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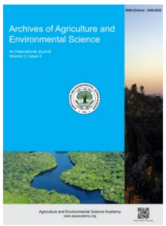

ORIGINAL RESEARCH ARTICLE

CrossMark

Impact of integrated nutrient management on vegetative growth and flowering quality of gladiolus (*Gladiolus hybridus* Hort.) cv. American Beauty

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ABSTRACT

A field study on 'effects of integrated nutrient management on vegetative growth and flowering quality of gladiolus (*Gladiolus hybridus* Hort.) cv. American Beauty' was carried out at College of Horticulture and Forestry, Jhalawar during 2016-17. It was found that cv. American Beauty with treatment the tallest plants (121.50 cm), maximum number of leaves per plant (9.03), the maximum leaf length (38.20 cm), earliest spike emergence (59.22 days), minimum number of days to floret opening (12.50 days), maximum number of florets per spike (17.53), maximum spike length (108.50 cm), maximum floret diameter (9.01 cm), maximum rachis length (39.03 cm) was found in T_{12} (RDF 75% + Azotobacter + PSB + Mycorrhiza). The maximum stem diameter (1.52 cm) and maximum spike girth (0.97 cm) was recorded in T_{10} (RDF 75% + PSB + Mycorrhiza). On the basis of foregoing summary, the results may be concluded as follow: The different bio-fertilizer treatments had significant influence on the vegetative growth, flowering and post-harvest of gladiolus in the present study. Application of bio fertilizer singly and in different combinations has significant effect on all the vegetative, floral and corms parameters. Therefore, among various bio fertilizers and their combinations, Azotobacter, PSB and Myccorhiza were found the best, followed by un-inoculated treatment show least value for these parameters during the seasons of experiment.

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INTRODUCTION

Gladiolus (*Gladiolus hybridus* Hort.) generally known as "sword lily" due to its sword shaped leaves or corn flag as it grows in Africa in corn fields as a weed (Sharma *et al.*, 2008; Singh *et al.*, 2014). It is an important member of family Iridaceae and sub-family Ixiodeae and originated in South Africa, having the basic chromosome number (x =15). It is popularly called as "Queen of the bulbous flowers" being a prominent bulbous cut flower crop. It is valued for its long beautiful spikes possessing a number of florets of vibrant colours and variable sizes. It is having high demand in both domestic and international markets due to use of flower spikes in bouquets, interior decorations and flower arrangements (Ali *et al.*, 2013; Kumari *et al.*, 2014). Nutrition is one of the important aspects in increasing the flower yield and quality of gladiolus spikes. After the green revolution, use of chemical fertilizers and pesticides in plants production increased, which is dangerous to ecology and environment. Thus, the application of nutrients in small doses frequently, favours better growth and flower production. Supply of total nutrient requirements of the crops using organic and inorganic sources along with use of biofertilizers under integrated nutrient management, could be the best solution for nutrient efficiency and sustainable agriculture (Gupta *et al.*, 2004; Singh *et al.*, 2003).

In recent times, biofertilizers have emerged as important supplements to mineral fertilizers and hold a promise to improve the yield as well as quality of crops. In gladiolus too, Azotobacter, Vascular arbuscular mycorrhizae (VAM) and Phosphorus solubilizing bacteria (PSB) are capable of mobilizing nutrient elements from non-usable forms to usable forms through biological processes (Bhalla *et al.*, 2006; Singh *et al.*, 2014). Therefore, keeping in view the need and importance integrated nutrient management the present investigation was planned to study the impact of integrated nutrient management on vegetative growth and flowering quality of gladiolus (*Gladiolus hybridus* Hort.) cv. American Beauty.

MATERIALS AND METHODS

Experimental design

The experiment will be laid out in randomized block design (RBD). The recorded data for the various characters under study will be analyzed using F- test as suggested by Gomez and Gomez (1984) for interpretation of the results.

Detail of treatments

The experiment was conducted using 20 treatments on gladiolus cv. American Beauty having three biofertilizers *viz*., Azotobacter, PSB and Mycorrhiza along with two level of RDF (75% and 100%) in a randomized block design (RBD) with three replications. Total no. of treatments T_0 Control, T_1 75% RDF, T_2 100% RDF, T_3 Azotobacter + PSB, T_4 Azotobacter + Mycorrhiza, T_5 PSB + Azotobacter + Mycorrhiza, T_6 RDF 75% + Azotobacter, T_7 RDF 75% + PSB, T_8 RDF 75% + Mycorrhiza, T_9 RDF 75% + Azotobacter + PSB, T_{10} RDF 75% + PSB + Mycorrhiza, T_{11} RDF 75% + Azotobacter + Mycorrhiza, T_{12} RDF 75% + PSB + Azotobacter + Mycorrhiza, T_{13} RDF 100% + Azotobacter, T_{14} RDF 100% + PSB, T_{15} RDF 100% + Mycorrhiza, T_{16} RDF 100% + Azotobacter + PSB, T_{17} RDF 100% + PSB + Mycorrhiza, T_{18} RDF 100% + Azotobacter + Mycorrhiza, T_{19} RDF 100% + PSB + Azotobacter + Mycorrhiza.

Observation and collection of data

Vegetative characters

Days to sprouting

Number of days taken from planting of corms to sprouting was recorded for the first three sprouted corms in each treatment plot and then average was calculated.

Plant height (cm)

Plant height was recorded in centimeters from ground to tip of the spike in three tagged plants by meter scale at peak flowering stage.

Number of leaves per plant

The number of leaves produced on each of the three tagged plants was counted after emergence of flower spike and then mean was worked out.

Leaf length (cm)

The length of 4th leaf from base was recorded in centimeters from base to tip of the leaf on each of three tagged plants using meter scale.

Leaf width (cm)

The width of leaf which was also employed for measuring length was recorded from margin to margin at the middle of leaf of each of three tagged plants using meter scale.

Stem diameter (cm)

The stem diameter was measured in centimeters with the help of digital vernier calipers about 3 cm above ground level of each of three tagged plants and then average was calculated.

Floral and yield characters

Days to spike emergence

Number of days taken for spike emergence from planting of corms was recorded for each of three tagged plants and later on average was calculated.

Days to first floret opening from spike emergence

Number of days taken from spike emergence to opening of first basal floret on spike of each of three tagged plants was noted and average was calculated.

Spike girth (cm)

The girth of spike was measured in centimeter with the help of digital vernier calipers about 2 cm below the first basal floret of the spike.

Spike length (cm)

Spike length was measured in centimeters from the first visible ring to tip of the spike using meter scale on each of the three tagged plants.

Rachis length (cm)

Rachis length was measured in centimeters from base of first floret to tip of the spike after opening the last floret on the spike on each of the three tagged plants.

Floret diameter (cm)

Diameter of the second floret of spike produced on each of three tagged plants was measured in centimeters at fully opened stage using digital vernier calipers and then the average was calculated.

Statistical analysis

The experimental data were subjected to statistical analysis of variance and test of significance through the procedure described by Panse and Sukhatme (1967). The standard error of mean and critical difference for treatment comparisons was worked out where the “F-test” was found significant at 5 per cent level of significance.

RESULTS AND DISCUSSION

Vegetative parameters

Number of days taken for sprouting

The data pertaining to number of days taken for sprouting of corm are presented in the earliest sprouting of corms with the minimum number of days was recorded in T_0 control (7.83 days), whereas the maximum number of days taken for sprouting was recorded in control T_{11} (9.95 days). The early sprouting of corm can be attributed mainly to availability of sufficient nutrients to the corm for its normal metabolic activities. It is revealed from data presented in table that there were non–significant differences among the treatments in case of equal sprouting of corms. Non-significant results might be due to presence of store food in corms, which near about in equal sprouting (Table 1).

Plant height (cm)

The data pertaining to plant height of gladiolus have been presented. It is clear from the results that data had favorable effect on plant height with the maximum plant height of 121.27 cm noted in T_{12} RDF 75% + PSB + Azotobacter + Mycorrhiza, whereas the minimum plant height was noted in control T_0 (103.77 cm). Application of biofertilizers and chemical fertilizers alone and combination resulted in more plant height. The enhanced plant height may be due to more availability of nitrogen and other nutrient elements (Table 1). Nitrogen is a main constituent of chlorophyll, protein and amino acids and plays an important role in cell division, protein synthesis and metabolite transport that help to build the plant tissues. The increased plant height may also be attributed to the favorable effects of phytohormon like auxin and gibberellins produced by *Azotobacter*, PSB and Mycorrhiza which might have improved the root system of the plant, which in turn might have helped in better nutrient uptake and this might have enhanced the plant height (Gupta *et al.*, 2004). Similar findings have also been reported by Singh *et al.* (2003) in rose, Deshmukh *et al.* (2008) in Gaillardia.

Number of leaves per plant

The data pertaining to number of leaves per plant have been presented. The data reveal that the highest number of leaves was observed with T_{12} (9.03) RDF 75% + PSB + Azotobacter + Mycorrhiza, whereas the minimum number of leaves per plant was recorded in control T_0 (6.30). Increasing the number of leaves with application of bio and chemical fertilizers may be due to increased nitrogen availability as it is a constituent of protein, component of protoplast and increases the chlorophyll content in leaves (Table 1). All these factors contribute to cell multiplication, cell enlargement and differentiation which could have resulted in better photosynthesis and ultimately exhibited better vegetative growth (Kashyap *et al.*, 2014) and Yadav *et al.* (2005). Srivastava and Govil (2005) also reported increased number of leaves in gladiolus cv. Combined inoculation of arbuscular mycorrhiza and PSBs give better uptake of both native P from the soil and P coming from the phosphatic rock and enhance plant growth by solubilizing P from different fractions of soil (Dongardive *et al.*, 2009).

Leaf length (cm)

The data presented on leaf length reveal that the longest leaves were observed with T_{12} (38.20 cm) RDF 75% + PSB + Azotobacter + Mycorrhiza, whereas the shortest leaves were recorded in control T_0 (32.97 cm). The increase leaf length particularly may be due to the availability of more nitrogen continuously due to application of chemical and bio fertilizers resulting into abundant vegetative growth. Phosphorus stimulates root system through efficient translocation of certain growth stimulating substance formed in plant, which may have enhanced the absorption of nutrients thus resulting in a vigorous growth. Plant supplied with high phosphorus and potassium with nitrogen continuously maintains vegetative growth (Table 1). Nitrogen is a constituent of protein, component of protoplast and increases the chlorophyll content in leaves (Dalve *et al.*, 2009). Similar results were observed by Chauhan and Kumar (2007) and Kumar *et al.* (2013).

Leaf width (cm)

The data pertaining to leaf width are presented in the most broad leaves were recorded with T_{10} (3.52 cm) RDF 75% + PSB + Mycorrhiza, while the narrowest leaves were recorded in control T_0 (2.32 cm) (Table 1). Application of RDF with biofertilizers promoting the leaf width influenced with nitrogen application, because nitrogen is an essential part of nucleic acid, which play vital role in promoting leaf area. All these factors contribute to cell multiplication, cell enlargement and differentiation which could have resulted in better photosynthesis and ultimately exhibited better vegetative growth (Sharma *et al.*, 2008) and Srivastava and Govil (2005).

Main stem diameter (cm)

Data pertaining to stem diameter as influenced by application of integrated nutrient management have been presented. The thickest stems were recorded with T_{10} (1.52 cm) RDF 75% + PSB + Mycorrhiza, whereas the thinnest stems were recorded in control T_0 (0.94 cm) (Table 1). Application of chemical and biofertilizers under INM increase stem thickest in gladiolus due to absorptive surface area of the roots due to VAM might have led to enhanced uptake and transportation of available water and nutrients like P, Zn, Fe, Mg and Cl, ultimately resulting in better sink for faster mobilization of photosynthates and early transformation of plant parts from vegetative to reproductive phase (Bohra and Kumar, 2014). These findings are also in confirmation with the findings of Kumari *et al.* (2014) in gladiolus. Stem diameter increase due to presence of growth promoting substances like essential plant nutrients, vitamins, enzymes and antibiotics in biofertilizers (Ali *et al.*, 2013). Phosphorus plays a significant role in several physiological and biochemical plant activities like photosynthesis, transformation of sugar to starch, and transporting of the genetic traits (Debnath *et al.*, 2009).

Flowering quality parameters

Days to spikes emergence

The data recorded on days to spikes emergence are presented in the earliest spikes emergence was observed in T_{12}(59.22 days) RDF 75% + PSB + Azotobacter + Mycorrhiza, with the maximum number of days taken to spike emergence in control T_0 (67.83 days). The early emergence of spike with application of bio-fertilizers along with two levels of RDF could be attributed to vigorous growth of the plant due to increased nutrient availability to the plants ultimately resulting in better sink for faster mobilization of photosynthates and early transformation of plant parts from vegetative to reproductive phase (Kumari *et al.*, 2014). The activities of the biofertilizers nitrogen fixation, production of phytohormones etc. with simultaneous uptake of nutrients. The increased availability of phosphorus to due to PSB bacterium might have the plant roots caused emergence of early spike (Kumar, 2014).

Days to first floret opening from spike emergence

The data for days to first floret opening from spike emergence are presented in Table 2. The earliest first floret opening from spike emergence was observed in T_{12}(12.50 days) RDF 75% + PSB + Azotobacter + Mycorrhiza, whereas the most late first floret opening was observed in control T_0 (16.30 days) (Table 2). The beneficial effect of INM of earliness of spike emergence could be attributed to the good vegetative and reproductive growth of plant which in turn resulted in early floret opening (Kumari *et al.*, 2014). The present findings are in agreement with the observations of Sharma *et al.* (2008) and Kumar (2014) in gladiolus.

Number of florets per spike

It is evident from the data on number of florets per spike are presented that application of fertilizers and biofertilizers had significant effect. The maximum number of florets per spike was recorded with T_{12}(17.53) RDF 75% + PSB + Azotobacter + Mycorrhiza, whereas the minimum number of florets was recorded in control T_0 (11.93) (Table 2). More number of floret due to when treated directly with Azotobacter and PSB help as they help in supplying nitrogen and phosphorus. Hence, application of biofertilizers including NPK increase availability of micro nutrient as well as plant hormones due to which more number of floret (Chaudhary, *et al.*, 2013).

Spike girth (cm)

The data on spike girth are presented. It is also clear from the data that had significant effect on spike girth with the thickest spikes were recorded in T_{10} (0.97 cm) RDF 75% + PSB + Azotobacter + Mycorrhiza, whereas the thinnest spikes were produced in T_0 (0.66 cm) (Table 2). Enhanced girth of spikes with application of integrated nutrient management may be attributed to promoted vegetative growth due to active cell division and cell enlargement significantly affecting spike diameter (Kumar *et al.*, 2010). Increase in vegetative growth may be due to better flow of various macro - and micro-nutrients along with plant growth. Simultaneously, VAM in association with plant roots is known for exploration of more soil volume thereby making the nutrients available for diffusion of phosphate ion and increasing the surface area for absorption of nutrients such as N, K, Mn and Zn (Venkatesha *et al.*, 2003).

Table 1. Effect of INM on vegetative parameters of gladiolus.

Treatment	Treatment combination	Number of days taken for sprouting	Plant height (cm)	No. of leaves per plant	Leaf length (cm)	Leaf width (cm)	Stem diameter (cm)
T_0	Control	7.83	103.77	6.30	32.97	2.32	0.94
T_1	75% RDF	9.07	111.30	7.07	35.27	2.99	1.25
T_2	100% RDF	8.93	114.30	7.87	38.17	3.11	1.39
T_3	Azotobacter + PSB	8.97	104.50	6.40	33.57	2.64	0.97
T_4	Azotobacter + Mycorrhiza	8.67	105.40	6.67	33.83	2.77	0.98
T_5	PSB + Azotobacter + Mycorrhiza	9.07	106.33	6.83	33.93	2.82	1.07
T_6	RDF 75% + Azotobacter	9.20	119.40	7.63	36.83	3.30	1.34
T_7	RDF 75% + PSB	9.33	118.53	7.57	36.60	3.27	1.37
T_8	RDF 75% + Mycorrhiza	9.03	118.87	7.60	36.77	3.34	1.42
T_9	RDF 75% + Azotobacter + PSB	8.93	120.30	8.57	37.07	3.37	1.46
T_{10}	RDF 75% + PSB + Mycorrhiza	9.03	119.97	8.53	37.30	3.52	1.52
T_{11}	RDF 75% + Azotobacter + Mycorrhiza	9.95	120.17	8.90	37.83	3.45	1.48
T_{12}	RDF 75% + PSB + Azotobacter + Mycorrhiza	8.03	121.50	9.03	38.20	3.49	1.50
T_{13}	RDF 100% + Azotobacter	8.90	122.20	9.30	38.33	3.59	1.64
T_{14}	RDF 100% + PSB	9.37	121.87	9.20	38.13	3.57	1.62
T_{15}	RDF 100% + Mycorrhiza	8.77	121.93	9.23	38.17	3.63	1.66
T_{16}	RDF 100% + Azotobacter + PSB	9.50	122.30	9.37	38.37	3.65	1.57
T_{17}	RDF 100% + PSB + Mycorrhiza	9.43	122.17	9.40	38.43	3.76	1.64
T_{18}	RDF 100% + Azotobacter + Mycorrhiza	9.33	122.63	9.43	38.50	3.60	1.60
T_{19}	RDF 100% + PSB + Azotobacter + Mycorrhiza	9.07	122.67	9.47	38.53	3.75	1.61
CD at 5%		NS	8.28	158	2.67	0.69	0.15
SEm±		NS	4.09	0.78	1.32	0.34	0.07

Table 2. Effect of INM on flowering parameters of gladiolus.

Treatment	Treatment combination	Days to spike emergence (days)	Day to first floret opening (days)	Spike girth (cm)	Spike length (cm)	Rachis length (cm)	Floret diameter (cm)
T0	Control	67.83	16.3	0.66	90.77	33.53	7.73
T1	75% RDF	65.09	14.97	0.79	98.3	36.87	8.32
T2	100% RDF	63.87	13.93	0.84	101.3	37.4	8.56
T3	Azotobacter + PSB	65.22	15.1	0.68	91.5	34.33	8.26
T4	Azotobacter + Mycorrhiza	65.16	15	0.72	92.4	34.63	8.37
T5	PSB + Azotobacter + Mycorrhiza	65.13	14.87	0.75	93.33	34.53	8.4
T6	RDF 75% + Azotobacter	59.15	12.77	0.9	106.4	38.73	8.72
T7	RDF 75% + PSB	59.53	12.47	0.93	105.53	37.63	8.66
T8	RDF 75% + Mycorrhiza	59.4	12.67	0.95	105.87	38.83	8.82
T9	RDF 75% + Azotobacter + PSB	59.36	12.63	0.96	107.3	38.87	8.85
T10	RDF 75% + PSB + Mycorrhiza	59.33	12.6	0.97	106.97	38.9	8.87
T11	RDF 75% + Azotobacter + Mycorrhiza	59.25	12.53	0.94	107.17	38.97	8.9
T12	RDF 75% + PSB + Azotobacter + Mycorrhiza	59.22	12.5	0.95	108.5	39.03	9.01
T13	RDF 100% + Azotobacter	59.11	12.47	0.94	109.2	39.23	9.07
T14	RDF 100% + PSB	59.18	12.43	0.93	108.87	39.1	9.03
T15	RDF 100% + Mycorrhiza	58.95	12.4	0.95	108.93	39.3	9.1
T16	RDF 100% + Azotobacter + PSB	58.74	12.37	0.96	109.3	39.33	9.13
T17	RDF 100% + PSB + Mycorrhiza	58.62	12.33	0.98	109.17	39.37	9.17
T18	RDF 100% + Azotobacter + Mycorrhiza	58.33	12.3	0.97	109.63	39.53	9.19
T19	RDF 100% + PSB + Azotobacter + Mycorrhiza	58.28	12.23	0.98	109.67	39.6	9.2
CD at 5%		2.2	1.21	0.06	8.28	1.01	0.26
SEm±		1.08	0.6	0.03	4.09	0.5	0.13

Spike length (cm)

The data on spike length are presented in the longest spikes were produced in T_{12} (108.50 cm) RDF 75% + PSB + Azotobacter + Mycorrhiza, whereas the shortest were produced in control T_0 (90.77 cm). It is evident from the results that spike length was directly correlated with plant height (Table 2). Combined application of chemical fertilizers and biofertilizers showed a significant influence on growth of gladiolus cv. American Beauty (Shrivastva and Govil, 2007). Application of biofertilizers and chemical fertilizers alone and combination resulted in more spike length. The enhanced spike length may be due to more availability of nitrogen and other nutrient elements. Nitrogen is a main constituent of chlorophyll, protein and amino acids and plays an important role in cell division, protein synthesis and metabolite transport that help to build the plant tissues. The increased spike length may also be attributed to the favorable effects of phytohormones like auxin and gibberellins produced by *Azotobacter*, PSB and Mycorrhiza which might have improved the root system of the plant, which in turn might have helped in better nutrient uptake and this might have enhanced the plant height (Gupta *et al.*, 2004). Similar findings have also been reported by Singh *et al.* (2003) in rose, Deshmukh *et al.* (2008) in Gaillardia, Gayithri *et al.* (2004) in statice, Yadav *et al.* (2005) and Chaudhary *et al.* (2013) in gladiolus.

Rachis length (cm)

The data pertaining to rachis length have been presented in Table 2. The longest rachis was observed with T_{12} (39.03) RDF 75% + PSB + Azotobacter + Mycorrhiza, while the shortest rachis was recorded in control T_0 (33.53) (Table 2). It is also clear that combined application of chemical fertilizers along with biofertilizers at higher rates showed the beneficial effect on various growth and flowering attributes in tuberose. It might be due to that Azotobacter accumulate the nitrogen near the root zone of plant and PSB convert unavailable phosphorus to available form and increase the availability of phosphorus to plants (Kumar *et al.*, 2012). it directly translocates the nutrients like phosphorus, Zn, Cu, K, Al, Mn and Mg from the soil to root cortex and increase the growth of associated plants by producing auxins, antibiotics etc. (Chauhan and Kumar, 2007).

Floret diameter (cm)

It is evident from the data that the largest floret was observed with T_{12} (9.01 cm) RDF 75% + PSB + Azotobacter + Mycorrhiza, while the smallest was recorded in control T_0 (7.73 cm) (Table 2). These increased attributes is due to application of biofertilizers in combination with RDF because of balanced nutrition and better availability of nutrients due to fungal and bacterial activity in the root zone. Bio-fertilizers and inorganic fertilizers with combination have improved the length and diameter of florets significantly. Increased length and diameter of floret ultimately results in increased size of the floret, which is also an important quality attribute of gladiolus as cut flower. These results clearly show that had significantly improved the length of florets by enhancing the nutrient uptake, especially helped in production of auxin like substances which was translocated to apical region and increased the floret length respectively (Kumari *et al.*, 2014) and Chauhan and Kumar (2007).

Conclusion

On the basis of findings of the present experiment the following conclusion may be drawn. Out of the total 20 treatments application of integrated nutrient management on cv. American Beauty was found different treatment to have the minimum number of days to sprouting (7.83 days) was found in (T_0) and corm diameter (5.47 cm) was found in (T_2). Minimum number of days to spike emergence (59.22 days), floret opening from spike emergence (12.50 days), floret diameter (9.01 cm), Maximum number of spike per plant (2.28), per plot (45.33), per hector (2.04 lakh), Maximum plant height (121.50 cm), number of leaves (9.03), leaf length (38.20 cm), Spike length (108.50 cm) and rachis length (39.03 cm) was found in (T_{12}) and Leaf width (3.75 cm), stem diameter (1.52 cm), longest vase life of spike (13.97 days), number of corm per plant (3.10) and per plot (62.00), weight of corm (104.75 g) was found in (T_{10}). Maximum number of cormels per plant (26.07), per plot (347.56) and weight of cormels (27.67 g) was found in (T_7). Maximum benefit: cost ratio (0.72) was found in T_{12}. From present investigation, it is concluded that in respect of cultivation of gladiolus under Jhalawar condition. The application of RDF 75% + Azotobacter + PSB + Mycorrhiza was effective in enhancing vegetative growth and quality of gladiolus. Therefore, under Jhalawar growing conditions, for improved yield of spikes and corms with superior quality produce integrated nutrient management may be suggested for application in gladiolus cv. American Beauty.

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