Evaluation of On-Farm Drip Irrigation Systems Design in Bengaluru Rural District, Karnataka - A Case Study

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A B S T R A C T

K e y w o r d s Frictional head loss, Horsepower, Pipelines, Pressure drop **Article Info** *Accepted:* 16 August 2018 *Available Online:* 10 September 2018	The study was undertaken in Bengaluru rural district during 2017-18 to evaluate the design of the inline drip irrigation systems in farmers' fields. There are 15 farmers' fields selected for the evaluation. Detailed information of farmers' was collected from Karnataka state Department of Horticulture. The objective of this study is to evaluate the design of drip irrigation systems. The design of the installed irrigation system is evaluated for the suitability of pump, head loss, horse power, discharge and pressure at 1.00 Kg/cm^2 operating pressure. To estimate the friction head loss of drip systems, the Darcy-Weishbach equation for smooth pipes in drip irrigation can be combined with the Blassius equation is used. The informations on existing HP in the fields were collected from individual farmers. Finally, the calculated horsepower and the existing horsepower are compared to know the suitability of power to operate the irrigation system. The results of design evaluation showed that 10 fields having a good operating system and the 5 fields are not capable to operate the system, which results in poor performance of the system.

Introduction

Water is one of the important and primary inputs in agricultural production. Agriculture consumes about 70 - 80 per cent of available water in the world (Duhrkoop *et al.,* 2009). However, the scarcity of water availability has necessitated for improvement in efficient irrigation methods in agriculture.

The increase in demand for water in different areas such as industrial, agricultural and domestic purposes cause the needs for improving the new water use efficiency techniques for cultivation of crops. As the conventional methods of irrigation have less water use efficiency, it is important to adopt alternative water application methods such as micro-irrigation techniques which include sprinkler and drip irrigation methods.

The application efficiency of the conventional methods is very low and it is less than 50 percent. The excess application of water creates a problem of water loss by surface runoff and also results in deep percolation losses.

The improved water application method such as the drip irrigation allows précised uniform distribution of water and also decreases nutrient leaching (Phene *et al.,* 1994).

Properly designed and installed Drip irrigation system results in reduced water loss and cost of the system. Also the best-designed drip irrigation system needs proper maintenance and periodic evaluation (Dasberg and Bresler, 1985). The evaluation procedure consists of periodic measurements of pressure losses through the filters and measurement of discharge rate and pressure at several locations.

Materials and Methods

The present study was carried out during 2017-18 in the farmer's field of different villages of Nelamangala, Devanahalli, Doddaballapura and Hosakote taluks of Bengaluru rural district. The detail of farmers is collected from the State Government, Department of Horticulture pertaining to different taluks of Bengaluru rural district. The information of different farmers of Bengaluru rural districts who have installed drip irrigation system is collected from Karnataka state Department of Horticulture. The questionnaire for interview and evaluation was prepared to get the details of the farmer's field. The schedule includes the general information of farmers, water source, pump, drip irrigation system, dripper discharge and lateral pressure.

Proper design is very important for successful operation of the drip irrigation system. The design of the drip irrigation system is developed by considering certain factors including agro-climatic conditions, crop physiology, soil characteristics, water source and other engineering factors. Evaluation of such design parameters is cross-checked for the different drip installations for its suitability of pump, head loss, horsepower, discharge and pressure.

The observations of emitter discharge and submain discharge were calculated to find the required HP of the system. To calculate the required HP, the frictional head loss in the laterals, submains and mains has to be observed. To estimate the friction head loss of drip irrigation laterals, the Darcy-Weishbach equation for smooth pipes in drip irrigation is combined with the Blassius equation as follows.

$$H_{fl} = K \times L \times Q^{1.75} \times D^{-4.75} \times F \ (1)$$

Where,

H_{fl} = Frictional loss in lateral pipes

K = A constant whose value is $7.89 * 10^5$ for SI unit of water at 20^0C

L = length of the pipe in, m

Q = rate of flow in pipe, l/sec

D = diameter of the pipe, mm

F = factor of the multiple outletsflows.

The value of F is 0.376 and 0.389 for laterals and sub-main respectively. The value of F is 1 for mainline as the main is having only a few outlets for sub main connections. Christiansen's formula (1942) is used to calculate the F values.

The system design is divided in sequence as main, submain and lateral. There could be one or few submains and each submain has got few laterals. The drippers are positioned on the laterals to irrigate the fields. The rate of discharge of each emitter and the total number of emitters of all the drippers on the laterals must have sufficient discharge capacity to accommodate flow from the main and submain. For the number of submain and lateral, there should be enough pressure for the flow to meet the expected discharge from individual drippers. Any mismatching of a

number of submain, lateral and emitter capacity will results in poor discharge or damage to the system. Therefore effective functioning of the drip irrigation system mainly depends on the designed discharge

The equation (1) can also be used to calculate the head loss due to friction in submain and mains. This head loss may vary from laterals due to varied length, diameter and discharge as suggested by Giuseppe *et al.,* (2005). Generally, the discharge of both the main and submain are uniform and equal to the value of the pump discharge.

The main and submain friction head loss is denoted as H_{fm} and H_{fs} respectively. By using the digital Vernier callipers and measuring tape, the diameter and length of the laterals, submain and main are measured in the farmer's field.

In all the fields, the frictional loss due to filters bends, etc. is taken as 1.5m for the complete drip irrigation system. The pressure drop due to filters is specified as 0.3 to 0.5m. (Hema Krishna, 2009). Then the total head requirement of the system is calculated by using Darcy-Weishbach equation as

H_{sys}= Head require for operation + friction loss + filter loss + bend losses

$$H_{sys} = H_o + H_{fl} + H_{fs} + H_{fm} + H \ (2)$$

Where,

H_{sys} = Total head requirement of the system, m

H_o = Head required to operate the System, m

H_{fl} = Total head loss in the lateral, m

H_{fs} = Total head loss in the Sub-Main, m

H_{fm} = Total head loss in the Main, m

H = Head loss due to Bends and Filters, m

The friction losses in the suction pipes are taken as 6m per 100m pipe as a proposal by Al-Ghobari (2005)

Therefore the head required for the pump is

$$H_{Total} = H_{sys} + H_s + H_{fs} + H_d + H_v + H_{fd} \ (3)$$

Where,
(Darcy-Weishbach equation)

H_{sys} = Total head requirement of the system, m

H_s = Total suction Head, m

H_{fs} = Friction loss in Suction Pipe, m

H_d = Delivery head, m

H_v = Velocity head, m

Then, the size of the pumping unit can be calculated using the equation

$$H.P = \frac{Q \times H}{75 \times \eta_p \times \eta_m} \ (4)$$

Where,

H.P = Horsepower of the pump

Q = Capacity of the drip irrigation system, l/sec

H = Total head requirement of the pump, m

η_p = Efficiency of the pump, fraction

η_m = Efficiency of the motor, fraction

The efficiency of the pump and motor is assumed as 90 per cent as all the pumps used are centrifugal monoblock directly coupled to the motor drive.

Results and Discussion

There are 15 drip irrigating farm fields of different farmers who are considered for the studies. The drip irrigation system of different farmer's field area ranges from 0.65 to 3acre. The power required to operate the drip irrigation system is estimated by considering the various losses in the system. The estimated horsepower and the existing horsepower are compared to know the suitability of power to operate the irrigation system. The irrigation system operation is measured and compared with the estimated power requirement. Also the head losses in the different section of the drip irrigation system for the selected field is worked out.

The drip irrigation system comprises of main pipeline, sub-pipeline and laterals. The diameter of the main pipeline used in the design of drip irrigation system is observed to be 63 mm size. The submain pipeline diameter is observed to be in between 40 mm and 50 mm. Similarly, the laterals used in all the fields are with 16 mm diameter with an emitter capacity of 4 lph. Also the drippers are spaced at 40 cm on laterals.

The power requirement of the drip irrigation system is estimated for 15 farmer's field. Among the different fields, there are 10 farmer's field having a water source as bore well and the remaining 5 farmers having a water source as a farm pond (Table 1).

Table.1 Diameter and lengths of laterals, sub-mains and mains of the drip irrigation systems

Sl. No.	Field No.	Area (acre)	Depth of water source (m)	Emitter Capacity Q (lph)	Diameter (mm)			Length (m)		
					Main	Sub main	Lateral	Main	Sub main	Lateral
1	F$_1$	3.03	92.0	4	63	50	16	215	298	2440
2	F$_2$	1.15	275	4	63	50	16	452	100	1530
3	F$_3$	2.55	244	4	63	40	16	569	227	1440
4	F$_4$	1.05	77.0	4	63	40	16	365	70	1500
5	F$_5$	2.07	274	4	63	50	16	2200	240	1056
6	F$_6$	2.46	77.0	4	63	40	16	240	246	2120
7	F$_7$	0.65	305	4	63	40	16	69	46	633
8	F$_8$	1.23	198	4	63	50	16	385	164	1290
9	F$_9$	2.00	168	4	63	50	16	192	200	1640
10	F$_{10}$	3.28	183	4	63	50	16	165	150	1485
11	F$_{11}$	1.20	3.00	4	63	50	16	95	92	1560
12	F$_{12}$	1.75	10.0	4	63	40	16	100	200	1428
13	F$_{13}$	2.05	3.35	4	63	40	16	152	300	836
14	F$_{14}$	1.25	3.00	4	63	40	16	154	164	810
15	F$_{15}$	1.08	3.00	4	63	50	16	138	144	720

Table.2 Power requirement of the drip irrigation system for bore well as water source

Sl. No.	Field No.	Area (acre)	Existing HP / Stages	Frictional head (m)						Calculated HP
				H_{fm}	H_{fs}	H_{fl}	H_{sys}	H_{suc}	H_{total}	
1	F1	3.03	10 / 17	2.40	2.18	16.57	18.20	92	115.78	8.60
2	F2	1.15	25 / 48	5.76	1.62	6.27	19.51	275	311.04	22.45
3	F3	2.55	22 / 42	7.72	3.29	10.01	23.24	244	281.93	21.79
4	F4	1.05	7.5 / 15	4.21	1.52	13.38	17.12	77	98.76	6.40
5	F5	2.07	17.5 / 32	10.7	1.51	1.48	24.24	274	314.74	26.39
6	F6	2.46	7.5 / 14	2.86	4.22	4.32	19.14	77	100.78	5.97
7	F7	0.65	20 / 40	1.46	1.6	14.07	15.92	305	339.25	23.79
8	F8	1.23	15 / 26	4.59	1.085	9.26	17.83	198	227.74	16.76
9	F9	2.00	12 / 20	1.99	1.33	7.93	15.45	168	193.56	13.12
10	F10	3.28	15 / 30	1.84	0.94	7.18	14.94	183	208.96	14.57

Table.3 Power requirement of the drip irrigation system for farm pond as water source

Sl. No.	Field No.	Area (acre)	Existing HP	Frictional head (m)						Calculated HP
				H_{fm}	H_{fs}	H_{fl}	H_{sys}	H_{suc}	H_{total}	
1	F11	1.20	5	2.62	2.60	18.5	17.76	3	21.01	2.70
2	F12	1.75	5	2.65	15.60	16.03	49.33	10	59.98	3.93
3	F13	2.05	2	1.90	2.20	5.18		3.35	19.96	1.93
4	F14	1.25	5	3.90	7.03	13.09	23.46	3	27.27	7.21
5	F15	1.08	3	1.43	0.81	12.71	26.95	3	30.14	4.71

The results of Table 2 shows that among the 10 farmer fields having a bore well, 6 fields (F1, F2, F3, F4, F6 and F10) having the sufficient pump size to operate the drip irrigation system. Observation of the 2 field (F8 and F9) showed that the calculated pump size is slightly more than existing pump size.

However, with some modifications in the field, the system can be operated efficiently. Observation of the 2 farmer's field (F5 and F7) indicated that the calculated pump size is higher than the existing pump size. Therefore the pump is not sufficient to operate the drip irrigation system effectively. Poorly designed system results in the overall poor performance with low-pressure head, large variation in operating pressure between the lateral inlet and end plug position of the lateral. Therefore the design is inadequate to operate the drip irrigation system.

The results of Table 3 show that there are 5 farmer field having a farm pond as a water source. The 3 different fields (F11, F12 and F13) having the sufficient pump size to operate the drip irrigation system. But in F14 and F15 farmer field, the existing pump size is not sufficient to operate the drip irrigation system.

The study was carried out to evaluate the design of the inline drip irrigation systems in

the farmers' fields. The design was evaluated in the farmer's field by calculating the different frictional losses in the drip irrigation systems at 1.00 Kg/cm^2 operating pressure. The overall results of the study revealed that only 60 per cent of the farmers' fields having good operating systems. Therefore, there is a need to redesign for the best operating system.

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