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Hydraulic Performance of Micro Irrigation System under Greenhouse conditions

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ABSTRACT: The research was carried out in Southern parts of Karnataka to determine the hydraulic parameters such as coefficient of manufacturer variation, emission uniformity; uniformity coefficient, application efficiency, and distribution efficiency for all irrigation systems of different makes were found to be excellent at both 0.75 and 1.00 kg/cm^2 operating pressure for all irrigation systems of different makes. The distribution of water application and discharges from emitters along the lateral was measured using ASAE criteria. On a sub main, one at the inlet, one at the far end, and two in the middle at the one-third and two-thirds positions will be selected. On each lateral, the four dripper sites are tested: one at the input, one at the submain, and one at the outlet. As a result, there are a total of 16 measurement points. This is accomplished by measuring the flow volume collected in a graduated cylinder over a ten-minute period, and repeating the procedure for different pressure ranges such as 0.75 kg/cm^2 and 1 kg/cm^2. However, the emitter flow variation was found to be acceptable only for companies A, C, and E at 1.00 kg/cm^2 operating pressure, but not for all irrigation makes at 0.75 kg/cm^2. The emitter exponent and discharge coefficient values ranged from 0.37 to 0.79 and 2.72 to 3.34, respectively, indicating a nearly turbulent flow. As a result, all of the company's drippers were discovered to be non-pressure compensating. Company A has a higher hydraulic efficiency than companies B, C, D and E.

Keywords: Application efficiency, uniformity coefficient, Pressure compensating, distribution efficiency.

INTRODUCTION

The vast majority of small and marginal farmers in the fast-emerging countries like India confront water scarcity and a lack of water resource management tools. Water-saving management methods must be developed in order to alleviate the problem of water scarcity in agriculture. When natural rainfall isn't enough or isn't evenly distributed, irrigation water is delivered to the plants to replace soil moisture at the root zone. The implementation of a high-efficiency irrigation system, such as a micro-irrigation system, allows for the efficient use of irrigation water. The drip irrigation system is one of the most effective water application technologies ever devised (Laib *et al.*, 2018).

The application efficiency of the conventional methods is very low and it is less than 50 per cent. The excess application of water creates a problem of water loss by surface runoff and deep percolation losses in the field. An alternative water application method such as the drip irrigation method allow much more uniform distribution along with precise control of the amount of water applied and which result in decreased nutrient leaching (Asif *et al*., 2015).

The function and capacity of the drip irrigation system mainly depends upon the emitter. In micro irrigation system, the emitters are used to dissipate pressure and discharge water drop by drop to plant root zone. Ideally, an emitter permits a small uniform flow as a constant discharge that does not vary significantly throughout the field (Ren *et al*., 2018).

The constructions of the emitter and performance standards are very important. Emitters are always subjected to degradation due to weathering especially sunlight and other cultural operations like fertigation (Musa, 2018). Emitters are designed to reduce the contradiction between the requirements for low flow rate and requirements for a relatively large opening for water to flow, so as to minimize the potential for emitter clogging. Additionally, uniform flow from one emitter to the next is critical in the design and manufacture of this device (Bilal *et al.*, 2011).

Micro-irrigation systems in greenhouses have not been researched and compared to other brands in a real-world setting. As a result, it is proposed that the design of micro irrigation systems be studied in a greenhouse setting. Micro irrigation systems appear to be problematic in many greenhouses, and farmers are reporting poor system design and clogging, low-efficiency distribution networks, insufficient maintenance, repair labour, and friction losses. As a result, a research was conducted to examine and appraise the performance of several greenhouse systems from various manufacturers in Karnataka's southern region II (Sharu and Ab Razak, 2020).

MATERIALS AND METHODS

The current research was conducted in the greenhouses of various taluks in southern Karnataka, including Doddaballapura, Sakaleshpur, Malur, Sidlaghatta, Chikkaballapur, Ramanagar, Bangalore north, and Hoskote, during the 2018-19 academic year.

The information on greenhouse farmers was gathered from various irrigation firms. namely Jain Irrigation Systems Ltd., Sujay Irrigation Systems, Godavary Polymers Pvt. Ltd., Megha Agro tech Pvt. Ltd. and Vedantha Irrigation Systems Pvt. Ltd and they are named as A, B, C, D, and E Respectively.

A. Hydraulic parameters calculation of drip irrigation system

(i) Measurement of discharge from emitters. The distribution of water application and discharges from emitters along the lateral was measured using ASAE criteria. These methods are based on the following emitter discharge data (Mangrio *et al.,* 2013).

1. A sub main will have four lateral lines: one at the inlet, one at the far end, and two in the middle at one-third and two-thirds places.

2. On each lateral, the four dripper sites are tested: one at the inlet, one at the far end, and two in the middle at one-third and two-thirds.

Therefore there are total of 16 measurement positions. This is done by measuring the flow volume collected in a graduated cylinder over a ten-minute period and this procedure is continued for different pressure ranges like 0.75 kg/cm^2 and 1 kg/cm^2 (Acar *et al.,* 2011).

(ii) Pressure measurement of drip irrigation system. Maintaining the system's regular operating pressure is critical for ensuring irrigation consistency. To indicate the pressure of the head control unit, a pressure gauge is fitted at the input and outflow of the filtration unit of the drip irrigation system (Sharma, 2013).

Plate 1: Instruments used for evaluation of drip irrigation system.

(iii) Evaluation of pressure variation. The pressure variation of 20 per cent is allowed in Indian conditions for the better performance of the drip irrigation systems (Arya *et al.*, 2017). To establish the same in the farmer's fields, one lateral is randomly chosen in the field and the pressure at the inlet end and at the end plug were measured with the help of a pressure gauge. The observations are reported in the subsequent chapter.

B. Performance evaluation of drip irrigation system

Despite the drip irrigation system's efficacy, there are a number of issues with regard to water application and fertiliser management. Though the system has a lot of promise for high irrigation efficiency, it can also be inefficient due to poor design, administration, and maintenance, which results in non–uniform emitter discharge throughout the irrigated fields. To get around these issues, the irrigators decided to over-irrigate the land. Excessive irrigation can result in water and nutrient waste, as well as the risk of groundwater contamination due to excessive leaching.

Plate 2: Pressure measurement at the end of the lateral.

(i) Coefficient of manufacturer's variation (Cv). The coefficient of manufacturer's variation is defined as the ratio of the standard deviation of flow to the mean flow for a sample number of emitters (Keller and Karmeli, 1974). The manufacturer's variation coefficient is a statistical metric with the following formula:

$$C_v = \frac{S_d}{q_{ave}} \times 100$$

Where,

S_d = Standard deviation of flow

$$= \sqrt{\frac{(q_1^2+q_2^2+q_3^2+q_n^2-nq_{ave}^2)}{(n-1)}}$$

q_{ave} = Mean flow for a sampled number of emitters

$$= \frac{q_1+q_2+.....q_n}{n} \times 100$$

q_1, q_2, q_3, q_n = are the discharges (lph)

n = Number of emission devices tested

The coefficient of manufacturing variation is a parameter that can be used to measure the variation in emitter flow caused by variations in emitter production. The failure to maintain dimensional precision owing to moulding pressure and temperature fluctuations in the material used are two common reasons of manufacturing variances. The ability of a manufacturer to manage deviations is determined not just by manufacturing and material quality control, but also by the design of the emitter. Aside from individual emitter flow rate variations, the measured mean flow rate differs from the emitter's nominal flow rate. The difference in percentage between the real and nominal flow rates (Deshmukh *et al.,* 2014).

$$Q_d = \left(\frac{q_r - q_{ave}}{q_{ave}} \right) \times 100$$

Where,
Q_d = Mean flow rate deviation, (%)
q_r = The nominal emitter flow rate, lph
q_{ave} = Average emitter flow rate

(ii) Emission uniformity (EU). Because it assesses the consistency of emitter discharge from all emitters in a drip irrigation system, emission uniformity is the single most important criterion for evaluating system performance (Keller and Karmeli 1974). The link between minimum and average emitter discharge is presented by the European Union (EU). EU is required to calculate irrigation gross depth, irrigation intervals, and system capacity. It is determined by the water temperature and the manufacturer's stipulated coefficient of variation for the system (Valiahary *et al.*, 2014).

During the field test, the EU is the ratio of average emitter discharge from the lowest 1/4th of the emitter to the average discharge of all the emitters.

$$EU = \frac{q_m}{q_a} \times 100$$

Where,
EU = The field test emission uniformity, percentage
q_m = Average of the lowest 1/4th of the field data emitter discharge, lph
q_a = Average of all the field data emitter discharge, (lph)

(iii) Uniformity coefficient (UC). The uniformity coefficient can be calculated using Bralts and Kesner, (1982) equation and Christiansen (1942) equation.

(a) The uniformity coefficient by Bralts and Kesner, (1982) equation

$$UC = 100\ (1 - V_q) = 100 \left(1 - \frac{S_d}{q_a} \right)$$

Where,
UC = Statistical uniformity coefficient (%)
V_q = Coefficient of variation emitter flow
S_d = Standard deviation of emitter flow
q_a = Mean emitter flow rate, lph

(b) The uniformity coefficient by using Christiansen (1942) equation.

$$Cu = 1 - \left(\frac{\sum_{i=1}^{n} |q_i - q_{ave}|}{\sum_{i=1}^{n} q_i} \right) \times 100$$

Where,
q_i = individual emitter flow rate, lph
q_{ave} = average emitter flow rate, lph

C. Drip Irrigation Efficiency

Irrigation efficiency (Ei) is the ratio of the volume of irrigation water utilised by plants to build plant tissue to the total volume of irrigation water pumped. Irrigation efficiency can be divided into two categories: distribution efficiency and application efficiency.

(i) Distribution efficiency (Ed). The uniformity with which irrigation water is supplied over the field is determined by the drip irrigation system's distribution efficiency. It can be computed using the emitter flow variation along a lateral line in a drip irrigation system layout in the field, and the equation can be used to express it (Manisha and Tripath, 2015).

$$E_d = 100 \times \left[1 - \frac{\Delta_{qa}}{q_m} \right]$$

Where,
E_d = distribution efficiency in percentage
q_m = mean emitter flow rate, lph
Δ_{qa} = average absolute deviation of each emitter flow from the mean emitter flow.

$$\Delta_{qa} = \frac{q_r - q_{ave}}{q_{ave}} \times 100$$

q_r = rated flow, lph
q_{ave} = Average emitter flow rate, lph

(ii) Application efficiency (Ea). The ratio of water required at the root zone to the total amount of water applied is known as application efficiency. It demonstrates how effectively irrigation water is applied, i.e. how much water is stored in the root zone and available for plant use.

The water required in the root zone is supposed to be applied at the lowest flow rate possible and for the entire irrigation period. As a result, application efficiency can be defined as follows:

$$E_a = \frac{N.\ Q_{min}\ T}{V_w} \times 100$$

Where,
E_a = Application efficiency, %
N = Total number of emitters
Q_{min} = Minimum emitter flow rate, lph
T = Total irrigation time,
V_w = Total volume of water applied, l
Since, the mean emitter flow (Q_{avg}) is,

$$Q_{avg} = \frac{V_w}{N.T.}$$

The application efficiency can also be expressed as,

$$Ea \; \frac{Q_{min}}{Q_{avg}} \times 100$$

Where,

Q_{min} = minimum emitter flow rate, lph

Q_{avg} = average emitter flow rate, lph.

RESULTS AND DISCUSSION

Micro irrigation methods in southern Karnataka greenhouses were investigated in these studies. The observations were made on hydraulic parameters such as Coefficient of manufacturer variation, Emission uniformity, Uniformity co-efficient, Application efficiency and Distribution efficiency. The research was carried out in the greenhouse growers of southern Karnataka, the parameters show some interesting facts which are briefly explained in this chapter. The data are presented in the form of different tables. The results of the study and the discussion are presented in this chapter under different headings.

A. Description of the farm field

The investigations were conducted in 15 greenhouses belonging to various growers. Different greenhouses' drip irrigation systems covered an area ranging from 1.06 to 3.03 acres. The irrigation systems in the 15 greenhouses were installed by five separate drip irrigation firms. Irrigation systems for different firms' growers are labeled with codes ranging from G1 to G15.

B. Hydraulic performance of drip irrigation system under greenhouse conditions

The drip irrigation system's hydraulic performance was assessed using ASAE methodologies and standards (1996). The experiment was carried out in greenhouse fields with 4 lph drippers positioned 40 cm apart on laterals.

The dripper output was collected in catch cans at 16 different points on the system for 10 minutes. The total amount of water gathered was measured with a graduated cylinder. For five drip irrigation firms, Company A, Company B, Company C, Company D, and Company E,

The drip irrigation system's hydraulic performance was evaluated on the basis of Coefficient of manufacturer variation, Emission uniformity, Uniformity co-efficient, Emitter flow variation, Application efficiency and Distribution efficiency with different operating pressure. The results obtained are discussed as follows.

(i) Coefficient of manufacturer variation (C_v). All the five different manufactures of drip irrigation system were operated at 1.00 and 0.75 kg/cm^2 operating pressure for 4 lph drippers on which the dripper spacing was 40 cm on the laterals. Table 1 shows the coefficient of manufacturer variation Cv for 4 lph drippers at various operating pressures.

It is critical to consider the manufacturer coefficient, which can be found online (point source) or inline, when grading the system as good, average, marginal, or exceptional (line source). The coefficient of manufacturer variation (Cv) for five distinct business drippers operating at pressures of 0.75 and 1.00 kg/cm^2 is shown in Table 1. Cv for 4 lph dripper discharge is found to be within the range of classification as good for both operating pressures.

Table 1: Coefficient of manufacturer variation (Cv) of drip irrigation system under different operating pressure for different makes.

Greenhouse No.	Irrigation Company	Coefficient of Manufacturer variation (C_v) (%)		Classification	
		0.75 (kg/cm^2)	1.00 (kg/cm^2)	0.75 (kg/cm^2)	1.00 (kg/cm^2)
G_1	A	0.0443	0.0374	Good	Good
G_2		0.0395	0.0140	Good	Good
G_3		0.0420	0.0301	Good	Good
G_4	B	0.0405	0.0313	Good	Good
G_5		0.0367	0.0300	Good	Good
G_6		0.0276	0.0205	Good	Good
G_7	C	0.0344	0.0274	Good	Good
G_8		0.0345	0.0318	Good	Good
G_9		0.0268	0.0183	Good	Good
G_{10}	D	0.0298	0.0175	Good	Good
G_{11}		0.0485	0.0455	Good	Good
G_{12}		0.0396	0.0317	Good	Good
G_{13}	E	0.0518	0.0496	Average	Good
G_{14}		0.0549	0.0395	Average	Good
G_{15}		0.0278	0.0191	Good	Good

For business A, the coefficient of manufacturer variation (Cv) was determined to be 0.0443 at 0.75 kg/cm2 operating pressure in G1 farmer and 0.0140 at 1.00 kg/cm2 operating pressure in G2 farmer. Similarly, the coefficient of manufacturer (Cv) variation of 0.0405 was found to be highest in G4 farmer at 0.75 kg/cm^2 operating pressure and lowest in G6 farmer at 1.00 kg/cm^2 operating pressure. The coefficient of manufacturer variation (Cv) of 0.0345 in company C was found to be highest at 0.75 kg/cm^2 operating pressure in G8 farmer and lowest at 1.00 kg/cm^2 operating pressure in G9 farmer. Similarly, the coefficient of manufacturer variation (Cv) for firm D was determined to be 0.0485 in G11 farmer at 0.75 kg/cm^2 operating pressure and

0.0175 in G10 farmer at 1.00 kg/cm^2 operating pressure. The coefficient of manufacturer variation (Cv) of 0.0549 was found to be highest in G14 farmer at 0.75 kg/cm^2 operating pressure and lowest in G15 farmer at 1.00 kg/cm^2 operating pressure. For all drip irrigation systems of different manufacturers, the coefficient of manufacturer variation (Cv) decreases as the operating pressure increases, as seen in the above data. The result also shows that there is a less effect of operating pressures on the coefficient of manufacturer variation (C_v) of different company drippers and also it is apparent that when the working pressure of drip irrigation system is increased, coefficient of manufacturer variation (C_v) diminishes implying that pressure directly influenced the release rate of the emitter.

(ii) Emission Uniformity (EU). Emission uniformity (EU) helps to find out the uniformity of emitters discharge of the drip irrigation system and also it serves as one of the important parameter for checking the hydraulic performance of the drip irrigation system.

The Table 2 shows the emission uniformity (EU) of five different company drip irrigation system operated at 0.75 kg/cm^2 and 1.00 kg/cm^2 operating pressure for 4 lph dripper discharge at a spacing of 40 cm on the laterals respectively.

The emission uniformity (EU) of 99.42 per cent was discovered to be the maximum at 1.00 kg/cm^2 operating pressure in G_3 farmer and minimum of 94.84 per cent at 0.75 kg/cm^2 operating pressure in G_1 farmer for company A. Similarly, for company B, emission uniformity (EU) of 99.12 per cent was discovered to be the maximum at 1.00 kg/cm^2 operating pressure in G_6 farmer and minimum of 96.81 per cent at 0.75 kg/cm^2 operating pressure in G_4 farmer. The company C, emission uniformity (EU) of 98.88 per cent was discovered to be the maximum at 1.00 kg/cm^2 operating pressure in G_7 farmer and minimum of 96.69 per cent at 0.75 kg/cm^2 operating pressure in G_8 farmer. Similarly, in company D, emission uniformity (EU) has 98.75 per cent was discovered to be the maximum at 1.00 kg/cm^2 operating pressure in G_{10} farmer and minimum of 94.75 per cent at 0.75 kg/cm^2 operating pressure in G_{12} farmer. While in company E, emission uniformity (EU) of 97.75 per cent was discovered to be the maximum at 1.00 kg/cm^2 operating pressure in G_{15} farmer and minimum of 92.79 per cent at 0.75 kg/cm^2 operating pressure in G_{14} farmer. It is clear from the table that for a particular spacing emission uniformity (EU) increases, the pressure of the operating system increases for all the five different company emitters.

Emission Uniformity (EU) for 4 lph dripper discharge is found to be excellent for both the operating pressure and the operating temperature. As the "ratio of minimal rate of discharge to average rate of discharge," emission uniformity (EU) is defined. The ratio of the minimum discharge rate to the average discharge rate. increases, increasing emission uniformity. Due to a constant emitter point along the lateral length, emission uniformity (EU) increases at a specific spacing.

Table 2: Emission Uniformity of dripper under different operating pressure.

Greenhouse No.	Irrigation Company	Emission uniformity (EU) (%)		Classification	
		0.75 (kg/cm^2)	1.00 (kg/cm^2)	0.75 (kg/cm^2)	1.00 (kg/cm^2)
G_1	A	94.84	97.98	Excellent	Excellent
G_2		95.54	99.83	Excellent	Excellent
G_3		96.64	99.42	Excellent	Excellent
G_4	B	96.81	97.68	Excellent	Excellent
G_5		98.12	98.42	Excellent	Excellent
G_6		98.68	99.12	Excellent	Excellent
G_7	C	98.15	98.88	Excellent	Excellent
G_8		96.69	98.01	Excellent	Excellent
G_9		97.01	98.73	Excellent	Excellent
G_{10}	D	95.54	98.75	Excellent	Excellent
G_{11}		95.05	96.98	Excellent	Excellent
G_{12}		94.75	98.22	Excellent	Excellent
G_{13}	E	95.67	97.65	Excellent	Excellent
G_{14}		94.45	96.06	Excellent	Excellent
G_{15}		94.95	97.75	Excellent	Excellent

(iii) Uniformity coefficient (Us). One of the most significant elements in the selection and design of a successful irrigation system is the uniformity coefficient (Us). A drip irrigation system was created to deliver water to the root zone of the plants in a consistent and precise amount. The uniformity coefficient (Us) describes how evenly the drip irrigation system distributes water throughout the land.

Table 3 and 4 provide the computed uniformity coefficient (Us) statistics for five drip irrigation brands running at 0.75 kg/cm2 and 1.00 kg/cm^2 operating pressure for 4 lph dripper discharges at a 40 cm spacing. The uniformity coefficient (Us) can be calculated using two alternative formulas. The first is the Bralts formula. Table 3 reveals the data of uniformity coefficient (Us) of five different company drip irrigation system operated at 0.75 kg/cm^2 and 1.00 kg/cm^2 operating pressure for 4 lph dripper discharge at a spacing of 40 cm respectively by using the Bralts and Kesner (1982) equation.

At operating pressures of 0.75 kg/cm^2 and 1.00 kg/cm^2, the uniformity coefficient (Us) for firm A was 94.31 and 97.95 percent (G1 farmer), 95.74 and 98.59 percent (G2 farmer), and 95.15 and 96.99 percent (G3 farmer) (G3 farmer). Similarly, at 0.75 kg/cm^2 and 1.00 kg/cm^2, the Uniformity coefficient (Us) for firm B was 95.54 and 96.68 percent (G4 farmer), 94.32 and 96.79 percent (G5 farmer), and 97.14 and 98.38 percent (G6 farmer). At 0.75 kg/cm^2 and 1.00 kg/cm^2, the Uniformity coefficient (Us) in company C was 97.25 and 96.65 (G7 farmer), 95.83 and 96.74 percent (G8 farmer), and 95.97 and 97.73 percent (G9 farmer). Similarly, at 0.75 kg/cm^2 and 1.00 kg/cm^2, the Uniformity coefficient (Us) for firm D was 97.10 and 98.17 (G10 farmer), 96.82 and 98.24 percent (G11 farmer), and 94.99 and 95.09 percent (G12 farmer). At 0.75 kg/cm^2 and 1.00 kg/cm^2, the business E has a uniformity coefficient (Us) of 94.32 and 96.79 (G13 farmer), 89.18 and 95.66 per cent (G14 farmer), and 86.02 and 94.15 per cent (G15 farmer).

Table 4 shows the data of Uniformity coefficient (Us) by using Christiansen (1942) equation. The Uniformity coefficient (Us) for company A at the operating pressure of 0.75 kg/cm^2 and 1.00 kg/cm^2 was 96.12 and 98.69 per cent (G_1 farmer), 97.65 and 98.21 per cent (G_2 farmer) and 95.20 and 96.78 per cent (G_3 farmer). Similarly, for company B, Uniformity coefficient (Us) of 97.90 and 99.11 per cent (G_4 farmer), 97.36 and 98.14 per cent (G_5 farmer) and 96.43 and 96.91 per cent (G_6 farmer) at 0.75 kg/cm^2 and 1.00 kg/cm^2. In the company C, Uniformity coefficient (Us) of 97.26 and 98.23 (G_7 farmer), 97.93 and 98.44 per cent (G_8 farmer) and 97.05 and 98.83 per cent (G_9 farmer) at 0.75 kg/cm^2 and 1.00 kg/cm^2. Similarly, for company D, Uniformity coefficient (Us) of 96.89 and 97.53 (G_{10} farmer), 97.01 and 97.91 per cent (G_{11} farmer) and 95.33 and 96.73 per cent (G_{12} farmer) at 0.75 kg/cm^2 and 1.00 kg/cm^2. The company E, Uniformity coefficient (Us) of 96.89 and 97.53 (G_{13} farmer), 97.58 and 98.05 per cent (G_{14} farmer) and 97.90 and 99.11 per cent (G_{15} farmer) at 0.75 kg/cm^2 and 1.00 kg/cm^2.

The above data shows that, for both Bralts and Kesner (1982) equation and Christiansen (1942) equation, the Uniformity coefficient (Us) increases as the operating pressure increased for all the drip irrigation system of different manufacturers. At a particular spacing, Uniformity coefficient (Us) increases as the emitter point remains constant over the lateral length.

Table 3: Estimation of uniformity coefficient (Us) under different operating pressure by using Bralts and Kesner equation.

Greenhouse No.	Irrigation Company	Uniformity coefficient (Us) (%)		Classification	
		0.75 (kg/cm^2)	1.00 (kg/cm^2)	0.75 (kg/cm^2)	1.00 (kg/cm^2)
G_1	A	94.31	97.95	Excellent	Excellent
G_2		95.74	98.59	Excellent	Excellent
G_3		95.15	96.99	Excellent	Excellent
G_4	B	95.54	96.68	Excellent	Excellent
G_5		94.32	96.79	Excellent	Excellent
G_6		97.14	98.38	Excellent	Excellent
G_7	C	97.25	96.65	Excellent	Excellent
G_8		95.83	96.74	Excellent	Excellent
G_9		95.97	97.73	Excellent	Excellent
G_{10}	D	97.10	98.17	Excellent	Excellent
G_{11}		96.82	98.24	Excellent	Excellent
G_{12}		94.99	95.09	Excellent	Excellent
G_{13}	E	94.32	96.79	Excellent	Excellent
G_{14}		89.18	95.66	Very good	Excellent
G_{15}		86.02	94.15	Very good	Excellent

Table 4: Estimation of Uniformity coefficient (Us) under different operating pressure by using Christiansen equation

Greenhouse No.	Irrigation Company	Uniformity coefficient (Us) (%)		Classification	
		0.75 (kg/cm^2)	1.00 (kg/cm^2)	0.75 (kg/cm^2)	1.00 (kg/cm^2)
G_1	A	96.12	98.69	Excellent	Excellent
G_2		97.65	98.21	Excellent	Excellent
G_3		92.50	96.78	Excellent	Excellent
G_4	B	97.90	99.11	Excellent	Excellent
G_5		97.36	98.14	Excellent	Excellent
G_6		96.43	96.91	Excellent	Excellent
G_7	C	97.26	98.23	Excellent	Excellent
G_8		97.93	98.44	Excellent	Excellent
G_9		97.05	98.83	Excellent	Excellent
G_{10}	D	96.89	97.53	Excellent	Excellent
G_{11}		97.01	97.91	Excellent	Excellent
G_{12}		95.33	96.73	Excellent	Excellent
G_{13}	E	96.89	97.53	Excellent	Excellent
G_{14}		97.58	98.05	Excellent	Excellent
G_{15}		97.90	99.11	Excellent	Excellent

(iv) Application Efficiency (E_a). Application efficiency (E_a) of the drip irrigation system was estimated for five different make drip irrigation company, drip irrigation system were operated at 0.75 kg/cm^2 and 1.00 kg/cm^2 operating pressure for 4 lph drippers on which the dripper spacing was 40 cm on the laterals and are given in Table 5.

The Application efficiency (E_a) of 98.91 per cent was discovered to be the maximum at 1.00 kg/cm^2 operating pressure in G_1 farmer and minimum of 92.79 per cent at 0.75 kg/cm^2 operating pressure in G_2 farmer for company A. Similarly, for company B, Application efficiency (E_a) of 97.09 per cent was found was discovered to be the maximum to be maximum at 1.00 kg/cm^2 operating pressure in G_6 farmer and minimum of 92.64 per cent at 0.7 was discovered to be the maximum 5 kg/cm^2 operating pressure in G_5 farmer. The company C, Application efficiency (E_a) 98.73 per cent was found to be maximum at 1.00 kg/cm^2 operating pressure in G_9 farmer and minimum of 91.95 per cent at 0.75 kg/cm^2 operating pressure in G_7 farmer. Similarly company D, Application efficiency (E_a) has 98.92 per cent was found to be maximum at 1.00 kg/cm^2 operating pressure in G_{10} farmer and minimum of 92.64 per cent at 0.75 kg/cm^2 operating pressure in G_{12} farmer. The company E, Application efficiency (E_a) has 98.36 per cent was discovered to be the maximum at 1.00 kg/cm^2 operating pressure in G_{14} farmer and minimum of 93.91 per cent at 0.75 kg/cm^2 operating pressure in G_{14} farmer. It is clear from the table that for a particular spacing Application efficiency (E_a) increase as the pressure of the operating system increases for all the five different company emitters.

Table 5: Application Efficiency (E_a) of drip irrigation systems under different operating pressure.

Greenhouse No.	Irrigation Company	Application Efficiency (E_a) (%)	
		0.75 (kg/cm^2)	1.00 (kg/cm^2)
G_1	A	96.54	98.91
G_2		92.79	97.71
G_3		94.62	98.82
G_4	B	94.92	96.77
G_5		92.64	95.49
G_6		95.74	97.09
G_7	C	91.95	96.15
G_8		93.01	96.93
G_9		96.93	98.73
G_{10}	D	94.08	98.92
G_{11}		92.93	96.49
G_{12}		92.64	95.64
G_{13}	E	94.77	97.88
G_{14}		93.91	98.36
G_{15}		94.02	96.24

(v) Distribution Efficiency (E_d). Distribution efficiency (E_d) of the drip irrigation system was estimated for five different brand drip irrigation company, drip irrigation system were operated at 0.75 kg/cm^2 and 1.00 kg/cm^2 operating pressure for 4 lph drippers on which the dripper spacing was 40 cm on the laterals and are given in Table 6.

Table 6: Distribution Efficiency (E_d) of drip irrigation system under different operating pressure.

Greenhouse No.	Irrigation Company	Distribution Efficiency (E_d) (%)	
		0.75 (kg/cm^2)	1.00 (kg/cm^2)
G_1	A	96.01	98.45
G_2		97.92	99.16
G_3		97.42	98.03
G_4	B	96.61	97.94
G_5		96.89	97.84
G_6		96.14	98.34
G_7	C	96.55	97.62
G_8		96.54	97.73
G_9		97.93	98.02
G_{10}	D	97.89	98.08
G_{11}		95.33	96.83
G_{12}		96.89	97.54
G_{13}	E	97.68	98.33
G_{14}		92.26	96.61
G_{15}		93.36	97.16

The Distribution efficiency (E_d) of 99.16 per cent was found to be maximum at 1.00 kg/cm^2 operating pressure in G_2 farmer and minimum of 96.01 per cent at 0.75 kg/cm^2 operating pressure in G_3 farmer for company A. Similarly, for company B, Distribution efficiency (E_d) of 98.34 per cent was found to be maximum at 1.00 kg/cm^2 operating pressure in G_6 farmer and minimum of 96.14 percent at 0.75 kg/cm^2 operating pressure in G_6 farmer.

The company C, Distribution efficiency (E_d) 98.02 per cent was discovered to be the highest at 1.00 kg/cm^2 operating pressure in G_9 farmer and minimum of 96.54 per cent at 0.75 kg/cm^2 operating pressure in G_8 farmer. Similarly company D, Distribution efficiency (E_d) has 98.08 per cent was found to be maximum at 1.00 kg/cm^2 operating pressure in G_{10} farmer and minimum of 95.33 per cent at 0.75 kg/cm^2 operating pressure in G_{11} farmer. The company E, Distribution efficiency (E_d) has 98.33 per cent was found to be maximum at 1.00 kg/cm^2 operating pressure in G_{13} farmer and minimum of 92.26 per cent at 0.75 kg/cm^2 operating pressure in G_{14} farmer. It is clear from the table that for a particular spacing, Distribution efficiency (E_d) increase as the pressure of the operating system increases for all the five different company emitters.

(vi) Emitter exponent (x) and discharge coefficient (K). The value of x determines how sensitive the emitter discharge is to operating pressure. Typically, the value of x is between 0.1 and 1.0. The discharge exponent value might to be used in calculations the minimal permitted pressure fluctuation to meet the design criterion in the drip line of a 10% discharge variation via the emitter in the field.

The emitter exponent (x) and discharge coefficient (K) of all the tested emitter of different manufacturers are shown in Table 7. The highest emitter exponent (0.79) was observed in company E and the lowest emitter exponent (0.37) was observed in company D. The highest discharge coefficient (3.34) was observed in company A and the lowest emitter exponent (2.72) was observed in company D.

Table 7: Emitter exponent (x) and discharge coefficient (K) of different drip irrigation system

Sr. No.	Irrigation company	x	K
1.	A	0.52	3.34
2.	B	0.40	3.03
3.	C	0.44	2.88
4.	D	0.37	2.72
5.	E	0.79	2.93

The data shows that the emitter exponent varied between 0.3698 and 0.7855. Hence the flow is said to be almost turbulent flow.

(vii) Pressure discharge relationship. Table 8 shows the average discharge of different business emitters for 4 lph capacity drippers in farmers' fields at various operating pressures. The outflow from the various corporate drippers rose when the working pressure was increased, which was visible. The exponential structure of numerous manufacturers' mathematical relationships is displayed in the Table 3. The average number of pressure–discharge connections was discovered to be 8. The R2 values for companies A, B, C, D, and E were 0.54, 0.91, 0.76, 0.64, and 0.73, respectively. Because we only have two operating pressures, the R2 model is not well suited for irrigation companies.

Table 8: Developed models for the pressure discharge relationship of different manufacturers for 4lph drippers.

Irrigation company	Developed model	R^2
A	$Q = 3.34 \times H^{0.5227}$	$R^2 = 0.54$
B	$Q = 3.03 \times H^{0.3994}$	$R^2 = 0.91$
C	$Q = 2.88 \times H^{0.4384}$	$R^2 = 0.76$
D	$Q = 2.72 \times H^{0.3698}$	$R^2 = 0.64$
E	$Q = 2.93 \times H^{0.7855}$	$R^2 = 0.73$

CONCLUSION

The drip irrigation system's hydraulic performance was determined by collecting the discharge from the emitters at 16 different sites on irrigation systems with operating pressures of 0.75 kg/cm^2 and 1.00 kg/cm^2. By taking into account all of the following hydraulic characteristics, business A demonstrated superior hydraulic efficiency by achieving ASCE criteria, Company B, Company C, Company E, and Company D are the following companies.

FUTURE SCOPE

1. This study should be conducted in different regions of India.
2. This study was carried out for different capacity drippers like 2lph, 8lph, 12lph etc. at different spacing of drippers on the laterals.
3. This study was carried out for 12mm size laterals and also for online drip irrigation systems.
4. A computer model may be developed to calculate the emitter flow characteristics.

CHALLENGES OF THE STUDY

The study was carried out to evaluate and assess the five different company Inline drip irrigation systems on the basis of their design effectiveness and hydraulic performance in the greenhouses. The design was evaluated in the greenhouses by calculating the different frictional losses in the drip irrigation systems at 1.00 Kg/cm^2 operating pressure. The hydraulic performance of drip irrigation systems was evaluated by collecting discharge from the laterals at a different position of the system at 0.75 Kg/cm^2 and 1.00 Kg/ cm^2 operating pressure. The total cost of installation of different companies also calculated.

Conflict of Interest. None.

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