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Performance Assessment of Drip System of Irrigation used for Cultivating Tomato in Premises of the Centre of Excellence Protected Cultivation, Raipur, Chhattisgarh, India

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Authors' contributions

This work was carried out in collaboration among all authors. Author VS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors JR and SK managed the analyses of the study. Author A managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A technical report was conducted for checking performance assessment of drip irrigation system which was used for cultivating tomato in premises of the Centre of Excellence Protected Cultivation, Raipur (Chhattisgarh). A uniformity coefficient was found for drip irrigation system which ranges from 73.2 % to 83.6%. The coefficient of variance varies between 0.0055 to 0.0068 for the measured discharges of four laterals laid in the field. It shows that there is the least variation between the obtained flow rates of different laterals under study. The application efficiency of four different lateral lines operating at a pressure of 1.25 kg/cm^2 was calculated and it found to be more than 90.00 %, excluding lateral line (L2). Almost same amount of flow variation (8-9%) is found in

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lateral lines L1, L3 and L4, although Lateral line (L2) discharges 11.00 % more water among others. The maximum flow variation was found for the lateral line (L3) and the least flow variation was for the lateral line (L1). The distribution efficiency of all the laterals was found more than 97.45 %.

Keywords: Drip irrigation; tomato; protected cultivation; irrigation efficiency.

1. INTRODUCTION

The state of Chhattisgarh has long been known as the rice bowl of the central part of India, with paddy as the main crop. Although, cereals such as maize, kodo-kutki and few small millets, the pulses such as kulthi and tur beside oilseeds such as sunflower, groundnut, soybean and niger were cultivated in the region [1,2]. (Annual Action Plan 2014-2015) About 32 % of the net sown area was found irrigated in Chhattisgarh state for the year 2018-2019. While on an average 40% of the area was found irrigated in India. Under the Annual Action Plan 2014-2015, the state scheme of drip irrigation was started [3,4]. A proper irrigation scheduling is essential for better growth of crops according to the plant stages such as flowering and fruit settling. When optimal moisture level i.e. field capacity and soil fertility is maintained then the highest productions could be achieved [5,6]. In hot weather conditions, irrigation should be applied at an interval of every 3rd to 4th day while in the winter season irrigation should be given at an interval of every 7 to 12 days for the Chhattisgarh plains [7-9]. The recommended dose of N: P: K is 200:150:100 kg/ha.

2. MATERIALS AND METHODS

The performance of the drip irrigation system for tomato crops was evaluated in a 1 ha area grown under protected cultivation. The drip system getas water supply from bore-well, fitted with a submersible pump of 5 hp size. A sub-main was operated with control valves in the test field to supply water in the different lateral lines.

2.1 Specification of Drip System of Irrigation

Raipur is the state capital of Chhattisgarh and falls between the latitude of 21 ° 14 ° 02' North and longitude of 81 ° 43 ° 11' East at a height of 298 m above the mean sea level. One-month-old seedlings of tomato (laila) was transplanted in the field on 10 September 2019. A 70 tomato seedlings were transplanted at plant to plant spacing and row to row spacing of 0.65 m and 1.5 m respectively. A 12 such a lateral line of 45 m length was installed in the field. Tomato crop was cultivated under drip irrigation system with the gross and net cultivated area of 0.081 ha and 0.0108 ha respectively. Miscellaneous crops were also irrigated with drip irrigation, but the present study was confined to the field performance of tomato crops only.

2.2 Water Source and Component of Drip Irrigation System

A deep tube well was used as water source to irrigate the tomato crop by means of 5 hp submersible electric pump set, with a discharge capacity of 5 lps. A pond was used as supplement water resource in scary season. The drip irrigation system was installed with a submersible pump, non-return valve,

Table 1. Technical specification for drip system and crop

Crop	Tomato
Emitter type	Inline emitter
Row to row distance	1.5 m
Plant to plant spacing	0.65 m
Length of lateral	45 m
Emitter discharge capacity	2.4 lph
Gross area	0.081 ha
Net area	0.0108 ha
Total no. of laterals	12
Total plant	828
Water source	Tube-well + Pond

water meter, filters, fertigation assembly, flow control valves, air release and pressure release valves. The pressure gauge was also fitted at the appropriate place to check pressure differences. The mainline was buried at a depth of 45 cm to avoid damage due to vehicles and equipment movements. The main pipe of size 75 mm in diameter was used in system. The PVC pipes were used in system layout and solvent welding was done to connect them. Sub-mains (3 in numbers) were also laid out underground, at a depth of 45 cm to avoid damage due to vehicles and equipment. The sub-main pipe is 63 mm in diameter. Water is trickled evenly over the length of the laterals utilizing drippers or emitters. Generally, laterals are made up of LDPE and LLDPE. Lateral lines, (16 mm diameter) were laid out. These were made of black low-density polyethylene (L.D.P.E). Line source emitters were used because line source tubing fits well with row crop vegetables, also it provides linear wetted strips desired and delivers the right flow rate at the right pressure. The number of emitters per lateral was 69 having a spacing of 0.65. For the calculation of different irrigation efficiency, only 4 laterals out of 12 laterals have been selected for data analysis.

2.2.1 Manufacturing characteristics

2.2.1.1 Coefficient of manufacturer's variation

The statistical parameter; coefficient of variation is denoted as C_v, as follows:

$$C_v = \frac{s}{q_{avg}}$$

---eqn(1)

Where 's' is known as the standard deviation of flow and term q_{avg} is the average rate of flow for a given sampled entity of emitters of a similar kind verified at a constant temperature (20 ^{o}C) and pressure.

2.2.2 Operational characteristics

2.2.2.1 Emission Uniformity (EU)

Emission uniformity throughout the field test is the ratio of the percentage of the mean emitter flow rate from the lowest ¼th of the emitter to the mean flow rate of all the emitters of the drip system.

$$EU_f = \frac{q_n}{q_a} \times 100$$

Where, EU_f is the field test emission uniformity denoted in percentage, q_n is known for a mean of the least ¼ of the field data emitter flow rate in l/ha, q_a is the average of the field date emitter flow rate in l/h.

2.2.3 Drip irrigation efficiency

2.2.3.1 Distribution efficiency

It was determined by the emitter discharge variation along a lateral or (sub-main) in drip irrigation in the field and it denoted by the following equation

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

Where E_d is the uniformity coefficient or distribution efficiency, q_m is the average emitter discharge in lph and q_a is the average absolute deviation of every emitter flow from the average emitter discharge.

2.2.4 Application efficiency

Application efficiency (E_a) can be illustrated as the irrigation water is applied and the percentage of supplied water which was stored in the root zone as required and gets readily available for plant use. The application efficiency is illustrated as,

$$E_a = \frac{Q_{min}}{Q_{avg}} \times 100$$

3. RESULTS AND DISCUSSION

The results obtained during the course of investigation on performance evaluation of drip irrigation system installed in the field. The results indicate that the average flow rate of emitter across length of lateral was found to be 2.26 lph. The average flow rate in head reaches was 2.371 lph which was 1.04 % higher than the overall average discharge of emitters located at different laterals parts. The average flow rate in the middle reaches was found to be 2.265 lph. It was slightly 1 % lower than the overall mean discharge of emitters. Instead, the average discharge of emitters located at tail end reaches was found to be 2.216 lph. which was the lowest. It was 0.98 % lower than the overall average discharge of emitters located in different parts of laterals.

3.1 Irrigation Efficiency

The irrigation efficiency consists of application efficiency, uniformity coefficient, distribution

efficiency, emitter flow variation, etc. as described.

3.1.1 Application efficiency

Application efficiency can be described as the ratio of the amount of water needed in the root zone before irrigation and the quantity of the water supplied. Fig. 1 indicates that the application efficiency of four different lateral lines at an operating pressure of 1.25 kg/cm^2. All the lateral lines having application efficiency more than 90.00 %, except lateral line (L2) as shown in Fig. 1.

3.1.2 Emitter flow variation (%)

Emitter flow variation of different lateral lines is shown in Fig. 2. The lateral lines L1, L3 and L4 was found giving almost same amount of flow variation (8-9%), whereas lateral line (L2) having 11.00 % maximum flow variation. The least amount of emitter flow variation between laterals shows that the equal of pressure variation among laterals.

3.1.3 Distribution efficiency

How evenly the amount of irrigation water can be trickled through a drip irrigation system into a field is well known as the distribution efficiency. The maximum flow variation was found in lateral line (L3) and the least flow variation was in lateral line (L1) in Fig. 3. The distribution efficiency of all the laterals was more than 97.0 % which shows that fewer variations (i.e. uniformly distribution of water) occurs between these four lateral lines.

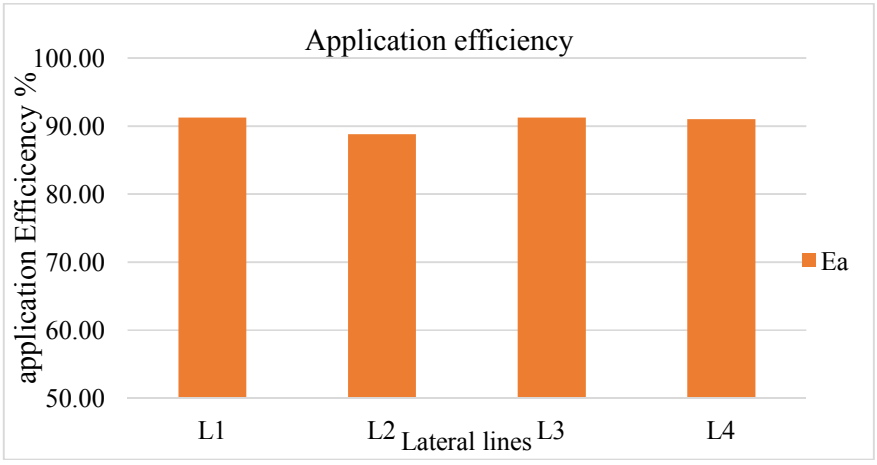

Fig. 1. Application efficiency of different laterals of drip system at operating pressure of 1 kg/cm^2

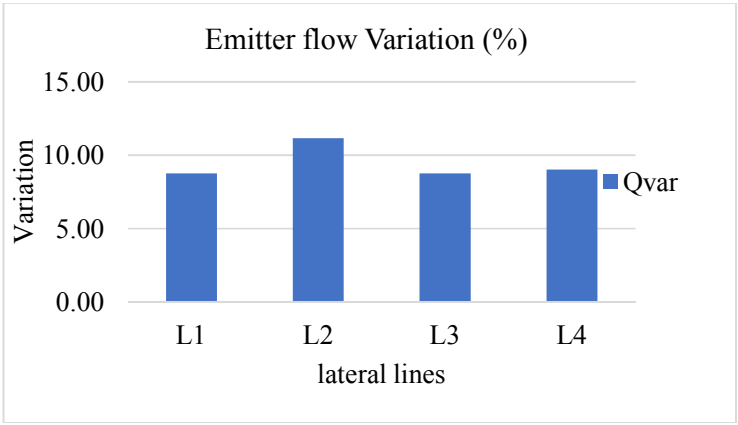

Fig. 2. Emitter flow variation of different laterals of drip system at operating pressure of 1 kg/cm^2

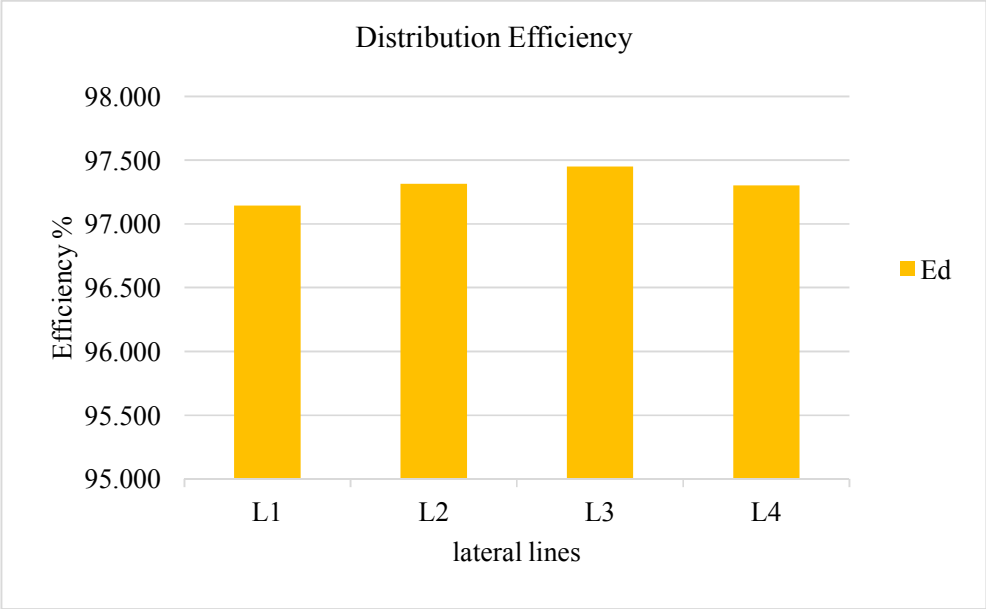

Fig. 3. Distribution efficiency of different laterals of drip system at operating pressure of 1 kg/cm^2

3.1.4 Uniformity coefficient (%)

The uniformity coefficient of all the lateral lines is shown in Fig. 4. The lateral line (L3) having a maximum uniformity coefficient that is 96.76%. A study showed that the least uniformity coefficient occurs at the lateral line (L2) that is 96.37 %. Uniformity coefficient of different laterals of drip system was operated at a pressure of 1 kg/cm^2. The uniformity coefficient of all the laterals was about L1 which shows that fewer variations occur between these four lateral lines.

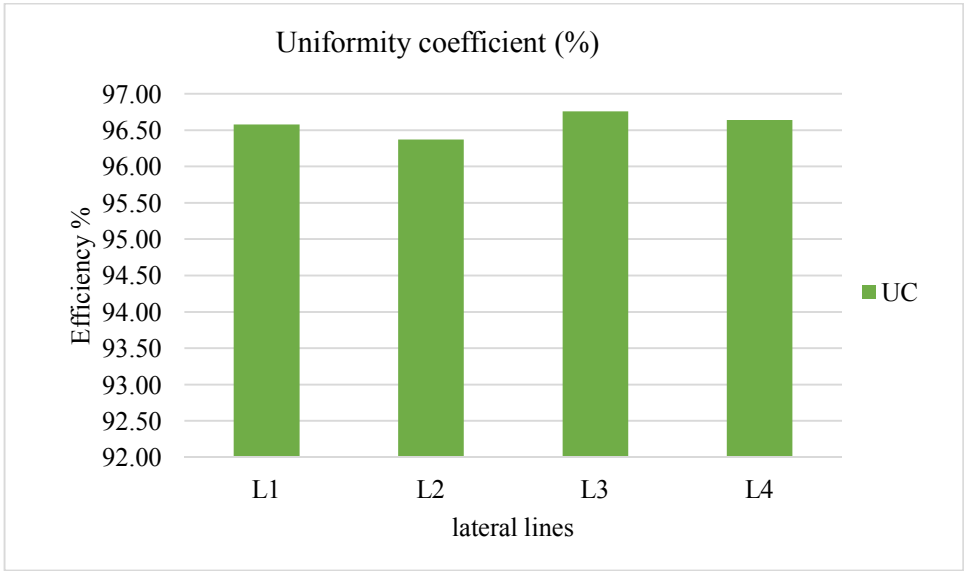

Fig. 4. Uniformity coefficient of different laterals of drip system at operating pressure of 1 kg/cm^2

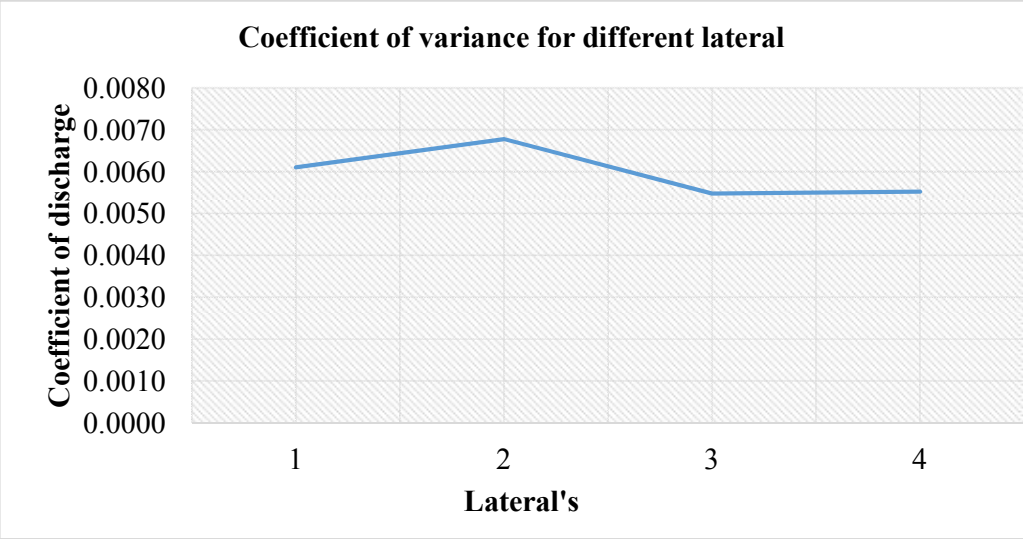

Fig. 5. Coefficient of the variance of different laterals of drip system at operating pressure of 1 kg/cm^2

The coefficient of variance varies between 0.0055 to 0.0068 for the measured discharges of four laterals laid in the field #. It shows that there is the least variation between the obtained flow rates of laterals.

4. CONCLUSIONS

By performance analysis of emitter discharges, it was reviewed that the average flow rates were 2.371 lph, 2.265 lph and 2.216 lph at the head end, middle and tail end respectively. The flow rate was seeming to be higher than the overall discharge by 3.84 % at the head end, less than the overall discharge by 0.83 % and 2.98 % at the middle and tail end respectively. Based on the observations made in the field emission uniformity was found to be 95.50%. This shows better water application uniformity by the emitters in the field. Thus, it can be concluded that uniform application of water is ensured in the field by a drip system. Also, there are fewer percolation losses and water is stored within the root zone which helps obtain higher yields. The uniformity coefficient as calculated by the Christiansen formula was found to be 96.40%. This value represents an efficient drip system of irrigation. The design emission uniformity as expressed by the formula given by Karmelli and Keller was estimated as 94%. The irrigation efficiency was found to be 89.55%. The irrigation water requirement of an area depends upon the type of crop, weather data, type of soil and area under cultivation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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