RESEARCH ARTICLE Agricultural Science Digest, Volume 41 Issue 1: 89-92 (March 2021)

Study of the Hydraulic Performance Parameters of the Drip Irrigation System at Various Operating Pressures

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10.18805/ag.D-5192

ABSTRACT

Background: Drip irrigation system is one of the best water application methods that have been used in the world among the other irrigation methods because of its upright and high uniformity and high-water use efficiency. Hydraulic performance evaluation is widely accepted for the evaluation of overall uniformity of a drip irrigation system.

Methods: In an experimental study carried out at School of Engineering, RK University, Rajkot; hydraulic performance evaluation parameters *viz*., Pressure discharge relationship, Christiansen's uniformity coefficient (CU), manufacturing coefficient of variation (CVm) and emission uniformity (EU) of non-pressure compensating emitters were calculated for 2 lph inline and 2 lph, 4 lph, 8 lph online emitter at various operating pressure of 0.8, 0.9, 1.0, 1.1 and 1.2 kg/cm^2 as per American Society of Agricultural and Biological Engineers (ASAE) standards.

Result: The study concluded that rated discharge of the emitter can be obtained at the operating pressure of 1.0 kg/cm^2. Pressure discharge relationship revealed that discharge of the emitter upsurges as pressure rises. CU and EU were more than 95% for all the cases and they were maximum at 1.0 kg/cm^2. CV_m was less than 0.0200 for all the cases and it was minimum at 1.0 kg/cm^2. Study concludes that all the parameter *viz*., CU, EU and CV_m were excellent and very good categories for all emitters as per American Society of Agricultural and Biological Engineers (ASAE) standards.

Key words: Christiansen's uniformity, Drip irrigation, Emission uniformity, Performance evaluation.

INTRODUCTION

Water is the most valuable gift of nature and is the utmost vital matter in our progress and our daily lives. Life as we know it would not have been thinkable if there was no water there would be no life on this planet. Water is also important for the healthy growth of farm crops and farm stock and is used in the production of many goods. It is also used in generating hydroelectricity and the farmers need water for growing crops and plants. It is necessary to cut down the use of water in agriculture to bring more area under irrigation, reduce the cost of irrigation per hectare and increase the yield per unit area and unit quantum of water. This can be achieved only by introducing advanced water saving irrigation methods like drip irrigation with improved water management practices.

Drip irrigation system is one of the finest water application approaches that have been used in the world among the other irrigation methods because of its upright and high uniformity and high-water use efficiency. In drip irrigation system water is applied regularly and small quantities of irrigation water at essential points of a field surface/subsurface near the plants. Drip irrigation has advanced ability for minimalizing the loss of water by evaporation, runoff and deep percolation in contrast to other irrigation systems that supply water to the soil surface (Alizadeh, 2001). With drip irrigation water and fertilizer necessities can be applied directly to the plant root zone with least losses which is called fertigation, maintaining uniform moisture in the soil profile. In addition, drip irrigation system has the benefit of fitting to hard landscape. Less interruption with cultural operations and improved cultural practices allows field operations even during irrigation, less nutrient and chemical leaching and deep percolation, reduced weed germination and growth, reduced pest and disease damages due to drier and less humid crop canopies, warmer soils, no soil crusting due to irrigation and also well suited to widely spaced crops.

The drip irrigation system efficiency is allied with application uniformity and water losses that can be assessed by direct measurements of emitter flow rates. If the water losses are high or distribution uniformity is poor, it would result in low application efficiency. However, the distribution of water as measured in the field does not really signify the distribution of moisture in the soil. The initial cost of the system, operating cost and crop yield response to irrigation, all are related to the uniformity of water application.

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How to cite this article: Kapupara, P.J., Bhatu, H.M. and Gohel, J. (2021). Study of the Hydraulic Performance Parameters of the Drip Irrigation System at Various Operating Pressures. Agricultural Science Digest. 41(1): 89-92. DOI: 10.18805/ag.D-5192.

Submitted: 14-04-2020 **Accepted:** 09-09-2020 **Online:** 19-12-2020

MATERIALS AND METHODS

The study was conducted at School of Engineering, RK University, Rajkot in 2019. RK University is located at 22.24° N latitude and 70.90° E longitude with an altitude of 74 m above mean sea level. The climate of the Rajkot is subtropical and semi-arid type with an average annual rainfall of 674 mm and average annual pan evaporation of 8.23 mm/day.

Installation of drip irrigation system

Drip irrigation system with head control unit in which non-return valve, fertigation unit, pressure gauge, disc filter, water meter and air release valve were installed in the field. Water distribution system consisting integral dripper line of 16 mm diameter with emitter spacing of 40 cm was laid out in the experiment field. The dripper lines of 10 m length were laid at 1.2 m apart. Emitters with different discharge rates of 2 lph, 4 lph, 8 lph online and 2 lph inline were used for study. Control valves was provided at each treatment with 3 lateral lines to facilitate the operation of the system according to irrigation time. The field layout plan of experiment is presented in Fig 1.

Hydraulic performance evaluation of drip system

Hydraulic performance evaluation of the drip irrigation system was carried out based on a method suggested by ASAE (ASAE Standards, 1996). The system was tested for its uniformity coefficient (CU), emission uniformity (EU), manufacturing coefficient of variation (CV_m) and Pressure-discharge relationship. Drippers discharge capacity *i.e.* 2.0, 4.0, 8.0 lph online and 2.0 lph inline is tested at various operating pressure *i.e.* 0.8, 0.9, 1.0, 1.1 and 1.2 kg/cm^2. Control valve and bypass valve were used to control the pressure of the whole system at desired operating pressure. Pressure gauge was used for measuring the value of pressure of system as well as each lateral line. For measuring the discharges 3 drippers per each lateral were selected. Plastic containers were used to collect the water emitting from the emitter. Water collected in an hour in containers was measured with the help of measuring cylinder.

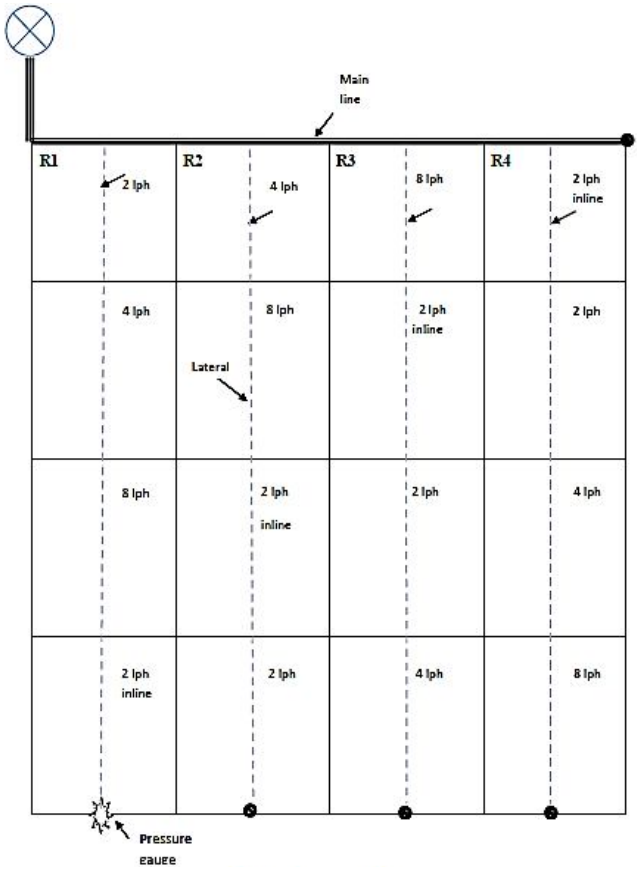


Fig 1: Experiment field layout.

Pressure discharge relationship

The pressure discharge relationships were determined by following equation (Karmeli, 1997; Wu and Gitlin, 1977).

$$Q = K H^X \quad \ldots(1)$$

Where, Q = Discharge rate of drippers (lph), K = Discharge coefficient, H= Pressure Head (kg/cm^2), X= Dripper flow exponent.

Uniformity coefficient (UC)

The degree of emitter flow variation can expressed by the uniformity coefficient. UC was calculated by the following formula (El-Nemr, 2012).

$$UC=1 - \frac{\sum_{i=1}^{n} q_i - q_a}{q_a \times n} \times 100 \quad \ldots(2)$$

Where, n = number of observed emitters, q_i = emitter flow rate (lph), q_a = average of emitters flow rates (lph).

Emission uniformity (EU)

Emission uniformity shows relationship between minimum and average emitter discharge.

$$EU=100[1-1.27Cv/ (\sqrt{n})] (q_{min}/q_{avg}) \quad \ldots(5)$$

Table 1: Uniformity classification based on uniformity coefficient.

Uniformity coefficient	Interpretation
90% or greater	Excellent
80 to 90%	Very good
70 to 80%	Fair
60 to 70%	Poor
less than 60%	Unacceptable

(Source: ASAE Standard EP 458, 1996).

Table 2: Classification of emission uniformity.

EU range	Merriam and Keller (1978)	IRYDA(1983)
<70%	Poor	Unacceptable
70-80%	Acceptable	Poor
80-86%	Good	Acceptable
86-90%	Good	Good
90-94%	Exclent	Good
>94%	Exclent	Exclent

Where, EU = Emission uniformity, Cv = Manufacturer's coefficient of variation, n = Number of emitters per lateral for crop, q_{min} = Minimum emitter discharge rate for the minimum pressure in the section (lph), q_{avg} = Average emitter discharge rate for the all emitter on the lateral (lph).

Coefficient of manufacturing variation (CV_m)

Coefficient of manufacturing variation (CV_m) was calculated to measure of emitter flow variation caused by variation in manufacturing of the emitter.

$$CV_m = S/q \quad \ldots(3)$$

Where, CV_m = Manufacturing coefficient of variation, S = sample standard deviation, q= Average emission rate of sample.

Standard deviation can be calculated by following equation,

$$S = \sqrt{\sum_{i=1}^{n}(q_i - q_a)^2} \quad \ldots(4)$$

Where, n = number of observed emitter, q_i = emitter flow rate (lph), q_a = average of emitters flow rates (lph).

RESULTS AND DISCUSSION

Emitters with different discharge rates of 2 lph, 4 lph, 8 lph online and 2 lph inline were selected for computing discharge variation at 0.8, 0.9, 1.0, 1.1 and 1.2 kg/cm^2. Volume at various operating pressure for 9 individual emitters was collected for the period of 1 hour. Study showed that minimum discharge of emitters was at 0.8 kg/cm^2, while it was found maximum at 1.2 kg/cm^2 operating pressure. The results clearly showed that as the operating pressure amplified, discharge of emitters also increases.

Pressure Discharge Relationship

Obtained Pressure discharge relationship is shown in the Table 4. Coefficient of determination (R^2) is also shown in the Table 4. Result shows that discharge coefficient was found 2.168, 2.145, 4.093 and 8.444 for 2 lph Inline and 2 lph, 4 lph, 8 lph online emitters respectively. Similarly, exponent was found as 0.4735, 0.473, 0.4449, 0.4437 respectively. From the Table 4 it can be concluded that exponent (x) and discharge coefficient (K) of emitters was obtained when operating pressure was kept at 1.00 kg/cm^2.

Uniformity coefficient (CU)

Uniformity Coefficient at various operating pressures was calculated as per Christiansen's formula. CU of different emitters at various operating pressure are depicted in Figure 2. It was observed that maximum CU obtained were 98.83, 98.67, 98.83 and 98.45at 1 kg/cm^2 operating pressure for 2 lph Inline and 2 lph, 4 lph, 8 lph online emitters respectively. All the emitters fall under excellent category, As per ASAE (1996) recommendation.

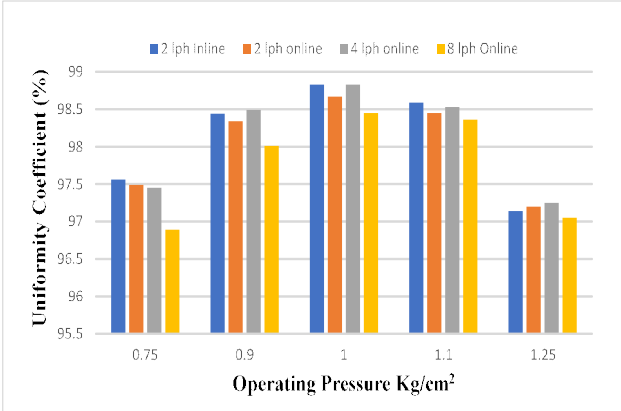


Fig 2: Uniformity coefficient at various operating pressures.

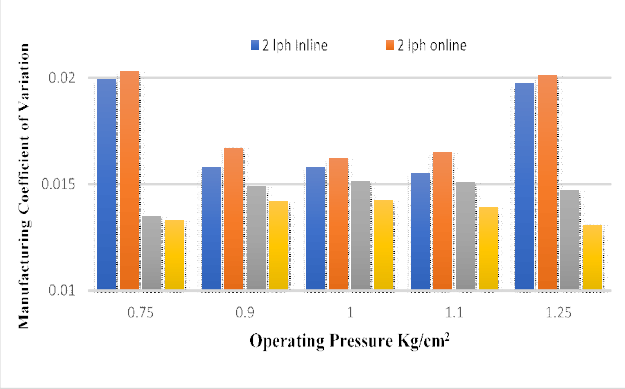


Fig 3: Manufacturing coefficient of variation at various operating pressures.

Table 3: Interpretation of manufacturing coefficient of variation.

Emitter type	Manufactures Coefficient	Interpretation
Point source	< 0.05	Excellent
	0.05- 0.07	Average
	0.07-0.11	Marginal
	0.11- 0.15	Poor
	> 0.15	Unacceptable
Line source	< 0.10	Good
	0.10-0.20	Average
	>0.20	Marginal to unacceptable

(Source: ASAE Standard 405.1,2005).

Table 4: Pressure discharge relationship for various emitter rating.

Emitter rating	Developed model	Discharge coefficient	Exponent	R^2
2 lph Inline	$y = 2.1684x^{0.4735}$	2.168	$R^2 = 0.9994$	0.4735
2 lph online	$y = 2.1457x^{0.473}$	2.145	$R^2 = 0.9994$	0.473
4 lph online	$y = 4.0937x^{0.4449}$	4.093	$R^2 = 0.9959$	0.4449
8 lph online	$y = 8.4443x^{0.4437}$	8.444	$R^2 = 0.9956$	0.4437

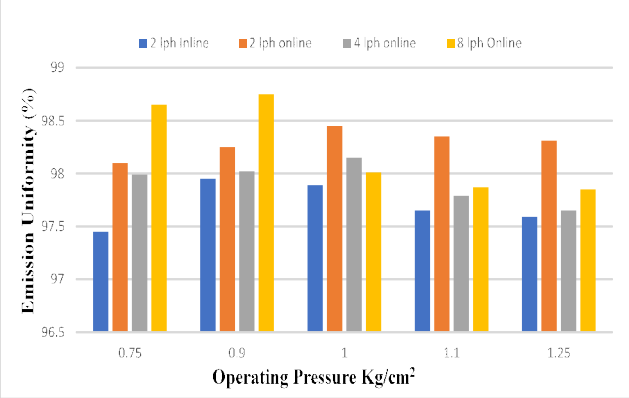


Fig 4: Emission uniformity of variation emitters at various operating pressure.

Manufacturing coefficient of variation

Variation in discharge for a sample of different emitters can be estimated by the manufacturing coefficient of variation (CVm). CVm of different emitters at various operating pressure are depicted in Fig 3. It was observed that minimum CVm obtained were 0.0158, 0.0162, 0.0151 and 0.0142 at 1 kg/cm^2 operating pressure for 2 lph Inline and 2 lph, 4 lph, 8 lph online emitters respectively. All emitters fall under excellent and good category, As per ASAE (2005) recommendation.

Emission uniformity

The study revealed that the maximum Emission Uniformity EU was obtained as 97.89, 98.45, 98.15 and 98.10 at 1 kg/cm^2 operating pressure for 2 lph Inline and 2 lph, 4 lph, 8 lph online emitters respectively. All emitters fall under excellent category as per Merriam and Keller (1978) recommendation and categorized as excellent and good as per IRYDA (1983) recommendation. Fig 4 shows the Emission uniformity of variation emitters at various operating pressure.

CONCLUSION

Hydraulic performance evaluation parameters *viz.*, pressure discharge relationship, uniformity coefficient, manufacturing coefficient of variation and emission uniformity of drip irrigation system was calculated in field at various operating pressure. It was concluded that the hydraulic performance of all the emitters is good when operating pressure is 1 kg/cm^2. Emitter discharges water at its rated discharge rate at 1 kg/cm^2 operating pressure. The values of CU, CVm and EU obtained at 1 kg/cm^2 falls under excellent and very good category for emitters as per the ASAE standard.

REFERENCES

Alizadeh, A. (2001). Principles and Practices of Trickle Irrigation. Ferdowsi University, Mashad, Iran.

ASAE Standards. (2005). EP405.1 FEB03. Design and Installation of Microirrigation Systems. ASAE, St. Joseph, Michigan.

ASAE Standards, (1996). EP458. Field Evaluation of Microirrigation Systems. 43rd ed. St. Joseph, Mich. ASAE: 756-761.

El-Nemr, M.K. (2012). An interactive spreadsheet for drip irrigation system uniformity parameters evaluation. International Journal of Agriculture Sciences. 4(4): 216-220.

IRYDA. (1983). Rules for the Drafting of Localized Irrigation Projects. Ministry of Agriculture, Fisheries and Feeding. Madrid (in Spanish).

Karmeli, D. (1977). Classification and flow regime analysis of drippers. Journal of Agricultural Engineering Research. 22: 165-173.

Merriam, J.L., Keller, J. (1978). Farm irrigation system evaluation. A guide for management. UTAH State University. Logan, UTAH, USA.

Wu, I.P., Gitlin, H.M. (1977). Drip irrigation efficiency and schedules. Transactions of the American Society of Agricultural Engineers. 26(1): 92-97.