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Effect of Gibberellic Acid (GA_3) Pretreatment on the Growth and Yield of Tuberose (*Polianthes tuberosa* L.) cv. Single and Double Cut Flower

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ABSTRACT

A premier field research was carried out to study the effect of plant growth regulators GA_3 pretreatment and variety on the growth and yield of tuberose cut flower. The two-factor experiment was laid out with Randomized Complete Block Design (RCBD) with three (03) replications and two factors, viz. variety, i.e. Single (V_1), Double (V_2) and concentration of GA_3 (0, 50, 100, 150 ppm). Data were evaluated with MSTAT-C software package and sums were separated by Duncan's multiple range test (DMRT) at 1% level of significance. Results exhibited that the pretreatment of different concentrations of GA_3 had significantly upgraded different growth and yield parameters. Highest vegetative growth traits in terms of plant height, number of leaves per plant, length and breadth of leaf and yield traits such as length of spike and rachis, the weight of spike, numbers of floret per spike, the diameter of the floret, length of the floret, number of spike per plant, the yield of spike per hectare was observed in double variety and lowest in a single variety. In case of GA_3 concentration, 150 ppm GA_3 pretreated bulbs had the highest vegetative growth and yield traits, while the lowest of above these parameters were perceived with G_1 (control). Combined results of GA_3 and tuberose cultivar (single and double) revealed that double cut flower with 150 ppm GA_3 pretreatment (V_2G_4) had the highest vegetative and reproductive parameters and the lowest growth and yield was obtained from the combination of control with single cut flower (V_1G_1). Therefore, it was concluded that double variety, when combined with 150 ppm GA_3 concentration, proved to be the greatest combination in enhancing all the vegetative and yield characteristics in tuberose.

Keywords: *Gibberellic Acid, Plant growth regulator, Tuberose, Growth and Yield*

INTRODUCTION

Tuberose (*Polianthes tuberosa*) is considered one of the most popular flowering plants of tropical and sub-tropical regions in the family Amaryllidaceous, a native of Mexico, produces attractive, elegant and fragrant white flowers (Amin et al., 2017).

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Today, it is widely cultivated in India, Bangladesh, France, Italy, South Africa, the United States, and many tropical and subtropical regions (Mazed et al., 2015). It has great economic importance for the cut flower market and the essential oil industry. Spikes are suitable as a vase decoration or a cut flower bouquet, while individual florets, on the other hand, are used to make veins, wreaths, buttonholes, or crowns. It has a pleasant scent and is a raw material for tuberose. The natural flower oil of tuberose is one of the most expensive perfume ingredients (Singh et al., 2009). Tuberose flowers have a long shelf life and are commonly used as cut flowers because they stay fresh for a long time, can endure long-distance transportation, and fill a useful niche in the flower industry (Verma & Singh, 2021). Tuberose propagates on tubers having four varieties viz. Single (corolla segment has bears one row), Semi-double (corolla segments have paired to threefold rows), Double (corolla segments have more than threefold rows) and Variegated (with golden striped leaf) (Fatmi & Singh, 2020). In addition to numerous usages, tuberose flowers are becoming progressively attractive to growers and sellers because of the increasing demand for tuberose in the domestic and international markets as cut and loose flowers (Sendhilnathan et al., 2021).

Normal strengths to develop of plant is regulated by naturally occurring chemicals or phytohormones. Thus, large scale production technology needs to be improved, which can be achieved by establishing in vitro techniques, exogenous application of phytochemicals doses, or applying better agricultural techniques to produce tuberose with better quality and extended shelf life (Sadique et al., 2021). Given the foregoing, the use of plant growth regulators to create higher-quality products will become much more significant, benefiting both consumers and producers and marketers (Rani & Singh, 2013; Afsana et al., 2020). Their function can often be increased by the use of synthetic growth-regulating substances or hormones, such as the possible use of growth regulators in flower development, which has recently piqued scientific attention (Libik-Konieczny et al., 2021). Plant growth regulators have been found in several studies to stimulate the growth and development of buds (Wang et al., 2021; Fragoso-Jimenez et al., 2021). At ideal concentrations, plant growth regulators are known to govern and control several stages of growth and development, including flowering. Exogenously applied growth chemicals are thought to work by modifying the amounts of naturally occurring growth regulators, hence affecting plant growth and development. Gibberellins (GA_3) are known to improve plant physiological and morphological growth when applied exogenously (Iqbal et al., 2011). GA_3 treatments have been shown to stimulate a variety of processes throughout plant development, including induced early flowering, increased plant height, leaf number, chlorophyll content, yield, and quality in a variety of flowering crops (Rani & Singh, 2013; Sure et al., 2012). As a result, the purpose of this study was to see how the phytohormone GA_3 pretreatment bulb affected the growth and flowering of two tuberose cultivars in open field circumstances.

MATERIALS AND METHODS

The experiment was conducted at the Landscaping section, Department of Horticulture, Bangladesh Agricultural University, Mymensingh, which is situated at 24.6^0 N latitude and 90.5^0 E longitude in open field conditions under prevailing conditions of silty clay loam soil with pH varying from 5.5-6.8, about 35-19 ^{0}C temperature and 75-85 % relative humidity. Healthy bulbs of tuberose cv. Single and Double variety having a diameter of about 2.0 to 3.0 cm were used for propagation. Bulbs were procured from Jhikargacha Upazila of Jessore district (double variety) and Department of Horticulture, Bangladesh Agricultural University, Mymensingh (Single variety). Afterword's, bulbs were immersed the whole night at four different GA_3 concentrations viz. 0, 50, 100 and 150 ppm concentration and were planted in each plot at a depth of 6 cm after 24 hours. Plants were mulched, irrigated and other inter cultural activities were done at regular intervals. The two factor experiment was carried out in Randomized Complete Block Design (RCBD) with three replications. Numerous growth traits such as plant height, leaves number, length, and diameter; and yield traits such as the spike and rachis length, weight of spike emergence, number and length of florets per spike etc. were recorded. To determine the significance of variation resulting from the experimental treatments, the recorded data on various parameters were statistically evaluated using the MSTAT-C computer package program developed by Russel (1986). The mean of the treatments was obtained, and the F (variance ratio) test was used to do an analysis of variance for each of the characters. The least significant difference (LSD) test was used to determine the significance of the difference between the pairs of treatment means at a 1% level of probability (Gomez & Gomez, 1984).

RESULTS AND DISCUSSION

3.1 Effect of GA_3 on growth parameters of studied tuberose varieties

Plant growth contributing traits of studied variety (single and double) of tuberose were collected at 30, 60 and 90 days after planting showed a statistically significant variation. The results revealed that GA_3 treated tuberose bulbs exhibited a significant effect on all growth attributes. Generally, pretreated tuberose bulbs displayed a significant upsurge in all parameters considering growth compared to controls. Every single factor is important and has great contributions in tuberose growing and yield performances. Both the factors viz., variety and GA_3 concentration altered the studied parameters. Maximum plant height (32.76 cm, 39.82 cm, and 45.67 cm) V_2G_4 was observed with combined effects with GA_3-treated bulb at 150 ppm in double cut flower tuberose variety (Table 2). The plant height declined with the decreasing in GA_3 concentration and single variety. Similarly, GA_3 treatment at 150 ppm gave the maximum number of leaves (11.33, 14.33 and 17.33) V_2G_4 and control with single variety tuberose were observed to have the lowermost number of leaves /plant (5.33, 7.33 and 10.33) V_1G_1. Individually the highest plant height were noted from double variety (V_2) of tuberose at 30, 60 and 90 days, respectively, whereas the shortest were found from single variety (V1) at 30, 60 and 90 days after planting, respectively (Table 2). In combination with the effect of variety and GA_3 concentration showed significant difference in all the observations. The maximum (17.33) leaves/plant was attained from the treatment combination of 100 ppm and 150 ppm from double variety (V_2G_3 and V_2G_4) whereas the minimum (10.33) was obtained from control condition of single variety (V_1G_1) (Table 2). Planting different variety of tuberose had significant influence on length of leaves which was found to be gradually increasing trend in length of leaves of tuberose at 30, 60 and 90 days after planting. The maximum leaf length (41.56 cm) was documented from double variety (V_2) while the minimum (38.00 cm) was recorded from single variety (V_1) at 90 days after planting (Table 1). On the other hand, the maximum leaf length (44.20 cm) was recorded from 150 ppm (G_4) and minimum (31.68 cm) was found from control (G_1) at 90 days after planting (Table 1). Similarly, when the cumulative effect of variety and GA3 concentration was considered, the treatment combination of double variety and 150 ppm (V2G4) yielded the longest leaf length (45.67 cm) of tuberose 90 days after planting, while the single variety and control condition yielded the shortest (30.50 cm) (V1G1) (Table 2). According to Taiz and Zieger (1998), increased plant growth features may be owing to an increase in auxin levels, which causes improved cell division and elongation. In other research, it was discovered that GA3 and auxin have a relationship in inter biosynthesis, enhancing their concentration and, as a result, assisting in growth improvement via enzyme activation (Zhang et al., 2020; Pan et al., 2010).

Table 1. Individual effect of variety and GA_3 concentration on growth contributing characters of tuberose

GA_3 concentration ppm	Leaf length (cm)	Breadth of leaves (cm)	Variety	Leaf length (cm)	Breadth of leaves (cm)
G_1 -0	31.68	1.62	Single	38.00	1.78
G_2 -50	39.20	1.80	Double	41.56	1.99
G_3 -100	44.03	2.05			
G_4 -150	44.20	2.08			
$LSD_{0.05}$	0.95	0.06		0.67	0.04
$LSD_{0.01}$	1.32	0.08		0.93	0.05
Level of significance	**	**		**	**

** = Significant at 1% level of probability

Table 2. Combined effects of variety and GA_3 concentration on growth contributing characters at different days after planting of tuberose

Treatment combination	Plant height (cm) at DAP			No. of leaves/plant at DAP			Leaf length (cm)	Breadth of leaves (cm)
	30	60	90	30	60	90	60	60
V_1G_1	26.11	30.20	34.24	5.33	7.33	10.33	30.50	1.53
V_1G_2	29.18	34.42	41.96	7.33	10.00	12.67	36.17	1.73
V_1G_3	30.42	36.54	44.83	7.67	12.33	14.67	42.60	1.93
V_1G_4	30.53	36.62	44.98	7.67	12.33	14.67	42.73	1.93
V_2G_1	27.52	33.41	38.72	6.67	9.33	11.67	32.87	1.70
V_2G_2	30.64	36.55	43.85	8.67	12.33	14.33	42.23	1.87
V_2G_3	32.50	39.60	46.55	11.00	14.33	17.33	45.47	2.17
V_2G_4	32.76	39.82	46.76	11.33	14.33	17.33	45.67	2.23
$LSD_{0.05}$	0.38	0.25	0.92	0.64	0.15	0.35	1.35	0.08
$LSD_{0.01}$	0.53	0.35	1.28	0.89	0.20	0.48	1.87	0.11
Level of significance	**	**	**	**	**	**	**	*

** = Significant at 1% level of probability, * = Significant at 5% level of probability, V_1 = Single, V_2 = Double, G_1 = 0 ppm, G_2 = 50 ppm, G_3 = 100 ppm, G_4= 150 ppm

3.2 Effect of GA_3 on yield parameters of studied tuberose varieties

There was a significant variation due to variety and concentration of GA_3 in respect of yield attributes such as length of spike and rachis, diameter of single spike, fresh weight of spike, number of floret per spike, diameter of floret, number of bulblets per plant, number of spike per plant, length of floret, number of spike per m^2, number of spike per hectare in the same reproductive growth stages. The different variety of tuberose had significant effect on yield parameters which was the highest length of spike (72.11 cm) and rachis (28.77 cm), weight of spike (44.43 g), number of floret per spike (31.25), diameter of floret (4.80 cm), length of floret (5.33 cm), number of bulblets per plant (16.52), number of spike per plant (1.73), number of spike per m^2 (27.68) and per hectare (276.78) thousand was observed by planting double variety of tuberose (V_2) while the lowest the lowest length of spike (63.85 cm) and rachis (23.13 cm), weight of spike (37.77 g), number of floret per spike (24.48), diameter of floret (3.77 cm), length of floret (5.06 cm), number of bulblets per plant (13.84), number of spike per plant (1.53), number of spike per m^2 (24.38) and per hectare (243.42) thousand was observed by planting single variety of tuberose (V_1) (Table 3 & 4). Similarly, different concentration of GA_3 have significantly influenced on plant yield traits. The longest (73.17 cm) length of spike, longest length of rachis (28.48 cm) and maximum (31.17) number of floret per spike was recorded from G_4 (150 ppm) while the shortest (60.81 cm) length of spike, shortest length of rachis (21.41 cm) and minimum

(23.07) number of florets per spike was obtained in control condition (G_1-0 ppm). Similarly, in case of all the other parameters, the maximum yield results were recorded from G_4 (150 ppm GA_3) and the minimum was obtained from control (G_1). Table 5 evidently directed that 150 ppm concentrations of GA_3 and double tuberose variety understudy succeeded in respect of all the yield attributes viz., length of spike and rachis, diameter of single spike, fresh weight of spike, number of floret per spike, diameter of floret, number of bulblets per plant, number of spike per plant, length of floret, number of spike per m^2, number of spike per hectare as compared to control with single variety.

When comparing early appearance flowering where incase of 150 ppm GA_3 compared to control plant which took maximum days for flowering might be due to prompt flower primordial development, improved cell differentiation and proper utilization of nutrients. The increase in spike length and rachis length could be attributable to an increase in intercalary meristem cell division and cell elongation, resulting in fast internode elongation (Shankar et al. 2011). Higher concentrated GA_3 might have reduced the vegetative period, resulting in induction of early flower development. Research supported that, GA_3 treatments at the highest concentration significantly shortened the time taken from planting to flowering in *Polianthes tuberosa* L. (Arsha et al., 2021; Asil et al., 2011). According to Arsha et al. (2021), Plant growth regulators are important for vegetative propagation, abscission suppression, bud dormancy prevention, growth control, flowering stimulation, floral vase life extension, and senescence retardation. GA_3 are natural plant growth regulators that contain tetracyclic, diterpenoid chemicals that are commercially employed to increase yield and morpho-physiological features in a variety of ornamental and vegetable crops (Arsha et al., 2021; Al-Dur & Al-atrakchii, 2021). Favorable effect of application of gibberellins on number of florets and floret diameter might be due to improve physiological efficiency, selective ion absorption, sufficient water absorption causing a high storage deposition rate.

Table 3. Individual effect of Variety and GA_3 concentration on yield contributing characters of tuberose

GA_3 concentration (ppm)	Spike Length (cm)	Rachis Length (cm)	No. of florets per spike	Diameter of florets (cm)	Length of floret (cm)	No. of bulblets/plant	**Variety**	Rachis Length (cm	No. of florets per spike	Diameter of florets (cm)	Length of floret (cm)	No. of bulblets per plant
G_1- 0	60.81	21.41	23.07	3.89	4.90	12.45	Single	23.13	24.48	3.77	5.06	13.84
G_2- 50	65.27	25.68	26.13	4.20	5.13	15.17	Double	28.77	31.25	4.80	5.33	16.52
G_3 -100	72.68	28.22	31.10	4.51	5.38	16.50						
G_4 -150	73.17	28.48	31.17	4.54	5.36	16.60						
$LSD_{0.05}$	1.05	0.43	0.79	0.12	0.04	0.44		0.56	0.09	0.03	0.31	0.74
$LSD_{0.01}$	1.45	0.59	1.10	0.17	0.05	0.61		0.78	0.12	0.04	0.43	1.03
Level of significance	**	**	**	**	**	**		**	**	**	**	**

** = Significant at 1% level of probability

Table 4. Individual effect of variety and GA_3 concentration on yield contributing characters of tuberose

GA_3 concentration	No. of spike/plant	No. of spike per m^2	No. of spike/ha (Thousand)	Wt. of spike (g)	Variety	No. of spike/plant	No. of spike per m^2	No. of spike/ha (Thousand)	Wt. of spike (g)
G_1- 0	1.24	19.87	198.72	36.71	Single	1.53	24.38	243.42	37.77
G_2- 50	1.53	24.50	244.97	40.02	Double	1.73	27.68	276.78	44.43
G_3 -100	1.86	29.86	297.73	43.68					
G_4 -150	1.89	29.90	298.97	43.99					
$LSD_{0.05}$	0.08	0.74	3.15	0.50		0.06	0.52	2.23	0.35
$LSD_{0.01}$	0.11	1.02	4.37	0.69		0.08	0.72	3.09	0.49
Level of significance	**	**	**	**		**	**	**	**

** = Significant at 1% level of probability, G_1 = 0 ppm, G_2 = 50 ppm, G_3 = 100 ppm, G_4 = 150 ppm

Table 5. Combined effects of variety and GA_3 concentration on growth and yield contributing characters of tuberose

Treatment combination	No. of spike/plant	No. of spike per m^2	Wt. of spike (g)	Length of spike (cm)	Length of rachis (cm)	No. of florets per spike	Diameter of florets (cm)	Length of floret (cm)	No. of bulblets per plant
V_1G_1	1.09	17.43	33.23	58.50	18.07	21.07	3.50	4.73	10.46
V_1G_2	1.39	22.28	36.22	60.92	22.40	23.70	3.78	4.96	13.78
V_1G_3	1.80	28.92	40.75	67.83	25.93	26.67	3.90	5.29	15.56
V_1G_4	1.85	28.91	40.88	68.15	26.13	26.50	3.91	5.24	15.56
V_2G_1	1.40	22.31	40.19	63.11	24.75	25.07	4.28	5.08	14.44
V_2G_2	1.68	26.72	43.82	69.63	28.96	28.57	4.62	5.29	16.56
V_2G_3	1.92	30.80	46.61	77.53	30.51	35.53	5.11	5.47	17.44
V_2G_4	1.93	30.89	47.10	78.18	30.84	35.83	5.17	5.48	17.64
$LSD_{0.05}$	0.11	1.04	0.70	1.48	0.60	1.12	0.18	0.06	0.62
$LSD_{0.01}$	0.15	1.45	0.98	2.06	0.84	1.56	0.24	0.08	0.86
Level of significance	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability, V_1 = Single, V_2 = Double, G_1 = 0 ppm, G_2 = 50 ppm, G_3 = 100 ppm, G_4 = 150 ppm

CONCLUSION

GA3, a plant growth regulator, has a significant impact on plant growth and yield contributing characteristics. The purpose of this study was to see how GA_3 and variety affected tuberose growth, flowering, and quality flower output. From our research outcomes, it was established that GA_3 at 150 ppm and double tuberose variety ascertained to be the best combination in enhancing all the vegetative (plant height, number of leaves per plant, length and breadth of leaf), reproductive growth (length of spike and rachis, weight of spike, number of floret per spike, diameter of floret, length of floret, number of spike per plant, yield of spike per hectare) and bulblets traits in tuberose. GA_3 also resulted in premature blossoming and higher shelf life which are considered as the main contributing features for floriculture trades. Improved performance of tuberose with GA_3 was possible due to its application in stimulating photosynthetic enzymes, and cell elongation, high light capturing ability that upregulate photosynthetic rate and proficient nutrient management. Further biochemical and molecular analysis could ensure the exact role of GA_3 and variety on improving growth and yield attributing traits.

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Md. Abdur Razzak: Conceptualization, Data curation, writing original draft. **Md. Habibur Rahman:** Supervision; funding acquisition;

Investigation; Methodology; Project administration; Resources; Validation; Visualization, Data curation, **Md. Mokter Hossain:** Investigation, Supervision Writing – review & editing. **Md. Najmol Hoque:** Methodology, Formal analysis, Writing – review & editing.

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