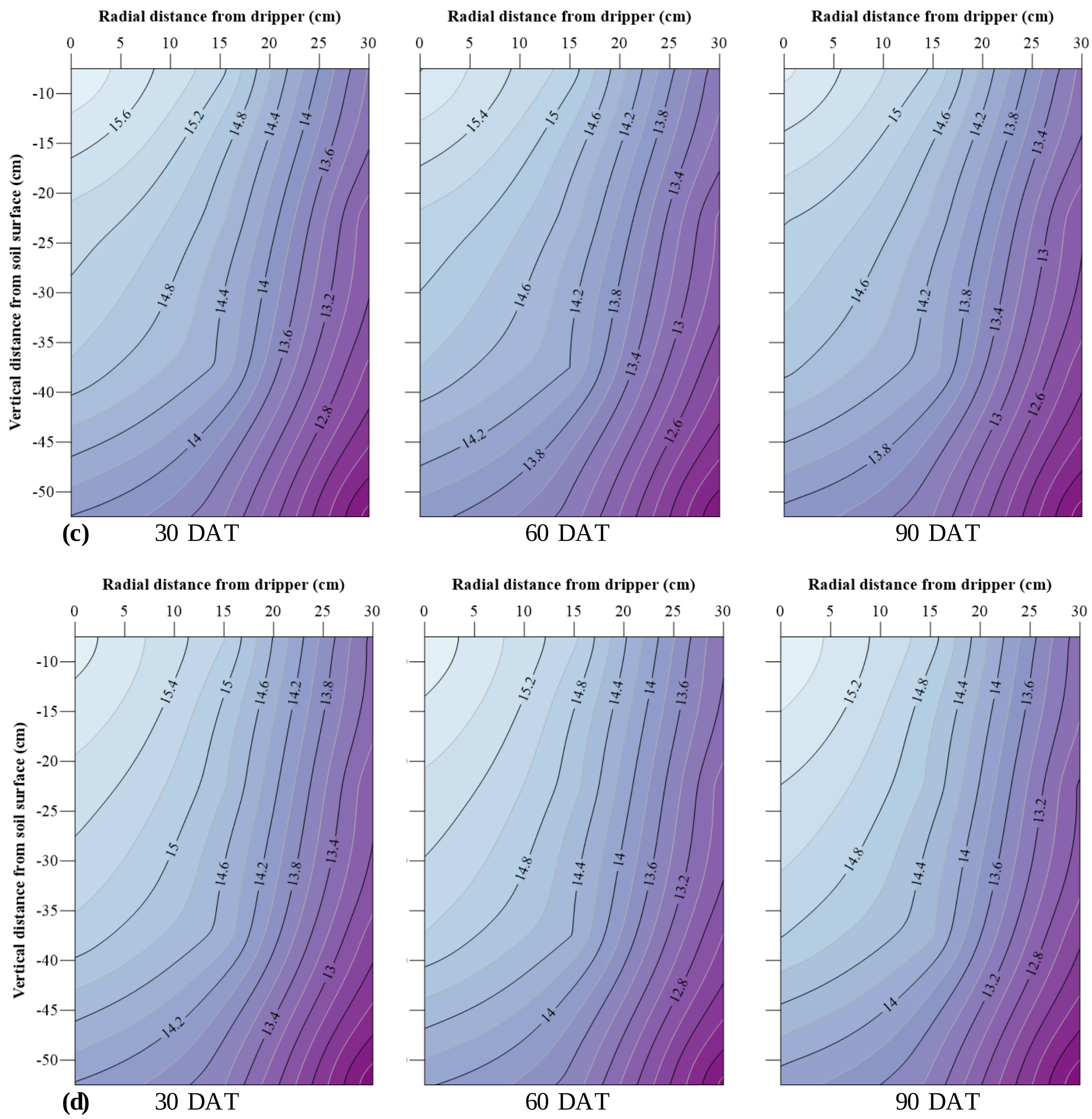


Fig. 2: Spatio-temporal distribution of gravimetric moisture content (%) for treatments (a) Sr45 (b) Sb45 (c) Sr60 and (d) Sb60

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