Effect of Plant Growth Regulators on Growth and Flower Yield of Lisianthus (Eustoma grandiflorum) Under Prayagraj Agro-Climatic Conditions

ABSTRACT

An experiment was carried out under naturally ventilated polyhouse conditions, Department of Horticulture, SHUATS, Prayagraj, during November, 2023 to April, 2024. The experiment was laid out in Completely Randomized Design (CRD) with three replications. There were ten treatments comprising of CCC, GA3, NAA at different concentrations viz., GA3 (100, 200, 300) ppm and CCC (250, 500, 750) ppm and NAA (30, 45, 60) ppm along with control. The results revealed foliar application of 300 ppm GA3 for Lisianthus, significantly enhanced the treatment T_3 - GA_3 @300 ppm was found in superior among other treatments in terms of Plant height (20.66cm), number of leaves (33.06), plant spread (11.3cm), stem diameter (3.23cm), leaf area(15.43cm^2), bud length (2.62cm), number of buds per plant (6.43), stalk length(5.70cm), Number of flowers per plant(6.43), number of branches per plant (3.12),chlorophyll content (66.10), minimum number of days for bud initiation(122.50), Flower yield per plant(6.43), flower yield per 250m^2 (40187.50), benefit cost ratio (4.08) per 250m^{2}was also observed in T_3 - GA_3 @300 ppm.

Keywords: Lisianthus, NAA, GA3, CCC, Polyhouse.

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1. INTRODUCTION

Eustoma grandiflorum Shinn. Syn. *Lisianthus russelianus* Hook., (2n=36) belongs to family Gentianaceae. Lisianthus is also known as ‗Texas Blue Bell'and Prairie Gentian (Halevy and Kofranek, [1]). Eustoma is named after the two Greek words Eu (beautiful, good, well), and stoma (mouth). Although delicate and soft-hued in style, Lisianthus flowers boast powerful symbolism. This floral species represents charisma, appreciation, and gratitude. It mainly used for beautification, bouquets, showy purposes and decorating walls, fences, gates, hedges. It is not only popular as a cut flower but also a bedding plant and a pot plant in the market (Grueber [2] and Harbaugh [3]). Lisianthus *(Eustoma grandiflorum [Raf.] Shinn*) is an ornamental species that has acquired great importance due to the attractiveness of its flowers, bright colours and long vase life. As cut flower, its acceptance in the international markets has increased in recent years and currently it is among the 10 most sold flowers in the world. It is a plant native to the northern states of Mexico and southern United States of America

(Domı´nguez-Ramı´rez [4]. Lisianthus is an annual or biannual species; the period from sowing to flowering can be divided into two stages. The first one is from seed germination up to the liners are ready for transplant; in this stage, the plants form a rosette with four leaf pairs. The second stage begins with the elongation of the stems and ends with flowering. Lisianthus has been ranked one of the lucrative and expensive cut flowers in the world. It has a great cosmopolitan demand mainly for its large and attractive flowers, long and hard stem, wide range of colors specially have purple, blue, lavender and has a long vase life which are the common traits of an ideal and best quality cut flower. Lisianthus, herbaceous annual growing to 15 to 60 cm tall, with bluish green, slightly succulent leaves. These are having large funnel-shaped flowers growing 32on long straight stems, sometimes erect single stems, other times growing on branching stems that can rise to be eighteen feet tall. The flowers can grow up to two inches across and can be found in a variety of colors. Lisianthus are long-stemmed flowers in cymes, with often only a few openings at a time. Sepals on Lisianthus are only fused close to the base and are much smaller than petals Namratha et al. [5]. In Tamil Nadu, production of lisianthus is concentrated in limited area in the hill stations namely, Ooty and Kodaikanal. Lisianthus is a crop which has immense potential as cut flower and pot plant (katharai et al. [6]). Research work on the use of Gibberellic acid, CCC, NAA plays a vital role in improving the vegetative growth characters of the plants as they enhance the elongation and cell division by promoting the DNA synthesis in the cell. It reduced the juvenile phase due to increase in photosynthesis and respiration with enhanced CO2 fixation in the plant Thirumal et al. [7] Gibberellic acid (GA3) is endogenous plant hormone, belongs to gibberellinsgroup and takes part in various metabolic processes (Eason [8]**)** GA3 is mostly known to enhance the production of hydrolyses (α-amylase) in the endosperm of cereals (Kolumbina.et.al., [9]

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ie variety was
planted on polythene bags. The bags were filled with a mixture of soil, vermicompost, FYM and cocopeat in the ratio of 1:1:1:1. Before planting the seedling in the polythene bags, soil was treated with fungicide, i.e. Copper oxychloride @ 2%. During transplanting potting media was pressed firmly around the seedlings so that they do not get disturbed after irrigation. The experiment was conducted in Completely Randomized Design (CRD) with 10 treatments and three replications. Also in this experiment, plant was sprayed with Gibberellic acid (GA_3) (at 100, 200, 300 ppm), cycocel (CCC) (at 250, 500, 750 ppm) and Naphthalene Acetic Acid (NAA)(at 30, 60, 90 ppm). The treatments were sprayed at 30, 60, 90, 120, 150 days of

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intervals, three plants were selected randomly from each treatment per replication and their observation were recorded at 30 days intervals.

Table 1. Treatment details

SI.No.	Treatment	Notation
1	T_O	Control
2	T_1	GA3 @100 ppm
3	T_2	GA3 @200 ppm
4	T_3	GA3 @300 ppm
5	T_4	Cycocel @250ppm
6	T_5	Cycocel @500ppm
7	T_6	Cycocel @750ppm
8	T_7	NAA @30 ppm
9	T_8	NAA @45 ppm
10	T_9	NAA @60 ppm

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3. RESULT AND DISSCUSSION

Effect of different concentration of vegetative, flowering, yield and economic parameters are presented in table 2, 3, 4 and 5 respectively.

3.1 Vegetative parameter

3.1.1 Plant height (cm)

The data on vegetative parameters are given in table 2. It is clear from the table that significant difference among the treatments for plant height (cm) of lisianthus. Maximum Plant height (cm) was observed with T_3 - GA_3 @300ppm (20.66 cm) which was at par with T7- CCC @750 ppm (18.19 cm) whereas, minimum was reported in T_0 - Control (13.86 cm). These are similar finding reported by Kathari [6] in lisianthus. and Aparna [10] reported GA3 induce m-RNA synthesis pertaining to hydrolytic enzymes, which promotes mitotic activity in apical meristem and increase cell division and cell elongation, leading to increased length of internodes, in turn increases the plant height. Providing conductive environment inside the naturally ventilated polyhouse at night time helped in better plant height also.

3.1.2 Number of leaves per plant

The data on vegetative parameters are given in table 2. It is clear from the table that significant difference among the treatments for number of leaves per plant of lisianthus. Maximum number of leaves per plant was observed with T_3 - GA_3@300ppm (33.06) which was at par with T_9 - NAA @60 ppm (29.40) whereas, minimum was reported in T_4- CCC @250ppm (25.0). The higher number of side shoots is also associated with higher number of leaves. Similar trend was also observed previously in chrysanthemum Habiba et al. [11] and he reported GA3 influencing the increased vegetative growth by increasing cell division and cell elongation is the reason behind the production of a greater number of leaves per plant

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3.1.3 Plant Spread (cm^2)

The data on vegetative parameters are given in table 2. It is clear from the table that significant difference among the treatments for plant spread (cm^2) of lisianthus. Maximum Plant Spread (cm^2) was observed with T_3 - GA_3 @300 ppm (11.3 cm^2) which was at par with T_5 - CCC @500 ppm (9.54 cm^2) whereas, minimum was reported in T_0 - Control (7.96 cm^2). This might be attributed to the higher concentration of GA3, which is more efficient in cell multiplication and elongation of immature tissues, whereas lesser quantities were less favourable. Palei [13]and Doddagoudar [12] comparable results reported that the application of plant growth regulators enhances cell division with rapid internode elongation and is confined in the sub-apical meristem, which increases the plant spread.

3.1.4 Number of branches per plant

The data on vegetative parameters are given in table 2. It is clear from the table that significant difference among the treatments for number of branches per plant of Lisianthus. Maximum number of branches per plant was observed with T_3 - GA_3 @300 ppm (3.12) which was at par with T_2 - GA_3 @200 ppm (2.35) whereas, minimum was reported in T_9- NAA @60ppm (1.87). The increase in number of branches per plant application of GA3 may be ascribed to increase cell division and cell enlargement, promotion of protein synthesis in the plant. Stimulation of branching may also be attributed to the breakage of apical dominance.

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3.1.5Chlorophyll content

The data on vegetative parameters are given in table 2. It is clear from the table that significant difference among the treatments for chlorophyll content of Lisianthus. The maximum Chlorophyll content was observed with T_3 - GA_3 @300 ppm (66.10) which was at par with T_7- NAA @30 ppm (64.61) whereas, minimum was reported in T_1- GA_3 @100ppm (60.70). Changes in chlorophyll content caused by growth regulators may be attributed to decrease chlorophyll breakdown and enhance the chlorophyll synthesis.

3.1.6 Stem diameter (cm)

The data on vegetative parameters are given in table 2. It is clear from the table that significant difference among the treatments for stem diameter (cm) of lisianthus. The maximum Stem diameter (cm) was observed with T_3 - GA_3 @300ppm (3.23 cm) which was at par with T_8- NAA @45 ppm (2.53 cm) whereas, minimum was reported in T_0 - Control (1.85 cm). Increase in stem diameter is directly proportional to increase in plant height. The maximum plant height was obtained in T3 which may have been led to maximum diameter of stem T3. With the increase in the concentration of GA3 diameter increases due to a reflection of the stimulation of cambium and its immediate cell progeny. Similar Doddagoudar [12], reported comparable results in marigold.

3.1.7 Maximum Leaf area (cm^2)

The data on vegetative parameters are given in table 2. It is clear from the table that significant difference among the treatments for maximum leaf area (cm^2) of lisianthus. The data on vegetative parameters are given in table 2. It is clear from the table that is significant difference among the treatments for number of leaves per plant of lisianthus. Kumar [14] reported that GA3 promotes cell division and cell elongation, thereby increase the leaf length and leaf area and enhance sugar translocation.

3.2 Floral parameters

3.2.1 Stalk length(cm)

The data on floral parameters are given in table 3. It is clear from the table that significant difference among the treatments for stalk length (cm) of lisianthus. The maximum Stalk length (cm) was observed with T_3 - GA_3 @300ppm (5.70 cm^2) which was at par with T_4- Cycocel @250ppm (5.14 cm^2) whereas, minimum was reported in T_0 - Control (3.92 cm^2). GA3 was the best for obtaining better growth of plants, maximum number of cut blooms with longer stalk as well as bigger flower size obtained. A similar trend was observed previously in China aster by Sailaja and Panchali [15].

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3.2.2 Bud length (cm)

The data on floral parameters are given in table 3. It is clear from the table that significant difference among the treatments for bud length (cm) of lisianthus. The maximum Bud length (cm) was observed with T_3 - GA_3 @300ppm (2.62 cm) which was at par with T_2- GA3 @200 ppm and T1 GA3 @100 ppm (2.45 cm) whereas, minimum was reported in T_7 - NAA @30 ppm (2.08 cm). Justo et al. [16] in carnation reported that the increase in the length of the flower bud in GA3 treated plants is due to rapid cell elongation, increased cell divisions and cell enlargement. Foliar application of GA3 also significantly increased flower bud length.

3.2.3 Number of buds per plant

The data on floral parameters are given in table 3. It is clear from the table that significant difference among the treatments for number of buds per plant of lisianthus. The maximum number of buds per plant was observed with T3- GA_3 @300 ppm (6.43) which was at par with T_8 - NAA@45 ppm (5.34) whereas, minimum was reported in T_4- CCC @250ppm (4.02). The effect of different growth regulators showed significant influence on the number of buds per plant. Similar results were recorded by Kumar et al. [17] in marigold.

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3.2.4 Number of days for bud initiation

The data on floral parameters are given in table 3. It is clear from the table that significant difference among the treatments for number of days for bud initiation lisianthus. The minimum Number of days for bud initiation was observed with T_3 - GA_3 @300 ppm (122.50) which was at par with T_5 - CCC @500 ppm (128.7) whereas, maximum was reported in T_7- NAA@30ppm (131.06). Holkar [18] reported that GA3 application enhances food translocation for the development of floral primordia, which leads to early flowering. This is due to increase in photosynthesis and respiration along with enhanced fixation by GA3 that led to flower bud initiation.

3.2.5 Number of flowers per plant

The data on floral parameters are given in table 3. It is clear from the table that significant difference among the treatments for number of flowers per plant of lisianthus. The maximum number of flowers per plant was observed with T_3 - GA_3 @300 ppm (6.43) which was at par with T_8 - NAA@45 ppm (5.34) whereas, minimum was reported in T_4- CCC @250ppm (4.02). Increased number of flower is attributed to the production of large number of flower buds along with the fact that termination of vertical growth by pinching lead to more laterals/secondary branches at early stage of growth, which then had sufficient time to accumulate carbohydrates for proper flower bud differentiation producing a greater number of flowers per plant. GA3 helps in breaking bud dormancy and acts as florigen initiating flowering. Similar results were also reported by Mithilesh Kumar [19] in Marigold.

3.3 Yield Parameters

3.3.1 Flower yield per plant

The data on yield parameters are given in table 4. It is clear from the table that significant difference among the treatments for flower yield per plant of lisianthus. The maximum flower yield per plant was observed with T_3 - GA_3 @300 ppm (6.43) which was at par with T_8 – NAA @45 ppm (5.34) whereas, minimum was reported in T_4– CCC@250ppm (4.02). Increase in flower yield per plant due to the fact that plant growth regulators stimulate vegetative growth and induced changes in vegetative morphology, and thereby accelerate growth parameters. These findings are also inaccordance with those of Rakesh [20] in carnation.

3.3.2 Flower yield per 250 m^2

The data on yield parameters are given in table 4. It is clear from the table that significant difference among the treatments for flower yield per 250 m^2 of lisianthus. The maximum flower yield per 250 m^2 was observed with T_3 - GA_3 @300 ppm (40187.50) which was at par with T_8 - NAA @45 ppm (33375.00) whereas, minimum was reported in T_4 – CCC @ 250ppm (25125.00). GA3 treatment enhance induction of flower bud break i.e., differentiation of floral primordia in the apical region which leads to increase production of flowers per plants and hence increase the flower yield. These results are also in close conformity with the findings of Ryagi [21] in Carnation.

3.4 Economic Parameter

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The data on economic parameters are given in table 5. It is clear from the table that significant difference among the treatments of lisianthus. The maximum gross return was observed with T_3 - GA_3 @300 ppm (401875.0) which was at par with T_8 - NAA @45 ppm (3.50) whereas, minimum was reported in T_4- CCC @ 250 ppm (251250.0). The maximum net return was observed with T_3 - GA_3 @300 ppm (303412.00) which was at par with T_8 - NAA @45 ppm (3.50) whereas, minimum was reported in T_4- CCC @ 250 ppm (148387.00). The maximum Benefit cost ratio was observed with T_3 - GA_3 @300 ppm (4.08) which was at par with T_8 - NAA @45 ppm (3.50) whereas, minimum was reported in T_4- CCC @ 250 ppm (2.44).

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Table 2. Effect of different concentration of GA3, CCC and NAA on vegetative parameters of Lisianthus.

Treatment Notation	Treatments	Plant spread (cm^2)	Plant height (cm)	Number of Leaves	Number of Branches	Chlorophyll content	Stem Diameter (cm)	Leaf area (cm^2)
T_0	Control	7.96	13.86	26.29	2.18	61.43	1.85	13.34
T_1	GA3@100 ppm	8.06	15.30	25.04	2.30	60.70	2.27	11.29
T_2	GA3@200 ppm	8.09	16.28	26.26	2.35	60.86	2.14	13.35
T_3	GA3@300 ppm	11.3	20.66	33.06	3.12	66.10	3.23	15.43
T_4	Cycocel@250ppm	8.50	15.96	25.0	2.08	62.92	2.37	12.97
T_5	Cycocel@500ppm	9.54	17.61	26.33	2.11	63.12	2.19	13.09
T_6	Cycocel@750ppm	9.38	16.81	25.20	1.90	63.54	2.51	12.20
T_7	NAA@30 ppm	9.5	18.19	27.53	1.94	64.61	2.47	13.38
T_8	NAA@45 ppm	8.99	16.98	28.04	1.92	63.68	2.53	13.60
T_9	NAA@60 ppm	9.1	16.21	29.40	1.87	63.65	2.42	13.93
	F-Test	**S**	**S**	**S**	**S**	**S**	**S**	**S**
	S.Ed (+)	0.14	0.90	0.30	0.16	0.53	0.25	0.92
	CD (5%)	0.30	0.89	0.64	0.33	1.11	0.54	1.93
	CV	1.95	6.57	1.38	8.97	1.03	13.21	8.52

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Table 3. Effect of different concentration of GA3, CCC and NAA on floral parameters of Lisianthus.

Treatment Notation	Treatments	Stalk length(cm)	Bud length(cm)	No. of buds per plants	No. of days for bud initiation	No. of flowers per plant
T_0	Control	3.92	2.13	4.49	4.49	4.49
T_1	GA3@100 ppm	4.36	2.43	4.99	4.99	4.99
T_2	GA3@200 ppm	3.77	2.45	5.31	5.31	5.31
T_3	GA3@300 ppm	5.70	2.62	6.43	6.43	6.43
T_4	Cycocel@250ppm	5.14	2.09	4.02	4.02	4.02
T_5	Cycocel@500ppm	4.69	2.30	4.45	4.45	4.45
T_6	Cycocel@750ppm	4.68	2.11	5.28	5.28	5.28
T_7	NAA@30 ppm	4.75	2.08	5.13	5.13	5.13
T_8	NAA@45 ppm	4.88	2.14	5.34	5.34	5.34
T_9	NAA@60 ppm	4.93	2.11	5.19	5.19	5.19
	F-Test	S	S	S	S	S
	S.Ed (+)	0.12	0.09	0.25	0.25	0.25
	CD (5%)	0.25	0.18	0.54	0.54	0.54
	CV	3.22	4.87	6.25	6.25	6.25

Table 4. Effect of different concentration of GA3, CCC and NAA on yield parameters of Lisianthus.

Treatment Notation	Treatments	Yield per plant	Yield per ($250\ m^2$)
T_0	Control	4.49	28062.50
T_1	GA3@100 ppm	4.99	31187.50
T_2	GA3@200 ppm	5.31	33187.50
T_3	GA3@300 ppm	6.43	40187.50
T_4	Cycocel@250ppm	4.02	25125.00
T_5	Cycocel@500ppm	4.45	27812.50
T_6	Cycocel@750ppm	5.28	33000.00
T_7	NAA@30 ppm	5.13	32062.50
T_8	NAA@45 ppm	5.34	33375.00
T_9	NAA@60 ppm	5.19	32437.50
	F-Test	S	S
	S.Ed (+)	0.25	480.11
	CD (5%)	0.54	1017.78
	CV	6.25	13.05

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Table 5. Effect of different concentration of GA3, CCC and NAA on Economic parameters of Lisianthus.

Treatment Notation	**Treatments combination**	**Total cost of cultivation**	**Gross Return**	**Net Retutn**	**Benefit cost ratio**
T_0	Control	94875.00	280625.0	185750.00	2.95
T_1	GA3@100 ppm	96063.00	311875.0	215812.00	3.24
T_2	GA3@200 ppm	97263.00	331875.0	214612.00	3.20
T_3	GA3@300 ppm	98463.00	401875.0	303412.00	4.08
T_4	Cycocel@250ppm	102863.00	251250.0	148387.00	2.44
T_5	Cycocel@500ppm	107752.00	278125.0	170373.00	2.58
T_6	Cycocel@750ppm	113461.00	330000.0	216539.00	2.90
T_7	NAA@30 ppm	95231.00	320625.0	225394.00	3.36
T_8	NAA@45 ppm	95355.00	333750.0	238395.00	3.50
T_9	NAA@60 ppm	95434.00	324375.0	228941.00	3.39

CONCLUSION

From the present investigation, it is concluded that among the different treatments, the treatment T3 - GA3 @300 ppm was found in superior among other treatments in terms of Plant height, number of leaves , plant spread , stem diameter, leaf area, bud length, number of buds per plant, stalk length , Number of flowers per plant, number of branches per plant, chlorophyll content, minimum number of days for bud initiation, Flower yield per plant, flower yield per $250m^2$, benefit cost ratio per$250m^2$ was also observed in T3 - GA3 @300 ppm.GA3 @300 ppm could be recommended for plant growth and flowering of Lisianthus (*Eustoma grandiflorum*).

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