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CLOGGING RATIO OF EMITTERS AS AFFECTED BY SINGLE AND DOUBLE INLET LATERALS AND SUB-MAIN SIZES

B. MOHANTY[1], S. C. SENAPATI[2], A. P. SAHU[3] & B. PANIGRAHI[4]

[1]Research Scholar, Department of Soil & Water Cons. Engineering, CAET, OUAT, Bhubaneswar, Odisha, India

[2]Professor, Department of Soil & Water Cons. Engineering, CAET, OUAT, Bhubaneswar, Odisha, India

[3]Associate Professor, Department of Soil & Water Cons. Engineering, CAET, OUAT, Bhubaneswar, Odisha, India

[4]Professor and Head, Department of Soil & Water Cons. Engineering, CAET, OUAT, Bhubaneswar, Odisha, India

ABSTRACT

Experiments were carried out during three growing seasons of 2011 to 2013 in the farmer's field at village Jamunali of Chhendipada block in the district Angul, Odisha, India. The effect of five different single and double inlet lateral connections with three different commonly available sub-main pipe sizes (40, 50 and 63 mm) on clogging ratio of emitters in drip irrigated brinjal (*Solanum melongena* L.) crop was studied. Measurement of discharge of new emitters (at the starting of the cropping season) and discharge of emitters after harvest of crop was taken which exhibited greater values than the corresponding single inlet systems. Maximum mean discharge at starting of cropping season (1.992 lph) and after harvest of crop(1.964 lph) was observed in case of double inlet system with two sub-mains laid at two sides of the plot and the lateral connecting to both the sub-mains at two ends (L_5). For this situation, value of clogging ratio of emitters (CRE) is found to be minimum (1.37) and CRE value (1.41) is very close to the lateral connection where sub-main is laid at the centre of the plot and laterals are laid and looped at both sides of the sub-main (L_4). Value of CRE in case of the single inlet lateral connection where sub-main is laid at one side of the plot and laterals are laid on one side of the sub-main and closed at the tail end (L_1) is maximum (6.51) amongst all the lateral connections. When single inlet laterals laid at one side of sub-main (L_1) is converted to L_2 by looping the laterals, CRE value decreases to 2.52. Similarly CRE value in case of single inlet laterals laid at both side of the sub-main (L_3) is 3.15 and it decreases to 1.41 when L_3 is converted to L_4 by looping the laterals. Values of CRE along the different sub-mail sizes are less in case of higher diameter pipes and more in case of small diameter pipes i.e. the CRE value is minimum (2.92) in case of 63 mm pipe (S_3) and maximum (3.05) in case of 40 mm pipe (S_1). Combining both the factors, it is observed that S_3 L_5 (T_{15}) is the treatment with minimum value of CRE. It is also observed that when single inlet systems with laterals laid at one side or both sides of the sub-main are converted to the corresponding double inlet systems by looping the laterals (L_1 to L_2 and L_3 to L_4), the clogging ratio gets reduced which has a direct bearing on the life of the system.

KEYWORDS: Clogging Ratio of Emitters, Double Inlet Lateral, Single Inlet Lateral, Sub-Main

INTRODUCTION

Drip irrigation is considered as the most advanced and efficient method of irrigation system for supplying water precisely to the root zone of the plants as per their requirement resulting in enhancement of yield. In 2050 an increase in water consumption up to 11% and duplication in food production needs have been predicted by UNESCO-WWAP (2003). Hence drip irrigation can find a pivotal role to meet the increasing demand for water and food production.

The irrigation system performance in any study area is evaluated on the basis of adaptability, efficiency and distribution uniformity. The distribution uniformity is a parameter which indicates the irrigation system's capability to apply water at the same rate in case of surface and sprinkler methods or discharge at same rate from each emitter in case of drip irrigation method. Without an appropriate uniformity of distribution it is impossible to irrigate in appropriate and efficient manner and with good water use efficiency. In drip irrigation system application of water should be uniform. In fact, with scarce distribution uniformity, some zones will be over-watered and other zones will be under watered. (Burt, 1997; Camp, 1997; Lameck, 2011). The part receiving more water cause deep percolation losses and the other part receiving less water involves poor plant growth and fewer yields. This is affected mainly by the pressure variation and hydraulic properties of the emitters. The hydraulic properties of the emitters include the emitter design, discharge rate, quality and temperature of water etc. The flow rate of emitters is affected by the pressure variation in the laterals which is caused due to friction loss.

Emitter clogging is affected primarily by the interactions between emitter location, emitter type and flushing frequency treatment. The number of completely clogged emitters are affected by the interaction between irrigation system and emitter type. There is an average of 3.7% less totally clogged emitters in flushed surface drip lines with the pressure compensating emitter as compared to flushed sub surface laterals with the non-pressure compensating emitter (Puig-Bargues *et al.,* 2010, Yavuz *et al.,* 2010).

The experimental study revealed that clogging ratio of emitters (CRE) decreased by increasing the number of irrigation pulses at 100%, 75% and 50% from actual water requirement under surface and sub surface drip irrigation. The values of CRE under pulse surface drip irrigation were found to be lower than values of CRE under pulse sub surface drip irrigation (Abdelraouf *et al.,* 2012; Tayel *et al.,* 2013).

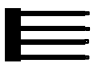
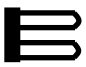
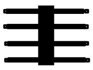
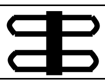
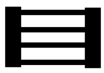
In the conventional drip system, laterals are connected to the sub-main and run along the rows of crops and are closed at the extreme end by end cap or line end. Laterals are connected to the sub-main at one end and water moves through the laterals from the connecting end, hence termed as single inlet type. When the laterals are connected with the sub-main pipe at both the ends allowing water to flow from sub-main to the laterals from the two connecting ends or inlets, it is termed as double inlet drip system. In drip irrigation system, length of laterals is much more and diameter of laterals is much less in comparison to the length of sub-main and main pipe lines. Laterals being more in length and less in diameter pose a major concern of frictional head loss in the system. Methodology to reduce head loss in the laterals is certainly an area of interest to irrigation engineers. Nayak, (2007) made theoretical analysis of frictional head loss in both single and double inlet laterals using Williams and Hazen formula and concluded that frictional head loss in single inlet system is 7.22 times that in case of double inlet system and suggested replacement of single inlet system in stationary drip unit with double inlet system for reducing frictional head loss considerably. This would result in reduction of pump capacity and also will reduce the cost of the drip system by reducing the main and sub-main pipe sizes.

Though double inlet drip irrigation system seems to be hydraulically more efficient in reducing frictional head loss compared with singe inlet system, not much work has been done in the field of research to verify its impact in the field condition. With the above hypothetical analysis, the present study is undertaken in the farmer's field to study the effect of five different single and double inlet lateral connections with three different commonly available sub-main pipe sizes on discharge and clogging ratio of emitters.

MATERIALS AND METHODS

Field experiments were conducted during January to June continuously for three years (2011 to 2013) in a farmer's field. The experimental site is located at Jamunali village of Chhendipada block in Angul district of Odisha, India. The study area has 21^0 2' 41" N latitude, 84^0 50' 14" E longitude and 217 m altitude above mean sea level. The area comes under Mid-Central Table Land Zone of Odisha. The soil of the experimental field is categorised under loamy sand type (85.2 % sand, 3.2 % silt and 11.6 % clay). The field capacity, wilting point and bulk density of the soil are observed to be 14.7 %, 4.9 % and 1.53 gm/cm^3 respectively. Chemical properties such as pH, EC and organic content of the field soil are found to be 5.5, 1.2 ds/m and 0.62 gm/kg respectively. Water from the existing dug well was used for irrigation purpose to the plant through drip irrigation system. Experiment was conducted in brinjal crop (cv. Tarini) irrigated through in-line drip system with lateral spacing (row to row spacing) of 1.2 m and plant to plant spacing of 0.6 m. Split plot design with three replications was followed by taking three different commonly available sub-main pipe sizes i.e. 40 mm, 50 mm and 63 mm in the main plots. Similarly five different types of lateral connections in which two were of single inlet type and three were of double inlet type had been taken in the sub-plots making the total number of treatments to be fifteen (15). Details of the treatments along with line diagram of different lateral connections have been presented in Table 1.

Table 1: Experimental Lay Out in the Field

Sub-Main Size → Lateral Connection ↓ Sub Plots		Main Plots		
		S_1 (Sub-main size –40mm)	S_2 (Sub-main size – 50mm)	S_3 (Sub-main size – 63mm)
L_1		S_1L_1 (T_1)	S_2L_1 (T_6)	S_3L_1 (T_{11})
L_2		S_1L_2 (T_2)	S_2L_2 (T_7)	S_3L_2 (T_{12})
L_3		S_1L_3 (T_3)	S_2L_3 T_8)	S_3L_3 (T_{13})
L_4		S_1L_4 (T_4)	S_2L_4 (T_9)	S_3L_4 (T_{14})
L_5		S_1L_5 (T_5)	S_2L_5 (T_{10})	S_3L_5 (T_{15})

Field preparation, application of FYM (well decomposed cow dung @ 150 q/ha), seedling raising and planting in the main field, application of fertilizer (N:P:K::150:75:75), bio-fertilizer, plant protection measures were taken up as per recommendations.

DETERMINANTS OF THE STUDY

Discharge at different emission points along the lateral in different treatments were measured with the help of measuring cylinder at a pressure head of 10.3 m. Similarly discharge of emitters at different points were measured with the help of measuring cylinder after harvest of crop. The two discharge observations were used for determining clogging ratio of emitters.

Clogging ratio of emitters, one of the important parameters is used in the evaluation process for drip irrigation performance. Especially drip tape can become non-uniform to a point where it is completely debilitated in the midst of a growing season if emitters become plugged. This can result from any of the following: (1) Organic or inorganic sediment in the irrigation water. (2) A vacuum condition inside of the drip tape causing dirt to siphon back in through the outlet. (3) Mineral builds up in the flow channel or at the outlet. The clogging ratio of emitters "CRE" was determined by using the equation given by Sultan (1995).

$$CRE = 1 - \eta \quad (1)$$

and

$$\eta = \frac{q_{used}}{q_{new}}$$

Where,

CRE = clogging ratio of emitters, %

η = efficiency of emitter, %;

q_{used} = average discharge for used emitters, lph and

q_{new} = average discharge for new emitters, lph

RESULTS AND DISCUSSIONS

Discharge of Emitters as Affected by Different Treatments

Discharge from each emitter was collected in glass pots (catch cans) for a time period of 1 hour. The volume of water collected was measured with the help of a measuring cylinder. The discharge of emitters as affected by different treatments has been presented in Table 2.

Table 2: Discharge of Emitters (lph) as Affected by Different Treatments

	L_1	L_2	L_3	L_4	L_5	Mean
S_1	1.877	1.978	1.922	1.990	1.991	1.952
S_2	1.879	1.979	1.923	1.991	1.992	1.953
S_3	1.880	1.980	1.925	1.992	1.993	1.954
Mean	1.878	1.979	1.923	1.991	1.992	1.953

	S	L	S x L	L x S
SEM±	0.0003	0.0015	NS	NS
$CD_{0.05}$	0.0011	0.0044	NS	NS

Discharge of Emitters after Harvest as Affected by Different Treatments

Similar observation of discharge was taken for each emitter along the laterals in different treatments after harvest of the crop. The observation on discharge of emitters thus taken have been presented below in Table 3.

Table 3: Discharge of Emitters (lph) after Harvest as Affected by Different Treatments

	L_1	L_2	L_3	L_4	L_5	Mean
S_1	1.753	1.927	1.860	1.961	1.963	1.893
S_2	1.756	1.928	1.862	1.963	1.965	1.895
S_3	1.760	1.932	1.866	1.965	1.966	1.898
Mean	1.756	1.929	1.863	1.963	1.964	1.895

	S	L	S x L	L x S
SEM±	0.0003	0.0015	NS	NS
$CD_{0.05}$	0.0012	0.0043	NS	NS

Effect of Irrigation Treatments on Clogging Ratio of Emitters

Clogging ratio of emitters under different treatments have been determined by using discharge of emitters before and after the growing season and putting the values in Eqn. 1. The values thus obtained have been analysed and presented in Table 4 and plotted in Figure 1.

Table 4: Clogging Ratio of Emitters (%) as Affected by Different Treatments

	L_1	L_2	L_3	L_4	L_5	Mean
S_1	6.61	2.58	3.23	1.46	1.41	3.05
S_2	6.55	2.56	3.17	1.41	1.36	3.01
S_3	6.38	2.42	3.07	1.36	1.36	2.92
Mean	6.51	2.52	3.15	1.41	1.37	2.99

	S	L	S x L	L x S
SEM±	0.009	0.009	0.021	0.016
$CD_{0.05}$	0.034	0.026	0.068	0.046

Value of clogging ratio of emitters (CRE) is found to be minimum (1.37) in case of double inlet system with two sub-mains laid at two sides of the plot and the lateral connecting to both the sub-mains at two ends (L_5) and the value (1.41) is very close to the lateral connection where sub-main is laid at the centre of the plot and laterals are laid and looped at both sides of the sub-main (L_4). Value of CRE in case of the single inlet lateral connection where sub-main is laid at one side of the plot and laterals are laid on one side of the sub-main and closed at the tail end (L_1) is maximum (6.51) amongst all the lateral connections. When single inlet laterals laid at one side of sub-main (L_1) is converted to L_2 by looping the laterals, CRE value decreases to 2.52. Similarly CRE value in case of single inlet laterals laid at both side of the sub-main (L_3) is 3.15 and it decreases to 1.41 when L_3 is converted to L_4 by looping the laterals. Values of CRE along the different sub-mail sizes are less in case of higher diameter pipes and more in case of small diameter pipes i.e. the CRE value is minimum (2.92) in case of 63 mm pipe (S_3) and maximum (3.05) in case of 40 mm pipe (S_1). Combining both the factors, it is observed that S_3 L_5 (T_{15}) is the treatment with minimum value of CRE. It is also observed that when single inlet systems with laterals laid at one side or both sides of the sub-main are converted to the corresponding double inlet systems by looping the laterals (L_1 to L_2 and L_3 to L_4), the clogging ratio gets reduced. The reason may be due to the less head loss in case of double inlet systems than the corresponding single inlet systems leading to more mean pressure in case of double inlet systems. Due to more mean pressure in laterals, clogging is less and value of CRE is less in case of double inlet systems than the corresponding single inlet systems.

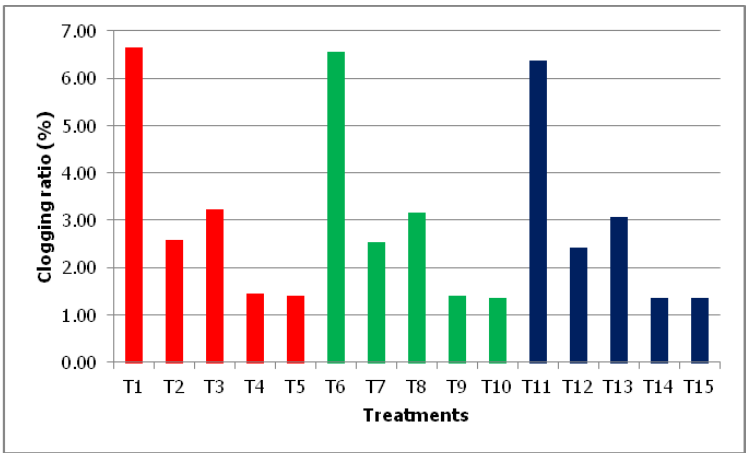


Figure 1: Clogging Ratio of Emitters in Different Treatment

CONCLUSIONS

From the experiment it is concluded that performance of the system (in terms of clogging ratio and discharge) is better in case of double inlet systems than the corresponding single inlet systems. Single inlet systems can be converted to double inlet systems just by looping the laterals and the system performance in terms of clogging ratio gets reduced. The double inlet system where two sub-main pipes are laid on both sides of the field and laterals are connected to the sub-main pipes at both the ends is found to give minimum value of clogging ratio. But, in this case the cost of the system is increased substantially due to provision of two sub-main pipes at two sides of the plot. But when the sub-main pipe is laid in the centre of the plot and laterals are looped on both sides of the sub-main, clogging ratio value is low and at par with the previous one with less cost. Hence the idea can be taken one step forward to bring suitable modification in the traditional drip irrigation design to convert single inlet system to double inlet system for achieving better hydraulic performance and getting more life of the system.

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