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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(4): 2404-2407

www.thepharmajournal.com
Received: 21-01-2023
Accepted: 28-02-2023

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Response of biofertilizers and chemical fertilizers on growth parameters of gladiolus (*Gladiolus grandiflorus* L.) Var. Arka Amar

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Abstract
A field experiment was carried out during the successive seasons of 2021-2022. The aim of this study was to investigate the response of biofertilizers and chemical fertilizers on the growth characteristics of gladiolus (*Gladiolus grandiflorus* L.) var. Arka Amar. The experiment was laid out in a Randomized Block Design with three replications and nine treatment combinations, comprising of T_1 (Control), T_2 (100% RDF + Azotobacter), T_3 (100% RDF + Azospirillum), T_4 (50% RDF + Azotobacter), T_5 (50% RDF + Azospirillum), T_6 (100% RDF + Azotobacter + PSB), T_7 (50% RDF + Azotobacter + PSB), T_8 (100% RDF + Azospirillum + PSB) and T_9 (50% RDF + Azospirillum + PSB). Results of the study revealed that minimum days to sprout (8.20), the highest number of sprouts/hill (3.53), maximum plant height (69.66), plant girth (7.66), number of leaves/hill (12.40), longest leaf (52.92) and broadest leaf (3.54) were registered in treatment T6 (100% RDF + Azotobacter + PSB).

Keywords: Gladiolus, bio-fertilizer, Azotobacter, Azospirillum

Introduction
Gladiolus (*Gladiolus grandiflorus* L.), sometimes known as "Glad", is a well-known bulbous cut flower plant that is native to South Africa and is a member of the family Iridaceae. Due to its sword-shaped leaves, it is sometimes referred to as the Sword Lily or Corm Lily. It holds a prominent place among commercial flower crops and enjoys great demand in both domestic and export markets since it is a significant bulbous decorative plant. It holds the eighth spot in the worldwide cut flower market (Ahmad *et al*., 2013). The intriguing spike is covered with numerous florets of various sizes and shapes, each with a smooth ruffle or sharply crinkled sepals. Currently, there is roughly 3500 ha of bulbous crops being grown in India, with gladiolus taking up more than 1200 ha of the total. The north Indian plains are ideal as the primary gladiolus growing regions (Singh *et al.*, 2012) [19].

One of the key factors in improving the bloom quantity and quality of gladiolus spikes is nutrition. The use of artificial fertilizers and pesticides in the production of plants surged after the green revolution, endangering the ecology and ecosystem. Therefore, applying fertilizers frequently in small doses encourages higher development and flower production. The best way to ensure nutrient effectiveness and sustainable agriculture is to supply crops with all of their nutritional needs using both organic and inorganic sources as well as biofertilizers (Gupta *et al*., 2004; Singh *et al.*, 2003) [7, 18]. In recent times, biofertilizers have emerged as important supplements to mineral fertilizers and hold a promise to improve the yield as well as the quality of crop. In gladiolus, biofertilizers like Azotobacter, Azospirillum, Phosphorus solubilizing bacteria (PSB) etc. 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, the present investigation was planned to study the response of biofertilizer and chemical fertilizers on different growth characteristics of gladiolus (*Gladiolus grandiflorus* L.) var. Arka Amar.

Materials and Methods
The present investigation was conducted at Agricultural Research Station, Binjhagiri, Chatabara of the Institute of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar, Odisha during November 2021 to March 2022. The experiment consists of nine treatments such as T1 (control), T2 (100% RDF + Azotobacter), T3 (100% RDF + Azospirillum), T4 (50% RDF + Azotobacter), T5 (50% RDF + Azospirillum), T6

(100% RDF + Azotobacter + PSB), T7 (50% RDF + Azotobacter + PSB), T8 (100% RDF + Azospirillum + PSB) and T9 (50% RDF + Azospirillum + PSB). The treatments were replicated thrice in a Randomized Block Design. Corms of gladiolus were planted at a spacing of 40 cm x 40 cm to accommodate twenty plants per plot. Both fertilizers and biofertilizers were applied to the corms as soil application. Biofertilizers like PSB, Azospirillum and Azotobacter were applied @ 4 kg/ha in two split doses, first before spike emergence stage and second after harvesting of spikes for better corm growth. Similarly, fertilizers were applied in three split doses, first as basal, second before spike emergence and third after harvesting of spikes. Observations were taken on different growth characteristics like plant height, plant girth, number of leaves, length of leaves, width of leaves along with days taken to sprout and number of sprouts per hill. And the data obtained from various characters under study were analyzed by the statistical analysis of variance and test of significance through the procedure described by Panse and Sukhatme (1967) [14].

Results and Discussion

The data depicted in Table-1 showed that least number of days (8.2 days) for sprouting of corms was observed in treatment T_6 (100% RDF + *Azotobacter* + PSB) followed by 9.2 days in T_8 (100% RDF + *Azospirillum* + PSB) and 9.4 days in T_7 (50% RDF + *Azotobacter* + PSB). However, maximum number of days (14.46 days) required for corm sprouting was found in control (T_1). The earliness in sprouting of corm might be due to addition of *Azotobacter* and PSB, which provided a more balance nutrition for plants as well as optimum absorption of biofertilizers by corms accelerated the physiological process and improved the germination phenomenon. Similar results were reported earlier by Sharma (2014) [16] and Srivatsava and Govil (2007) [7] in gladiolus.

On the perusal of data tabulated in Table-1, it is evident that maximum number of sprouts per corm (3.53) were observed in treatment T_6 (100% RDF + *Azotobacter* + PSB) followed by 3 in treatment T_8 (100% RDF + *Azospirillum* + PSB). However, lowest number of sprouts per corm (2.06) were observed in treatment control (T_1). Similar result was shown by Pandey *et al.* (2020) [13]. This might be due to active and quick increase of bacteria especially in rhizosphere creating favorable condition for nitrogen fixation and phosphorus solubilization at higher rate through nitrogen supply by nitrogenous fertilizers and supply of other nutrients, bacterial secretion, hormone production and supply of antibacterial and antifungal compounds, which were favorable for growth and ultimately increased yield. Bio-fertilizer contains growth-promoting substances *viz*., GA, cytokine, and different micronutrients like Fe, Zn, Mn, and Cu. These nutrients play a very important role on the growth and development of gladiolus plants, because of its stimulatory and catalytic effects on flower yield and metabolic processes. These findings corroborate with those of Basoli *et al*., (2014) [3] in gladiolus, Ali *et al*., (2013) [2] in gladiolus.

The data presented in Table-1 revealed that maximum plant height (69.66 cm) was observed in treatment T_6 (100% RDF + *Azotobacter* + PSB) followed by 68.14 cm in T_8 (100% RDF + *Azospirillum* + PSB). Whereas, T_1 recorded minimum plant height (60.17 cm). Similar results were observed by Meena *et al.* (2018) [12], that the maximum plant height of 121.27 cm noted in T_{12} RDF 75% + PSB + *Azotobacter* + Mycorrhiza. This may be due to application of biofertilizers and chemical fertilizers in combination resulted in more plant height. The enhanced plant height may be due to more availability of nitrogen and other nutrients. 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 phytohormone 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) [7].

From the data tabulated in Table-1, it is evident that highest plant girth (7.66 cm) was observed in treatment T_6 (100% RDF + *Azotobacter* + PSB) followed by 7.40 cm in treatment T_7 (50% RDF + *Azotobacter* + PSB). However, lowest plant girth (6.93) was observed in treatment T_1 (control). Similar result was shown by Marak *et al.* (2020) [11]. Maximum stem girth showed by *Azospirillum* + PSB + VC + 50% RDF (15.47 cm) was on par with *Azospirillum* + PSB + FYM + 50% RDF (15.40 cm), while, minimum stem girth was observed in control (13.13 cm). Ravindra *et al*. (2013) [15] stated that combination of organic manures and bio-fertilizers along with inorganic fertilizers resulted in maximum thickest stem.

Table 1: Effect of biofertilizers and RDF on various growth characters

	Treatments	Days taken to sprouting (days)	No. of sprouts/ hill (nos)	Plant height (cm)	Plant girth (cm)
T_1	Control	14.46	2.06	60.17	6.93
T_2	100% RDF + *Azotobacter*	11.00	2.46	65.21	7.23
T_3	100% RDF + *Azospirillum*	11.66	2.33	64.47	7.20
T_4	50% RDF + *Azotobacter*	12.53	2.26	64.10	7.16
T_5	50% RDF + *Azospirillum*	13.66	2.20	62.75	7.06
T_6	100% RDF + *Azotobacter* + PSB	8.20	3.53	69.66	7.66
T_7	50% RDF + *Azotobacter* + PSB	9.40	2.66	67.71	7.40
T_8	100% RDF + *Azospirillum* + PSB	9.20	3	68.14	7.33
T_9	50% RDF + *Azospirillum* + PSB	10.26	2.6	66.90	7.26
S.Em		0.153	0.105	0.301	0.071
CD 5%		0.461	0.317	0.903	0.215

The data presented in Table-2 showed that, maximum number of leaves per plant (12.4) was observed from plants grown in the treatment T_6 (100% RDF + *Azotobacter* + PSB) followed by 12 in treatment T_8 (100% RDF + *Azospirillum* + PSB). The minimum number of leaves (8.13) was observed from the plants grown in control plot. The increase in number of leaves under biofertilizers might be attributed due to easy absorption and translocation of nutrients, which would promote protein synthesis from reserved carbohydrate leading to production of higher number of leaves. The result is in confirmation with the findings of Kumar *et al.* (2012) [8] in tuberose and Kumar *et al.* (2011) [10] in gladiolus.

The observation on length of the longest leaf were recorded and the data are given in Table-2. It is observed from the table that the length of the longest leaf was maximum i.e., 52.92 cm in treatment T_6 (100% RDF + *Azotobacter* + PSB) followed by 52.27 in treatment T_8 (100% RDF + *Azospirillum* + PSB). However, minimum length of the leaf (47.00 cm) was found in control (T_1). The result is in confirmation with Meena *et al.* (2018) [12], which might 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. Nitrogen is a constituent of protein, component of protoplast and increases the chlorophyll content in leaves (Dalve *et al.*, 2009) [6]. Similar results were observed by Chauhan and Kumar (2007) [5] and Kumar *et al.* (2013) [9].

The observation was recorded in Table-2 that the width of the longest leaf was maximum i.e., 3.54 cm in treatment T_6 (100% RDF + *Azotobacter* + PSB) followed by 3.24 in treatment T_8 (100% RDF + *Azospirillum* + PSB). However, minimum length of the leaf (47.00 cm) was found in control (T_1). The result is in confirmation with Meena *et al.* (2018) [12], who found the most broad leaves with T_{10} (3.52 cm) RDF 75% + PSB + Mycorrhiza. 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, Srivastava and Govil, 2005) [17, 7].

Table 2: Effect of biofertilizers and RDF on number, length and width of leaves

Treatments		No of leaves/hill (nos)	Length of the longest leaf (cm)	Width of the longest leaf (cm)
T_1	Control	8.13	47.00	2.02
T_2	100% RDF + *Azotobacter*	10.4	50.63	2.80
T_3	100% RDF + *Azospirillum*	10.2	49.68	2.50
T_4	50% RDF + *Azotobacter*	9.80	49.02	2.19
T_5	50% RDF + *Azospirillum*	9	48.06	2.10
T_6	100% RDF + *Azotobacter* + PSB	12.40	52.92	3.54
T_7	50% RDF + *Azotobacter* + PSB	11.53	51.48	3.10
T_8	100% RDF + *Azospirillum* + PSB	12	52.27	3.24
T_9	50% RDF + *Azospirillum* + PSB	11.20	51.04	2.95
S.Em		0.082	0.162	0.061
CD 5%		0.247	0.487	0.184

Conclusion

The results may be concluded as application of bio fertilizer singly and different combinations has significant effect on all growth. Among various biofertilizer and there combinations, (100% RDF + *Azotobacter* + PSB) were found best, followed by 100% RDF + *Azospirillum* + PSB and control treatment show least value for these parameters during both the seasons of experiment.

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