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EFFECT OF BIOFERTILIZERS WITH DIFFERENT LEVELS OF NITROGEN AND PHOSPHORUS FERTILIZERS ON GROWTH AND FLOWER YIELD OF GLADIOLUS (*GLADIOLUS GRANDIFLORUS* L.) CV. CANDYMAN

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ABSTRACT

The present experiment was carried out with gladiolus cv. Candyman in randomized block design with three replications. The experiment comprised of 7 different levels of nitrogen and phosphorous fertilizers with biofertilizers (Azotobacter and PSB). The effect of different treatments were observed and noted that application of T_7 (75% N and P (112.5:75:80 kg NPK ha^{-1}) + Azotobacter + PSB) significantly increased early sprouting of corms (4.33 days), leaves per plant (11.33), early spike emergence (59.87 days), early opening of first pair of florets (74.80 days), early 50 % flowering (82.20 days), length of fully opened florets (8.70 cm), diameter of fully opened florets (10.33 cm), length of spike (77.13 cm), length of rachis (50.73 cm), florets per spike (14.87), spikes per plant (1.47), corms per plant (1.93) and cormels per plant (65.46). However, plant height (153.33 cm) was significantly increased with T_6 (100 % N and P (150:100:80 kg NPK ha^{-1}) + Azotobacter + PSB). Hence it can be said that the application of 75% Nitrogen and Phosphorous (112.5:75:80 Kg NPK ha^{-1}) through inorganic source as well as corm inoculation with Azotobacter and PSB was most effective treatment for getting higher spike and corm yield in gladiolus.

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INTRODUCTION

Gladiolus is a flower of glamour and perfection which is known as the queen of bulbous flowers due to its flower spikes with florets of massive form, brilliant colours, attractive shapes, varying size and excellent shelf life. Being an important bulbous ornamental plant, it occupies a prime position among commercial flower crops which has high demand in both domestic and international markets (Sharma *et al.*, 2013). Flowering and corm production in gladiolus are affected by non-availability of various nutrients. Under the present trend of exploitive agriculture in India, inherent soil fertility can no longer be maintained on the sustainable basis. Apart from the soil fertility and productivity issues, use of chemical fertilizers is also becoming more and more difficult for the farmers due to their high costs and scarcity during peak season. Application of biofertilizers is considered today to limit the use of mineral fertilizers and supports an effective tool for land development under less polluted environments, decreasing agricultural costs, maximizing crop yield due to providing them with an available nutritive elements and growth promoting substances (Metin *et al.*, 2010).

There have been positive effects of inoculation in gladiolus with various biofertilizer sources on the spike yields (Rajhansa *et al.*, 2010; Singh *et al.*, 2014). Kukde *et al.* (2003) reported that the tuberose bulb treated with Azotobacter and PSB at 2.5 g kg^{-1} bulb gave maximum vegetative growth, better flower quality parameter and maximum yield of flowers ha^{-1}. Azotobacter naturally fixes atmospheric nitrogen in the rhizosphere (Kukde *et al.*, 2006). The use of phosphate solubilizing bacteria as inoculants bring sparingly insoluble inorganic or organic phosphates in to the soluble forms by secreting organic acids which lower soil pH, and in turn, bring about dissolution of immobile forms of soil phosphate (Kumar *et al.,* 2015). However there is no information is available on the effect of biofertilizers in gladiolus and other flower crops in respect of growth and flower quality under Chhattisgarh plains. Thus, the present investigation has been under taken to find out the suitable combination of biofertilizers and levels of chemical fertilizers on plant growth, flower production and corm yield of gladiolus.

MATERIALS AND METHODS

The persent study was conducted at the Horticulture Nursery, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during the year 2015-16. The site is located between 21^{0}14' 06.8" N latitude and 81^{0}4 2'41" E longitude at an altitude of 289.56 m above mean sea level. The soil character of experimental site was medium pH (7.6), normal EC (0.35 dS/m), medium organic carbon (0.72 %), low nitrogen (175.62 kg/ha), low phosphorus (10.75 kg/ha) and medium potassium (251.66 kg/ha). Treatments consists 100% RDF (150:100:80 kg NPK ha^{-1}) as Control (T_1), 100% N and 100% P (150:100:80 kg NPK ha^{-1}) + Azotobacter (T_2), 75% N and 100% P (112.5:100:80 kg NPK ha^{-1}) + Azotobacter (T_3), 100% N and 100% P (150:100:80 kg NPK ha^{-1}) + PSB (T_4), 100% N and 75% P (150:75:80 kg NPK ha-

^{1}) + PSB (T_5), 100% N and P (150:100:80 kg NPK ha^{-1}) + Azotobacter +PSB (T_6) and 75% N and P (112.5:75:80 kg NPK ha^{-1}) + Azotobacter + PSB (T_7) and experiment was laid in randomized block design. Each treatment was replicated thrice. The biofertilizers were applied through slurry method at the time of planting. Slurry was prepared by mixing 200 g packet of boifertilizers in sufficient water and small quantity of jaggery was added to it so that the inoculants could stick to corms properly. The corms of gladiolus were immersed in the suspension for 20 minutes and dried in shade before planting. The corms were planted at a spacing of 30 X 20 cm. The recommended fertilizer doses i.e. nitrogen (150 kg/ha), phosphorus (100 kg/ha) and potassium (80 kg/ha) were used in control treatment during the course of the experiment (Rajhansa *et al.,* 2010). According to the treatments full doses of potassium and phosphorus were given as basal application at the time of planting and nitrogen was given in 2 split doses at 3 and 6 leaf stages. The observations were recorded on various growth parameters viz. days required for sprouting of corms, number of leaves per plant, height of plant (cm); flowering parameters viz. days required for spike emergence, days required for opening of first pair of florets and days required for 50 % flowering; quality parameters viz. length of fully opened florets (cm), diameter of fully opened florets (cm), length of spike (cm) and length of rachis (cm) and yield parameters viz. number of florets per spike, number of spikes per plant, number of spikes per plot, number of spikes per hectare and number of corms and cormels per plant. Statistical analysis was done using method suggested by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

From the data (Table 1) it was revealed that, early sprouting was recorded (4.33 days) in treatments T_7 and T_6 while late sprouting in treatment T_3 and T_4. The possible reason for induced sprouting might be due to synthesis and secretion of thiamin, riboflavin, pyridoxine, nicotinic acid, pantothenic acid, indole-acetic acid (IAA) and gibberellins like substances in addition to the production of antifungal antibiotics by the *Azotobacter*, which inhibit harmful soil fungi. Pandhare *et al.* (2009) reported early sprouting with application of Azotobacter and PSB in tuberose.

Maximum number of leaves per plant at 90 days after planting (11.33) was observed under treatment T_7 which was at par with T_6 with 11.20 leaves. The minimum number of leaves (10.07) was observed under treatment T_2. Increased number of leaves could be attributed to the proper availability of nitrogen fixed by Azotobacter. Since nutrients like N and Fe are important constituents of chlorophyll, increased availability of these nutrients as a result of bio-fertilizer activity might have led to higher chlorophyll content. Moreover, Fe is important for the synthesis of pheophytin, which acts as precursor for chlorophyll synthesis. Owing to the direct involvement of chlorophyll and leaf area in photosynthesis the corresponding increase in vegetative growth rate can be reasoned act. Similarly results were obtained by Kukde *et al.* (2006) in Tuberose.

At 60 and 90 days after planting highest plant height was recorded in T_6 (94.27 and 153.33 cm) closely followed by T_7 (92.40 cm and 150.00 cm) whereas, lowest plant height was recorded in control (88.70 cm and 141.13 cm). Application of phosphorus solubilizers bacteria along with Azotobacter may result the plants having luxurious vegetative growth and especially nitrogen increase the cation exchange capacity of plant roots and these makes them more efficient in absorbing other nutrient ions like phosphorous, potassium, calcium etc. and it is an important constituent of chlorophyll, thus increases photosynthesis process in plants. On the other hand phosphorus stimulates the root formation, helps in cell division, increases protein and mineral contents in plants (Kumar *et al.*, 2015). Similarly results were recorded by Chandrikapure (1998) in marigold and Hnamte *et al.* (2013) in coriander.

The flow of various nutrients as well as improved availability and efficacy of these nutrients that induced the changes occurred during spike initiation may be attributed to the established fact that azotobacter is capable of producing antifungal and antibacterial compounds, growth regulators and siderophores (Pandey and Kumar, 1989). Therefore, the treated corm with biofertilizer facilitated earliness in sprouting mighthave influenced due to improved level of growth regulators. Thereby it might have favoured for stimulation and production of auxiliary buds resulting in formation of more number of branches. Data presented in Table 2 indicated that,

Table 1: Effect of biofertilizers with different levels of nitrogen and phosphorous fertilizers on growth of gladiolus

Treatments	Days required for sprouting of corms	Number of leaves			Plant height (cm)			Days required for spike emergence	Days required for opening of first pair of florets	Days required for 50% flowering
		30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP			
T_1	7.00	2.80	8.07	10.27	38.93	88.07	141.13	66.80	78.93	85.27
T_2	6.33	2.80	8.20	10.07	38.93	91.07	145.80	65.80	77.87	84.93
T_3	7.33	2.80	7.93	10.20	39.07	87.00	141.80	66.53	78.93	86.67
T_4	7.33	3.07	7.67	10.20	38.60	88.40	138.13	63.80	78.07	86.67
T_5	6.67	2.93	8.33	10.13	39.67	89.27	144.13	65.53	77.47	86.53
T_6	4.33	3.33	8.80	11.20	42.33	94.27	153.33	64.87	75.87	83.60
T_7	4.33	3.20	8.73	11.33	42.40	92.40	150.00	59.87	74.80	82.20
SE (m)	2.13	0.51	0.74	0.84	5.57	4.88	8.08	3.55	1.10	2.43
CD at 5 %	1.89	NS	0.65	0.74	NS	4.33	10.06	3.16	0.98	2.16

T_1 : 100% RDF (150:100:80 Kg NPK ha^{-1}) as Control; T_2 : 100% N and 100% P (150:100:80 Kg NPK ha^{-1}) + Azt.; T_3 : 75% N and 100% P (112.5:100:80 Kg NPK ha^{-1}) + Azt.; T_4 : 100% N and 100% P (150:100:80 Kg NPK ha^{-1}) + PSB; T_5 : 100% N and 75% P (150:75:80 Kg NPK ha^{-1}) + PSB; T_6 : 100% N and P (150:100:80 Kg NPK ha^{-1}) + Azt. + PSB; T_7 : 75% N and P (112.5:75:80 Kg NPK ha^{-1}) + Azt. + PSB

Table 2: Effect of biofertilizers with different levels of nitrogen and phosphorous fertilizers on flowering and corm yield of gladiolus.

Tretments	Length of fully opened florets(cm)	Diameter of fully opened florets (cm)	Length of spike (cm)	Length of rachis (cm)	No. of florets per spike	No. of spikes per plant	No. of spikes per plot	No. of spikes per hectare (,000)	No. of corms per plant	No. of cormels per plant
T_1	7.91	9.29	67.87	41.27	13.60	1.07	49.66	213.33	1.33	55.67
T_2	8.03	9.59	68.00	43.53	13.13	1.00	49.00	200.00	1.40	54.78
T_3	7.73	9.33	65.47	38.93	11.80	1.07	52.00	213.33	1.47	56.16
T_4	8.18	9.55	71.60	44.20	13.47	1.27	49.33	253.33	1.53	60.51
T_5	7.83	9.64	66.00	41.40	13.13	1.13	52.66	226.66	1.60	59.46
T_6	8.41	10.06	75.93	48.67	14.40	1.33	54.66	266.66	1.80	61.76
T_7	8.70	10.33	77.13	50.73	14.87	1.47	55.33	293.33	1.93	65.46
SE (m)	0.33	0.58	3.24	3.41	1.11	0.29	2.53	16.58	0.09	1.52
CD at 5 %	NS	0.51	2.87	3.03	0.99	0.26	NS	51.67	0.28	4.73

T_1 : 100% RDF (150:100:80 Kg NPK ha^{-1}) as Control; T_2 : 100% N and 100% P (150:100:80 Kg NPK ha^{-1}) + Azt.; T_3 : 75% N and 100% P (112.5:100:80 Kg NPK ha^{-1}) + Azt.; T_4 : 100% N and 100% P (150:100:80 Kg NPK ha^{-1}) + PSB; T_5 : 100% N and 75% P (150:75:80 Kg NPK ha^{-1}) + PSB; T_6 : 100% N and P (150:100:80 Kg NPK ha^{-1}) + Azt. + PSB; T_7 : 75% N and P (112.5:75:80 Kg NPK ha^{-1}) + Azt. + PSB

minimum day required for spike emergence (59.87 days) was observed in T_7. However, the earliest initiation of flowering spike may be due to reduced level of nitrogen fertilizer application which caused the early stunted growth of plant resulting into earlier initiation having flowers in spike (Kukde *et al.,* 2006), but growth was retained after fixation of atmospheric nitrogen to the plant due to azotobacter. These results are similar with the finding of Pandhare *et al.* (2009).

Early opening of first pair of florets on spike (74.80 days) were observed under treatment T_7 while the maximum days (78.93) in treatment T_3. The treatment $T_{7,}$ T_6 and T_5 are at par. The earliness of flowering may be attributed to the presence of bio-fertilizers which consequently lead to flower initiation and more flower duration. This may be ascribed to easy uptake of nutrients and simultaneous transport of growth promoting substances like cytokinins to the auxiliary buds resulting in breakage of apical dominance. Ultimately, they resulted in better sink for faster mobilization of photosynthates and early transformation of plant parts from vegetative to reproductive phase (Singh *et al.,* 2014). Similar observation was recorded by Pandhare *et al.* (2009) in tuberose and Gayithri *et al.* (2004) in statice.

Minimum days (82.20 days) required for 50% plant population for flowering were observed under treatment T_7, whereas maximum days (86.67 days) under treatment T_3 closely followed by treatmet T_4 i.e. 86.67 days respectively. Treatments T_7 and T_6 were found to be at par with each other. The above results might be due to the facts that higher application of nitrogen fertilizer with azotobacter prolonged the vegetative growth and delay flowering. Similar observation was recorded by Hnamte *et al.* (2013) in coriander.

Table 2 showed non significant difference in length of fully opened florets among treatments. The might show the influence of factor other than nutrients in flower growth and quality. Length of flower is also affected by plant hormones like gibberellins and unknown compounds like florigen, while flowers are also responsive to day length, diurnal temperature and light spectrum.

In case of diameter of fully opened florets, it was maximum under treatment T_7 (10.33 cm) which was at par with T_6 (10.06) and minimum diameter of florets was observed under the control treatment T_1 (9.29 cm). This may be due to continues supply of additional nitrogen and phosphorus to the plants by fixation which keeps the plants in healthy growing condition resulting in to better quality of florets. This result is in close conformity with the results was obtained by Chandrikapure (1998) in marigold.

Data shows maximum length of spike (77.13 cm) was observed under the treatment T_7 which was at par with treatment T_6 (75.93 cm). The minimum length of spike (65.47 cm) was recorded under treatment T_3. The reason may be due to increased availability of nitrogen and production of phytohormones under the treatment due to biofertilizer application. Increased foliage might have resulted in production of more photosynthates enhancing the yield potential (Choudhary *et al.,* 2015). Similar results were reported by Gayithri *et al.* (2004) in statice and Kumar *et al.* (2015) in tuberose.

The maximum length of rachis (50.73 cm) was observed under the treatment T_7 which was found to be at par with T_6 i.e. 48.67 cm. The minimum length of rachis (38.93 cm) was recorded under treatment T_3. Increase in rachis length might be due to increased availability of nitrogen and better mobilization, solubilization of phosphate and better uptake of N and P as well as micronutrients like Zn, which is precursor of auxin which improved the vegetative growth, dry matter accumulation and their partitioning towards the developing spikes (Sharma *et al.,* 2013). Similar results were also obtained by Gayithri *et al.* (2004) in statice.

Data indicates that the maximum number of florets per spike (14.87) was observed under treatment T_7 (14.87) which was found to be at par with T_6 (14.40). The minimum number of florets per spike (11.80) was observed under treatment T_3. Maximum florets were obtained with combined application of Azotobacter and PSB might be due to availability of more N and P nutrients for growth, which were mobilized in soil by the beneficial micro organisms and these nutrients were transferred to the spike as photo assimilates which resulted in increase number of florets. Similar results were reported by Kumar *et al.* (2015) in tuberose.

Table 2 revealed that, maximum number of spike per plant (1.47) and spikes per ha. (293330) was observed under the treatment T_7 which was at par with T_6 and T_5. Increased yield of spike may be the results of balanced nutrition with nitrogen and phosphorus, which caused boosting of vegetative growth resulting in to synthesis of more food material. Influence of PSB is more in number of spikes per plant because of its ability to produe indole acetic acid (IAA) which is precursor of auxin and induces vigrous growth and flower yield (Patten and Glick 2002). These finding were in close conformity with the result of Gayithri *et al.* (2004) in Statice.

The maximum number of corms and cormels per plant was recorded under treatment T_7 followed by T_6 and minimum number of corms was observed under control treatment T_1 Increase in corms and cormels might be due to the action of Azotobacter and PSB which provide stronger root frame, results in to more number of leaves per plant produced under these treatments, which helped to produce more carbohydrates in the plant. Thus more food accumulation was transferred towards corms and there by increased number of corms and cormels per plant. The other reasons may be the additive effect of biofertilizers which might have provided better soil conditions inclusive of improved soil fertility, nitogen fixation, phosphate solubilization, enhanced the efficacy of applied N and P; enhanced the activities of other microbes and also release of growth stimulants (Choudhary *et al.,* 2015).

The results obtained revealed that the application of biofertilizers to gladiolus plant was significantly influence the vegetative growth, flowering and corms production. The application of 75% Nitrogen and Phosphorous (112.5:75:80 Kg NPK ha^{-1} with Azotobacter and PSB to gladiolus plants was most effective in influencing most of parameters rather than recommended dose of fertilizers.

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