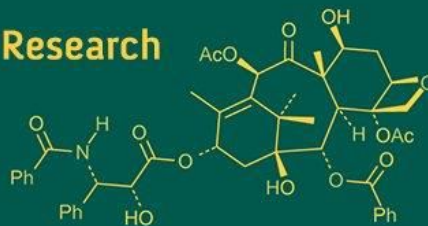
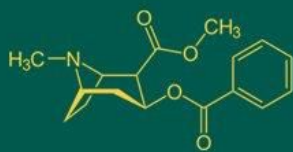


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Hydraulic performance evaluation of drip system

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Abstract

A best and desirable feature of trickle irrigation is the uniform distribution of water and it is governed by proper design, management and adoption of the system. Proper design and operating of drip irrigation system also significantly minimize water use and energy consumption. The poor design of drip irrigation system may lead to under watering many plants and over watering the others rather than distributing water over the whole field. Hence, a field experiment was conducted to evaluate the hydraulic performance of existing drip irrigation system in the experimental site during the year 2023-24 at Center of Excellence on Protected Cultivation, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) The treatment comprised of three irrigation levels I_1 drip with 0.7 IW/CPE ratio, I_2 drip with 0.85 IW/CPE ratio and I_3 drip with 1.0 IW/CPE ratio with three fertigation level F_1 70% recommended dose of fertilizer, F_2 85% recommended dose of fertilizer and F_3 100% recommended dose of fertilizer with 9 treatment combination and 3 replication in Randomized block design. The result indicated that the average value of the hydraulic performance indicators namely emitter discharge, emission uniformity, distribution efficiency and application efficiency obtained were 1.17 lph, 94.9 percent, 95.7 percent and 93.9 percent respectively at 1.2 kg cm⁻² operating pressure in 2 lph inline dripper which were in acceptable limit.

Keywords: Hydraulic performance, emission uniformity, distribution efficiency, drip irrigation

Introduction

Applying consistent water directly to each plant's root zone using drip irrigation has been found to be an effective way to reduce water application and increase water use efficiency, especially in regions where rainfall is rare and irrigation water is expensive. (Sinha and Shashikant, 2021) [5]. For agriculture to increase output and save irrigation water, a precious but finite resource, rational irrigation water usage is essential. This can be achieved by using additional improved water management strategies in conjunction with contemporary irrigation techniques like trickle irrigation. The fundamental idea behind drip irrigation is to irrigate the crop's root zone as opposed to the entire land surface, which maximizes agricultural output and water consumption efficiency. Drip irrigation, thus, reduces traditional losses such as soil evaporation, runoff, and deep percolation. Together with healthier crop response, it permits the application of insecticides, fertilizers, and other water-soluble compounds with irrigation water (Sinha *et al.* 2021) [5]. The various drip irrigation system hydraulic performance metrics are highly helpful for efficient design and how the system functions. Gil *et al.* (2002) [2].

Materials and Methods

The experiment was conducted in netted condition at Center of Excellence on Protected Cultivation, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during the year 2023-24. The experimental site is located at 21°23' N latitude, 81°63' E longitude and 285 m above mean sea level in the central part of the state of Chhattisgarh.

Discharge of emitters

Emitter having discharge capacity of 2 lph respectively were tested at different operating pressure i.e. 0.8, 1.0 and 1.2 kg cm⁻² and these pressures are maintained by using control valve at head control unit and end of lateral. A pressure gauge was used to determine the operating pressure. To direct the discharge into the plastic and glass container, water was gathered using drippers. The duration of the tests varied depending on the pressure and

drillers employed, and the results were converted into discharge per hour. Water collected in containers was measured with the help of measuring cylinder.

Emission uniformity (EU)

The EU during the field test is the ratio expressed as a percentage of average emitter discharge from the lower 1/4th of emitter to the average discharge of all the emitters of the drip system.

The average of lowest 1/4th of emitter was selected as a practical value for minimum discharge, as recommended by the United State Soil Conservation Services for field evaluation of irrigation systems and is expressed by the equation:

$$EU = \frac{q_m}{q_a} \quad \dots(1)$$

Where,

EU = Emission uniformity, percentage

q_m = Average of the lowest 1/4th of the field data emitter discharge, l/h

q_a = Average of all the field data emitter discharge, l/h

Table 1: General criteria for emission uniformity

S.N.	Emission uniformity	Classification
1.	90% or greater	Excellent
2.	80 to 90%	Good
3.	70 to 80	Fair
4.	Less than 70%	Poor

Source: American society of agriculture and biological engineers (ASAE)

Distribution efficiency (E_d)

The distribution efficiency determine show uniformly irrigation water can be distributed through a drip irrigation system into the field. It can be determined from the emitter flow variation along a lateral line in a drip irrigation system layout in the field and can be expressed by the equation:

$$Ed = 100 * [1 - \frac{\Delta q_a}{q_m}] \quad \dots(2)$$

Where,

E_d = Distribution efficiency in percentage

q_m = Mean emitter flow rate, lph

Δq_a = Average absolute deviation of each emitter flow from the mean emitter flow

$$\Delta q_a = \left[\frac{q_r - q_{ave}}{q_{ave}} \right] \quad \dots(3)$$

q_r = rated flow, lph

q_{ave} = Average emitter flow rate, lph

Application efficiency (E_a)

The ratio of water required at the root zone to the total amount of water applied is known as application efficiency. It demonstrates how well irrigation water is applied that is, what percentage of the water applied is stored in the root zone as needed and is available for plant use (Mane *et al.*

2018) [4]. The water required in the root zone is supposed to be applied at the lowest flow rate possible and for the entire irrigation period. Therefore, application efficiency can be expressed as,

$$Ea = 100 \left(\frac{q_{min}}{q_{avg}} \right) \quad \dots(4)$$

Where,

E_a = application efficiency, %

q_{min} = minimum emitter flow rate, lph

q_{avg} = average emitter flow rate, lph

Average emitter flow rate can be expressed by equation

$$q_{avg} = \frac{V_W}{N T} \quad \dots(5)$$

Where,

V_W = total volume of water applied

N = total number of emitters

T = total irrigation time

Results and Discussion

The data obtained from experimental trials from drip irrigation system were used to determine different hydraulic performance indicators for evaluating the existing operational systems. The parameters namely emitter flow rate, emission uniformity distribution efficiency and application efficiency were used to evaluate the hydraulic performance of drip system.

Emitter Discharge

That Drip irrigation system was operated under field condition to study the different hydraulic parameters of the system.

Table 2: Performance parameter of drip irrigation system

S. no.	Emitter	parameter	Operating pressure (kg/cm ²)		
			0.8	1.0	1.2
1	2 lph	Discharge	1.08	1.11	1.17
2		Emission uniformity	90	93.3	94.9
3		Distribution efficiency (%)	90.2	92.8	95.7
4		Application efficiency (%)	75.5	88.4	98.9

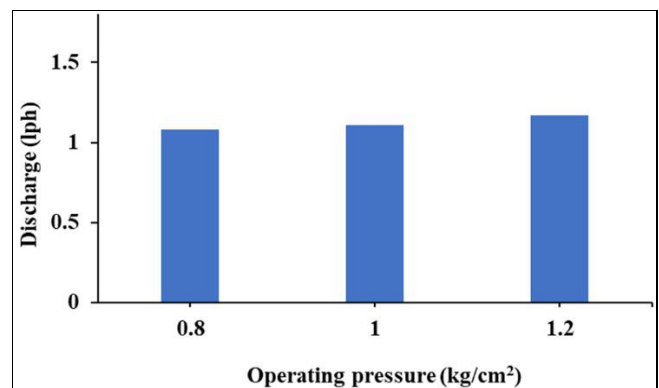


Fig 1: Discharge for 2 lph dripper under different operating pressure

For this purpose, drip irrigation discharges were measured at operating pressure of 0.80 to 1.0 kg cm⁻² and 1.2 kg cm⁻² for 2 lph emitter discharge. The data pertaining in table 2 and fig 1 depicts the Average emitter flow rate of 1.17 lph was found to be maximum at 1.2 kg cm⁻² operating pressure and a minimum of 1.08 lph at 0.8 kg cm⁻².

Emission uniformity

It is clear from the table 2 and figure2 that the average emission uniformity coefficient for 2 lph dripper was found to be 94.90, 93.30 and 90.00 percent at 1.2, 1.0 and 0.8 kg cm⁻² pressure, respectively. The supreme average emission uniformity (95.19 percent) was obtained at 1.2 kg cm⁻² operating pressure while the minimum average emission uniformity (90 percent) was observed at 0.8 kg cm⁻² operating pressure.

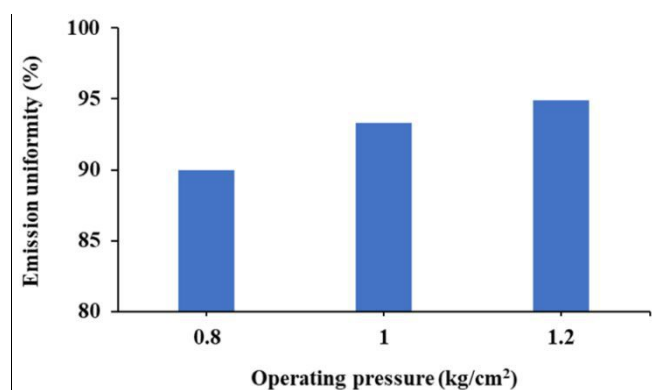


Fig 2: Emission uniformity for 2 lph dripper under different operating pressure

Distribution efficiency (E_d)

The distribution efficiency of drip irrigation system was observed for 2 lph emitters under the given operating pressure as shown in table 2. It is shown in fig 3 that the maximum distribution efficiency was found to be 95.7% at 1.2 kg cm⁻² operating pressure and minimum was 90.20% at 0.8 kg cm⁻² pressure. Thus, for a particular spacing of dripper, distribution efficiency increases with the increased pressure of the operating system for all irrigation systems. Similar findings have been reported by Kumar *et al.* 2020^[3].

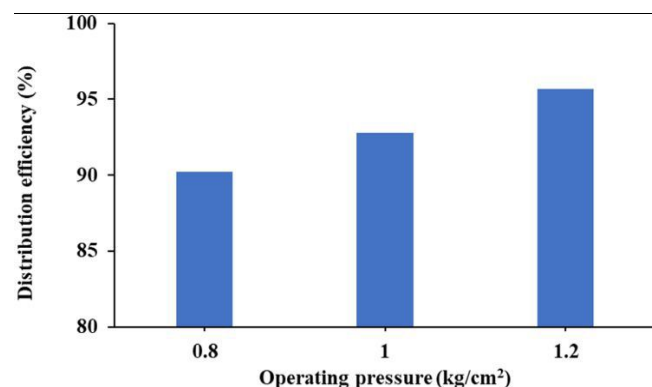


Fig 3: Distribution efficiency for 2 lph dripper under different operating pressure

Application efficiency

The data pertaining in table 2 and fig 4 depicts that the application efficiency was highest in 1.2 kg cm⁻² and lowest in 0.8 kg cm⁻², with a maximum of 98.90 percent and a minimum of 75.7 percent. The reasons for the poor

performance of the system may be due to clogging problems, poor handling, less care and lack of fittings and laterals supply, lack of skilled person knowledge about the system.

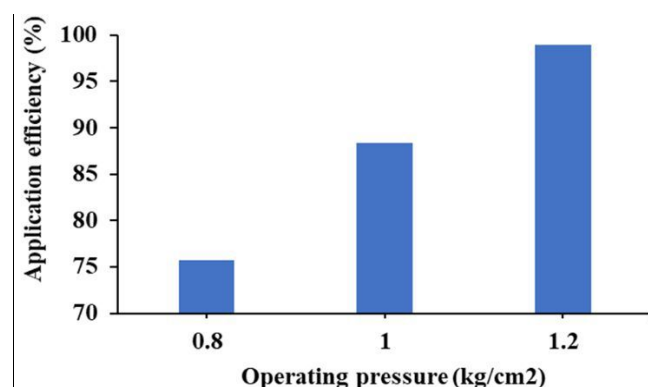


Fig 4: Application efficiency for 2 lph dripper under different operating pressure

Conclusion

Based on the result of the present study it can be concluded that the maximum average value of the hydraulic performance indicator mainly emitter discharge, emission uniformity, distribution efficiency and application efficiency obtained were 1.17 lph, 94.90 percent, 95.70 percent and 98.90 percent were obtained at 1.20 kg cm⁻² operating pressure in 2.0 lph. The average value of the hydraulic performance indicators of the drip system shows satisfactory performance of the system. Overall performance parameters of drip irrigation system were in the recommended level. Hence there is potential for the adoption of drip irrigation technology which could increase the yield and the farmer's income by increasing the extent of cultivation with the available water resource.

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