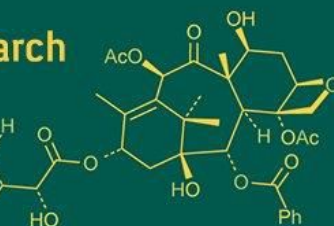


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Assessing the influence of GA₃ on growth attributes of *Crossandra* genotypes (*Crossandra infundibuliformis* L.) under plain zones of Chhattisgarh

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Abstract

The experiment evaluated the effects of gibberellic acid (GA₃) on the growth of *Crossandra* genotypes in Chhattisgarh plains using a Factorial Randomized Block Design. Three genotypes—Arka Chenna (V₁), Local-1 (V₂) and Local-2 (V₃) and four GA₃ concentrations (control, 150 ppm, 200 ppm and 250 ppm) were tested. Local-2 (V₃) excelled in growth parameters and spraying of GA₃ @ 250 ppm (P₃) performed best in all growth parameters. Combination of Local-2 with GA₃ 250 ppm (V₃P₃) achieved the highest plant height (50.96 cm), no. of branches (13.53), number of leaves (200.08), stem diameter (6.93 cm) and plant spread (N-S, E-W) (35.98 cm, 50.46 cm).

Keywords: *Crossandra* genotypes, GA₃ concentrations, growth attributes

Introduction

Crossandra (*Crossandra infundibuliformis* L.) is a tropical evergreen shrub indigenous to India and Sri Lanka, thriving in various tropical and subtropical regions worldwide, including South Asia, South America, South Africa and Madagascar (Bailey, 1950) [8]. Belonging to the Acanthaceae family, *Crossandra* is renowned for its vibrant and visually captivating flowers. The term "Crossandra" finds its roots in the Greek words 'Krossoi' and 'Aner', meaning fringe and male respectively alluding to its fringed stamens. Commonly known as 'Crossandra' or 'Firecracker,' the plant gets its latter nickname from its dried seed pods, which burst open with a loud sound when exposed to water, resembling the explosion of a firecracker (Kumar *et al.*, 2008) [12]. It is referred as 'Kanakambara' in South-Indian region, as in Marathi it is called 'Aboli', while as 'Priyadarsha' in Sanskrit/Hindi. They grow in dense, sessile spikes adorned with prominent bracts. Flower colors range widely, from the common orange to shades of salmon-orange, apricot, coral, red, yellow and even turquoise. *Crossandra* occupies approximately 2,401 hectares in Karnataka, producing around 16,214 metric tonnes annually (Horticulture Statistics at a Glance, 2016–17) [6].

Plant growth substances play a vital role in regulating *Crossandra* growth and development. Endogenous hormones control various processes, while exogenous application can alter growth patterns, accelerate flowering and enhance vase life in ornamental plants. These substances regulate physiological functions such as photosynthesis, transpiration, nutrient uptake and stress resistance, improving overall productivity. Gibberellins stimulate seed germination, trigger transitions from meristem to shoot growth, juvenile to adult leaf stage, vegetative to flowering, determines sex expression and grain development along with an interaction of different environmental factors *viz.*, light, temperature and water, these applications ultimately modify plant growth and improve yield.

Crossandra is recognized as an emerging loose flower in recent floriculture trade. In this context, the incorporation of plant growth regulators, particularly gibberellic acid (GA₃) will be beneficial for increasing flower yield and commercialization of *crossandra* farming in Chhattisgarh.

Materials and Methods

The experiment was conducted at Pt. Kishorilal Shukla College of Horticulture and Research

Station, Rajnandgaon (C.G.), MGUVV, Chhattisgarh, during 2023–24. It followed a factorial randomized block design with 12 treatments and 3 replications, there were 2 factors which comprised 3 and 4 levels *viz.* Crossandra genotypes: Arka Chenna (V_1), Local-1 (V_2) and Local-2 (V_3) and GA₃ concentrations: Control (P_0), GA₃ 150 ppm (P_1), GA₃ 200 ppm (P_2) and GA₃ 250 ppm (P_3). Rooted cuttings from each genotype were transplanted in November 2023 at 45 × 50 cm spacing Gibberellic acid of the respective concentration were foliar sprayed with the help of hand sprayer started from 45 DAT.

The observations regarding growth attributes, including plant height, number of branches, leaves per plant, stem diameter, leaf breadth and plant spread, were recorded at 85 DAT.

Results and Discussion

Performance of Crossandra genotypes and effect of GA₃ on growth attributes:

Plant height

The experimental data revealed that among the three genotypes, Local- 2 (V_3) consistently exhibited the highest plant height (49.52 cm) at 85 days after transplanting (DAT), while Local- 1 (V_2) produced the lowest plant height (48.74 cm) at each observation. Genetic factors influenced plant height differences among genotypes as previously observed in Crossandra, Marigold (Nandakishor and Ragahava, 2001) [20], China Aster (Singh *et al.*, 2004) and Chrysanthemum (Baskaran *et al.*, 2004; Kulkarni *et al.*, 1996; Singh and Mandhar, 2004; Dahiya *et al.*, 2007).

Different concentrations of GA₃ significantly increased plant height, with the maximum height (50.44 cm) observed in plants treated with GA₃ 250 ppm (P_3) at 85 DAT, respectively. Conversely, the control (P_0) produced the lowest plant height (47.58 cm). GA₃ is known to induce active cell elongation, increase auxin levels and enhance the conversion of tryptophan to IAA, leading to active cell division and elongation (Abel and Theologis, 1996). Additionally, GA₃ may promote growth by facilitating osmotic water and nutrient uptake, softening cell walls and increasing plant height (Lockhart, 1960). A similar finding was reported by Tripathi *et al.*, (2003) and Acharya *et al.*, (2021) [3] on Marigold.

The interaction between genotype and GA₃ also significantly influenced plant height. The highest plant height (50.96 cm) was observed in the treatment combination of Local-2 with GA₃ 250 ppm (V_3P_3), which was statistically comparable to Arka Chenna with GA₃ 250 ppm (V_1P_3) at 85 DAT. However, Local-1 with control (V_2P_0) exhibited the lowest plant height (47.06 cm) during the study.

Number of branches

Among the three genotypes, Local- 2 (V_3) consistently exhibited the highest number of branches per plant (12.54) at 85 DAT, while Local- 1 (V_2) produced the lowest number of branches per plant (11.92) at each observation. The observed increase in branch number in certain genotypes can be attributed to their genetic constitution. This finding aligns with the conclusions of Nandakishor and Raghava, (2001) [20], who observed that, it was primarily due to the production of more branches and a wider angle between primary and secondary branches. Subsequent studies by Kulkarni and Reddy, (2004) [21] in China aster and

Peddilaxmi *et al.*, (2008) [27] in Chrysanthemum further corroborate this conclusion.

Increased number of branches per plant, with the maximum branches (13.16) observed in plants treated with GA₃ 250 ppm (P_3) at 85 DAT, respectively. Conversely, the control (P_0) produced the lowest number of branches per plant (11.03). Gibberellin was identified as a key factor in reducing apical dominance, thereby stimulating growth on lateral branches. This finding aligns with similar results reported by Binisundar *et al.*, (2008) [12] in Crossandra; Lal and Mishra, (1986) [28] in Aster and Marigold; and Doddagoudar (2004) [15] in China Aster; Padmapriya and Chezhian, (2003) [24] in Chrysanthemum and Amit *et al.*, (2011) [5] in African Marigold. Furthermore, GA₃ is known to influence translocation and transcriptional mechanisms related to protein biosynthesis. It also stimulates cell division, cell elongation and increases cell wall plasticity. These processes contribute to increased plant height with more productive branches. Notably, these observations corroborate the recent findings of Hande *et al.*, (2022) [17] on China Aster.

The interaction between genotype and GA₃ also significantly influenced number of branches. The highest branches (13.53) were observed in the treatment combination of Local-2 with GA₃ 250 ppm (V_3P_3), which was statistically comparable to Arka Chenna with GA₃ 250 ppm (V_1P_3) at 85DAT. However, Local-1 with control (V_2P_0) exhibited the lowest number of branches per plant (10.69) during the study.

Number of leaves

In this study, the Local-2 (V_3) Crossandra genotype exhibited the highest leaf production, with significantly more leaves (171.51) at 85 days after transplanting (DAT), respectively, while Local-1 (V_2) produced the fewest leaves (160.74) at the corresponding time point. Leaves are essential for photosynthesis, particularly due to their chlorophyll content, significantly influencing plant growth and flower yield. These findings align with previous observations of genotypic variation in leaf number per shoot in China Aster Poornima *et al.*, (2006) [29] and Gerbera (Bhattacharjee, 1981; Jayaprakash, 1998) [11, 18].

Plants treated with GA₃ at a concentration of 250 ppm (P_3) exhibited the highest leaf production, with significantly more leaves (196.58) observed at 85 days after transplanting, while the control (P_0) produced the fewest leaves (139.45) at these time point. The increased leaf initiation at higher GA₃ concentrations is likely attributed to enhanced cell division, cell elongation and tissue differentiation. Additionally, the greater number of shoots in these treatments may have contributed to increased leaf production. These findings are consistent with previous studies by (Alhajhoj 2017; Sajid *et al.*, 2016) [4, 25] and (Kumar *et al.*, 2020; Khangarakpam *et al.*, 2019) [22, 19] on African marigold.

The interaction between genotype and GA₃ also significantly influenced number of leaves. The highest number of leaves (200.08) were observed in the treatment combination of Local-2 with GA₃ 250 ppm (V_3P_3), which was statistically comparable to Arka Chenna with GA₃ 250 ppm (V_1P_3) at 85 DAT. However, Local-1 with control (V_2P_0) exhibited the lowest number of leaves per plant (138.67) during the study.

Stem diameter

Among the three varieties, Local-2 (V_3) exhibited significantly the highest stem diameter, with measurements of (5.56 cm) at 85 DAT. Conversely, Local-1 (V_2) displayed the lowest stem diameter (4.89 cm) at these time point. The observed variation in stem girth among genotypes can be attributed to differences in their genetic makeup. Similar variations in stem diameter among genotypes have been previously reported by (Singh and Kumar, 2008) [12].

Plants treated with GA_3 at a concentration of 250 ppm (P_3) exhibited the highest stem diameter, with significantly greater measurements of (6.35 cm) observed at 85 days after transplanting, while the control (P_0) displayed the lowest stem diameter (3.93 cm) at these time point. The observed increase in stem diameter is likely attributed to the influence of GA_3 on cell enlargement and cell division. Similar results have been reported by Gautam *et al.* (2006) [16] in *Chrysanthemum* and Bhattacharjee *et al.*, (1984) [10] in *Dahlia*.

The interaction between genotype and GA_3 significantly affected stem diameter. The highest stem diameter (6.93 cm) was observed in the treatment combination of Local-2 with GA_3 250 ppm (V_3P_3), which was comparable to Arka Chenna with GA_3 250 ppm (V_1P_3) at 85 DAT. In contrast, Local-1 with the control treatment (V_2P_0) exhibited the lowest stem diameter (2.94, 3.05 and 3.78 cm) throughout the study.

Plant spread (N-S, E-W)

Among the three genotypes, Local-2 (V_3) exhibited significantly the highest plant spread (N-S), with measurements of (30.87 cm) at 85 DAT. Conversely, Local-1 (V_2) displayed the lowest spread (18.93, 24.19 and 28.19 cm) at these time point. External factors such as climatic fluctuations and soil nutrient conditions, may have also contributed to the observed variations in plant spread. Similar findings have been reported by Nandakishor and Raghava, (2001) [20]; Gautam *et al.*, (2006) [16] in *Chrysanthemum*.

Plants treated with GA_3 at a concentration of 250 ppm (P_3) exhibited the highest plant spread (N-S), with significantly greater measurements of (33.79 cm) observed at 85 days after transplanting, while the control (P_0) displayed the lowest plant spread (25.08 cm) at these time point. GA_3 plays a significant role in increasing internodal length,

leading to greater plant height and optimal plant spread. This increase in plant spread is a result of the development of more primary branches, which originate from dormant buds along the main axis. Deshmukh *et al.*, (2014) [14] observed this effect and similar findings were reported by Acharya *et al.*, (2021) [3]; Hande *et al.*, (2022) [17] in *Marigold*.

The combination of different Crossandra and GA_3 concentrations significantly affected plant spread (N-S). The most extensive plant spread (N-S) (35.98 cm) was observed in the treatment combination of Local-2 with GA_3 250 ppm (V_3P_3), which was similar to Arka Chenna with GA_3 250 ppm (V_1P_3) at 85 DAT. In contrast, Local-1 with the control treatment (V_2P_0) exhibited the smallest plant spread (N-S) (23.76 cm) throughout the study.

Among the three genotypes, Local-2 (V_3) exhibited significantly the highest plant spread (E-W), with measurements of (43.16 cm) at 85 DAT. Conversely, Local-1 (V_2) displayed the lowest spread (39.31 cm) at these time point. The increased number of branches in some genotypes may be attributed to the genetic makeup of the cultivars. By obtaining similar results, Nandakishor and Raghava, (2001) [20] concluded that the increase in plant spread was primarily due to the production of increased numbers of branches and wider angles between primary and secondary branches at the coupling point. This conclusion was further supported by Kulkarni and Reddy, (2004) [21] in *China Aster* and Peddilaxmi *et al.*, (2008) [27] in *Chrysanthemum*.

Data on plant spread (east-west) revealed that plants treated with GA_3 at 250 ppm (P_3) had the widest canopy spread (46.98 cm) at 85 days after treatment, while the control (P_0) displayed the narrowest canopy spread (35.66 cm). This variation in plant spread is likely attributed to increased plant height, a higher number of main axis and the development of more primary branches from dormant buds. Similar findings have been reported by Gautam *et al.*, (2006) [16] in *Chrysanthemum*.

The combination of different Crossandra genotypes and GA_3 concentrations significantly affected plant spread (E-W). The most extensive plant spread (E-W) (50.46 cm) was observed in the treatment combination of Local-2 with GA_3 250 ppm (V_3P_3), which was similar to Arka Chenna with GA_3 250 ppm (V_1P_3) at 85 DAT. In contrast, Local-1 with the control treatment (V_2P_0) exhibited the smallest plant spread (E-W) (35.02 cm) throughout the study.

Table 1: The performance of Crossandra genotypes with different GA_3 concentrations on Growth Attributes

	Plant height (cm)	No. of branches/plant	No. of leaves/plant	Stem diameter (cm)	Plant Spread (N-S) (cm)	Plant Spread (E-W) (cm)
	85 DAT	85 DAT	85 DAT	85 DAT	85 DAT	85 DAT
V_1	48.97	8.31	166.08	55.07	29.45	42.06
V_2	48.74	7.26	160.74	49.45	28.19	38.75
V_3	49.52	8.91	171.51	51.76	30.87	42.43
C.D.	0.26	0.09	3.37	0.60	0.37	0.87
SEM	0.09	0.03	1.15	0.21	0.13	0.30
P_0	47.58	7.33	139.45	39.25	25.08	35.66
P_1	48.64	8.24	147.66	48.66	28.34	39.31
P_2	49.63	8.43	180.75	64.21	30.79	43.25
P_3	50.44	8.64111	196.582	56.2589	33.7933	46.09
C.D.	0.30	0.11	3.89	0.69	0.43	1.00
SEM	0.10	0.04	1.33	0.24	0.15	0.34

Table 2: The performance of Crossandra genotypes with different GA₃ concentrations on Growth Attributes

	Plant height (cm)	No. of branches/plant	No. of leaves/plant	Stem diameter (cm)	Plant Spread (N-S) (cm)	Plant Spread (E-W) (cm)
	85 DAT	85 DAT	85 DAT	85 DAT	85 DAT	85 DAT
V ₁ P ₀	47.33 ^f	10.87 ^f	139.65 ^{fg}	3.87 ^k	24.93 ^h	35.16 ^f
V ₁ P ₁	48.62 ^e	12.03 ^{cd}	146.79 ^f	4.87 ^h	28.69 ^e	39.65 ^d
V ₁ P ₂	49.42 ^d	12.23 ^c	178.83 ^c	5.74 ^e	30.79 ^d	41.52 ^d
V ₁ P ₃	50.49 ^{ab}	13.1 ^b	199.03 ^a	6.23 ^b	33.38 ^b	46.7 ^b
V ₂ P ₀	47.06 ^f	10.69 ^f	138.67 ^g	3.78 ^k	23.76 ⁱ	35.02 ^f
V ₂ P ₁	48.61 ^e	11.93 ^d	141.55 ^{fg}	4.64 ⁱ	27.55 ^f	37.33 ^e
V ₂ P ₂	49.42 ^d	12.2 ^c	172.08 ^d	5.25 ^f	29.45 ^e	41.13 ^d
V ₂ P ₃	49.87 ^{cd}	12.86 ^b	190.64 ^b	5.88 ^d	32.02 ^c	43.77 ^c
V ₃ P ₀	48.36 ^e	11.52 ^e	140.02 ^{fg}	4.13 ^j	26.55 ^g	36.81 ^{ef}
V ₃ P ₁	48.69 ^e	12.15 ^{cd}	154.63 ^e	5.09 ^g	28.79 ^e	40.95 ^d
V ₃ P ₂	50.06 ^{bc}	12.98 ^b	191.33 ^b	6.1 ^c	32.14 ^c	44.45 ^c
V ₃ P ₃	50.96 ^a	13.53 ^a	200.08 ^a	6.93 ^a	35.98 ^a	50.46 ^a
C.D.	0.52	0.19	6.74	1.20	0.74	01.73
SEM	0.18	0.06	2.30	0.41	0.25	0.59
C.V.	0.84	1.89	3.30	1.87	2.05	3.43

^a Means with same letter in the column were not significantly different by DMRT method at $p < 0.05$, $n = 12$

Conclusion

According to the results obtained in this experiment, it can be concluded that among the interactions between different genotypes and varying concentrations of Gibberellic acid, the combination of Local-2 with GA₃ 250 ppm showed maximum growth parameters. The studies also corroborate that the genotypes Local- 2 can be used for various ornamental purposes, such as hedges, topiary, shrubbery, etc.

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