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Optimization of gravity-fed surface drip irrigation system for small farm under varying head and length of laterals

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Abstract

Gravity fed drip irrigation system is low-cost irrigation system which directly supply water from overhead tank which is kept at some specific height. Gravity provides the pressure needed for the system. The water source is situated above 10 m from ground level. With the process of siphoning, water is directly supplied from the water source from higher elevation to lower elevation. A small area of 10 x 12 m2 is chosen for the purpose of the project. Optimization of low head gravity fed drip irrigation system under variable operational head of 1 m, 1.5 m, 2 m along with varying length of laterals i.e. 8 m, 9 m, 10 m, 12 m. A constant height of 1 m, 1.5 m, 2 m is maintained by continuous flow water from the water source in such a way that inflow of water is more than outflow from a given head. The drip line is identified as L1, L2, L3, L4 emitter position on each dripline is identified as A, B, C. The average emitter charge was observed to be maximum under operating of 2 m with 8 m length of lateral and was minimum when head decreased to 1 m and length of lateral was 12 m with 4 number of laterals. At 2 m head laterals of 8 m, 9 m, 10 m length provides reasonably good uniformity of water through low head gravity fed drip irrigation with UC> 65%. It can be concluded from the experiment that uniformity coefficient under 1 m head observed to be low i.e. 44.57% and high at 2 m head i.e.68%.

Keywords: Gravity fed drip irrigation system, uniformity coefficient, optimization, average emitter discharge

Introduction

Drip irrigation is the latest irrigation technology; is also known as trickle irrigation. In this method, the daily required of water is applied to crop root zone, in the form of water droplets, as a result the loss of water due to evaporation, seepage, deep percolation, etc. gets minimized to a large extent. n Chhattisgarh, farmers usually have small bari/ kitchen garden in small area around 0.3 decibel to 0.5 ha, where farmers usually grow fruits & vegetables to meet their family needs. There was no test initiated for the Mungeli soil and climate which are favorable for growing fruits and vegetables, oil seeds and pulse crops at BRSM CAET & RS campus. A mango orchard in Chatarkhar of about 1 ha length is available on the right side of the college building, which has 28 varieties of mango plants (45 years old). So far, surface irrigation was being done in the orchard. Near Mungeli, many farmers have small orchard/ kitchen garden close to the house. Keeping this in view, we are working on "Optimization of Low Head Gravity fed surface drip irrigation system in mango orchard under varying head and length of laterals". So that the farmers can grow fruits & vegetables easily. Mungeli is located at an elevation of 281.8 meters (924.54 feet) above Mean Sea Level (MSL), Mungeli has a Tropical wet and dry or savanna climate (Classification: Aw). The district's yearly temperature is 30.13 ℃ (86.23ºF) and it is 4.16% higher than India's averages. Mungeli typically receives about 38.29 millimeters (1.51 inches) of precipitation and has 34.19 rainy days (9.37% of the time) annually.

Components & Methodology Study area

The work was carried out in the village of Chatarkhar, Block District Mungeli at college campus (BRSM CAET & RS). The distance of research field is about 11 m from BRSM CAET & RS. Study area was located at latitude of 22°03'59" N and longitude of 81°38'32" E. The experiment was conducted on mango orchard. The soil in the site of the experiment is black cotton soil.

Data collection

The tiny research area of 12 x 10 m2 was used for this investigation. Three emitter discharge points that were mounted on drip lines were the subject of the evaluation. The emitter positions on each dripline are designated as A, B, and C as shown in fig 1. Driplines are marked as L1, L2, L3, and L4. As a result, L1A, L1B, and L1C were determined to be the discharge points; this also applied to L2A to L2C and L4A to L4C. The water in the overhead tank is collected with the help of siphoning from higher elevation to lower elevation from water source situated above 10 m from the ground level. A 2 L container of specified size was utilized. A stopwatch was utilized to gather the water flow from each discharge point and it is also used to determine the drippers' chosen discharge rate. For analysis, the discharge rate was determined and noted at specific locations along each drip line. A constant height of 1 m, 1.5 m, 2 m is maintained by continuous flow water from the water source in such a way that inflow of water is more than outflow from a given head as shown in fig 2. The average value of the three sets of each data point was recorded as the data.

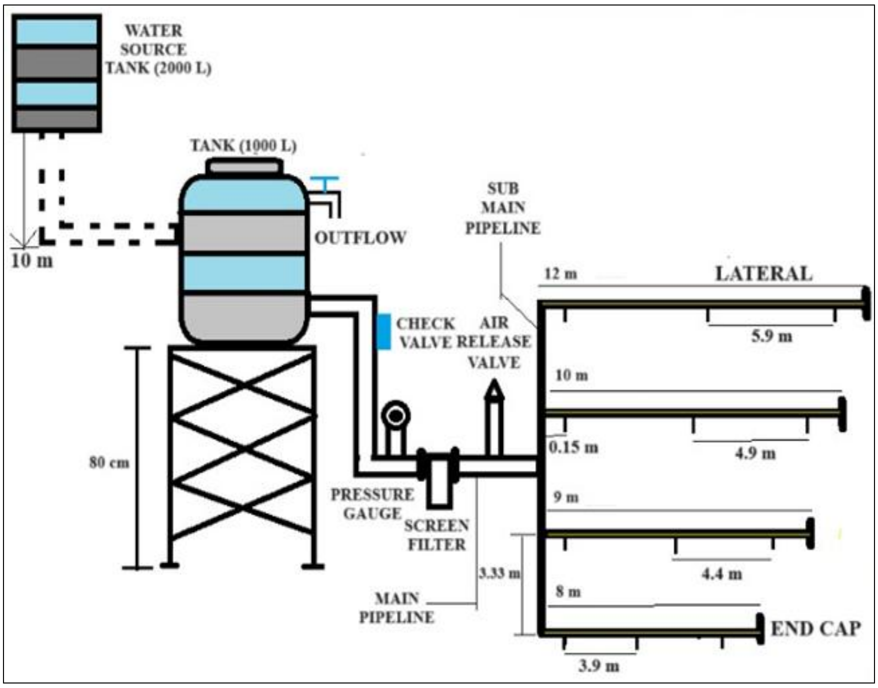

Fig 1: Components & layout of Gravity fed Drip Irrigation System

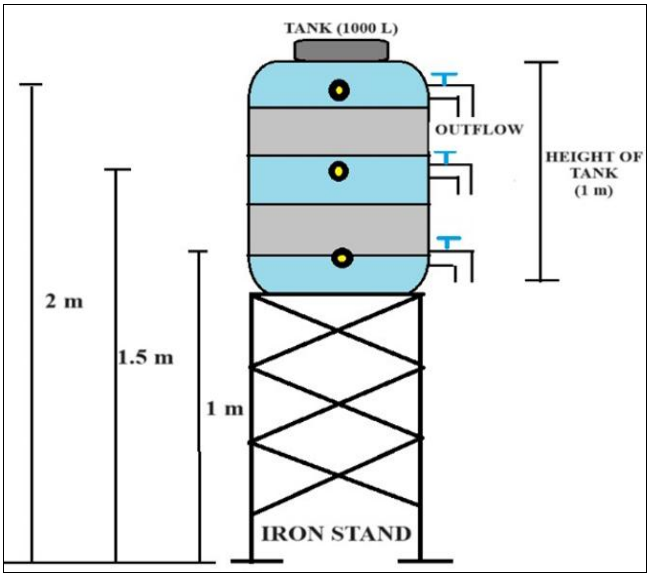

Fig 2. Maintenance of water level at different heights

Parameter used to evaluate drip emitter discharge

1. Average Emitter Discharge Rate (qa)

The average emitter discharge rate (q) is the total amount of water emitted by all of the drippers in a given amount of time.

Equation yields it as:

$$q_a = \frac{1}{n} \sum_{i=1}^{n} q_i$$

where;

qi = flow rate of the emitter *i* (m3/s) or (l/h)

n = Total number of emitters

2. Uniformity Coefficient (UC)

Uniformity coefficient is defined as the factor which determines how uniformly the water is distributed in a given area. The equation is considered as:

$$UC = 100 \left[1 - \frac{1}{n\, q_a} \sum_{i=1}^{n} |q_i - q_a|\right]$$

where;

UC = Uniformity Coefficient (%)

n = number of emitters under consideration qa = mean flowrate of the emitter (l/h)

qi = flowrate of the emitter i (l/h)

Results and Discussion

Table 1: Classification of Uniformity Coefficient

Uniformity Coefficient, UC (%)	Classification
Above 90	Excellent
90-80	Good
80-70	Fair
70-60	Nearly Fair
60-50	Unacceptable

Table 2: Average emitter discharge obtained after 2 hours operation

Head (m)	Length of Lateral (m)	Average Emitter Discharge from 3 discharge points for 2 hours (ml)
2	8.00	1018.88
	9.00	1010.00
	10.00	977.78
	12.00	957.78
1.5	8.00	810.00
	9.00	797.77
	10.00	795.55
	12.00	788.89
1	8.00	771.00
	9.00	753.33
	10.00	752.22
	12.00	751.11

When the head varies from 2 m to 1 m, the discharge also varies accordingly. Here, the number of laterals was kept constant as shown in fig 1. It can be observed from the Table No. 2 that as the length of lateral is increased the average emitter discharge also decreases and vice versa. Similarly, as the discharge head increases the average emitter discharge also increases and vice versa. The average emitter charge was observed to be maximum under operating of 2 m with 8 m length of lateral was minimum when head decreased to 1 m and length of lateral was 12 m with 4 number of laterals. Therefore, in order to obtain maximum discharge, the length of lateral should be kept minimum and the head should be kept at higher elevation. Also, it is observed that to obtain more discharge the head should be equal to or more than 2 m depending on the farm/ kitchen garden/bari size.

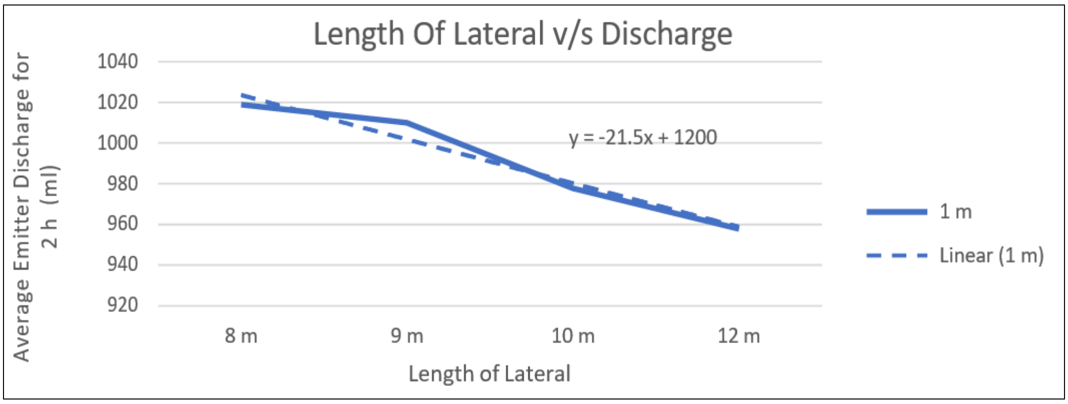

Fig 3: Variation of average emitter discharge and length of laterals at 2 m head

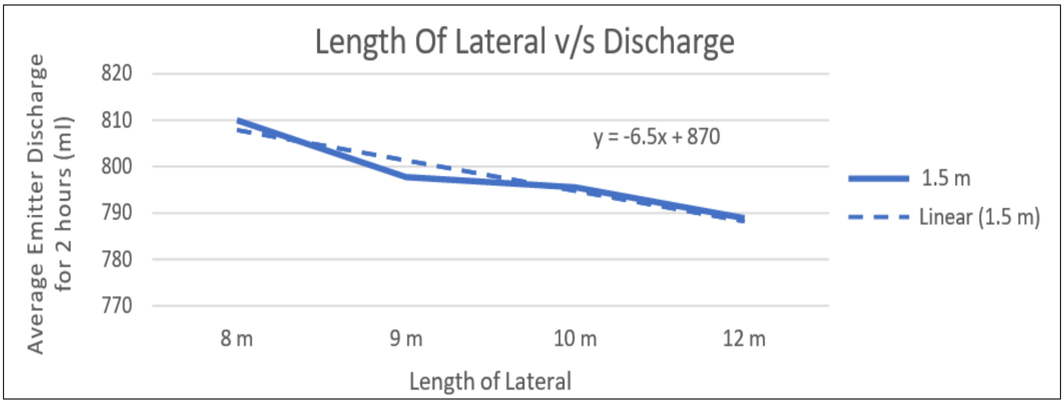

Fig 4: Variation of average emitter discharge and length of laterals at 1.5 m operating head

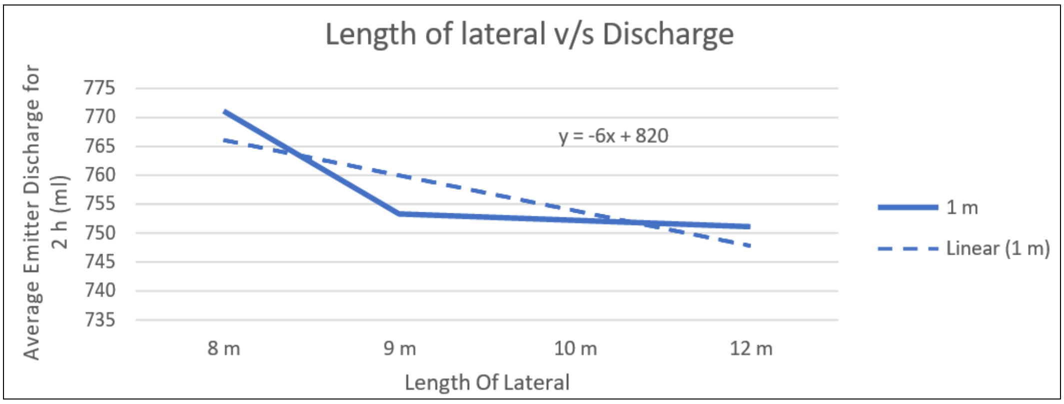

Fig 5: Variation of average emitter discharge and length of laterals at 1 m operating head

From the graph it is observed that there are some deviations which arise because of human error and undulating field. Here are following prediction equations for calculating average emitter discharge which are generated using the graph for head 2 m, 1.5 m, 1 m

Table 3: Equation for predicting average emitter discharge

Head (m)	Equation
2	y = - 21.5x+1200
1.5	y = - 6.5x + 870
1	y = - 6 x+ 820

where,
y = average emitter discharge (ml)
x = length of lateral (m)

Table 3: Uniformity coefficient obtained at varying heads and length of laterals

Head (m)	Lateral	Length of lateral (m)	Uniformity Coefficient (%)
2	L1	8	68.00
	L2	9	67.33
	L3	10	65.15
	L4	12	63.00
1.5	L1	8	51.00
	L2	9	49.76
	L3	10	49.53
	L4	12	48.82
1	L1	8	46.87
	L2	9	44.81
	L3	10	44.70
	L4	12	44.57

From table 3 it was observed that, uniformity coefficient of the system increases with increase in head and vice versa. Similarly, the uniformity coefficient decreases as the in length of lateral is increased and vice-versa. At 2 m head, 8 m, 9 m & 10 m length of laterals seem to provide fair uniformity of water application with UC>65% having 4 number of laterals. So, to achieve maximum uniformity the head should be kept equal to more than 2 m depending on the farm/ kitchen garden/ bari size.

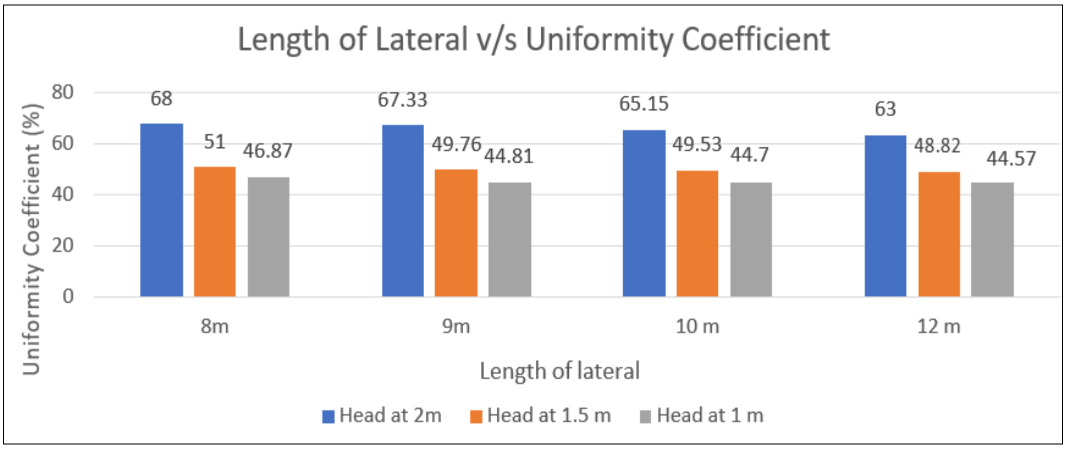

Fig 6: Variation of uniformity coefficient with length of laterals

Summary and Conclusion

1. We concluded that the study to test 8 m, 9 m, 10 m & 12 m length of laterals for varying head at 2 m, 1.5 m, 1 m. We observed that 2 m head provides better uniformity than other heads.
2. We took 3 heads (2 m, 1.5 m, 1 m) and observed UC and found at 2 m head maximum uniformity of 68%.
3. We also observed that at 2 m head and 8 m length of lateral, maximum uniformity coefficient is obtained whereas at 1 m head and 12 m length of lateral, the uniformity coefficient obtained is minimum.
4. Hence for lateral length of 8 m, head of 2 m or more is suitable.

Suggestion for future work

1. Further study is required on higher heads and larger length of lateral. So that a generalized equation for gravity fed drip irrigation system can be developed.
2. More study is required to study the frictional head losses and friction factor in different size of PVC pipes and also in the micro tubes serving as emitters.

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