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EFFECT OF DRIP IRRIGATION ON YIELD AND WATER USE EFFICIENCY ON BRINJAL (SOLANUM MELONGENA) CV. PANT SAMRAT

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ABSTRACT

Drip irrigation is an irrigation method that saves water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone through a network of valves, pipes, tubing and emitters. It is done through narrow tubes that deliver water directly to the base of the plant. 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. Diversification of cropping pattern particularly in favour of vegetable crops is becoming popular among farmers because vegetables are most important component in a balanced diet. But diversification of area from field crops to olericulture to meet the demand is not desirable. The maximum yield of crop 900 gm/plant and minimum of yield 600 gm/plant and total yield 52270 gm (52.270 kg).The increase in water use efficiency for drip irrigation system. Among the drip irrigation levels, the highest field water use efficiency (6148.31kg ha^{-1} cm^{-1}) was found at 65% irrigation level, indicating comparatively more efficient use of irrigation water with a possibility of water saving of 35% water by adopting brinjal plot (1.58 litre $plant^{-1}day^{-1}$).

KEYWORDS: Crop yield, Water Use Efficiency, Drip Irrigation Systems.

INTRODUCTION

Drip irrigation is an irrigation method that saves water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters. It is done through narrow tubes that deliver water directly to the base of the plant. 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.

Diversification of cropping pattern particularly in favour of vegetable crops is becoming popular among farmers because vegetables are most important component in a balanced diet. But diversification of area from field crops to olericulture to meet the demand is not desirable. Short duration vegetables grown in-between the agricultural crops is the recent advancement to fulfill the requirement of vegetables without any reduction of agricultural area. Fertigation, is one form of chemigation is hence the effect irrigation water requirements and fertigation the technique of supplying dissolved fertilizers to on growth, yield and some grain quality traits of wheat crops through the irrigation system, it is a modern cultivar. Agro-technique provides an excellent opportunity to maximize yield and minimize environmental pollution by increasing fertilizer use efficiency, minimizing fertilizer application and increasing return on the fertilizer invested. This system also allows precise application of watersoluble 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 labour 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.

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. 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. Subsurface drip irrigation (SDI) is an adaptation of drip irrigation, where the irrigation drip tube is installed below the soil surface to reduce water losses due to soil evaporation thereby increasing water use efficiency. A potential limitation to the use of subsurface drip irrigation in sandy soils is the establishment period when root systems are confined to the upper 5–10 cm and plant water supply depends on capillary rise which may be limited on sandy soils. In order to overcome this limitation, and to also reduce potential nitrate leaching, combined surface applied fertigation via drip tape with subsurface drip irrigation controlled by soil moisture sensor irrigation. In fact, subsurface drip irrigation is an adaptation of a partial root zone drying technique, which requires wetting part of the root zone and leaving the other part dry, thereby utilizing reduced amount of irrigation water applied. It is expected that such a practice may increase irrigation-water-use efficiency (IWUE) leading to reduction in irrigation water requirement, while maintaining Brinjal yields. Various minor irrigation systems were tested and modified in different parts of the world by number of researchers. Some of them are Pessarakli and Dris (2004); Vijayakumar *et* al. (2010); **kumar *et al*. (2010);** Bhogi *et al*. (2011); Ndereyimana *et* al. (2013); Erdal *et* al. (1013); Ughade and Mahadkar (2015); Badr *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 studies was conducted during the Rabi season of 2015 to 2016. Experiment 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). Brinjal (*Solanum melongena*) "Pant smart" variety was used for the study.

Component of Drip irrigation system: A drip irrigation system consists of the following components.

Pump unit

It consist a pump to lift water and to produce desire pressure (about 1 atmospheres pressure) from the sources to distribution the water through the nozzles.

Control head:

As drip irrigation used to obtain high irrigation efficiency, flow and control devices are an integral part of the system. Flow and pressure are to the control during each phases of irrigation. The flowing devices are for control flow and pressure control.

- Flow control valve
- Pressure regular valve

Main and sub-mains

These are normally of flexible material such as PVC or plastic. The diameter of the mains sub-mains should be sufficient to carry the design discharge in the system. There should be a balance between the diameter of mains and Sub-mains friction losses. The size of main and sub-mains is range from 5 cm to 11 cm in diameter.

Laterals or drip line

Use 12 mm PVC or polyethylene irrigation pipes for mainlines ("mains") and laterals. The total length of the mainline and the lateral together should not be more than 120 meters (400 feet). So you could have 100 meters of mainline and 20 meters of lateral, for a total of meters of both. But you should not have 80 meters of mainline and

60 meters of lateral because the total of both would be more than 120 meters. The laterals are usually made of low density polyethylene. The size of laterals ranges from 10mm to 20 mm inside diameter.

Dripper or emitter

An emitter is also called a dripper and is used to transfer water from water from a pipe or tube of the area that is to be irrigated. Typical emitter flow rates are from (1.52 to 15 L/h). These emitters employ silicone diaphragms or other means to allow them to mainline a near-constant flow over a range of pressure, for example from 8 to 40 psi (56 to 280 KPa)

Location of Water Source

T0 supply the water in different near to the drip irrigation system designed irrigation systems a tube well available in the most of the field at 90 meter Distance. The depth of the water level in the tube well is 70 meter since.

Soil Parameters

Since certain soil characteristics are used in design of irrigation system for marigold crop. These characteristics are directly result and estimated in actual field conditions.

Soil Types: 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	47.76	49.75	2.49	Sandy	21.0	10.1	4.7	0.35
20-40	56.72	39.56	3.72	Sandy	19.0	13.5	5.6	0.32
40-60	36.76	59.40	3.84	Sandy	22.0	12.5	4.6	0.44

Infiltration Rate

Soil infiltration rate was measured in the field by installing single ring infiltrometer at important locations.

Field Capacity and Wilting Point

Since soil is judged as a sandy loam soil the recommended values of the filed capacity, permanent wilting point and moisture holding capacity of the soil by F. A. O. 1998 was taken for design considerations.

Selected Crops for Design

- Varity - Pant samrat
- Family - Solanaceae
- Scientific Name - Solanum melongena

Pan Evaporation

Daily Pan Evaporation data of last three years (2013,2014 and 2015) was collected from the meteorological observatory C.C.S. University Campus, Meerut and mean value of daily Pan Evaporation was calculated.

Pan Coefficient

Pen coefficient (Kp) for class A pan for different pan sittings and environment and different trend of wind, relative humidity and wind speed (FAO, paper no. 24) were studied and an coefficient of 0.90 was selected in Meerut and pan is placed in dry fallow area.

Estimation of Maximum Crop (Evapotransporation)

The maximum crop Evapotranspiration for different crop was calculated by the following formula.

ETm = Epan* Kc* Kp .... (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

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Design of Irrigation System

The design of the drip system is essentially a decision regarding selection of emitters. In the present study, the existing pumping system used by the farmers for irrigation was considered for the system and the flow and pressure requirement was regulated with the help of control valves. To economize the drip installation cost for brinjal crop based on the wetting zone in the soil for 4 lph emitter, the spacing of lateral and spacing between emitters were selected as 1.5 m and 0.6 m respectively Water was pumped from the source through a 5 HP submersible pump and conveyed to the field using 63 mm diameter PVC pipes. From the main line, sub main lines of 63 mm and 50 mm diameter PVC pipes were taken off. From the sub main lines, inline emitter lateral lines of 16mm.

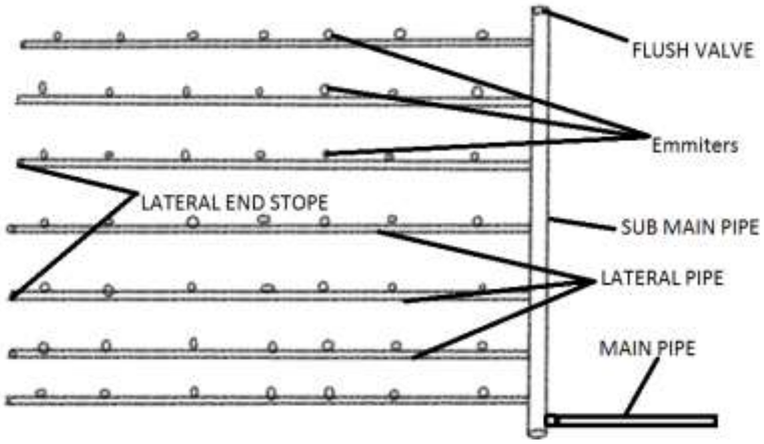

Fig.1 layout of drip irrigation system

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Fig. 2 Wetted area covered by plant

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	Brinjal	Crop
Net irrigation Area	Ha.	0.006
Row to Row Spacing	Mtr.	0.60 m
Plant to Plant Spacing	Mtr.	0.90 m
Row Direction	-	East-West
Total No. of Plants	No.	120
Type of irrigation System	-	Drip Irrigation System
Emitter Type	-	online Emitter
Emitter Per Plant	No.	1 Emitter
Emitter Discharge	LPH	1.58
Lateral Spacing	Mtr.	0.90m
Emitter Spacing	Mtr.	0.60m
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	1-2
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

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Design of Drip Irrigation System for Brinjal 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	60 cm
Plant to plant distance	90 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

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

where,

Eu = water use efficiency, per cent

Wu = water beneficially used

Wd = water delivered

Water use efficiency is also defined as (i) crop water use efficiency and (ii) field water efficiency.

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

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

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)

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

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.

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

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).

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

G + E + T + D = WR

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

Deep percolation is important for rice crop. For other crops seepage is important. Of the two indices defined, the crop water use efficiency is more of research value whereas the field water use efficiency has grater practical importance for planners and farmers.

Climatological Parameter

Layout: A careful planning with respect to distribution of crop in the area and areas under different crop is needed to optimize the resource. Location of main, sub main and lateral lines and respective length are likewise to be decided accordingly. Locating control value and main control values should be located nearer to pumping unit, should be have adequate working around and should be easily accessible.

Number of plants in area = $\frac{\text{Area of the field}}{\text{Area covered by each plant}}$ .... (7)

$ET_{Max} = Kc_{max} \times E_{pan} \times K_p$ .... (8)

3.9.4 Wetted area of one dripper = πr^2 .... (9)

Where is the radius of one dripper

$r = \sqrt{\frac{q}{rHc}}$ .... (10)

Where,

Q = Discharge rate cm^3/h

Hc = Saturated infiltration rate cm/h

Percentage wetted area (Wa) = $\frac{\text{Wetted area of drippers in the field}}{\text{Total area of the field}} \times 100$ .... (11)

Net water depth application (NWDA) = $(FC - PW) \times AS \times Zr \times 10(1 - CP) \times WA$ ... (12)

Where,

FC = Field capacity in %

PW = Perameter wetting pion %

AS = Specific gravity gm/cm^3

Zr = Rooting depth in, m

CP = Critical poin for drip trigatin system allowable deptetion = 20%

Gross water depth application (GWDA)

$GWDA = \frac{NWDA}{\mu}$ .... (13)

Where, μ = Efficiency of drip irrigation system

Irrigation interval (in days)

$r = \frac{NWDA}{ETmax}$ .... (14)

Duration of water application

$Du = \frac{GWDA}{\text{Application rate}}$ .... (15)

Application rate = $\frac{\text{Discharge}}{\text{Row to row distance} \times \text{plant to plant distance}}$

System capacity + Design for main line

$Q = \frac{A \times GWDA}{t \times tw}$ .... (16)

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 = $\frac{\text{Discharge(ltr. per sec.)}}{\text{Total No. of laterals}}$ .... (17)

Design of lateral

Determination of head loss in the lateral line by using dray-wise bach-blassing equation

$Hf = K*L*Q^{1.75}D^{-4.75}F$ .... (18)

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.

$H_{Total} = HS + HgS + Hd + Hfd + Vd^2/2g + Hsys$. .... (19)

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 brinjal crop research farm of **IFTM University Moradabad (U.P).**

Design layout of typical drip irrigation system

The drip line design is the design of the irrigation system at field level. It is consists in choosing, depending on the characteristics of the field, the drip line that provides better uniformity while having a look at the investment cost. Drip line 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 1 and Fig. 1 and fig.2.

Table 1 Observation value of drip irrigation system

S.N.	Observations	Values
1.	Area coverd by each plant	0.54 m^2
2.	No. of plant population per hectare	18518
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	120 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 8 cm inner diameters
17.	Total head for the pump	0.2604 H.P.

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 900 gm/plant and minimum of yield 600 gm/plant and total yield 52270 gm (52.270 kg).

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

Treatment	Parameter				
	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (gm)	Fruit yield (g/plant)	Fruit yield (Kg)
T_1	13	6.7	57	900.0	6.252
T_2	11	5.0	46	776.0	6.950
T_3	11	4.5	44	700.0	7.323
T_4	12	5.5	52	810.0	10.745
T_5	9.5	6.0	52	790.0	9.841
T_6	10.5	6.2	54	800.0	11.159

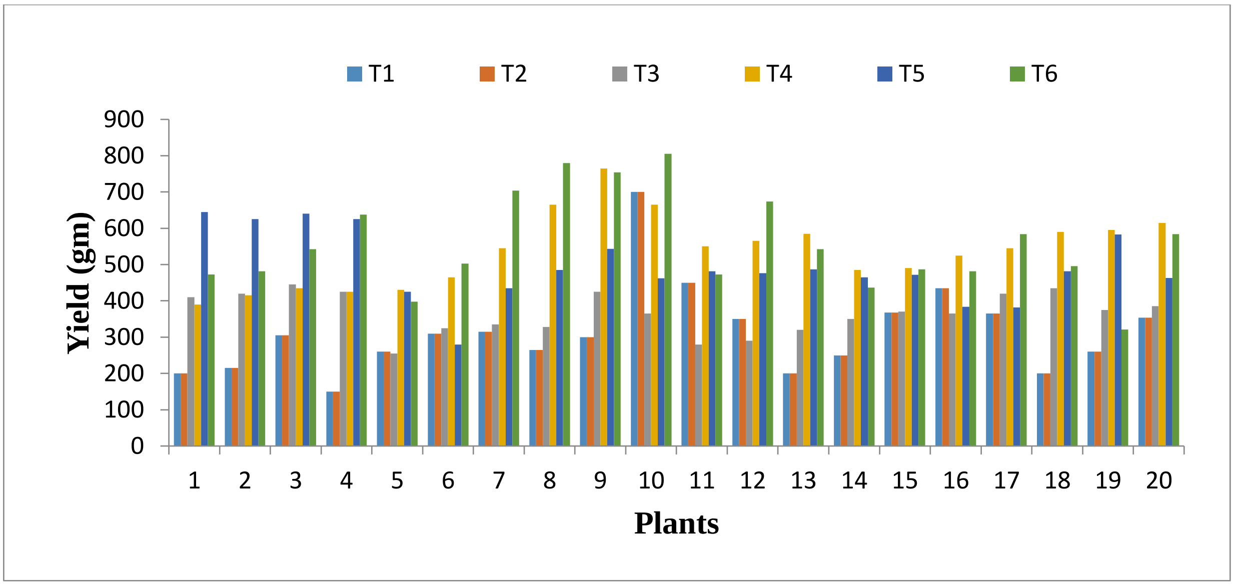

Fig. 1 Effect of drip irrigation levels on yield

Water use efficiency (WUE): Water use efficiency (yield per unit area per unit depth of water used) decreased with increase in irrigation levels 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 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 brinjal plot (1.58 litre $plant^{-1}day^{-1}$). The graph represents the effect of drip irrigation levels on water use efficiency of brinjal crop show in fig. 2.

Table 3 Field water use efficiency of Brinjal 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	**6.252**	5.5	50	**1.136**
T$_2$: 65% drip irrigation level	**6.950**	6.5	35	**1.069**
T$_3$: 75% drip irrigation level	**7.323**	7.5	25	**0.964**
T$_4$: 80% drip irrigation level	**10.745**	8.0	20	**1.343**
T$_5$: 90% drip irrigation level	**9.841**	8.5	10	**1.157**
T$_6$:100% drip irrigation level	**11.159**	9.5	0	**1.220**

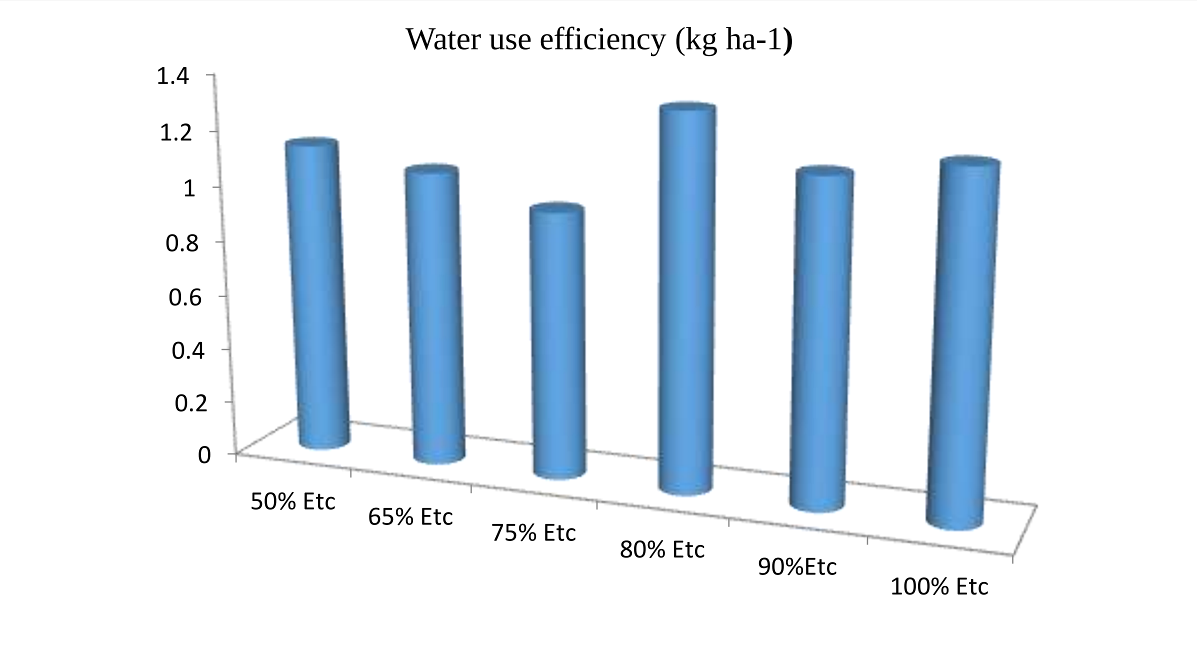

Fig. 2 Effect of drip irrigation levels on WUE

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