Response of Different Irrigation Scheduling and Nutrients on Growth, Flowering and Corm Traits of Gladiolus (*Gladiolus hybridus* Hort.) under Delhi Condition

ABSTRACT

The present experiments were undertaken for standardization of irrigation interval and nutrients on the performance of gladiolus variety under Delhi condition. The field experiments were conducted at the research farm of the Division of Floriculture and Landscaping, ICAR-Indian Agricultural Research Institute, New Delhi, during the winter season of the year 2021 and 2022. The experiment was laid out in factorial completely randomized block design with three replications and consisting of four irrigation regimes and five nutrients' levels including bio-fertilizers. The results of two year experiments showed that maximum plant height (120.56 cm), spike length (97.26 cm), rachis length (63.13 cm) and single corm's weight (50.73 g) and P content % in plant before flower emergence was found maximum with the application of seven irrigations at 15 days intervals along with treatment N_4 i.e. application of Azotobacter + Bio-phosphorous +Bio-potash + Bio-iron +Bio-Zn each 3 litre per hectare foliar spray at 30 and 60 days after planting. Number of florets per spike (21.20), estimated benefit cost ratio (1:2.86), P and K content in plant before flower emergence was found maximum with the application of five irrigations at the interval of 25 days after planting with 50 % RDF + organic manure @ 5 tonnes/ha + Azotobacter + VAM +PSB + KSB @ 2 g per plant.

Keywords: Gladiolus, irrigation schedule, nutrients, bio-fertilizers, growth, flowering, corm traits

1. INTRODUCTION

Gladiolus (*Gladiolus hybridus* Hort.) is popularly known as "Queen of the bulbous flowers" it is a very prominent bulbous cut flower crop and having a more demand in domestic and international markets due to its use in bouquets, decoration of interior and also in flower arrangements, Ali et al.(2), Kumari et al.(15). It is well known ornamental bulbous plant because it has beautiful inflorescence with dazzling colours of florets long keeping quality, varying forms and sizes and it can be kept in vases for about 8 to 10 days depends on varying variety and ambient conditions prevailing in the room. It is an important part in most of flower arrangements including offering in bouquets. The irrigation frequency depends more on the type of soil and availability of climatic conditions, the soil should have sufficient moisture content at the time of planting of gladiolus corms so that up to sprouting no

UNDER PEER REVIEW

watering is required, during hot or warm weather irrigation requirement is twice a week is needed to root zone to wet it. The quality and yield of gladiolus flowers were best when the plants watered at an interval of 12 to 17 days and a soil moisture minimum of 58% field capacity for successful gladiolus cultivation in sandy clay soil, Begum et al.(4). The gladiolus has sensitivity to drought conditions in different stages of its growth and development. The critical moisture content of soil decreases yields and differed at various developmental stages and condition according to whereas crop grown for its corm or flower, two phases of growth sensitive to water stress condition is the early stage of growth when initiation of flower takes place and another from 4th leaf stage through elongation of flower stem (Halevy, A.H.(8). Gladiolus in water deficient condition reduces the assimilate mobilizing in the inflorescence; increased that of corm and translocation delayed from the leaves due to reduction in CO_2 fixation and slightly assimilate translocation is delayed from the source leaves (Robinson, M. 1983). Flower crops are more responsive to fertilizers and it is capable of high exhausting of huge nutrients from native soils, so there is requirement of higher amount of organic and inorganic fertilizer in balance proportion for obtaining in maximum production of flower. Fertilizer requirement in gladiolus and other crops has prominent role in quality, growth, corm and cormel production, Afify,(1). Nutrition is important aspects in increasing the quality and flower yield of gladiolus spikes, after the green revolution, the excess usage of chemical fertilizers and pesticides in plant production was increased and it is dangerous to environment, so the nutrient application frequently in small doses favours better growth and production of flower spikes, best solution for sustainable agriculture and nutrient efficiency is supply of total nutrients to the crops using organic, inorganic along with bio fertilizer use under integrated nutrient management. Tadayon and Hosseini (2023) reported in their experiment conducted on olive that the increment of irrigation water to 75% of the water requirements during flower initiation along with foliar nutrition at both times had significant influence on the increment of shoot and inflorescence length and perfect flowers with ovary rate 3–4 developed ovules by 56.9%, 39% and 118.9%, respectively. Also, this treatment had the highest increment of water productivity and fruit oil content by 184.2% and 64.8%. Gladiolus requires balanced fertilizer application for its better growth and production of quality flowers, the increasing application of N results in better growth with increase in higher length of flower spike, weight of corm and size with more number of cormels per plant, increase in stalk length and number of florets per stalk, Shah et al. (21), Lehri et al. (17). In recent times the bio fertilizers are emerged as most important in improving yield and

UNDER PEER REVIEW

as well as quality of crops, in gladiolus phosphorus solubilizing bacteria (PSB), azatobacter, vascular arbuscular mycorrhizae (VAM) are capable of mobilization of nutrients from non-available form to available form through biological processes, Bhalla et al. (5), Singh et al. (23). Therefore, the present experiments were designed with varying water regimes and nutrient levels in a sustainable agricultural production system in order to minimize the amount of more chemical fertilizers and to get maximum plant growth, flowering traits and corm production of gladiolus.

2. MATERIALS AND METHODS

The field experiment was conducted at the research farm of the Division of Floriculture and Landscaping, ICAR-Indian Agricultural Research Institute, New Delhi, during the winter season of the year 2021 and 2022 from October to April to see the effect of varying irrigation regimes and nutrients on growth, flowering and corm traits of gladiolus (*Gladiolus hybridus* Hort.) under Delhi condition. New Delhi is situated at the altitude of 28.4° North, longitude 77.1° East and is 250 meter above mean sea level. Geographically, it falls in the semi-arid and sub-tropical region with hot dry summers and cold winter. In general monsoon commences during the first week of July and ends by the second fortnight of September. The experiments were laid out in factorial completely randomized block design with three replications consisting four irrigation regimes and five nutrients' levels including bio-fertilizers. There were four levels of irrigation or water as (i) $\mathbf{W_0}$- 0 control (only supporting irrigation) , (ii) $\mathbf{W_1}$- 3 irrigations (at the interval of 35 DAP), (iii) $\mathbf{W_2}$- 5 irrigations (at the interval of 25 DAP), (iv) $\mathbf{W_3}$- 7 irrigations (at the interval of 15 DAP) and five levels of nutrients (i) $\mathbf{N_0}$- Control (ii) $\mathbf{N_1}$- 100% RDF (200:100:100kg/ha NPK), (iii) $\mathbf{N_2}$- 50% RDF + Organic manure 5t/ha + Azatobacter + VAM + PSB + KSB (Each bio fertilizer 2g/plant) (iv) $\mathbf{N_3}$- 25% RDF + Organic manure 10t/ha + Azatobacter + VAM + PSB + KSB (Each bio fertilizer 2g/plant) (v) $\mathbf{N_4}$- Azatobacter + Bio-Phosphorous + Bio-Potash + Bio-Iron + Bio- Zn (Each bio fertilizer 3 Litre/ha foliar spray at 30 and 60 days after planting). A new gladiolus variety "Pusa Shanti" released by IARI has been taken for this study. This variety was a selection among the progeny obtained from the cross between Yellow Stone x Melody. The soil is alluvial, sandy loam in texture, alkaline in reaction, having pH 7.4 and free from salinity occurring on nearly level to very gently sloping land. The available organic carbon (0.33%), and available N, P, and K content was 203.40, 18.65 and 178.60 kg/ha respectively. The recommended dose of fertilizers (200:100:100 kg/ha N,

UNDER PEER REVIEW

P, and K applied in the field. Organic manure in the form of vermicompost and all bio-fertilizers were applied treatment wise before and at the time of sowing/planting. All the other cultural operations were carried out as per recommendation to keep the crop healthy. The volume of irrigation water in each plot/treatment was measured by Star Flow. The initial one common irrigation was applied in all plots including control plot after planting for the proper establishment of the plants and thereafter, irrigation was applied as per treatment. The observations/ data were collected as vegetative parameters such as plant height, spike length rachis length, number of florets per spike and corm parameters as number of corms per plant, number of cormels per plant, single corm weight, N, P, and K content in plant before flower emergence and estimated cost benefit ratio were recorded. The data recorded for various parameters under study were subjected to statistically analysed ANOVA given by Gomez and Gomez (7) to draw an exact conclusion. The variation in the treatment mean was tested by using critical difference (CD) values at a 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Growth characters

The observations/ data were collected, compiled and statistically analysed. The results showed that different water intervals and nutrient levels had significant effect on almost all the growth characters and results of two year experiments showed that maximum mean value of plant height (120.56 cm), spike length (97.26 cm), rachis length (63.13 cm) was found maximum with the application of seven irrigations at 15 days intervals along with treatment N4 i.e. application of Azotobacter + Bio-phosphorous +Bio-potash + Bio-iron +Bio-Zn each 3 litre per hectare foliar spray at 30 and 60 days after planting (table 1 and 2). Similar results were also reported by Ahmmad and Abdullatif (2) and they revealed that when gladiolus variety Cartago treated with 2% poultry manure, bio fertilizer and magnetic water in irrigation resulted in significant increase in plant vegetative growth characters. Demirel et al. (6) stated that when gladiolus varieties i.e. Red Balance, Priscilla and Peter Pears treated with drip irrigation with 4 irrigation levels 25, 50, 75 and 100% and Priscilla was found that it is more sensitive for water stress, so the use of thermal imaging with regard to both selection of variety resistant to drought and water stress is useful method. Kumar et al. (13) investigated that when Sancerre variety of gladiolus plant treated with T_{17} CBD + vermicompost 5t/ha + panchagavya 3% + manchurian tea 3% resulted in maximum spike length 88.2 cm, plant height 101.2cm and

UNDER PEER REVIEW

rachis length 62.4cm. Kumar et *al*. (14) reported that when gladiolus variety Peater Pears treated with T_4 (75% RDF + 2g/plant azospirullum + 25% vermicompost + 2g/plant PSB) significantly increases height of plant and T_{10} (50% RDF + 50% vermicompost + 2g/plant azospirullum+ 2g/plant PSB) treatment minimize days required for opening of first flower on spike and more longevity of spike. Pansurya et al. (19) revealed that when the gladiolus variety American Beauty was treated with the humic acid 0.2% with the azatobacter is 2.5ml/plant + PSB is 2.5ml/plant + KSB is 2.5ml/plant at 30 days after planting, 2nd spray at 45 DAP and the 3rd spray at 60 DAP of soil application of bio-fertilizers and bio-stimulants during the planting time and the 2 months after the planting results in higher growth of vegetative characters, flowering and the quality parameters in gladiolus. Younis et al. (24) observed that when White Prosperity variety of gladiolus treated with azospirullum resulted in significant increase in vegetative and reproductive attributes. Zhang et al. (2023) reported that irrigation significantly promoted the growth of edible sunflower although the effects varied with treatments by plant height, stem diameter, leaf area, stem weight, disc weight, and leaf weight. Further, Wan H et al. (2023) reported in maize crop that overall, these findings suggest that WSP combined with PRD could be a promising strategy to improve the growth and nutrient uptake of maize plants. These findings are similar to the present study.

3.2 Floral characters

Number florets per spike (21.20) was found maximum with the application of five irrigations at the interval of 25 days after planting with 50 % RDF + organic manure @ 5 tonnes/ha + Azotobacter + VAM +PSB + KSB @ 2 g per plant. Bastug et al. (3) had reported similar results that when gladiolus plants treated with drip irrigation for two varieties Eurovision and Peter Pears and its results are found that the levels of irrigation affect the growth and flowering, flowering quality of gladiolus and highest quality of flowers obtained at L_3 i.e. 18.1mm/week and every mm of water is helped in increasing flowering percentage of gladiolus about 0.3%. Hassan and El-Azeim (9) reported that when gladiolus plants were treated with compost (organic nile compost) 15t/fed resulted in significant increase in flowering parameters, number of florets/spike, and increased yield and spike length. Kumar et al. (13) investigated that when Sancerre variety of gladiolus plant treated with T_{17} CBD + vermicompost 5t/ha + panchagavya 3% + manchurian tea 3% resulted in maximum number of florets per spike 14.4. Pandey et al. (18) described that an experiment on gladiolus cv. American Beauty with the use of different bio-fertilizers combination and obtained best results with (azospirullum+ phosphobacteria) like more number of florets per spike i.e. 10.86, per

UNDER PEER REVIEW

plant spikes are 2.90, per ha spikes are 398065.70. The results of present investigation are similar with the above said workers.

3.3 Corm characters

The number of corms per plant (3.46), and single corm's weight (50.73 g) was found maximum with the application of seven irrigations at 15 days intervals along with treatment N_4 i.e. application of Azotobacter + Bio-phosphorous +Bio-potash + Bio-iron +Bio-Zn each 3 litre per hectare foliar spray at 30 and 60 days after planting; while number of corms per plant (3.36) and number of cormels (42.16) was recorded with 5 irrigations at the interval of 25 DAP with 100 % RDF followed by 50 % RDF + organic manure 5 tones/ha + Azotobactor + VAM + PSB + KSB @ 2 g per plant. Jha et al. (10) concluded that when cv. Candyman of gladiolus plants were treated with T_7 75% RDF + FYM 10t/ha resulted in better characters like corm diameter, total corm weight and T_{10} 75% RDF + vermicompost 3t/ha resulted in high length of spike, more number of florets/ spike and vase life. Khanam et al. (11) reported that when gladiolus plants were treated with 50% of RDF with 2.5t/ha vermicompost results in maximum flower yield (9731kg/ha), number of corms per plant (3.5) and improved flower quality and productivity. Kumar et al. (12) stated that when gladiolus plant treated with the T_7 (panchagavya 4% + manchurian mushroom tea 2%) resulted in significant increase in more number of florets/spike (16.50). T_1 (panchagavya 2%) resulted in increase of spike length (86.19cm), corm size (5.16cm), spike weight (78.83g) and corm weight (43.75g). Kumar et al. (13) investigated that when Sancerre variety of gladiolus plant treated with T_{17} CBD + vermicompost 5t/ha + panchagavya 3% + manchurian tea 3% resulted in maximum average corm weight 36 g and T_{16} CBD + vermicompost 5t/ha + panchagavya 3% resulted in maximum number of corms per plant 2.3 and cormel weight found 24.5 g. Kumar et al. (16) investigated that when Plumtart cultivar of gladiolus was treated with T_{11} (75%RDF + 25% vermicompost) resulted in significant increase in shoots/corm per plant (2.47), spikes/ha (1,40,848), number of corms per plant (3.20) and corms/ha (2,41,482). Pandey et al. (18) conducted an experiment on gladiolus cv. American Beauty with use of different bio-fertilizers combination and obtained best results with (azospirullum+ phosphobacteria) and reported that per plant corms were 2.59, weight of corms 74g/plant, weight of cormel 11.92g/plant.

3.4 Nitrogen, Phosphorus and Potash (N, P and K) content in plant before flower emergence

Further, the mean value of N, P and K content % in plant before flower emergence (3.005, 0.247 and 3.440 respectively) was recorded with 3 and 7 irrigations along with 50 % RDF +

UNDER PEER REVIEW

organic manure @ 5 tonnes/ha + Azotobacter + VAM +PSB + KSB @ 2 g per plant followed by application of Azotobactor+Bio-phosphorus+Bio-potash+Bio- iron+Bio Zn each 3 L/ha foliar spray at 30 and 60 DAP. Kumar et al. (13) investigated that when Sancerre variety of gladiolus plant treated with T_{17} CBD + vermicompost 5t/ha + panchagavya 3% + manchurian tea 3% resulted in maximum NPK of leaf. Younis et al. (24) observed that when White Prosperity variety of gladiolus treated with azospirullum resulted in significant increase in vegetative and reproductive attributes and azospirullum application is followed by azatobacter resulted in increase of total chlorophyll content, protein, soluble sugars and nutrients N, P and K was high in plants.

3.5 Economics

Estimated benefit cost ratio (1:2.68 and 1:2.86) was found maximum with treatment W_2N_2 i.e. application of 5 irrigations at the interval of 25 days after planting with 50 % RDF + organic manure @ 5 tonnes/ha + Azotobacter + VAM+PSB+KSB @ 2 g per plant followed by treatment W_3N_1. Sharma et al. (22) reported almost similar results when African marigold was treated with PSB + azospirullum + 5% cow urine +5% RD of N + vermicompost + 50% dose of NPK results showed maximum benefit: cost ratio.

4. CONCLUSION

From the present investigations, a new variety of gladiolus like Pusa Shanti needs to be irrigated 7 times at the interval of 15 DAP (805 mm water) along with 50 % RDF+Organic manure 5 tones/ha +Azotobactor+VAM+PSB+KSB@ 2g/plant followed by 5 irrigations at the interval of 25 DAP (575 mm water) with application of Azotobactor+Bio-phosphorus+Bio-potash+Bio-iron+Bio- Zn, each 3 L/ha foliar spray at 30 and 60 DAP to produce economically optimum corms/cormels yield and number of florets under the Delhi condition.

UNDER PEER REVIEW

UNDER PEER REVIEW

Table 1. Effect of varying irrigation regimes and nutrients on growth characters of gladiolus, variety Pusa Shanti under Delhi condition

S. N.	Treatment and Notations	Plant height (cm)		Mean	Spike length (cm)		Mean
		First year	Second year		First year	Second year	
1.	(i) Control (0) only supporting irrigation (W_0)	108.33	111.46	109.89	89.20	88.80	89.00
	(ii) 3irrigations at the interval of 35 DAP (345mm) (W_1)	113.00	118.33	115.66	90.66	95.40	93.03
	(iii)5 irrigations at the interval of 25 DAP (575 mm) (W_2)	117.13	120.80	118.96	90.06	97.73	93.89
	(iv) 7 irrigations at the interval of 15 DAP (805 mm) (W_3)	119.13	122.00	120.56	96.06	98.46	97.26
	C D at 5 %	**2.00**	**4.833**		**5.13**	**3.647**	
	SE(M)	**1.480**	**1.231**		**1.269**	**1.131**	
2.	(i) Control (N_0)	116.00	115.75	115.87	90.58	96.42	93.50
	(ii) 100 % RDF (200:100:100 kg/ha NPK (N_1)	112.91	118.75	115.83	91.91	94.33	93.12
	(iii) 50 % RDF+Organic manure 5 tone/ha +Azotobactor+VAM+PSB+KSB@ 2g/plant (N_2)	109.41	121.00	115.20	91.25	97.33	94.29
	(iv) 25 % RDF+Organic manure 10 tone/ha +Azotobactor+VAM+PSB+KSB@ 2g/plant (N_3)	117.58	115.50	116.54	91.38	93.16	92.27
	(v) Azotobactor+Bio-phosphorus+Bio-potash+Bio iron+Bio Zn each 3 L/ha foliar spray at 30 and 60 DAP (N_4)	116.08	119.75	117.92	92.41	94.25	93.33
	C D at 5 %	**1.33**	**1.33**		**0.59**	**0.591**	
	SE(M)	**1.230**	**1.680**		**0.123**	**1.419**	

UNDER PEER REVIEW

Table 2. Effect of varying irrigation regimes and nutrients on rachis length and number of florets per spike of gladiolus, variety Pusa Shanti under Delhi condition

S. N.	Treatment and Notations	Rachis length (cm)		Mean	Number of florets per spike		Mean
		First year	Second year		First year	Second year	
1.	(i) Control (0) only supporting irrigation (W_0)	57.66	54.33	55.99	20.46	19.86	20.16
	(ii) 3irrigations at the interval of 35 DAP (345mm) (W_1)	61.93	58.40	60.16	20.60	20.86	20.73
	(iii)5 irrigations at the interval of 25 DAP (575 mm) (W_2)	63.20	57.86	60.53	21.20	21.20	21.20
	(iv) 7 irrigations at the interval of 15 DAP (805 mm) (W_3)	64.26	62.00	63.13	20.66	20.60	20.63
	C D at 5 %	**4.740**	**3.505**		**0.140**	**0.755**	
	SE(M)	**1.219**	**1.127**		**0.263**	**0.294**	
2.	(i) Control (N_0)	60.25	57.25	58.75	20.50	20.33	20.41
	(ii) 100 % RDF (200:100:100 kg/ha NPK (N_1)	62.75	57.58	60.16	20.75	20.75	20.75
	(iii) 50 % RDF+Organic manure 5 tone/ha +Azotobactor+VAM+PSB+KSB@ 2g/plant (N_2)	61.75	59.42	60.58	21.33	20.25	20.79
	(iv) 25 % RDF+Organic manure 10 tone/ha +Azotobactor+VAM+PSB+KSB@ 2g/plant (N_3)	61.83	58.75	60.29	20.41	20.50	20.45
	(v) Azotobactor+Bio-phosphorus+Bio-potash+Bio iron+Bio Zn each 3 L/ha foliar spray at 30 and 60 DAP (N_4)	62.25	57.75	60.00	20.66	21.33	20.99
	C D at 5 %	**1.750**	**1.251**		**0.170**	**0.150**	
	(SE(M)	**1.633**	**1.363**		**0.126**	**0.264**	

UNDER PEER REVIEW

Table 3. Effect of varying irrigation regimes and nutrients on N, P and K content in plant before flower emergence of gladiolus, variety Pusa Shanti under Delhi condition

S. N.	Treatment and Notations	N content in plant before flower emergence (%)		Mean	P content in plant before flower emergence (%)		Mean	K content in plant before flower emergence (%)		Mean
		First year	Second year		First year	Second year		First year	Second year	
1.	(i) Control (0) only supporting irrigation (W_0)	2.47	2.46	2.465	0.223	0.221	0.222	2.86	2.89	2.875
	(ii) 3irrigations at the interval of 35 DAP (345mm) (W_1)	2.91	2.92	2.915	0.240	0.242	0.241	3.33	3.39	3.360
	(iii)5 irrigations at the interval of 25 DAP (575 mm) (W_2)	2.91	2.90	2.905	0.240	0.241	0.241	3.05	3.20	3.121
	(iv) 7 irrigations at the interval of 15 DAP (805 mm) (W_3)	2.67	2.69	2.680	0.245	0.246	0.246	3.20	3.29	3.245
	C D at 5 %	**0.013**	**0.014**		**0.01**	**0.02**		**0.14**	**0.13**	
	SE (M)	**0.010**	**0.011**							
2.	(i) Control (N_0)	2.41	2.39	2.400	0.238	0.238	0.238	2.95	2.93	2.940
	(ii) 100 % RDF (200:100:100 kg/ha NPK (N_1)	2.81	2.82	2.815	0.239	0.239	0.239	2.92	2.96	2.940
	(iii) 50 % RDF+Organic manure 5 tone/ha +Azotobactor+VAM+PSB+KSB@ 2g/plant (N_2)	2.74	2.75	2.745	0.248	0.247	0.247	3.42	3.46	3.440
	(iv) 25 % RDF+Organic manure 10 tone/ha+Azotobactor+VAM+PSB +KSB@ 2g/plant (N_3)	2.74	2.74	2.740	0.229	0.225	0.227	3.19	3.24	3.215
	(v)Azotobactor+Bio-phosphorus+Bio-potash+Bio iron+Bio Zn each 3 L/ha foliar spray at 30 and 60DAP (N_4)	3.00	3.01	3.005	0.228	0.229	0.228	3.07	3.12	3.095
	C D at 5 %	**0.150**	**0.160**		**0.001**	**0.003**		**0.080**	**0.091**	

UNDER PEER REVIEW

	SE(M)	**0.140**	**0.131**		**0.002**	**0.002**		**0,061**	**0.076**	

Table 4. Effect of varying irrigation regimes and nutrients on corms, cormels and economics of gladiolus, variety Pusa Shanti under Delhi condition

S. N.	**Treatment and Notations**	Number of corms per plant		Mean	Number of cormels per plant		Mean	Single corm weight (g)		Mean	Cost benefit ratio (Estimated)
		First year	Second year		First year	Second year		First year	Second year		
1.	(i) Control (0) only supporting irrigation (W_0)	3.33	2.80	3.06	34.13	33.60	33.86	43.46	44.53	43.99	1:1.47
	(ii) 3irrigations at the interval of 35 DAP (345mm) (W_1)	3.33	3.46	3.40	33.73	38.33	36.03	47.33	46.33	46.83	1:2.36
	(iii)5 irrigations at the interval of 25 DAP (575 mm) (W_2)	3.60	3.33	3.46	36.40	34.20	35.30	47.13	48.80	47.96	1:2.68
	(iv) 7 irrigations at the interval of 15 DAP (805 mm) (W_3)	3.46	3.20	3.33	35.33	36.53	35.93	50.61	50.86	50.73	1:2.47
	C D at 5 %	**0.180**	**0.330**		**1.021**	**0.643**		**4.875**	**0.760**		**-**
	(SE(M)	**0.117**	**0.110**		**0.139**	**0.125**		**0.265**	**0.231**		
2.	(i) Control (N_0)	3.25	2.58	2.91	34.00	31.58	32.79	43.66	45.33	44.49	1:1.71
	(ii) 100 % RDF (200:100:100 kg/ha NPK (N_1)	3.33	3.16	3.24	42.66	41.66	42.16	53.58	45.16	49.37	1:2.63
	(iii) 50 % RDF+Organic manure 5 tone/ha +Azotobactor+VAM+PSB+KSB@ 2g/plant (N_2)	3.50	3.50	3.50	33.25	38.25	35.75	46.25	48.41	47.33	1:2.86
	(iv) 25 % RDF+Organic manure 10 tone/ha +Azotobactor+VAM+PSB+KSB@ 2g/plant (N_3)	3.58	3.33	3.45	30.75	29.00	29.87	45.58	46.83	46.20	1:2.18
	(v)Azotobactor+Bio-phosphorus+Bio-potash+Bio iron+Bio Zn each 3 L/ha foliar spray at 30 and 60 DAP (N_4)	3.50	3.41	3.45	33.83	37.83	35.83	46.91	52.41	49.66	1:2.54

UNDER PEER REVIEW

	C D at 5 %	**0.120**	**0.378**		**1.333**	**0.719**		**5.450**	**0.853**		**-**
	SE(M)	**0.112**	**0.101**		**0.156**	**0.133**		**0.297**	**0.101**		

REFERENCES

1. Afify M M. Effect of high fertilizer rates on the growth flowering of three gladiolus cutlivars. *Kerleszefi Egyatem Kozlemenyel*, 1983; 47(13), 75-82.
2. Ali M, Hussain R, Bashir A, Raza S and Ahmad N D A. Investigation of bio fertilizers influence on vegetative growth, flower quality, corm yield and nutrient uptake in gladiolus (*Gladiolus grandiflorus* L.) *International Journal of Plant Animal Envirnomental Science*, 2013; 4(1): 94-99.
3. Bastug R, Karaguzel O, Aydinsakir K and Buyuktas D. The effects of drip irrigation on flowering and flower quality of glasshouse gladiolus plant. *Agricultural water management*, 2006; 81(1-2), 132-144.
4. Begum R A, Rahman M N, Mondol A T, M A I, Rahman M J and Khan F N. Effect of different moisture regimes on the growth and quality of gladiolus. *International Journal of Sustainable Crop Production*, 2007; 2(5): 43-45.
5. Bhalla R, Kanwar P, Dhiman S R and Jain R. Effect of bio fertilizers and bio stimulants on growth and flowering in gladiolus. *Journal of Ornamental Horticulture*, 2006; 9(4), 248-252.
6. Demirel K, Camoglu G and Akcal A. Effect of water stress on four varieties of gladiolus. *Fresenius Environment Bulletin*, 2019; 27(12), 9300-9307.
7. Gomez KA, and Gomez AA. Statistical Procedures for Agricultural Research, 2nd Ed. New
   i. York: John Wiley & Son. 1984:680.
8. Halevy A H. Water stress and the timing of irrigation. *Horticultural Science*. 1972;7: 113-114.

UNDER PEER REVIEW

9. Hassan A A and El-Azeim A. Impacts of compost, bio-fertilizer and/or some antioxidant treatments on gladiolus (*Gladiolus grandifloras*) corms and cormels production and some chemical constituents. *Scientific Journal of Flowers and Ornamental Plants*, 2020; 7(3), 285-301.
10. Jha S, Kaushik M Parihar, B S and Sinha P K. Effect of different component of integrated nutrient management on growth, yield and quality of gladiolus (*Gladiolus grandiflorus* L.) Cv. Candyman. *Journal of Pharmacognosy and Phytochemistry*, 2020; 9(3), 831-833.
11. Zhang J, Du L, Xing Z, Zhang R, Li F, Zhang T, Ren F, Yin M, Ding L, Liu X. Effects of dual mulching with wheat straw and plastic film under three irrigation regimes on soil nutrients and growth of edible sunflower. *Agricultural Water Management*. 2023 Oct.1,288:108453.
12. Khanam R, Kundu D and Patra S K. Integrated nutrient management on growth, quality, yield and soil fertility of gladiolus in lower gangetic plain of India. *International Journal of Current Microbiology and Applied Sciences*, 2017; 6(4), 453-459.
13. Kumar P, Kumar R and Kumar A. Effect of organic culture on growth, development and post-harvest life of gladiolus (*Gladiolus hybridus*). *Journal of Ornamental Horticulture*, 2008; 11(2), 127-130.
14. Kumar R, Kumar R and Kumar P. Effect of integrated use of chemical fertilizers, bio-fertilizers and bio-stimulants in gladiolus (*Gladiolus grandiflorus* L.) cv. Sancerre. *Progressive Horticulture*, 2011; 43(1), 149-152.
15. Kumar M. Effect of different sources of nutrients on growth and flowering in gladiolus (*Gladiolus hybridus* hort.) CV. "Peater Pears". *Annals of Horticulture*, 2014; **7**(2), 154-158.
16. Kumari R V, Kumar D P, Arunkumar B and Mahadevamma M. Effect of integrated nutrient management on floral and cormal parameters in gladiolus (*Gladiolus hybridus* L.). *International Journal of Agricultural Sciences*, 2014; 10(1), 15-22.
17. Kumari S, Chowdhuri T K and Mandal T. Effect of bio-fertilizers on growth and flowering of Dendrobium var. Sonia. *Journal of Crop and Weed*, 2018; 14(2), 85-88.
18. Lehri S M, Kurd A A, Rind M A and Bangulzai N A. The response of *Gladiolus tristis* L. to N and P_2O_5 fertilizers. *Sarhad Journal of Agriculture*, 2011; 27(2), 185-188.

UNDER PEER REVIEW

19. Pandey D K, Singh K K, Pandey A and Pandey A K. Effect of bio-fertilizer on flowering, and corm parameters of Gladiolus cv. American Beauty. *Journal of Pharmacognosy and Phytochemistry*, 2020; 6: 73-75.
20. Pansuriya P B, Varu D K and Viradia R R. Effect of bio-stimulants and bio-fertilizers on growth, flowering and quality of gladiolus (*Gladiolus grandiflorus*, L.) cv. American Beauty under greenhouse conditions. *International Journal of Chemical Studies*, 2018; 6(2), 2191-2196.
21. Robinson M. Influence of abscisic acid and ethylene on assimilate distribution in *Gladiolus grandiflorus*. *Annals of Botany*, 1983; 51(6), 779-785.
22. Shah A, Lal S D and Seth J N. Effect of different levels of nitrogen, phosphorus on growth, flowering and corm yield of gladiolus cv. Vinks Glory. *Progressive Horticulture*, 1984; 16(3-4), 305-307.
23. Sharma G, Sahu N P and Shukla N. Effect of bio-organic and inorganic nutrient sources on growth and flower production of African marigold. *Horticulturae*, 2017; 3(1), 11.
24. Singh R, Kumar M, Raj S and Kumar S. Effect of integrated nutrient management (INM) on growth and flowering in gladiolus (*Gladiolus grandiflorus* L.) cv. White Prosperity. *Annals of Horticulture*, 2014; 6(2): 251-258.
25. Tadayon MS, Hosseini SM. Effect of irrigation regimes and foliar nutrition on flower development and water productivity of olive (*Olive europaea* L. cv. Shengeh). *Journal of Plant Growth Regulation*. 2023, Feb; 42 (2):735-747.
26. Wan H, Liu X,Shi C, Chen Y, Jiang M, Zhang J, Cui B, Hou J, Wei Z, Hossain MA, Liu F. Biochar amendment alters root morphology of maize plant: Its implicatios in enhancing nutrient uptake and shoot growth under reduced irrigation regimes. *Frontiers in Plant Science*. 2023 Jan. 20:14:1122742.
27. Younis A, Zahir Z, Riaz A and Tariq U. Microbial inoculation increases the nutrient uptake efficiency for quality production of *Gladiolus grandiflorus*. *Pakistan Journal of Agriculture Sciences*, 2014; 51(4), 875-880.

UNDER PEER REVIEW

UNDER PEER REVIEW