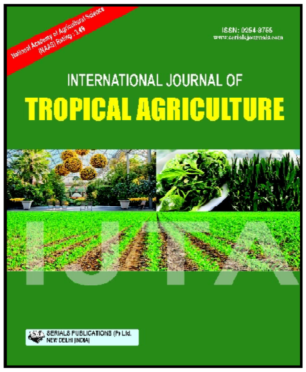

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Study of In-Situ Wetting Pattern of Drip Irrigation System under Different Emitter's Discharge and Different Soil

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Abstract: The wetting pattern is an important factor to consider for designing and managing a drip irrigation system. The dimensions of the wetting pattern are imperative in selecting the right spacing between emitters and the suitable distance between laterals. The field experiments with surface drip irrigation involving three discharge rates (2 lph, 4 lph and 8 lph). The experiment carried in on two different soil sandy clay loam and clay loam after determining various physical property of soil like moisture content, bulk density, field capacity. The experiments were conducted by drip emitters of different discharge rates on separate laterals on different beds for one hour. The horizontal spreading and vertical depth of infiltration of the water into soil was measured. The experiment concluded that when discharge rate increased from 2 lph to 4 lph then maximum horizontal distance was found to be increased by 44.4% and from 2 lph to 8 lph maximum horizontal spreading was found to be increased by 111.1%. While when discharge rate increased from 2 lph to 4 lph then maximum vertical distance was found to be decreased by 4.76% and from 2 lph to 8 lph maximum vertical distances was found to be decreased by 14.28%. Therefore, more is the discharge rate less is the vertical movement and vice-versa. It was also observed that the lateral movement of water is more for clay loam soil than the sandy clay loam soil while the vertical distance is greatest for sandy clay loam than the clay loam. Thus, the more is the sandy nature of the soil more is the vertical movement of water and comparatively less in lateral movement.

Key Words: Wetting pattern, discharge rate, emitters, moisture profile, soil types, horizontal spreading, infiltration.

1. INTRODUCTION

Land and water are the two basic pre-requisites for life. The demand of these two natural resources are increasing more and more due to the escalation of population, large scale industrialization and food needed for the growing population. According to 2011 census of India, the decade percentage increase in population of India is 17.70%. It is essential that food production should increase about 2.5% per year to feed the growing population. More is the demand for food more will be the requirement of water to irrigate the field. Though, the water resource is limited and it has to be optimally harnessed and beneficially utilized with appropriate priorities of use. To achieve water security and food security it is necessary to increase the water use efficiency and water productivity, producing more with less water in all water sectorial uses particularly the agriculture sector is a big challenge. On farm water efficiency not exceeding the 50%, major efforts are directed toward the agriculture through increasing crop water productivity, reducing water losses and raising the water use efficiency. To improve water and nutrient use efficiency, growers need to maintain the soil water in the crop root zone at optimal levels for plant growth and minimal nutrient leaching. To increase water use efficiency of crop it is necessary to apply irrigation water beneath the crop root zone depth. This can be fulfilling by the use of drip irrigation system. One of the important aspects of planning and managing a Drip Irrigation system is the soil moisture movement pattern below it. The wetting profile in the root zone is dynamic and affected by crop root interactions with the soil. As the crop biomass increases, evapotranspiration will increase and use more of the volume of water in the wetted profile. Considering aforesaid point in view a study carryout under specific topic entitled "In-Situ Wetting Pattern of Drip Irrigation System under Different Emitter's Discharge and Different Soil".

Singh *et al.* (2005) found that the information on depths and widths of wetted zone of soil under subsurface application of water plays the great significance in design and management of subsurface drip irrigation (SDI) system for delivering required amount of water and chemical to the plant. **Acar *et al.*** (2009) studied the effect of different applied water by use of different emitter discharges on the wetting patterns of a loam or clay-loam soil under trickle source. Irrigation water was applied when the soil water depletion of 30 and 50% from available water capacity of soil in 0 - 90 depth.

Kandelous & Simunek (2010) found that to properly manage SDI systems, and increase the efficiency of the water/fertilizer use while reducing water losses due to evaporation, the precise distribution of water around the emitters. **Al-Ghobari & Marazky** (2012) evaluated the wetting patterns around drip and subsurface irrigation systems (DI and SI), respectively with three irrigation scheduling techniques. The drip and subsurface irrigation systems were used to irrigate a tomato crop. The wetting patterns for each irrigation system and each irrigation scheduling technique was evaluated below the soil surface at different distances and depths from the emitter 24 and 48 h after irrigation. **Sekhar (2014)** studied about soil moisture profile under different discharge rates of drip emitter. Based on the analysis he found that the horizontal spread of water increases with increase in discharge of emitter. The horizontal spread was observed to be about 23.3% and 43.3% more when the emitter discharge rate increased from 2 lph to 4.4 lph and 6.0 lph respectively and he vertical spread of water decreases with increase in emitter discharge rate. The vertical spread was observed to be about 18.0% and 32.0% less when discharge was increased from 2 lph to 4.4 lph and 6.0 lph respectively.

2. MATERIAL AND METHODS

2.1. Location of experimental site

The experimental site was located in the farm of Soil mechanics shed of College of Agricultural

Engineering situated in Pusa block of Samastipur district and in village Gorain situated in Kalyanpur block of Samastipur district. The experimental site is located in Samastipur district of North Bihar. It lies at 25.98^{0}N latitude, 85.67^{0}S longitudes and at about 52.92 m above the sea level. Climate is sub-humid- west monsoon. The annual rainfall in the area is about 1270 mm, out of which 1026 mm (80.78%) is received during monsoon months (July-September) and rest during other seasons of the year. The average minimum and maximum temperature during the hottest months of May to June goes up to 3– 4^{0}Cand 43 - 44 ^{0}C respectively.

2.2. Description of the materials used in the experiment

Water tank, main line, PVC pipe, laterals, drippers of different discharge, tape, scale, core cutter, beaker, funnel, measuring cylinder, regulating valve, and pressure gauge was used for conducting this experiment.

2.3. Determination of Soil Texture

Soil texture was determined by hydrometer method. The experiment was conducted on Sandy Clay Loam and Clay Loam near soil of Soil Mechanics shed, CAE, of Pusa block and village Gorain, of Kalyanpur block respectively. The contribution of the sand, silt and clay were 52%, 18% and 30 % respectively in Pusa block and the contribution of sand, silt and clay are 40%, 34% and 26% respectively comes under the soil of village Gorain situated in Kalyanpur block.

2.4. Determination of Bulk Density

It can be determined by the use of core cutter of known dimension which is driven into soil properly and take the soil sample for oven dry for 24 hours at temperature 105^{0}C. Then, the bulk density is calculated by using the equation given below:

$$Bulk\ Density = \frac{mass\ of\ oven\ dry\ soil\ sample(g)}{total\ volume\ of\ core\ cutter\ (cm3)} \qquad 2.1$$

2.5. Determination of soil field capacity

The soil sample (measuring upto the level of 100 ml of the measuring cylinder) was kept at cotton which is placed in funnel. Add 100 ml water to the soil sample and leave it for 1 hour until the last drop. Then the collected water in the beaker was measured with the help of measuring cylinder. Calculate water holding capacity of soil by subtracting collected water in beaker from 100 ml. The retained water is the field capacity of the soil.

2.6. Determination of moisture content of soil

A specimen of soil sample was kept in a clean container and put in a thermostatically controlled oven and maintaining the temperature between 105^{0}C to 110^0 C for 24 hours for fully drying. After cooling, the soil sample was weigh. The moisture content of soil sample was determined by the equation 2.2 as given below:

$$Moisture\ Content, M = \frac{M_2 - M_3}{M_3 - M_1} \times 100 \qquad 2.2$$

Where, M_1 = Mass of container with lid, M_2 = Mass of container with lid and wet soil and M_3 = Mass of container with lid and dry soil.

2.7. Bed preparation

Bed was prepared for calculating experiment of size 6 m × 1 m × 0.50 m (l × b × h) m so that the drippers should easily installed.

2.8. Installation of drip system

Water tank of capacity 500 litre was used which was kept at suitable height from ground level so as to maintain pressure level in drippers. The pressure in main line was measured by pressure gauge which is maintained by regulating valve. The water source was connected to a main line which is connected to three lateral both the main line and laterals of specified diameter was used and regulating valve was installed at the entrance of the main line. The emitters of different discharge rates were attached to the different laterals. The three emitters of same discharge attached to same laterals of equal spacing was installed.

2.9. Determination of discharge rates

A container of suitable capacity was placed under each emitter to measure the discharge rate of emitters by collecting water for one hour. The collected water was measured from each container with the help of measuring cylinder. Regulating valve adjusted in such a way that emitter discharge rate of 2 litre per hour, 4 litre per hour and 8 litre per hour (lph) was obtained.

2.10. Experimental procedure

The emitter was placed on the bed at the 1.5 m spacing on laterals and water was allowed to flow. The application of water was done for 1 hour and reading was taken after 24 hour so that water gets enough time for infiltration. After 24 hours the dry soil was removed from the sides in such a way that the wet soil gets completely exposed. Thereafter the top surface measurement was taken. The maximum lateral spreading of water was measured using tape and plumb bob. The clod soil was removed vertically from the smaller part so that vertical measurement can be done. Thereafter, from the point of the application of the water the radial distance was measured for different vertical distances.

3. RESULTS AND DISCUSSION

Bulk Density

The bulk density of soil sample taken from the experimental site for bed 2 lph, 4 lph, and 8 lph was obtained 0.29, 0.30 and 0.29 g/cm^3 respectively for sandy clay loam and for clay loam soil it is 0.29, 0.29 and 0.28 g/cm^3 respectively for bed 2 lph, 4 lph, and 8 lph. The volume of core cutter obtained was found to be 777.15 cm^3.

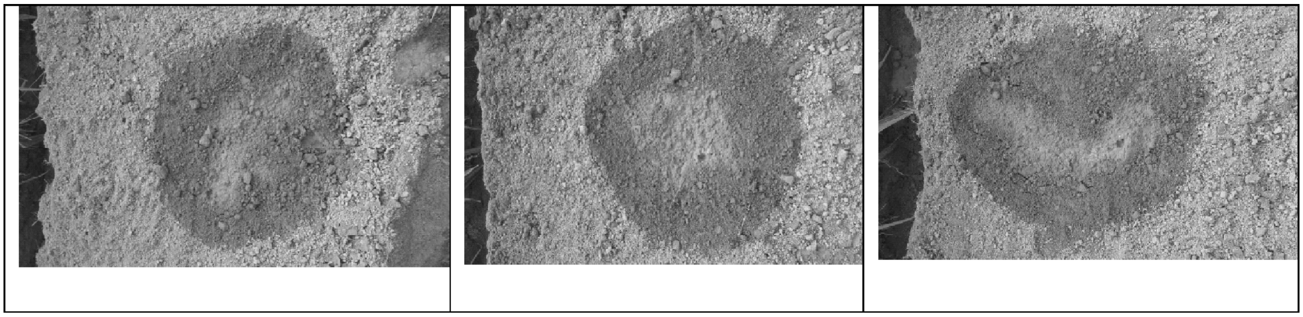
Moisture content of soil

The moisture content prior to the experiment for bed 2 lph, 4 lph, and 8 lph was obtained 15.7, 16.6 and 15.6 % respectively of sandy clay loam soil and 23.8, 23.8 and 22.9%respectively for bed 2 lph, 4 lph, and 8 lph for clay loam soil.

Wetting pattern

The average measurement of vertical depth of infiltration and horizontal spreading of wetting of three same emitters on single laterals and three different wetting clod of sandy clay loam soil for discharge rate for 2 lph was obtained at 0 cm, 8 cm, 16 cm, 24 cm, 32 cm, 40 cm and 44 cm vertical distribution was 34.3 cm, 36 cm, 30.3 cm, 25 cm, 15.3 cm, 7.6 cm and 0 cm respectively horizontal distribution. Likewise, wetting pattern at 4 lph emitters discharge rates at vertical distribution 0 cm, 8 cm, 16 cm, 24 cm, 32 cm, 40 cm and 44 cm, the horizontal distribution was obtained 50.3 cm, 52 cm, 44.6 cm, 38.6 cm, 19.6 cm, 6.3 cm and 0 cm respectively. And also, wetting pattern at 8 lph emitters discharge rates at vertical distribution 0 cm, 6 cm, 12 cm, 18 cm, 24 cm, 30 cm, 36 cm and 38 cm, the horizontal distribution was obtained 72.3 cm, 76 cm, 76 cm, 58 cm, 44 cm, 18 cm, 9 cm and 0 cm respectively.

The average measurement of vertical and horizontal distance of wetting of soil of three wetting clod of clay loam soil for discharge rate for 2 lph was obtained at 0 cm, 6 cm, 12 cm, 18 cm, 24 cm, 30 cm, 36 cm and 40 cm vertical distribution was 37.3 cm, 40 cm, 32.6 cm, 30 cm, 25 cm, 15 cm, 6.6 cm and 0 cm respectively horizontal distribution. Likewise, wetting pattern at 4 lph emitters discharge rates at vertical distribution 0 cm, 6 cm, 12 cm, 18 cm, 24 cm, 30 cm, 36 cm and 38 cm, the horizontal distribution was obtained 52.3 cm, 56 cm, 50 cm, 40 cm, 28 cm, 15 cm, 9 cm and 0 cm respectively. And also, wetting pattern at 8 lph emitters discharge rates at vertical distribution 0 cm, 6 cm, 12 cm, 18 cm, 24 cm, 30 cm, and 36 cm, the horizontal distribution was obtained 76 cm, 80 cm, 80 cm, 62 cm, 50 cm, 32 cm, and 0 cm respectively.



2 lph **4 lph** **8 lph**

Figure 1: Top view of wetting clod of three different emitter's discharge of sandy clay loam soil

Comparison of soil moisture profile at different discharge rates of emitter

The movement of the water in the soil is effected by the emitters discharge. At discharge rates 2 lph, 4 lph, and 8 lph, the maximum radial distance of moisture profile was 36 cm, 52 cm, and 76 cm respectively for sandy clay loam soil and it was 40 cm, 56 cm, and 80 cm respectively for clay loam soil. This clearly shows that the radial distance is greatest for 8 lph, followed by 4 lph, and last is 2 lph discharge. Thus, it can be said that more is the discharge rate more is the lateral movement of water. While at discharge rate 2 lph, 4 lph, and 8 lph, the vertical depth of infiltration was 44 cm, 42 cm, and 38 cm respectively for sandy clay loam soil and it was 40 cm, 38 cm and 36 cm respectively for clay soil. This clearly shows that the vertical distance is greatest for 2 lph, followed by 4 lph and last is 8 lph discharges. Thus, it can be said that lower is the discharge rate greater is the vertical movement of water.

Comparison of soil moisture profile for different soil type

The movement of water is also effected by soil types. At discharge rates 2 lph, 4 lph, and 8 lph, the radial distance of moisture profile is 36 cm, 52 cm, and 76 cm respectively for sandy clay loam soil and it is 40 cm, 56 cm, and 80 cm respectively for clay loam soil. This clearly shows that the lateral movement of water is more for clay loam soil than the sandy clay loam soil. Thus, the more is the silt and clay nature of the soil more is the lateral movement of water. While at discharge rate 2 lph, 4 lph, and 8 lph, the vertical depth of infiltration is 44 cm, 42 cm, and 38 cm respectively for sandy clay loam soil and it is 40 cm, 38 cm and 36 cm respectively clay loam soil. This clearly shows that the vertical distance is greatest for sandy clay loam than the clay loam. Thus, the more is the sandy nature of the soil more is the vertical movement of water.

The Moisture Profile for different emitter's discharge for different soil is given below in fig. 2 and fig. 3 as:

4. CONCLUSIONS

Based on the experiments the conclusions can be drawn that when discharge rate increased from 2 lph to 4 lph then maximum horizontal distance was found to be increased by 44.4% and from 2 lph to 8 lph maximum horizontal spreading was found to be

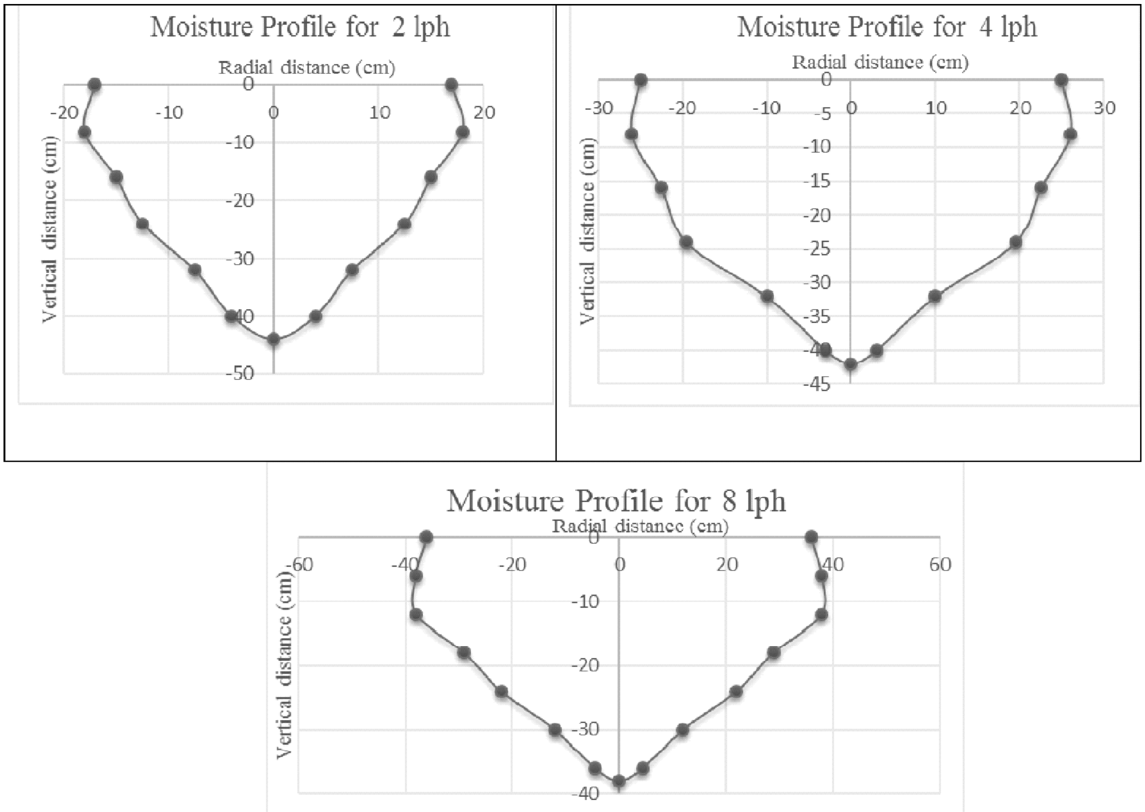


Figure 2: Moisture Profile for different emitter's discharge of Sandy clay loam soil

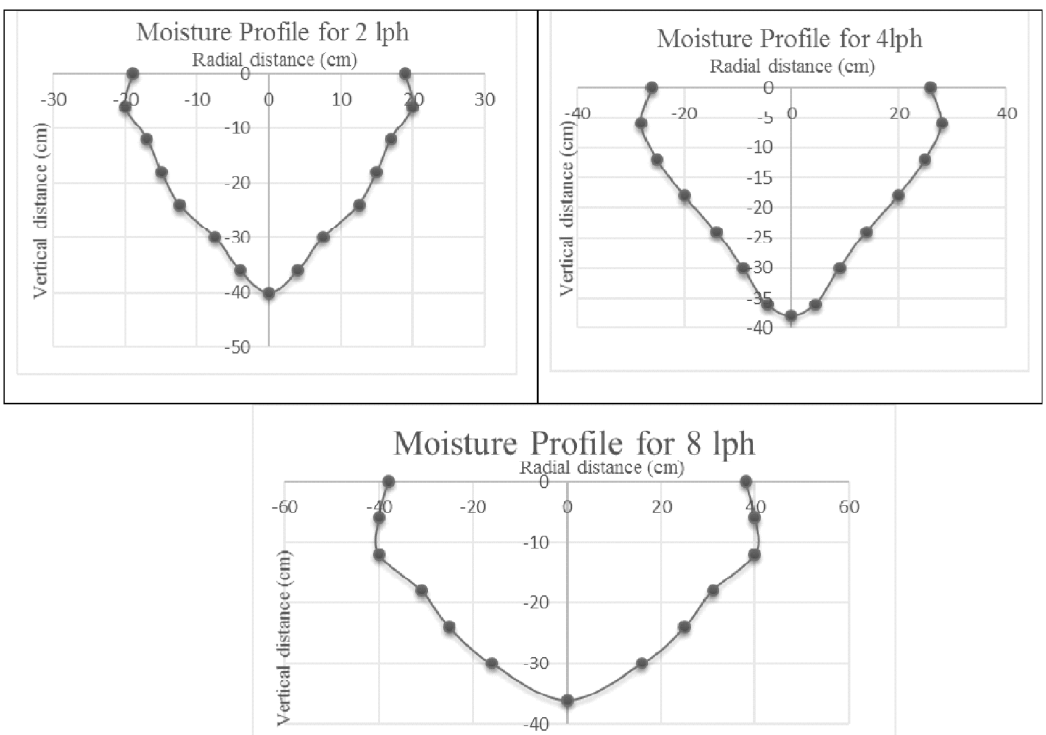


Figure 3: Moisture Profile for different emitter's discharge of clay loam soil

increased by 111.1% while when discharge rate increased from 2 lph to 4 lph then maximum vertical distance was found to be decreased by 4.76% and from 2 lph to 8 lph maximum vertical distance was found to be decreased by 14.28% for sandy clay loam soil. While when discharge rate increased from 2 lph to 4 lph then maximum horizontal distance was found to be increased by 40% and from 2 lph to 8 lph maximum horizontal spreading was found to be incrased by 100% and when discharge rate increased from 2 lph to 4 lph then maximum vertical distance was found to be decreased by 5.26% and from 2 lph to 8 lph maximum vertical distance was found to be decreased by 11.1% for clay loam soil.

For 2 lph discharge, the maximum horizontal distance in clay loam soil was increased by 11.1% and maximum vertical distance was decreased by 10% than sandy clay loam soil. For 4 lph discharge, the maximum horizontal distance in clay loam soil was increased by 7.62% and maximum vertical distance was decreased by 10.52% than sandy clay loam soil. For 8 lph discharge, the maximum horizontal distance in clay loam soil was increased by 5.26% and maximum vertical distance was decreased by 5.55% than sandy clay loam soil.

Based on the soil moisture profile recorded at different points below the discharging emitter under different discharge rates it can be concluded that the spread of water increases in horizontal direction and decreases in vertical direction when the emitter discharge is increased. Hence, the crops which have deeper root system must be irrigated with smaller discharge rates compared to crops which have shallow roots. While for deep rooted crop one can use less discharge rate and more sandy nature of soil.

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