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Full Research Article

Studies on Drip Irrigation and Nitrogen Management in Gladiolus (*Gladiolus grandiflorus* L.)

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Abstract

A field experiment was conducted at Central Research Farm of Bidhan Chandra Krishi Viswavidyala, Gayespur, West Bengal during the winter seasons of 2012-2013 and 2013-2014 to study the effect of drip and surface irrigation in gladiolus with different sources of nitrogen management. The experiment was laid out in split-plot design replicated thrice. Main plot treatments consist of four levels of irrigation such as surface irrigation with IW:CPE 1.0 and three drip irrigation at 1.0, 0.8 and 0.6 of crop-evapotranspiration (ETc), and three nitrogen sources like 100% N through vermicompost, 50% N through vermicompost+50% N through inorganic fertilizer and 100% N through inorganic fertilizer in sub-plots. The results showed that drip irrigation at 0.8 ETc showed significantly higher plant height, number of spikes plot^{-1}, florets spike^{-1}, spike length, spikeweight and spike yield, which was at par with drip irrigation at 1.0 ETc. Minimum yield attributes and spike yield was obtained withdrip irrigation at 0.6 ETc. Similarly, higher plant variables and spike yield was noticed with 50% inorganic N+50% organic N as vermicompost. However, drip irrigation at 0.6 ETc with 50% inorganic N plus 50% organic N recorded the maximum water use efficiency. The interaction effect showed that drip irrigation at 0.8 ETc along with integrated nitrogen management (50% inorganic N+50% organic N) showed significantly higher spike yield. The highest gross returns, net returns and benefit: cost ratio were recorded with drip at 0.8 ETc and integrated sources of nitrogen (50% inorganic N+50% organic N).

1. Introduction

In the state of West Bengal in India, diversification in cropping pattern is a very recent phenomenon other than the case of plantation crop from the pre-independence period. However,the diversification towards high value crops is being considered as a way to increase the contribution of non-rice crops to output ratio to attain higher agricultural growth rates in the future (Bhattacharyya, 2013). In this regard, gladiolus is an important cash crop due to its short life cycle, easy driving crop with low implantation costs and fast payback. These factors allow for its cultivation in small areas in which commercial production of bulbs for domestic and foreign markets is also possible. Furthermore, it has high economic value because it is one of the most important cut flowers grown in India.

While in farmers practice for raising the gladiolus crop with 5-6 irrigations by surface method leads to high water demand. However, availability of irrigation water in drier months is the main limiting factor to enhance crop productivity in semi-arid region of the state. Irrigation source for cultivating winter flower crop are mainly by harvesting of rainwater in farm ponds. Hence, the efficient use of water should be prioritized to increase crop-water productivity in dry season. Drip system may be an alternative of conventional surface irrigation, especially for growing fruits, vegetables and flowers due to its precise and direct application of water in root zone (Imtiyaz et al., 2000). Irrigation management in drier months will shift from emphasizing production unit^{-1} area towards maximizing the production unit^{-1} of water consumed (Fereres and Soriano, 2007). To obtain high quality flowers, it is essential to supply water when it is required. The optimum use of irrigation can be characterized as the rooting area, and at the same time, avoiding the leaching of nutrients into deeper soil layers (Raina et al., 2002). High frequency water management by drip irrigation minimizes soil as a storage reservoir for water, provides at least daily requirements of water to a portion of the root zone of each plant and maintains a high soil matric potential in the rhizosphere to reduce plant water stress.

However, many of the imported varieties require a heavy input of fertilizers and irrigation resulting in an increase in cost of cultivation and reduction in the margin of profit. The fertilizer requirements of gladiolus are highly dependent on soil types and climatic conditions. Maximum flower yield and quality are obtained with an adequate level of fertilization. Cultivars showing rapid growth and developing large plants and large flower spikes responds more to fertilizer than those with low vigour and producing smaller plants and spike (Woltz, 2001). Smaller corms require more fertilizer than large corms mainly due to their stored reserve and partly to greater feeding ability of the extensive root system produced by large corms (Pal, 2000). Nitrogen is one of the most important nutrients producing growth and yield response in gladiolus (Bhattacharjee, 2001). Leaf analysis indicates that the leaves should contain on dry weight basis 2.5 to 3% nitrogen or more for optimum yield (Militiu et al., 2002).

Use of inorganic fertilizers under intensive agriculture has been associated with reduced crop yield, soil acidity and nutrient imbalance. Continuation uses of inorganic fertilizers in highly weathered soil create poor physical structure and nutrient retention characteristics, hence adversely affect crop growth and yield. Therefore, the application of plant nutrients through organic sources like compost, FYM and bio-fertilizers remains the alternative choice of growers for maintaining its sustainable production (Subbaiah et al., 1982; Dart, 1986). Plants require both organic manures and inorganic fertilizers in an adequate combination to produce better production. Therefore, the present experiment was attempted to assess the effect of different drip irrigation as compared with conventional surface irrigation on growth and flower production of gladiolus under different nitrogen sources.

2. Materials and Methods

A field experiment was conducted during the winter seasons of 2011-2012 and 2012-2013 at the Central Research Farm, Gayeshpur, Bidhan Chandra Krishi Viswavidyalaya, encompassing the New Alluvial Zone of West Bengal, (22.1° N latitude, 89.2° E longitude and 9.75 m above mean sea level) to study the response of various levels of irrigation under drip and surface systems and different sources of nitrogen on growth, flower production and water use efficiency of gladiolus. The experimental soil was sandy loam in texture with pH 6.8, organic carbon 0.54%, available nitrogen 152.3 kg ha^{-1}, available phosphorus 15.3 kg ha^{-1} and available potassium 189.6 kg ha^{-1}. The experiment was laid out in a split plot design with three replications. There were 12 treatments consisting of surface irrigation with IW:CPE 1.0 (I_1) and three drip irrigations at 1.0 (I_2), 0.8 (I_3) and 0.6 ETc (I_4) in main plots and three nitrogen sources i.e., 100% recommended N as vermicompost (N_1), 50% recommended N as vermicompost+50% N as inorganic fertilizer (N_2) and 100% recommended N as inorganic fertilizer (N_3) in sub-plots. The gladiolus variety *American Beauty* was tested as plant material. Plot size was 3.0×4.0 m^2. Medium sized corms were planted at 5 cm depth during first fortnight of November in each year in a spacing of 30×25 cm^2. The recommended dose of fertilizer was applied as 100:60:60 kg N:P_2O_5:K_2O ha^{-1} respectively. The source of inorganic N was urea applied as per treatment. The phosphatic and potassic fertilizers were applied as single super phosphate and muriate of potash respectively. The organic source of nitrogen like vermicompost containing 1.8 % N was applied during the final land preparation. Full dose of phosphorus and potassium and one third of inorganic nitrogen (urea) was applied as basal through band placement in furrows (2.5 cm below the corm). The remaining inorganic nitrogen was applied through drip irrigation in two equal splits at 25 and 50 days after planting. During the experiment, the necessary cultural practices such as weeding, earthing up etc. and the plant protection measures were equally performed in all the treatments. Harvesting was started on 3rd week of January and continued up to second week of February for both the years. Harvested spikes were immediately kept in water and while packing, spikes are graded into A and B categories based on the length of the spike and number of floretsper spike.

Soil moisture studies were done during the entire crop period starting from sowing to final harvest of gladiolus.Irrigation treatments were based on open pan evaporation data (Epanin mm) obtained from a Class A Pan evaporimeter installed near the experimental field (Doorenbos et al., 1984). The pan was located on a wooden support at a height of 15 cm above the soil surface and readings were recorded daily. Lateral lines of 12 mm diameter wereplaced for each drip plot at 30 cm distance along the crop row. One dripper plant^{-1} was provided near the base of the plant at 25 cm interval over the lateral. The application of water in drip system wasby the gravity force and the discharge rate of emitters was 1.8 liter hour $^{-1}$ at a pressure of 1.2 kg cm^{-2}. The volume of water for drip irrigation was calculated as

$$V=\Sigma\ (Ep\times Kc\times Kp\times A\times N-Re\times A)$$

where, V: Volume of water required for crop evapo-transpiration (ETc); Ep: Daily pan evaporation (mm day^{-1}); Kc: Crop factor (as calculated by Doorknobs et al., 1984); Kp: Pan factor (using 0.75 value forthis region); A: Area of plot; N: Number of days in a month for which the volume of applied water calculated; Re: Effective rainfall (mm); Σ: Signifies total of all the crop season. The irrigation frequency by drip system was every 3 days interval based on 0.6, 0.8 and 1.0 ETc. In surface method of irrigation, water was applied at IW:CPE 1.0, keeping 40 mm depth of irrigation. The number of surface irrigation was 4 in 2011-12 and 5 in 2012-2013 during the crop period. Depth of irrigation was maintained with the help of par-shall flume. The total rainfall during the crop growth period was 8.2 and 10.37 mm in 2011-12 and 2012-13 respectively. The maximum and minimum temperatures during crop period were 26.7 and 15.5 °C in 2011-12 and 27.6 and 14.3 °C in 2012-13 respectively. The pan evaporation, rainfall and temperature during the growing period were present in Figure 1.

The seasonal crop water use (WU) of gladiolus was computed

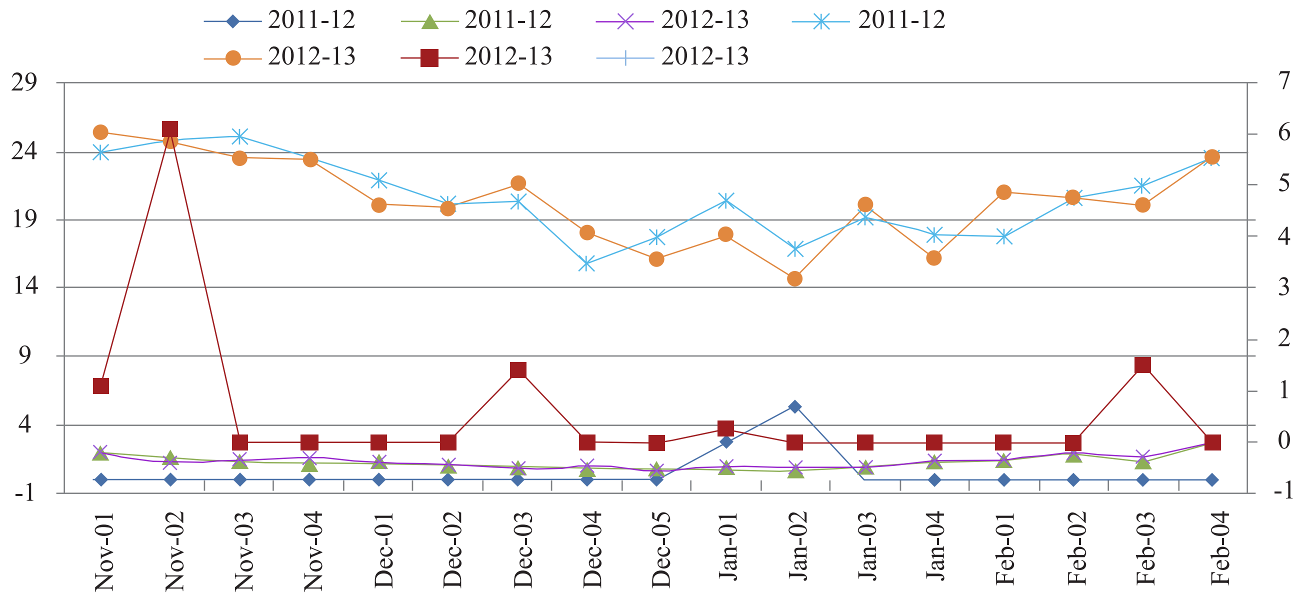

Figure 1: Weekly pan evaporation, rainfall, temperature during the period of the experiment

using the following water balance equation:

$$WU=P+I+Cp-Dp-Rf \pm \Delta SW$$

Where, WU is the total water use (mm), P is the precipitation (mm), I is the total irrigation water applied (mm), Cp is the contribution from capillary rise from groundwater (mm), Dp is the deep percolation loss (mm), Rf is the surface runoff loss of water (mm) and ΔSW is the change in soil water storage (mm) from the entire crop root zone (0-45 cm) during the cropping period (just before planting and after harvesting). Since groundwater was below 3 m during the crop growing period, Cp was assumed to be negligible. Dp was assumed neglected beyond 45 cm as it was considered that change in soil moisture storage below 45 cm were negligible and there was no loss of water through runoff (Rf) occurred since there was no heavy rainfall. Thus the above equation computed as WU=P+I+ΔSW.

The growth attributes like plant height, leaf area and leaf area index (LAI) were recorded at 60 days after planting. Similarly yield attributes and spike yield were recorded during harvest. Water use efficiency (WUE) was calculated as the ratio of spike yield and total water used including irrigation water applied, effective rainfall and soil profile moisture contribution. For calculating the economics in drip system, the life span of a well maintained drip system had been normally considered for 10 years. The interest rate was fixed at 10% and depreciation cost per annum was 4% on drip irrigation system. The fixed cost towards the installation of the gravity drip irrigation system was worked out to be ₹ 92,510. A seasonal cost of ₹ 8,453 was included in the cost of cultivation for the annual maintenance and repair including interest rate and depreciation of the drip system. From the mean data, economics was worked out on the basis of prevailing market price of the produce and input used in the experiment.

3. Results and Discussion

3.1. Growth and yield variables and flower yield

The growth and yield contributing characters of gladiolus such as plant height, leaf area (cm^2) leaf area index, number of spikes $plot^{-1}$, number of florets $spike^{-1}$, spike length, weight of single spike and spike yield were significantly influenced by the levels of drip irrigation and conventional surface irrigation and the administration of inorganic and organic nitrogen sources either alone or, their proportionate combination as presented in Table 1. The mean data showed that drip irrigation at 0.8 ETc produced significantly higher plant height (74.50 cm), leaf area (734.95 cm^2), leaf area index (1.75), number of spikes $plot^{-1}$ (67.5), number of florets $spike^{-1}$ (9.1), longer spike length (62.9 cm), higher weight of single spike (41.0 g) and spike yield (9398 kg ha^{-1}) over the drip irrigation 0.6 ETc and surface irrigation IW:CPE 1.0. However, this treatment was statistically at par with drip irrigation 1.0ETc, which showed the highest values of growth and yield attributes and also spike yield. These also clearly indicate that optimal or marginal deficit application of irrigation water through drip system on regular basis enhanced the growth and yield promoting characters and flower yield of plant. The marked reduction in yield improvement parameters and spike yield in drip irrigation at 0.6 ETc was particularly due to water stress which might have failed to fulfill the water requirement of the plant and consequently resulted in lower yield characters and spike yield (Begum et al., 2007). However, this treatment was statistically at par with surface irrigation. Therefore, it revealed to the fact that higher degree of deficit irrigation as well as excess irrigation was not at all conducive to promote the yield augmenting parameters of gladiolus, leading to the decreased marketable quality of flower production. Boodley (1981) found that water deficit in gladiolus reduced the assimilate mobilizing of the inflorescence, increased that of the corm and delayed translocation from leaves. The yield of flowers were best when the plants were irrigated with drip irrigation as it maintaineda minimum soil moisture content of 58% field capacity which was necessary for successful gladiolus cultivation in sandy clay soil (El-Gamassy et al., 1977).

As regards to the sources of N, the highest plant height (67.2 cm), leaf area (794.80 cm^2), leaf area index (1.74), maximum number of spikes $plot^{-1}$ (67.0), number of florets $spike^{-1}$ (9.4), longer spike length (61.7 cm), higher weight of single spike (41.6 g) and maximum spike yield (9303 kg ha^{-1}) was obtained with the conjunctive use of 50% N through vermicompost+50% N through inorganic fertilizer, which was found superior to 100% N through vermicompost, but statically at par with 100% N through inorganic fertilizer (Table 1). The lowest growth and yield parameters and spike yield were registered with thesole application of 100% N vermicompost. The overall effects of full dose of nitrogen through inorganic fertilizer in increasing the growth and yield factors of plant were intermediate. These findings thereby indicated that a combined application of organic (vermicompost) and inorganic N (fertilizer) at 1:1 proportion of the recommended N dose had pronounced impacts in promoting the growth, yield contributing characters and spike yield of gladiolus. The positive effect vermicompost on yields might be due to that vermicompost as a source of macro and micronutrients, vitamine, and growth hormones like gibberellins which promotes the growth and yield attributes of plant, resulting in increased yield. These results were in agreement with the findings of Kumar et al. (2007).

Table 1: Effect of irrigation levels and nitrogen sources on plant growth, yield attributes and flower yield of gladiolus (mean of two years)

parameter	Plant height (cm)	Leaf area (cm^2)	Leaf area index	No. of spikes $plot^{-1}$	No. of florets $spike^{-1}$	Spike length (cm)	Weight of single spike (g)	Spike yield (kg ha^{-1})
Irrigation level								
I_1 (Surface irrigation IW:CPE 1.0)	63.10	561.95	1.24	59.70	8.40	57.10	40.90	8230
I_2 (Drip 1.0 ETc)	76.20	816.77	1.95	69.80	9.40	63.90	41.80	9797
I_3 (Drip 0.8 ETc)	74.50	734.95	1.75	67.50	9.10	62.90	41.00	9398
I_4 (Drip 0.6 ETc)	60.40	511.95	1.14	56.50	7.60	55.10	39.40	7961
SEm±	0.56	166.97	0.15	0.72	0.12	0.44	0.25	142
CD (p=0.05)	1.95	57.17	0.44	2.49	0.43	1.50	0.87	492
Nitrogen sources								
N_1 (100% N vermicompost)	65.90	558.51	1.31	60.00	8.00	57.70	39.70	8255
N_2 (50% N vermicompost+ 50% N inorganic)	67.20	794.80	1.74	63.50	9.40	61.70	41.60	9303
N_3 (100% N inorganic)	66.90	615.81	1.52	67.00	8.40	59.60	40.90	8981
SEm±	0.28	102.32	0.09	0.56	0.19	0.46	0.16	93
CD (p=0.05)	1.09	35.04	0.27	2.21	0.73	1.80	0.61	367

The interaction effect between irrigation schedules and Nsources for the two years was statistically analyzed (Table 2). The interaction effect showed significantly higher spike yield (9899 kg ha^{-1}) with drip irrigation at 0.8 ETc along with 50% inorganic N plus 50% organic N through vermicompost. However, this treatment combination was found statistically at par with drip irrigation at 1.0 ETc supplemented with 50% N vermicompost+50% N inorganic. The minimum spike yield was registered at drip irrigation 0.6 ETc and 100% N vermicompost combination or, with at surface irrigation with 100% N vermicompost. The greater water availability in drip

Table 2: Interaction effects of irrigation levels and nitrogen sources on spike yield (kg ha^{-1}) of gladiolus (mean of two years)

Irrigation schedule	Nitrogen sources			Mean
	N_1 (100% N vermicompost)	N_2 (50% N vermicompost+50% N inorganic)	N_3 (100% N inorganic)	
I_1 (Surface irrigation IW:CPE 1.0)	7561	8551	8577	8229
I_2 (0.1% ETc)	9323	10256	9813	9797
I_3 (0.8% ETc)	8783	9899	9512	9398
I_4 (0.6% ETc)	7356	8504	8023	7961
Mean	8255	9303	8981	-
	I	N	I×N	N×I
SEm±	142	93	231	234
CD (p=0.05)	492	367	712	723

irrigation 0.8 or 1.0 ETc might have facilitated greater root growth and nutrient uptake and thereby produced higher yield of gladiolus over other treatments. However, based on water and fertilizer nitrogen economy to plant, application of water through gravity drip irrigation system at 0.8 ETc coupled with the fertilization of 50% N vermicompost+50% N inorganic @ 50 kg N ha^{-1} each proved to be beneficial to gladiolus growers.

3.2. *Water use and water use efficiency*

The amount of irrigation water based on the measured evaporation values was initiated on second fortnight of November and ended on first fortnightof February in both the years. During the plant growing season, the amount ofwater applied through drip irrigation at 0.6, 0.8 and 1.0 ETc was 83.15, 110.91 and 138.58 mm, whereas the corresponding figure for surface irrigation with IW:CPE 1.0 was 180 mm (Table 3). The total water use and water use efficiency varied with the magnitude of water application, moisture contribution from soil profile and incorporation of inorganic and organic sources of nitrogen.The interaction results showed that the total water use during the crop period was maximum (244.39 mm) in surface irrigation with IW:CPE 1.0 along with 50% N vermicompost+50% N inorganic. However, the highest water use efficiency (64.56 kg ha mm^{-1}) recorded with drip irrigation at 0.6 ETc and 50% N vermicompost+50% N

Table 3: Components of soil water balance, water use and water use efficiency of gladiolus under different irrigation levels and nitrogen sources (mean of two years)

Treatment	Profile contribution (mm)	Irrigation (mm)	Effective rainfall (mm)	Total water use (mm)*	Spike yield (kg ha^{-1})	WUE (kg ha mm^{-1})
$I_1 N_1$	15.00	180.00	9.29	224.29	7561.00	33.71
$I_1 N_2$	15.10	180.00	9.29	224.39	8551.50	38.11
$I_1 N_3$	15.01	180.00	9.29	224.30	8577.00	38.24
$I_2 N_1$	15.60	138.58	9.29	183.47	9323.00	50.81
$I_2 N_2$	15.36	138.58	9.29	183.23	10256.00	55.97
$I_2 N_3$	15.33	138.58	9.29	183.20	9813.00	53.56
$I_3 N_1$	17.31	110.91	9.29	157.51	8783.00	55.76
$I_3 N_2$	17.01	110.91	9.29	157.21	9899.50	62.97
$I_3 N_3$	17.06	110.91	9.29	157.26	9512.00	60.49
$I_4 N_1$	19.48	83.15	9.29	131.92	7356.00	55.76
$I_4 N_2$	19.28	83.15	9.29	131.72	8504.50	64.56
$I_4 N_3$	19.34	83.15	9.29	131.78	8023.50	60.89

*Including a common irrigation of 20 mm for seedling emergence inorganictreatment which was comparable with drip irrigation at 0.8 ETc provided with 50% N vermicompost+50% N inorganic (I_3N_2) showing a value of 62.97 kg ha mm^{-1}. The lowest WUE (33.71 kg ha mm^{-1}) was recorded under surface irrigation IW:CPE 1.0 with 100% N vermicompost. This implied thatthe water use efficiency decreased progressively with increased water supply. The reduced flower yield and water use efficiency in surface irrigation IW:CPE 1.0 might be due to the losses of water and nutrients as a result of deep percolation beyond the crop root zone and also evaporation mechanisms. On the other hand, the higher WUE under drip could be attributed to precise amount of water delivered in root zone in a regular manner without wetting the entire surface area and thereby, minimizing evaporation and deep percolation losses.

3.3. *Economics*

The highest gross return, net return and benefit-cost ratio were obtained with irrigation scheduled at 0.8 ETc (Table 4). However, the benefit: cost ratio was lowest at 0.6 ETc due to lower production of spikes and gross return. Among the nitrogen sources, the highest gross return, net return and benefit-cost ratio were found with application of 50% N vermicompost+50% N inorganic. This was due to more number of quality flowers (grade A) were produced under this treatment than others. However, the lowest benefit-cost ratio with 100% N through vermicompost might be owing to less spike yield as well ashigh cost of cultivation due to huge quantity of vermicompost applied to meet the crop requirement. This organic treatment produced higher percentage of grade A flowers compared to 100% inorganic N, which had compensated itsgross return nearer to 100% inorganic N.

Table 4: Cost of cultivation for gladiolus in one hectare area (mean of two years)

Treatment	Spike yield (kg ha^{-1})	Total cost of cultivation (×10^4 ₹ ha^{-1})	Gross return (×10^4 ₹ ha^{-1})	Net return (×10^4 ₹ ha^{-1})	B:C Ratio
Irrigation level					
I_1 (Surface irrigation IW:CPE 1.0)	8230	26.67	54.63	27.96	2.05
I_2 (0.1% ETc)	9797	33.26	78.51	45.25	2.36
I_3 (0.8% ETc)	9398	30.43	80.86	50.43	2.66
I_4 (0.6% ETc)	7961	28.96	51.63	22.67	1.79
Nitrogen sources					
N_1(100% N vermicompost)	8255	36.47	56.82	20.35	1.55
N_2 (50% N vermicompost+50% N inorganic)	9303	28.60	81.79	53.19	2.86
N_3(100% N inorganic)	8981	24.42	60.61	36.19	2.48

*Selling prices of grade A and B spikes ₹ 4 and 2 each, respectively

4. Conclusion

Drip irrigation at 0.8 ETc in combination with 50% N vermicompost+50% N inorganicgave the best results in terms of growth, yield and economics of gladiolus. Water use efficiency was recorded highest in drip irrigation 0.6 ETc which was comparable with 0.8 ETc under the same sources of combined N application. Therefore, this drip technology may be recommended in the water scare regions of West Bengal.

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