Friction losses in Low-Head in Low Head Drip Irrigation system For Small Plot holders

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Abstract—The micro irrigation in general and drip irrigation in particular has received considerable attention from policy makers, researchers, economists etc. for its perceived ability to contribute significantly to groundwater resources development, agricultural productivity, economic growth, and environmental sustainability. Also the land holding sizes in developing countries like India has been declining under continuous population pressure and average holding size is less than 2 ha. In this paper, the comparative study of Low head drip irrigation system which worked on gravitational force and conventional Basin Irrigation has been studied. This low head drip method of irrigation has been found to have a significant impact on resources saving, cost of cultivation, yield of crops and farm profitability.

Hence, the policy should be focused on promotion of Low head drip irrigation in those regions where scarcity of water, electricity and labour is alarming. On this theme the work was initiated in Maharashtra considering the small and marginal land holdings, design and development of low head farmers friendly drip irrigation set was attempted, in the Village Antarwala at Jalna district of Marathwada region where people have to survive in drought condition during the summer and in load shedding near about 9 hours per day and all the frictional losses and other parameters were compared by matlab results.

Index Terms: Low head Grvity fed Drip Irrigation, Basin Irrigation, Pressure head, crop yield, Frictional losses.

I. INTRODUCTION

Water is becoming increasingly scarce worldwide and more than one-third of the world population would face absolute water scarcity by the future. The worst affected areas would be the semi-arid regions of Asia, the Middle-East and sub-Saharan Africa, all of which are already having a heavy concentration of population living below poverty line. The situation in India is also critical, where absolute water scarcity is already affecting a substantial part of the population and this proportion is increasing rapidly .Much of the water scarcity in India is due to spatial variation in demand and supply of water. Developing infrastructure for the water resources and their management have been the common policy agenda in many developing economies, particularly in the arid and semi-arid tropical countries like India. A study by the International Water Management Institute (IWMI) has shown that around 50 per cent of the increase in demand for water by the year 2025 can be met by increasing the effectiveness of irrigation.[6]

The yield of crop does not increase indefinitely with increasing amount of irrigation water. The water given in excess goes waste as deep percolation below the root zone of the crop and causes not only the water logging conditions in certain areas but also it takes along with it the valuable soil nutrients that are in the root zone . Thus it may be seen that, the only optimum quantity of irrigation water is necessary for a higher yield. In view of the present high cost of drip irrigation system, there is an urgent need to develop cost effective micro-drip irrigation system, matching with the limited water and protected land for growing second crop to combat household food insecurity in the region. Low head drip system operates under pressure of 0.5-2.0 m water head compared to 10-15 m water head needed for standard drip irrigation.[2]

II. METHODOLOGY

The Half hector farming area was Irrigated with Low head drip system which contains an infield water storage tank and half hector farming area was Irrigated with Basin Irrigation method for the crop Tomato. The impact of this Low head drip irrigation has been studied on farming system in terms of water resources use and crop yield. An area of about 1 Ha was taken for research work. From the field data like Infiltration rate was 5.5 mm/hr, Evapotranspiration rate was 7mm/day, Effective root zone depth 0.04 m, Field Capacity was 27%,Bulk Density of soil was 1.36 g/cm, Critical Point for Drip Irrigation 85%,Application Efficiency 90%, Lateral Spacing was 1.2 m, Emmitter Spacing 0.5 m, Permanent wilting Point 17%. [11]

The various parameters of drip irrigation design were worked out based on above mentioned data. Drip Irrigation ystem was design for the farm according to that Net depth of water to be applied in one irrigation was 8.16mm, Gross depth of water to be applied in one irrigation 9.066mm, Irrigation interval was 1 day, Volume of water per plant for Tomato 1.68 lit/day, Total no. of plants for Drip Irrigation was 8332 and therefore volume of water required daily was 13.997m^3/day.[9]

Various PVC materials like PVC pipe, LDPE pipes and HDPE tank were used to fabricate the unit micro drip irrigation set in the farmer's field. The unit consisted of an adjustable platform, 50 mm PVC pipe, 40 mm for main pipe and sub-main, control valve, filter and 12 mm LDPE pipes for laterals. A 1000 liter syntax plastic tank was installed at a height of 2.2 m to create pressure head for flow through pipes and emitters through the gravity. The syntax tank was connected to 50 mm PVC pipe as main with inline filter and control valve, with the help of 50mm-40mm reducer, mainline was connected to sub-main and by means of 40mm -12mm reducer tee, sub-main was connected to laterals.

It was planned that, the total area of drip irrigation i.e. half hectare is divided into eight sub-plots and 625 m^2 areas will be irrigated in 2.10 hour in one day. Therefore 2500 m^2 area was irrigated with 8.4 hours in one day and remaining 2500 m^2 area was irrigated with 8.4 hours on next day because one day irrigation cycle interval.

III. HYDRAULIC CHARACTERISTICS OF WATER

A. Frictional Head losses in different components:

Table 1: Frictional head losses Hf in the different sections of the Lateral

Lateral length m	Length of section	Velocity m/s	Reynolds's Number Re	Friction Factor F	Hf cm	Cumulative Hf	Discharge Q in m^3/s
0	2.5	0.18	1783.9	0.036	1.466	1.466	1.43E-05
2.5	2.5	0.16	1603.2	0.04	1.327	2.793	1.28E-05
5	2.5	0.14	1422.9	0.045	1.189	3.982	1.14E-05
7.5	2.5	0.12	1243	0.051	1.05	5.032	9.96E-06
10	2.5	0.1	1063.6	0.06	0.913	5.945	8.52E-06
12.5	2.5	0.09	884.73	0.072	0.775	6.72	7.09E-06
15	2.5	0.07	706.4	0.091	0.638	7.358	5.66E-06
17.5	2.5	0.05	528.67	0.121	0.502	7.86	4.24E-06
20	2.5	0.03	351.63	0.182	0.365	8.225	2.82E-06
22.5	2.5	0.02	175.4	0.365	0.23	8.455	1.41E-06
25	2.5	0	34.674	1.846	0.122	8.577	2.78E-07

Table 2: Frictional head losses Hf in the different sections of the Sub-Main Pipe

Sub main length m	Length of section	Velocity m/s	Reynolds's Number Re	Friction Factor f	Hf cm	Cumulative Hf cm	Discharge Q in m^3/s	Discharge Q in m^3/s
0	5	0.53623	19840.359	0.003	0.638845	0.63884	5.766E-04	5.766E-04
5	5	0.48235	17846.914	0.004	0.574657	1.21350	5.186E-04	5.186E-04
10	5	0.42852	15855.099	0.004	0.510522	1.72402	4.607E-04	4.607E-04
15	5	0.37473	13865.009	0.005	0.446443	2.17046	4.029E-04	4.029E-04
20	5	0.32099	11876.762	0.005	0.382423	2.55289	3.451E-04	3.451E-04
25	5	0.26731	9890.503	0.006	0.318467	2.87135	2.874E-04	2.874E-04
30	5	0.21369	7906.425	0.008	0.254581	3.12593	2.298E-04	2.298E-04
35	5	0.16013	5924.794	0.011	0.190774	3.31671	1.722E-04	1.722E-04
40	5	0.10665	3946.024	0.016	0.127059	3.44377	1.147E-04	1.147E-04
45	5	0.05327	1970.899	0.032	0.063461	3.50723	5.727E-05	5.727E-05
50	5	0.01329	491.778	0.130	0.015835	3.52306	1.429E-05	1.429E-05

Table 3: Frictional head losses Hf in the different sections of the Main pipe

Main length m	Length of section	Velocity m/s	Reynolds's Number Re	Friction Factor f	Hf cm	Cumulative Hf cm	Discharge Q in m^3/s	Discharge Q in m^3/s
0	2.6	0.350362	16116.662	0.004	0.140429	0.1404	5.823E-04	5.823E-04
2.6	2.6	0.350018	16100.813	0.004	0.140291	0.2807	5.817E-04	5.817E-04
5.2	2.6	0.349673	16084.972	0.004	0.140153	0.4209	5.811E-04	5.811E-04
7.8	2.6	0.349329	16069.140	0.004	0.140015	0.5609	5.806E-04	5.806E-04
10.4	2.6	0.348985	16053.316	0.004	0.139877	0.7008	5.800E-04	5.800E-04
13	2.6	0.348641	16037.501	0.004	0.139739	0.8405	5.794E-04	5.794E-04
15.6	2.6	0.348298	16021.694	0.004	0.139601	0.9801	5.788E-04	5.788E-04
18.2	2.6	0.347954	16005.895	0.004	0.139464	1.1196	5.783E-04	5.783E-04

20.8	2.6	0.347611	15990.105	0.004	0.139326	1.2589	5.777E-04	5.777E-04
23.4	2.6	0.347268	15974.323	0.004	0.139188	1.3981	5.771E-04	5.771E-04
26	2.6	0.346925	15958.550	0.004	0.139051	1.5371	5.766E-04	5.766E-04

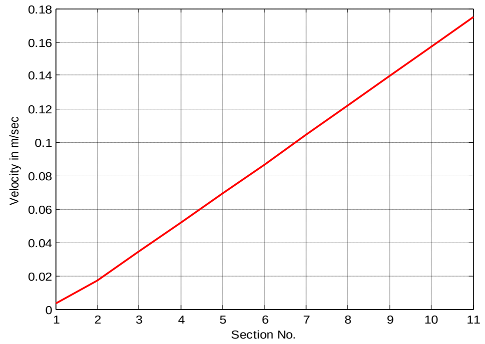

Figure 14: Lateral length of section versus Velocity

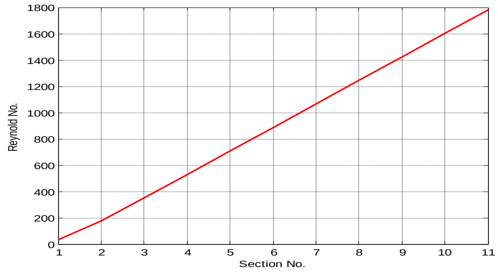

Figure 15: Lateral length of section versus Reynolds's Number

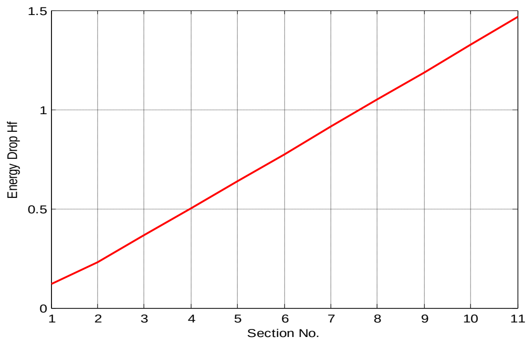

Figure 16: Lateral length of section versus Energy Drop

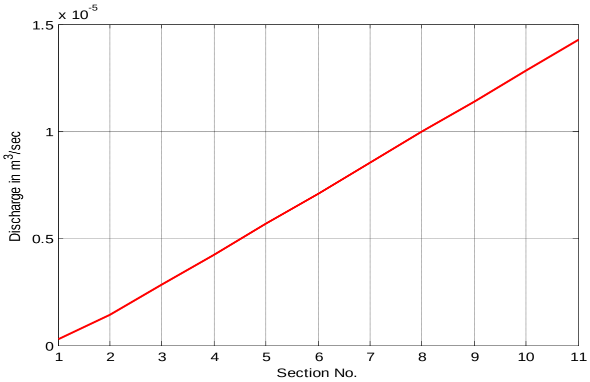

Figure 13: Lateral length of section versus Discharge

B.Pressure-Head Relationship

An effort was made to study the effect of variation in water heads on the pressure of main pipe, sub-main pipe & laterals at its various sections. At the various interval i.e. 2.6m interval for main pipe of 10 nos.; 5m interval for sub-main pipe of 10 nos.; 2.5m interval for lateral of 10 nos. pressure were observed as figure 1,2,3. The relationship between various operating water heads from 2.2m to 3.2m and the corresponding pressures at various main pipe, sub-main pipe & lateral sections was developed graphically and analytically.

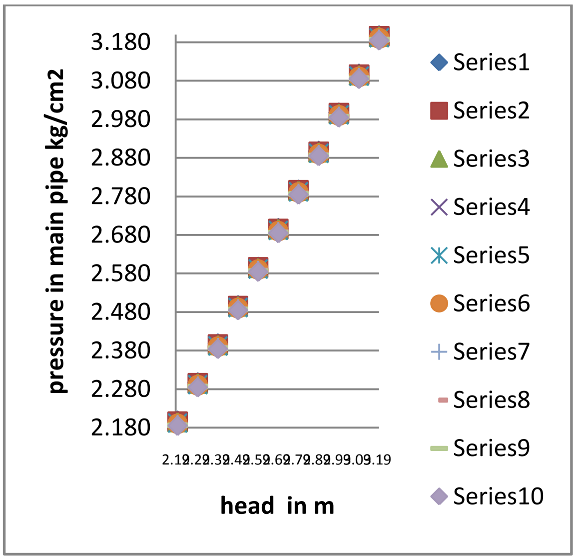

Fig1: Head versus Pressure Co-relative Graph of Main pipe

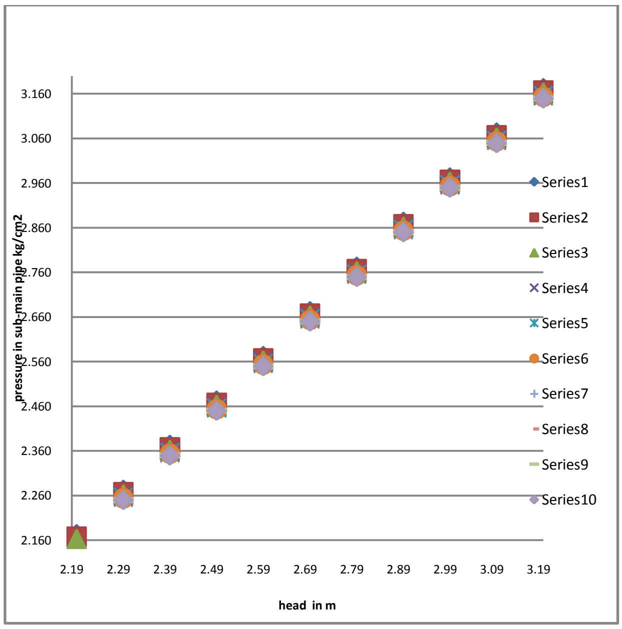

Fig 2: Head versus Pressure Co-relative Graph of sub Main pipe

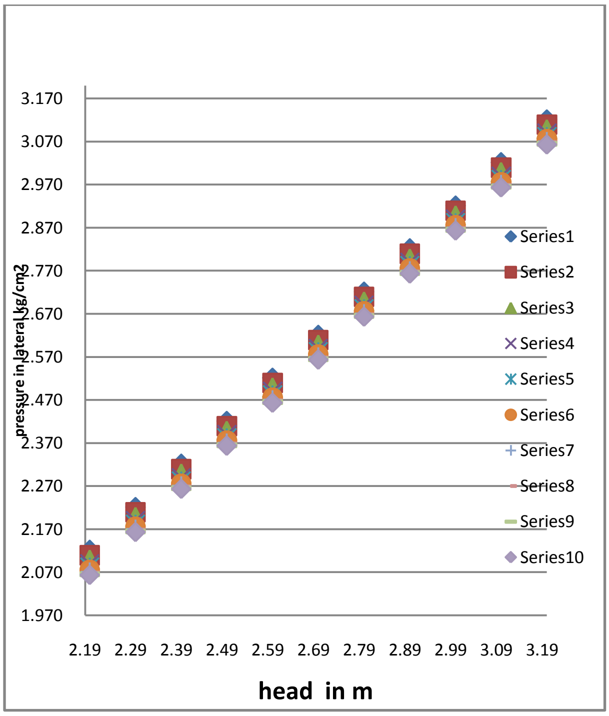

Fig 3: Head versus Pressure Co-relative Graph of Lateral

IV. TECHNO-ECONOMICS OF MICRO DRIP IRRIGATION SYSTEM

In order to decide the feasibility and installation of MDIS, systematic economic analysis of developed drip irrigation set as well as traditional basin irrigation was done. All the costs were included and overall benefit cost ratio was analyzed. The quality and current market price of production was taken in to account.

Drip irrigation set was fabricated using various PVC materials, PVC tank and LDPE pipes.. A 1000 liter syntax plastic tank was installed at a height of 2.2 m to create pressure head for flow through pipes and emitters. It was planned that, the total area of drip irrigation i.e. half hectare is divided into eight sub-plots and 625 m^2 areas will be irrigated in 2.10 hour in one day. Therefore 2500 m^2 area was irrigated with 8.4 hours in one day and remaining 2500 m^2 area was irrigated with 8.4 hours on next day because one day irrigation interval.

The layout of the field is shown below

V. CONCLUSION

The calculation frictional head losses has more importance in deciding the total discharge and can be calculated by more precise programme like Matlab/c+ . Land slope pronounced effect on water distribution uniformity as compared to either head or lateral length. In the present research work, coefficient of uniformity and emission uniformity were found to be more than 97 and 87 per cent respectively. This is quite satisfactory under farmer's condition. The effective length of laterals under the present layout was found to be 25 m, thereafter the discharge of emitters reduced drastically. The techno-economic feasibility system was found in labour cost, saving water, saving fertilizer and higher B/C ratio over the conventional irrigation method. The program in Matlab/c+ was developed for computation of head loses in low cost drip irrigation set and was found to be more advantageous in determining graphs.

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