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RESPONSE OF WATER USE EFFICIENCY THROUGH FERTIGATION ON GROWTH AND YIELD OF CHILLI CROP

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ABSTRACT

Water is the vital source for crop production and is the most limiting factor in Indian agricultural scenario. Though India has the largest irrigation network, the irrigation efficiency does not exceed 40%. The average rainfall in Uttar Pradesh is 650 mm as against the average rainfall of 1200 mm in the country. Due to water scarcity, the available water resources should be very effectively utilized through water saving irrigation technologies. The need of the hour is, therefore, to maximize the production per unit of water. Hence, further expansion of irrigation may depend upon the adoption of new systems such as pressurized irrigation methods with the limited water resources. Amongst those pressurized irrigation methods, drip irrigation has proved its superiority over other methods of irrigation due to the direct application of water and nutrients in the vicinity of root zone. Improper management of water and nutrient has contributed extensively to the current water scarcity and pollution problems in many parts of the world, and is also a serious challenge to future food security and environmental sustainability. The results shown the drip irrigation system of fruit characteristics recorded after every picking and the average values are expressed under various treatments of fruit yield and quality. At harvesting time, samples of green pepper fruits were randomly harvested from each plot to measure fruit length and fruit diameter. In addition, total weight of fruits in each treatment were recorded by harvesting pepper fruits twice weekly and then the total yield as Kg/fed., was calculated. The maximum yield of crop 900 gm/plant and minimum of yield 600 gm/plant and total yield 52270 gm (52.270 kg).

KEYWORDS: Drip Irrigation, rainfall, food security.

INTRODUCTION

The modern technology of drip irrigation is successfully practiced in many countries for orchards, vegetables, ornamental crops and as well as high value field crops. It is gaining momentum and its prospects in the years to come are expected to be very bright. Though India has the largest irrigation network, the irrigation efficiency does not exceed 40%.The average rainfall in Uttar Pradesh is 650 mm as against the average rainfall of 1200 mm in the country. Due to water scarcity, the available water resources should be very effectively utilized through water saving irrigation technologies. The need of the hour is, therefore, to maximize the production per unit of water. Hence, further expansion of irrigation may depend upon the adoption of new systems such as pressurized irrigation methods with the limited water resources. Amongst those pressurized irrigation methods, drip irrigation has proved its superiority over other methods of irrigation due to the direct application of water and nutrients in the vicinity of root zone. Improper management of water and nutrient has contributed extensively to the current water scarcity and pollution problems in many parts of the world, and is also a serious challenge to future food security and environmental sustainability.

Bringing more area under irrigation would depend largely upon efficient use of water. In this context, micro irrigation has most significant role to achieve not only higher productivity and water use efficiency but also to have sustainability with economic use and productivity. Fertilizer management is the most important agro-technique, which controls development, yield and quality of a crop. Fertilizer use efficiency is only 50 per cent in conventional practice sites specific drip fertigation of soil application. Location specific fertilizer management practices are essential for increasing fertilizer use efficiency for optimizing the fertilizer input and maximizing the productivity. Every attempt is therefore necessary, in achieving this objective of higher water and fertilizer use efficiency. Under these circumstances, drip fertigation, which is known to be hi-tech and efficient way of applying fertilizers through irrigation system as a carrier and distributor of crop nutrients, holds bright promise (Magen, 1995).

This system also allows precise application of water-soluble fertilizers and other agricultural chemicals. It helps to achieve yield gains of up to 100%, water savings of up to 40-80%, and associated fertilizer, pesticide, and labor savings over conventional irrigation systems5. Apart from reducing water consumption, drip irrigation also helps in reducing cost of cultivation and improving productivity of crops as compared to the same crops cultivated under flood method of irrigation. Use of drip irrigation methods are becoming popular since water requirement in these methods is about half and water use efficiency is high. Fertigation through drip irrigation recorded higher water use efficiency than soil application under drip irrigation or surface irrigation.

Maximization of crop yield, quality and minimization of leaching loss of nutrients below the rooting zone could be achieved by managing fertilizer concentrations in measured quantities of irrigation water using drip irrigation (Hagin and Lowengart, 1995). Prabhakar and Hebbar (1999) based on field trials conducted at IIHR, Bangalore reported that highest fruit yield of capsicum hybrid green gold was obtained with 100 per cent fertigation using water soluble fertilizers, irrigated at 0.7 Epan level. The higher yield was the result of better plant growth coupled with yield components like more number of marketable fruits per plant and higher fruit size. This yield was nearly two and a half times that capsicum grown at 0.5 Epan without fertigation. Benefits of fertigation over traditional broadcast or drop fertilizing methods include:

- Increased nutrient absorption by plants,
- Reduction in fertilizer and chemicals needed,
- Reduction in water usage due to increased root mass being able to trap and hold water,
- Reduced leaching to the water table, and
- Nutrients are applied near the root zone of the crop, hence the crop responds very well.

Efficient management of water resources is essential to meet the increasing competition for water between agricultural and non-agricultural sectors and the present day share of 80 per cent of water used for agriculture is anticipated to be reduced by 70 per cent in the coming decade. This necessitates scientific management of available water resources, particularly in agricultural sector. Sustainability of any system requires optimal utilization of resources such as water, fertilizer and soil. Apart from the economic considerations, the adverse effect of injudicious use of water and fertilizers on the environment can have far reached implications. There is a need to develop agro technologies, which will help in sustaining the precious resources and maximize the crop production, without any detrimental impact on the environment. Various minor irrigation systems were tested and modified in different parts of the world by number of researchers. Some of them are Kumar *et al.* (2010); Fawzy Z.F. *et al*. (2012); Hakkim (2014); Bhuriya, R. *et al.* (2015), Gupta *et al.* (2015); Ughade *et al.* (2015); they suggested that continuous drip irrigation method could provide better yield and water use efficiency.

MATERIALS AND METHODS

The study was conducted in the farmers field located at IFTM University Moradabad, during the period of 2015 to 2016 Rabi season. The study area of 0.006 between Field 280 50’ 33.826” N latitude, 780 46’ 48.535” E longitude were studied during the Rabi season of 2015 to 2016. Experimental plots, one from low fertility area and other from high fertility area were selected for the study. In the test plots, the soil belongs to Moradabad series, having sandy soil (texture). Chilli (*Capsicum annuum*) “Pant Chilli-1” variety was used for the study. The experimental plot was laid out in a completely randomized design with three treatments. Soil samples were collected from the experimental sites one month before planting.

Soil Type

The detailed physical properties of the soils are given in Table 1

Table 1: Soil physical characteristics of experiment

Soil Depth (cm)	**Particle Size distribution of soil**			**Texture Class**	**Saturated Point (%)**	**F.C. (%)**	**W.P. (%)**	**EC (dSm^{-1})**
	Coarse Sand	Fine Sand	Clay Silt					
0-20	45.72	46.76	2.75	**Sandy**	22.0	10.5	4.6	0.30

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20-40	55.73	40.55	3.50	**Sandy**	20.0	12.4	5.5	0.34
40-60	37.62	58.42	3.76	**Sandy**	21.0	11.8	4.4	0.46

Selected Crops for Design

- Varity - Pant Chilli-1
- Family - Solanaceae
- Scientific Name - *Capsicum annuum*
-

Estimation of Maximum Crop (<u>Evapotranspiration)</u>
The maximum crop Evapotranspiration for different crop was calculated by the following formula.

$$ETm = Epan * Kc * Kp \qquad .... (1)$$

Where,
ETm = Maximum crop evapotranspiration(mm/day)
Epan= Maximum pan evapotranspiration (mm/day)
Kc =maximum crop coefficient
Kp =pan coefficient recorded for (0.90) for arid and semi arid region = 0.90

Design of Irrigation System

The design data of the drip irrigation system and the experimental details for the test plots are given in Table 1

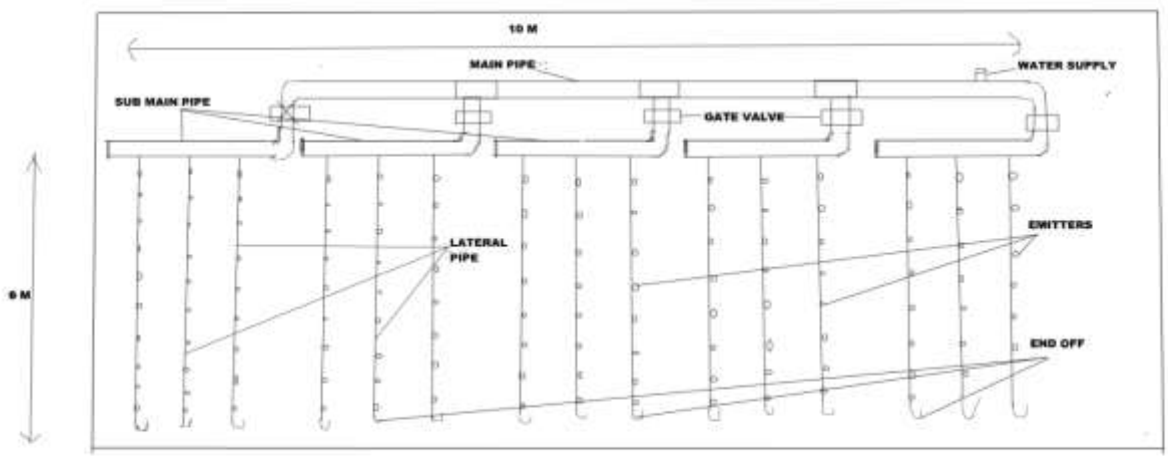

Fig.1 layout of typical drip irrigation system

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Fig. 2 Wetted area covered by plant

The design Data of the drip irrigation system and the experimental details for the test plots are given in Table 1.

Table 1 Experimental details

Description	Unit	Details
Crop	Chilli	Crop
Net irrigation Area	Ha.	0.006
Row ot Row Spacing	Mtr.	0.50 m
Plant ot Plant Spacing	Mtr.	0.70 m
Row Diraction	-	East-West
Total No. of Plants	No.	192
Type of irrigation System	-	Typical Drip Irrigation System
Emitter Type	-	online Emitter
Emitter Per Plant	No.	1 Emitter
Emitter Discharge	LPH	1.46
Lateral Spacing	Mtr.	0.70m
Emitter Spacing	Mtr.	0.50m
No. of Lateral Per Row	No.	1 Lateral
Application Rate	mm/hr	10%
Daily Peak Water Requirement	mm/hr	4.8
Daily Peak Water Requirement	ltr/day/plant	1
Irrigation Interval	hrs(Day)	24(one day)
Duration of One Shift	hr.	1
No. of Shift		1
Maximum Dailly Duration	hr.	1
Electricity Available Per Day	hr.	2-3
Maximum discharge Variation	%	Uniform
Exiting Pump Flow (at G.L.)	m^3/hr	25
Exiting Pump	HP	5
Pump Head Required	Mtr.	10
Water Source		Tub well
Water Source Depth	m.	30
Delivery Size of Pump	cm	10

Since design of irrigation system in the present study is for chilli crop different characteristics, which is crop water requirement) the following steps were considered for designing purpose.

Design of Drip Irrigation System for Chilli Crop

The layout of drip irrigation system design is given in table 2 are as follows.

Table 2 Crop specification

Crop Particular	Specification
Row to Row distance	70 cm
Plant to plant distance	50 cm
Plantation time	January
Duration of crop	150-200 days
Temperature	25-30°c
E_{pan} Maximum	14.5 mm/day
K_{pan}	0.90

Water Use Efficiency:
Having conveyed water to the point of use and having applied it, the next efficiency concept of concern is the efficiency of water use. It is expressed in kg/ha cm. The proportion of water delivered and beneficially used on the project can be calculated using the following formula

$$WUE = \frac{W_u}{W_d} \text{ X } 100 \quad \text{...... (2)}$$

where,
Eu = water use efficiency, per cent
Wu = water beneficially used
Wd = water delivered

Crop Water Use Efficiency: It is the ratio of yield of crop (Y) to the amount of water depleted by crop in evapotranspiration (ET).

$$CWUE = \frac{Y}{ET} \quad \text{.... (3)}$$

Where,
CWUE = Crop water use efficiency
Y = Crop yield
ET = Evapotranspiration

CWUE is otherwise called consumptive water use efficiency. It is the ratio of crop yield (Y) to the sum of the amount of water taken up and used for crop growth (G), evaporated directly from the soil surface (E) and transpired through foliage (T) or consumptive use (Cu)

$$CWUE = \frac{Y}{G+E+T} \quad \text{.... (4)}$$

Where,
(G + E + T) = Cu
In other words ET is Cu since water used for crop growth is negligible.

Field Water Use Efficiency
It is the ratio of yield of crop (Y) to the total amount of water used in the field.

$$FWUE = \frac{Y}{WR} \quad \text{.... (5)}$$

where,
FWUE = field water use efficiency
WR = water requirement

This is the ratio of crop yield to the amount of water used in the field (WR) including growth (G), direct evaporation from the soil surface (E), transpiration (T) and deep percolation loss (D).

$$FWUE = \frac{Y}{G+E+T+D} \quad \text{.... (6)}$$

$$G + E + T + D = WR$$

It is expressed in kg/ha/mm (or) kg/ha/cm

System capacity + Design for main line

$$Q = \frac{A \times GWDA}{t \times tw} \quad \text{.... (7)}$$

Where,
Q = Discharge rate (l/s)
A=Area in, M

T = Time in seconds
Tw = Working time in, hr.

Design for lateral line.

Capacity of each lateral = $\frac{\text{Discharge(ltr. per sec.)}}{\text{Total No. of laterals}}$ .... (8)

Hf = $K*L*Q^{1.75}D^{-4.75}F$ .... (9)

Where,
F = Reduction coefficient
L = Length of the main pipe, M
Q = Discharge rate of lateral pipe, l/s
K = Constant=7.85 × 105
D = Selected diameter of pipe, MM

Total head required of the system

Hsys = Head required for operation + function loss (Lateral + Sub main + main + filter)

Selection pump: Total head for the pump

H_{Total} = Suction head + friction loss on section pipe + delivery head + friction loss in delivery pipe + velocity + total head.

$H_{Total} = HS + HgS + Hd + Hfd + Vd^2/2g + Hsys.$ .... (10)

Water horse power = $\frac{\text{Qpmp (ltr. per s)} \times \text{H total}}{75 \times \eta}$

Where, $\eta = \eta_{Derive} \times \eta_{Pump} \times \eta_{Motor}$

Results and Discussions

This chapter deals with the results obtained from the present study of Designing of irrigation system for chilli crop research farm of IFTM University Moradabad (U.P)

Design layout of typical drip irrigation system

Drip systems available in the study area and used in the design the result of the investigation into the emitters available in the study area gave the following table 2 and Fig. 1 and fig. 2.

Table 1 Observation value of drip irrigation system

S.N.	Observations	Values
1.	Area covered by each plant	0.35 m^2
2.	No. of plant	2857
3.	Maximum crop evapotranspiration (ET)	15 mm/day
4.	Wetted area of one dripper	0.479m^2
5.	Number of drippers in the field in actual conditions	192 drippers in (0.006) hectare
5.	total wetted area of the drippers	53.76 m^2
6.	Net water application	438.38 m
7.	Gross water depth application	30
8.	Duration of water application	7.19 hrs.
9.	Main Line: capacity (flow rate)	0.512 m/s
10.	Laterals: Capacity of each lateral	0.032m/s
11.	Capacity of the Emitter is its discharge	10.5 ×m^3/h
12.	Design of laterals	0.211m
13.	Design of sub main line	0.9078m
14.	Design of main line	0.04909m
15.	Total head required of the system	7.00m
16.	Selection of pump	G.I. of 8cm inner diameters
17.		0.2604 H.P.

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Total head for the pump

Effect of drip irrigation levels on yield (Yield and Yield Parameters)

The fruit characteristics recorded after every picking and the average values are expressed under various treatments are shown in Fig. 1 and table 2. Fruit yield and quality: At harvesting time, samples of green pepper fruits were randomly harvested from each plot to measure fruit length, fruit diameter. In addition, total weight of fruits in each treatment were recorded by harvesting pepper fruits twice weekly and then the total yield as Kg/fed. was calculated. The maximum yield of crop 490 gm/plant and minimum of yield 32 gm/plant and total yield 33123 gm (33.123 kg).

Statistical Analysis

The Data on various parameters studied during the course of investigation were statistically analyzed, applying the technique of analysis of variance suggested by Panse and Sukhatme (1978). Wherever the treatment differences were found significant, ("F" test) critical difference was worked out at five per cent probability level. The treatment differences that were not significant were denoted by "NS".

Table 2 Effect of fertigation Yield parameters of chilli for low fertility area

Treatment	Parameter				
	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (gm)	Fruit yield (g/plant)	Fruit yield (Kg)
T1	5.5	1.9	5.5	490.5	4.126
T2	5	1.8	4.5	320.5	6.995
T3	4.4	1.9	5.2	420.5	5.575
T4	5.2	1.8	5	410.6	7.529
T5	4.5	2	4.5	420.6	8.122
Mean	**4.92**	**1.88**	**4.94**	**412.54**	**6.469**
S. E. D.	0.080	0.060	0.070	2.450	0.080
CD (0.01)	0.04**	0.02**	0.03**	0.09**	0.02**
CD (0.05)	0.02	0.01	0.02	0.04	0.02

*** - significant at 5 % level, **- significant at 1 % level, NS – not significant**

In case of low fertility area the fruit length increased with increased rate of fertigation, whereas no significant

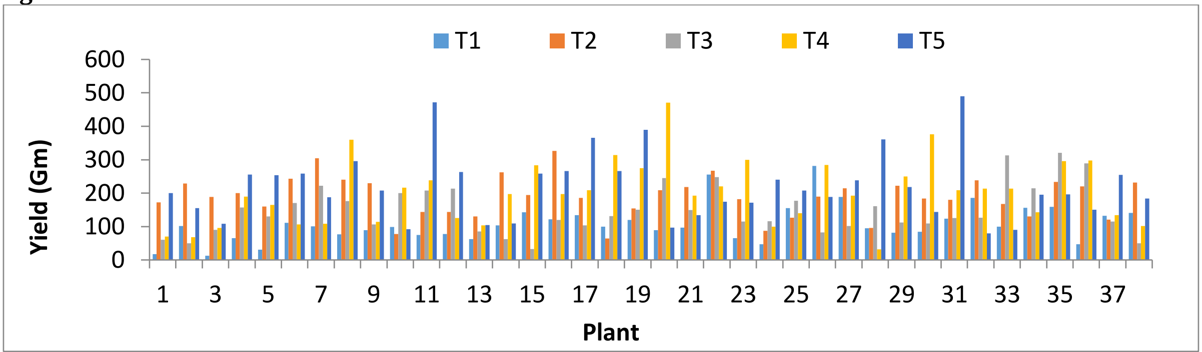

Fig. 1 Effect of drip irrigation levels on yield of per plants

Water use efficiency (WUE): Water use efficiency (yield per unit area per unit depth of water used) decreased with increase in irrigation levels i.e. 0.7 VD, 0.9 VD and 7 VD for all the treatments of drip irrigation system. The increase in water use efficiency for drip irrigation system, Among the drip irrigation levels, the highest field water

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use efficiency (6148.31kg ha^{-1} cm^{-1}) was found at 65% irrigation level, indicating comparatively more efficient use of irrigation water (Table 3) with a possibility of water saving of 35% water by adopting chilli plot (1.42 litre $plant^{-1}day^{-1}$). The graph represents the effect of drip irrigation levels on water use efficiency of chilli crop (Fig. 2).

Table 3 Field water use efficiency of chilli as influenced by drip irrigation levels

Irrigation schedule	Yield (kg ha^{-1})	Water used (cm)	Water saving (%)	Water use efficiency (kg ha^{-1})
T_1: 50% drip irrigation level	**4.126**	5.5	50	**0.750**
T_2: 65% drip irrigation level	**6.995**	6.5	35	**1.076**
T_3: 75% drip irrigation level	**5.575**	8.5	25	**0.655**
T_4: .90% drip irrigation level	**7.529**	9.0	10	**0.836**
T5: 100% drip irrigation level	**8.122**	10.0	0	**0.812**

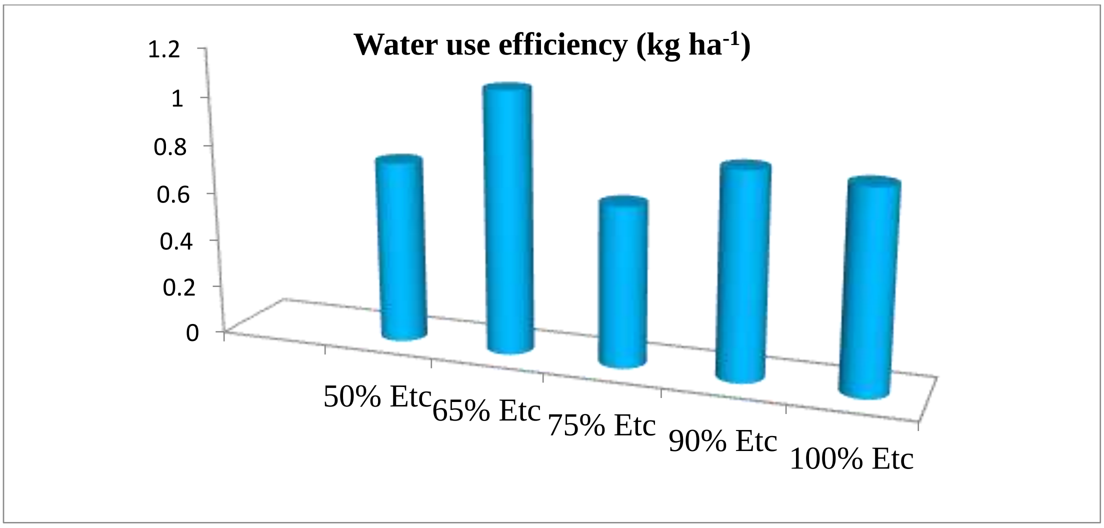

Fig. 2 Effect of drip irrigation levels on WUE

CONCLUSIONS

- The water use efficiency of the crops has to be increased in order to reduce the water loss from the field.
- Drip irrigation system is considered as the most effective micro irrigation method, as water is applied directly into soil at the crop root zone.
- The results of the study showed that drip irrigation levels have significant ($P < 0.05$) effects on crop yield.
- There were significant positive correlations ($P < 0.01$) between fruit number, fruit weight and fruit yield. Increase in fruit number was the most important factor representing yield increase.
- Hence it can be concluded that drip irrigation level of 65% (1.46 litre $plant^{-1}$ day^{-1}) is the best irrigation level recommendation for salad cucumber grown under naturally ventilated polyhouse in order to get higher economical cucumber yield.

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