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Hydraulic performance evaluation of drip irrigation system under field condition in Chhattisgarh plain

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Abstract
Due to limited water resources and environmental consequences of common irrigation systems, drip irrigation technology is getting more attention and playing an important role in agricultural production, particularly with cash crops of high value. Proper design and operating of drip irrigation system 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. The efficient water application through drip irrigation is mainly depends upon the hydraulic parameters of the system, which includes the effect of pressure on coefficient of manufacturer variation, emitter flow variation, emission uniformity, uniformity coefficient, application efficiency and distribution efficiency. The present study was undertaken to evaluate the hydraulic performance of drip irrigation system in farmer's field at 1.00 kg/cm^2 operating. Twelve farmers of each 12 villages of three blocks of Mungeli district of Chhattisgarh were randomly selected among the farmers who were given drip irrigation system on subsidy basis. The average value of the hydraulic performance indicators namely emitter flow rate, co efficient of manufacturer, emitter flow variation, emission uniformity, distribution efficiency, and application efficiency obtained were 3.10 lph, 0.0310, 24.90%, 87.77%, 86.44% and 87.10%, respectively. The results of hydraulic performance indicators revealed that only 5 (41.66%) farmer's field showed a better hydraulic efficiency (Emitter flow variation) by meeting the standards set by ASCE. Rest of 7 (58.34%) farmer's field showed low hydraulic performance (Emitter flow variation). The reasons for the low performance of drip irrigation system were mismanagement of the system, clogging problems, poor handling and less care, lack of skilled person, lack of knowledge about the system and lack of fittings and laterals supply.

Keywords: Drip irrigation, application efficiency, uniformity coefficient, distribution efficiency and emission uniformity

Introduction
Reducing water use, saving water, and improving water use efficiency in agriculture are challenging tasks, especially under the current and future climate change conditions. Improved irrigation methods are essential for avoiding water and nutrient leaching from soils as well as reducing groundwater pollution, all of which play an important role in achieving desired crop yields (Pawar *et al.*,2013) [10] 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. Applying a small quantity of water to each plant means that uniform distribution of water is extremely critical. The drip-irrigation system (DIS) is a controlled method of irrigation, consisting of water pump/water tank, filter, pressure gauge regulator, valve, tube (main, sub mains and laterals) and emitters. It maintains the optimum level of water in the crop root zone by slow application of water either directly on land or into the root zone of the crops rather than the entire land surface, and improves the water use efficiency through providing precise amounts of water directly to the root zone of individual crops (Sarker *et al*, 2019) [11]. The heart of the DIS is the emitter, delivering water in small amounts to individual plants rather than broadcasting over the whole field area. It is not necessary to store more water in the soil profile and crop yields are increased by maintaining soil moisture in the root zone close to field capacity.
The improvement of irrigation water management is becoming critical to increase the efficiency of irrigation water use and to reduce water losses. 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.

Drip irrigation evaluation in the field under a set of 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. Ideally, a well-designed system applies nearly equal amount of water to each plant to meets its water requirements in addition to rational design and economics. The causes of the irrigation discharge variations are mainly due to manufacturing variations, pressure differences, emitter plugging, aging, frictional head losses, change in irrigation water temperature and the emitter sensitivity results in flow rate variations even between two identical emitters (Kumar and Ashoka, 2020) [7].

The distribution uniformity of water is one of the important parameters to characterize drip emitters and design of a drip irrigation system. The uniformity coefficient and emission uniformity increased while coefficient of variation decreased as the operating pressure head increased for all emission devices (Kumar and Singh, 2007) [8]. 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) [4]. The pressure discharge relationship follows a power function (Sharma *et al*., 2005) [12]. 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) [3]. Well-designed drip irrigation will lose practically no water to runoff, deep percolation or evaporation (Hussain and Gupta, 2017) [5].

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) [14]. Moreover, non-static operating pressure causes some problems such as defective pressure regulators, broken lines, and plugged emitters (Tyson and Curtis, 2009) [13, 15]. 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 present study was conducted in newly formed Mungeli district of Chhattisgarh plain which is situated between 22.06^0 N latitude and 81.68^{0}E longitude in the year of 2016-17. The average altitude above sea level is 287 m. Here farmers are using all possible modern technology to enhance their crop yield. For collecting information on drip irrigation system technologies, the field surveys were conducted in the rural areas of Mungeli belonging to the different agro- climatic zones of Chhattisgarh state. The study was conducted at Different sprinkler irrigation of Chhattisgarh on the basis of agro-climatic zone. Out of 27 districts of Chhattisgarh, one district Mungeli was randomly selected. In which three blocks namely Mungeli, Pathariya and Lormi of the district were selected. Four villages of each selected block were identified for the purpose of study. The average temperatures of irrigation season within the plant growth period in the district according to the long terms records range from 7.8 and 35˚C. The maximum and minimum relative humidity during the crop period was 19 to 96% respectively.

The present study was carried out in the each farmer's field of 12 different-villages (Chhatrakhar, Dhanagon, Fandwani, Khapri, Dani Pendri, Chandali, Junwani, Lamti, Barbaspur, Sukli, Jotpur and Kanchanpur of three blocks (Mungeli, Lormi and Pathariya) of Mungeli district. There were 12 different irrigating field involved for the study.

Emitter Discharge: The study was conducted in the farmers' fields having a 4 lph dripper spaced at 40 cm on laterals. The distribution of water application and discharges from emitters along the lateral are measured using ASAE Standards. After removing the entrapped air from the different components of the system like main, sub main and laterals through flush valve and attending the stable flow condition at a desired operating pressure of 1.0 kg/cm^2, the observation were taken. The four lateral lines were selected on a sub main - one at the inlet, one at the far end and the two in the middle which was at the one-third and two-thirds positions. The four dripper positions were tested on each lateral - one at the inlet, one at the far end and the two in the middle which was at the one-third and two-thirds positions. Therefore, there were 16 measurement positions used for the study. The discharge was measured by collecting the water from individual drippers using measuring cylinders. The discharge was collected in catch can for duration of 10 minute of operating pressures 1.0 kg/cm^2 and was measured by a measuring flask. The procedure was repeated thrice and the average of the volume of the water was considered as the discharge for a particular position (Kumar and Ashoka, 2020) [7].

Coefficient of Manufacture's Variation: A parameter which can be used as a measure of emitter flow variation caused by variation in manufacturing of the emitter is called the coefficient of manufacturing variation and is computed with the formula given by Keller and Karmeli (1974).

$$\mathrm{Cv} = \frac{\mathrm{S}}{\mathrm{q_a}} \tag{1}$$

Where,
Cv= coefficient of manufacturer variation
S= standard deviation
q_a= Average emitter discharge

The recommended classification of manufacturer's coefficient of variation as per ASAE (Desmukh *et al*, 2013) is;

Table 1: Classification of manufacturer's coefficient of variation

Emitter type	Cv range	Classification
Point Source	< 0.05	Good
	0.05 to .10	Average
	0.10 to 0.15	Marginal
	> 0.15	Unaccepted
Line Source	< 0.10	Good
	0.10 to 0.20	Average
	> 2.0	Marginal

Emission Uniformity: 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 (Barlt *et al*., 1979). The average of lowest 1/4th of emitter was selected as a practical value for minimum discharge, as recommended by the United States soil conservation services for field evaluation of irrigation systems and is expressed by the equation.

$$EU = \frac{q_n}{q_a} \times 100 \quad (2)$$

Where,
EU = the field test uniformity, percent
q_n = average of the lowest 1/4th of the field data emitter discharge, lph
q_a = Average emitter discharge

The recommended classification of emission uniformity as per ASAE is in table 2

Table 2: Recommended classification of emission uniformity

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

Emitter Flow Variation: The second method of field evaluation of emission uniformity relies on the design procedure based on estimating emitter flow variation (Wu, 1997) [16]. It consists of finding the minimum and maximum pressure in the sub-units and the emitter flow variation (q_{var}) was worked out using the following equation.

$$q_{var} = 100\left[1 - \frac{q_{max}}{q_{min}}\right] \quad (3)$$

Where;
qvar = emitter flow variation in percentage
qmin = minimum emitter discharge rate in the system, lph
qmax = average or design emitter discharge rate, lph

General criteria for q_{var} values are 10 per cent or less (desirable) and 10 to 20 per cent Acceptable and greater than 25 per cent Not Acceptable (Kumar and Ashoka, 2020) [7].

Distribution efficiency (Ed): The distribution efficiency determines how 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,

$$E_d = 100\left(1 - \frac{\Delta q_a}{q_m}\right) \quad (4)$$

Where,
E_d = distribution efficiency in percentage
q_m = mean emitter flow rate, lph
q_a = average absolute deviation of each emitter flow from the mean emitter flow

Application Efficiency (Ea): The application efficiency is defined as the ratio of water required in the root zone to the total amount of water applied. It shows how well irrigation water is applied that is, what percentage of water applied is stored in the root zone as required and is available for plant use (Mane *et al*., 2018) [9] The water required in the root zone is assumed to be applied at the minimum flow rate and over the total irrigation time. Therefore, application efficiency can be expressed as,

$$E_a = 100\left(\frac{q_{min}}{q_{avg}}\right) \quad (5)$$

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

$$q_{avg} = \frac{V_w}{N\,T} \quad (6)$$

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 that were used to evaluate:

Emitter Flow rate: Drip irrigation system was operated under field condition to study the different hydraulic parameters of the system. For this purpose, drip irrigation discharges were measured at operating pressure of 1.00 kg/cm^2 for 4 lph emitter discharge. The Average emitter flow rate of 3.69 lph was found to be maximum at given operating pressure in F4 followed by F7 fields and a minimum of 2.71 lph in F5 fields (Table 4).

Coefficient of Manufacturer: The coefficient of manufacturer was found to be high value of 0.0562 for F10 followed by F5 fields as shown in Table 3. It is clear from the table that low value of 0.0151 of Cv was observed under given operating pressure in F4 fields. The low Cv indicates a good performance of the system throughout the cropping season. Thus, for a particular spacing, coefficient of variation and emitter flow variation and operating pressure having inverse relation for all emission devices. To decide whether the system is good, average, marginal and excellent, it is necessary to determine the manufactures coefficient of variation either for point source or line source. It is observed that, Cv for 4 lph discharge of drippers comes under the range of classification as good for given operating pressure in 10 farmer's fields whereas two farmer's fields under the average range of classification. The average value of Cv was 0.0310 that comes under good range of classification.

Emitter Flow Variation: The emitter flow variation (q_{var}) is shown in Table 3. It is clear from the observations that the emitter flow variation for 4.0 lph emitter was found to be maximum of 31.43% in F10 and minimum of 16.14% in F4. The emitter flow variation is acceptable at given operating pressure for F2, F4, F6, F7, and F11 fields. The results of hydraulic performance indicators revealed that only 5 (41.66%) farmer's field showed a better hydraulic efficiency (Emitter flow variation) by meeting the standards set by ASCE. However, rest of all 7 (58.34%) farmer's field showed low hydraulic performance (Emitter flow variation in not acceptable at same pressure). Unacceptable flow variation may be due to water quality, punching problem and clogging effect of emitters.

Emission Uniformity: Emission uniformity of the system decides the uniformity distribution of discharge by each emitter or uniformity distribution of water to each crop. The emission uniformity of 94.82% for 4 lph emitter was found to be maximum in F4 field (Table 3) which comes under the excellent hydraulic performance of the system set by ASAE. While minimum of 69.48 and 69.90% was observed in F5 and F10 fields which indicate poor performance of the system.

The reasons for the poor performance of drip irrigation system were mismanagement of the system, clogging problems, poor handling and less care, lack of skilled person, lack of knowledge about the system and lack of fittings and laterals supply.

Table 3: Performance parameters of drip system at farmer's field

Farmer's Field	Coefficient of manufacture's (C_v,)	Emission uniformity (EU,%)	Emitter flow variation (q_{var},%)
F1	0.0311 (Good)*	87.79 (Good)*	30.37 (Not Acceptable)*
F2	0.0268 (Good)	91.48 (Excellent)	21.00 (Acceptable)
F3	0.0288 (Good)	88.31 (Excellent)	26.71 (Not Acceptable)
F4	0.0151 (Good)	94.82 (Excellent)	16.14 (Acceptable)
F5	0.0525 (Average)	69.48 (Poor)	30.31 (Not Acceptable)
F6	0.0274 (Good)	91.85 (Excellent)	23.13 (Acceptable)
F7	0.0183 (Good)	92.61 (Excellent)	16.17 (Acceptable)
F8	0.0317 (Good)	89.45 (Good)	26.22 (Not Acceptable)
F9	0.0295 (Good)	88.58 (Good)	27.31 (Not Acceptable)
F10	0.0562 (Average)	68.90 (Poor)	31.43 (Not Acceptable)
F11	0.0268 (Good)	91.79 (Excellent)	23.56 (Acceptable)
F12	0.0282 (Good)	89.26 (Excellent)	26.50 (Not Acceptable)
Average	0.0310 (Good)	87.77 (Good)	24.90 (Acceptable)

*Recommended classification

Distribution Efficiency: The distribution efficiency of drip irrigation system was observed for 4 lph emitters under the given operating pressure shown in table 4. The distribution efficiency of 94.10% found to be maximum in F4 field which indicates a good performance of the system. The minimum value of 74.15 and 75.09% was observed in F10 and F5 fields, respectively which indicates the poor performance of the system. This may be due to clogging problems, poor handling, less care and lack of fittings and laterals supply. The average value was 87.10%.

Application Efficiency: The application efficiency of 93.52% found to be maximum in F4 field and minimum of 73.54% and 75.30% at given operating pressure in F10 and F5 fields (Table 4). The poor performance of the system may be due to clogging problems, poor handling, less care and lack of fittings and laterals supply. The average value was 86.44%.

Table 4: Performance parameters of drip system at farmer's field

Farmer's Field	Average emitter flow Rate (lph)	Distribution Efficiency (E_d, %)	Application Efficiency (E_a, %)
F1	2.78	85.52	84.82
F2	3.06	91.80	90.24
F3	2.95	87.22	86.20
F4	3.69	94.10	93.52
F5	2.71	75.09	75.30
F6	3.22	92.15	91.25
F7	3.58	93.55	92.63
F8	2.96	84.05	84.41
F9	2.98	87.15	86.33
F10	2.96	74.15	73.54
F11	3.22	92.23	91.73
F12	3.12	88.25	87.33
Average	3.10	87.10	86.44

Conclusion

The hydraulic performance indicators used to evaluate drip irrigation system are emitter flow rate, co-efficient of manufacturer, emitter flow variation, emission uniformity, distribution efficiency, and application efficiency, respectively. The average value of the hydraulic performance indicators namely emitter flow rate, co-efficient of manufacturer, emitter flow variation, emission uniformity, distribution efficiency, and application efficiency obtained were 3.10 lph, 0.0310, 24.90%, 87.77%, 86.44% and 87.10%, respectively. The results of hydraulic performance indicators revealed that only 5 (41.66%) farmer's field showed a better hydraulic efficiency (Emitter flow variation) by meeting the standards set by ASCE. Rest of 7 (58.34%) farmer's field showed low hydraulic performance (Emitter flow variation). The reasons for the low performance of drip irrigation system were mismanagement of the system, clogging problems, poor handling and less care, lack of skilled person, lack of knowledge about the system and lack of fittings and laterals supply. The average value of the hydraulic performance indicators of the drip system showing 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.

References

1. ASAE. Design, Installation and Performance of Trickle Irrigation System. ASAE standard EP405, St. Joseph, Michigan 1985, 507-51.
2. Bralts VF, Wu IP. Emitter flow variation and uniformity for drip irrigation. St. Joseph Mich., ASAE 1979.
3. Ella VB, Reyes MR, Yoder R. Effect of hydraulic head and slope on water distribution uni-formity of a low cost drip irrigation system. Applied Engineering in Uniformity Agriculture 2009;25:349-356.
4. Gil JA, Khan L, Hernandez R. Evaluation of the hydraulic performance of several imported emitters for drip irrigation. Revista Cientifica UDO Agricola 2002;2:64-72.
5. Hussain Mairaj, Gupta Sudhiranjan Prasad. A field study on hydraulic performance of drip irrigation system for optimization of operating pressure. Journal of Applied and Natural Science 2017;9(4):2261-2263.
6. Keller J, Karmeli D. Trickle irrigation design parameters. Trans. ASAE 1974;17(4):678-784.
7. Kumar Ajay HP, Ashoka HG. Study on Hydraulic Performance of Drip Irrigation System under Field

Condition. Int. J. Curr. Microbiol. App. Sci, 2020;9(2):626-633.
8. Kumar S, Singh P. Evaluation of hydraulic performance of drip irrigation system. Journal of Agricultural Engineering 2007;44(2).
9. Mane MS, Ayare BL, Magar SS. Principal of Drip Irrigation System. Jain brothers. Karnataka 2008, 80-130.
10. Pawar DD, Dingre SK, Kale KD, Surve. U.S. Economic feasibility of water-soluble fertilizer in dripirrigated tomato (Lycopersicon esculentum). Indian J. Agric. Sci 2013;3:703-707.
11. Sarker KK, Kumer Akbar Hossain, Khandakar Faisal Ibn Murad, Sujit Kumar Biswas, Farzana Akter, Rahena Parvin Rannu, *et al*. Development and Evaluation of an Emitter with a Low-Pressure Drip-Irrigation System for Sustainable Eggplant Production. Agri Engineering 2019;1:376-390.
12. Sharma KN, Ghosh P, Pradhan PC. Studies of discharge performance of different types of emitters used in drip irrigation. Drainage and Irrigation Water Management 2005, 186-192.
13. Tyson TW, Curtis LM. Evaluating Water Distribution Uniformity in Micro-Irrigation Systems 2009. available at: http://www.aces.edu/anr/irrigation/documents/BSENIRR 0901 Field Evaluation of System Uniformity.pdf (accessed at 30 September 2017).
14. Valipour M. Sprinkle and Trickle Irrigation System Design Using Tapered Pipes for Pressure Loss Adjusting” Journal of Agricultural Science 2012;4(12):125-133.
15. Tyson TW, Curtis LM. Evaluating Water Distribution Uniformity in Micro-Irrigation Systems” available at:http://www.aces.edu/anr/irrigation/documents/BSENI RR0901 Field Evaluation of System Uniformity.pdf (accessed at 30 September 2017) 2009.
16. Wu IP. An assessment of hydraulic design of micro-irrigation systems" Agricultural Water Management 1997, 275-284.