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Effect of time of planting and bio inoculants on vegetative growth of Gladiolus cv White prosperity

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Abstract
Effect of time of planting and bio inoculants on vegetative growth of Gladiolus cv White prosperity was studied at Agri-Tourism Centre, CCS Haryana Agricultural University, Hisar during the year 2020-21. Among the different planting dates, the minimum number of days to sprouting (7.88 days), the maximum number of leaves (9.06), the maximum plant height (110.49 cm), maximum leaf length (35.39 cm) and maximum leaf width (3.73 cm) were recorded in the 1st fortnight of October. While among different treatments of bio inoculants, treatment T_8 (RDF + *Azotobacter* + PSB + Mycorrhiza) performed best with the minimum number of days to sprouting (7.33), the maximum number of leaves (10.31), maximum plant height (115.12 cm), maximum leaf length (37.42 cm) and maximum leaf width (4.70 cm).

Keywords: Time of planting, bio inoculants, growth, gladiolus, corm

Introduction
India is a country with diverse agroclimatic conditions that makes it suitable for flower cultivation round the year. The government of India has ascertained floriculture as an emerging industry and granted it 100% export-oriented status (Palanisingh *et al*., 2022) [13]. At present, floriculture is among the most remunerative professions of agriculture with higher returns per unit area compared to other professions (Datta 2019) [3]. Urbanization, increase in purchasing power of people, improved standards of living and growing consciousness among the people to live in environment friendly atmosphere have led to a steady increase in the demand of floriculture products worldwide (Singh 2017) [21], (Saha 2005) [16]. As a result, there has been an increasing demand for cut flowers like gladiolus, rose, gerbera, orchid, carnation, lilium, etc. Owing to a steady increase in demand for flowers, floriculture has become one of the important commercial trades in Agriculture. Floriculture exports of India are US $ 103.50 million in 2020-21 and it registered a 32.96 percent growth in the previous year. The share of Floriculture export is 0.42 per cent in 2021-22. India is the largest exporter to the United States having a value of US $ 29.83 million in 2020-21 (APEDA).

Gladiolus (*Gladiolus grandiflorus* L.) is a perennial bulbous flower belongs to the family Iridaceae. It is native to South Africa (Ahmad *et al*., 2011) [1]. It is popularly known as sword lily due to its sword shaped leaves. In India, it is mainly grown for cut flowers. Its inflorescence is known as spike which consists of a number of florets with a wide variety of colours and forms. The florets open acropetally over a longer duration in the spike responsible for the longer vase life of the spike. Vase-life of gladiolus spikes varies from 5-10 days. Longer vase life is the key factor responsible for its suitability for export purposes (NHB). By selling spikes, corms and cormels of gladiolus farmers can get more profit.

Gladiolus is grown for its beautiful spike worldwide and is known as the queen of bulbous flowers (Sarkar *et al*., 2014) [14]. The major gladiolus growing countries are the United States (Florida and California), Holland, France, Italy, Bulgaria, Poland, Brazil, India, Australia and Israel (Wahocho *et al*., 2016) [22]. In India, the winter season is the ideal time for the production of gladiolus. The main gladiolus growing places are suited to the north Indian plains and hills up to 2400 m from mean sea level. Among the cut flowers in India, gladiolus occupied the third position in both area and production. The major gladiolus producing states in the country are West Bengal, Uttar Pradesh, Odisha, Haryana, Maharashtra and Chhattisgarh. Gladiolus is also grown in states like Karnataka, Andhra Pradesh, Sikkim and Uttarakhand (Devi *et al*., 2019) [4]. In Haryana gladiolus is mainly grown in Yamuna Nagar, Faridabad, Panipat and Palwal in an area of 51 hectares with a production of 2,57,3300 no. of sticks in 2020-21 (Horticulture department Govt. of Haryana).

The time of planting plays a key role in obtaining better growth and production. The time of planting is indirectly related to the temperature and day length, both of which are important for the flowering of Gladiolus. Proper planting time provides optimum climatic conditions to plant for better growth. So, this experiment was conducted to explore the best planting time for Gladiolus.

Similarly, biofertilizers being an organic source of nutrients, play an important role in flower growth and development. The production of flower crops depends on the productivity (nutrient status) of the soil. Biofertilizers are beneficial microorganisms capable of fixing N and solubilizing P, and these are the primary elements required by plants for growth. So, biofertilizers act as low-cost, efficient, and sustainable sources of nutrients for flower production. Small and marginal farmers can use biofertilizers as a financially viable tool to help them achieve their ultimate objective of increasing productivity (Boraste *et al*., 2009) [2]. Along with increasing the yield of the crop, they also maintain good physicochemical properties of soil. Keeping in view the above facts, the present experiment was carried out to study the effect of time of planting and bio inoculants on the vegetative growth of Gladiolus.

Material and Method

The experiment entitled, "Effect of time of planting and bio inoculants on vegetative growth of Gladiolus cv White prosperity" was carried out under open field conditions at Agri-Tourism Centre, CCS Haryana Agricultural University, Hisar (Haryana). Hisar is located in the subtropics at N 29o 10'' latitude and E 75o 46'' longitude with an elevation of 215.2 meters above mean sea levels during the year 2020-21. The mean maximum day temperature during the hottest month of summer varies between 40 to 46 °C, while the mean minimum temperature in the coldest month of winter varies between 1.5 to 4 °C. The period of monsoon is last week of June to mid-September. The mean annual rainfall is around 450mm, 75 to 80 percent of which is received during the SW Monsoon season (June to September).

The texture of the soil where the experiment was carried out was sandy loam. The soil is well levelled and well drained having good water holding capacity and medium fertility with a slightly alkaline pH of 8.3.

For experimental purposes, uniformly sized corms of gladiolus cv. White prosperity were procured from a private nursery at Hisar. It involved a combination of four different times of plantings and eight treatment combinations of bio inoculants and recommended dose of fertilizers in a factorial RBD design replicated three times. The corms were first dehusked and then by using the corm dip method treated with different treatments of bio inoculants for 15 minutes. The inoculum of PSB, Azotobacter and Mycorrhiza were obtained from Department of Microbiology, CCS HAU, Hisar. The treated corms were sown at optimum depth with a plant-to-plant spacing of 30 cm and with 30 cm spacing between rows on raised beds on four different time of planting *viz*. 1st fortnight of October 2020, 2nd fortnight of October 2020, 1st fortnight of November 2020 and 2nd fortnight of November 2020. While planting corms, care was taken to maintain the bud on the top in a vertical position.

Weeding, earthing up, irrigation etc. operations were carried out as per requirement. The treatments were as follows:

T_1: Recommended dose of fertilizers (RDF)
T_2: RDF + *Azotobacter*
T_3: RDF + Phosphate solubilizing bacteria
T_4: RDF + Mycorrhiza
T_5: RDF + *Azotobacter* + PSB
T_6: RDF + PSB + Mycorrhiza
T_7: RDF + *Azotobacter* + Mycorrhiza
T_8: RDF + *Azotobacter* + PSB + Mycorrhiza

The vegetative growth characters for each treatments were observed in five plants selected.

Statistical analysis

The data recorded for growth and yield characters during the course of the investigation were subjected to statistical analysis by using randomized block design for analysis of variance (ANOVA) using the software OPSTAT (Sheoran *et al*., 1998) [20]. The critical difference (CD) was worked out at a 5% level of significance to judge the significance of the difference between the two treatment means.

Results and Discussion

Days to corm sprouting: Corm sprouting is an important vegetative character. A significant difference in the number of days taken for corms sprouting was recorded due to variations in planting time. Corms planted in the 1st fortnight of October resulted in early sprouting of corms (7.88 days), whereas planting in the 2nd fortnight of November resulted in late sprouting corms (8.28 days). The delayed sprouting in the late sown condition is due to a fall in temperature. On the other hand, in earlier planting times, early sprouting of corms was due to the positive effect of high temperature on sprouting. When corms were planted on 1st fortnight of October, they were exposed to high temperatures compared to other plantings. High temperature up to a threshold value promotes the corm sprouting. Ahmad *et al*., (2011) [1] recorded the same results that days to corm sprouting reduce with an increase in temperature.

The results related to different treatments of bio inoculants also showed significant variations. The corm treated with T_8 treatment (RDF + *Azotobacter* + PSB + Mycorrhiza) recorded the minimum number of days (7.33) to sprout followed by T_6 treatment (RDF + PSB + Mycorrhiza) (7.64). The maximum number of days (9.75) for corm sprouting were recorded under treatment T_1 (RDF). Superiority of T_8 treatment may be due to better nutrient absorption, like early absorption of N through primary roots, which might have stimulated the early sprouting of corms. Similarly, Kumar *et al*., (2007) and E. Sathyanarayana *et al*., (2018) [18] recorded the minimum days of corm sprouting when inoculated with biofertilizers.

Interaction between the time of planting and bio inoculants treatment was found non-significant in influencing days to corm sprouting.

Table 1: Effect of time of planting and bio inoculants on days to corm sprouting in gladiolus cv. White prosperity

Treatments	Time of planting				Mean
	1st fortnight of October	2nd fortnight of October	1st fortnight of November	2nd fortnight of November	
T_1: RDF	9.22	9.45	10.11	10.22	9.75
T_2: RDF + *Azotobacter*	8.67	9.11	9.56	10.00	9.33
T_3: RDF + PSB	8.33	8.89	9.11	9.67	9.00
T_4: RDF + Mycorrhiza	7.67	8.11	8.45	8.78	8.25
T_5: RDF + Azo + PSB	8.00	8.22	8.78	9.11	8.53
T_6: RDF + PSB + Myco	7.00	7.56	7.67	8.33	7.64
T_7: RDF + Azo + Myco	7.33	7.78	8.00	8.34	7.86
T_8: RDF+Azo+PSB+Myco	6.78	7.11	7.56	7.89	7.33
Mean	7.88	8.28	8.65	9.04	
CD at 5%	Treatments (T): 0.24,Time of planting (P): 0.17, T×P: NS				

Corm sprouting (%)

A hundred per cent corm sprouting was found in all four different planting times and under all eight treatments of bio inoculants. It might be due to the congenial environment conditions like optimum soil moisture, temperature and relative humidity at the time of corm sprouting. Results are in contradiction with the findings of Ahmad *et al.*, (2011) [1], who reported that corm sprouting percentage decreased with delay in planting time.

Table 2: Effect of time of planting and bio inoculants on corm sprouting (%) in gladiolus cv. White prosperity

Treatments	Time of planting				Mean
	1st fortnight of October	2nd fortnight of October	1st fortnight of November	2nd fortnight of November	
T_1: RDF	100	100	100	100	100
T_2: RDF + *Azotobacter*	100	100	100	100	100
T_3: RDF + PSB	100	100	100	100	100
T_4: RDF + Mycorrhiza	100	100	100	100	100
T_5: RDF + Azo + PSB	100	100	100	100	100
T_6: RDF + PSB + Myco	100	100	100	100	100
T_7: RDF + Azo + Myco	100	100	100	100	100
T_8: RDF + Azo + PSB + Myco	100	100	100	100	100
Mean	100	100	100	100	

Leaf length and leaf width

Leaf length influenced significantly by different time of plantings. It was noted that leaf length and width decreased considerably with the advancement in time of planting. Maximum leaf length (35.39 cm) and leaf width (3.73 cm) were recorded in the 1st fortnight of October plantings, and minimum leaf length (32.68 cm) and leaf width (3.52 cm) were recorded in the 2nd fortnight of November plantings. Superior values of leaf length and width in the 1st fortnight of October planting might be due to prevailing optimal climatic conditions. Ideal conditions promotes better root development which is further responsible for more uptake of nutrients. Nutrients take part in physiological activity of plant which is responsible for growth and development of different plant parts like leaf length and leaf width. The results are in close conformity with data observed by Nagar *et al.*, (2016), Ramzan *et al.*, (2013), Ahmad *et al.*, (2011) [1] and Nasar *et al.*, (2018) [12].

There was a significant difference among bio inoculants treatment for leaf length and leaf width. The significantly higher leaf length (37.42 cm) and leaf width (4.70 cm), were observed in treatment T_8 (RDF + *Azotobacter* + PSB + Mycorrhiza), followed by (36.69 cm) leaf length and (4.31 cm) leaf width in treatment T_6 (RDF + PSB + Mycorrhiza) and minimum leaf length (30.77 cm) and leaf width (2.74 cm) was observed under treatment T_1 (RDF). It might be due to the maximum availability of nutrients by the activity of bio inoculants, *viz.* nitrogen fixation, the release of P from insoluble phosphate, and enhanced nutrient uptake by increased root surface area by VAM. Increased cell elongation and cell multiplication due to enhanced nutrient uptake by plants following inoculation of *Azotobacter* and P-solubilizing bacteria (PSB) might have caused the increased vegetative growth. These results are in line with the findings of Mittal *et al.*, (2010) [9], Mohanty *et al.*, (2013) [10], Sharma *et al.*, (2017) [19] and Rolania *et al.*, (2017).

Interaction between the time of planting and bio inoculants treatment were found significant in influencing leaf length and leaf width. Among interaction of time of planting and bio inoculants treatment, maximum leaf length (38.42 cm) and leaf width (4.85 cm) was observed in corms planted in the 1st fortnight of October under treatment T_8 (RDF + *Azotobacter* + PSB + Mycorrhiza). In contrast, minimum leaf length (27.19 cm) was recorded in the 2nd fortnight of November planting under treatment T_2 (RDF + *Azotobacter*) and minimum leaf width (2.67 cm) was recorded in T_1 (RDF) in the 2nd fortnight of November planting.

Table 3: Effect of time of planting and bio inoculants on leaf length (cm) in gladiolus cv. White prosperity

Treatments	Time of planting				Mean
	1st fortnight of October	2nd fortnight of October	1st fortnight of November	2nd fortnight of November	
T_1: RDF	31.72	31.04	30.56	29.77	30.77
T_2: RDF + Azo	33.38	32.75	31.95	27.19	31.32
T_3: RDF + PSB	33.02	32.52	32.17	31.32	32.26
T_4: RDF + Myco	35.62	34.99	34.30	33.70	34.65
T_5: RDF + Azo + PSB	34.42	33.60	33.25	32.60	33.47
T_6: RDF + PSB + Myco	39.68	36.20	35.82	35.05	36.69
T_7: RDF + Azo + Myco	36.85	36.50	35.80	35.27	36.10
T_8: RDF + Azo + PSB + Myco	38.42	37.54	37.17	36.53	37.42
Mean	35.39	34.39	33.88	32.68	
CD at 5%	Treatment (T)= 0.62, time of planting(P)= 0.44, T × P= 1.25				

Table 4: Effect of time of planting and bio inoculants on leaf width (cm) in gladiolus cv. White prosperity

Treatments	Time of planting				Mean
	1st fortnight of October	2nd fortnight of October	1st fortnight of November	2nd fortnight of November	
T_1: RDF	2.82	2.77	2.71	2.67	2.74
T_2: RDF + Azo	3.03	2.99	2.93	2.87	2.95
T_3: RDF + PSB	3.28	3.21	3.15	3.10	3.19
T_4: RDF + Myco	3.81	3.76	3.67	3.61	3.71
T_5: RDF + Azo + PSB	3.53	3.47	3.40	3.34	3.44
T_6: RDF + PSB + Myco	4.45	4.38	4.24	4.17	4.31
T_7: RDF + Azo + Myco	4.08	3.99	3.93	3.87	3.97
T_8: RDF + Azo + PSB + Myco	4.85	4.74	4.66	4.55	4.70
Mean	3.73	3.66	3.59	3.52	
CD at 5%	Treatment (T)= 0.01, time of planting(P)= 0.01, T × P= 0.03				

Plant height and number of leaves

Among the different planting dates, maximum plant height (110.49 cm) and the number of leaves (9.06), were recorded in the 1st fortnight of October. While minimum plant height (105.56 cm) and number of leaves (8.06) were recorded in the 2nd fortnight of November planting. These values in the 1st fortnight of October plantings might be due to optimal climatic conditions. The reason might be exposure of early plantings of the gladiolus to favourable high temperature, and longer photoperiod that promotes more accumulation of photosynthates which are further utilized in growth and development of plant. More values of leaf length and breadth is also indirectly responsible for more plant height as leaves synthesize more photosynthates which are utilized in growth. The plant had acquired maximum efficiency for growth due to better root development in ideal conditions. It encouraged maximum photosynthesis resulted in a well-established structure and maximum height of plant with the maximum number of leaves. It was reported that plant with greater plant height produces more number of leaves. The results are in close conformity with data observed by Nagar *et al*., (2016), Ramzan *et al*., (2013), Ahmad *et al*., (2011) [1] and Nasar *et al*., (2018) [12].

Growth parameters differed significantly for different combinations of bio inoculants. Among all the treatments of bio inoculants, treatment T_8 (RDF + *Azotobacter* + PSB + Mycorrhiza) performed best with the maximum plant height (115.12 cm) and number of leaves (10.31) followed by (113.25 cm) plant height and number of leaves (9.39) in treatment T_6 (RDF + PSB + Mycorrhiza) and minimum plant height (101.07 cm) and number of leaves (7.58) was observed under treatment T_1 (RDF). It might be due to the maximum availability of nutrients by the activity of bio inoculants, *viz*. nitrogen fixation, phosphorus solubilization, and enhanced nutrient uptake by increased root surface area by VAM. Increased cell elongation and cell multiplication due to enhanced nutrient uptake by plants following inoculation of *Azotobacter* and P-solubilizing bacteria (PSB) might have caused the increased vegetative growth. These results are in line with the findings of Mittal *et al*., (2010) [9], Mohanty *et al*., (2013) [10], Sharma *et al*., (2017) [19] and Rolania *et al*., (2017).

Table 5: Effect of time of planting and bio inoculants on plant height (cm) in gladiolus cv. White prosperity

Treatments	Time of planting				Mean
	1st fortnight of October	2nd fortnight of October	1st fortnight of November	2nd fortnight of November	
T_1: RDF	102.24	101.03	101.76	99.26	101.07
T_2: RDF + Azo	105.60	104.13	103.63	102.17	103.88
T_3: RDF + PSB	108.67	109.13	106.70	103.83	107.08
T_4: RDF + Myco	108.20	107.77	105.63	100.97	105.64
T_5: RDF + Azo + PSB	111.43	112.67	109.13	106.03	109.82
T_6: RDF + PSB + Myco	116.20	112.84	113.27	110.70	113.25
T_7: RDF + Azo + Myco	115.34	112.30	113.47	108.87	112.49

T_8: RDF + Azo + PSB + Myco	116.20	115.43	116.20	112.63	115.12
Mean	110.49	109.41	108.73	105.56	
CD at 5%	Treatments= 1.52, Time of planting= 1.07, Interaction= NS				

Interaction between the time of planting and bio inoculants treatment were found non significant in influencing plant height and no. of leaves.

Table 6: Effect of time of planting and bio inoculants on the number of leaves per plant in gladiolus cv. White prosperity

Treatments	**Time of planting**				**Mean**
	1st fortnight of October	**2nd fortnight of October**	**1st fortnight of November**	**2nd fortnight of November**	
T_1: RDF	8.33	8.00	7.00	7.00	7.58
T_2: RDF + Azo	8.22	8.00	7.33	7.00	7.64
T_3: RDF + PSB	8.22	7.89	7.56	7.22	7.72
T_4: RDF + Myco	8.89	8.56	8.22	7.89	8.39
T_5: RDF + Azo + PSB	8.56	8.78	7.78	7.44	8.14
T_6: RDF + PSB + Myco	9.89	9.56	9.22	8.89	9.39
T_7: RDF + Azo + Myco	9.78	9.45	9.11	8.78	9.28
T_8: RDF + Azo + PSB + Myco	10.56	10.22	10.22	10.22	10.31
Mean	9.06	8.81	8.31	8.06	
CD at 5%	Treatments (T)=0.68, Time of planting (P)=0.48, Interaction =NS				

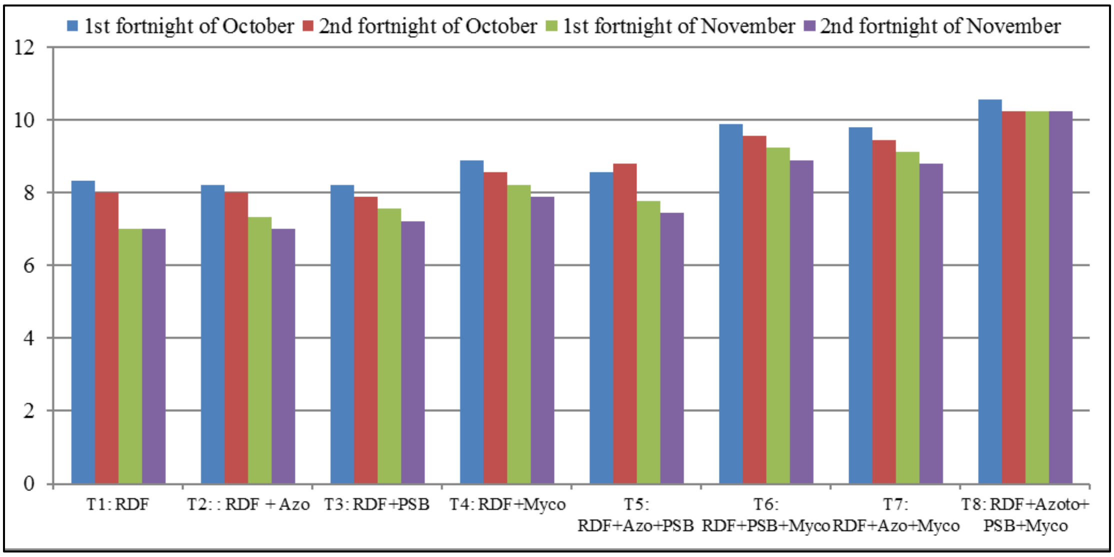

Fig 1: Effect of time of planting and bio inoculants on the number of leaves per plant in gladiolus cv. White prosperity

Conclusion

The experiment's findings give us important information on how different treatment combination of *Azotobacter*, PSB and Mycorrhiza affect the various vegetative characters of Gladiolus. The results of this experiment indicate that inoculation of PSB and Mycorrhiza along with RDF application improved vegetative characters and leads to higher productivity.

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