Agriculture Association of Textile Chemical and Critical Reviews Journal (2025) 590-593

AATCC Review

03 July 2025: Received
22 August 2025: Revised
30 August 2025: Accepted
28 September 2025: Available Online

https://aatcc.peerjournals.net/

Original Research Article Open Access

Effect of pre-treatment with GA_3 and geometry of planting on sprouting and growth of calla lily (*Zantedeschia spp*) cv. 'Captain Murano' under shade net condition

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ABSTRACT

An experiment was carried out at Floricultural Research Station to study the effect of pre pre-treatment of rhizomes with GA_3 and planting geometries on sprouting, growth, and flowering of calla lily cv. Captain Murano under shade net conditions. From the pooled data of both the years 2020-21, 2022-23 it was found among the different treatment combinations pre treatment with GA_3 at 500 ppm and planting at 45 x 45 cm spacing recorded minimum days to early sprouting (7.92 days), days to 50 % sprouting (13.18 days) and days to maximum sprouting (16.56 days), whereas, maximum plant height at 30 days (48.53 cm), 60 days (64.57 cm) and 90 days (73.18 cm), was recorded with GA_3 at 500 ppm and planting at 30 x 30 cm. The study faced several challenges that needed to be addressed to ensure accurate and reliable results. One major challenge was maintaining uniform shade net conditions throughout the experimental period, especially considering varying climatic factors across the two years (2020–21 and 2022–23). Another difficulty was ensuring consistent rhizome quality and size for uniform pre-treatment with GA_3, as variability in planting material could affect sprouting and growth responses. Pest and disease management under shade net conditions also demanded close monitoring to avoid confounding effects on growth and flowering parameters. The study successfully demonstrates how integrating plant growth regulators with precise planting strategies can improve commercial flower crop performance under shade net conditions.

Keywords: *Calla lily, GA_3, Gibberellic acid, Rhizome pre-treatment, Planting geometry, Sprouting, Growth, Flowering, Captain Murano, Shade net, Spacing, Floricultural research, Plant height.*

Introduction

Zantedeschia spp., belonging to the family Araceae, is a genus comprising six to seven species, all of which are native to South Africa [8]. One of the most well-known species, *Zantedeschia aethiopica*, is commonly referred to as the arum lily. The plant produces rhizomes, which serve as the primary means of propagation. Its arrow-shaped leaf blades are borne on long, thick petioles that sheath the base of the stem. The flowers are arranged on a spadix, bearing both male and female florets without any sterile flowers separating them [21]. The underground storage organ is thickened and fleshy, and has been variously described in the literature as a corm, tuber or rhizome [11].

Zantedeschia flowers are conspicuous for their shape, colour, and exceptionally long vase life. They are popular in mono bouquets, mixed bouquets and as a single flower in a vase and are also used in bridal bouquets. *Zantedeschia* is now in the top 20 of cut flowers at Dutch flower auctions.

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DOI: https://doi.org/10.21276/AATCCReview.2025.13.04.590

They are mostly grown for cut flowers and they rank thirteenth in the flower trade in the Netherlands. Due to unsatisfactory flower harvests and high prices of rhizomes, calla lilies are not so popular among the producers.

Dormancy is a physiological state in which living organisms temporarily cease or significantly reduce growth and metabolic activity. It can be described as a period of profound inactivity, during which organisms enter a state of rest or "deep sleep" to survive unfavourable environmental conditions. In plants, dormancy is a crucial survival strategy, particularly because they are immobile and cannot actively protect themselves or withstand prolonged periods without water. As a result, many plant species enter dormancy during times of environmental stress [5].

The calla lily is commercially propagated through rhizomes. One of the major challenges in its commercial cultivation is the inability to produce flowers and rhizomes year-round, which limits a consistent supply to the market. This is primarily due to the mandatory dormancy or rest period that rhizomes must undergo after each growing cycle. The duration of this dormancy varies widely from a few weeks to several months depending on factors such as cultivar, rhizome size and grade, and environmental conditions [17].

The physiological basis of rhizome dormancy in calla lily is primarily attributed to the accumulation of growth-inhibiting substances, particularly abscisic acid (ABA), both within the rhizome tissue and in the scales that encase them. Various methods to reduce dormancy in calla lily rhizomes have been explored by researchers, but with only limited success. In addition to conventional approaches such as cold storage, some chemical treatments especially the use of plant growth regulators have been tested by a few investigators to overcome dormancy.

Among the various plant growth regulators, pre-treatment of rhizomes with gibberellic acid (GA_3) has been shown to promote early sprouting and enhance plant development, leading to improved rhizome yield [6][7][13]. The exogenous application of GA_3 counteracts the inhibitory effects of abscisic acid (ABA) and also stimulates an endogenous increase in gibberellic acid levels, which plays a crucial role in seed germination. Gibberellic acid is involved both in overcoming dormancy and regulating the hydrolysis of stored reserves. Adequate levels of GA_3 in seeds stimulate the synthesis, activation, and secretion of hydrolytic enzymes, particularly α-amylase, which breaks down starch into reducing sugars and amino acids essential for embryo growth [15] [23] [22].

Material and Methods

The experiment was laid out in a factorial completely randomized block design (FCRD) with replications. Treatments within each replication were randomly assigned. Medium-sized rhizomes (4–6 cm diameter), selected prior to planting, were soaked in a solution of Copper Oxychloride (3 g/l) and Streptocycline (0.1 g/l) for 30 minutes, then dried in the shade for one day. Following this seed treatment, the rhizomes were soaked in gibberellic acid (GA_3) solutions at varying concentrations (250 ppm, 500 ppm, and 1000 ppm) according to treatment groups, while control rhizomes were soaked in distilled water for 15–20 minutes. The treated rhizomes were then dried for an additional 24 hours before planting. Planting was conducted randomly in designated plots, with spacing treatments of 30 x 30 cm, 30 x 45 cm, and 45 x 45 cm, at a depth of 10 cm on raised beds under shade netting. Throughout the experiment, all recommended cultural practices were followed. Data on various parameters of corm production were recorded and statistically analyzed [24].

Results and Discussion

1. Sprouting parameters

Data on rhizome sprouting influenced by GA_3 pre-treatment and different planting geometries are presented in table 1. Pooled data from both years revealed that the interaction G_2S_3 (GA_3 500 ppm + 45 x 45 cm spacing) resulted in the earliest sprouting, with the minimum number of days to initial sprouting, 50% sprouting, and maximum sprouting recorded at 7.92 days, 13.18 days and 16.56 days respectively. This was followed by G_1S_3 (GA_3 250 ppm + 45 x 45 cm), which recorded 9.34 days, 14.96 days and 18.00 days for the same parameters. The longest duration for sprouting was observed in G_4S_1 (control + 30 x 30 cm), with 21.18 days, 31.96 days and 42.25 days respectively.

The effectiveness of GA_3 treatment in inducing early sprouting is likely due to its role in altering the hormonal balance and stimulating the production of hydrolytic enzymes. These enzymes facilitate the breakdown of stored starch into simple sugars in the presence of adequate moisture, thereby providing the energy necessary for early and vigorous sprouting. These findings are consistent with previous studies on gladiolus by [16] [29] [18] [27] [4] [3] [26].

Plants grown at wider spacing (45 x 45 cm) exhibited earlier and more abundant sprouting. This may be attributed to the fact that rhizomes planted at wider spacings can more effectively utilize environmental resources, enhancing the plant's absorption capacity and promoting better tissue development. As a result, this improved resource utilization leads to earlier and greater sprouting [12]. Similar findings have also been reported by [19] in gladiolus.

2. Growth parameters

Data recorded on plant height at 30, 60 and 90 days as influenced by GA_3 pre pre-treatment, planting geometry and their interactions are presented in table 2

Among the interactions, G_2S_1 (GA_3 500 ppm + 30 x 30 cm spacing) recorded the highest plant height at 30, 60, and 90 days after planting (DAP), measuring 48.53 cm, 64.57 cm and 72.80 cm, respectively. This was followed by G_1S_1 (GA_3 250 ppm + 30 x 30 cm), with plant heights of 41.67 cm, 62.66 cm and 70.99 cm at the same intervals. In contrast, the lowest plant heights were observed in G_4S_3 (control + 45 x 45 cm), with values of 29.78 cm, 35.23 cm and 44.52 cm.

These results clearly indicate that GA_3 treatments significantly increased plant height at 30, 60, and 90 DAP compared to the control. Among the GA_3 concentrations tested, 500 ppm was the most effective, while higher concentrations beyond this level tended to reduce plant height.

The maximum plant height observed at GA_3 500 ppm may be attributed to gibberellin's role in regulating biomass production in vegetative parts. At this concentration, gibberellin promotes the synthesis of DNA, RNA, and proteins, which in turn facilitates cell development by activating hydrolytic enzymes. These enzymes increase cell wall flexibility and reduce the water potential within cells, leading to the expansion of leaves, shoots, and stems. Similar effects of GA_3 on plant growth have been reported by [2] [30] [25] [10] [20].

With increased plant population at closer spacing, plants tend to grow more vertically compared to those in wider spacing. This response is likely due to reduced light penetration into the canopy, which causes low light conditions that promote an increase in internodal length through etiolation. Under these conditions, auxin experiences less photo-oxidation and degradation, resulting in enhanced stem elongation and taller plants. Similar observations of taller plants under closer spacing and higher plant density have been reported by [14] [1] [28] [9].

Table 1: Effect of GA_3 pre treatment and geometry of planting on sprouting parameters

	Pooled data (2021-22 & 2022-23)											
Treatments	Sprouting Initiation				Days for 50 % Sprouting				Days for maximum sprouting			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
G_1	15.24	13.44	9.34	12.67	19.26	17.4	14.96	17.21	21.87	19.74	18	19.87
G_2//	14.32	10.84	7.92	11.03	18.37	16.94	13.18	16.15	20.76	18.68	16.56	18.69
G_3	18.16	17.34	16.83	17.44	20.81	19.44	17.85	19.36	24.41	22.06	21.14	22.54
G_4	21.18	20.44	19.45	20.36	31.96	29.66	24.63	28.75	42.25	37.84	31.24	37.11
Mean	17.23	15.51	13.38		22.59	20.86	17.65		27.33	24.58	21.74	
	S.Em ±		CD (5%)		S.Em ±		CD (5%)		S.Em ±		CD (5%)	
Pre treatment with GA_3 (G)	0.107		0.314		0.102		0.301		0.177		0.52	
Spacing (S)	0.093		0.272		0.089		0.261		0.153		0.451	
G x S	0.185		0.544		0.178		0.521		0.307		0.901	

Factor 1: Pre treatment with GA_3 (G) Factor II : Geometry of planting (S)
G_1: GA_3 250 ppm S_1: 30 x 30 cm
G_2: GA_3 500 ppm S_2: 30 x 45 cm
G_3: GA_3 1000 ppm S_3: 45 x 45 cm
G_4: Distilled water soaking

Table 2: Effect of GA_3 pre treatment and geometry of planting on growth parameters

	Pooled data (2021-22 & 2022-23)											
Treatments	Plant height (30 DAP)				Plant height (60 DAP)				Plant height (90 DAP)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
G_1	41.67	41.31	39.72	40.9	62.66	57.86	53.55	58.02	70.99	67.61	63	67.2
G_2	48.53	45.64	41.83	45.33	64.57	59.2	56.72	60.16	72.8	69.47	61.38	67.88
G_3	40.11	39.75	36.57	38.81	55.46	49.41	46.27	50.38	64.13	58.95	55.61	59.56
G_4	36.15	32.29	29.78	32.74	52.63	40.81	35.23	42.89	59.5	50.35	44.52	51.46
Mean	41.6	39.75	36.98		58.83	51.82	47.95		66.86	61.59	56.13	
	S.Em ±		CD (5%)		S.Em ±		CD (5%)		S.Em ±		CD (5%)	
Pre treatment with GA_3 (G)	0.256		0.752		0.484		1.422		0.341		1.002	
Spacing (S)	0.222		0.651		0.419		1.231		0.296		0.868	
G x S	0.444		1.302		0.839		2.462		0.591		1.735	

Factor 1: Pre treatment with GA_3 (G) Factor II : Geometry of planting (S)
G_1: GA_3 250 ppm S_1: 30 x 30 cm
G_2: GA_3 500 ppm S_2: 30 x 45 cm
G_3: GA_3 1000 ppm S_3: 45 x 45 cm
G_4: Distilled water soaking

Conclusion

Calla lily rhizomes pre-treated with gibberellic acid at 500 ppm and planted at wider spacings exhibited superior sprouting performance, while rhizomes planted at closer spacings showed enhanced growth attributes at various stages of development.

Future scope

- Evaluate long-term effects of GA_3 on flowering, rhizome multiplication, and post-harvest quality.
- Assess the economic viability of using GA_3 at various concentrations under different agro-climatic conditions.
- Investigate molecular and hormonal mechanisms involved in dormancy release and vegetative growth in calla lily.
- Explore the integration of other plant growth regulators or biostimulants with GA_3 for enhanced productivity.

Conflict of Interest

- The authors declare that there is no conflict of interest related to the publication of this study.

Acknowledgement

Firstly, I am forever grateful to my family for their unwavering encouragement, patience, and moral support throughout my academic journey.

I express my sincere gratitude to Dr. P.Prasanth, my major advisor, for their invaluable guidance, encouragement, and support throughout the course of this research. I am deeply thankful to the Department of Floriculture and Landscape Architecture, Sri Konda Laxman Telangana Horticultural university for providing the necessary facilities and resources for conducting this study.

I also extend my heartfelt thanks to the teaching and non-teaching staff of the department for their assistance and cooperation during fieldwork and data collection. Special thanks to my fellow researchers and friends for their constant support, motivation, and constructive suggestions.

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