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Influence of gibberellic acid (GA_3) and bio-inoculants on vegetative growth of gladiolus (*Gladiolus grandiflorus* L.) cv. Nova Lux

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ABSTRACT

An investigation on "Effect of GA_3 and Bio-inoculants on vegetative growth of Gladiolus (Gladiolus grandiflorus L.) cv. Nova Lux" was carried out at the Experimental Farm, Division of Floriculture and Landscaping, Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu, during 2022–23 and 2023–24. The factorial randomized block design consists of four levels of GA_3 (0, 50, 100 and 150 ppm) and five levels of bio-inoculants (No-inoculation, Bacillus subtilis, Actinomycete, Pseudomonas fluorescens and consortia). Overall data shows that among the treatments, T_{20} consists of GA_3 @ 150 ppm combined with consortia (Bacillus subtilis, Actinomycete and Pseudomonas fluorescens) recorded maximum plant height (124.62 cm), number of leaves per plant (9.96), leaf length (63.45 cm), leaf width (5.33 cm) and leaf area (71.28 cm^2). The study suggests that the integrated use of GA_3 and bio-inoculants can significantly enhance the vegetative growth of gladiolus.

Keywords: *GA3, bio-inoculants, gladiolus, vegetative parameters and Nova Lux.*

Introduction

Gladiolus (*Gladiolus grandiflorus* L.), a striking ornamental plant belonging to the Iridaceae family, is admired for its elegant floral spikes and is widely known as the "Sword Lily" or "Corn Flag". Originating from South Africa gladiolus holds a prominent position in the global floriculture industry, ranking fourth among commercially traded flowers. Often referred to as the "queen of bulbous flowers," it is cultivated extensively for its broad spectrum of vibrant hues, various floret sizes and prolonged vase life. Its capacity to adapt to different climatic conditions enhances its value, especially for long-distance transportation and extended shelf life, contributing to its increasing market demand. It is a major floriculture crop across hilly regions such as Himachal Pradesh, West Bengal, Sikkim and parts of southern and northeastern states, including Karnataka, Tamil Nadu, Andhra Pradesh (notably Telangana), Assam and Tripura. The flower's sturdy spikes, vibrant blooms and transport resilience make it ideal for both domestic and international trade. India is home to a wide range of gladiolus varieties both native and introduced. However, the performance of these cultivars is greatly influenced by their genetic traits and the prevailing climatic conditions of a region. In India, commercial flower cultivation including gladiolus relies heavily on synthetic fertilizers, pesticides and chemical growth regulators. While these inputs contribute to higher yields, their prolonged use has led to critical issues such as soil degradation, contamination of water bodies and reduced soil fertility, which in turn threaten long-term agricultural sustainability.

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In response, the concept of natural and sustainable farming has gained traction, promoting the use of organic amendments and bio-based alternatives to chemical inputs. Among these alternatives, biofertilizers (or bio-inoculants) have emerged as cost-effective and eco-friendly tools for sustainable crop production. These microbial inoculants facilitate nutrient availability through mechanisms like nitrogen fixation and phosphorus solubilization. In addition to boosting growth, bio-inoculants help suppress soil-borne diseases and some can even produce antibiotics, thereby supporting plant health. Being composed entirely of beneficial microorganisms, bio-inoculants do not pollute the environment and are suitable for various crops including ornamentals like gladiolus, rose, tuberose, chrysanthemum, marigold and dahlia. The application of plant growth regulators is now a widely adopted strategy to influence the developmental patterns of ornamental and flowering plants. Gibberellic acid (GA_3) in particular has proven highly effective in enhancing vegetative growth and initiating flowering in gladiolus. Plant development is controlled by individual hormones or through their combined interactions which play a vital role in the allocation and movement of essential metabolites within the plant system. Vegetative traits are fundamental, as they significantly affect photosynthetic efficiency, productivity and overall crop quality. Given the potential of both GA_3 and bio-inoculants in enhancing the performance of gladiolus the present investigation titled "Effect of GA_3 and Bio-inoculants on vegetative growth of Gladiolus (*Gladiolus grandiflorus* L.) " was conducted under the agro-climatic conditions of Jammu.

Material and Methods

The field experiment was conducted at the Experimental Farm, Division of Floriculture & Landscaping, Sher-e-Kashmir University of Agricultural Sciences and Technology Chatha, Jammu during 2022–23 and 2023–24.

The experiment was laid out in a factorial randomized block design (FRBD) with three replications, comprising 20 treatment combinations formed by four concentrations of gibberellic acid (0, 50, 100 and 150 ppm) and five bio-inoculant treatments (no inoculation, *Bacillus subtilis*, Actinomycete, *Pseudomonas fluorescens* and consortia of all three). GA_3 was applied through two methods: corm dipping for 24 hours before planting and foliar spraying while bio-inoculants were applied by dipping the corms in the respective solutions for 30 minutes before planting. Uniform-sized, healthy corms of *Gladiolus grandiflorus* cv. Nova Lux was planted on raised beds. Standard cultural practices, including irrigation, manual weeding and basal fertilizer application, were uniformly adopted across all plots. Observations on vegetative traits such as plant height, number of leaves, leaf length, leaf width and leaf area were recorded.

Results and Discussion

Overall data revealed that GA_3 @ 150 ppm recorded the highest plant height (122.19 cm) whereas the control recorded the lowest (103.56 cm). Maximum plant height is due to its role in promoting cell division, elongation and expansion of meristematic tissues, enhancing stem elongation and vegetative development[1];[2];[3]. Several studies [4];[5];[6];[7];[8] corroborate GA_3's efficacy in improving plant height and foliage traits in gladiolus and other ornamentals. Among the bio-inoculant treatments the maximum average plant height (116.85 cm) was recorded with consortia while the minimum (111.15 cm) was observed in the control. Consortia (*Bacillus subtilis*, Actinomycetes and *Pseudomonas fluorescens*) enhanced plant height by improving nutrient availability, fixing atmospheric nitrogen and mobilizing phosphorus and potassium [9];[10]. The combined application of GA_3 and consortia showed a synergistic effect with the highest plant height (124.62 cm) confirming their complementary roles [11]. Foliage parameters i.e the number of leaves (9.71), leaf length (61.89 cm), leaf width (4.82 cm) and leaf area (69.16 cm^2) were also maximized with GA_3 @ 150 ppm. This is due to enhanced cell expansion and leaf development[12]. Among the bio-inoculant treatments the maximum number of leaves (8.54), leaf length (57.62 cm), leaf width (4.31 cm) and leaf area (64.32 cm^2) whereas the minimum was noted in the control. Consortia also significantly improved foliage through better root development and nutrient uptake [13]; [14]. Plants under the combined GA_3 and consortia treatment recorded the highest foliage measurements including the number of leaves (9.96), leaf length (63.45 cm), leaf width (5.33 cm) and leaf area (71.28 cm^2), confirming their synergistic role in boosting vegetative growth [11].

Table 1. Effect of GA3 and Bio-inoculants on plant height (cm) in gladiolus

Bio-inoculants	Gibberellic acid (GA_3)														
	2022-23					2023-24					Overall				
	Control	GA_3 50 ppm	GA_3 100 ppm	GA_3 150 ppm	Mean	Control	GA_3 50 ppm	GA_3 100 ppm	GA_3 150 ppm	Mean	Control	GA_3 50 ppm	GA_3 100 ppm	GA_3 150 ppm	Mean
Control	99.43	111.36	116.73	121.06	112.15	97.50	108.51	114.75	119.85	110.15	98.46	109.94	115.74	120.46	111.15
Bacillus subtilis	103.76	113.13	117.83	122.77	114.37	103.88	110.88	116.58	121.30	113.16	103.82	112.01	117.21	122.03	113.77
Actinomycete	102.70	112.90	117.70	121.36	113.66	101.60	109.47	115.90	120.34	111.83	102.15	111.18	116.80	120.85	112.75
Pseudomonas fluorescens	105.16	114.56	118.96	123.96	115.66	104.74	111.25	117.07	122.01	113.76	104.95	112.90	118.01	122.99	114.71
Consortia	109.70	116.30	120.43	125.36	117.95	107.16	113.00	118.98	123.87	115.75	108.43	114.65	119.71	124.62	116.85
Mean	104.15	113.65	118.33	122.90		102.97	110.62	116.65	121.47		103.56	112.13	117.49	122.19	
	GA_3 (A)	Bio-inoculants (B)	Interaction (A × B)			GA_3 (A)	Bio-inoculants (B)	Interaction (A × B)			GA_3 (A)	Bio-inoculants (B)	Interaction (A × B)		
SE(m)	0.31	0.35	0.71			0.34	0.38	0.77			0.23	0.26	0.53		
C.D (5%)	0.91	1.02	2.04			0.99	1.10	2.12			0.68	0.76	1.53		

Table 2. Effect of GA3 and Bio-inoculants on number of leaves in gladiolus

Bio-inoculants	Gibberellic acid (GA_3)														
	2022-23					2023-24					Overall				
	Control	GA_3 50 ppm	GA_3 100 ppm	GA_3 150 ppm	Mean	Control	GA_3 50 ppm	GA_3 100 ppm	GA_3 150 ppm	Mean	Control	GA_3 50 ppm	GA_3 100 ppm	GA_3 150 ppm	Mean
Control	5.66	7.40	8.20	9.13	7.60	5.33	7.53	8.46	9.33	7.66	4.46	7.13	8.40	9.36	7.34
Bacillus subtilis	7.13	7.76	8.46	9.33	8.17	6.73	8.13	9.00	9.53	8.35	6.15	7.61	8.93	9.76	8.11
Actinomycete	7.00	7.66	8.26	9.26	8.05	6.33	7.86	8.66	9.40	8.06	6.05	7.46	8.60	9.57	7.92
Pseudomonas fluorescens	7.23	7.96	8.73	9.47	8.35	7.00	8.26	9.06	9.66	8.50	6.65	7.91	9.00	9.90	8.36
Consortia	7.36	8.06	8.93	9.53	8.47	7.13	8.40	9.13	9.86	8.63	6.85	8.16	9.20	9.96	8.54
Mean	6.88	7.77	8.52	9.34		6.50	8.04	8.86	9.56		6.03	7.66	8.82	9.71	
	GA_3 (A)	Bio-inoculants (B)	Interaction (A × B)			GA_3 (A)	Bio-inoculants (B)	Interaction (A × B)			GA_3 (A)	Bio-inoculants (B)	Interaction (A × B)		
SE(m)	0.04	0.04	0.09			0.07	0.08	0.15			0.05	0.06	0.13		
C.D(5%)	0.12	0.13	0.27			0.20	0.22	0.45			0.16	0.18	0.37		

Table 3. Effect of GA3 and Bio-inoculants on leaf length in gladiolus

Bio-inoculants	Gibberellic acid (GA_3)														
	2022-23					2023-24					Overall				
	Control	**GA_3 50 ppm**	**GA_3 100 ppm**	**GA_3 150 ppm**	**Mean**	**Control**	**GA_3 50 ppm**	**GA_3 100 ppm**	**GA_3 150 ppm**	**Mean**	**Control**	**GA_3 50 ppm**	**GA_3 100 ppm**	**GA_3 150 ppm**	**Mean**
No application	45.93	53.15	56.06	60.72	53.96	42.33	52.53	56.67	60.19	52.93	44.13	52.84	56.37	60.45	53.44
Bacillus subtilis	49.38	54.68	58.12	62.07	56.06	46.83	54.10	58.63	61.63	55.30	48.11	54.39	58.36	61.85	55.68
Actinomycete	48.14	53.81	57.31	61.89	55.28	45.40	53.36	57.10	60.93	54.20	46.77	53.59	57.20	61.41	54.74
Pseudomonas fluorescens	51.70	54.85	58.88	62.90	57.08	49.77	55.03	58.80	61.73	56.33	50.73	54.94	58.84	62.31	56.70
Consortia	52.84	55.22	59.85	63.97	57.97	51.83	55.05	59.26	62.93	57.21	52.33	55.13	59.56	63.45	57.62
Mean	49.60	54.34	58.04	62.31		47.23	54.01	58.09	61.48		48.41	54.17	58.07	61.89	
	GA_3 (A)	Bio-inoculants (B)	Interaction (A × B)			GA_3 (A)	Bio-inoculants (B)	Interaction (A × B)			GA_3 (A)	Bio-inoculants (B)	Interaction (A × B)		
SE(m)	0.19	0.21	0.43			0.29	0.33	0.67			0.20	0.22	0.45		
C.D(5%)	0.55	0.62	1.24			0.86	0.96	1.92			0.58	0.65	1.29		

Table 4. Effect of Bio-inoculants and GA3 on leaf width in gladiolus.

Bio-inoculants	Gibberellic acid (GA_3)														
	2022-23					2023-24					Overall				
	Control	**GA_3 50 ppm**	**GA_3 100 ppm**	**GA_3 150 ppm**	**Mean**	**Control**	**GA_3 50 ppm**	**GA_3 100 ppm**	**GA_3 150 ppm**	**Mean**	**Control**	**GA_3 50 ppm**	**GA_3 100 ppm**	**GA_3 150 ppm**	**Mean**
Control	2.80	3.63	4.07	4.66	3.79	2.84	3.60	3.93	4.42	3.70	2.82	3.61	4.00	4.54	3.74
Bacillus subtilis	3.39	3.87	4.40	4.80	4.11	3.41	3.72	4.20	4.74	4.02	3.40	3.79	4.30	4.77	4.06
Actinomycete	3.21	3.79	4.33	4.76	4.02	3.18	3.59	4.05	4.56	3.84	3.19	3.68	4.19	4.66	3.93
Pseudomonas fluorescens	3.41	3.88	4.47	4.90	4.17	3.49	3.77	4.29	4.77	4.08	3.45	3.82	4.38	4.83	4.12
Consortia	3.55	3.91	4.67	5.16	4.32	3.56	3.86	4.31	5.51	4.31	3.55	3.88	4.49	5.33	4.31
Mean	3.27	3.81	4.39	4.86		3.30	3.71	4.16	4.80		3.28	3.76	4.27	4.82	
	GA_3 (A)	Bio-inoculants (B)	Interaction (A × B)			GA_3 (A)	Bio-inoculants (B)	Interaction (A × B)			GA_3 (A)	Bio-inoculants (B)	Interaction (A × B)		
SE(m)	0.02	0.03	0.05			0.05	0.06	0.11			0.02	0.03	0.06		
C.D(5%)	0.07	0.08	0.16			0.15	0.16	0.33			0.08	0.09	0.18		

Table 5. Effect of GA3 and Bio-inoculants on leaf area (cm2) in gladiolus

Bio-inoculants	Gibberellic acid (GA_3)														
	2022-23					2023-24					Overall				
	Control	**GA_3 50 ppm**	**GA_3 100 ppm**	**GA_3 150 ppm**	**Mean**	**Control**	**GA_3 50 ppm**	**GA_3 100 ppm**	**GA_3 150 ppm**	**Mean**	**Control**	**GA_3 50 ppm**	**GA_3 100 ppm**	**GA_3 150 ppm**	**Mean**
Control	47.16	57.93	63.40	66.06	58.64	48.13	57.23	63.10	67.06	59.80	47.65	58.91	63.75	66.57	59.22
Bacillus subtilis	55.13	59.10	64.43	68.05	61.68	57.23	61.36	65.06	70.63	63.57	56.18	60.23	64.75	69.34	62.63
Actinomycete	54.00	58.40	63.80	67.83	61.00	55.00	60.36	64.96	70.06	62.60	54.50	59.38	64.38	68.95	61.80
Pseudomonas fluorescens	55.50	59.93	64.76	68.66	62.21	57.50	62.06	65.80	70.66	64.00	56.50	61.00	65.28	69.67	63.11
Consortia	56.23	60.73	65.53	70.26	63.19	58.90	63.76	66.90	72.30	65.46	57.56	62.25	66.22	71.28	64.32
Mean	53.60	59.22	64.38	68.17		55.35	61.49	65.36	70.14		54.48	60.35	64.88	69.16	
	GA_3 (A)	Bio-inoculants (B)	Interaction (A × B)			GA_3 (A)	Bio-inoculants (B)	Interaction (A × B)			GA_3 (A)	Bio-inoculants (B)	Interaction (A × B)		
SE(m)	0.45	0.50	1.00			0.47	0.53	1.07			0.40	0.45	0.90		
C.D(5%)	1.29	1.44	2.89			1.37	1.53	3.07			1.15	1.29	2.58		

Conclusion

The study concludes that the combined application of GA_3 @ 150 ppm and consortia significantly enhances the vegetative growth and overall physiological performance of gladiolus cv. Nova Lux. Such integrated nutrient and hormone management approaches align with sustainable horticultural practices by reducing sole dependence on synthetic inputs while maximizing crop potential.

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