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Research Paper :

Moisture distribution studies through emitters of drip irrigation in soil

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ABSTRACT

The ever increasing population growth rate has compelled to maximize food production per unit of water used, as water is major resource for agricultural production. The micro irrigation system has now become indispensible for increase in crop production as water is directly applied to the root zone of the plant. Thus micro irrigation minimizes conventional losses due to deep percolation, runoff and soil evaporation and also permits the effective utilization of fertilizers, pesticides and other water soluble chemicals along with irrigation water with better crop response. A perfect design of trickle irrigation requires knowledge of water distribution pattern in soil. The moisture distribution pattern will determine effectiveness of drip irrigation system in field conditions. One of the important parameter affecting water distribution to the plant in the field condition is hydraulic characteristics of drip irrigation system, therefore, it is essential to understand hydraulic performance of drip irrigation system in relation to soil moisture distribution.

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Key words : Emitter, Moisture distribution, Drip irrigation, Uniformity

Now a days India facing the major problem of population explosion, therefore, the micro irrigation system has now become indispensible for increasing in crop production. Micro irrigation is an efficient method for providing prescribed amount of irrigation water directly in to the soil at the root zone of the plant. Also it is science of planning and designing of efficient low cost economic system tailored to fit natural condition.

Efficient trickle irrigation system requires selection of emitters spacing, water application rate and duration of irrigation. This parameter depends upon the hydraulics of soil moisture plant and growth stage of crop to be irrigated. Water moves across the soil surface away from the emitters until the infiltration rate of the ponded area matches with the discharge area. The rate of application of water in the drip irrigation is an important factor which governs moisture distribution in soil profile. Water moves through soil profile under gravitational and capillary forces. A high rate may cause deep percolation loss where as very low rate may contribute to evaporation losses.

METHODOLOGY

The present investigation moisture distribution study through emitters of drip irrigation systems was carried out at Pad. Dr. D.Y. Patil college of Agricultural Engineering and Technology during May 2007 to June 2008. The details regarding the materials used and methodology adapted is explained as below.

Specifications of equipment used:

Pump and filter unit :

A monoblock centrifugal pump set of following specification was used to lift water from tank. HP- 1, rpm- 2880, size – 50cm x 40 cm, voltage 180/ 240, make – Bhangar enterprises Bombay. An ISI mark 100 mesh was used for the present study to make the water free from dust and debris.

Laterals:

An ISI marks LLDPE tube of 16 mm diameter and 20 m length was used for the present investigation. The inner diameter of lateral was 13.66 mm and thickness was 1.17mm. The emitter was spaced at every 60cm along total lateral length to be tested.

Emitters :

The following specifications emitters were used for this study.

Pressure gauge :

The pressure gauge was used to measure operating system of system and was attached on the main line as well as at inlet and outlet of the screen filter. The pressure gauge at screen filter was used to measure pressure difference at inlet and outlet of the filter so as to understand clogging of filter element by physical agents during the experimentation. The pressure gauge attached on main line before start of lateral was used to measure and maintained operating during experimentation.

Bypass assemblies:

The bypass assembly was attached to regulate flow of water from pump to laterals through filter unit. It was also used to maintain the prescribed operating pressure.

METHODOLOGY

The study was carried out on research farm of CAET, Talsande. The above mentioned emitters were selected for hydraulic performance test. Thirty samples of each type were selected randomly and emitters were placed on separate laterals at spacing of 60 cm, the schematic diagram of experiment set up is shown in Fig. 1. The emitters were tested at pressures from 0.8 kg/ cm^2 to 1.2 kg/cm^2 with an increment of 0.2 kg/cm^2 the prescribed pressure was maintained at the lateral end with the help of bypass assembly located directly downstream from pump set. The pressure gauge located on the main line was used to monitor pressure throughout the test. The catch cans of 1500ml capacity were placed underneath each alternate emitter to measure the discharge. The test was replicated thrice to minimize errors in readings. The test for each emitter was run for 10 min.

The discharge data obtained for each type of emitter in each set of observation was used to determine mean flow rate and standard deviation at each operating pressure. The coefficients of variation, emission uniformity, distribution uniformity, discharge coefficient and discharge exponent were determined for each emitter type to know the type of flow regime. Prior to this test the properties of soil and water were recorded and presented in Table 1.

Table 1: Properties of soil and irrigation water

Physical properties	Observed value
Soil properties	
Bulk density	1.423 gm/cc
Field capacity	15.06 %
Initial moisture content range	1.24 %
Infiltration rate	60mm/hr
Sand	50 %
Silt	30 %
Clay	20%
Textural class	Sandy Loam
Chemical properties	Observed value
Electrical conductivity (EC)	0.124 dS/m
pH	4.98
Irrigation water quality	
EC	0.0875 dS/m
pH	5.87

The system was run for all types of emitter at 0.8 kg/cm^2, 1.0 kg/cm^2 and 1.2 kg/cm^2 operating pressures. The system was run for 2 hrs for each test. Thus making the volume of water application in soil as 4, 8 and 16 liters from 2, 4, 8 lph drippers, respectively. The soil moisture observation were recorded at 8, 16 and 24 hrs after irrigation was overed for each emitter type to measure the movement of soil moisture with respect to time. The statistical parameters were determined (*i.e.* Regression coefficient) for model validation to predict vertical and horizontal movement of water after irrigation through each type of emitters.

RESULTS AND DISCUSSION

The results of the present study as well as relevant discussion have been summarized under following heads:

Moisture distribution through emitters at different pressures:

An attempt has been made to highlight two dimensional water movement in sandy loam soil through point source of application. For the study the observations were recorded for three different emitter discharges (2, 4 and 8 lph) at 0.8, 1 and 1.2 kg/cm^2 operating pressures. The movement of soil moisture was recorded at 8, 16 and 24hrs. For each emitter discharge and operating pressure. The observations were replicated thrice to minimize the error in the recordings. The moisture content contours were drawn for all the observations and are presented and discussed as below

Moisture distribution through emitters at 0.8 kg/ cm^2 :

Moisture distribution through 2 lph emitter:

The observations of moisture movement through soil profile for irrigation through 2 lph emitter are presented in Table 2. It is clear from table that the horizontal movement of both side emitter (30 cm) was more than the vertical movement (25.56 cm). It is also observed that the horizontal advance decreased and vertical advance increased with the time increment. The equation for horizontal advance for 2 lph emitter indicated that the horizontal advance decreases linearly with respect to time with the rate of 0.625 cm/hr. The prediction of horizontal

Table 2: Stastical analysis and water distribution through different types of emitter

Emitter	Parameters	Horizontal Advance (HA)	Vertical Advance (VA)
0.8 kg/cm^2			
2 lph	Water distribution rate (cm/hr)	0.625	0.2425
	Regression equation	HA=-0.625T + 19.627	VA= 0.2425T + 22.453
	Regression coefficient (R^2)	0.9835	0.4796
4 lph	Water distribution rate (cm/hr)	1.5508	1.435
	Regression equation	HA=0.2956T + 12.027	VA= 0.1737T + 38.98
	Regression coefficient (R^2)	0.8769	0.8247
8 lph	Water distribution rate (cm/hr)	2.0141	1.7591
	Regression equation	HA= 0.5213T + 9.26	VA = 0.6594T + 25.347
	Regression coefficient (R^2)	0.5016	0.8941
1.0 kg/cm^2			
2 lph	Water distribution rate (cm/hr)	0.9375	0.7063
	Regression equation	HA= -0.9375T + 25.133	VA = 0.7063T + 14.5
	Regression coefficient (R^2)	0.9461	0.872
4 lph	Water distribution rate (cm/hr)	0.3706	0.1906
	Regression equation	HA = 0.3706T + 12.897	VA = 0.1906T + 36.117
	Regression coefficient (R^2)	0.9997	0.1517
8 lph	Water distribution rate (cm/hr)	0.2775	0.2431
	Regression equation	HA = 0.2775T + 15.187	VA = 0.2431T + 33.517
	Regression coefficient (R^2)		
1.2 kg/cm^2			
2 lph	Water distribution rate (cm/hr)	0.6721	0.7518
	Regression equation	HA = 0.6721T + 19.521	VA = 0.7518T + 21.582
	Regression coefficient (R^2)	0.8521	0.8121
4 lph	Water Distribution Rate (cm/hr)	0.4863	0.20
	Regression equation	HA = 0.4863T + 13.237	VA= -0.2081T + 47.22
	Regression coefficient (R^2)	0.9983	0.75
8 lph	Water distribution rate (cm/hr)	0.2936	0.364
	Regression equation	HA = 0.2956T + 17.307	VA = 0.365T + 34.807
	Regression coefficient (R^2)	0.5088	0.5804

advance was highly significant ($R^2 = 0.9835$). The vertical advance was found increasing with respect to time at the rate of 0.2425 cm/hr, however, the regression coefficient found to be 0.4796.

Moisture distribution through 4 lph emitter:

The observations of moisture movement through soil profile for irrigation through 4 lph emitter are presented in Fig. 1. The Fig. 1 shows that the horizontal advance was less (27.76 cm) as compared to vertical advance (37.22 cm) in the initial period, it progressed with respect to time. After 16 hrs the horizontal spread increased to 35.56 cm and vertical spread decreased to 36.94 cm while after 24 hrs, it further increased to 37.22 cm vertical spread decreased to 34.44 cm. After 24 hrs the bulb of moisture content became like shape of onion, this indicate proper redistribution of moisture content in the soil profile with the irrigation with 4 lph emitter.

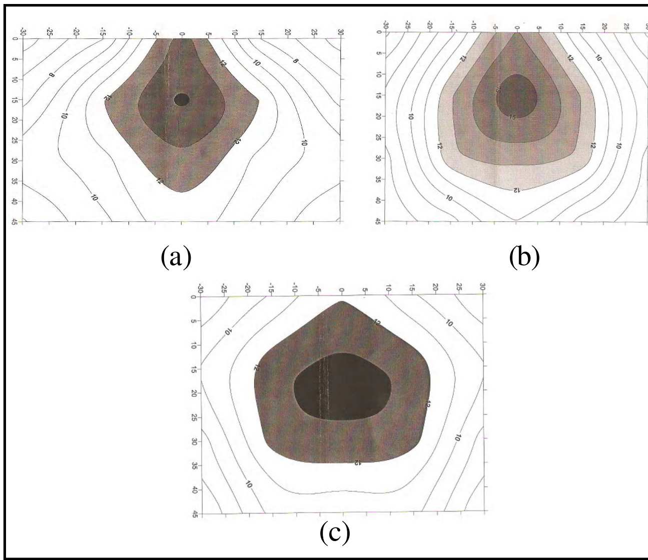

Fig. 1 : Moisture distribution through 4 lph emitter at 8, 16 and 24 hrs after irrigation at 0.8kg/cm^2, respectively

Moisture distribution through 8 lph emitter:

The observations of moisture movements through soil profile through 8 lph emitter are presented from Table 2. It was clearly noticed from Table that the moisture content had uniform redistribution in horizontal and vertical direction through soil profile after 8 hrs irrigation. After 16 hrs horizontal spread remained constant (31. 66 cm) and vertical spread increased (33.33 cm), while after 24 hrs the horizontal as well as vertical spread increased further to 48.34 cm and 42.22 cm, respectively. The observation indicates that increase in horizontal advance and vertical advance was at the rate of 0.5213 cm/hr and 0.6594 cm/hr, respectively. This increase in advance is apparent due to sufficient application of volume of water which is mostly penetrates below the root zone of crop. Hence, water applied through 8 lpm emitter has the chances of deep percolation in the soil profile.

Moisture distribution through emitters at 1 kg/cm^2:

Moisture distribution through 2 lph emitter:

The observation of moisture movements through soil profile through 2 lph emitter are presented in Table 2. It was observed that similar trend of moisture movement as in case of 2lph emitter operated at 0.8 kg/cm^2 for 8,16,24 hrs after irrigation. However, in this case horizontal advance showed decrease and vertical advance showed increase and trend at the rate of 0.9375 cm/hr and 0.7063 cm/hr, respectively.

Moisture distribution through 4 lph emitter:

The observation of moisture movements through soil profile through 4 lph are presented in Fig. 2. It was observed that the horizontal advance showed increase in trend in respect to time while vertical advance decreased with respect to time for 8, 16 and 24 hrs after irrigation. The observations indicated that the increase in horizontal advance with water application was 0.3706 cm/hr and vertical advance with the rate of 0.1906 cm/hr.

Moisture distribution through 8 lph emitter:

The observation of moisture movements through soil profile through 8 lph are presented in Table 2. The moisture contours were hatched for moisture content of 85 % and above the field capacity to understand clearly the soil moisture movement with respect to time. The trend of moisture movement through soil profile is similar to 0.8 kg/cm^2. The observation indicates that increase in horizontal advance with water application is 0.2775 cm/hr and the vertical advance with the rate of 0.2431cm/hr.

Moisture distribution through emitters at 1.2 kg/cm^2:

Moisture distribution through 4 lph emitter:

The observation of moisture movements through soil profile through 4lph emitter *i.e.* for 8 litres of volume application at 8, 16 and 24 hrs after irrigation operated at 1.2 kg/cm^2 are presented in Fig. 3. The moisture contours were hatched for the moisture content of 80% of the field capacity had similar trend in case of horizontal spread but the vertical advance was comparatively more than that of 0.8 and 1.0 kg/cm^2. This may have penetrated below the rootzone result in deep percolation losses. The observation indicated that increase in horizontal advance was 0.4863 cm/hr and vertical advance with rate of 0.20

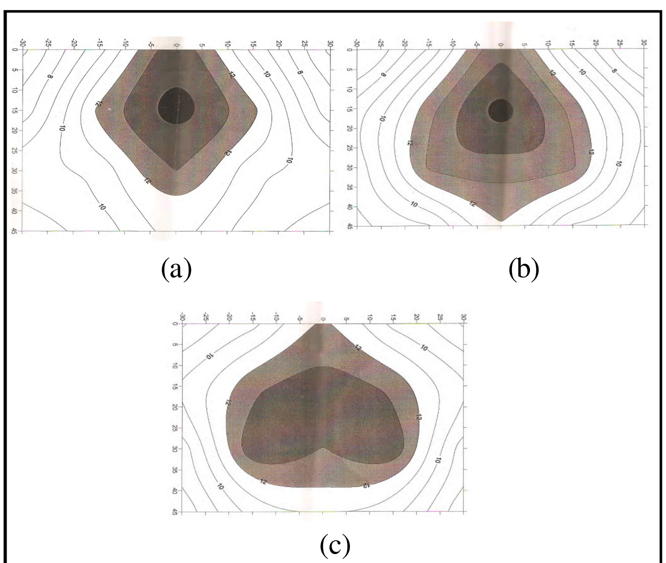

Fig. 2 : Moisture distribution through 4 lph emitter at 8, 16 and 24 hrs after irrigation at 1.0 kg/cm^2, respectively

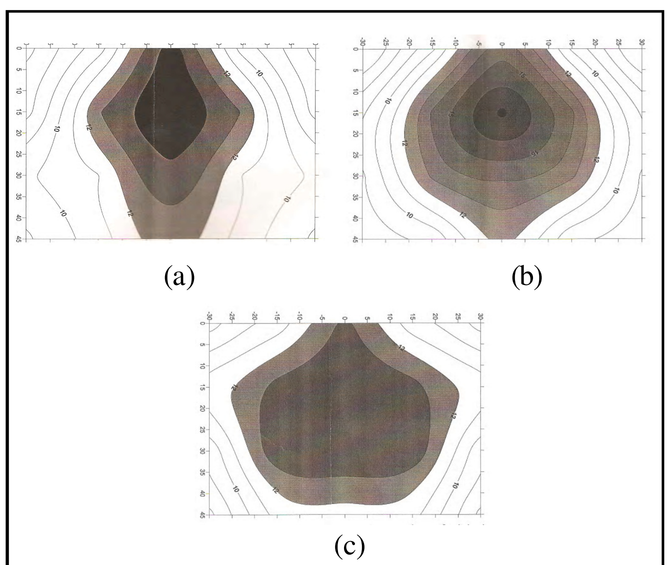

Fig. 3 : Moisture distribution through 4 lph emitter at 8, 16 and 24 hrs after irrigation at 1.2kg/cm^2, respectively

cm/hr.

Moisture distribution through 8 lph emitter:

The observation of moisture movements through soil profile through 8 lph emitter ie for 16 litres of volume of application at 8, 16 and 24 hrs after irrigation are presented in Table 2. The observation indicates that increase in horizontal advance with water application through 8 lph emmiter is 0.2956 cm/hr and vertical advance with rate of 0.364 cm/hr thus it was seen that vertical advance for 8 lph emitter increased with increase in operating pressure. This is due to the fact that as pressure increases the discharge increases, which affects horizontal and vertical pressure. The moisture content had similar trend in case of horizontal spread as it was with 8 lph emitter operating at 0.8 and 1 kg/cm^2 but vertical advance was comparatively more than that pressure and may have penetrate below the rootzone resulting in deep percolation losses. Dahiwalakar *et al*. (1994) and Pawar and Bhoi (2002) have also made some investigations on drip irrigation in the same pattern.

Conclusion:

It was found that the minimum uniformity coefficient of 93.62 per cent for 4 lph emitter operating at 0.8 kg/cm^2 and the maximum value of uniformity coefficient observed was 97.46 per cent for 8 lph operating at 1.2 kg/cm^2. The uniformity coefficient for 2, 4 and 8 lph emitter was greater than 94 per cent which is more than 10 per cent that of acceptable level *i.e.* 85 per cent. The change in pressure did not change the uniformity coefficient to considerable extent. The minimum distribution coefficient of 90.15 per cent was found for 8 lph emitter operating at 1 kg/cm^2 where as maximum value of distribution coefficient of 98.11 per cent was found for 4 lph emitter operating at 1.2 kg/cm^2. Average discharge of 2 lph emitter range between 1.59 to 2.10 lph at operating pressure of 0.8 kg/cm^2 to 1 kg/cm^2 where as 4 lph emitter ranges between 3.39 to 4.42 lph and 8 lph emitter ranges between 7.05 to 8.71 lph for operating pressure of 0.8 to 1 kg/cm^2. The pressure discharge relationship for 2, 4 and 8 lph emitter are $Q= 1.9573H^{0.2031}$, $Q = 3.8625\ H^{0.5346}$ and $Q = 7.9787\ H^{0.4921}$, respectively. The horizontal and vertical advance for 2, 4 and 8 lph emitter increase with respect to time with increase in pressure from 0.8 to 1 kg/cm^2. The linear relationship between pressure and discharge for different type of emitter was found. For low discharge emitters at low pressure s the vertical and horizontal spread was less whereas for high discharge emitters at high pressure the moisture movements was below 45 cm from the point source. The 4 lph emitter operated at 1 kg/cm^2 shown uniform distribution of moisture even after 24 hrs from the irrigation.

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