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Analyzing Different Spacing and Fertilizer Applications Interaction Effect on Growth, Flowering and Yield of Gladiolus (*Gladiolus grandiflorus* L.)

Santosh Kumar Beck[1], Manoj Kumar Beck[2*] and Premanshu Agrawal[1]

[1]Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad (U.P.), India
[2]Department of Agrometeorology, IGKV, Raipur (CG), India

**Corresponding author*

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A B S T R A C T

An experiment was conducted in factorial Randomized Block Design (FRBD) with three replications and twelve treatments. The allocation of treatments to the individual plots was done using random numbers in each replication. The corms were planted on 17 Oct. 2015. The treatments consisted of three various spacing i.e., 30cm x 30cm, 30cm x 15cm and 40 x 15 cm and four combination of fertilizers RDF 200:200:200, NPK 75% + FYM 25%, NPK 75% + GM25%, NPK 75% + VC25%. The treatment T_{12}: 30 x 15cm^2 + NPK 75% + VC25% performed higher in number of leaves per plant, height of the plant (cm), crop growth rate (CGR), days to spike emergence, length of the spike, number of florets per spikes, vase life of cut spikes (days),days to opening of first florets, longevity of first florets (days). whereas the earliest 50% sprouting, number of sprouts per mother corm, the yield of corms per hectare, number of corms per plant, number of spike per plant and spike yield per hectare recorded highest in Treatment T_8:30cm x 15cm + NPK 75% + VC25% and the treatment T_{11}: 40 x 15cm^2 + NPK 75% + GM 25% performed best in Diameter of corms (cm) and Weight of corms (g). Treatment T_{10}: 40x15 cm^2 +75% NPK + 25% FYM i.e. observed highest in width of leaf (cm). The cost and return associated with the cultivation of gladiolus in the present investigation clearly indicated that the net return Rs.14,28,591/ha and benefit cost ratio (2.89: 1) were highest in treatment T_8.

Introduction

Gladiolus name is derived from the Latin word *'gladius'* means sword because of leaves being sword-like in appearance. Gladiolus (*Gladiolus grandiflorus*) is said to be the "Queen of bulbous plant", because the gladiolus is top in the list of its beauty, glamour, keeping quality, long range of colour like white, crimson, pink, orange, salmon, red, purple cream and rose etc. shades and shapes. Gladiolus is one of the most popular flowering plants, because of its colourful and attractive succession from the bottom. They are available in an extensive array of colours. They produce flowers in almost every shade and may be bi-or tri-coloured. The flowers open first at the base of the spike with the older ones dying as the new ones unfurl. They may be frilly, ruffled, or plain. Plants are generally of two types (1) Having large florets (2) Having miniature or

butterfly type flowers. Plant is straight and leaves are also straight, spike stand straight from the base. Beyond the limit or higher rate of nitrogen delayed the time of flowering and increased the spike length, weight and size of corms. The higher rate of phosphorus and potassium tended to improve the flower quality.

Materials and Methods

Field preparation was done by ploughing the field with mould board plough once, followed by levelling and weeding manually. Then the field was divided into three blocks spaced at one meter distance. Each block was further sub-divided into twelve sub-plots at a distance of 0.5 m. The given amount of FYM, Vermicompost and Goat manure was applied in each sub plot treatment wise and then and mixed properly. The usual method of propagation of gladiolus is through corms and cormels. Healthy corms size ranged between 3cm to 5cm were planted after treating with Bavistin@ 1gm/kg corm. FYM, Vermicompost and Goat manure were given as basal in the given plots treatment wise. Recommended fertilizer of dozes Nitrogen (N=0.130gm/plot) phosphorous (P=0.375gm/ plot) and potassium (K=0.99gm/plot) were given during course of experiment. Full doses of potassium and phosphorous were given as basal application at the time of planting and nitrogen was given in three split doses i.e. one forth as basal and remaining three fourth in two equal and split dozes i.e. one at 3 and another at 6 leaf stages. Before planting of corms in the soil, a soil sample was collected from experimental field and analyzed for physical-chemical characteristics. Gladiolus may be grown on wide range of soils. Sandy loam soil is suitable for good growth and flowering. The most suitable pH range is 6-7. The soil should be well drained and free from soil borne disease. It is grown in open fields, beds, pots and a border etc. The soil of experimental field was sandy loam in texture and slightly alkaline in reaction. The soil was low in organic carbon (0.45), available nitrogen low (155.40), available phosphorus medium (14.76), and available potassium medium (139.82).

Results and Discussion

The data presented in Table 1 envisaged that the fifty percent of sprouting the minimum number of days (5.33) was taken by treatment T_8 (30 X 15 cm^2 + 75% NPK + 25% Vermicompost), whereas the maximum number of days (6.46) for 50 percentages sprouting was recorded in the treatment T_1 (30 X 30 cm^2 + 200:200:200 kg NPK). The earliness in sprouting may be due to the application of chemical fertilizer in combination with FYM which promotes or induces early sprouting of corm. This result is confirmed with the findings of Bisen and Barholia (1990) and Singh (1998) in potato and gladiolus respectively.

The data presented in Table 1 envisaged that the maximum number of sprouts per mother corm (1.46) was found in the treatment T_8 (30 X 15 cm^2 + 75% NPK + 25% Vermicompost). The minimum number of sprouts per mother corm (1.00) was recorded in treatment T_1 (30 X 30 cm^2 + 200:200:200 kg NPK). The superiority of treatment T_8 over the rest of the treatments might be due to availability of optimum amount of nutrient from inorganic fertilizer in combination with Vermicopost. This result is in close conformity with the findings of Singh and Singh (1971).

The data presented in Table 1 envisaged that the number of leaves per plant was counted at 30, 60 and 90 days after planting. The maximum number of leaves was observed (10.40) in treatment T_{12} (40x15 cm^2 + NPK 75% + Vermicompost 25%). Minimum number of leaves per plant was observed

(6.86) in treatment T_1 (30 X 30 cm^2 + 200:200:200 kg NPK). This might be due to continues availability of essential nutrient to the crop by the application of inorganic fertilizer in combination with organic Vermicompost. These observations followed the results of Ahmed *et al.*, (2004).

The data presented in Table 1 envisaged that the data on height of the plant was recorded at 30, 60 and 90 days after planting. The maximum height of the plant was observed (124.13 cm) in treatment T_{12} (40x15 cm^2 + NPK 75% + Vermicompost 25%) and it was significantly superior over all of the treatments. Minimum height of the plant was noted (117.66 cm) in treatment T_1 (30 X 30 cm^2 + 200:200:200 kg NPK). The maximum height of plant under the treatment T_{12} might be associated with the availability of optimum nutrient to the plant throughout the growth period by the application of inorganic fertilizer in combination with Vermicompost. This is in accordance with the findings of Widjajanto and Widodo (1982).

The data presented in Table 1 envisaged that the maximum leaf width (3.69) was obtained in treatment T_{10} (40X15 cm^2 + NPK 75% + FYM 25%) and the treatment T_1 (30 X 30 cm^2 + 200:200:200 kg NPK) recorded the minimum leaf width (3.05).

Similar result was recorded by Shankar (2001). He observed that the leaf breadth of gladiolus was maximum in the treatment NPK@ 40:20:20g/m2, Singh and Bijimol (2000) (Tuberose).

The data presented in Table 2 envisaged that the days to opening of first florets was recorded minimum in treatment T_{12} (40x15 cm^2 + NPK 75% + Vermicompost 25%) (16.00) and minimum number of florets per spikes was recorded in the treatment T_1 (30 X 30 cm^2 + 200:200:200 kg NPK) (11.02). Findings are in conformity with the findings of Singh and Bijimol (2000).

The data presented in Table 2 envisaged that the maximum longevity of first florets in $Al_2(So_4)_2$ 200 ppm (5.74) was obtained in the treatment T_{12} (40x15 cm^2 + NPK 75% + Vermicompost 25%) whereas the minimum longevity was found in the treatment T_1 (30 X 30 cm^2 + 200:200:200 kg NPK) (4.11 days). It may be due to the exogenous supply of $Al_2(SO_4)_2$ & Sucrose which replaced the depleted endogenous carbohydrate, utilized during the postharvest life of lower and thereby enhanced vase life Kumar (2005).

The data presented in Table 2 envisaged that the minimum number of days to spike emergence 64.40 days was taken by the treatment T_{12} (40x15 cm^2 + NPK 75% + Vermicompost 25%). The maximum number of days to spike emergence 77.46 days. Was taken by the treatment T_1 (30 X 30 cm^2 + 200:200:200 kg NPK) The earliness in spike emergence by the application of Vermicompost in combination of inorganic fertilizer may be due to optimum availability of nutrients to the plant due to which plant completed their vegetative growth soon resulting in early spike emergence. These results are in close conformity with the findings of Ahmed *et al.*, (2004). They observed that the treatment which was comprised of 20 g urea/m2 + 40g (DAP)/m2 + 4kg FYM/m2 taken minimum number of days for emergence flower bud in Dahlia.

The data presented in Table 2 envisaged that the maximum length of spike (101. 35cm) was recorded in the treatment T_{12}. The minimum length of the spike 60.82cm.was obtained in treatment T_1 (30 X 30 cm^2 + 200:200:200 kg NPK) The maximum length of the spike in treatment T_{12} may be due to the availability of sufficient amount of nitrogen in different phases of growth and

development of plants which promotes the length of the spike. Similar result was recorded by Gupta *et al.,* (2008). They reported that the maximum length of the spike in gladiolus was obtained by applying Vermicompost @ 2.5kg/m^2.

The data presented in Table 2 envisaged that the maximum number of florets per spike 16.00 was counted in the treatment T_{12} (40x15 cm^2 + NPK 75% + Vermicompost 25%) and it was significantly superior over all the treatments. The minimum number of florets per spike (11.02) was observed in the treatment T_1 (30 X 30 cm^2 + 200:200:200 kg NPK) The superiority of treatment T_{12} for number of florets over the other treatments may be due to the availability of organic and inorganic fertilizers and other essential nutrients for longer period at optimum level resulting in more number of florets per spike. This result is in close agreement with the findings of Ahmed *et al.,* (2004).

The data presented in Table 2 envisaged that the Treatment T_{12} (40x15 cm^2 + NPK 75% + Vermicompost 25%) had the longest vase (13.13days) in $Al_2 SO_4)_2$ - 200ppm where as the minimum vase life 9.96 days in distilled water was obtained in treatment T_1 (30 X 30 cm^2 + 200:200:200 kg NPK). The maximum vase life in treatment T_{12} may be due to the positive effect of inorganic nitrogen in combination with organic manure Vermicompost on the vase life and also due to more accumulation of carbohydrate which increased the vase life of cut spikes. Similar findings are reported by Narendra *et al.,* (2013).

The data presented in Table 3 envisaged that the maximum diameter of corm was noticed in the treatment T_{11} 40x15cm^2 + 75% NPK + 25 % Goat manure) (5.66 cm) whereas the minimum diameter of corm was obtained in the treatment T_1 (30 X 30 cm^2 + 200:200:200 kg NPK) (3.35cm). It may be due to Goat manure and other essential nutrient NPK and proper spacing was regularly available to the plant at critical stage of growth and development of corm which, in turn, resulted in faster and better development of corm. This result is in close agreement with the findings of Varu *et al.,* (1994).

The data presented in Table 3 envisaged that the maximum weight per corm was recorded in the treatment T_{11} (40x15cm^2 + 75% NPK + 25 % Goat manure) (66.69g.) whereas minimum weight per corm was found in the treatment T_1 (30 X 30 cm^2 + 200:200:200 kg NPK) (32.43g). Similar result was obtained by Varu *et al.,* (1994).

The data presented in Table 3 envisaged that the no. of spike per plant was recorded maximum in Treatment T_8 (30 X 15 cm^2 + 75% NPK + 25% Vermicompost) (1.29) and spike was obtained minimum in Treatment T_1 (30 X 30 cm^2 + 200:200:200 kg NPK) (1.00). This result is in close agreement with the findings of Sud *et al.,* (2010).

The data presented in Table 3 envisaged that the highest no. Of corm was obtained in treatment T_8 (30 X 15 cm^2 + 75% NPK + 25% Vermicompost) (1.28) and minimum no. of corm was found in treatment T_1 (30 X 30 cm^2 + 200:200:200 kg NPK) (1.00). It may be due to higher germination percentage of corm with the application of inorganic fertilizer in combination with Vermicompost and proper spacing (30x15cm^2). This result is in close agreement with the findings of Sud *et al.,* (2010).

The data presented in Table 3 envisaged that the highest yield of spike per hectare was obtained in the treatment T_8 (30 X 15 cm^2 + 75% NPK + 25% Vermicompost) (2,60,000) and minimum spike yield was recorded in treatment T_1 (30 X 30 cm^2 + 200:200:200 kg

NPK) (1,11,111) The greater spike yield per hectare might be due to an optimum combination of fertilizers and manures with short spacing. The similar increase in flower yield due to increase in number of sprouts and spike length. Similar findings are reported by Radhika *et al.,* (2010).

The data presented in Table 3 envisaged that the maximum yield of corms 2,67407corms/ha. recorded in the treatment T_8 (30 X 15 cm^2 + 75% NPK + 25% Vermicompost) which was significantly superior over all the treatment. The minimum yield of corms (1, 11111) corms/ha was found in the treatment T_1 (30 X 30 cm^2 + 200:200:200 kg NPK). Increase in yield with treatment T_8 may be due to assimilation of carbohydrate and protein resulting in better vegetative growth of plant. This probably helped in better tuberization of corm and increase their weight and size may be due to higher germination percentage of corm with the application of inorganic fertilizer in combination with Vermicompost and proper spacing (30x15cm^2). This result is in close agreement with the findings of Hassandokht and Kashi (2000).

The highest benefit cost ratio was found in the treatment T_{12} (40x15 cm^2 + NPK 75% + Vermicompost 25%) (3.50:1) whereas the lowest benefit cost ratio was recorded in the treatment T_1 (30 X 30 cm^2 + 200:200:200 kg NPK) (2.77:1).

Table.1 Combined effect of planting density and organic and inorganic fertilizer on growth characteristics of gladiolus

Treatments	Growth Characteristics				
	Days to 50% sprouting	**Number of sprouts per corm**	**Plant height (cm)**	**Number of leaves per plant**	**Width of the leaf (cm)**
S_1 F_1 (T_1)	**6.46**	**1**	117.66	6.86	**3.05**
S_1 F_2 (T_2)	5.6	1.13	120.8	7.46	3.28
S_1 F_3 (T_3)	6.06	1.16	119.46	7.2	3.42
S_1 F_4 (T_4)	5.53	1.26	119	7.33	3.42
S_2 F_1 (T_5)	5.73	1.33	121.93	8.4	3.42
S_2 F_2 (T_6)	5.46	1.26	118.2	7.4	3.40
S_2 F_3 (T_7)	6.26	**1.43**	123.2	**9.7**	**3.63**
S_2 F_4 (T_8)	**5.33**	**1.46**	119.86	7.86	3.38
S_3 F_1 (T_9)	5.73	1.26	118.11	7.6	3.60
S_3 F_2 (T_{10})	5.8	1.26	120.86	7.73	**3.69**
S_3 F_3 (T_{11})	**5.4**	1.4	119.75	7.46	3.39
S_3 F_4 (T_{12})	5.66	1.26	124.13	**10.4**	3.47

S_1: 30cm x 30cm, S_2 : 30cm x 15cm , S_3: 40cm x 15cm, F_1: 200:200:200 kg/h, F_2: NPK 75% + FYM 25%, F_3: NPK 75% + GM 25%, F_4: NPK 75% + VC 25%

Table.2 Combined effect of planting density and organic and inorganic fertilizer on floral characteristics of gladiolus

Treatments	Floral Characteristics						
	Days to Spike initiation	**Opening Of first floret (days)**	**Spike length (cm)**	**Number of florets per spike**	**Longevity of first floret In $Al_2(so_4)_3$ (days)**	**Vase Life of Spikes In $Al_2(so_4)_3$**	**No. of spikes per plant**
S_1 F_1 (T_1)	**77.46**	94.35	60.81	**11.02**	**4.11**	**10.66**	1
S_1 F_2 (T_2)	70.19	83.73	80.78	11.87	4.86	11.66	1.15
S_1 F_3 (T_3)	75.39	84.66	64.83	11.57	4.45	11	1.11
S_1 F_4 (T_4)	72.3	85.24	72.75	**14.45**	4.90	11.33	1.07
S_2 F_1 (T_5)	65.57	89.24	65.83	13.07	4.53	12	1.00
S_2 F_2 (T_6)	72.53	89.34	99.35	12.27	4.49	12	1.15
S_2 F_3 (T_7)	77.30	90.01	**100.39**	13.34	**5.44**	**13**	**1.17**
S_2 F_4 (T_8)	67.44	88.12	87.32	14.35	5.21	12	**1.29**
S_3 F_1 (T_9)	76.35	89.66	87.40	12.44	4.86	12.33	1.01
S_3 F_2 (T_{10})	67.39	**80.77**	67.09	12.01	5.13	12	1.03
S_3 F_3 (T_{11})	**65.43**	88.59	86.63	12.07	4.68	11.66	1.15
S_3 F_4 (T_{12})	**64.40**	**80.33**	**101.34**	**16**	**5.74**	**13.13**	1.08

S_1: 30cm x 30cm, S_2: 30cm x 15cm , S_3: 40cm x 15cm, F_1: 200:200:200 kg/h, F_2: NPK 75% + FYM 25%, F_3: NPK 75% + GM 25%, F_4: NPK 75% + VC 25%

Table.3 Combined effect of planting density and organic and inorganic fertilizer on yield characteristics of gladiolus

Treatments	YieldCharacteristics					
	Diameter of corm (cm)	**Weight of Corms (g)**	**No. of Spike per plant**	**Number of Corms per plant**	**Spike yield per hectare ('000 Hectare)**	**Corm yield per hectare**
S_1 F_1 (T_1)	3.35	32.43	1	1.01	111.111	111111
S_1 F_2 (T_2)	4.87	54.17	1.15	1.06	128.148	211481
S_1 F_3 (T_3)	5.40	58.03	1.11	1.15	124.074	139629
S_1 F_4 (T_4)	5.41	60.63	1.07	1.07	120.37	124074
S_2 F_1 (T_5)	4.38	50.19	1.00	1.00	223.703	223703
S_2 F_2 (T_6)	4.55	56.98	1.15	1.15	240	232592
S_2 F_3 (T_7)	5.59	63.55	1.17	1.17	255.555	255555
S_2 F_4 (T_8)	3.54	42.98	1.29	1.28	260.000	267407
S_3 F_1 (T_9)	4.54	53.68	1.01	1	168.333	168333
S_3 F_2 (T_{10})	3.85	38.92	1.03	1.15	172.777	177777
S_3 F_3 (T_{11})	5.65	66.69	1.15	1.11	191.666	191666
S_3 F_4 (T_{12})	4.51	52.70	1.08	1.07	239.999	213333

S_1: 30cm x 30cm, S_2: 30cm x 15cm , S_3: 40cm x 15cm, F_1: 200:200:200 kg/h, F_2 : NPK 75% + FYM 25%, F_3: NPK 75% + GM 25%, F_4: NPK 75% + VC 25%

On the basis of this research, treatment T_{12} (40x15 cm^2 + NPK 75% + Vermicompost 25%) performed higher in number of leaves per plant, height of the plant (cm),days to spike emergence, length of the spike, number of florets per spikes, vase life of cut spikes (days),days to opening of first florets, longevity of first florets(days).Whereas the earliest 50% sprouting, number of sprouts per mother corm, the yield of corms per hectare, spike yield per hectare, was recorded highest in Treatment T_8 (30 X 15 cm^2 + 75% NPK + 25% Vermicompost) and the treatment T_{11} (40x15cm^2 + 75% NPK + 25 % Goat manure) performed best in Diameter of corms (cm) and Weight of corms (g). These characters may affect significantly due to different combination of spacing and source of fertilizer. However, since this is based on one season experiment, further trials may be needed to substantiate the results.

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