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Evaluation of hydraulic performance of drip irrigation system on papaya

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Abstract
Proper design and operating of drip irrigation system also significantly minimize water use and energy consumption. The poor design of drip irrigation system may leads 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 study the effect of different levels ofirrigation andfertigation on growth and yield of papaya during the year 2020-21 at Borsi Instructional Farm of Dau Kalyan Singh College of Agriculture and Research Station, IGKV, Bhatapara (C.G.). The experiment was laid out in the rendomized block design with nine treatments combinations and three replications. The experiment comprised of nine treatments under drip method of irrigation with combination of three irrigation regimes *viz.* 60%, 80% and 100% of cumulative pan evaporation (CPE), three different levels of fertilizer 80%, 100% and 120% of RDF. The average value of the hydraulic performance indicators namely emitter discharge, emission uniformity, distribution efficiency and application efficiency obtained were 1.87 lph, 95.19 percent, 98.07 percent and 93.58 percent, respectively at 1.2 kg cm^{-2} operating pressure in 2 lph inline dripper.

Keywords: Drip irrigation, emitter discharge, emission uniformity, distribution efficiency and application efficiency

Introduction

Rational use of irrigation water for agriculture is important for rising productivity and to save irrigation water, which is valuable and scanty resource. This can be gained by modern techniques of irrigation like trickle irrigation accompanied with other enhanced water management techniques. Drip irrigation is based on the basic approaches of irrigating root zone of crop rather than entire land surface, which results in maximum water use efficiency and crop yield. Thus, drip irrigation declines conventional losses like deep percolation, runoff and soil evaporation. It also allows the application of fertilizer, pesticides and other water-soluble chemicals applied with irrigation water with healthier crop response. Drip-irrigation is found to be an effective method for reducing water application and increasing water use efficiency by applying uniform water directly to root zones of each plant, particularly in areas where rainfall is scarce and irrigation water is very expensive. (Sinha and Shashikant, 2021) [5]. Drip irrigation evaluation in the field under a set of different operating conditions is very important to ensure the desired discharge to all the growing crops. 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. The distribution uniformity of water is one of the important parameters to characterize drip emitters and design of a drip irrigation system. The different measures for hydraulic performance of drip irrigation system are very useful for effective design and operation of the system (Gil *et al*., 2002) [2]. The coefficient of uniformity (CU) and the distribution uniformity (DU) generally increase with increasing heads and decrease with increasing slope. The CU generally followed a linear relationship with either head or slope (Ella *et al*., 2009) [1].

Operating pressure is considered a very important in drip irrigation system design. Therefore, not accurate operating pressure leads to lack of performance and failure of the system (Valipour, 2012) [6]. Nevertheless, due to the lack knowledge of uniformity parameters, under varied operating pressures, this system is still facing problems of supplying water uniformly throughout the field. Therefore, this study aims to evaluate the hydraulic performance of drip irrigation system, under different operating in the study area.

Material and Methods

Experimental site: The field experiment was conducted at the Borsi Instruction Farm of Dau

Kalyan Singh College of Agriculture and Research Station, Bhatapara (C.G.). This is situated 21º44'17" N latitude and 81º59'32" E longitude in the year 2020-21. It has an average elevation of 273 meter above sea level.

Emitter Discharge: Emitters having discharge capacity i.e. 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 drippers 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:

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

Where

EU = the field test 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 values

Emission uniformity	Classification
90% or greater	excellent
80 to 90%	good
70 to 80%	fair
less than 70%	poor

Distribution efficiency (Ed)

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,

$$Ed = 100 *[1-\frac{\Delta q_a}{q_m}]$$

Where

Ed = 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

$$\Delta q_a = [\frac{q_r - q_{ave}}{q_{ave}}] * 100$$

q_r = rated flow, lph

q_{avg} = Average emitter flow rate, lph

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 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,

$$E_a = 100 (\frac{q_{min}}{q_{avg}})$$

Where

Ea= application efficiency, %

qmin = minimum emitter flow rate, lph

qavg = average emitter flow rate, lph

Average emitter flow rate can be expressed by equation

$$q_{avg} = \frac{v_w}{N\,T}$$

Where

Vw = total volume of water applied, l

N = total number of emitter

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 parameters of drip irrigation system

S No.	Emitter	Parameters	Operating pressure (kg cm^2)		
			0.8	1.0	1.2
1	2 lph		1.16	1.74	1.87
2			89.65	93.10	95.19
3			93.37	96.79	98.07
4			86.21	91.95	93.58

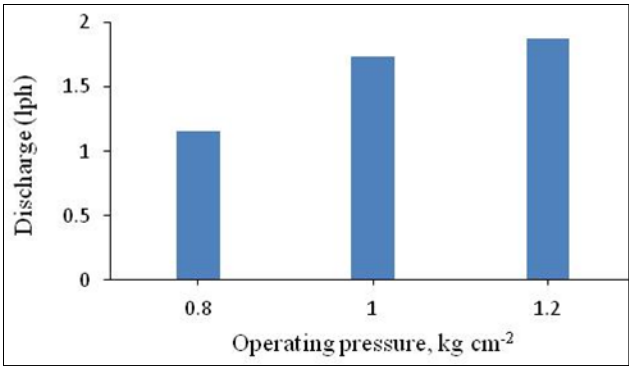

Fig 1: Effect of operating pressure on emitter discharges

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 1.87 lph was found to be maximum at 1.2 kg cm^{-2} operating pressure and a minimum of 1.16 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 95.19, 93.10 and 89.65 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 (89.65 percent) was observed at 0.8 kg cm^{-2} operating pressure.

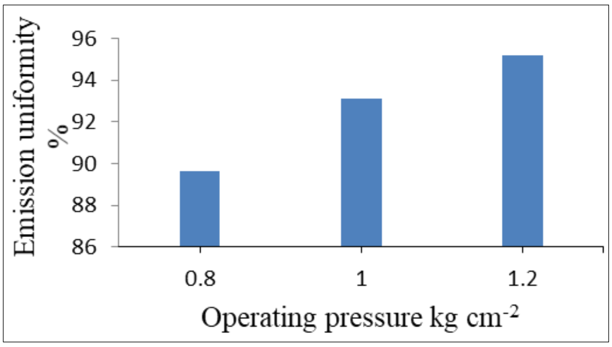

Fig 2: Effect of operating pressure on emission uniformity

Distribution Efficiency

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 98.07% at 1.2 kg cm^{-2} operating pressure and minimum was 93.37% 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 *el al.* 2020.

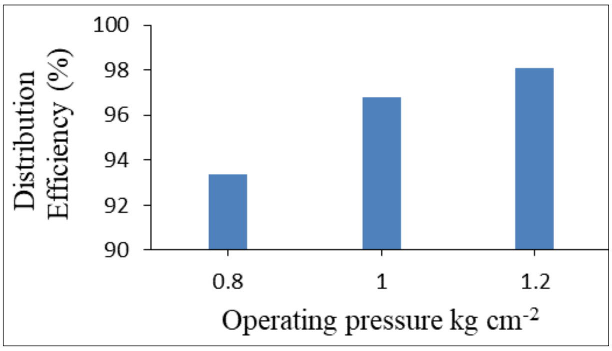

Fig 3: Effect of operating pressure on emission uniformity

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 93.58 percent and a minimum of 86.21 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.

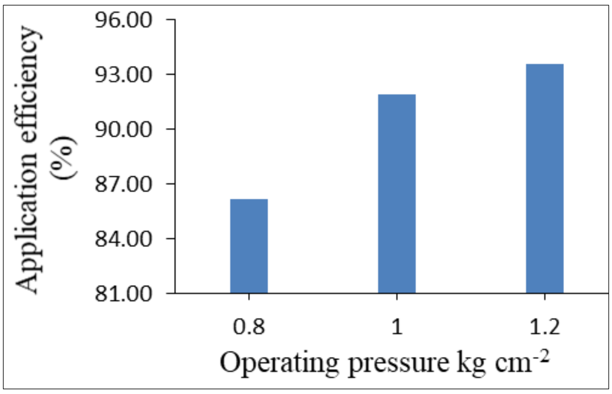

Fig 4: Effect of operating pressure on emission uniformity

Conclusion

Based on the results of present investigation it can be conclude that the maximum average value of the hydraulic performance indicators namely emitter flow rate, emission uniformity, distribution efficiency, and application efficiency obtained were 1.87 lph, 95.19%, 98.07%, and 93.58%, respectively at 1.2 kg cm^{-2} operating pressure in 2 lph dripper. The average value of the hydraulic performance indicators of the drip system show 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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