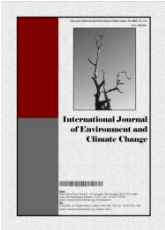

International Journal of Environment and Climate Change

12(11): 1914-1920, 2022; Article no.IJECC.90796
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Integrated Effect of Bio-fertilizers, Organic and Inorganic Fertilizers on Flowering, Corms and Cormel Yield Attributes of Gladiolus (*Gladiolus grandiflorus* L.) cv. Nova Lux

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2022/v12i1131179

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/90796

Original Research Article

Received 15 June 2022
Accepted 24 August 2022
Published 27 August 2022

ABSTRACT

An Investigation entitled "Influence of biofertilizers on vegetative growth, flower quality and bulb yield of gladiolus (*Gladiolus grandiflorus* L.)" was conducted at the Horticultural Research centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) during the year 2021-2022 in Randomized Block Design (RBD) with three replications to assess the effect of different biofertilizer. Total fourteen treatment combination T_1(Control), T_2(200 qt. FYM + 300KgN_2 +200 Kg P_2O_5+200 Kg K_2O/ha)(RDF), T_3(RDF + 30% FYM), T_4(RDF + 30% Vermicompost), T_5(70% RDF+30% FYM), T_6(70% RDF + 30% Vermicompost), T_7(75% RDF + Azospirillum), T_8(75% RDF+ 25% FYM + Azospirillum), T_9(75%RDF + 25% FYM + Azospirillum + PSB + Azotobacter), T_{10}(75% RDF + 25% Vermicompost + Azospirillum + PSB + Azotobacter), T_{11}(RDF + ZnSO4 (0.3%) + PSB, T_{12}(RDF + FeSO4(0.4%) + Azotobacter), T_{13}(RDF + $ZnSO_4$ (0.3%) +

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Azotobacter + PSB + Azospririllum), T_{14}(RDF + $FeSO_4$ (0.4%) + Azotobacter +PSB) and they were tried to access the vegetative, nutrition and parameter of gladiolus. Out of these, treatment T_{10}(75% RDF + 25% Vermicompost + Azospirillum + PSB + Azotobacter)Was observed as the most superior treatment in terms of minimum days taken to 50% sprouting, plant height(cm), number of leaves per plant, length of longest leaf (cm), width of longest leaf (cm), days taken for opening of first spike, days taken to opening of florets, number of flower per plant, diameter of flower(cm), length of rachis(cm), length of spike (cm), diameter of spike(cm), longevity of spike(days), diameter of corm(cm), number of corms per plant, weight of corms, weight of corms per plant, number of cormels per plant, weight of cormels per plant(g), number of spikes per plant, number of spikes per plot, number of spikes per hectare, yield of corms per hectare, yield of cormels per hectare, yield of corms and cormels per hectare however, the above parameters were found minimum under control during both the years of experimentation.

Keywords: Biofertilizers; corms; cormel; yield; organic and inorganic fertilizers.

1. INTRODUCTION

Pliny the Elder (2379 AD) first used the term "gladiolus" to refer to the blade's sword-like form (Latin word gladiolus means sword). Tetraploids from South Africa and diploid sp. from Europe are its sources. It contains basic chromosome 15 in its genetic makeup. Gladiolus are found in 260 different species. The majority of species in the genus are heteroploids, with chromosome numbers ranging from 2n = 30 to 120. (diploids, triploids, tetraploids, pentaploids, hexaploids, octaploids, and hyperaneuploids).

The Latin word gladiolus, which means "little sword," gave gladiolus flowers their name. It alludes to the plant's leaves and inflorescences, which have a sword-like form and look. Gladiolus flowers are sometimes referred to as irises or corn lilies due to their look. Additionally, a gladiolus bloom is referred to by the term xiphium. It is derived from the Greek word "sword," xiphios. Gladiolus is the name given to gladiolus flowers in commerce.

A gentle herbaceous perennial, gladiolus is grown both from seeds and bulbs. The bulb is covered with 4-6 dry scales or sheaths that are the bases of older leaves formed during the previous growing season. The point where the scale is attached to the corm is called the node. Each node has one or two buds. Each bud has the potential to become a shoot. The roots begin to emerge from the base of the bulb. These roots are called thread roots. When the plant reaches the nearly 4 leaf stage, new contracting roots emerge from the base of the growing stem where the new bulb begins to develop. The leaves are sword-shaped, clustered at the base of the stem. The flowers are 2 cymbals with 6 funnel-shaped perianth segments and pistils. Stamens in the number of 3 are placed opposite the petals, and stamens with separate and basal filaments. The fallopian tubes are tricuspid, synchronous with the lower ovary.

Gladiolus is a delicate herbaceous perennial that may be cultivated from both seeds and bulbs. Six to eight dry scales or sheaths, which are the bases of elder leaves created during the previous growth season, cover the bulb. The node is the location where the scale connects to the corm. The number of buds per node varies. Each bud has the capacity to develop into a shoot. The flowers are 2 cymbals with 6 funnel-shaped perianth segments and pistils. Stamens in the number of 3 are placed opposite the petals, and stamens with separate and basal filaments. The fallopian tubes are tricuspid, synchronous with the lower ovary. The fruits are 3-chambered oval 2 capsules with winged seeds. When fully ripe, it turns brown and divides into three vertical lines. It is a significant commercial flower crop that plays a key role in domestic and international markets as a cut flower. Flowers are used in bouquets, floral arrangements, and home décor. This flower ranks second in the Netherlands and other European nations in the trade of cut flowers for bulb plants, and fourth globally in the trading of decorative plants for cut flowers. Gladiolus, a potential flowering plant, is a part of India's 200 crore rupee floriculture industries. Gladioli are estimated to grow on about 11,660 hectares (Anonymous 2020-21) across India.

Bio-fertilizers have been shown to be beneficial in flower crops such as gladiolus, tuberose, rose, chrysanthemum and marigold. The effect of various organic fertilizers including bio-inoculants alone or in combination with chemical fertilizers has been investigated on the growth and yield characteristics of chrysanthemum, China aster,

tuberose, marigold and of several other ornamental plants [1,2]. There is currently an urgent call for a temporary complement to inorganic fossil fertilizers, not only because of the increase in fertilizer prices, but also to maintain long-term soil productivity and environmental sustainability. the effect of bio-inoculants with reduced doses of inorganic fertilizers for optimum growth and flowering of tuberose. The results obtained in the experiment suggested that use of bio-inoculants with reduced doses of inorganic fertilizers significantly influenced the growth and flowering of tuberose [3]. The use of bio-fertilizers with reduced doses of nitrogen significantly influenced the flowering of gladiolus [4]. The effect of farmyard manure (FYM), vermicompost and Trichoderma alone and in combination on flowering and corm yield in gladiolus [5].

Gladiolus blossoms are a well-known symbol of nostalgia and romantic love. A gladiolus flower also represents honour, loyalty, endurance, composure, integrity, and moral fortitude in the language of flowers. Gladiolus is a perennial floral plant that develops from structures resembling bulbs.

The consumption of traditional inorganic fertilisers can be decreased with the help of bio-fertilizers, also known as microbial inoculants. Many of them can function as bio-fertilizers because they can fix nitrogen, aid in accessing nutrients like phosphate and nitrogen from organic fertilisers and soil reserves, boost drought resistance, enhance plant health, or raise salt tolerance [6].

2. MATERIALS AND METHODS

The present investigation entitled “Influence of bio-fertilizers on vegetative growth, flower quality and bulb yield of gladiolus (*Gladiolus grandiflorus* L.)” was carried out during *Rabi season* 2020-2021 at Horticulture Research Center of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh.

2.1 Experimental Design and Treatments

The experiment made use of the gladiolus Nova Lux cultivar. The NBRI in Lucknow provided the Nova Lux corms, which were in good health. IARI, New Delhi, is the organisation that produced Nova Lux. Three replications of the experiment were used in its Randomized Block Design layout. There are 14 different treatment combinations in each replication. With the use of a rope and measuring tape, the experimental plan was put out in the field, and the treatments were distributed as perverted randomised units in each replication. A single corm was sowed with a consistent depth of 5 to 6 cm at a spacing of 30 cm between plants and 20 cm between rows. The corms' necks were kept pointing upward toward the soil's surface. Corms were buried and then covered with earth. Inorganic fertilisers (Urea, SSP, and MOP), micronutrients (Fe and Zn), organic manures (FYM and Vermicompost), and bio-fertilizers were all included in the study's total of 14 treatments (Azotobacter, Azospirillum and PSB). The specifics of the treatment allocation are as follows: T_1(Control), T_2(200 qt. FYM + 300KgN +200 Kg P_2O_5+200 Kg K_2O/ha)(RDF), T_3(RDF + 30% FYM), T_4(RDF + 30% Vermicompost), T_5(70% RDF+30% FYM), T_6(70% RDF + 30% Vermicompost), T_7(75% RDF + Azospirillum), T_8(75% RDF+ 25% FYM + Azospirillum), T_9(75%RDF + 25% FYM + Azospirillum + PSB + Azotobacter), T_{10}(75% RDF + 25% Vermicompost + Azospirillum + PSB + Azotobacter), T_{11}(RDF + ZnSO4 (0.3%) + PSB, T_{12}(RDF + $FeSO_4$(0.4%) + Azotobacter), T_{13}(RDF + $ZnSO_4$ (0.3%) + Azotobacter + PSB + Azospririllum), T_{14}(RDF + FeSO4 (0.4%) + Azotobacter +PSB). In order to properly mineralize the soil before planting corms, the complete estimated dose of farmyard manure for each treatment combination was spread as a base dose and blended in to the individual specified plots before two weeks. However, at the three and six leaf stages, soil was combined with vermicompost and bio-fertilizers such PSB, Azatobacter, and Azospirillum. The treatment combinations were followed while applying inorganic fertilisers. A basal dosage of single superphosphate and muriate of potash was administered at the time of planting. At the three and six leaf stages, the crop received a top dressing of nitrogen [7-11].

2.2 Attributes of Study

2.2.1 Flowering yield attributes

2.2.1.1 Number of spikes per plant

Flowering spike per corm of the selected five randomly plants was counted during the entire experimental period. The number of flowering spikes produced by selected plants and average was calculated.

2.2.1.2 Number of spikes per plot

The number of spikes per plot was computed from each plot and average was worked out.

2.2.1.3 Number of spikes per hectare

The number of spikes was counted from five randomly selected plants in each plot and mean values were expressed in hectare.

2.2.2 Corm and cormel attributes

2.2.2.1 Diameter of corm (cm)

Diameter of corm from each plot was recorded with the help of Vernier callipers and average expressed in centimetre.

2.2.2.2 Number of corms per plant

The total number of corms per plant was counted from five randomly selected plants in each plot after harvesting with suitable methods and carefully average was computed accordingly.

2.2.2.3 Weight of single corm (g)

Weight of corm from each plot was measured with the help of electronic balance and the average was worked out and expressed in gram.

2.2.2.4 Weight of corms per plant (g)

Corms of five randomly selected plants of gladiolus were dug out separately after drying of leaves taken plot-wise and weight of corms per plant were taken. The average was worked out and recorded in gram unit.

2.2.2.5 Number of cormels per plant

The number of cormels per plant was counted after harvesting of five randomly selected plants from each plot and the mean value worked out.

2.2.2.6 Yield of corms per hectare (q/ha)

Corms should be weighted (g) from five randomly selected plants in each plot with the help of electrical balance and the weight unit is converted from grams to quintals per hectare.

2.2.2.7 Yield of cormels per hectare (q/ha)

Cormels should be weighted (g) of five randomly selected plants from each plot with the help of electric balance and mean values were expressed in quintals per hectare.

2.2.2.8 Yield of corms and cormels per hectare (g/ha)

Corms and cormels were weighted (g) separately from each five randomly selected plants with the help of electric balance and the average was performed in quintals per hectare.

2.3 Statistical Analysis

2.3.1 Standard error of mean

The Standard Error (S.E.) and Critical Difference (C.D.) values were calculated by the following method as described below,

Formula:

$$\mathrm{SE(Mean)} \pm = \sqrt{\frac{2\mathrm{MSE}}{\mathrm{r}}}$$

Where,

MSE = Mean sum of square due to error
r = Number of replications

2.3.2 Critical difference

The critical difference at 5% at level of probability was workout to compare treatments means wherever “F” test will be significant.

The calculation of C.D. at 5% was calculated with the help of following formula:

C. D.=

$$SEm \pm \sqrt{2} \times tabulated\ value\ error\ d.f.\ at\ 5\%$$

Where,

C. D.= Critical difference
SE (m) ± = Standard error of mean

3. RESULTS AND DISCUSSION

In the present era where humans are more attracts towards flowers, Gladiolus *(Gladiolus grandiflorus L.)* has great economic value as a cut flower and for decoration and known as queen amongst the bulbous flowers. As we know the physical, chemical, and biological properties of soil is adversely affected by imbalanced use of chemical fertilizers. Moreover, in developing countries like India, the cost of cultivation is increasing due to the imbalance use of chemical

fertilizers and high price. An organic fertilizer complemented with chemical fertilizers, bio-fertilizers and Vermi-compost with other sources of nutrients. Accordingly, to develop low-cost input management performs in crop production is urgently required as they have the proficiencies to improve the soil fertility and provide essential plant nutrient to the crop.

3.1 Flowering Yield Attributes

Number of spikes per plant: The number of spikes per plant ranges from 1.34 to 2.23 was revealed, respectively. The maximum spikes per plant i.e., 2.23 were recorded into the treatment T_{13} (RDF + ZnSO4 (0.3%) + Azotobacter + PSB + Azospirillum) which in the treatment T_{13} (RDF + $ZnSO_4$ (0.3%) + Azotobacter + PSB + Azospirillum) significantly superior to treatment T_{12} (RDF+ $FeSO_4$ (0.4%) + Azotobacter) viz. (1.89), while the minimum spikes per plant 1.34 were recorded in T_1 (control).

Number of spikes per plot: The number of spikes per plot ranged from 180.76 to 305.45, respectively. The maximum number of spikes per plot (305.45) were recorded under treatment T_{10} (75% RDF+ 25% Vermicompost + Azospirillum + PSB + Azotobacter), whereas minimum number of spikes per plot (180.76) was noted under treatment T_1 (control).

Number of spikes per hectare: The maximum number of spikes per hectare 135242 was showed in the treatment T_{10} (75% RDF + 25 % Vermi-compost+ Azospirillum + PSB + Azotobacter), while minimum number spikes per hectare (90420) was observed under treatment T_1 (control).

3.2 Corm and Cormel Attributes

Diameter of corm (cm): The diameter of corm ranges from 5.67 to 6.95 cm. The maximum diameter of corm (6.95cm) was showed under treatment T_{10} (75% RDF + 25% Vermi-compost + Azospirillum + PSB + Azotobacter) which was statistically higher than treatment T_{14} (RDF + $FeSO_4$ (0.4%) + Azotobacter + PSB) viz. (6.40 cm) during year of investigation. However, the minimum diameter of corm (5.67 cm) was observed in control.

Number of corms per plant: The maximum number of corms per plant recorded (2.45) in T_{10} (75% RDF + 25% Vermi-compost + Azospirillum + PSB + Azotobacter) during the year of investigation. The minimum number of coms per plant (1.35) were recorded with T_1 (control).

Weight of Single corm (g): The maximum weight of corm was recorded range of 57.36 g to 69.78 g at final harvest, respectively. The maximum weight of corm (69.78 g) was noted with an application of treatment T_{10} (75% RDF + 25% Vermi-compost + Azospirillum + PSB + Azotobacter) which was significantly higher than T_9 (75% RDF + 25% FYM + Azospirillum + PSB + Azotobacter) viz. (67.87 g). The control plants, however, had the minimum (57.36 g).

Weight of corms per plant (g): The weight of corms per plant varied from 44.07 to 71.89 g. Among the treatments applied in the experimental plot, the maximum weight of corms per plant (71.89 g) was recorded with T_{10} (75% Vermi-compost + Azospirillum + PSB + Azotobacter) which was followed by treatment T_9 (75% RDF + 25% FYM + Azospirillum + PSB + Azotobacter) viz. (68.44g). In the case has given the minimum weight of corms per plant (44.07 g) observed under control treatment.

Number of cormels per plant: Treatment T_{13} (75 RDF + ZnSO4 (0.3%) + Azotobacter+ PSB+ Azospirillum) had highest value for number of cormels per plant i.e., 54.93 and statistically at par with treatment T_{14} (RDF + $FeSO_4$ (0.4%) +Azotobacter + PSB) viz. 53.65. While the minimum number of cormels per plant (31.56) was recorded under treatment T_1 (control).

Yield of corms per hectare (q/ha): The yield of corms per hectare varied from74.10 q/ha to 91.52 q/ha. The maximum yield of corms per hectare (91.52 q/ha) was noted in treatment T_{10} (75% RDF + 25% Vermi-compost + Azospirillum + PSB + Azotobacter) which was statistically at par with treatment T_{13} (RDF + $ZnSO_4$ (0.3%) + Azotobacter + PSB + Azospirillum) viz. (88.69 q/ha), while the minimum corm yield (74.10 q/ha) was observed under treatment T_1 (control).

Yield of cormels per hectare (q/ha): The yield of cormels per hectare ranges from 38.45 q/ha to 68.41 q/ha. The maximum yield of cormels per hectare (68.41 q/ha) was record in treatment $T1_0$ (75% RDF + 25% Vermi-compost + Azospirillum + PSB + Azotobacter) viz. (65.78 q/ha) was noticed under treatment T_9 (75 % RDF+ 25% FYM+ Azospirillum + PSB + Azotobacter), while the minimum yield of cormels per hectare (38.45 q/ha) was reported under T_1 (control).

Table 1. Integrated effect of bio-fertilizers, organic and inorganic fertilizers on flowering and corms and cormel yield attributes of Gladiolus (*Gladiolus grandiflorus* L.) cv. Nova Lux

Sr. No.	Notation	Treatment	Flowering Yield Attributes				Corm and Cormel Attributes						
			No. of spikes per plant	No. of spikes per plot	No. of spikes per hectare	Diameter of corm (cm)	No. of corms per plant	No. of cormels per plant	Weight of corms per plant (g)	Weight of Single corm (g)	Yield of corms per hectare (q/ha)	Yield of cormels per hectare (q/ha)	Yield of corms and cormels per Hectare (g/ha)
1.	T_1	Control	1.34	180.76	90420	5.67	1.35	31.56	44.07	57.36	74.10	38.45	106.67
2.	T_2	200 qt. FYM+300KgN_2+200KgP_2O_5 +200KgK_2O/ha (RDF)	1.56	208.24	104120	5.56	1.56	35.98	51.56	59.65	76.75	43.24	114.57
3.	T_3	RDF+ 30%FYM	1.65	237.47	111145	6.97	1.56	41.48	54.98	59.68	78.98	48.34	117.76
4.	T_4	RDF+ 30%Vermicompost	1.37	252.09	118735	6.45	1.87	42.78	54.98	61.85	79.98	50.13	122.87
5.	T_5	70%RDF+30%FYM	1.28	235.67	126040	6.21	1.56	42.45	55.44	61.87	80.34	52.67	123.56
6.	T_6	70% RDF+ 30% Vermicompost	1.67	251.65	117820	6.04	1.87	46.97	56.74	62.56	81.65	51.67	122.45
7.	T_7	75% RDF+ Azospirillum	1.89	259.67	125838	6.73	1.45	45.71	57.55	62.56	83.87	56.78	126.56
8.	T_8	75%RDF+ 25%FYM + Azospirillum	1.85	250.54	127514	6.56	1.45	46.18	64.51	61.45	81.18	55.67	131.90
9.	T_9	75%RDF+25%FYM+Azospirillum+PSB+ Azotobacter	1.65	285.40	132206	6.76	2.35	50.45	68.44	67.87	89.50	65.78	133.67
10.	T_{10}	75%RDF+25%Vermicompost+Azospirillum+PSB+ Azotobacter	1.56	305.45	132242	6.95	2.45	45.35	71.89	69.78	91.52	68.41	146.34
11.	T_{11}	RDF+$ZnSO_4$(0.3%) + PSB	1.67	235.32	124445	5.67	1.78	49.04	59.33	60.65	78.90	55.87	124.34
12.	T_{12}	RDF+$FeSO_4$(0.4%) + Azotobacter	1.89	225.40	115678	6.10	1.88	53.45	62.44	60.06	86.98	60.87	142.45
13.	T_{13}	RDF+$ZnSO_4$ (0.3%) + Azotobacter +PSB+ Azospririllum	2.23	274.50	130256	6.55	2.10	54.93	66.45	66.95	88.69	54.78	129.53
14.	T_{14}	RDF+$FeSO_4$ (0.4%) +Azotobacter +PSB	1.56	260.50	129664	6.40	2.00	53.65	65.04	63.45	87.78	61.76	128.45
SE(m)			0.03	3.96	1545	0.06	0.01	0.33	0.57	0.63	1.62	0.93	2.46
C.D. At 5%			0.08	11.58	4517	0.16	0.04	0.96	1.66	1.85	4.75	2.73	7.20
C.V. (%)			2.99	2.77	2.22	1.53	1.36	1.24	1.66	1.75	3.39	2.96	3.37

Yield of corms and cormels per hectare (g/ha): The yield of corms and cormels per hectare ranges from 106.67 q/ha to 146.34 q/ha. The maximum yield of corms and cormels per hectare (146.34 q/ha) was recorded in treatment T_{10} (75% RDF + 25% Vermi-compost + Azospirillum + PSB + Azotobacter) which was statistically at par with treatment T_{12} (RDF + FeSO4 (0.4%) + Azotobacter) viz. (142.45 q/ha), while the minimum yield of corms and cormels per hectare (106.67 q/ha) was reported under treatment T_1 (control).

4. CONCLUSION

Based upon the results recorded in the investigation it could be concluded that the treatment T_{10} (75 % RDF + 25% Vermicompost + Azospirillum + PSB + Azotobacter), was found best treatment with reference to flowering and quality attributes in gladiolus cv. Nova lux as compared to control and other treatments. In order to achieve the highest yield and better quality for the commercial cultivation of gladiolus crop, it is advised to apply a combination of chemical fertilisers, organic manure, micronutrients, and bio-fertilizers, i.e., treatment T_{10}(75% RDF + 25% Vermicompost + Azospirillum + PSB + Azotobacter).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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