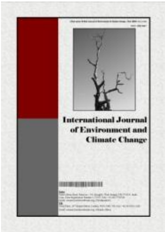

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Effect of Nanochitosan and Biocapsules on Growth, Flowering and Flower Yield of Gladiolus (*Gladiolus grandiflorus* L.*)* Var. Priscilla

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Authors' contributions

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

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ABSTRACT

An experiment on Gladiolus was conducted during November 2021 to March 2022, in Horticulture Research Field, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, and Technology & Sciences, Prayagraj (U.P) India. The results of the investigation, regarding the performance of the 10 Treatments of Gladiolus i.e. T0 Control NPK (RDF)-120:150:150 Kg/ha, T1 Biocapsule 200 ppm, T2 Biocapsule 400 ppm, T3 Biocapsule 600 ppm, T4 Nanochitosan 50 ppm, T5 Nanochitosan 100 ppm, T6 Nanochitosan 150 ppm, T7 Nanochitosan 50 ppm & Biocapsule 200 ppm, T8 Nanochitosan 100ppm & Biocapsule 400 ppm, T9 Nanochitosan 150 ppm & Biocapsule 600 ppm to find out the best performance in terms of growth, flowering and flower yield. The experiment was conducted in Randomized Block design, were each treatment replicated thrice the results from the present investigation concluded that in

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terms of growth and yield treatment the treatment T7 (Nanochitosan 50 ppm & Biocapsule 200 ppm) was recorded with maximum number of flower spike (4.71 lakhsspike/ha) & corms yield (4.81 lakhs/ha)The treatment T7 was also recorded with highest net profit (3023506) with maximum cost benefit ratio (4.85).whereas in terms of shelf life the treatment T8 Nanochitosan 100 ppm& Biocapsule 400 ppm recorded with maximum shelf life.

Keywords: Nanochitosan; biocapsule; priscilla.

1. INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.) is an ornamental bulbous plant native to South Africa, known as Sward lily belongs to monocot family Iridadceae, having approximately one hundred and fifty known species. It has its natural habitat in the Mediterranean regions.

Gladiolus is one of the most important bulbous cut flowers in the flower industry. It occupies the fifth position in the international floriculture trade. It has great economic value as a cut flower and for decoration and known as queen amongst the bulbous flower [1]. It is among the leading cut flowers and occupies eighth position in international cut flower trade [2].

Nanochitosan has broad antimicrobial activity against fungal pathogens however, the bulk size limits its solubility which affects the antimicrobial property. Chitosan nanoparticles have great potential over the bulk counter parts as size can alter several properties compare to bulk material. The exclusive properties of these materials, such as a large surface area and greater reactivity, have also raised concerns about adverse effects on environmental health (Ghadi et al. 2004).

Biocapsules are important because it involves encapsulation of the desired microorganisms in a gelatin capsule for its delivery to the crops for the enhanced soil nutrient solubilization, enhanced growth and yield. One-gram capsules are very efficient as it contains the microbial population equivalent to what is present in a one-kg pack of powder-based biofertilizer or a one-litre bottle. Also, as these microbial strains are retained in the dormant stage, there is no issue of their viable loss in room temperatures as is the case with many liquid-based bio formulations. It consists of a carrier medium rich in living microorganisms. When applied to seed, soil or living plants, it increases soil nutrients or makes them biologically available. Biocapsules contain different types of fungi, root bacteria or other microorganism. They form a mutually beneficial or symbiotic relationship with host plants as they grow in the soil. Increase the nitrogen and phosphorus available to plants more naturally than other fertilizers. They do not pollute the soil or the environment, whereas chemical fertilizers often result in too much phosphate and nitrogen in the soil.

Biocapsule, a bio-fertilizer technology developed by the IISR (Indian Institute of Spices Research). It uses a select combination of beneficial microorganisms such as Trichoderma, Pseudomonas and Bacillus. They form a mutually beneficial microorganism in a gletin capsule for its delivery to the crops for the enhanced soil nutrient solubilization, enhanced growth, and yield.

2. MATERIALS AND METHODS

An Experiment on Gladiolus was conducted throughout Nov 2021 to March 2022, in horticulture Research field, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, and Technology & Sciences Prayagraj (U.P) India. The treatments of the investigation, concerning the performance of Nanochitosan and Biocapsule in the 10 treatments i.e. To Control (NPK): 120:150:150 Kg/ha, T_1 Biocapsule 200 ppm, T_2 Biocapsule 400 ppm, T_3 Biocapsule 600 ppm, T_4 Nanochitosan 50 ppm, T_5 Nanochitosan 50 ppm, T_6 Nanochitosan 100 ppm, T_7 Nanochitosan 150 ppm, T_8 Nanochitosan 50 ppm + Biocapsule 200 ppm, T9 Nanochitosan 100 ppm + Biocapsule 400 ppm, T8 Nanochitosan 150 ppm + Biocapsule 600 ppm. To find out the best performance in terms of growth, flowering and corm yield. The experiment was conducted in Randomized Block design, with each treatment replicated thrice. The mean (maximum and minimum) temperature was 37.98°C and 24.21°C respectively, mean (maximum and minimum) relative humidity was 82.16 percent and 45.26 percent during the crop growing season. The experimental soil was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.318%), medium in available N (100 Kg/ha), medium available P (50 Kg/ha) and medium available K (50 Kg/ha). Fertilizers were applied in the form of urea, single super phosphate and murate of potash, respectively. The field beds were prepared and the corms have been directly sown with respective spacing and covered by soil. The observation regarding yield were recorded after harvesting of crop.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Data pertaining to growth parameters which are Days to first flowering, Plant height, Number of leaves (at last harvesting), Number of shoots per corm were recorded and tabulated in Table 1.

3.2 Number of Shoots

The maximum number of shoots (2.47) in the treatment T7 Nanochitosan 50 ppm & Biocapsule 200 ppm, followed by the treatment T8 Nanochitosan 100 ppm & Biocapsule 400 ppm and minimum number of shoots was recorded in the treatment T6 Nanochitosan 150 ppm(1.47).

Combined treatment of biofertilizer with organic manure was found to improve shoot growth with least number of days taken to emergence of shoots [3]. It is due to increase in nutrient uptake,photosynthetic activites so increase vegetative growth of plant.

3.3 Plant Height (30DAS)

The maximum height of plant after 30DAS (31.59 cm) in the treatment T8 Nanochitosan 100 ppm & Biocapsule 400 ppm followed by the treatment T3 Biocapsule 600 ppm (30.05 cm) and minimum height of plant was recorded in the treatment T0 control NPK (RDF)-120:150:150 Kg/ha (19.47 cm).

Increase in plant height and vegetative characters might be due to the fact that nitrogen is a constituent of protein which is essential for the formation of protoplasm thus affecting the cell division and cell enlargement and ultimately resulting in better vegetative growth. The improvement in plant height might be due to enhanced photosynthetic and other metabolic activities for cell division and elongation.

3.4 Plant Height (60DAS)

The maximum height of plant after 60DAS (89.86 cm) in the treatment T9 Nanochitosan 150 ppm & Biocapsule 600 ppm followed by the treatment T8 Nanochitosan 100 ppm & Biocapsule 400 ppm (89.84 cm) and minimum height of plant was recorded in the treatment T3 Biocapsule 600 ppm (49.90 cm). Nano Chitosan (CHT) has been proven to stimulate plant growth and plant height in various horticultural commodities [4]. It is due to increase Giberellic acid (GAs), as GA is mainly responsible for shoot elongation.

3.5 Plant Height (90DAS)

The maximimum height of plant after 90DAS (113.17 cm) in the treatment T8 Nanochitosan 100 ppm & Biocapsule 400 ppm and minimum height of plant was recorded in the treatment T5 Nanochitosan 100 ppm (85.65 cm). Dhawale et al., 2011 concluded that the plant height may also be due to balance C:N ratio, abundant supply of available nutrients from soil with comparatively lesser retention in roots and more translocation to aerial parts for protoplasmic proteins and synthesis of other compounds.

3.6 Number of Leaves (At Last Harvesting)

The maximum number of leaves (8.52) in the treatment T8 Nanochitosan 100 ppm & Biocapsule 400 ppm followed by the treatment T9 Nanochitosan 150 ppm & Biocapsule 600 ppm (8.23), T7 Nanochitosan 50 ppm & Biocapsule 200 ppm (7.93).

T1 Biocapsule 200 ppm (7.84), T5 Nanochitosan 100 ppm (7.58), T4 Nanochitosan 50 ppm (7.36).

Leaf number is not affected by the application of nanochitosan. It is regulated by a complex interaction of various genes whose expression is modulated by growth hormones Ethylene controls the leaf number by regulating leaf abscission and inhibition of ethylene action reduces the event of abscission [5].

3.7 Yield Parameters

Data pertaining to yield parameters which are Days to first flowering,Weight of spike (g),Flower diameter (cm), Flower length (cm), Number of flower spikes per plant,Number of corms per plant, Spike yield per ha (lakhs), Number of corms yield per ha (lakhs) were recorded and tabulated in Table 2a.

3.8 Days to First Flowering

The minimum days to first flowering (84.08) in the treatment T7 Nanochitosan 50 ppm &

Biocapsule 200 ppm and maximium days to first flowering was recorded in the treatment T0 control NPK (RDF)-120:150:150 Kg/ha (117.09). Gonzalez et al., 2010 concluded that Nanochitosan treatment decreases days to first flower emergence. Application of Nanochitosan along with the recommended doses of fertilizers included early initiation of flower bud. It might be due to formation of Indole acetic acid and enhanced nitogenase activity and early flowering.

3.9 Weight of Spike (g)

The maximum weight of spike (79.21 gm) in the treatment T7 Nanochitosan 50 ppm & Biocapsule 200 ppm and minimum weight of spike was recorded in the treatment T0 control NPK (RDF)-120:150:150 Kg/ha (65.70 gm).

Biofertilizer strain of Bacillus subtilis A13 increased weight of flower in dahlia and carnation and another strain WW27 in celosia and carnation Broadbent et al. [6].

3.10 Flower Diameter (cm)

The maximum flower diameter (10.20 cm) in the treatment T8 Nanochitosan 100 ppm & Biocapsule 400 ppm and minimum flower diameters was recorded in the treatment T3 Biocapule 300 ppm (6.71 cm).

The most efficient use of photo assimilates (C/N:1.22) and highest flower ,flower diameter and weight, soil and plant nitrogen content with 60 kg N, with Azospirillum treated during third month after planting and 1000 ppm Ravichandran et al. [7]. This finding was concluded by Mondal et al., 2012. The nanochitosan treatment increases might be due to enhanced photosynthesis accumulation of carbohydrates and favourable effect on vegetative growth which increased the flower diameter.

3.11 Flower Length (cm)

The maximum flower length (10.46 cm) in the treatment T9 Nanochitosan 150 ppm & Biocapsule 600 ppm and minimum flower length was recorded in the treatment T1 Biocapule 200 ppm (6.05 cm).

It might be due to the growth promoted by 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 vegetative growth. Increase in supply of nitrogen which in turn increased synthesis of amino-acid and chlorophyll formation and better carbohydrates transformation resulted into better growth. Nitrogen helped in increasing amount of assimilates that are needed for improvement in length of spike; thus, increased the flower bearing portion with number of florets on the spike. Mishra [8] reported increased number of florets per spike in Gladiolus with the application of Azotobacter.

3.12 No of Flower Spikes per Plant

The maximum spike length (84.89 cm) in the treatment T7 Nanochitosan 50 ppm & Biocapsule 200 ppm and minimum spike length was recorded in the treatment T0 control NPK (RDF)-120:150:150 Kg/ha (64.77). Inoculated biofertilizers can beneficial in crops and ornamental plants like rose, jasmine, chrysanthemum, carnation, marigold, aster, tuberose, gladiolus due to better root development, floral stalk production. Bhattacharya et al., [9]. Increase in supply of nitrogen which in turn increased synthesis of amino-acid and chlorophyll formation and better carbohydrates transformation resulted into better growth.

3.13 Number of Corms per Plant

The maximum number of corms per plant (2.89) in the treatment T7 Nanochitosan 50 ppm & Biocapsule 200 ppm and minimum number of corms per plant (1.23) was recorded in the treatment T0 control NPK (RDF)-120:150:150 Kg/ha(1.23).

The combined inoculation of gladiolus corms with azotobacter and phosphorous solublising bacteria corm and cormel weight and increased propagation coefficient. Dubey et al. (2005).This may be due to ability of biofertilizers to produce growth promoting substances such as IAA and gibberellins like substances viz., vitamins and riboflavin’s etc. which might have helped in increasing size and weight of corms and cormels.

3.14 Spike Yield per Ha (Lakhs)

The maximum number of flower spikes yield per hectare (4.71) in the treatment T7Nanochitosan 50 ppm& Biocapsule 200 ppm and minimum number of flower spikes yield per hectare (1.83) was recorded in the treatment T1 Biocapule 200 ppm.

Table 1. Performance of nanochitosan and biocapsules on plant height, No of leaves, No of Shoots of gladiolus

Notation	Treatments	Plant height 30(DAS)	Plant height 60(DAS)	Plant height 90(DAS)	Number of leaves	Number of shoots
T0	CONTROL-NPK (RDF) – 100:50:50 Kg/ha	19.47	51.20	89.15	6.56	1.60
T1	Biocapsule 200 ppm	22.45	59.96	95.23	7.84	1.93
T2	Biocapsule 400 ppm	28.25	57.73	90.63	7.27	1.87
T3	Biocapsule 600 ppm	30.05	49.90	97.46	6.95	2.00
T4	Nanochitosan 50 ppm	30.12	68.83	95.44	7.36	1.53
T5	Nanochitosan 100 ppm	29.19	73.51	85.65	7.58	1.80
T6	Nanochitosan 150 ppm	28.27	63.44	103.70	6.68	1.47
T7	Nanochitosan 50 ppm & Biocapsule 200 ppm	29.17	69.72	107.35	7.93	2.47
T8	Nanochitosan 100 ppm & Biocapsule 400 ppm	31.59	89.84	113.17	8.52	2.20
T9	Nanochitosan 150 ppm & Biocapsule 600 ppm	29.19	89.86	102.02	8.23	1.74
	F test	S	S	S	S	s
	S. Ed (±)	0.52	0.72	0.91	0.26	0.15
	C.V.	2.29	1.32	1.13	4.22	9.60
	C.D at 5%	1.09	1.09	1.99	0.54	0.31

Table 2a. Performance of nanochitosan and biocapsules on days to firsflowering, Weight of spike (g), Flower diameter (cm), Flower length (cm), Number of flower spikes per plant, of gladiolus

Notation	Treatments	Days to first flowering	Weight of spike(g)	Flower diameter(cm)	Flower length(cm)	No of flower spikes per plant.
T0	CONTROL-NPK (RDF) – 100:50:50 Kg/ha	117.09	65.70	7.51	7.55	
T1	Biocapsule 200 ppm	110.06	68.26	7.50	6.05	1.93
T2	Biocapsule 400 ppm	105.03	69.96	9.06	7.50	1.87
T3	Biocapsule 600 ppm	108.04	67.43	6.71	6.68	2.00
T4	Nanochitosan 50 ppm	99.00	69.15	7.48	7.25	1.53
T5	Nanochitosan 100 ppm	88.00	71.66	8.60	7.83	1.80
T6	Nanochitosan 150 ppm	115.07	75.75	8.17	7.39	1.47
T7	Nanochitosan 50 ppm & Biocapsule 200 ppm	84.08	79.21	9.47	9.44	2.47
T8	Nanochitosan 100 ppm & Biocapsule 400 ppm	95.06	76.23	10.20	9.83	2.20
T9	Nanochitosan 150 ppm & Biocapsule 600 ppm	93.05	71.83	8.83	10.46	1.74
	F test	S	S	S	S	s
	S. Ed (±)	0.84	0.69	0.26	0.26	0.15
	C.V.	1.01	1.18	3.79	3.96	9.60
	C.D at 5%	1.76	1.45	0.54	0.54	0.31

Table 2b. Performance of nanochitosan and biocapsules on number of corms per plant, Spike yield per ha (lakhs), Number of corms yield per ha (lakhs) of gladiolus

Notation	Treatments	Number of corms per plant	Spike yield per ha(lakhs)	Number of corms yield per ha (lakhs)
TO	CONTROL-NPK (RDF) – 100:50:50 Kg/ha	1.23	1.91	2.04
T1	Biocapsule 200 ppm	1.47	1.83	2.44
T2	Biocapsule 400 ppm	1.33	1.99	2.21
T3	Biocapsule 600 ppm	1.51	2.33	2.51
T4	Nanochitosan 50 ppm	1.45	2.21	2.41
T5	Nanochitosan 100 ppm	1.81	2.41	3.01
T6	Nanochitosan 150 ppm	1.91	3.48	3.18
T7	Nanochitosan 50 ppm & Biocapsule 200 ppm	2.89	4.71	4.81
T8	Nanochitosan 100 ppm & Biocapsule 400 ppm	2.51	2.44	4.18
T9	Nanochitosan 150 ppm & Biocapsule 600 ppm	2.05	2.54	3.41
	F test	S	S	S
	S. Ed (±)	0.15	0	0.15
	C.V.	10.42	2.96	5.98
	C.D at 5%	0.32	0.42	0.31

Heba et al. 2017, Treatment of wheat plants grown on sandy soil with nano chitosan-NPK fertilizer induced significant increases in harvest index, crop index and mobilization index of the determined wheat yield variables, as compared with control yield variables of wheat plants treated with normal non-fertilized wheat plants with the ratio of 23.5% (130 days compared with 170 days for yield production from date of sowing).

3.15 Number of Corms Yield per Ha (Lakhs)

The maximum number of corms yield per hectare (4.81) in the treatment T7 Nanochitosan 50 ppm& Biocapsule 200 ppm followed by the treatment T8 Nanochitoan 100 ppm & Biocapsule 400 ppm minimum number of corms was recorded in the treatment T0 control NPK (RDF)-120:150:150 Kg/ha (2.04). Evaluated the potential of using chitosan on cereal crops in the face of climate change and demonstrates that chitosan is highly effective against the most dangerous diseases and pathogens for cereals. Furthermore, it also contributes to improving yield and chlorophyll content, as well as some plant growth parameters Joanna kociecka et al. [10].

3.16 Quality Parameters

Table 3. Data pertaining to quality parameters which are spike length and floret number, Floret size, Shelf life

Notation	Treatments	Spike length	floret number	Floret size	Shelf life
T0	CONTROL-NPK (RDF) – 100:50:50 Kg/ha	64.77	9.57	9.09	8.33
T1	Biocapsule 200 ppm	67.26	11.42	8.28	9.89
T2	Biocapsule 400 ppm	70.77	10.06	8.36	8.89
T3	Biocapsule 600 ppm	75.07	9.96	9.43	8.11
T4	Nanochitosan 50 ppm	73.75	10.57	8.31	6.95
T5	Nanochitosan 100 ppm	69.26	10.54	8.27	8.22
T6	Nanochitosan 150 ppm	80.89	11.47	8.95	7.11
T7	Nanochitosan 50 ppm & Biocapsule 200 ppm	84.89	11.48	9.09	10.06
T8	Nanochitosan 100 ppm & Biocapsule 400ppm	76.50	11.47	9.13	10.22
T9	Nanochitosan 150 ppm & Biocapsule 600 ppm	71.88	11.43	9.66	9.89
	F test	S	S	S	S
	S. Ed (±)	0.69	0.15	0.26	0.26
	C.V.	1.15	1.69	3.57	3.61
	C.D at 5%	1.45	0.31	0.54	0.54

3.17 Spike Length

The maximum spike length (84.89 cm) in the treatment T7 Nanochitosan 50 ppm& Biocapsule 200 ppm and minimum spike length was recorded in the treatment T0 control NPK (RDF)-120:150:150 Kg/ha (64.77). Nitrogen helped in increasing amount of assimilates that are needed for improvement in length of spike; thus, increased the flower bearing portion with number of florets on the spike. Mishra [8] reported increased number of florets per spike in Gladiolus with the application of Azotobacter.

3.18 Floret Number

The maximum number of floret (11.48) in the treatment T7 Nanochitosan 50 ppm& Biocapsule 200 ppm followed by the treatment T8 Nanochitoan 100 ppm & Biocapsule 400 ppm (11.47), T9 Nanochitoan 150 ppm & Biocapsule 600 ppm (11.43), T6 Nanochitoan 150 ppm (11.47), T1 Biocapsule 200 ppm (11.42) and minimum number of floret per plant was recorded in the treatment T0 control NPK (RDF)-120:150:150 Kg/ha (9.57).Results obtained in the preent experiment suggest that,use of biofertilizer with reduced doze of nitrogen significantly influenced the growth, flowering and yield of gladiolus.The gowth parameters like number of leaves, plant height, number of florets per spike, flower yield, corms yield P. D. Dalve et al., [11].

3.19 Floret Size

The maximum floret size (9.66) in the treatment T9Nanochitosan 150 ppm & Biocapsule 600 ppm followed by the treatment T8Nanochitosan 50 ppm& Biocapsule 200 ppm (9.13) and minimum floret size was recorded in the treatment T5 Nanochitosan 100 ppm (8.27).

A combined application of phosphorous solublising bacteria, Azotobacter and azospirillum in marigold, produced wit maximum plant height,number of branches, flower size and yield when compared with single application of thee biofertilizers and uninoculated plants Mathew et al., [12].

3.20 Shelf Life

The maximum shelf life (10.22) in the treatment T8 Nanochitosan 100 ppm& Biocapsule 400 ppm followed by the treatment treatment T7 Nanochitosan 50 ppm& Biocapsule 200 ppm (10.06), T9 Nanochitoan 150 ppm & Biocapsule 600 ppm (9.89), T1 Biocapsule 200 ppm (9.89), minimum number of self life was recorded in the treatment T4 Nanochitoan 50 ppm (6.95).

Longer vase life with more number of florets, longer vase life might be attributed to the better overall food and nutrient status under these treatments. Phosphorus participating in the skeleton of plasma membrane, nucleic acid and co-enzymes regulates metabolic activity of cut spikes by lowering the respiration activity and dehydration thereby increasing post harvest character [13].

4. SUMMARY AND CONCLUSION

The results from the present investigation it is concluded that in terms of growth and Flowering and flower yield of gladiolus The results from the present investigation concluded that the treatment T7 (Nanochitosan 50 ppm & Biocapsule 200 ppm) was recorded with maximum number of flower spike (4.71 lakhsspike/ha) & corms yield (4.81l akhs/ha)The treatment T7 was also recorded with highest net profit (3023506) with maximum cost benefit ratio (4.85).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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