

Original Research Article

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Effect of Irrigation and Fertigation on Gladiolus Crop Water Requirement, Yield and Water Use Efficiency in Chhattisgarh Plain

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ABSTRACT

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Agricultural sector consumes the largest percentage of freshwater to cater to the need for food forever increasing population but the resources like land and water are becoming scares. Therefore, we need to increase water use efficiency by incorporating the modern drip method of irrigation. One of the ways of alleviating water scarcity is by enhancing its use efficiency or productivity. Improving Water use efficiency (WUE) and fertilizer use efficiency in agriculture will require an increase in crop water productivity (an increase in marketable crop yield per unit of water used by plant) and reduction in water losses from the crop root zone. Therefore, this experiment was carried out at Borsi Farm, DauKalyan Singh Agricultural College & Research Station, Bhatapara (IGKV, Raipur) with three different irrigations and fertigation levels to work out crop water requirement, Water use efficiency and Fertilizer use efficiency. The results of the study revealed that 60 % of cumulative pan evaporation (CPE) water and 80 % water solubilizing fertilizer (WSF) through drip gave the maximum yield of Gladiolus (110119 spikes ha⁻¹) and (110119 corms ha⁻¹), which is 29% more over conventional irrigation. The results also revealed that the water used by the crop was maximum in the conventional method (454.4 mm), water use efficiency was recorded maximum in 60 % CPE water by drip (72.52%), and water-saving also. Similarly, the fertilizer use efficiency (6.39 kg kg⁻¹) and fertilizer saving (73.4%) was observed maximum in 80% WSF by drip.

Introduction

Gladiolus (*Gladiolus sp.*) is a very popular bulbous ornamental plant. Its magnificent inflorescence with florets of dazzling colors, varying forms and sizes, and long keeping quality makes it an attractive cut flower. Gladiolus spikes can be kept in the vases for 8-10 days depending on the variety and the ambient conditions prevailing in the room. Gladiolus is an essential component of most flower arrangements including bouquets (Agricoop). A cutflower is being grown in an

area of 277000 ha in the country with an estimated production of 527000 MT cut flowers and 1.9 MT ha⁻¹. Amongst the cut flowers, gladiolus occupied the third position in terms of both area and production.

The major gladiolus producing states in the country are Uttar Pradesh, West Bengal, Odisha, Chhattisgarh, Haryana & Maharashtra. Gladiolus is also grown in states like Uttarakhand, Karnataka, Andhra Pradesh, and Sikkim. Even though gladiolus is mainly a winter season flower crop, in areas having

moderate climatic conditions, gladiolus can be grown throughout the year (DAC&FW2015-16). In Chhattisgarh, the total Area of Flower production is 7130 ha and production 26604 MT and Productivity 3.73 MT ha⁻¹. Out of which the Gladiolus occupies Area of 1346.63 ha and Production 3949.4 MT with Productivity of 2.93 t ha⁻¹. Which is the third rank in production and second rank in the area after tuberose (www.scribd.com).

Flower crops are very much responsive to fertilizer. It is highly capable of exhausting huge nutrients from native soil. So, it requires a higher amount of chemical fertilizer in a balanced proportion for ensuring maximum flower production. Fertilizer requirements of gladiolus like other crops have a vital role in growth, quality, corn, and cornel production. There are some reports on the requirement of Nitrogen (N), Phosphorus (P), Potassium (K), and other fertilization in many countries. Major nutrients like nitrogen, phosphorus, potassium along with zinc noticeably increase the number of flowers, florets/spike, length of the spike, and flowering stem of gladiolus (Halder *et al.*, 2007).

Materials and Methods

The field experiment was conducted at the Borsi Farm of DauKalyan Singh College of Agriculture and Research Station, Bhatapara (IGKV) Chhattisgarh during the winter season of the year 2018. The experimental site is situated at 21.73° N latitude and 81.93° E longitude. It has an average elevation of 261 m.

The district Balodabazar-Bhatapara is located at the central part of Chhattisgarh under the Chhattisgarh plain agro-climatic zone. The average rainfall of the district is 1100 mm, the minimum and maximum temperatures are 13.66°C to 27.98°C respectively. The average

relative humidity is 61.43% and the average wind velocity is 2.08 m s⁻¹. The experimental site has sandy loam soil and falls under the semi-arid zone. The properties of the soil such as field capacity, wilting point, bulk density, and soil depth were determined by usual standard methods.

The moisture content was taken at 0.15, 0.30, and 0.45 m depths of soil in each plot. The experimental field was 5.6 m long and 43 m wide. The raised beds of standard size i.e. 5.6×0.6 m² were prepared for the sowing of Gladiolus. The row-to-row and plant-to-plant spacing were 0.40 and 0.30 m respectively, 28 no. of the plant were planted in each row.

Drip irrigation system

The entire experimental drip irrigation system consisted of tube well (water source), pump, control valves, pressure gauge, fertilizer intake assembly, filter, main pipeline, sub-main line, and laterals. The drippers and lateral spacings were 0.40 m and 1.2 m, respectively. These investigations were carried out using ten treatments with three replications. Treatments were tested in a randomized block design. The details of the treatments are given below:

Irrigation and fertilizer treatments

Combinations – (T₁ = I₁F₁, T₂ = I₁F₂, T₃ = I₁F₃, T₄ = I₂F₁, T₅ = I₂F₂, T₆ = I₂F₃, T₇ = I₃F₁, T₈ = I₃F₂, T₉ = I₃F₃)

I₁ – Irrigation of 0.6 CPE by drip (Cumulative Pan Evaporation)

I₂ – Irrigation of 0.8 CPE by drip

I₃ – Irrigation of 1.0 CPE by drip

F₁ – 80% RDF (Recommended dose of fertilizer)

F₂ – 100% RDF

F₃ – 120% RDF

Control

I₄ – Surface Irrigation at CPE

Water requirement of gladiolus

Gladiolus corms were sown on 7 November 2017. All treatment plots were irrigated to attain moisture content at field capacity. The amount of water applied during this period was accounted for the total water requirement of the crop. The detailed estimation of the amount of water applied and the time of operation for each treatment is presented in Table 1. Irrigation water was applied at every alternate day based upon cumulative pan evaporation during that period for three irrigation level I₁, I₂, and I₃. Scheduling of irrigation was done by using crop coefficients in drip irrigation (Doorenbos and Pruitt, 1977) and the same methodology was adopted by Khanam and Patra (2015), Singh *et al.*, (2016) to determine water use by the gladiolus.

The volume of water per bed was calculated by using the following formula.

$$V = \frac{ET_o \times K_c \times S_l \times S_e \times W_a \times \text{No. of plant}}{E} \quad \dots(1)$$

Where,

V = Volume of water (lit day⁻¹ plant⁻¹), ET_o = Reference evapotranspiration (mm day⁻¹), K_c = Crop coefficient (as per growth stages), S_l = Spacing between laterals (m), S_e = Spacing between emitters (m), W_a = Wetted area (%), E = Efficiency of system (%)

The operation time of the system (T) was calculated by using the following formula:

$$T = \frac{V}{q \times N_e} \quad \dots(2)$$

Where,

T = Operating time of system (hr), V = Total volume of water (lit), q = Emitter discharge

(lph), N_e = Number of emitters plot⁻¹

Hydraulic performance calculation of drip irrigation

Uniformity coefficient (UC)

Uniformity coefficients of emitters were tested using the Christiansen's (1942) formula. It gives the information that how efficiently water is distributed in the field. For determination of the uniformity coefficient of emitter i.e. in-line drip irrigation system, the catch beakers were placed at each selected emission device of selected laterals. The system was operated at pressure 1.2 kg cm⁻². The water was allowed to the emitter in the beaker for 5 minutes continuously. The volume of water collected in the beaker was measured with the help of a measuring cylinder. The precipitation depth was calculated by dividing the volume of collected water with a cross-sectional area of the beaker.

$$CU = 100 \left[1 - \frac{\sum x}{MN} \right]$$

Where,

CU = Uniformity coefficient (%), M = Average value of all observations (mm), N = Total number of observation points, X = Absolute deviation of individual observations from the average application rate (mm)

Irrigation efficiencies

Water use efficiency (WUE)

Water use efficiency (WUE) of gladiolus is computed by dividing the flowering percentage (%) by total water use (WU, mm) for each treatment. The flowering percentage was computed by dividing the number of gladiolus plant that has flower by the total number of the gladiolus plant in that plot (Aydingsakir *et al.*, 2005).

$$\text{WUE} = \frac{\text{Flowering Percentage}}{\text{Total Water use}} \times 100 \quad \dots(3)$$

Where,

WUE = Water use efficiency (%)

$$\frac{\text{Flowering Percentage}(\%) \times 100}{\text{Flowered plants} / \text{planted Gladiolus plant}}$$

Fertilizer use efficiency (FUE)

The fertilizer use efficiency was determined from the yield data and total fertilizer applied. Similar studies were done by Azza *et al.*, (2016) and Solamalai *et al.*, (2005) on gladiolus to study yield and flowering characteristics. Fertilizer use efficiency was computed using the following equation:

$$\text{FUE} = \frac{\text{Yield of Gladiolus (kg ha}^{-1}\text{)}}{\text{Fertilizer applied (kg ha}^{-1}\text{)}}$$

Where,

FUE = Fertilizer use efficiency(kgkg⁻¹)

Economics of drip irrigation system under gladiolus production

The cost of production included the variable cost and fixed cost of the product. The variable cost involved paid out the cost on hired human labour, ploughing, seeds, fertilizers, plant protection, water, supervision, electricity charges, interest on working capital, interest on fixed capital, depreciation, repair, and maintenance charges for installation of drip irrigation system.

The gross monetary returns per hectare were worked out by considering the spike yield from different treatments and prevailing market prices and the net returns were worked out by subtracting the cost of production from gross monetary returns in each treatment.

The benefit: cost ratio was worked out using the formula below:

$$\text{B:C ratio} = \frac{\text{Net monetary returns}}{\text{Cost of Production}}$$

Results and Discussion

The observations on growth and yield parameters of gladiolus in each treatment were taken to know the effect of different levels of irrigation and fertigation. The results obtained from the study are discussed below:

Among all treatments, the maximum seasonal amount of water (454.4 mm) was applied in Furrow irrigation followed by level I3 (303.7), I2 (242.96 mm), I1 treatment (182.22 mm) respectively from Table 1. It can be observed that the depths of water applied in November, December, and in February are less as compared to the depth of water applied in January.

Effect of irrigation and fertigation levels on vegetative growth parameters

Accessibility of the data in the table 3 revealed that the application of irrigation at 0.6 CPE irrigation regime proved its superiority by recording the maximum and significantly higher yield attributes viz, presented in table 3. The maximum plant height (76.44 cm), leaves per plant (8.13), no. of shoot per plant (1.29), the diameter of a plant at the base (1.50 cm) was observed in treatment combination I₁F₁ and the lowest plant height (69.44 cm), the diameter of a plant at the base (1.25 cm) was observed in the control (furrow irrigation with 100 RDF) at the 60 DAP of the crop. The treatment combination I₁F₁ created optimum soil conditions for the growth of Gladiolus and also registered maximum spike yield. From the above results, it is concluded that the plant vegetative growth parameters of Gladiolus increased with the advancement of the age of the crop.

The plant needed sufficient water from initial to harvesting stages. In the irrigation level, the I_1 height of the plant was more due to the supply of sufficient water. The maximum number of leaves helping to cover a large cross-sectional area. Ultimately resulted in enhancing the photosynthesis activity and contributing to higher yield. In the case of irrigation level I_1 (0.6 PE), more number of leaves produced per plant which helped to increase the yield. Similar findings were reported by Salma *et al.*, (2013).

Effect of irrigation and fertigation levels on spike yield

Irrigation and fertigation significantly influenced plant spike initiation, minimum days to spike initiation (70.67), also no. of the spike, as presented in table 4 was observed in treatment combination ($I_1= 60\%$, $F_1= 80\%$) and the maximum days to spike initiation (76) in control irrigation similarly minimum days to plant colour show (78), flowering (82.67), full bloom (19.33), maximum spike length (80.12 cm), rachis length (65 cm), no. of floret (2.67), basal floret (13.08), durability (32) in I_1F_1 and minimum values of the parameter was recorded in control irrigation. This might be because the crop is sensitive to irrigation and it was getting more water than needed for sustainable growth at the different irrigation levels. The number of flower effects on yield of spike per plant. The yield was reduced due to decreasing in the mean fruit weight and a diminished fruit number, (Serrano *et al.*, 1992). The diminished fruit number was reported due to mild water deficits and excessive irrigation. This showed that for the increasing irrigation levels the yield of the crop was decreased. The reduction in yield was found due to water quantities exceeded the proper rates for optimal growth, (Rossi *et. al* 1988). This result was close to that obtained by Biswas *et al.*, (2015).

Effect of irrigation and fertigation levels on corms and cormel yield

The maximum number of corm (1.32), weight (86.81g), and diameter (6.66 cm) cormel was recorded in treatment combination I_1F_1 and the minimum number of corm (1.03), weight (45g), diameter (4.2 cm) was recorded in control irrigation, Similarly maximum no. of cormels per plant (80), weight (30.60g), and minimum no. of cormel per plant (46), weight (18.20) were recorded in control irrigation. This showed that for the increasing irrigation levels the yield corms and cormels were shown decreasing trend. Similar findings were obtained by Panwar *et al.*, (2016).

Water-saving

The treatment combinations I_1F_1 is statistically at par, resulting in saving of 60% irrigation water, likewise, I_2F_1 is statistically at par saving of 45.45% presented in table 2 and vice versa of flood irrigation I_4 was higher than drip irrigation. Water was applied as per irrigation schedules, it was lowest in I_1 i.e. 60 % CPE of water, while it was highest under irrigation schedule I_3 i.e. 100 % CPE of water. Equally findings of Geerish *et al.*, (2017).

Uniformity coefficient

The maximum uniformity coefficient was 90% at 1.2 kg cm^{-2} operating pressure in 2 lph emitter discharge. The result falls under the good performance category of the Drip system. This means that the uniform coefficient increases as the operating pressure increases accordingly operating pressure.

At a particular spacing, the average rate of discharge increased as the operating pressure head increased due to constant emission point per unit length of lateral. Hence the uniformity coefficient increased as the operating pressure head increased for all

emission devices. The results conform to the findings of Popale *et al.*, (2011).

Water use efficiency

Water use efficiency significantly affected by different irrigation and fertigation level can be seen by figure 1, observed that the maximum water use efficiency 72.52% was found in treatment combination I₁F₁ followed by I₁F₂ and I₁F₃ (both 66.64%) presented in table 5. Levels of irrigation and fertigation T₂ and T₃, level T₄, T₅, T₆, and level T₇, T₈, T₉ are found at par with each other. T₁₀ is significantly different from other treatments, the relationship between treatments and WUE can be seen by figure 3. It is revealed that the water use efficiency ranged from 22.79% to 72.52% under different treatment combinations from the above results it is seen that the individual effect of irrigation (depth) level is very much important and responsible for productive growth of strawberry to get maximum yield and water use efficiency, Ankush *et al.*, (2014). Since the WUE values

considered only flowering percentage to compute WUE values, neglecting the effects of other quality characteristics on WUE. Similar findings were observed by Aydinsakir *et al.*, (2005), Thentu *et al.*, (2015) and Biswas *et al.*, (2015).

Fertilizer use efficiency

The maximum fertilizer use efficiency presented in table 6 i.e. 6.38 kg kg⁻¹ was found in treatment combination I₁F₁ and a minimum of 3.68 kg kg⁻¹ was observed in control due to very low yields concerning the amount of fertilizer as well as water applied can be seen by figure 2. This result is the conformity of the Agrawal *et al.*, (2018). Similar results were obtained by Kaushal *et al.*, (2012), where they reported that the drip irrigation adoption increases water use efficiency (60-200%), saves water (20-60%), reduces fertilization requirement (20-33%) through fertigation, produces a better quality crop and increases yield (7-25%) as compared with conventional irrigation.

Table.1 Water applied to gladiolus under different treatments for each month

Month	Depth of Water applied (mm)			
	0.60 CPE	0.80 CPE	1.00 CPE	Control
Nov(7-30)	44.64	59.52	74.4	110.7
December	53.76	71.68	89.6	134.4
January	61.44	81.92	102.4	153.6
Feb(1-15)	22.38	29.84	37.3	55.95
Total	182.22	242.96	303.7	454.4

Table.2 Total depth of irrigation water applied under different irrigation levels

S.No.	Irrigation	The total depth of water applied (cm)	Water-saving (%) Over control
1.	I ₁ (0.60 CPE)	18.20	60.00
2.	I ₂ (0.80 CPE)	24.3	47.2
3.	I ₃ (1.00 CPE)	30.4	33
4.	Control (Furrow)	45.4	-

Table.3 Effect of different irrigation and fertigation on vegetative growth of gladiolus

Treatment	Plant height (cm)		Number of leaves		Number of Shoots		Girth (cm)	
	30 DAP	60 DAP	30 DAP	60 DAP	30 DAP	60 DAP	30 DAP	60 DAP
T ₁	55.0	76.44	5.20	8.13	1.08	1.29	1.11	1.50
T ₂	53.33	73.61	4.96	7.36	1.05	1.21	1.05	1.42
T ₃	53.33	73.56	4.13	7.07	1.04	1.21	1.03	1.37
T ₄	54.00	74.23	5.07	7.93	1.07	1.26	1.10	1.45
T ₅	52.67	73.06	4.07	7.07	1.03	1.15	1.00	1.35
T ₆	52.33	73.61	4.00	7.00	1.02	1.14	0.96	1.22
T ₇	53.67	74.00	5.00	7.40	1.07	1.25	1.10	1.44
T ₈	52.17	72.56	3.90	7.00	1.00	1.14	0.95	1.20
T ₉	52.00	72.00	3.50	6.87	0.98	1.14	0.95	1.20
T ₁₀	49.33	69.44	3.00	6.27	1.00	1.03	0.70	1.15
S.Em±	0.861	1.27	0.390	0.279	0.336	0.037	0.061	0.017
C.D at 5%	1.217	3.79	1.167	0.834	1.006	0.012	0.182	0.051

Table.4 Effect of different Irrigation and Fertigation on gladiolus characteristics and yield

Treatment	Days 50% Spike Initiation	Days 50% Colour show	Days to 50% flowering	Spike length(cm)	Rachis Length(cm)	Number of floret/spike	The Diameter of Basal floret(cm)	Days to Full Bloom	Durability	Days 50% Spike Initiation
T ₁	70.67	78.02	82.67	80.12	65.00	22.67	13.08	19.33	32.00	70.67
T ₂	74.00	81.50	83.33	79.00	63.33	20.00	12.77	20.33	31.33	74.00
T ₃	74.33	81.65	83.33	78.58	62.00	19.67	12.70	20.67	31.33	74.33
T ₄	73.33	81.00	83.00	80.08	64.50	22.33	12.98	20.00	31.67	73.33
T ₅	74.33	82.00	83.35	75.33	62.00	19.00	12.67	21.00	31.33	74.33
T ₆	75.00	82.02	84.00	75.13	61.20	18.33	12.57	21.33	31.00	75.00
T ₇	73.67	81.00	83.67	79.07	63.00	22.00	12.80	20.33	31.61	73.67
T ₈	75.00	82.07	84.33	73.60	60.00	18.00	12.50	21.67	30.00	75.00
T ₉	76.00	82.35	84.33	71.00	59.90	17.67	12.50	21.67	30.00	76.00
T ₁₀	77.00	83.00	84.67	69.63	59.00	17.33	11.92	22.00	29.00	77.00
S.Em±	0.612	0.378	0.095	2.312	0.068	0.341	0.016	0.106	0.027	0.612
C.D at 5%	1.834	1.131	0.285	6.923	0.203	1.021	0.049	0.318	0.081	1.834

Table.5 Water use efficiency under different treatment combinations

Treatments	Planted Gladiolus	Flowered Gladiolus	Flowering (%)	Total Water Use (mm)	WUE (%)
I ₁ F ₁	28	37.00	132	182.22	72.52
I ₁ F ₂	28	34.00	121	182.22	66.64
I ₁ F ₃	28	34.00	121	182.22	66.64
I ₂ F ₁	28	35.33	126	242.96	51.93
I ₂ F ₂	28	32.33	115	242.96	47.52
I ₂ F ₃	28	32.00	114	242.96	47.04
I ₃ F ₁	28	35.00	125	303.70	41.16
I ₃ F ₂	28	32.33	115	303.70	38.02
I ₃ F ₃	28	32.00	114	303.70	37.63
Control	28	29.00	104	454.40	22.79
S.Em±					1.762
C.D at 5%					5.277

Table.6 Fertilizer use efficiency under different treatment combinations

Treatments	Fertilizer applied (kg ha ⁻¹)	Spike (kg ha ⁻¹)	Fertilizer use Efficiency (kg kg ⁻¹)
I ₁ F ₁	336	2146.07	6.38
I ₁ F ₂	420	2010.46	4.78
I ₁ F ₃	504	1961.14	3.89
I ₂ F ₁	336	2057.43	6.12
I ₂ F ₂	420	1954.91	4.65
I ₂ F ₃	504	1954.64	3.87
I ₃ F ₁	336	2036.79	6.06
I ₃ F ₂	420	1924.40	4.58
I ₃ F ₃	504	1821.03	3.61
Control	420	1545.36	3.68

Table.7 Cost economics of gladiolus

Irrigation Levels	Spike no. (Yield ha ⁻¹)	Corm no. (Yield ha ⁻¹)	Cost of cultivation (Rs)	Total Cost (Rs)	Gross Returns (Rs)	Net Returns (Rs)	Benefit-Cost Ratio
T ₁	1101194	110119.4	231726.00	250691.0	880952.2	630260.2	2.51
T ₂	101190.7	101190.7	242427.32	261392.2	809523.6	548130.4	2.09
T ₃	101190.7	101190.7	253128.69	272094.9	809523.6	537429.7	1.97
T ₄	105148.0	105148.0	231968.54	250934.4	841190.0	590256.6	2.35
T ₅	96220.23	96220.23	242669.84	261635.4	769761.4	508126.0	1.94
T ₆	95238.09	95238.09	253371.21	272336.1	761904.2	489567.1	1.81
T ₇	10166.67	104166.67	232269.14	251234.74	833333.36	582098.62	2.32
T ₈	96220.23	96220.23	242970.44	261936.04	769761.84	507825.80	1.94
T ₉	95238.09	95238.09	253671.81	272637.1	761904.2	489267.1	1.80
Control	86309.52	86309.52	280300.00	280300	690476.7	410176.7	1.46

(Cost of cultivation = Fertilizer + Irrigation Water + Labour + Spray material)

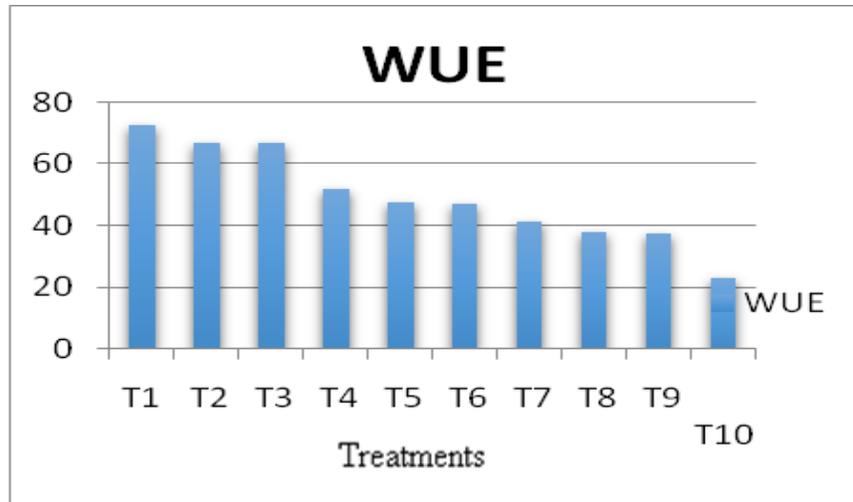


Fig.1 Illustrates the water use efficiency in treatment combinations.

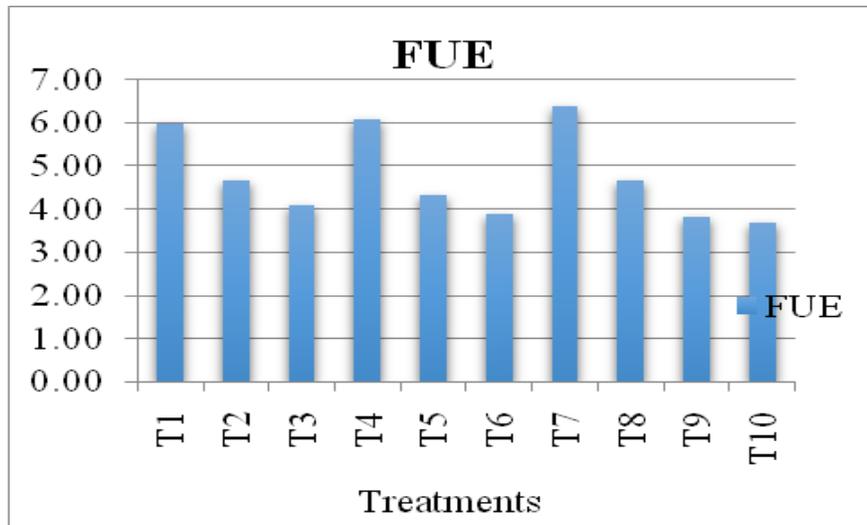


Fig.2 Illustrates the fertilizer use efficiency in all treatment

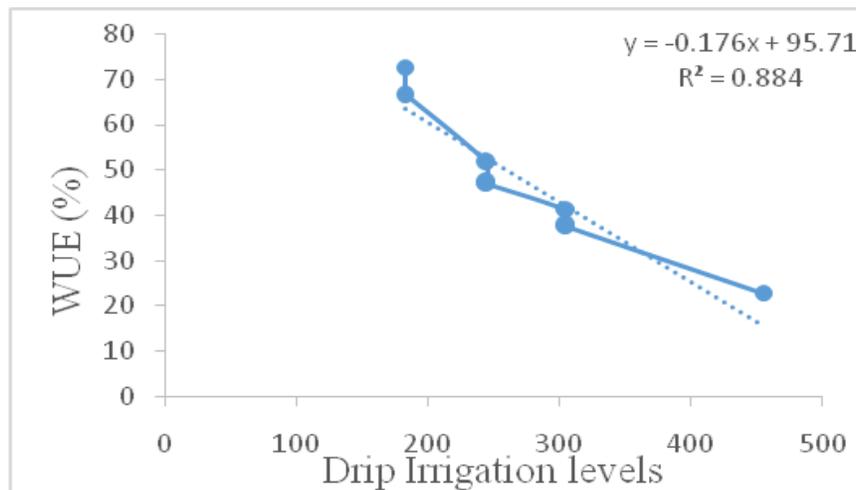


Fig.3 Relation between drip irrigation levels and WUE

Cost economics for cultivation of gladiolus with drip irrigation system

Table 7 shows the cost economics of Gladiolus and Maximum net returns of Rs. 630260.72 per ha was obtained under treatment I₁F₁, which is almost 1.50 times more as compared to control (Rs. 410176.17 per ha) methodology used which was adopted by Patil *et al.*, (2010). The benefit-cost ratio was also obtained maximum under I₁F₁ (2.51) and minimum under control (1.46).

The selling price of Gladiolus was taken of Rs.5 per spike because the quality of the produce was good in treatment I₁F₁ as compared to the rest of the treatments. This increase in income may be due to application of water-soluble-fertilizer through the drip system, which could help in a long way for efficient and uniform application of fertilizers with minimum labour involvement to improve the productivity and quality of the produce. The recommended dose of fertilizer through fertigation (80%) will minimize the cost of cultivation with an increase in production resulted in a maximum benefit-cost ratio. Similar findings were reported by Gupta *et al.*, (2010), where they concluded that by adopting drip irrigation system, the highest income could be generated in capsicum as against realized under conventional method. The benefit-cost ratio was also noticed maximum with the same treatment combination i.e. 80% ET through drip + 80% recommended NPK through fertigation. Presented data is the conformity of the Biswas *et al.*, (2015).

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