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Effect of soaking with plant growth regulators on growth, yield and quality of *Gladiolus* (*Gladiolus grandiflorus*)

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Abstract
The present investigation entitled "Effect of soaking with plant growth regulators on growth, yield and quality of *Gladiolus* (*Gladiolus grandiflorus*)'' was carried out during winter season, 2021-22 at Horticultural Farm, College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, Dist. Mehsana, Gujarat. Experiment was laid out in randomized block design with three replications and was planted by soaking the corms for 24 hours in different plant growth regulators. *viz.* GA3, NAA and BA. Total thirteen treatments were evaluated in the present study *viz.*, T_1: without soaking; T_2: Soaking in 50 ppm GA3; T_3: Soaking in 100 ppm GA3; T_4: Soaking in 150 ppm GA3; T_5: Soaking in 200 ppm GA3; T_6: Soaking in 50 ppm NAA; T_7: Soaking in 100 ppm NAA; T_8: Soaking in 200 ppm NAA; T_9: Soaking in 300 ppm NAA; T_{10}: Soaking in 25 ppm BA; T_{11}: Soaking in 50 ppm BA; T_{12}: Soaking in 100 ppm BA and T_{13}: Soaking in 150 ppm BA. Treatments were evaluated with respect to growth, yield and quality parameters of *Gladiolus*. Among various treatments, soaking in 100 ppm GA3 was found significantly superior to rest of the treatments with respect to growth, spike yield, cormel yield and quality. However, treatment soaking in 100 ppm BA was found significantly superior among all the treatments with respect to maximum number of sprouts per corm and maximum number of corms per plant, per plot and per hectare. On the basis of economics of the treatments, the highest benefit cost ratio and net realization obtained with treatment of GA3 at 100 ppm.

Keywords: *Gladiolus*, GA3, NAA, BA, growth, flowering, corm production, cormel

Introduction
Gladiolus (*Gladiolus grandiflorus*) is one of the most important bulbous flower crops. It is popularly known as "Sword Lily", an ornamental cormelous plant native to South Africa. This plant is commercially used for cut flowers and occasionally used for landscape purpose. The propagating material of *Gladiolus* is called "corm" which is a food-storing underground stem. Upon plantation, *Gladiolus* corm produces on its top a new daughter corm each year and itself shrivels and dies. Thimann, proposed the term phytohormone as these hormones are synthesized in plants (Thimann, 1949) [2]. It is known fact that application of growth regulators such GA3, NAA and BA have positive effects on growth and development of *Gladiolus* plants at different concentrations. GA3 enhance the growth, development and yield of *Gladiolus* at different concentrations, it increases the height of plants, number of flowers and induce early flowering (Uddin *et al.* 2013) [24]. GA3 is very effective for germination, growth promotion, flowering and senescence inhibition (Murti and Upreti, 1995) [9]. BA has major role in plants like cell division, elongation and enlargement, induction of flowering, apical dormance-over coming in present days different treatment are given to *Gladiolus* crop to improving its physiological characters.

Materials and Methods
The present investigation entitled Effect of soaking with plant growth regulators on growth, yield and quality of *Gladiolus (Gladiolus grandiflorus)* to explore the production potential of *Gladiolus* was conducted at College Farm, College of Horticulture, S. D. Agricultural University, Jagudan during *rabi* 2021-22. There were in all thirteen treatments *viz.*, four levels each of GA3 (50, 100, 150 and 200 ppm), NAA (50,100, 200 and 300 ppm) and BA (25, 50, 100 and 150 ppm) including a control, replicated thrice in randomized block design. The corms of uniform size were soaked in required concentration of plant growth regulators thoroughly for twenty-four hours. The planting of corms was done at a distance of 45 x 20 cm and about 5 cm deep in the raised bed accommodating 20 corms per plot. The farm yard

manure (FYM) at the rate of 20 tons per hectare and recommended dose of fertilizer @ 200: 200: 200 NPK kg per hectare were applied. One third quantity of nitrogen in the form of DAP and whole quantity of P_2O_5 and K_2O as basal dose was given in the form of single super phoshphate (SSP) and muriate of potash (MOP) respectively and remaining quantity of nitrogen was applied in the form of urea as top dressing after 40 and 60 days of planting. Uniform and standard cultural practices were followed. Data on sprouting of corms, vegetative growth, flowering and corm production attributes were recorded and analyzed statistically.

Results and Discussion

Growth attributes

The data presented in table 1 indicated that, growth parameters in *Gladiolus viz*., days to sprouting of corms, number of sprouts, plant height (cm) and number of leaves per plant in *Gladiolus* were significantly influenced by growth regulator treatments.

Significantly the earliest sprouting of *Gladiolus* corms (5.60 days) was found in GA3 @ 100 ppm which was statistically at par with GA3 @ 150 ppm (T_4), GA3 @ 200 ppm (T_5) and GA3 @ 50 ppm (T_2).

The maximum number of sprouts (3.87) were recorded by the corms treated with BA @ 100 ppm, which was statistically at par with T_{11} and T_{13}. The minimum number of sprouts (1.07) were recorded under control. This might be due to action of BA which promotes cell division and shoot differentiation resulting into increased number of sprouts per corm (Roy *et al.*, 2017) [12]. These results are in line with Baskaran and Mishra (2007) [25], Khan *et al.* (2011) [6], Baskaran *et al*. (2014) [1] in *Gladiolus*.

Maximum plant height (90.09 cm) was observed in GA3 @ 100 ppm and is at par with GA3 @ 150 ppm (T_4) and GA3 @ 200 ppm (T_5). Whereas, corms treated with BA @ 150 ppm (T_{13}) showed minimum plant height (48.60 cm). Increased plant height was might due to gibberellins, which helps in rapid elongation of internodes, cell division and cell elongation at internodal region as reported by Greulach and Haesloop (1958). The minimum plant height with application of BA might be due to counteracting the apical dominance. Similar results were obtained by Maurya and Nagada (2002) [8], Khan *et al.* (2011) [6], Sajid *et al.* (2015) [14] and Sajjad *et al.* (2015) [15].

Corms treated with GA3 @ 100 ppm (T_3) had maximum number of leaves per plant (15.13) and was at par with T_2, T_4, T_5, T_9, T_{10}, T_{11}, T_{12} and T_{13}. However, minimum number of leaves per plant (7.60) was found in control. The increasing number of leaves per plant under the treatment of GA_3 may be due to GA3 improves the physiological efficiency of the plant such as improvement of rate of photosynthesis, control of transpiration and photorespiration, efficient water and nutrient uptake, control of leaf senescence (Roy *et al*. 2017) [12]. Similar results were obtained by Padmalatha *et al.* (2013) [10] and Sable *et al.* (2015) [13] in *Gladiolus*.

Flower yield

The data on spike yield per plant, per plot and per hectare as influenced by different treatments of growth regulators is presented in table 2. Maximum number of spikes per plant (2.20) were recorded in treatment GA3 @ 100 ppm (T_3) and it was found at par with T_2 and T_5. While control and BA @ 150 ppm (T_{13}) recorded the minimum number of spikes per plant (1.07). The increased spike yield, observed in GA3 treatments might be due to cell elongation and production of maximum food material by enhancing photosynthesis (Chopde *et al.*, 2015) [3]. Similar views have also been expressed by Shyla and Kumar (2021) [17] in *Gladiolus*.

Maximum number of spikes per plot (13.33) and per hectare (1, 58, 741) were recorded in treatment GA3 @ 100 ppm (T_3), which was on par with T_2, T_5 and T_{10}. While BA @ 100 ppm (T_{12}) and BA @ 150 ppm (T_{13}) recorded minimum number of spikes per plot (5.33) and per hectare (71,433).

Corm and cormel production

The data on corm and cormel production per plant, per plot and per hectare as influenced by different treatments of growth regulators is presented in table 3. The number of corms per plant (4.60) was maximum in corms treated with BA @ 100 ppm (T_{12}), which was at par with T_{11} and T_{13}. Whereas, control (T_1) recorded minimum number of corms per plant (1.07). Corms treated with BA @ 100 ppm (T_{12}) recorded maximum number of corms per plot (26.67) and per hectare (3,17,481), while control (T_1) recorded minimum number of corms per plot (6.33) and per hectare (75,402). This might be due to the fact that BA has promoted the sink activity of developing corms and cormels at the expense of flower spike, this might be the reason for increase in number of corms and cormels and poor quality of spikes (Roy *et al.*, 2017) [12]. BA, like other cytokinins characteristically causes more splitting and cell division than increasing the size of corms (Baskaran *et al.*, 2009) [2] in *Gladiolus*. Similar results have been reported by Chopde *et al.* (2015) [3], Singh *et al.* (2020) [18], and Jithendra *et al.* (2009) [5] in tuberose.

Corms treated with GA3 @ 100 ppm (T_3) recorded maximum number of cormels per plant (9.60) and it is found at par with treatment T_2, T_4 and T_5. While control (T_1) recorded minimum number of cormels per plant (4.20). Corms treated with GA3 @ 100 ppm (T_3) recorded maximum number of cormels per plot (56.67) and per hectare (6,74,648), and it was at par with T_2, T_4 and T_5. While control (T_1) recorded minimum number of cormels per plot (26.33) and per hectare (3,13,513).

Flowering and quality attributes

The data on flowering and quality parameters as influenced by different treatments of growth regulators is presented in table 4. Early emergence of spike (56.48 days) was recorded in treatment GA3 @ 100 ppm (T_3) and was statistically at par with T_4, T_2 and T_5. While the emergence of spike was delayed (104.80 days) by corms treated with BA @ 150 ppm (T_{13}). Early spike initiation by GA3 might be attributed to the enhanced vegetative growth early phase due to increased photosynthesis and CO2 fixation. Further exogenous application of GA3 would have favoured the convenience of factors influencing floral initiation *i.e*., carbohydrate pathway and photo periodic pathway with GA3 pathway (Tameshwar and Lal 2017) [21]. Advanced bud formation and onset of flowering in GA3 treated plants are responsible for early flowering (Baskaran *et al.*, 2014) [1]. Corms treated with BA took more time for spike initiation. The reason could be multiple shooting rather than cell elongation (Khan *et al.*, 2011) [6]. The results are in conformity with Kumari *et al.* (2011) [7] and Ramchandrudu and Thangam (2007) [11].

Early harvesting of spike (69.97 days) was recorded in treatment GA3 @ 100 ppm (T_3) and is statistically at par with

T_4, T_2, and T_5. While the harvesting of spike was delayed (115.53 days) by corms treated with BA @ 150 ppm (T_{13}).

Maximum length of spike (80.35 cm) was recorded in the treatment GA3 @ 100 ppm (T_3). However, it was statistically at par with treatment GA3 @ 150 ppm (T_4). Whereas, the minimum length of spike (38.55 cm) was obtained in treatment BA @ 150 ppm (T_{13}). Optimum level of GA3 promoted the efficacy of plants in terms of photosynthetic activity, enhanced uptake of nutrients and their translocation, better partitioning of assimilates into reproductive parts (Sweety *et al*., 2019) [23]. Minimum spike length by BA might be due to it might have enhanced source to sink ratio to corms production by reducing the partition of carbohydrates to the spike (Tameshwar and Lal, 2017) [21]. The similar records were obtained by Sajjad *et al.* (2015) [15], Sudhakar and Kumar (2012) [26], Kumari *et al*. (2011) [7] and Shyla and Kumar (2020) [18].

The maximum length of rachis (42.55 cm) was recorded in the corms which were treated with GA3 @ 100 ppm. Whereas, minimum rachis length (15.60 cm) was obtained in treatment BA @ 150 ppm (T_{13}). This might be due to higher plant height produced consequently long rachis length (Singh *et al*., 2016) [19]. Another reason might be due to action of GA3 which cause stem elongation *i.e.* rapid elongation of internodes due to both cell division and elongation which would result in longest rachis (Srisha and Naik, 2017) [20]. These results are in accordance with findings of Khan *et al.* (2011) [6].

Maximum number of florets per spike (16.00) were recorded in GA3 @ 100 ppm (T_3) which was at par with GA3 @ 150 ppm (T_4) and GA3 @ 200 ppm (T_5). Significantly maximum number of florets per spike were obtained by treatments of GA3, as Gibberellic acid promotes the growth of auxiliary buds and their flowering (Baskaran *et al*., 2014) [1]. While minimum number of florets per spike (4.40) were recorded in treatment BA @ 150 ppm (T_{13}). This might be due to reduced number of nodes which resulted from reduced plant height and spike length, and ultimately reduced rachis length and have minimum number of florets per spike. Similar results have been reported by Khan *et al.* (2011) [6], Sudhakar and Kumar (2012) [26] and Sajid *et al*. (2015) [14].

The maximum vase life period (17.67 days) was recorded in GA3 @ 100 ppm (T_3) and was at par with T_2, T_4, T_5 and T_8. While, the minimum vase life period (8.33 days) was recorded in BA @ 150 ppm (T_{13}). This might be due to reduced water loss and anti- senescence properties. Similar results were found by Sajid *et al.* (2015) [14] and Kumari *et al.* (2011) [7].

Table 1: Effect of plant growth regulators on vegetative growth parameters of *Gladiolus* cv. Punjab dawn

Tr. No.	Treatments detail	Days to sprouting	Number of sprouts	Plant height (cm)	Number of leaves per plant
T_1	Without soaking	11.87	1.07	75.50	7.60
T_2	Soaking in 50 ppm GA3	7.00	1.93	78.71	13.73
T_3	Soaking in 100 ppm GA3	5.60	2.20	90.09	15.13
T_4	Soaking in 150 ppm GA3	5.87	1.53	85.57	12.07
T_5	Soaking in 200 ppm GA3	6.13	2.00	82.51	14.67
T_6	Soaking in 50 ppm NAA	12.53	1.47	72.69	10.87
T_7	Soaking in 100 ppm NAA	13.80	1.33	73.27	9.67
T_8	Soaking in 200 ppm NAA	14.67	1.40	72.25	11.47
T_9	Soaking in 300 ppm NAA	14.47	1.85	76.75	13.00
T_{10}	Soaking in 25 ppm BA	10.73	3.00	67.03	14.53
T_{11}	Soaking in 50 ppm BA	11.27	3.73	63.22	14.93
T_{12}	Soaking in 100 ppm BA	11.67	3.87	57.26	13.53
T_{13}	Soaking in 150 ppm BA	12.53	3.47	48.60	12.13
S.Em. ±		1.08	0.19	3.78	1.08
C.D. (P = 0.05)		3.14	0.55	11.04	3.15
C.V. %		17.54	14.64	9.03	14.86

Table 2: Effect of plant growth regulators on flower yield in *Gladiolus* cv. Punjab dawn

Tr. No.	Treatments detail	Number of spikes		
		Per plant	Per plot	Per hectare
T_1	Without soaking	1.07	6.33	75402
T_2	Soaking in 50 ppm GA3	1.93	11.67	138898
T_3	Soaking in 100 ppm GA3	2.20	13.33	158741
T_4	Soaking in 150 ppm GA3	1.60	10.67	126993
T_5	Soaking in 200 ppm GA3	1.87	12.33	146835
T_6	Soaking in 50 ppm NAA	1.53	9.33	111119
T_7	Soaking in 100 ppm NAA	1.33	7.33	87307
T_8	Soaking in 200 ppm NAA	1.27	8.33	99213
T_9	Soaking in 300 ppm NAA	1.73	10.67	126993
T_{10}	Soaking in 25 ppm BA	1.80	11.33	134930
T_{11}	Soaking in 50 ppm BA	1.20	7.00	83339
T_{12}	Soaking in 100 ppm BA	1.13	6.00	71433
T_{13}	Soaking in 150 ppm BA	1.07	6.00	71433
S.Em. ±		0.13	0.71	8472.3
C.D. (P = 0.05)		0.37	2.08	24728.9
C.V. %		14.46	13.32	13.32

Table 3: Effect of plant growth regulators on corm and cormel production in *Gladiolus* cv. Punjab dawn

Tr. No.	Treatments detail	Number of corms			Number of cormels		
		Per plant	Per plot	Per hectare	Per plant	Per plot	Per hectare
T_1	Without soaking	1.07	6.33	75402	4.20	26.33	313513
T_2	Soaking in 50 ppm GA3	1.93	11.00	130961	9.27	55.00	654806
T_3	Soaking in 100 ppm GA3	2.40	14.00	166678	9.60	56.67	674648
T_4	Soaking in 150 ppm GA3	1.67	10.33	123024	8.80	51.33	611152
T_5	Soaking in 200 ppm GA3	2.27	13.33	158741	8.73	50.33	599246
T_6	Soaking in 50 ppm NAA	1.53	8.67	103181	6.47	39.33	468285
T_7	Soaking in 100 ppm NAA	1.60	9.00	107150	6.87	41.00	488128
T_8	Soaking in 200 ppm NAA	1.73	9.33	111119	7.20	42.67	507970
T_9	Soaking in 300 ppm NAA	2.00	11.00	130961	7.47	44.00	523844
T_{10}	Soaking in 25 ppm BA	3.53	19.33	230174	6.33	38.00	452411
T_{11}	Soaking in 50 ppm BA	4.33	24.33	289702	5.67	34.33	408757
T_{12}	Soaking in 100 ppm BA	4.60	26.67	317481	5.33	31.33	373041
T_{13}	Soaking in 150 ppm BA	4.00	23.33	277796	4.73	28.00	333356
S.Em. ±		0.28	1.48	17676.51	0.65	3.55	42323.31
C.D. (P = 0.05)		0.80	4.33	51594.07	1.88	10.38	123533
C.V. %		18.98	17.91	17.91	16.04	14.87	14.87

Table 4: Effect of plant growth regulators on quality parameters in *Gladiolus* cv. Punjab dawn

Tr. No.	Treatments detail	Days to spike initiation	Days to first harvesting of spikes	Spike length (cm)	Rachis length (cm)	No. of florets per spike	Vase life (days)
T_1	Without soaking	71.81	86.67	62.72	31.86	13.87	14.67
T_2	Soaking in 50 ppm GA3	62.69	74.07	67.80	34.49	14.40	16.67
T_3	Soaking in 100 ppm GA3	56.48	69.97	80.35	42.55	16.00	17.67
T_4	Soaking in 150 ppm GA3	60.97	73.57	74.84	36.98	15.20	16.33
T_5	Soaking in 200 ppm GA3	63.11	76.27	71.23	35.23	15.00	16.00
T_6	Soaking in 50 ppm NAA	72.76	85.07	60.89	31.72	12.67	15.33
T_7	Soaking in 100 ppm NAA	75.47	88.23	62.54	31.73	12.07	14.67
T_8	Soaking in 200 ppm NAA	81.87	92.27	65.52	32.38	10.87	16.00
T_9	Soaking in 300 ppm NAA	79.39	93.28	67.21	33.83	11.27	15.67
T_{10}	Soaking in 25 ppm BA	77.32	89.08	57.61	25.49	9.60	13.00
T_{11}	Soaking in 50 ppm BA	90.60	98.51	48.94	23.07	8.47	12.33
T_{12}	Soaking in 100 ppm BA	99.95	108.97	43.33	20.41	7.33	10.00
T_{13}	Soaking in 150 ppm BA	104.80	115.53	38.55	15.60	4.40	8.33
S.Em. ±		3.26	3.20	2.56	1.80	0.46	0.59
C.D. (P = 0.05)		9.50	9.33	7.46	5.24	1.35	1.74
C.V. %		7.35	6.25	7.21	10.23	6.88	7.18

Conclusion

The study revealed that among different treatments of plant growth regulators GA3 at 100 ppm resulted better vegetative growth, flower quality attributes and number of spikes, cormels and economic returns. Whereas, BA at 100 ppm resulted in maximum corm yield.

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