

# Performance Evaluation of Drip Irrigation System and Profitability Analysis of Leafy Vegetables under Polyhouse

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## Authors' contributions

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

The present experiment on Performance evaluation of drip irrigation system and profitability analysis of leafy vegetables under polyhouse was conducted to study the performance parameters of the drip irrigation systems relating to crop performance. This was done by taking existing drip tapeline, new drip tape line and new inline drip irrigation system under the Polyhouse at the college of Agricultural Engineering, Kandi, Sangareddy, Telangana during the year 2018. Profitability of five green leafy vegetables viz. Palak, Sorrel, Methi, Amaranths and Coriander was also evaluated. The results reveal that the three drip line systems in-line got more uniform coefficient of 98% followed by new drip tape with 96% and preinstalled drip tape with 95%. Among the five green leafy vegetables methi has recorded highest gross (306000Rs acre<sup>-1</sup>) and net returns (285833) and benefit cost ratio (14.2) followed by Palak, Sorrel whereas Amaranthus has recorded lowest benefit cost ratio (7.6). In terms of performance characteristics, drip tape and in line system performed better in maintaining uniformity discharge and the designed drip irrigation operated excellently. Methi, Palak and sorrel

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found suitable and profitable in polyhouse where year- round cultivation of vegetables is feasible compared to open field in which crop establishment was very poor and could not be raised successfully due the heavy rains and growth characters of the leafy crops.

**Keywords:** Polyhouse; coefficient of variation; drip irrigation; uniformity coefficient and leafy vegetables.

## 1. INTRODUCTION

Water is the prime and most precious natural resource as well as a basic need of life. Agriculture, in future, has to produce ever increasing quantities of food and fiber with decreasing water availability for irrigation. Availability of fresh irrigation water is getting inadequate. Therefore, a sustainable management option and judicious use of water is the present-day challenge in the country [1]. This poses a challenge in producing more food and fiber to feed the increasing population. Looking to the future where water availability would become scarcer, nutritional security of nation and surplus food grain production will become a challenge. The switch over to horticultural crops and application of micro-irrigation seems a promising proposition. Micro-irrigation works at a minimum or no losses in surface runoff and deep percolation, at the same time provides higher application efficiency, generally, around 80-90 per cent or even higher [2].

Efficient use of available irrigation water is essential for increasing agricultural productivity for the alarming Indian population [3]. As the population of India is increasing day by day, the pressure on agriculture is increasing in the same way. Root system of most of the vegetables is confined only in upper layer of soil and required frequent irrigation (The Centre for Agriculture, Food and the Environment, [4]). Thus, micro-irrigation/drip irrigation is an effective, efficient and economic viable method for irrigation in vegetables [5].

Drip irrigation has the greatest potential for the efficient use of water and fertilizers. For minimizing the cost of irrigation and fertilizers, adoption of drip irrigation with fertigation is essential which maximizes the nutrient uptake while using minimum amount of water and fertilizer [6]. A best and desirable feature of trickle irrigation is that the uniform distribution of water is possible, which is one of the most important parameters in design, management, and adoption of this system. Ideally, a well-

designed system applies nearly equal amount of water to each plant, meets its water requirements, and is economically feasible [7]. But, due to manufacturing variations, pressure differences, emitter plugging, aging, frictional head losses, irrigation water temperature changes and emitter sensitivity result in flow rate variations even between two identical emitters [8].

The uniform distribution is reflected by the values of uniformity coefficient (*CU*) which, in turn, suggests the variability in the amount of water received by a plant in a sub unit system. A system with uniformity co-efficient of at least 85% is considered appropriate for standard design requirements [9]. However, the distribution uniformity (*DU*) and the uniformity coefficient (*CU*) are function of hydraulic head and slope of lateral and sub-main lines. The coefficient of uniformity, generally, follows a linear relationship either with head or slope. The *CU* and *DU* decrease substantially at sub-main slopes steeper than 30 % [10].

Establishment of Green/Polyhouses is a flagship programme in Telangana launched during 2014-15 with 75% subsidy to promote cultivation of high value vegetables and flowers. During 2016-17, the subsidy has been enhanced to 95% for SC/ST farmers [11]. Year-round production of vegetable crops particularly off-season production of vegetables is gaining importance [12]. Keeping Hence, while testing the efficiency of newly designed drip irrigation, instead of wasting the water, as a part of water conservation simultaneously, leafy vegetables were sown and evaluated in terms of profitability. Keeping all these in view the present study on Performance evaluation of Drip Irrigation system and profitability analysis of leafy vegetables under Polyhouse was taken up.

## 2. METHODOLOGY

### 2.1 Study Area

The field experiment was carried out in Polyhouse of College of Agricultural Engineering

in Kandi, Sangareddy, Telangana in 2018 and is having a total area of 220 m<sup>2</sup> (Fig. 1). This study area is located at 17°37' N-Latitude and 078°6' E-Longitude at the elevation of 516m above sea level in Central Telangana Zone (PJ TSAU.edu.in,2020). The rainfall is mostly concentrated in four monsoon months of June to September besides, some regeneration in the winter months. The district predominantly consists of red soils and cotton, rice, maize, green gram, mango are important crops [13].

The performance of drip irrigation system was evaluated on the basis of following parameters.

**Distribution efficiency:** The coefficient of uniformity (CU) is used to express how evenly the water is spread over the irrigated area. The discharge rate of dripper was recorded at randomly selected dripper points and a statistical approach was to obtain irrigation uniformity as suggested by Wu and Gitlin [14].

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

Where, E<sub>d</sub>=distribution efficiency (%) or uniformity coefficient, q<sub>m</sub> = mean emitter flow rate (l/h), Δq<sub>a</sub>=average absolute deviation of each emitter flow from the mean emitter low

**Application efficiency:** The application efficiency is defined as the ratio of water required in the root zone to the total amount of water applied and can be expressed as given below.

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

Where, E<sub>a</sub>= application efficiency, (%), Q<sub>min</sub>= Minimum emitter flow rate (l/h), Q<sub>avg</sub>= average emitter flow rate (l/h)

**Field emission uniformity (EU<sub>f</sub>):** It is the single most important parameter for evaluating system performance that depends upon water temperature and manufacturer's coefficient of variation of the system [15]. EU shows a relationship between minimum and average emitter discharge. To define the uniformity of water application by drip irrigation method, Keller and Karmeli [1] suggested two parameters, namely field emission uniformity (EU<sub>f</sub>) and absolute emission uniformity (EU<sub>a</sub>). The relations are given as under:

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

Where, EU<sub>f</sub> = Field emission uniformity, q<sub>n</sub>= Average of lowest 1/4th of the emitter flow rate (l/h), q<sub>a</sub> = Average of all emitters flow rate (l/h).

**Absolute emission uniformity (EU<sub>a</sub>):** The absolute emission uniformity was calculated by the formula is given below. Keller and Karmeli [16].

$$EU_a = 100 * \frac{1}{2} * \left(\frac{Q_{min} + Q_{avg}}{Q_x}\right)$$



Fig. 1. Location map of the study area

Where,  $EU_a$  = Absolute emission uniformity,  $Q_{min}$ = minimum flow rate through emitter (l/h),  $Q_{avg}$ =average flow rate through emitter (l/h),  $Q_x$  = average of the highest 1/8th of the emitters flow rate (l/h).

**Coefficient of variation (Cv):** The emitter flow variation caused by variation in manufacturing of the emitter is called the coefficient of manufacturing variation (Cv) [17]. The manufacturing coefficient of variation is determined from the flow rate measurement for several identical devices and is computed with following equation

$$C_v = \frac{s}{\bar{q}}$$

Where,  $C_v$ = Coefficient of variation of emitter flow,  $S$  = Standard deviation of the emitter flow,  $\bar{q}$  = mean flow for sampled emitters [17].

## 2.2 Design Emission Uniformity (EUd)

Keller and Karmeli [16] suggested design emission uniformity by the following equation:

$$EU_d = 100 \left( 1 - 1.27 \frac{V_m}{N_e^{0.5}} \right) \frac{q_{min}}{q_{avg}}$$

Where,  $EU_d$ =design emission uniformity, (%),  $V_m$ = manufacturing coefficient of variation  $N_e$ =number of emitters per plant,  $q_{min}$ =minimum flow rate through emitter, l/h  $q_{avg}$ = average flow rate through emitter, l/h

**Statistical uniformity coefficient (SUC):** The statistical uniformity was first presented by Wilcox and Swailes [18]. The statistical uniformity coefficient was based on the coefficient of variation and can be defined by the equation

$$SUC = 1 - C_v$$

Where, SUC =Statistical Uniformity Coefficient

**Evaluation of Leafy vegetables:** The treatments tested were 5 leafy vegetables viz T<sub>1</sub>: Palak T<sub>2</sub>: Sorrel T<sub>3</sub>: Methi T<sub>4</sub>: Amaranthus T<sub>5</sub>: Coriander evaluated in a randomized block design (RBD) with four replications. All the standard agronomic practices as recommended by Professor Jayashankar Telangana State

Agricultural University were adopted. Yield was recorded and economics was calculated.

## 3. RESULTS AND DISCUSSION

### 3.1 Existed Drip Tape

The average discharge rate of emitters was 0.68 lph and the distribution efficiency was 96%, field emission uniformity value was 93%, absolute emission uniformity 93%, design emission uniformity value was 85%, application efficiency was 91%. The low Cv indicates a good performance of the system throughout the cropping season. The calculated values of Cv was 0.054144 (Table 1). Statistical Uniformity Coefficient (SUC) was highly correlated to system uniformity. The high value of SUC indicates a good performance of the system. The calculated value of SUC was 95%.In addition, the used laterals, probably the internal spiral layer of the laterals, stretched during the lateral installation or the retrieving operation at the end of last season, which led to decreased discharge.

### 3.2 New Drip Tape

It is observed from Table 2, that the average discharge rate of emitters was 0.74 lph, distribution efficiency value was 96%, field emission uniformity value 96%, absolute emission uniformity value was 95%, design emission uniformity value was 89%, application efficiency was 94%.The low Cv indicates a good performance of the system throughout the cropping season. The calculated value of Cv was 0.04116. The high value of SUC 95.88% compared to existing drip tape indicates a good performance of the system. The average discharge of emitters dropped due to the partial clogging caused by algae infestation.

### 3.3 In-line Drip

It is observed from the Table 3 that, the average discharge rate of emitters was 1.44 lph, distribution efficiency value is 98%, field emission uniformity value 98%, absolute emission uniformity value is 98%, design emission uniformity value is 95%, application efficiency is 97%. The low value of Cv 0.017559 and high Statistical Uniformity Coefficient (SUC) of 98% observed in in-line drip indicated greater uniformity in discharge emission as compared to drip tape.

**Table 1. Performance parameters of existed drip tape**

S.NO	PRESSURE (Kg/cm <sup>2</sup> )	DISCHARGE	AVG	DIS-AVG	QM	ED	EA	APPL. EFF	FEU	STD	CV	DEC	UC
1	1	0.63	0.68	0.05	0.03	96%	91%	93%	93%	0.04	0.054	85%	94.5%
2	1	0.62	0.68	0.06									
3	1	0.72	0.68	0.04									
4	1	0.67	0.68	0.01									
5	1	0.69	0.68	0.01									
6	1	0.71	0.68	0.03									
7	1	0.72	0.68	0.04									
8	1	0.68	0.68	0									
9	1	0.65	0.68	0.03									
10	1	0.71	0.68	0.03									

**Table 2. Performance parameters of new drip tape**

S.no	Pressure (Kg/cm <sup>2</sup> )	discharge	AVG	DIS-AVG	QM	ED	EA	AEU	AU	STAND	C v	DEC	UC
1	1	0.73	0.744	0.014	0.0268	96%	94%	96%	95%	0.030623	0.04116	89%	95.88%
2	1	0.78	0.744	0.036									
3	1	0.78	0.744	0.036									
4	1	0.73	0.744	0.014									
5	1	0.78	0.744	0.036									
6	1	0.77	0.744	0.026									
7	1	0.73	0.744	0.014									
8	1	0.71	0.744	0.034									
9	1	0.7	0.744	0.044									
10	1	0.73	0.744	0.014									

**Table 3. Performance parameters of In-line drip**

S.NO	PRESSURE (Kg/cm <sup>2</sup> )	discharge	AVG	DIS-AVG	QM	ED	EA	EU	AU	STD	CV	DEC	UC
1	1	1.73	1.744	0.014	0.027	98%	97%	98%	98%	0.03062	0.01756	95%	98%
2	1	1.78	1.744	0.036									
3	1	1.78	1.744	0.036									
4	1	1.73	1.744	0.014									
5	1	1.78	1.744	0.036									
6	1	1.77	1.744	0.026									
7	1	1.73	1.744	0.014									
8	1	1.71	1.744	0.034									
9	1	1.7	1.744	0.044									
10	1	1.73	1.744	0.014									

**Table 4. Yield and economics of green leafy vegetables**

Crop	Yield (kg acre <sup>-1</sup> )	Current Market price (Rs.kg <sup>-1</sup> )	Cost of cultivation (Rs acre <sup>-1</sup> )	Gross returns (Rs acre <sup>-1</sup> )	Net returns Rs acre <sup>-1</sup>	Benefit cost ratio
Palak	3465	50	16302	173250	156948	9.6
Sorrel	4325	40	16242	173000	156758	9.6
Methi	3825	80	20167	306000	285833	14.2
Amaranthus	2420	75	21111	181500	160389	7.6
Coriander	2102	90	18497	189180	170683	9.2

### 3.4 Yield and Economics of Green Leafy Vegetables

Among the five green leafy vegetables Methi has recorded highest gross (Rs 3,06,000 acre<sup>-1</sup>) and

net returns (2,85,833) and benefit cost ratio (14.2) whereas Amaranthus has recorded lowest benefit cost ratio (7.6) (Table 4). The higher yields of green leafy vegetables in Polyhouse during summer were due to reduced weed

pressure, moisture conservation, reduction of certain insect pests and more efficient use of soil nutrients. Better performance of Amaranthus, Palak and coriander in polyhouse was reported by Sheeba Rebecca Isaac, [19].

#### 4. CONCLUSION

Uniformity co-efficient was tested using existed drip tape, new drip tape and in-drip laterals. When existing drip tape is compared with new drip tape observed that uniformity of co-efficient is the same when maintained properly. The absolute emission uniformity values for drip tape and inline drip was >90% hence, the drip irrigation system in water distribution uniformity is excellent. The low value of CV for inline drip system indicates good performance of the system with less variation in manufacturing of emitters compared to new drip tape and existed drip tape. In terms of performance characteristics, drip tape and in line system performed better in maintaining uniformity discharge. It can be concluded that the designed drip irrigation operated excellently.

The green leafy vegetables tested were Spinach, Sorrel, Coriander, Methi, Amaranths. Among the five different leafy vegetables, Methi has recorded highest gross (306000 Rs acre<sup>-1</sup>) and net returns (285833) and benefit cost ratio (14.2) whereas Amaranthus has recorded lowest benefit cost ratio (7.6). It was concluded that, in line drip lateral proved to be better than drip tape for getting higher uniformity coefficient. Among the leafy vegetables Methi, palak and sorrel can be grown in the month of June rather than other leafy vegetables under Polyhouse to get more net returns and benefit cost ratio to the farmers.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

#### REFERENCES

1. OECD. Sustainable Management of Water Resources in Agriculture. 2010; 27. Available:PJTSAU.edu.in/research.html-2020.
2. Suat Irmak, Odhiambo Lameck, Kranz O, William L, Eisenhauer Dean E. Irrigation Efficiency and uniformity, and crop water use efficiency. Biological Systems Engineering: Papers and Publications; 2011;451.
3. Dhawan. Water and Agriculture in india background paper for the south Asia expert panel during the global forum for food and agriculture (GFFA). 2017;13.
4. The centre for agriculture, Food and the environment. Irrigating vegetable Crops: University of Massachusetts Amherst; 2017.
5. Narayanamoorthy A, Bhattaraib M, Jothic P. An assessment of the economic impact of drip irrigation in vegetable production in India. Agricultural Economics Research Review. 2018;31(1):105-112.
6. Roma Kumari, Arun Kaushal. Drip fertigation in sweet pepper: A review. Int. J. Engi. Res. Appli. 2014;4(8):144-149.
7. Jamrey PK, Nigam GK. Performance evaluation of drip irrigation systems. The Pharma Innovation Journal. 2017;7(1):346-348.
8. Mized N, Kruse EG. Emitter discharge variability of subsurface drip irrigation in uniform soils: Effect on water application uniformity. Trans. of the ASAE. 2008;26:451-458.
9. Tekin Kara, Emine Ekmekci, Mehmet Apan. Determining the Uniformity Coefficient and Water Distribution Characteristics of Some Sprinklers. Pakistan Journal of Biological Sciences. 2008;11:214-219.
10. Ella VB, Reyesand MR, Yoder R. Effect of hydraulic head and slope on water distribution uniformity of a low-cost drip irrigation system. App. Eng. in Agric. 2009;25(3):349-356.
11. Horticulture Department, Telangana. spnhorti (at) Telangana (dot) gov(dot) in; 2020.
12. Jagadish Reddy. polyhouse subsidy in Telangana and construction cost. Agriculture Farming; 2019.
13. Sangareddy District Mandal wise crop areas; 2020. Available:Data.telangana.gov.in.
14. Wu IP, Gitlin HM. Hydraulics and uniformity of drip irrigation. J. Irrigation and Drainage Division, ASCE. 1973;99(2):157-167.
15. Mane MS, Ayare BL, Magar SS. Principles of drip irrigation system: Third revised and enlarged edition; 2014.
16. Keller J, Karmeli. Trickle irrigation design parameters. Transactions of the American Society of Agri. Engi. 1974;17(4):678-684.

17. Hezarjaribi A, Dehghani AA, Meftah Heigh M, Kiani A Hydraulic performances of various trickle irrigation emitters. *Journal of Agronomy*. 2008;7:265-271.
18. Wilcox JC, Swailes GE. Uniformity of water distribution by some under tree orchard sprinkler. *Journal of Scientific Agriculture*. 1947;27:565-583.
19. Sheeba Rebecca Isaac. Performance Evaluation of Leafy Vegetables in Naturally Ventilated Polyhouses. *International Journal of Research Studies in Agricultural Sciences (IJRSAS)*: 2015;1(3):1-4.
20. Abdi H. Coefficient of variation. In Neil salkind (Ed.) *Encyclopedia of research Design*. Thousand Oaks, CA: Sage; 2010.
21. Kaushal A, Patole R, Singh KG. Drip irrigation in sugarcane: A review. *Agri. Rev*. 2012;33:211–219.
22. Mistry P, Akil M, Suryanarayana TMV, Parekh FP. Evaluation of drip irrigation system for different operating pressures. *International Journal of Advance Engineering and Research Development (IJAERD)*: 2017;2348-4470.

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