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# Assessment of Number and Discharge Rate of Emitters and Laterals for a Hydraulic Ram Pump Fed Drip Irrigation System for Terrace Cultivation

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**Abstract**—*Lack of assured source of water and electricity in hilly terrain is a major challenge for crop production in higher altitudes. Proper selection of water saving irrigation system is a major hindrance to increase the productivity coupled with maintenance of terraces. The installation and maintenance of conventional pumping systems using diesel or gasoline or other forms of energy such as solar or electrical driven pumps are usually unaffordable for poor, remote communities living in the North East of India. Thus, a field experiment was carried out with a hydraulic ram pump (50 mm × 25.4 mm) and drip irrigation system with number of laterals and emitters to study the feasibility of the system for crop production in prevailing terrace cultivation in a hilly terrain of Assam University, Silchar. The study resulted average waste water discharge of 90.37 Lmin$^{-1}$ at 8 m and which was utilized for feeding drip irrigation system with high uniformity coefficient (98%) for the terrace cultivation. The field experimental trial revealed that the position of water sources of drip irrigation system at 1m vertical drop could feasible for maximum 25 numbers of emitters along the five laterals of crop of spacing (45 cm × 45 cm) in a terrace. However, the number of emitters and laterals could be increased with the increase land available in terrace and increase in vertical drop from the waste valve. The hydraulic ram pump fed drip irrigation system was found feasible for tomato crop production in hilly terraces with better vegetative growth and yield. Therefore, it could be suggested for implementation of hydraulic ram pump fed drip irrigation system with stream/rainwater harvesting in the hill and mountain agro-ecosystem having either inaccessible to electricity or unaffordable for it.*

**Keywords***: Assam, drip irrigation, hilly terrain, hydraulic ram pump, tomato.*

## 1. INTRODUCTION

In hilly terrains, irrigation is a major hindrance to increase the productivity coupled with maintenance of terraces. The traditional flood or ridge and furrow method of irrigating fields suffers from numerous problems such as considerable seepage [4] and [9], conveyance and evaporation loss [7-8] and [12]; higher energy cost; lower water productivity; and irrigation-induced soil erosion [2]. The recent advances in irrigation technology have made inroads in the cultivation of vegetables and horticultural crops or low duty crops in hilly terrain. The frontier technology of drip irrigation system not only provides higher water productivity but also minimizes the problems with the traditional irrigation system [6].The prevailing terrace cultivation in the hilly region provides ample scope for drip irrigation system [1]. This minimizes the fuel based energy or electricity requirement in operation of drip irrigation system which further increases profitability. The on-farm irrigation efficiency of properly designed and managed drip irrigation system is estimated to be about 90%, while the same is only about 35% to 40% for surface method of irrigation [3]. In sprinkler irrigation method (SIM), water saving is relatively low (up to 70 percent) as compared to drip irrigation since SIM supplies water over the entire field of the crop [3], [5]and [10]. Thus, drip irrigation system could be more efficient for Hill and Mountain agro-system [11]. While designing drip irrigation system due consideration is required to be given to hydrological properties which affect the water transmission pattern. By optimizing the numbers of lateral and emitter in designing drip system, investment on the system can be lowered down as it cost 70 per cent of the system.

However, to irrigate such hilly and terraced areas without the use of any outside source of energy which can supply homestead water needs, or garden, orchard, is necessary to find a solution with simple construction, easy to install, which does not consume petrol, diesel or electricity, which can operate for 24 hours per day and maintenance free. Hydraulic ram pump is therefore, one of the best solutions for hilly terrain to address the issue of water, productivity, and energy.

Addressing multitude of socio-economic and physical problems of the hilly region, the present study envisages the scope for utilization of waste water of hydraulic ram pump for appropriate selection of components for drip-irrigation systems and its effect on crop growth and yield parameters of tomato in prevailed terrace land of a hilly terrain.

## 2. MATERIALS AND METHODS

### 2.1. Study Site

One of the hillocks present at the Assam University Campus situated in the southern part of the Indian state of Assam is considered for the study site. The site is situated at latitude N 24˚41´ and longitude E 92º45´ with altitude 31.40 m above the sea level. The slope of the experimental site was found 26.39% where the ram pump was installed. A schematic view of the layout of the experimental site and hydraulic ram pump set up are shown in Fig. 1 and 2, respectively. The details of the specification of the ram pump selected for the experimental study are given in Table 1.

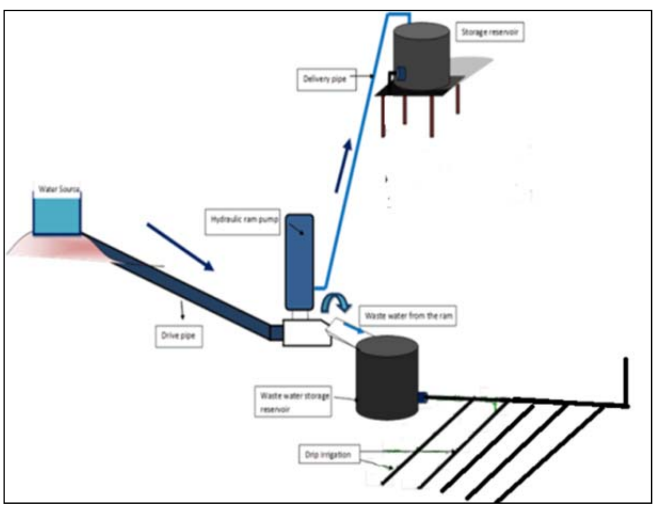


**Fig. 1: Layout for Hydraulic Ram Pump Fed Drip Irrigation System**

**Fig. 2: A View of the Hydraulic Ram Pump Installed In Study Site.**

**Table 1: Specification of the selected hydraulic ram pump**

| Sl no. | Components | Size (mm) |
|---|---|---|
| 1. | Inlet-Drive pipe | 50.8 |
| 2. | Outlet delivery pipe | 25.4 |
| 3. | Waste valve | 71.12 |
| 4. | Air vessel | 110.49 |
| 5. | Air vessel (length) | 1041.4 |

### 2.2. Operation of Hydraulic Ram Pump

Hydraulic ram pump works in the principle of 'water hammer effect' or impulse. When the waste valve is open, water accelerates down the drive pipe and discharges through the open valve. As the flow increases it reaches a speed where the drag force is sufficient to start closing the valve. Once it has begun to move, the valve closes very quickly. As the waste valve slams shut, it stops the flow of water through it. As the pressure rises higher than that in the air chamber, it forces water through the delivery valve. During each pumping cycle only a very small amount of water is pumped. However, with cycle after cycle continuing over 24 hours, a significant amount of water can be lifted. While the ram pump is operating, the water flowing out the waste valve splashes onto the floor or the pump house and is considered 'waste' water which have been considered for feeding of drip irrigation in a hilly terrace cultivation.

### 2.3. Quantification of waste water discharge

In order to quantify the water at the waste valve of the hydraulic ram pump, the pump was operated for six times and the discharge and time was noted. The average reading was considered to be the discharge rate of the waste water at the source.

### 2.4 Feasible emitter and lateral assessment

Based on the layout of the drip irrigation setup, the discharges of each emitter of laterals were measured and compared with the recommended discharge capacity of the emitters. The experiment was started with one emitter in a lateral and increased the emitters and laterals one by one up to maximum number as feasible for the study site. The discharge was measured starting from the first emitter point of lateral 1 for 5 min by keeping all other emitters laterals closed and then measured the 2nd, 3rd and so on. Likewise, discharge for all emitters was measured serially, simultaneously keeping the preceding emitters open and the succeeding ones closed. The measurement trials are replicated thrice.

### 2.5 Cropping experiment and monitoring

Based on the soil and climatic conditions, the tomato crops (Sweet Aperitif F1 Hybrid) were selected for field experiment on hydraulic ram pump fed drip irrigation system. Crop duration of tomato was 90 to 120 days. The tomato plant was transplanted with crop spacing of 0.45m × 0.45m. The daily water requirement of tomato crop is 0.45L/day/plant during early growth stage and 1.15 L/day/plant during the peak growth stage (www.yspuniversity.ac.in). The required irrigation was applied through drip irrigation system. The crop growth parameters such as height of plant, number of leaves and shoot thickness at the time of transplanting to harvesting and yield parameters such as number of fruits per plant; fruit weight in gram; yield per plant in kg were monitor for the agricultural production analysis.

## 3. RESULTS AND DISCUSSION

### 3.1. Variation of waste water discharge

The variation of waste water discharge with constant delivery heads (8m) in each experimental trials are presented Table 2. The waste water was measured using a cylindrical tank of 200 L and a stop watch.

**Table 2: Measured waste water discharge of ram pump**

| Trial No. | Waste Water Flow rate ($Lmin^{-1}$) | Average Flow rate ($Lmin^{-1}$) | Standard Deviation |
|---|---|---|---|
| 1 | 89.27 | 90.37 | 0.637 |
| 2 | 90.42 | | |
| 3 | 90.08 | | |
| 4 | 90.58 | | |
| 5 | 91.09 | | |
| 6 | 90.78 | | |

During the experiment, the maximum waste water delivery discharge at constant delivery head of 8 m and the average waste water delivery discharge were found to be 91.09 $Lmin^{-1}$ and 90.37$Lmin^{-1}$, respectively. It was observed that in order to get the 200L of water at delivery the same amount was found as waste water from the hydraulic ram pump which could be utilized for crop planning in hilly terrace.

### 3.2 Variation of discharge rate of lateral

Discharge rate of each lateral point for five lateral points of main-line from the water source (0.43m above lateral lines) of the irrigation system was measured and presented in Table 3. It was observed that lateral could provide average discharge of 3.47 L/min which could be sufficient for number of emitters.

**Table 3: Replication wise measured discharge for each lateral point and system**

| Lateral no. | Replication wise discharge ($Lmin^{-1}$) | | | | Average system discharge ($Lmin^{-1}$) |
|---|---|---|---|---|---|
| | R1 | R2 | R3 | Average | |
| 1 | 3.48 | 3.50 | 3.49 | 3.49 | 3.47 |
| 2 | 3.52 | 3.51 | 3.50 | 3.51 | |
| 3 | 3.47 | 3.48 | 3.46 | 3.47 | |
| 4 | 3.45 | 3.44 | 3.44 | 3.44 | |
| 5 | 3.44 | 3.45 | 3.45 | 3.45 | |

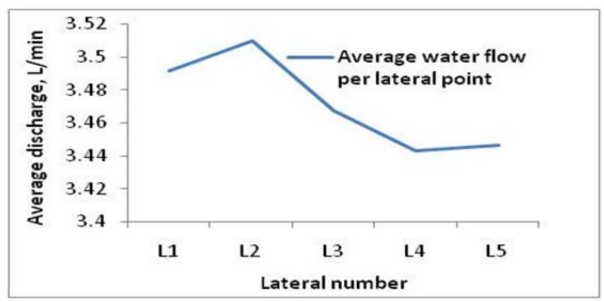


**Fig. 3; Variation of Discharge in Each Lateral Point**

The variations of discharge in laterals are found minimal which can be extended for more length.

### 3.3 Variation of discharge rate of emitters

The variation of discharge in twenty five emitter points of 5 laterals were measured and presented in Table 4.It can be seen from Table 4 that the discharge exhibits decreasing trend from lateral 1 to 5 and emitter point 1 to 25. The discharge obtained from 25th emitter (5th of lateral 5) presents an overall view of the discharge that can be obtained from the network of laterals and emitters that has been considered in the present study.

### 3.4 Response on growth and yield parameters

The lateral wise observed vegetative growth parameters such height of plant, number of leaves per plant, shoot thickness, and yield per plant are presented in Table 4. However, the emitter wise number of fruits and yield per plant are presented in Fig. 4 and 5, respectively. It was observed that the plant at 23rd emitter in Lateral 5 results more vegetative growth, fruits and also yields. So, it could be considered as the more significant emitter at 5th lateral of the drip irrigation system. However, other plants are found slightly lower than the 23rd emitters in 5th lateral. The discharge rate of the 23rd emitter was found 1.0 $Lmin^{-1}$.

**Table 4: Lateral wise measured discharge for each emitters of a drip irrigation system**

| | E | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lateral 1 | 1 | 1.38 | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2 | 1.38 | 1.36 | | | | | | | | | | | | | | | | | | | | | | | |
| | 3 | 1.37 | 1.36 | 1.36 | | | | | | | | | | | | | | | | | | | | | | |
| | 4 | 1.36 | 1.37 | 1.38 | 1.38 | | | | | | | | | | | | | | | | | | | | | |
| | 5 | 1.36 | 1.36 | 1.35 | 1.33 | 1.35 | | | | | | | | | | | | | | | | | | | | |
| Lateral 2 | 6 | 1.32 | 1.34 | 1.36 | 1.34 | 1.34 | 1.33 | | | | | | | | | | | | | | | | | | | |
| | 7 | 1.33 | 1.34 | 1.33 | 1.34 | 1.34 | 1.33 | 1.34 | | | | | | | | | | | | | | | | | | |
| | 8 | 1.33 | 1.34 | 1.35 | 1.34 | 1.36 | 1.32 | 1.34 | 1.35 | | | | | | | | | | | | | | | | | |
| | 9 | 1.32 | 1.34 | 1.35 | 1.36 | 1.33 | 1.31 | 1.32 | 1.32 | 1.31 | | | | | | | | | | | | | | | | |
| | 10 | 1.31 | 1.32 | 1.32 | 1.34 | 1.34 | 1.30 | 1.31 | 1.32 | 1.34 | 1.34 | | | | | | | | | | | | | | | |
| Lateral 3 | 11 | 1.30 | 1.31 | 1.32 | 1.33 | 1.35 | 1.29 | 1.31 | 1.31 | 1.33 | 1.34 | 1.32 | | | | | | | | | | | | | | |
| | 12 | 1.29 | 1.30 | 1.30 | 1.30 | 1.31 | 1.29 | 1.28 | 1.30 | 1.29 | 1.30 | 1.27 | 1.29 | | | | | | | | | | | | | |
| | 13 | 1.26 | 1.28 | 1.28 | 1.27 | 1.28 | 1.26 | 1.26 | 1.27 | 1.27 | 1.27 | 1.24 | 1.26 | 1.26 | | | | | | | | | | | | |
| | 14 | 1.24 | 1.24 | 1.25 | 1.25 | 1.27 | 1.24 | 1.25 | 1.27 | 1.26 | 1.26 | 1.23 | 1.25 | 1.26 | 1.26 | | | | | | | | | | | |
| | 15 | 1.22 | 1.24 | 1.23 | 1.22 | 1.22 | 1.21 | 1.22 | 1.22 | 1.21 | 1.21 | 1.22 | 1.22 | 1.22 | 1.23 | 1.23 | | | | | | | | | | |
| Lateral 4 | 16 | 1.20 | 1.19 | 1.19 | 1.19 | 1.20 | 1.17 | 1.19 | 1.20 | 1.20 | 1.19 | 1.18 | 1.19 | 1.19 | 1.20 | 1.20 | 1.19 | | | | | | | | | |
| | 17 | 1.19 | 1.16 | 1.17 | 1.18 | 1.18 | 1.18 | 1.17 | 1.16 | 1.18 | 1.19 | 1.16 | 1.16 | 1.18 | 1.18 | 1.17 | 1.17 | 1.15 | | | | | | | | |
| | 18 | 1.15 | 1.16 | 1.16 | 1.17 | 1.16 | 1.14 | 1.15 | 1.15 | 1.16 | 1.15 | 1.13 | 1.14 | 1.15 | 1.15 | 1.15 | 1.11 | 1.13 | 1.14 | | | | | | | |
| | 19 | 1.10 | 1.11 | 1.14 | 1.13 | 1.13 | 1.09 | 1.10 | 1.12 | 1.12 | 1.10 | 1.08 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 | 1.08 | 1.08 | 1.09 | | | | | | |
| | 20 | 1.09 | 1.10 | 1.11 | 1.10 | 1.10 | 1.08 | 1.09 | 1.11 | 1.10 | 1.10 | 1.08 | 1.08 | 1.09 | 1.10 | 1.10 | 1.08 | 1.08 | 1.08 | 1.08 | 1.06 | | | | | |
| Lateral 5 | 21 | 1.09 | 1.09 | 1.10 | 1.07 | 1.08 | 1.08 | 1.07 | 1.06 | 1.07 | 1.08 | 1.07 | 1.09 | 1.07 | 1.06 | 1.08 | 1.09 | 1.08 | 1.07 | 1.07 | 1.06 | 1.07 | | | | |
| | 22 | 1.10 | 1.08 | 1.08 | 1.10 | 1.09 | 1.08 | 1.09 | 1.10 | 1.09 | 1.08 | 1.08 | 1.09 | 1.10 | 1.08 | 1.08 | 1.08 | 1.08 | 1.07 | 1.07 | 1.07 | 1.07 | 1.06 | | | |
| | 23 | 1.08 | 1.05 | 1.07 | 1.06 | 1.06 | 1.05 | 1.06 | 1.04 | 1.04 | 1.05 | 1.06 | 1.04 | 1.04 | 1.06 | 1.06 | 1.05 | 1.04 | 1.05 | 1.05 | 1.07 | 1.03 | 1.04 | 1.04 | | |
| | 24 | 1.05 | 1.04 | 1.07 | 1.08 | 1.07 | 1.06 | 1.07 | 1.07 | 1.06 | 1.06 | 1.03 | 1.05 | 1.02 | 1.03 | 1.02 | 1.04 | 1.07 | 1.04 | 1.04 | 1.05 | 1.03 | 1.05 | 1.05 | 1.06 | |
| | 25 | 1.04 | 1.03 | 1.02 | 1.04 | 1.02 | 1.02 | 1.00 | 1.01 | 1.02 | 1.01 | 1.00 | 0.99 | 1.01 | 1.00 | 1.00 | 0.98 | 0.98 | 1.00 | 0.99 | 0.98 | 0.98 | 0.97 | 0.98 | 0.99 | 0.97 |

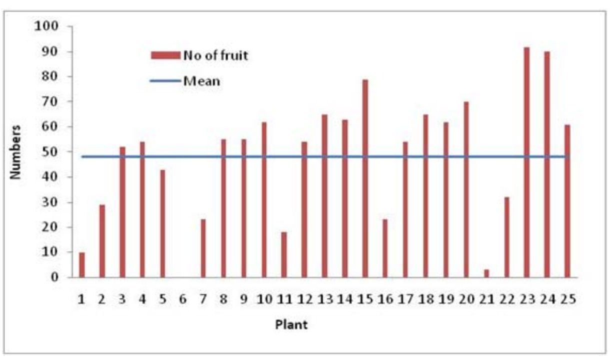


**Fig. 4. Variation of Number of Fruits in Each Emitters of The System**

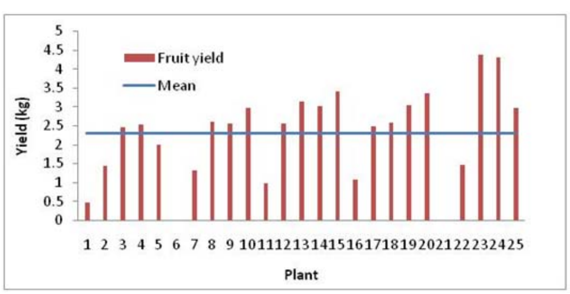


**Fig. 4: Variation of yield of tomato in each emitters of the system**

## 4. CONCLUSIONS

The waste water of hydraulic ram pump fed drip irrigation system was found one of the feasible systems for crop planning in the terraces of hilly terrains round the year. Hydraulic ram waste water was found sufficient for growth of short term vegetative in hilly terraces. The system could be feasible for 5 laterals and 23 number of emitters and could provide average yield 2.2964 kg per plant with total of number of fruits of 1214 and yield 57.41kg. Thus, we conclude that drip irrigation system fed by Hydraulic ram pump gives comparatively better vegetative growth and yield of tomato than the other irrigation system in hilly terraces. However, further details of feasibility study based on the varying area, slope and stability of terraces for soil erosion is needed foe sustainability of vegetables and other crops on the foot and hill top terraces of hilly terrain.

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