Original Research Article

SOIL MOISTURE DISTRIBUTION PATTERN UNDER DRIP IRRIGATION IN SANDY LOAM SOIL USING GRAVIMETRIC METHOD

Abstract: Soil moisture distribution pattern plays an important role in finding out the effectiveness of drip irrigation as the irrigation is scheduled based on the crop water requirement (CWR) and restricted to the root zone of the crop. The objective of this study was to characterize the soil moisture distribution pattern in the sandy loam soil of chilli field. The effective root zone of chilli crop was 18cm. The drip irrigation system with emitter discharge of 4lph was installed in the field. The soil moisture content at the depth of 10cm, 20cm, and 30cm respectively from the horizontal distance of 10cm,20cm,and 30cm from the emitter were recorded after 2hr and 24hr of irrigation. Soil moisture content was measured by the gravimetric method. The soil moisture distribution pattern was assessed by the SURFER-16Software from the recorded soil moisture content. The result shows that, in the sandy loam, the water movement was faster and there was more vertical distribution of the soil moisture than lateral distribution.

Keywords: Soil moisture distribution pattern, Drip irrigation, Sandy loam soil, Gravimetric method, Surfer-16software.

INTRODUCTION

To cope with, increasing water shortage conditions in arid and semi-arid regions that adversely affected crop productivity, increasing water use efficiency by precision agricultural technology (Allahyari *et al.,* 2016, Far *et al.*,2018) can be a tool to address food insecurity issues. Drip irrigation method is most essential for water saving in crop production and this acquired global acceptance as a systematic and low-cost method. It is best and new technology to produce accurate amount of water (Mmolawa and Or, 2000 ;Levidow *et al.,* 2014). It also decreases over utilization of underground water that occurs in surface irrigation (Bansal *et al.,* 2021). But most of the farmers provide irrigation based on their experiences in the field. This often results in decreasing the validity of the irrigation system. For the efficient water usage by drip irrigation, information regarding the soil moisture distribution pattern by the emitters on a particular soil for a specific crop can be very helpful for overcoming the problem of water loss by deep percolation (Amiri *et al.*, 2021).

Hulugalle (1987) examines the water uptake patterns of chilli pepper in irrigated and non-irrigated conditions and observed that higher water extraction is at 0.5m root depth. Chilli pepper was able to extract water at 1m root depth based on the root conductivity in the soil. Maqsood Ahmed Khan (2001) studied the water distribution pattern of surface and trickle irrigation in silt loam and sandy loam soils at different soil temperatures using TDR. It was found that soil temperatures greatly affect the spatial distribution of irrigation along with soil depth. At the top layer, the moisture content is found to be higher at lower temperature than at the higher temperature. But at lower layer, this pattern is reversed as irrigation water get stored at higher temperature.Mohamed El-Sayed Aburab (2011) analysed the soil moisture distribution pattern under surface and sub-surface drip irrigation system by using neutron probe technique and found out that the distance between laterals doesnot show any significant effect on the distribution pattern rather than the dripper spacing in the case of surface irrigation. For the SDI, 30cm depth is recommended for the system as it gives better water saving.Mallikarjun Reddy (2018) observed that, for the horizontal and the vertical movement of water, the models which showed higher regression coefficient were logarithmic and polynomial models respectively. The present study has undertaken to study the soil moisture distribution pattern of drip irrigation for green chilli in sandy loam soil.

MATERIALS AND METHODS

Study Area

The study was conducted in the Central farm, AEC & RI, Kumulur, Tamil Nadu. The experimental site is geographically situated at 10.93˚ N latitude and 78.84 ˚ E longitudes at an altitude of 57 m above mean sea level. The climate condition is semi-arid with a rainfall of 520.8 mm was received during the experiment period. The soil samples were collected from the field and the textural analysis was done by the International Pipette Method. The soil samples were also analysed for its physical and chemical properties and were determined as shown in Table 1.

Experimental design and Field Layout

Drip irrigation having emitters of 4lph was used for the study. Soil samples were collected from the depths of 10cm, 20cm, and 30cm to the horizontal distance of 10cm, 20cm, and

30cm from the emitter respectively. The effective rootzone of the green chilli plant is 18cm (Ahmet Ertek,2016). Soil moisture content was measured by using the gravimetric method and moisture distribution pattern was examined by the SURFER- 16 software.

RESULT AND DISCUSSION

The soil moisture distribution pattern of drip irrigation with emitter discharge of 4lph was studied by assessing the contour maps which were plotted based on the readings recorded during the study using SURFER -16 software. It was found that at 2hr after irrigation, the moisture content decreases as the vertical distance from the emitter increases (from 28% to 24%) and as the horizontal distance from the emitter increases the soil moisture decreases(from 27.6% to 26.5%) first but were increases (from 26.5% to 26.95%) due to the overlapping by the wetting front of adjacent emitter.

At 24 hrs after irrigation, the moisture content increases as the vertical distance from the emitter increases (from 9% to 12%) and as the horizontal distance from the emitter increases the soil moisture decreases(from 9% to 6%) first but were increases (from 6% to 8%) due to the overlapping by the wetting front of adjacent emitter. Soil moisture was found to be less at 24hr after irrigation than 2hr after irrigation due to evapotranspiration.It was also found out that, moisture content near 20cm (11.69%, 9.84%, 11.16% at horizontal distance of 10cm,20cm,30cm respectively) was less than that found near 30cm(11.83%, 11.5%, 11.65% at horizontal distance of 10cm,20cm,30cm respectively). This is due to the absorption of water by the roots of chilli crop.Thus, from the study, it was found that vertical distribution rate become more than lateral distribution as time increases.This is due to the fact thatduring infiltration, the soil water content changes both spatially and temporally, and redistribution of water in the soil strongly depends on the soil type, root distribution, rates of water application and irrigation methods.

Soil moisture distribution of drip irrigated soil mainly depends on the soil properties, dripper discharge and irrigation amount and the crop water uptake (Coelho and Or, 1999 ; Assouline 2002 ; Eugenio Coelho and Or, 1996). Elmaloglou and Diamantopoulos (2008) reported that for a fine sandy soil, the wetting front is lesser for higher discharge than the less discharge dripper

Table 1: Soil physical and chemical properties

Soil parameters	Value
Sand, Percent	68.5
Silt, Percent	20.5
Clay, Percent	10.1
Textural class	Sandy Loam soil
Bulk Density, g cm^{-3}	1.28
Field Capacity, Percent	23.5
Permanent Wilting Point, Percent	11.4
Infiltration Rate cm hr^{-1}	2.67
Available N, Kg ha^{-1}	143
Available P, Kg ha^{-1}	19
Available K, Kg ha^{-1}	121
Soil pH	7.56
Electric Conductivity, ds m^{-1}	0.13

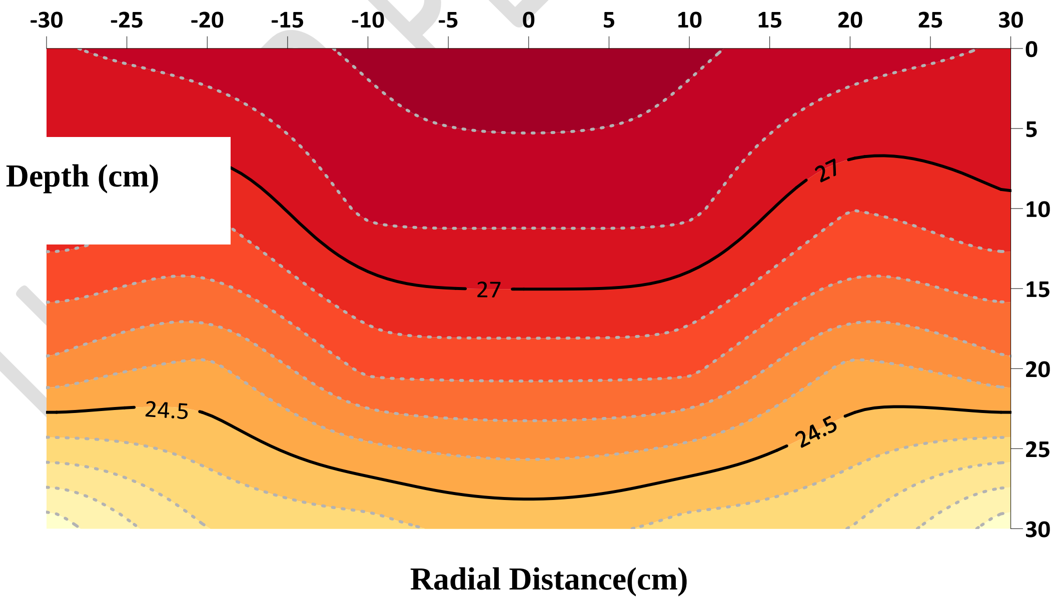

Fig.1 Soil moisture distribution at2 hr after irrigation

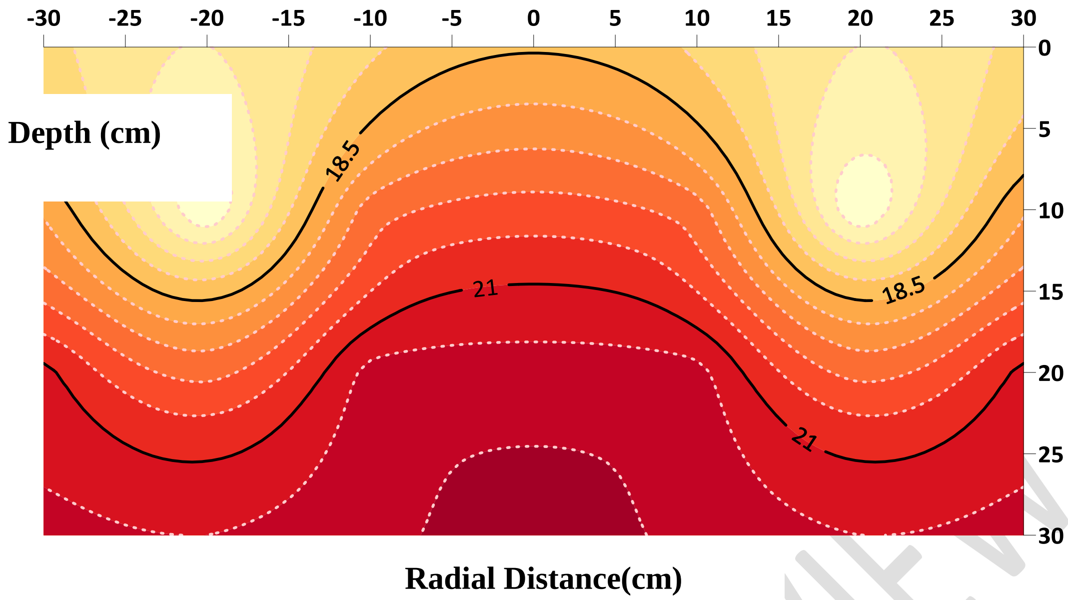

Fig.2 Soil moisture distribution at 24 hr after irrigation

Wetting pattern

The horizontal wetted zone radius and the vertical wetting zone depth as a function of time for 4lph emitter were recorded (Table 2) for the sandy loam soil in which the experiment was conducted.

Fig. 3 Horizontal water zone radius of 4 lph dripper

Fig.4 Vertical water zone depth of 4 lph dripper

Table 2Horizontal wetted zone radius and vertical wetted zone depth at different time intervals in sandy loam soil

Time (min)	Horizontal Wetted zone radius (cm)	Vertical Wetted zone depth(cm)
10	8.7	5.1
20	14.8	6.9
30	19.3	9.2
40	22.8	12.3
50	25	14.2
60	27.3	15.7
70	29.2	16.8
80	31.2	18.5
90	32.8	20.7
100	33.2	23.1
110	33.8	25.6
120	35.2	26.2

Horizontal wetted zone radius

The data pertaining to the diameter of the horizontal wetted zone during different durations of emission was presented in table 2. For a emitter of 4 lph discharge capacity, as the time increased from 10 min to 120 min, the rate of increase of wetted zone radius decreases (Fig.3). This was due to the lateral movement of soil moisture and increased area for downward movement of water (Arunadevi, 2005).

Fitting equation developed as given below.

$Y = 10.999 \ln(x) - 17.537$, $R^2 = 0.996$

Where,

Y = Horizontal advance (cm)

X = Elapsed time, min

R = Regression Co-efficient

Using the above equation, the horizontal wetted zone radius was predicted and was given in table3. It was found that there was no significant difference in observed and predicted values of horizontal water advance. Further the predicted values were tested using the chi-square test with the observed values for its goodness of fit. It was found that the relation between predicted and observed values were good. So, for the sandy loam soils, the logarithmic model can be used for the prediction of horizontal water advance. The behaviour of time v/s horizontal wetted radius confirmed the findings of Reddy *et al*, (2018).

Vertical wetted zone pattern

The data pertaining to the depth of vertical wetted zone during the different periods of emission was presented in table 2. The advancement in depth observed depends on the infiltration characteristics of the soil type. A regression equation of type $Y = AX^2 + BX + C$ was fitted and the fitted curves with the observed values were plotted in Fig. 4.

Fitting equation developed as given below.

$$Y = -0.0001x^2 + 0.2114x + 3.1473, \quad R^2 = 0.992$$

Where,

Y	=	Vertical advance (cm)
X	=	Elapsed time, min
R	=	Regression Co-Efficient

Using the above equation, the vertical wetting depth was predicted and was given in table 3. It was found that there was no significant difference in observed and predicted values of horizontal water advance. Further the predicted values were tested using the chi-square test with the observed values for its goodness of fit. It was found that the relation between predicted and observed values were good. So, for the sandy loam soils, the polynomial model can be used for the prediction of horizontal water advance. Similar relationships were observed by Reddy *et al.* (2018).

Table 3Observed and predicted values of horizontal wetted zone radius and vertical water zone depth at different time intervals in sandy loam soil

Time (min)	Horizontal Wetted zone radius (cm)		Vertical Wetted zone depth(cm)	
	Observed	Predicted	Observed	Predicted
10	8.7	7.8	5.1	5.3
20	14.8	15.4	6.9	7.3
30	19.3	19.9	9.2	9.4
40	22.8	23.0	12.3	11.4
50	25	25.5	14.2	13.5
60	27.3	27.5	15.7	15.5
70	29.2	29.2	16.8	17.5
80	31.2	30.7	18.5	19.4
90	32.8	32.0	20.7	21.4
100	33.2	33.1	23.1	23.3
110	33.8	34.2	25.6	25.2
120	35.2	35.1	26.2	27.1
χ^2	0.981		0.984	

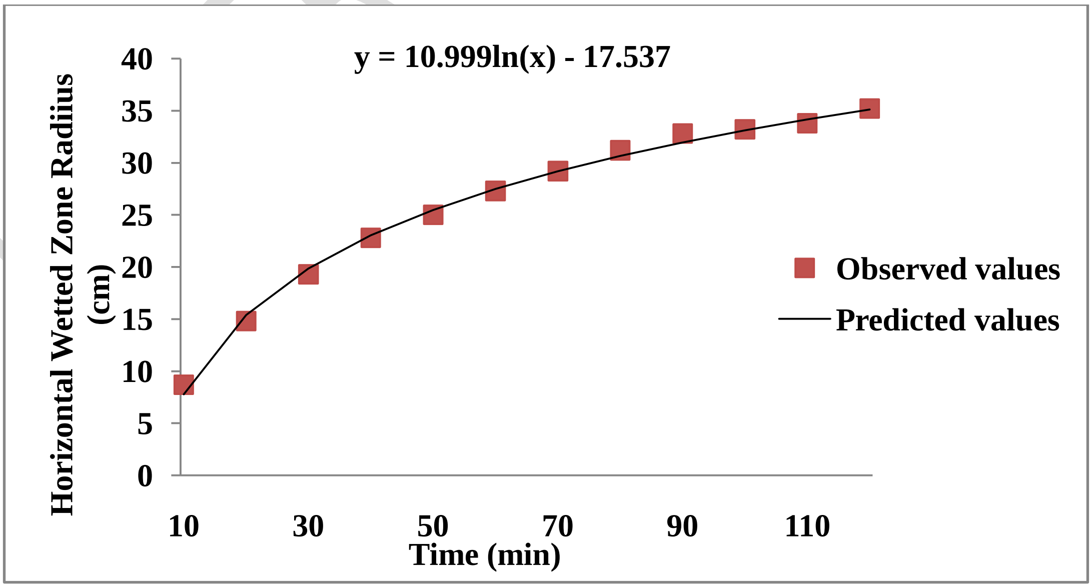

Fig 5 Time V/s Horizontal wetted zone radius

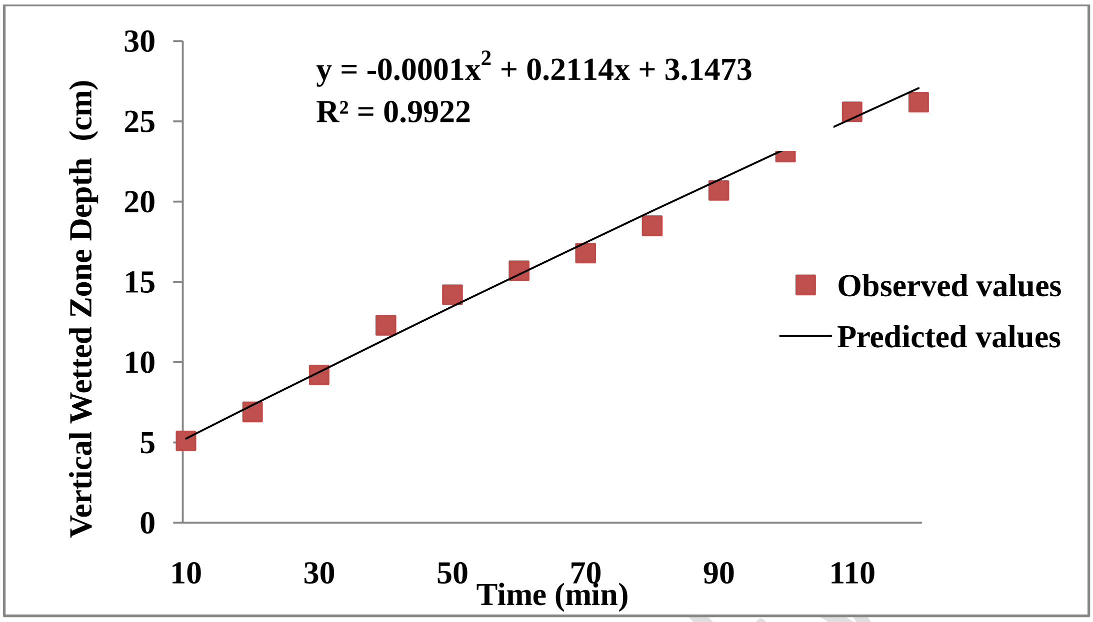

Fig 6 Time V/s Vertical wetted zone depth

CONCLUSION

Soil moisture content was calculated gravimetrically and the values were plotted by using the computer software "surfer 15" of windows version and contour maps were drawn.After 2 h of irrigation, the moisture content nearer to emitter was found to be higher than any other location. The moisture content at 30 cm from the emitter at 10 cm was higher than those at 20 cm distance of same depth due to the overlapping of the wetting pattern of emitters. The lateral movement was found to be more than the vertical movement. After 24 h of irrigation, the moisture content at 30cm depth was more than at 10 cm and 20 cm depth due to the evaporation loss and plant water uptake respectively.

The wetting pattern emitter (4 lph) was studied by operating the drip irrigation for 20 min. From the study it can be concluded that logarithmic model can be used for predicting horizontal wetted radius as it gave highest regression coefficient and for predicting the vertical wetted depth, polynomial model can be used.

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