IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
ISSN: 2319-2380, ISBN: 2319-2372. Volume 2, Issue 1 (Jan. - Feb. 2013), PP 15-20
www.iosrjournals.org

Hydraulic Performance of Drip Emitters under Field Condition

Pankaj Sharma

Abstract: *A field study was undertaken to evaluate the performance of on – line non pressure compensating drip emitters of 2, 4 and 8 lph discharge ratings. The system was tested for its uniformity coefficient, emission uniformity, manufacturing coefficient of variation and head discharge relationship. The study revealed that for better discharge of on-line emitters of 2, 4 and 8 lph capacity, optimal pressure of 40, 70 and 100 KPa is required respectively to achieve uniformity coefficient of more than 90%. In 2, 4 and 8lph capacity emitters, emission was 86.73, 84.37 and 91.6 per cent respectively. Manufacturing coefficient of variation for different emitters having 2, 4 and 8 lph capacity was 0.165, 0.171 and .101 respectively.*

For inline emitter of 1.3 lph capacity, optimal pressure 100 kPa is required to achieve uniformity coefficient of 85% and emission was 85.81 per cent respectively. Manufacturing coefficient of variation for the 1.3lph capacity emitter was .128 respectively.

Keywords: *Discharge, pressure, irrigation, emitter, manufacturing coefficient of variation, uniformity coefficient.*

I. Introduction

For achieving high effectiveness of water, use drip irrigation is one of the most appropriate technologies in modern irrigated agriculture with great potential. It also leads itself to easy adoption for chemigation and automation. Drip system permits the controlling of discharge and flexibility in time of water application. It saves water to extent of 30 to 70 per cent without significantly affecting the crop yield *(Satpute and Pandey, 1989; and Pandey et al., 2003)*. Drip irrigation systems are widely used for irrigating orchards, vegetables, spices, cash crops like sugarcane and cotton and the area covered under this system is about 3.5 lakh ha in India (kumar,2001).

In drip irrigation system, water is delivered precisely through the emitters. The capacity of the emitters available in the market varies from 2 to 16 lph. These are categorized as pressure and non-pressure compensating. The former show no variation in discharge due to the corresponding change in the pressure head but in the latter the discharge changes with pressure. Little scientific information is available on the flow characteristics of different emitters under operating pressure. Keeping this in view a field test was done to evaluate the hydraulics of on-line, non-pressure compensating emitters of different discharges ratings.

II. Materials And Methods

A drip irrigation system was installed in is the demonstration farm of IIT Roorkee(uttarakhand) located at $29^0$50’05.4” N latitude and $77^0$55’17.7”E longitude with an altitude of 248m above mean sea level.(fig1). The system was tested for its uniformity coefficient, emission uniformity, and manufacturing coefficient of variation. Pressure gauges readings were noted when they attained a constant value .cans was used for discharge collection and the collected water was measured in a measuring cylinder.

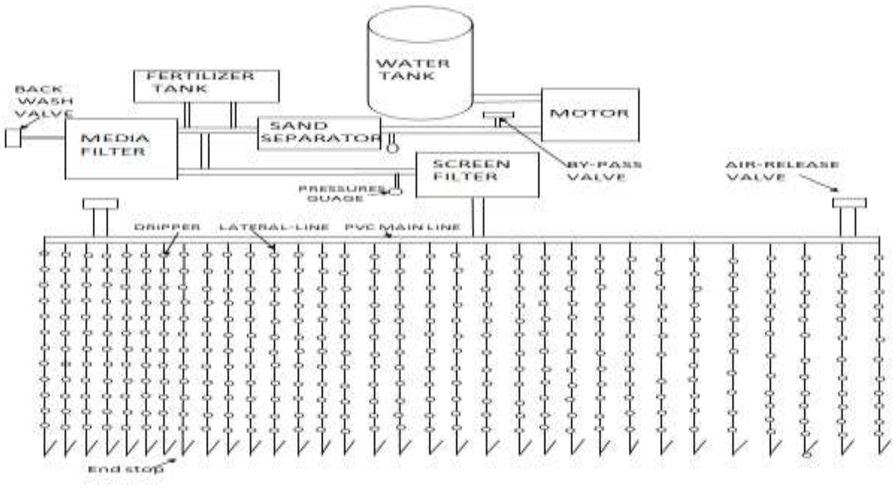


Fig. Experimental of the drip irrigation system layout in the field

III. Performance Evaluation

Uniformity coefficient

Uniformity coefficients of emitters were tested using the Christiansen's formula(1942). It gives the information that how efficiently water is distributed in the field.

$$Cu = 1000(1-\sum X / mn) \qquad \ldots\ldots (1)$$

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.

Emission uniformity

The coefficient of variation is defined as the ratio of standard deviations of the discharges (Madramootto, 1988), and is given by

$$EU = 100\,[1-1.27Cv/ (n^{0.5})]\,(q_{min}/q_{avg}) \qquad \ldots\ldots (2)$$

Where EU = Emission uniformity

C_V = Manufacturer's coefficient of variation

n= Number of emitters per plant for trees and shrubs

q_{min} = Minimum emitter discharge rate for the minimum pressure in the section

The emission uniformity of the water application varies with pressure, emitter variation, and number of emitters discharging. For a point source of drip irrigation system installed in uniform topography recommended value of EU ranges from 85-90 %(ASAE, 1989).

Manufacturing coefficient o variation

The coefficient of variation (C_V) is defined as the ratio of standard deviations of the discharges (Madramootto, 1988). 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 was expressed by the following relationship:

$$C_V = S / q \qquad \ldots\ldots (3)$$

Where C_V = Manufacturing coefficient of variation

S = sample standard deviation

q= Average emission rate of sample

Table 1: Classification of manufacturer's coefficient of variations

Emitter type	C_V 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

Head – discharge relationship

The head discharge relationships for emitters were expressed by the formula (karmeli, 1977, Wu and Gitlin, 1977)

$$Q = K_d H^X \qquad \ldots\ldots (4)$$

Where Q = Discharge rate of drippers (lph)

K_d = Discharge coefficient

H= Pressure Head

X= Dripper flow exponent

The value of X varies from 0 to 1 for wide range of drippers. If X approaches zero, the drippers are classified as fully pressure compensating and it is, however difficult to achieve in the manufacturing process. If the value of X lies between 0 to 0.5, the drippers are called pressure compensating and if X greater than 0.5, the drippers are classified as non- pressure compensating (Schwab et al 1993).

IV. Result And Discussions

Emitter discharge was measured at different operating pressures

Table2. Average discharges of online emitter s under different pressure

pressure (kPa)	Average discharge of emitters		
	2 lph	**4lph**	**8lph**
20	1.79	2.85	5.4
30	1.91	3.025	5.55
40	2.078	3.47	5.924
60	2.1345	3.8575	6.2975
70	2.414	4.0485	6.4575
80	2.54	4.285	7.378
90	2.615	4.44	7.67
100	2.662	4.817	8.272

Replicated four times. Data revealed that for a average discharge of 2 lph, the emitter discharge varied from 1.79 to 2.66 lph. The closest to the average discharge (2.078 lph) was obtained at 40 kPa and the discharge variation was only --------. Similar was the case with the emitters of other discharge ratings (Table2). The variation in the discharge of emitters was within the acceptable limit for 2, 4, and 8lph capacity emitter (wu and Gitlin ,1981).For the better performance , drip emitters of 2, 4 and 8 lph capacity require 40 ,70 and 100 kPa pressure , respectively.

Data revealed that the uniformity coefficient for 2 lph emitter was greater 70% in all observation; expect the case of 100 kPa. As a sample ,Table 3 gives detailed information for the 2 lph rated discharge emitter .Similarly , in the case of 4 and 8 lph rated emitters, the uniformity coefficient was 70 or higher except some cases . Emission uniformity for all the emitter s are given in Table 4 and all are greater than 60%.
Manufacturing coefficients of variation were 0.651, .171, and 0.101 for 2, 4 and 8 lph drip emitters, respectively. As per ASAE (1989) recommendation, it was concluded that the emitters were of good quality.

Average discharges of Inline emitter at different operating pressures

Pressure	Average discharge of emitters
40	0.57
50	0.61
60	0.71
70	0.8
80	0.91
90	1.05
100	1.38
110	1.24

Replicated four times. Data revealed that for Average discharge of 1.3 lph, the emitter discharge varied from .57 to 1.24 lph. The closest to the average discharge (1.38 lph) was obtained at 100 kPa. Data revealed that the uniformity coefficient for 1.3 lph emitter was greater 70% in all observation expect the case of 40 and 50 kPa.
Manufacturing coefficients of variation is .128 for 1.3 lph drip emitters, respectively. As per ASAE (1989) recommendation, it was concluded that the emitters were of good quality

Table3a: Uniformity coefficient of 2 lph

pressure (kPa)	Uniformity coefficient (Cu) %						
	1	2	3	4	Min	Max	Average
20	89	80	85	84	80	89	84.5
30	90.5	79.5	85.5	85	79.5	90.5	85
40	90.25	98	97	91.25	90.25	98	94.13
60	89	2.45	87.45	94	87.45	94	90.73
70	75.5	83.1	69.25	91.85	69.25	91.85	80.55
80	61.5	84.5	63	83	61.5	84.5	73
90	79.75	72.75	74.5	64	64	79.75	71.88
100	65	68.65	68.4	65.25	65	68.65	66.83

Table3b:Uniformity coefficient of 4lph

Pressure (kPa)	Uniformity coefficient (Cu) %						
	1	2	3	4	Min	Max	Average
20	65	77.5	60	70	60	77.5	68.75
30	80.25	71	70.25	81	70.25	81	75.63
40	89.25	81.75	82.5	87.5	81.75	89.25	85.5
60	82.25	87.125	87.5	85.125	82.25	87.5	84.88
70	89.375	92.05	89.625	91.8	89.375	92.05	90.71
80	89.5	89.25	86.75	92	86.75	92	89.38
90	77.75	85.775	80.25	83.275	77.75	85.775	81.76
100	88.875	91.375	92.875	86.625	86.625	92.875	89.75

Table3c: Uniformity coefficient of 8 lph

pressure (kPa)	uniformity coefficient (Cu) %						
	1	2	3	4	Min	Max	Average
20	66.38	68.63	70.13	63.75	63.75	70.13	66.94
30	65.5	73.25	72.625	66.125	65.5	73.25	69.38
40	70.788	77.31	75.1	77.5625	70.788	77.5625	74.18
60	79.31	78.13	79.25	78.19	78.13	79.31	78.72
70	81.25	80.19	79.375	82.06	79.375	82.06	80.72
80	87.69	89	85.1875	94	85.1875	94	89.59
90	93.56	90.43	94.4375	89.55	89.55	94.4375	91.99
100	94.38	91.2	97.3125	90.64	90.64	97.3125	93.98

Table3d: Uniformity coefficient of 1.3 lph

pressure (kPa)	uniformity coefficient (Cu) %						
	1	2	3	4	Min	Max	Average
40	45.385	42.31	49.23	38.46	38.46	49.23	43.85
50	47.308	45.77	53.08	40	40	53.08	46.54
60	91.38	61.54	63.85	44.62	44.62	91.38	68
70	59.231	92	85.08	66.15	59.231	92	75.62
80	68.846	70.77	67.69	71.92	67.69	71.92	69.81
90	96.4	84.08	75.62	86.31	75.62	96.4	86.01
100	89.846	92	97.23	84.62	84.62	97.23	90.93
110	81.615	89.77	84.15	87.23	81.615	89.77	85.69

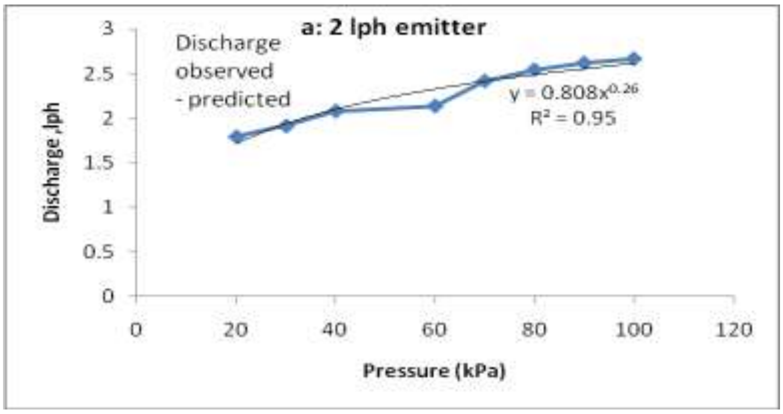
Table 4a. Emission uniformity of 2lph , 4lph and 8 lph capacity emitters

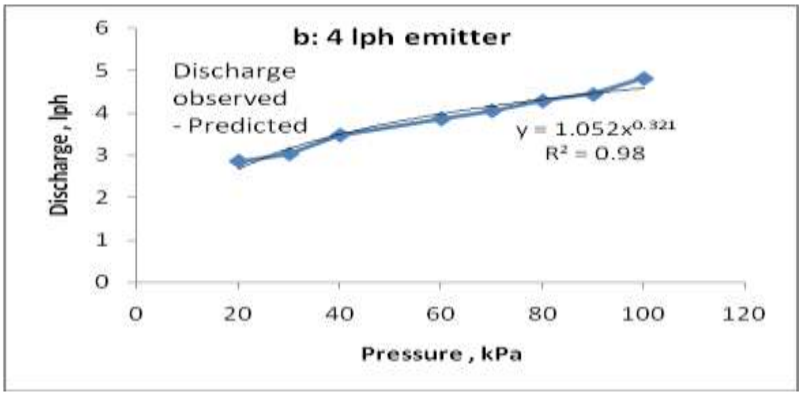
Pressure (kPa)	Emission uniformity , per cent		
	2 lph	**4 lph**	**8 lph**
20	73.83	61.54	78.17
30	71.61	72.32	82.99
40	86.37	69.69	79.78
60	84.86	75.35	84.55
70	66.76	84.73	88.97
80	59.05	82.98	76.36
90	68.62	68.36	88.31
100	73.13	81.56	91.6

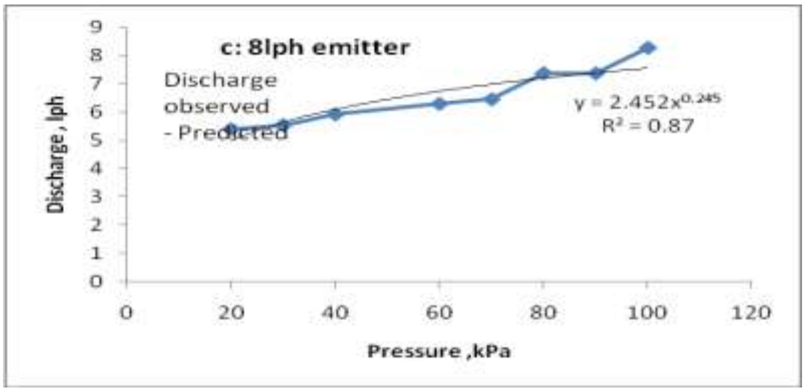
Table4b: Emission uniformity for 1.3 lph inline emitter

Pressure (kPa)	Emission Uniformity
40	66.25
50	67.56
60	77.54
70	83.81
80	83.49
90	85.81
100	83.91
110	78.39

Logarithmic relationships were developed between pressure and discharge for each of the online emitters of 2, 4 and 8 lph and for inline emitter 1.3 lph discharge ratings. The relations are shown in fig2.







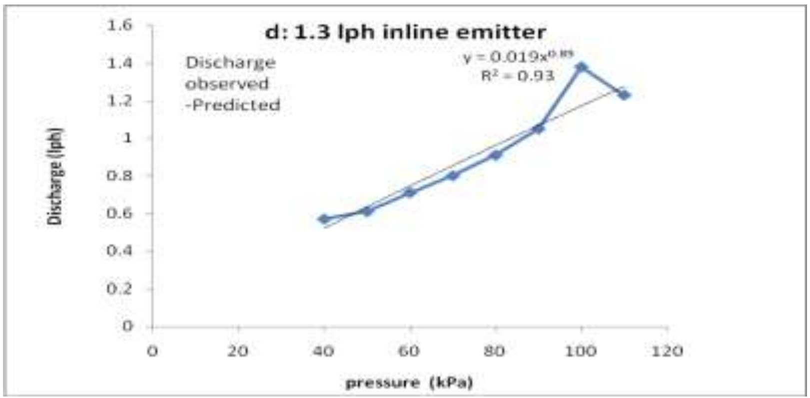


Fig: Relation between pressure and discharge of different emitters

V. Conclusions

Study revealed that for better discharges of online emitter s of 2, 4 and 8 lph rated discharge, operating pressure of 40, 70 and 100 kPa rated discharge and inline emitter of 1.3 lph rated discharge, operating pressure of 100 kPa is required, respectively to achieve uniformity coefficient of more than 80 %. Manufacturing coefficients of variation were 0.651, .171, and 0.101 for 2, 4 and 8 lph online-drip emitters and .128 for 1.3 lph inline-drip emitter respectively. According to ASAE (1989) standards, the emitters were of good quality.

References

[1] Pandey, A.(2005) Hydraulic Performance of Drip Emitters under Laboratory Condition. *J.Soil Wat. Conserv. India,4(3&4)*
[2] ASAE(1989) American Society of Agricultural Engineers. Design , installation and performance of trickle systems.EP405.1 *St. Joseph , MI.*
[3] Christiansean,JE.(1942) Hydraulics of sprinkling systems for irrigation . *Trans.ASCE. 107:221-239*
[4] Kumar ,A. (2001) State of art and research and development needs in micro irrigation . Proceeding of Manufacture.
[5] Meet cum Workshop on Automated Irrigation Equipment Testing Report No.CAIE/IDED/2002/277.pp. 51-57.
[6] Madramotto, C.A.(1988) Effect of pressure changes characteristics on the discharge characteristics of pressure compensating emitters. *J.Agri. Engg. Res. 40: 159-164.*Wu, I.P. and Giltin , H.M. (1977) Drip irrigation efficiency and schedules . *Trans of the ASAE,26(I) :92-97*
[7] Satpute,G.V and Pandey,N.N. (1988) Effect of drip layout and planting geometry of tomato and cost of drip system. Proc . Agri.Engg. Conference Bangkok, Thailand ;AIT(1992),773-781 pp.