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Genotypic variability in flowering, yield and economic attributes of crossandra (*Crossandra infundibuliformis*) genotypes under Konkan agroclimatic Conditions

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Abstract
The present investigation, entitled "Genotypic Variability in Flowering, Yield and economic attributes of Crossandra (*Crossandra infundibuliformis*) genotypes under Konkan Agroclimatic Conditions", was conducted during 2022-2024 at the Hi-Tech Nursery, College of Horticulture, Dapoli, with the objective of identifying suitable genotypes for commercial cultivation in the Konkan region. The study revealed significant variability among the evaluated genotypes with respect to flowering, yield, and economic attributes. Genotype G_8 (Jalgaon type 2) recorded the longest rachis length (10.37 cm), while G_1 (Gavhe type 1) produced the longest spike (12.57 cm). Arka Kanaka (G_4) exhibited the maximum number of pickings per spike (15.05) and outperformed all other genotypes in key yield parameters, including florets per spike (71.55), weight of 100 flowers (8.57 g), flowering duration (46.04 days), and flower yield (7.93 t/ha). This superior yield performance translated into the highest gross returns (₹16.65 lakh/ha), net returns (₹11.25 lakh/ha), and benefit-cost ratio (3.08).These findings clearly demonstrate the superiority of Arka Kanaka, establishing it as the most suitable genotype for commercial cultivation of Crossandra under Konkan agroclimatic conditions. In addition, G_{10} (Ladghar type 1), Arka Ambara (G_{11}), and G_2 (Gavhe type 2) also showed promising results and may be considered for further evaluation and potential large-scale adoption.

Keywords: ARKA, *Crossandra infundibuliformis*, genotypes evaluation, variability, flowering and yield attributes

1. Introduction

Flowers hold an integral place in human culture, valued for their beauty and their role in social, cultural, and religious occasions. Crossandra (*Crossandra infundibuliformis* (L.) Nees, 2n = 2× = 20), a perennial shrub of the family Acanthaceae, is popularly known as the firecracker plant. The genus name is derived from the Greek words *krossos* (fringe) and *aner* (man), referring to its fringed anthers. Native to the Arabian Peninsula, tropical Africa, Madagascar, India, and Sri Lanka, Crossandra is now widely cultivated in India, tropical Africa, and Madagascar. Its ornamental value has even earned it the Royal Horticultural Society's Award of Garden Merit. In India, floriculture is an expanding sector, with 283 thousand hectares under cultivation in 2021-22, yielding 2,295.07 thousand tonnes of loose flowers and 833.16 thousand tonnes of cut flowers (3rd Advance Estimate). During 2022-23, India exported 21,024.41 MT of floriculture products worth ₹707.81 crores (USD 88.38 million), (Anonymous, 2023) [1]. Crossandra is predominantly cultivated in South Indian states such as Karnataka, Tamil Nadu, and Andhra Pradesh. Though it lacks fragrance compared to jasmine or rose, it is prized for its vibrant colours, long shelf life, and cultural importance in garlands, gajaras, venis, and temple offerings. Its hardy nature also makes it suitable for landscaping and pot culture. The species occurs in five colour forms orange, yellow, red, deep orange, and bluish with orange being the most common, though highly susceptible to wilt and nematode infestation. Improved genotypes such as Arka Ambara, Arka Kanaka, Arka Shreeya, and Arka Shravya have been released by IIHR, Bengaluru, yet systematic crop improvement remains limited. Since genotype performance often varies with agro-climatic conditions, region-specific evaluation is essential. The Konkan region, with its distinct climate, offers significant potential for commercial floriculture.

However, information on the adaptability and performance of Crossandra genotypes here is scarce. Hence, evaluating available genotypes under Konkan conditions is crucial to identify high-yielding, market-preferred cultivars with better shelf life and stress tolerance.

2. Material and Methods

The present investigation, entitled ‘Genotypic Variability in Flowering, and Yield attributes of Crossandra (*Crossandra infundibuliformis*) genotypes under Konkan Agroclimatic Conditions’ was conducted at the Hi-Tech Nursery, College of Horticulture, Dapoli, Dist. Ratnagiri, during the Kharif seasons of 2022-23 and 2023-24. The average minimum and maximum temperature was 18.5°C and 30.8°C, respectively with an average precipitation of 3,500 mm, distributed mainly during four months from June to September. The soil is lateritic, sandy clay loam and acidic in reaction having pH ranging from 5.6 to 6.5. Fifteen genotypes were evaluated in a randomized block design (RBD) with two replications. Propagules of four released varieties, namely Arka Kanaka (G_4), Arka Chenna (G_6), Arka Shreeya (G_9) and Arka Ambara (G_{11}), were procured from IIHR, Bengaluru, while the remaining eleven local genotypes were collected from different locations in Dapoli tehsil. These included G_1 (Gavhe type 1), G_2 (Gavhe type 2), G_3 (Gavhe type 3), G_5 (Gavhe type 4), G_7 (Jalgaon type 1), G_8 (Jalgaon type 2), G_{10} (Ladghar type 1), G_{12} (Jalgaon type 3), G_{13} (Jalgaon type 4), G_{14} (Ladghar type 2) and G_{15} (Ladghar type 3). Each experimental plot measured 2.7 m × 1.8 m, and thirty days old healthy seedlings raised in polybags were transplanted at a spacing of 45 cm × 45 cm. Observations on flowering and yield attributes were recorded from five randomly selected plants per treatment. The pooled data over the two years were subjected to statistical analysis using standard procedures to evaluate the comparative performance of the genotypes under the agro-climatic conditions of the Konkan region.

General view of experimental plot

3. Results and Discussion

3.1 Flowering parameters

A) Rachis Length (cm)

The findings pertaining to rachis length over the two-year period were presented in Table 1. Analysis of the pooled data across both years revealed significant variation in flower rachis length among the genotypes under study. Genotype G_8 (Jalgoan type 2) exhibited the highest rachis length (10.37 cm), which was found to be statistically at par with genotype G_{12} (Jalgoan type 3) (9.32 cm). However, the minimum rachis length in the pooled analysis was recorded in genotype G_{10} (Ladghar type 1) (3.73 cm). The variation in rachis length among crossandra genotypes during evaluation trials can be attributed to both genetic and environmental influences. According to Vinodh and Kannan (2020) [8], rachis length exhibited high heritability coupled with high genetic advance, indicating that this trait is predominantly governed by additive gene action. Similar observations were made by Bhosale *et al*. (2018) [13], Gowsika *et al*. (2019) [2], Prasanth *et al*. (2020) [5], and Kavitha *et al*. (2025) [4], who documented significant variation in rachis length across different Crossandra genotypes under diverse agro-climatic conditions. Priyanka *et al.* (2023) [7] also reported consistent findings in Gladiolus.

B) Spike length (cm)

The detailed data pertaining to spike length was presented in Table 1. The data from both years were pooled, genotype G_1 (Gavhe type 1) recorded longest average spike length (12.57 cm) and this was followed by the genotypes G_{10} (Ladghar type 1) (11.71 cm) and G_{14} (Ladghar type 2) (11.41 cm) while genotype G_8 (Jalgoan type 2) recorded the shortest spike length i.e. (3.35 cm). The variation in spike length observed among different Crossandra genotypes may be attributed to their inherent genetic potential, which plays a critical role in determining floral traits such as spike development. Additionally, environmental factors, particularly light intensity whether insufficient or excessive can significantly affect the overall vegetative and reproductive growth of the plant, thereby influencing spike elongation. Similar trends have also been reported by Bhosale *et al*. (2018) [13], Prasanth *et al*. (2020) [5], Das *et al*. (2022) [14], and Hosagoudar *et al*. (2022) [3], who recorded comparable spike lengths across different agro-climatic regions, thereby reinforcing the consistency of this trait in Crossandra.

C) Number of pickings per spikes

The data on number of pickings per spikes was given in Table 1. The pooled analysis across both years confirmed the superior performance of genotype G_4 (Arka Kanaka), which achieved the highest mean number of pickings per spike (15.05). This was followed by the genotypes G_5 (Gavhe type 4), (12.32) and G_{12} (Jalgoan type 3) i.e. (11.97). On the other hand, genotype G_7 (Jalgoan type 1) consistently exhibited the lowest number of pickings per spike (4.80), highlighting its comparatively inferior performance in this trait. The number of pickings per spike among diverse crossandra genotypes demonstrates considerable variation, primarily influenced by both genetic makeup and environmental conditions. Each genotype possesses distinct genetic characteristics that govern spike initiation, floral density, and overall flower yield. Certain genotypes inherently exhibit profuse and continuous flowering patterns, thereby enabling a higher frequency of pickings throughout the flowering period. Similar findings were also reported by Prasanth *et al.* (2020) [5] in crossandra and analogous results were observed and documented in other plants by Byadwal *et al.* (2018) [9] in Gaillardia.

Table 1: Performance of crossandra genotypes with respect to flowering parameters

Genotypes	Rachis Length (cm)	Spike length (cm)	Number of pickings per spikes
G_1 (Gavhe type 1)	4.40	12.57	10.02
G_2 (Gavhe type 2)	7.74	3.85	9.27
G_3 (Gavhe type 3)	5.75	6.71	10.25
G_4 (Arka Kanaka)	7.71	11.35	15.05
G_5 (Gavhe type 4)	6.43	9.67	12.32
G_6 (Arka Chenna)	5.28	11.19	8.10
G_7 (Jalgoan type 1)	7.30	8.57	4.80
G_8 (Jalgaon type 2)	10.37	3.35	6.41
G_9 (Arka Shreeya)	8.62	7.37	7.30
G_{10} (Ladghar type 1)	3.73	11.71	11.40
G_{11} (Arka Ambara)	6.04	4.83	10.10
G_{12} (Jalgaon type 3)	9.32	4.32	11.97
G_{13} (Jalgaon type 4)	5.32	6.89	6.92
G_{14} (Ladghar type 2)	7.00	11.41	6.15
G_{15} (Ladghar type 3)	4.40	6.78	6.72
S.Em±	0.38	0.24	0.60
CD @ 5%	1.17	0.75	1.82

3.2 Yield Parameters

D) Number of florets per spikes

The number of florets per spikes was significantly influenced by different genotypes, which was presented in Table 2 and depicted Figure 1. The pooled data across both years revealed that genotype G_4 (Arka Kanaka) consistently produced the highest number of florets per spike (71.55), followed by genotype G_{10} (Ladghar type 1) with 45.52, and G_{11} (Arka Ambara) with 44.42. On the other hand, the lowest pooled mean was recorded in genotype G_8 (Jalgaon type 2), with 18.78 florets per spike. The findings of the present investigation clearly indicated that the number of florets per spike varied significantly among the evaluated crossandra genotypes. This genotypic variability can be primarily attributed to differences in genetic constitution, which inherently governs the floral developmental potential of the plant (Bhosale *et al*. 2018) [13]. Similar observations have been reported by Bhosale *et al*. (2018) [13], while Sree *et al.* (2023) [12] also documented significant genotypic variation in the number of florets per spike across diverse geographical locations during their evaluation of crossandra genotypes.

E) Average weight of 100 flowers (g)

The data on the average weight of 100 flowers (g) was presented in Table 2 and depicted in Figure 1. Pooled analysis across both years indicated that the maximum average flower weight was recorded in genotype G_4 (Arka Kanaka) (8.57 g), followed by G_{11} (Arka Ambara), (7.80 g), G_6 (Arka Chenna), (7.61 g), and G_9 (Arka Shreeya), (6.71 g). The minimum was observed in G_8 (Jalgaon type 2), (2.23 g). The observed variability may be attributed to genotypic differences influencing floral attributes such as floret length, floret width, and number of florets per spike, which collectively determine biomass accumulation per flower. These results corroborate earlier findings reported by Prasanth *et al*. (2020) [5], Das *et al*. (2022) [14], and Hosagoudar *et al.* (2022) [3] in crossandra and Rajiv *et al.* (2022) [10] in nerium.

F) Duration of flowering (days)

The data on flowering duration was presented in Table 2 and Fig 1. Pooled results across both years revealed that genotype G_4 (Arka Kanaka) exhibited the longest flowering duration (46.04 days), followed by G_{10} (Ladghar type 1) (42.25 days) and G_6 (Arka Chenna), (39.95 days). The shortest duration was observed in G_8 (Jalgaon type 2), (20.39 days). The variation in flowering duration may be attributed to genotypic differences, further influenced by environmental factors such as temperature, photoperiod, humidity, and nutrient availability, which modulate gene expression and thereby regulate the flowering process. Similar findings have been documented by Das *et al.* (2022) [14], who reported that the genotype 'Arka Shravya' exhibited the longest flowering duration among crossandra genotypes, recording a period of 45.00 days. This observation was further supported by Sree *et al.* (2023) [12], who also noted an extended flowering duration of 47.00 days in the same genotype.

G) Yield of flowers t/ha

The flower yield of Crossandra genotypes exhibited marked variation across the research trial. Data on yield (t/ha), presented in Table 2 and illustrated in Figure 1, showed that genotype G_4 (Arka Kanaka) consistently recorded the highest average yield (7.93 t/ha), followed by G_{10} (Ladghar type 1) (6.76 t/ha), G_{11} (Arka Ambara), (6.55 t/ha), and G_2 (Gavhe type 2) (6.13 t/ha). Conversely, G_8 (Jalgaon type 2) recorded the lowest yield (3.08 t/ha). The variability in flower yield among genotypes can be attributed to inherent differences in genetic makeup, growth habit, and environmental adaptability. Yield was positively associated with traits such as plant height, branching capacity, florets per spike, and 100-flower weight, highlighting the cumulative contribution of these attributes to overall productivity. The superior performance of Arka Kanaka may also be linked to its physiological and genetic characteristics. Its semi-erect canopy likely enhances light interception and aeration, promoting efficient partitioning of photosynthetic toward reproductive growth. Increased branching could result from favourable hormonal regulation possibly higher cytokinin activity or reduced apical dominance due to auxin balance thereby supporting prolific flowering. Furthermore, its partial photoperiod sensitivity may extend flowering duration, ensuring a longer harvesting window and higher cumulative yields. Comparable results were reported by Priyanka *et al*. (2017), who recorded the maximum yield in Arka Shravya (6.04 t/ha), which was statistically on par with ACC-1 (5.80 t/ha). Similar findings were observed by Das *et al*. (2022) [14] in crossandra and by Sharma and Topno (2024) [11] in chrysanthemum.

Table 2: Yield parameters of different crossandra genotypes

Genotypes	Yield parameters			
	Number of florets per spikes	Average weight of 100 flowers (g)	Duration of flowering (days)	Yield of flowers (t/ha)
G_1 (Gavhe type 1)	25.65	3.43	37.47	3.98
G_2 (Gavhe type 2)	41.80	4.20	35.89	6.13
G_3 (Gavhe type 3)	35.47	4.30	36.44	4.26
G_4 (Arka Kanaka)	71.55	8.57	46.04	7.93
G_5 (Gavhe type 4)	27.80	4.72	33.66	3.91
G_6 (Arka Chenna)	32.33	7.61	39.95	4.59
G_7 (Jalgaon type 1)	29.59	5.86	23.54	3.22
G_8 (Jalgaon type 2)	18.78	2.23	20.39	3.08
G_9 (Arka Shreeya)	37.17	6.71	34.66	4.71
G_{10} (Ladghar type 1)	45.52	5.59	42.25	6.76
G_{11} (Arka Ambara)	44.42	7.80	37.10	6.55
G_{12} (Jalgaon type 3)	39.95	4.96	36.82	4.80
G_{13} (Jalgaon type 4)	41.08	3.66	28.12	5.12
G_{14} (Ladghar type 2)	27.40	4.56	31.00	3.79
G_{15} (Ladghar type 3)	42.62	3.67	31.07	5.59
S.Em±	0.44	0.09	0.45	0.11
CD @ 5%	1.34	0.28	1.38	0.35

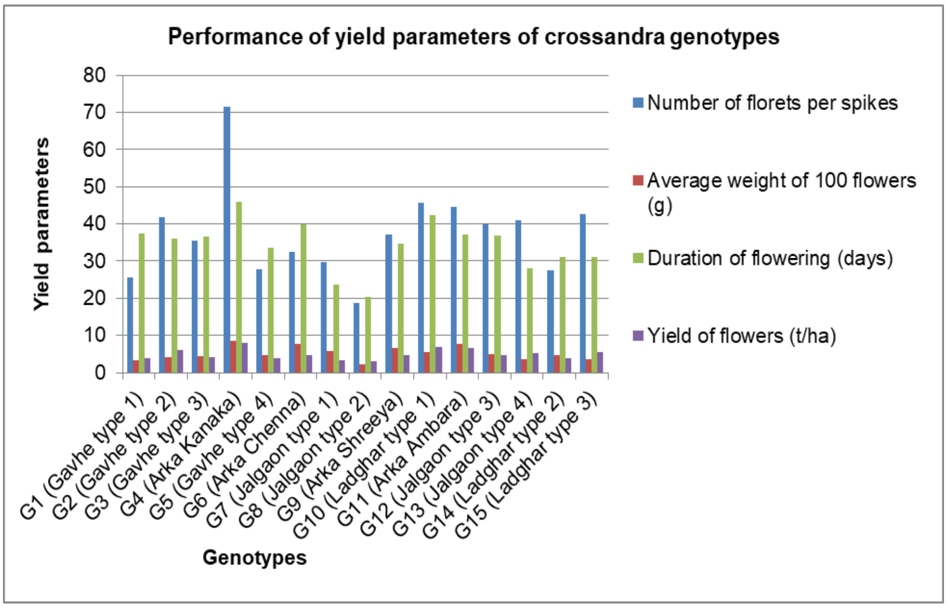

Fig 1: Performance of crossandra genotypes with respect to yield parameters

3.3 Economics for cultivation of different crossandra genotypes

The genotype G_4 i.e. Arka Kanaka achieved the highest gross returns of ₹ 1665300/- and net returns of ₹ 1124818/- among the crossandra genotypes. The benefit-cost (B:C) ratio varied significantly among the genotypes. Genotype Arka Kanaka (G_4) also led in this metric with a B:C ratio of 3.08, indicating high profitability due to its superior yield of florets per spikes and strong market demand. Flower price considered for economic calculations was ₹210 per kg. This clearly demonstrates that higher flower yield not only enhances cost-efficiency by spreading input and labour expenses over greater output, but also directly boosts market volume and profit margins, ensuring greater economic returns for growers. The crossandra crop will provide diversification to Konkan regions cropping pattern. Similar findings were reported by Das *et al.* (2022) [14], who observed that the highest benefit-cost (B:C) ratio was recorded for the genotype Arka Shravya (5.58) and Singh *et al*. (2023) [6] in African marigold.

4. Conclusion

The two year evaluation of crossandra genotypes revealed that Arka Kanaka consistently excelled in vegetative, floral traits, yield, and economic returns, making it highly suitable for large scale cultivation in the Konkan region. Genotypes G_{10} (Ladghar type 1), G_{11} (Arka Ambara), and G_2 (Gavhe type 2) also performed well in terms of growth, flowering, and yield, indicating their adaptability to local conditions. In contrast, local genotypes G_8 (Jalgaon type 2) and G_7 (Jalgaon type 1) showed poor floral productivity and are not recommended. Overall, Arka Kanaka, followed by G_{10}, G_{11}, and G_2, emerged as the most promising genotypes for commercial cultivation and future crop improvement.

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