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Effect of different plant growth regulators on growth, flowering and quality of tuberose (*Polianthes tuberosa* L.) cv. GKTC-4 under Prayagraj agro-climatic conditions

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Abstract
An experiment entitled Effect of different plant growth regulators on the growth, flowering an quality of tuberose (*Polianthes tuberosa* L.) cv. GKTC-4 under Prayagraj agro- climatic conditions was conducted in Horticulture Research Field, Faculty of Agriculture, Department of Horticulture, Naini Agricultural Institute, SHUATS, Prayagraj during April 2022-March 2023 with an aim to identify the most suitable plant growth regulator under the agro climatic conditions of Prayagraj. There were ten treatment replicated thrice in spacing of 0.3 m x 0.3 m randomly. Significant difference in different treatments of tuberose were recorded for all the parameters observed**.** From the present investigation, it is concluded that among the different treatments, the treatment T_3- GA3 @ 300 ppm was found in superior in terms of plant height (55.27 cm), plant spread (58.56 cm^2), Days to bud initiation (21.33 days), days taken for first flower opening from planting (36.66 days), spike length (74.86 cm), Rachis length (44.60), No. of florets (49.73), Diameter of Florets (4.51 cm), Weight of florets(2.06 g) Shelf-life (3.77 days), spike yield per plant (3.46) and flower yield for 1 ha (28.263 ton), Spike per ha (2,80,800). Among the different treatments, the highest gross return is 14, 69, 520 Rs/ha, Net return is 8, 79, 384 Rs/ha and benefit cost ratio is 2.49, obtained under the use of GA3 @300 ppm in the treatment T_3.

Keywords: Tuberose, treatment, PGRs

Introduction
Tuberose (*Polianthes tuberosa*) is a widely cultivated ornamental and aromatic plant known for its highly fragrant flowers. This review provides a comprehensive overview of the botanical, agronomic, and commercial aspects of tuberose cultivation. Originating from Mexico, tuberose spread to various parts of the world, including Europe, Africa, and Asia, during the 16th century. Its introduction to India is believed to have been facilitated by the British. The plant is characterized by long, narrow leaves and tall flowering stalks bearing clusters of waxy white flowers with a strong fragrance. Tuberose varieties are classified based on flower type: single, semi-double, double, and variegated. Various cultivars, such as Mexican, Calcutta, and Hyderabad, have been named after their place of origin or cultivation.

Tuberose is a half-hardy bulbous crop that thrives in mild climates with temperatures ranging from 20-35 °C, preferably with high humidity. It is commercially grown in several regions of India, including West Bengal, Karnataka, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, and limited areas of Haryana and Punjab. The production of tuberose flowers depends on climatic conditions, soil fertility, and agronomic practices. Under optimum conditions, a single hectare of tuberose can yield about 5,00,000 flower spikes or 10.5 tonnes of loose flowers. Despite its commercial importance, tuberose faces challenges in seed setting, particularly in single-flowered cultivars. However, variegated cultivars exhibit a higher degree of seed setting. The exact reasons for poor seed setting remain unclear but may be attributed to factors such as lack of pollinizers. Tuberose flowers are not only prized for their ornamental value but also for their essential oil, which is rich in compounds such as geraniol, nerol, and eugenol. The oil is extracted using solvents like hexane and is used in perfumery and aromatherapy.

This review concludes with a discussion on the genetic and chromosomal characteristics of tuberose, highlighting its close relation to other species within the Polianthes genus. Future research directions are proposed to address the challenges in tuberose cultivation and to explore its potential applications in various industries.

Materials and Methods

A field experiment entitled "Effect of different plant growth regulators on growth, yield and quality of tuberose (*Polianthes tuberosa* L.) c.v. GKTC-4"" under Prayagraj agroclimatic conditions" have been describes in this chapter. Experiment was carried out at the experimental field of the Department of Horticulture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P to find out most suitable plant growth regulator on growth, flowering and yield of tuberose. The experiment was conducted in Randomized Block Design with 9 treatment in three replications *viz.* T_0: CONTROL, T_1: GA3 @100ppm, T_2: GA3@200ppm, T_3: GA3@300ppm, T_4: CCC@1000ppm, T5: CCC@1500ppm, T_6: CCC@2000ppm, T_7: TRIA@4ppm, T_8: TRIA@6ppm, T_9: TRIA@8ppm. Crop was planted with the spacing of 30 cm × 30 cm.

Results and Discussion

Vegetative Parameters of Different Treatments on tuberose Variety

Plant height and plant spread

The investigation conducted at the Horticulture Research Field, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P.) from April 2023 to March 2024 revealed significant differences among tuberose varieties concerning plant height, and plant spread.

Among the treatments, treatment GA3@ 300ppm recorded significantly taller (55.27 cm), which was found to be followed by with TRIA@ 4ppm (52.13 cm) whereas, shorter plants (33.27 cm) water spray. These result are in agreement to those reported by the (Dhumal *et al*., 2018) [9].

Among the treatments, treatment GA3@ 300ppm recorded significantly more plant spread (58.56 cm^2), which was found to be followed by with TRIA@ 4ppm (57.7 cm^2) whereas, lesser plant spread (42.8cm^2) was recorded in Control (water spray). Significant variation in plant spread observed the among different varities may be attributed to hereditary traits and their manifestation in a given set of environmental condutions. These result are in agreement to those reported by the (Dhumal *et al*., 2018) [9].

Floral parameters of different varieties of tuberose

Days to First Spike Initiation and First Flowering

The minimum Days to bud initiation was observed with T_3- GA3 @ 300 ppm (21.33) which was at par with T_7- TRIA @4 ppm (23.22) whereas, maximum number of days was reported in T_0- Water spray (27.22).

The minimum Days taken for first flower opening from planting was observed with T_3- GA3 @ 300 ppm (36.66) which was at par with T_7- TRIA @4 ppm (36.88) whereas, maximum was reported in T_0- Water spray (48.4).

Early bud initiation may be attributed to higher photosynthetic assimilation due to vigorous plant growth, a factor governed by genetic composition of different varieties and impact of the growing environment. The data for early bud initiation in conformity with the findings of (Gawai *et al*., 2009) [8] and (Dalvi *et al*., 2021) [3].

Rachis and Spike Length

The maximum Rachis length (cm) was observed with T_3- GA3 @ 300 ppm (44.60) which was at par T_7- TRIA @4 ppm(41.86) whereas, minimum was reported in T_0- Water spray (22.46).

The maximum Flower spike length (cm) was observed with T_3- GA3 @ 300 ppm (74.86) which was at par with T_7- TRIA @4 ppm (73.40) whereas, minimum was reported in T_0- Water spray (59.20).

Rachis and spike length are genetically controlled traits and varies with genetic make- up of the varieties and the prevailing environmental conditions. Variation in rachis length in different treatment is also observed by (Amin *et al*., 2017) [2] and (Lakshmi *et al*., 2019) [1].

Number of Florets per Spike

The maximum Number of florets was observed with T_3- GA3 @ 300 ppm (49.73) which was at par with T_7- TRIA @4ppm (45.86) whereas, minimum was reported in T_0- Water spray (37.60).

Number of florets are genetically herited characters. This variation in number of florets may be due to among the different treatment of PGRs and prevailing environmental conditions. Variation in number of florets among the treatments was also reported (Patil *et al.*, 2009) [4].

Diameter of florets

The maximum Diameter of florets (cm**)** was observed with T_3- GA3 @ 300 ppm (4.51) which was at par with T_7- TRIA@4 ppm (4.46) whereas, minimum was reported in T_0- Water spray (4.10).

Diameter of florets are genetically herited characters. This variation in diameter of florets may be due to among the different treatment of PGRs and prevailing environmental conditions. Variation in number of florets among the treatments was also reported (Patil *et al.*, 2009) [4].

Weight of florets

The maximum Weight of florets (g) was observed with T_3- GA3 @ 300 ppm (2.06) which was at par with T_7- TRIA @4ppm (1.93) whereas, minimum was reported in T_0- Water spray (1.40).

Weight of florets are genetically herited characters.

This variation in weight of florets may be due to among the different treatment of PGRs and prevailing environmental conditions. Variation in number of florets among the treatments was also reported (Patil *et al.*, 2009) [4].

Shelf Life

The maximum Shelf life was observed with T_3- GA3 @ 300 ppm (3.77) which was at par with T_7- TRIA @4 ppm (3.66) whereas, minimum was reported in T_0- Water spray (2.33).

The variation in shelf life might be due to temperature that reduces the entire metabolism of the tissues, slows down the respiration and transpiration, ethylene action and retards the multiplication of bacteria and fungi. This observation is in the accountance with the (Kumar *et al*., 2018) [10].

Number of spike per plant

The maximum Number of spike per plant was observed with T_3- GA3 @ 300 ppm (3.46) which was at par with T_7- TRIA @4 ppm (3.20) whereas, minimum was reported in T_0- Water spray (2.46).

The variation in the total number of spike per clump might be attributed to the difference.

In utilization of nutrients by plants or the effect of cultural practices like hoeing and the genetic composition and environmental circumstances may also be directly connected to the variance in the number of spikes per plant. Similar finding is also observed by (Sobhana *et al.*, 2000) [6].

Spike per hectare of tuberose: The maximum Number of spike per hectare was observed with T_3- GA3 @ 300 ppm (2,80,800) which was at par with T_7-TRIA @4 ppm (2,59,200) whereas, minimum was reported in T_0- Water spray (1,99,800).

The variation in the total number of spike per hectare might be attributed to the difference in utilization of nutrients by plants or the effect of cultural practices like hoeing and the genetic composition and environmental circumstances may also be directly connected to the variance in the number of spikes per hectare (Maheshwari *et al.*, 2018) [11].

Table 1: Vegetative Parameters of Different Treatments on tuberose Variety

Treatments	Plant Height	Plant Spread
Control	33.27	42.800
GA3 @100ppm	40.00	48.520
GA3@200ppm	41.67	47.700
GA3@300ppm	55.27	58.567
CCC@1000ppm	41.87	49.067
CCC@1500ppm	42.13	43.767
CCC@2000ppm	40.80	48.933
TRIA@4ppm	52.13	57.700
TRIA@6ppm	41.20	51.033
TRIA@8ppm	38.53	44.267
F-Test	S	S
SE(d)	3.55	3.219
CD (5%)	7.47	6.816
CV	10.20	8.008

Table 2: Floral Parameters of Different Treatments on tuberose Variety

Treatments	Days to first bud initiation after treatment	Days to first flowering after treatment	Rachis length	Spike length	No. of Florets per spike	Diameter of florets
Control	27.222	48.400	22.467	65.467	37.600	4.100
GA3 @100ppm	22.444	42.883	32.067	65.267	40.667	4.167
GA3@200ppm	23.889	39.400	32.400	74.867	43.333	4.413
GA3@300ppm	21.333	36.666	44.600	61.333	49.733	4.513
CCC@1000ppm	26.222	42.440	31.400	59.667	39.733	4.353
CCC@1500ppm	25.889	40.663	22.867	63.000	39.800	4.297
CCC@2000ppm	26.889	41.663	35.667	73.400	39.267	4.303
TRIA@4ppm	23.222	36.883	41.867	73.400	45.867	4.467
TRIA@6ppm	25.889	39.547	29.400	62.533	38.867	4.127
TRIA@8ppm	26.222	41.107	33.933	59.200	40.000	4.213
F-Test	S	S	S	S	S	S
SE(d)	0.644	0.829	3.281	4.173	1.309	0.046
CD (5%)	1.363	1.755	6.894	8.768	2.713	0.098
CV	3.164	2.478	12.302	7.8390	3.864	1.313

Treatments	Weight of florets	Shelf life	Spike yield per plant
Control	1.400	2.330	2.467
GA3 @100ppm	1.627	2.440	2.600
GA3@200ppm	1.842	2.440	3.000
GA3@300ppm	2.063	3.773	3.467
CCC@1000ppm	1.587	2.663	2.667
CCC@1500ppm	1.698	2.663	2.733
CCC@2000ppm	1.740	2.330	2.800
TRIA@4ppm	1.933	3.663	3.200
TRIA@6ppm	1.479	2.550	2.733
TRIA@8ppm	1.616	2.550	2.767
F-Test	S	S	S
SE(d)	0.085	0.242	0.120
CD (5%)	0.180	0.508	0.254
CV	6.145	10.813	5.159

Conclusion

From the present investigation, it is concluded that among the different treatments, the treatment T_3- GA3 @ 300 ppm was found in superior in terms of plant height (55.27cm), plant spread (58.56 cm^2), Days to bud initiation (21.33 days), days taken for first flower opening from planting (36.66 days), spike length (74.86 cm), Rachis length (44.60), No. of florets (49.73), Diameter of Florets (4.51cm), Weight of florets(2.06g) Shelf-life (3.77 days), spike yield per plant (3.46) and flower yield for 1 ha (28.263 ton), Spike per ha (2,80,800). Among the different treatments, the highest gross return is 14,69,520 Rs/ha, Net return is 8,79,384 Rs/ha and benefit cost ratio is 2.49, obtained under the use of GA3 @300 ppm in the treatment T_3. Hence, GA3 @ 300 ppm can be recommended for plant growth, yield and quality of Tuberose (*Polianthes tuberosa*) cv. GKTC-4.

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Competing Interests

Authors have declared that no competing interests exist.

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