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VARIATION OF PRESSURE ALONG DRIP LATERAL IN RESPONSE TO SINGLE AND DOUBLE INLET LATERALS AND SUB-MAIN SIZES

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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 pressure variation along lateral in drip irrigated brinjal (*Solanum melongena* L.) crop was studied. The variation of pressure amongst different lateral connections and sub-main sizes are found to be significant where as the interaction effect is non-significant. Average pressure value is maximum (10.27 m) in case of double inlet system with two sub-mains laid at two sides of the plot and the laterals connecting to both the sub-mains at two ends (L_5) and the value is very close (10.26 m) 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).

Mean pressure in case of the 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 (single inlet type, L_1) is minimum (9.78 m) amongst all the lateral connections. When L_1 is converted to L_2 by looping the laterals, value of mean pressure increases to 10.18 m. Similarly mean pressure value in case of L_3 is 10.17 m and it increases to 10.26 m when L_3 is converted to L_4 by looping the laterals. Value of mean pressure along the different sub-main sizes shows higher values in case of higher pipe sizes and this value decreases as the pipe size decreases. The mean pressure value is maximum (10.15 m) in case of S_3 (10.15 m) and minimum (10.11 m) in case of S_1 (40 mm pipe size). Combining both the factors, it is observed that S_3L_5 (T_{15}) is the treatment which has the maximum value of mean pressure (10.29). 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 mean pressure value increases.

KEYWORDS: Double Inlet Lateral, Looping, Mean Pressure, 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. An increase in water consumption up to 11% and duplication in food production needs has been predicted by 2050 AD [1]. Hence drip irrigation can find a pivotal role to meet the increasing demand for water and food production.

In drip irrigation system, laterals being less in diameter and more in length in comparison to main and sub-main pipes, contribute more towards the head loss of the system. As water travels through the laterals, pressure head loss occurs for which there is a difference of pressure between the head and tail end. Inside the emitter water travels through a pre designed path and some amount of head is lost in the process. There are also some local losses caused due to protrusion of the emitter barbs into the flow.

For online emitters, local loss is due to the turbulence consequent to the protrusion of emitter barbs into the flow, where as for inline emitters, whose diameter is usually smaller than the pipe's diameter, local losses are due to both contraction and expansion of the flow stream lines at the emitter connections. In the later case, an additional continuous friction loss due to the diameter being smaller than the pipe's must be considered [2].

Flow constrictions at emitter insertions were estimated by analogy with contraction produced by water jets discharging through orifices. An experimental procedure was also developed to determine minor losses in situ in the laboratory or in the field. An approach was suggested to calculate either K or the emitter equivalent length as a function of lateral head losses, inlet head and flow rate. Internal diameter and length of lateral, emitter spacing, emitter discharge equation and water viscosity must be known for this purpose [3].

A definite relationship between the total friction loss and maximum and minimum pressure difference, or average and minimum can be determined for a micro-irrigation system under different field slope situations. The total friction loss can be considered as the sum of the total friction loss for the lateral and sub main. The length of the lateral and the size of sub main can be determined from the respective total friction pressure losses [4].

Evaluation of energy losses and consequently the design of drip irrigation lines are usually carried out by assuming the hypothesis that local losses can be neglected, even if previous experimental researchers showed that local losses can become a significant percentage of total head losses as a consequence of high number of emitters installed along the lines. A practical power relationship was deduced between the coefficients, expressing the amount of local losses as a fraction of the kinetic head and a simple geometric parameter characterizing the geometry of the emitter and the pipe. The proposed criterion for calculating the local losses was finally verified by using a step-by-step procedure [5].

The local pressure losses due to emitter connections and the major friction losses along the pipe based on the backward stepwise procedure, which are quickly implemented in a simple Excel spreadsheet to rapidly evaluate the relative contribution of each energy loss component to the amount of total energy losses. Hydraulic losses were calculated globally and locally and analysis outputs were presented to determine the head losses due to the inclusion of the emitters [6]. In general, reasons for the systems low performances were identified as inappropriate distribution of the pressure, excessive differences of the measured pressures overall the systems**,** poor quality and blockage of the emitters, low skills of irrigators and poor operation management of the systems [7].

The part receiving more water cause deep percolation losses and the other part receiving less water involves poor plant growth and less 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.

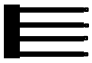
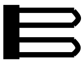
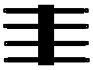
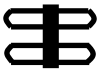
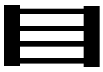
In the conventional drip system, laterals are connected to the sub-main and run along the rows of crops and are closed at the extreme end by end cap or line end. Lateral connected to the sub-main at one end and water moves through the lateral from the connecting end, hence termed as single inlet type. 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 would be 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 would certainly be the area of interest [8]. He 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 work was undertaken in the farmers' field to study the effect of five different single and double inlet lateral connections with three different commonly available sub-main pipe sizes.

MATERIALS AND METHODS

Field experiments were conducted during three seasons from month of January to June for three continuous 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 (21^0 2' 41" N latitude, 84^0 50' 14" E longitude and an altitude of 217m 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 were 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 1.2m 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. 40mm, 50mm and 63mm 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. Irrigation was given separately to each treatment by providing regulating valve at each junction point of the sub-main and main pipe. For measurement of pressure, arrangements were made so as to fit the digital pressure gauge with the lateral.

RESULTS AND DISCUSSIONS

Pressure at Different Emission Points as Affected by Different Treatments

Measurement of pressure at each emitter was carried out with the help of digital pressure gauge during the course of investigation. The mean value of pressure along laterals across different sub-main sizes and lateral connections have been presented in Table 2.

Table 2: Pressure (m) as Affected by Different Treatments

	L_1	L_2	L_3	L_4	L_5	Mean
S_1	9.747	10.162	10.152	10.242	10.248	10.110
S_2	9.762	10.176	10.168	10.262	10.275	10.128
S_3	9.838	10.191	10.178	10.271	10.287	10.153
Mean	**9.782**	**10.176**	**10.166**	**10.258**	**10.270**	**10.130**

	S	L	S x L	L x S
SEM±	0.0007	0.0093	NS	NS
$CD_{0.05}$	0.0026	0.0271	NS	NS

The data shows that minimum value of pressure is observed in case of L_1 (single inlet lateral connected at one side of sub-main) and for L_2 (laterals laid and looped at one side of sub-main), there is an increase of 4.03% over L_1. Similarly there is an increase of pressure by 0.9% in L_4 over L_3. The mean pressure in L_4 and L_5 connections were observed to be at par. In L_3 (lateral laid on both side of sub-main and closed at the extreme ends) the increase of mean pressure was about 3.93% over L_1. Maximum pressure was observed in L_5 and at par with L_4. Conversion of lateral connection from L_3 to L_4

showed an increase in pressure of 0.9%. Higher pressure is observed in L_5, i.e. when the laterals are connected to sub-mains at both the ends and the mean pressure in this case is 4.99%, 0.92%, 1.02% and 0.12% more in comparison to L_1, L_2, L_3 and L_4 connections respectively.

Variation of pressure along the lateral for different treatments have been presented in Figure 1, 2 and 3 for sub-main pipe sizes 40mm, 50mm and 63mm respectively.

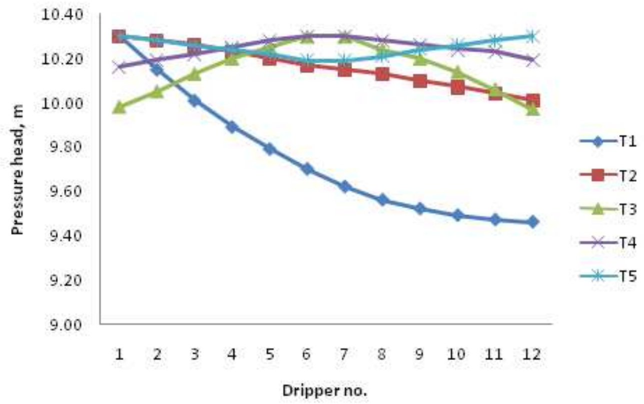


Figure 1: Ariation of Pressure along the Lateral in Different Lateral Connections (Sub-Main Size 40 mm)

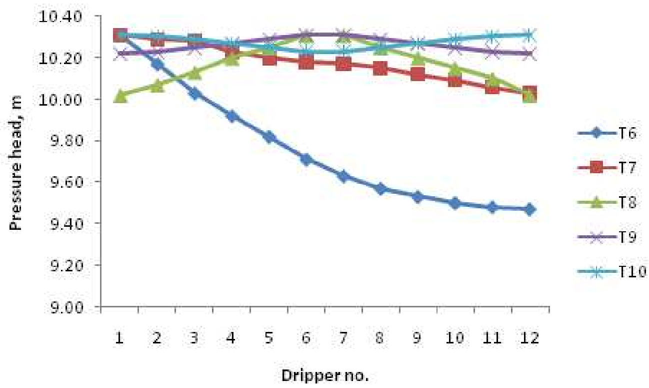


Figure 2: Ariation of Pressure along the Lateral in Different Lateral Connections (Sub-Main Size 50 mm)

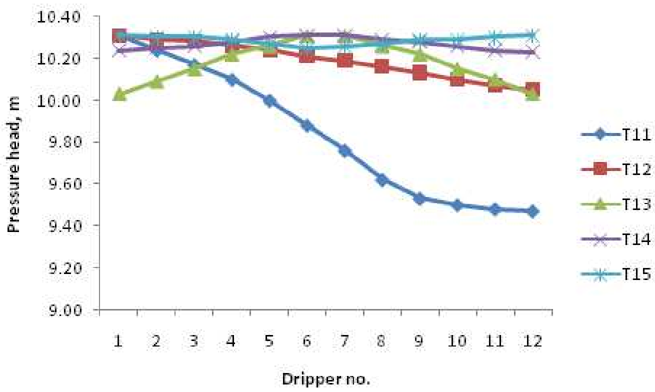


Figure 3: Ariation of Pressure along the Lateral in Different Lateral Connections (Sub-Main Size 63 mm)

Mean pressure in the laterals under different treatments for sub-main pipe sizes 40mm, 50mm and 63mm have been shown in Figure 4, 5 and 6 respectively.

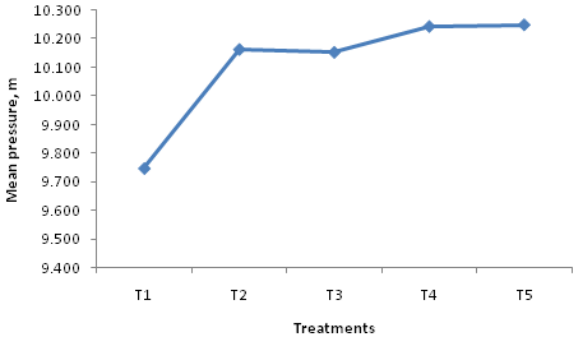


Figure 4: Ariation of Mean Pressure as Affected by Different Treatments (Sub-Main Size 40 mm)

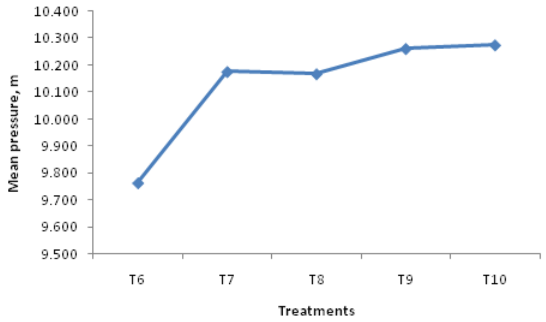


Figure 5: Ariation of Mean Pressure as Affected by Different Treatments (Sub-Main Size 50 mm)

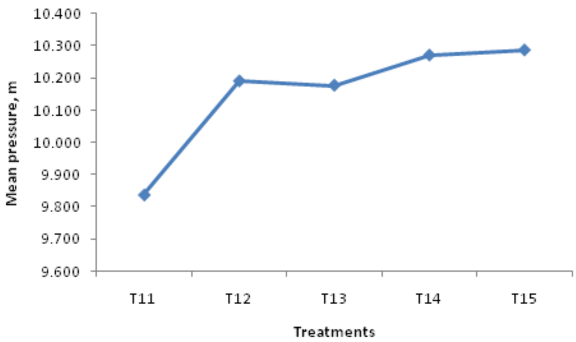


Figure 6: Ariation of Mean Pressure as Affected by Different Treatments (Sub-Main Size 63 mm)

Variation of pressure as affected by different treatments has been calculated and presented in Table 3.

Table 3: Ariation of Pressure along Lateral (%) as Affected by Different Treatments

	L_1	L_2	L_3	L_4	L_5	Mean
S_1	8.155	2.816	3.204	1.068	1.068	3.262
S_2	8.147	2.716	2.813	0.873	0.776	3.065
S_3	8.147	2.522	2.716	0.776	0.582	2.949
Mean	8.150	2.684	2.911	0.906	0.809	3.092

	S	L	S × L	L × S

SEM±	0.0002	0.0036	0.0072	0.0062
$CD_{0.05}$	0.0007	0.0105	0.0210	0.0182

Observation on variation of pressure along a lateral is highest in lateral connection L_1 (8.15%) and the values decreased in L_3, L_2, L_4 and L_5 type of lateral connections in sequence irrespective of the sub-main sizes. The highest variation in L_1 (8.15%) is decreased to 2.68% when the lateral connection is converted to L_2. The percent variation of pressure still decreased when laterals are connected on both sides of the sub-main (L_3) irrespective of the sub-main sizes. The lateral connections L_4 (0.91%) and L_5 (0.81%) exhibit at par value of variation in pressure along the laterals and L_5 is found to be the lowest.

When comparison is made between sub-main sizes, the pressure variations along the laterals were observed to be more or less same. The pressure variation along the laterals with different sub-main pipe connections are observed to differ significantly.

CONCLUSIONS

From the experiment it is concluded that performance of the system (in terms of pressure head loss) 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 can be improved, i.e. head loss 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 head loss and maximum value of mean pressure in the lateral. 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, pressure head loss is low and value of mean pressure is more and is 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.

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