Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 8 [2] January 2019 : 37-42

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.876
Universal Impact Factor 0.9804
NAAS Rating 4.95

ORIGINAL ARTICLE **OPEN ACCESS**

Temporal Effects on the Performance of Emitters

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ABSTRACT
Drip or trickle irrigation is the method of irrigation which is becoming increasingly popular in areas with water scarcity and salt problems. Drip irrigation is making a positive impression on sustainable agriculture in India. Very high water application efficiency (90-95%) can be obtained through drip irrigation method. In order to be efficient, a drip system must apply water uniformly throughout the area. This is accomplished by having little variation in flow rate among drippers (high emission uniformity). Drippers are generally specified according to their flow rate, for example, 4 L/h. This flow rate is a nominal discharge rate at a specified pressure, generally 100 Kpa found that different types of emitters had different susceptibilities to clogging, but for any particular type of emitter, clogging sensitivity was inversely proportional to the discharge of the emitter. The experiment was conducted at College of Agricultural Engineering, J.N.K.V.V., Jabalpur, (M.P) to study the characteristics of drippers and to compare the performance of new and used drippers. In 2 lph dripper size, the average uniformity coefficient 87.57 (excellent) for new dripper, 69.58 (fair) for 2 years used drippers, and 43.92 (unacceptable) for 4 years used drippers.
Keywords: *Uniformity coefficient, Discharge, Flow rate, Pressure, Emitter*

Received 22.09.2018 Revised 29.11.2018 Accepted 13.12.2018

INTRODUCTION

Drip or trickle irrigation is the method of irrigation which is becoming increasingly popular in areas with water scarcity and salt problems. It is a method of watering plants frequent and slow application of water to the soil near the root zone of the plant, thereby minimizing conventional losses such as deep percolation, runoff and soil water evaporation. Drip irrigation is making a positive impression on sustainable agriculture in India. Drip irrigation has proved its superiority over other conventional method of irrigation, especially in the cultivation of fruits and vegetables due to precise and direct application of water in root zone [1-3].

The principle of drip irrigation is to irrigate the root zone of the plant to get minimal wetted soil surface. Very high water application efficiency (90-95%) can be obtained through drip irrigation method. Drip irrigation technology has been developing in many parts of the world since the late 1950s. Vast improvements have been made, so that modern equipment is very efficient and has overcome many of the earlier problems encountered. Drip irrigation in its present form has become compatible with plastics that are durable and easily moulded into a variety and complexity of shapes required for pipe and emitters. The emitters is also known as drippers or drip nozzles which emit water in the form of drops and its flow rates not exceeding 15 lph except during flushing, under operating pressure of at least 1 kg/cm^2. Clogging of emitters is one of the most important aspects that affect the performance of micro irrigation systems. Emitters clogging may be due to poor quality of water that is being used or may be due to inadequate pressure under which the system in operation. Some of the factors affecting in drip irrigation designing include inlet pressure, it is one of the most important factors in drip irrigation design. If the inlet pressure head becomes greater than the required pressure head; it may cause water back-flow and if the inlet pressure head becomes lower than the total required pressure head, it may create negative pressure at the lateral which will affect the distribution uniformity. Consequently, to avoid both problems, the inlet pressure head must be determined precisely to balance the energy gain due to inlet flow and the total required pressure head within the lateral [4-7].

Enough work has been done to evaluate the performance of new drippers (emitters) under laboratory and field conditions, as indicated by the literature reviewed. It is necessary to evaluate the performance of used drippers to assess its usefulness and decide replacement policy.

Study Area:

The experiment was conducted at College of Agricultural Engineering, J.N.K.V.V., Jabalpur, (M.P). The soil of the Jabalpur region is broadly classified as vertisol as per norms of U.S. classification. It has medium to deep depth and black in colour. It has ability to swell after wetting and to shrink after drying. Thus, it develops deep and wide cracks on the surface during summer season. It has poor workability under excessive dry as well as wet conditions.

MATERIAL AND METHODS

Parameters used to evaluate performance of drip emitters:

Uniformity Coefficient:

Uniformity is an important parameter in the design and operation of micro irrigation systems. A higher level of uniformity leads to a more uniform distribution of water and nutrients in the soil; however, the initial installation costs of systems with greater uniformity values are relatively high, although the long-term ownership costs might be less for higher uniformity systems. Uniformity Coefficients of emitters were tested using the Christiansen's formula. It gives the information that how efficiently water is distributed in the field.

$$Cu = 100(1-\sum X/mn) \quad \text{………… (eq. 1)}$$

Where

Cu = coefficient of uniformity

m = Average value of all observations

n = Total number of observation points

X =Numerical deviation of all observation points from the average application rate.

Coefficient of variation:

The coefficient of variation (Cv) is defined as the ratio of standard deviations of the discharges. In the lateral design, emitter flow variation is used as a design criterion. The emitter flow variation comprises hydraulic variation and due to manufacturing variation among the emitters. The latter depends on the quality control in production. The unit to unit variation in the emitter flow is expressed by the following relationship

$$Cv = S/q \quad \text{……… (eq. 2)}$$

Cv= Manufacturing coefficient of variation

S= sample standard deviation

q= Average emission rate of sample

Classification of manufacturer's coefficient of variations -

Emitter type	Cv range	Classification
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

Emission Uniformity (EU):

In drip irrigation, ideally the application of water throughout the system should be uniform. It is necessary that the flow rates through the system should be uniform even though the pressure is not uniform [8]. In a well-designed drip irrigation system, the emission uniformity (EU) for emitters should be above a specific threshold level. The EU is a function of the expected discharge variation due to pressure variation throughout the system. Basically, EU is the ratio of the minimum emitter discharge to the average discharge of all the emitters under consideration, which can also be expressed as a percentage [9]. An acceptable value of EU can be obtained by limiting the variation of pressure in the system. Limiting the pressure variation can decrease the variation of discharge in the emitters. [10] recommended that EU should be at least 85% for drippers on flat terrain. Therefore, each lateral can be imagined as a larger emitter. This idea was first suggested by [9] and applied by [8] for pressure distribution along the manifold. The emission uniformity is given as:

EU= 100 [1-1.27Cv/ (n)] (q_{min}/q_{avg}) ……… (eq. 3)

Where,

EU = Emission uniformity
Cv = Manufacturer's coefficient of variation
n = Number of emitters
q_{min} = Minimum emitter discharge rate for the minimum pressure in the section.
q_{avg} = The average emitter discharge rate, (lph)

Classification of Emission Uniformity -

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

RESULTS AND DISCUSSION

The comparison between new vs. used drippers of 2lph, 4lph, and 8 lph sizes is done and the results are listed below –

Uniformity Coefficient:

In 2 lph dripper size, the average uniformity coefficient 87.57 (excellent) for new dripper, 69.58 (fair) for 2 years used drippers, and 43.92 (unacceptable) for 4 years used drippers as show in Table 1. It indicates that 4 years used dripper should not be used for irrigation as it will result into poor uniformity in application of water.

Table 1: Uniformity coefficient of 2 lph dripper at different operating pressure

Pressure, (Kpa)	New	2 years used	4 years used
60	87.07	65.91	42.61
80	87.24	69.58	43.92
100	78.18	60.81	41.29
120	87.57	61.07	43.08
140	87.05	59.07	40.15
Average	87.57	69.58	43.92

In 4 lph size dripper the uniformity coefficient is higher for new dripper followed by 2 years used dripper and lower for 4 years used dripper as shown in Table 2. The average value of Cu is 95.91 (excellent), 84.75 (very good), and 35.70 (unacceptable) resp. in new, 2 years and 4 years used drippers.

Table 2: Uniformity coefficient of 4 lph dripper at different operating pressure

Pressure, (Kpa)	New	2 years used	4 years used
60	95.91	84.09	35.14
80	96.73	85.69	36.50
100	95.69	84.21	35.97
120	94.03	86.30	35.64
140	95.26	84.66	36.65
Average	95.91	84.75	35.70

Similarly in case of 8 lph size drippers the uniformity coefficient is higher for new dripper followed by 2 years used dripper and lower for 4 years used dripper as shown in as shown in Table 3. The average value of Cu is 94.33 (excellent), 95.03 (excellent), and 63.42 (poor) resp. in new, 2 years and 4 years used drippers.

Table 3: Uniformity coefficient of 8 lph dripper at different operating pressure

Pressure, (Kpa)	New	2 years used	4 years used
60	94.05	96.16	62.61
80	93.93	95.53	63.96
100	94.38	95.77	63.03
120	95.04	94.13	64.13
140	93.78	97.55	64.74
Average	94.33	95.03	63.42

Coefficient of variation (Cv):

The Cv value at different size of dripper existing drip irrigation system during the study for selected field are given in Table 4. It may be observed from the following Tables that the average Cv value of 2 lph in the range from 0.05 (excellent), 0.33 (unacceptable), and 0.46 (unacceptable) resp. in new, 2 years used and 4 years used drippers respectively. Coefficient of variation shows that all new drippers are in excellent class and used drippers are in unacceptable class at all operating pressure heads as presented by [9]. It depends on the quality of the material used and temperature differences during manufacturing.

Table 4 : Coefficient of variation of 2 lph drippers at different operating pressure

Pressure, (Kpa)	New	2 years used	4 years used
60	0.05	0.36	0.48
80	0.05	0.35	0.45
100	0.04	0.33	0.46
120	0.05	0.32	0.44
140	0.04	0.30	0.49
Avg.	0.04	0.33	0.46

Similarly in case of 4 lph drippers, the Table 5 shows that the Coefficient of variation of all new drippers are in excellent class and used drippers are in unacceptable class at all operating pressure heads.

Table 5: Coefficient of variation of 4 lph drippers at different operating pressure

Pressure, (Kpa)	New	2 years used	4 years used
60	0.02	0.16	0.80
80	0.02	0.17	0.76
100	0.01	0.17	0.73
120	0.02	0.20	0.77
140	0.01	0.17	0.72
Average	0.02	0.17	0.77

In case of 8 lph size drippers when the Cv value compared between the new and used drippers the result shows with the help of Table 6 that new and 2 years used dripper comes under the excellent category as compared to 4 years used dripper which comes under unacceptable class.

Table 6: Coefficient of variation of 8 lph drippers at different operating pressure

Pressure, (Kpa)	New	2 years used	4 years used
60	0.03	0.03	0.25
80	0.05	0.05	0.22
100	0.05	0.04	0.25
120	0.06	0.05	0.21
140	0.05	0.07	0.25
Avg.	0.05	0.06	0.25

Emission uniformity (EU):

The emission uniformity of the drippers (NPC) at different operating pressures is presented in Table 7 which shows the result that 2 lph size drippers performed excellent at the pressure range of 60 to 140 Kpa, with the emission uniformity of 85.27 to 91.32 and 82.54 to 92.23 percent resp. in new and 2 years used drippers but in case of 4 years used drippers they performed very poor at all operating pressure.

Table 7: Emission uniformity of 2 lph at different operating pressure

Pressure, (Kpa)	New	2 years used	4 years used
60	85.87	91.66	18.74
80	89.27	92.23	18.71
100	91.32	85.71	17.91
120	90.92	89.16	18.43
140	89.58	82.54	19.54

Similarly 4 lph size dripper's emission uniformity as depicted in Table 8. The result shows that the drippers performed excellent at the pressure range of 60 to 140 Kpa, with the emission uniformity of 87.04 to 96.92 percent in new drippers but in case of 2 and 4 years used drippers they performed very poor at all operating pressure.

Table 8: Emission uniformity of 4 lph at different operating pressure

Pressure, (Kpa)	New	2 years used	4 years used
60	79.04	61.16	31.11
80	96.92	58.24	32.20
100	96.05	59.98	30.38
120	96.70	57.77	31.63
140	96.27	55.31	30.16

In 8lph size drippers the result shows that the drippers performed excellent at the pressure range of 60 to 140 Kpa as depicted in Table 9, with the emission uniformity of 81.34 to 89.13 and 82.44 to 92.92 percent resp. in new and 2 years used drippers but in case of 4 years used drippers they performed very poor at all operating pressure, this is the indication that the performance of 4 years used drippers is affected by clogging due to continuous used.

Table 9: Emission uniformity of 8 lph at different operating pressure

Pressure, (Kpa)	New	2 years used	4 years used
60	89.13	91.29	59.98
80	88.29	92.92	48.43
100	88.00	91.07	49.63
120	81.34	91.49	48.91
140	83.47	82.44	48.57

The above results show that the uniformity coefficient, coefficient of variation and emission uniformity for 2 years used drippers of all sizes at all operation pressure is within the acceptable limit, where values of above parameters for 4 years used drippers are in non- acceptable class, hence it can be concluded that drippers should not be used after 2 years.

CONCLUSION

Performance of new drippers of 2 lph, 4 lph and 8 lph size is excellent class. Performance of 2 years used drippers is very good to fair class and 4 years used drippers is poor to unacceptable class. Drippers should be cleaned and maintained regularly to give better uniformity even after 2 years otherwise replaced after 2 years of use.

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CITATION OF THIS ARTICLE

Ayushi Trivedi and Avinash Kumar Gautam. Temporal Effects on the Performance of Emitters. Bull. Env. Pharmacol. Life Sci., Vol 8 [2] January 2019: 37-42