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Exogenous cytokinins and gibberellins accelerate rootstock stem thickening and nursery readiness in Karonda (*Carissa carandas* L. cv. Konkarn Bold)

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ABSTRACT

Karonda (*Carissa carandas* L. cv. Konkarn Bold) is an important underutilized fruit crop in the humid tropics of Western India, yet sluggish juvenile seedling growth severely delays graftable rootstock readiness. A polyhouse experiment was conducted during 2025-2026 at Dapoli, Maharashtra, India, to standardize foliar plant growth regulator (PGR) treatments for accelerating rootstock growth and graftability. The experiment was arranged in a randomized block design with ten treatments and three replications: control (water spray), NAA (25, 50, 75 mg L⁻¹), GA₃ (50, 75, 100 mg L⁻¹), and 6-benzylaminopurine (BAP: 20, 30, 40 mg L⁻¹), applied twice at a 30-day interval on 3-month-old seedlings. Vegetative growth and grafting metrics were evaluated at 240 days post-application. Foliar application of GA₃ at 100 mg L⁻¹ (T₇) produced the maximum plant height (34.43 cm), whereas BAP at 30 mg L⁻¹ (T₉) induced superior radial stem expansion, yielding the highest collar girth (6.40 mm) and leaf count (57.90 leaves seedling⁻¹). Application of BAP at 40 mg L⁻¹ (T₁₀) and 30 mg L⁻¹ (T₉) significantly reduced the duration required to achieve graftable stem diameter (greater than 5.5 mm) to 207.33 and 210.33 days, respectively, compared to 222.00 days in the control. BAP at 30 mg L⁻¹ (T₉) recorded the highest proportion of graftable seedlings (92.67%). Foliar application of BAP at 30 mg L⁻¹ improved key nursery growth and graftability attributes of Karonda and reduced the time required to produce graftable rootstocks, indicating its potential for improving nursery propagation efficiency.

Keywords: Karonda, Growth regulators, *Carissa carandas* L., 6-Benzylaminopurine, Collar girth, Graftability

Introduction

Karonda (*Carissa carandas* L., family Apocynaceae) is a hardy, evergreen spiny shrub of significant horticultural value across the arid and semi-arid tropics of India. The crop is well-suited for cultivation throughout tropical and subtropical climatic zones of India. Its natural distribution has been recorded in Maharashtra, Bihar, West Bengal, Chhattisgarh, Odisha, Gujarat, Madhya Pradesh, Rajasthan and the Western Ghats. In Maharashtra the cultivation is concentrated in the sub-mountainous areas of Kolhapur, Ratnagiri and Pune (Sawant *et al.*, 2002) [1]. Globally, several species of *Carissa* are reported, while the Indian representatives include *C. carandas* L., *C. grandiflora* D. C., *C. bispinosa* Desf., *C. spinarum* D. C., *C. ovata*, *C. edulis* Vahl., *C. inermis* Vahl. Syn., *C. macrophylla*, *C. paucinervia* D. C., *C. spinarum* L. Syn. and *C. diffusa* (Singh and upphal., 2015) [2]. In India, major cultivated varieties comprise Pant Manohar, Pant Sudarshan, Pant Suvarna, Konkarn Bold, CHESK-II-7 and CHESK-35. Among these, Pant Manohar, Pant Sudarshan and Pant Suvarna are acidic varieties predominantly used for pickle production, whereas Konkarn Bold, CHESK-II-7 and CHESK-35 are suitable for table purposes (Kshirsagar *et al.*, 2021) [3]. The species is hardy, drought-tolerant and capable of growing under high-temperature conditions on a wide range of soils. Due to its spiny branches, it is also utilized as a hedge or bio-fence (Sharma *et al.*, 2010) [4]. Valued for its nutraceutical-rich fruits, it exhibits high tolerance to drought, high temperatures up to 44°C and saline-sodic soils. Nutritionally, ripe fruits contain 73.89% moisture, 20.17° Brix TSS, 11.48 % total sugars, 0.341 % acidity and 1.75 mg/100 g ascorbic acid (Joshi *et al.*, 1986) [5]. The ripe fruits are rich sources of iron (39.10 mg/100 g) and ascorbic acid (Peter, 2007) [6]. Depending on the cultivar, ripe fruits range from sub-acidic to sweet with a peculiar aroma and are suitable for preparation of various processed products such as jelly, jam, squash and sauce (Tripathi *et al.*, 2014) [7] also immature fruits are harvested for vegetable purposes, whereas ripe fruits are consumed fresh or processed into value-added products (Malik *et al.*, 2010) [8] making the crop commercially viable for processing and marginal land utilization. In Western India, particularly the Konkarn region, regional cultivars like Konkarn Bold present substantial potential for commercial orchard expansion. The species, native to India is described as a semi-vine shrub (Bankar *et al.*,

1994) [9] and is often regarded as a “poor man’s meal.” In the Konkan region, it is locally known as “Dongarchi Kali Maina” (Jadhav, 1996) [10].

Despite growing market demand, commercial expansion is severely hindered by the lack of quality planting material. In vegetatively propagated karonda, softwood grafting relies heavily on rootstock vigor, uniform collar girth and physiological maturity for rapid graft union formation and field establishment. However, karonda seedlings naturally exhibit sluggish juvenile growth and recalcitrant seed behavior, taking an extended period to achieve graftable stem diameter. This prolonged nursery cycle increases management costs and creates a supply-demand gap for elite planting material.

Exogenous application of Plant Growth Regulators (PGRs) offers a practical strategy to overcome juvenile dormancy and accelerate vegetative growth dynamics. Cytokinins and gibberellins are known to stimulate apical dominance, lateral meristem division, and cambial development, thereby promoting stem elongation and radial thickening. While PGR-induced growth enhancement has been demonstrated in various woody perennials, standardizing specific growth regulator regimes to accelerate rootstock readiness in *C. carandas* cv. Konkan Bold remains limited.

Therefore, the present investigation was undertaken to systematically evaluate the influence of foliar-applied plant growth regulators on seedling growth kinetics, temporal readiness for grafting and overall graftable yield in karonda cv. Konkan Bold. The objective was to standardize an optimized growth regulator protocol to shorten the nursery cycle and enable efficient mass propagation under Konkan agro-climatic conditions.

Material and method

The field experiment was conducted in a controlled polyhouse structure at the College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India (17°45' N latitude, 73°12' E longitude, altitude 280 m above mean sea level). The experimental site falls under the warm and humid tropical climate of the Konkan agro-climatic zone, characterized by high relative humidity throughout the year and an average annual rainfall of 2,700 mm, predominantly received during the south-west monsoon from June to September. The experimental potting medium comprised lateritic soil with a pH ranging from 5.6 to 6.5.

Uniformly vigorous and healthy three-month-old seedling rootstocks of karonda (*Carissa carandas* L.) cv. Konkan Bold were selected for the experiment. The study was laid out in a Randomized Block Design (RBD) comprising 10 treatments with three replications. Each replication consisted of a standardized number of experimental seedlings. The treatments comprised different concentrations of synthetic plant growth regulators as follows:

T₁: Control (distilled water spray), T₂: Alpha-naphthaleneacetic acid (NAA) at 25 mg L⁻¹, T₃: NAA at 50 mg L⁻¹, T₄: NAA at 75 mg L⁻¹, T₅: Gibberellic acid (GA₃) at 50 mg L⁻¹, T₆: GA₃ at 75 mg L⁻¹, T₇: GA₃ at 100 mg L⁻¹, T₈: 6-benzylaminopurine (BAP) at 20 mg L⁻¹, T₉: BAP at 30 mg L⁻¹ and T₁₀: BAP at 40 mg L⁻¹. Foliar applications were initiated one month after transplanting, when the three-month-old rootstocks were well established. The required concentrations of plant growth regulators were prepared by dissolving the respective chemicals in a suitable solvent according to their solubility and making up the final volume with double-distilled water. Two foliar sprays were applied at an interval of 30 days during the early morning hours between 08:00 and 10:00 h using a calibrated hand-operated sprayer until the foliage was thoroughly wetted.

Spray drift between adjacent treatments was minimized by using portable polyethylene sheets as temporary barriers during spraying. Irrigation, weeding, plant protection measures and other cultural practices were maintained uniformly for all treatments throughout the ex-

perimental period. Seedling growth parameters, including plant height, stem collar girth, number of leaves and leaf area, were recorded at regular intervals. Grafting-related parameters, including the number of days required to attain graftable size and the percentage of graftable seedlings, were also recorded, graftable seedlings are selected on the basis of girth at collar region i.e. >5 mm.

The data were subjected to analysis of variance (ANOVA) appropriate for a Randomized Block Design (RBD) following the procedure described by Panse *et al.* (1995) [11]. Treatment means were compared using the critical difference (CD) at the 5% level of significance.

Result and discussion

Exogenous application of plant growth regulators significantly influenced the vegetative growth and graftability of karonda (*Carissa carandas* L.) cv. Konkan Bold rootstock seedlings at the 5 per cent level of significance ($p \leq 0.05$) (Table 1).

Vertical shoot elongation varied significantly across treatment regimes at 240 days after spraying (DAS). Foliar application of GA₃ at 100 mg L⁻¹ (T₇) recorded the maximum plant height (34.43 cm), demonstrating significant superiority over all other treatments, whereas the untreated control (T₁) recorded the minimum height (27.07 cm). The pronounced height increase under GA₃ treatments is attributed to gibberellin-induced cell elongation and rapid cell division in the sub-apical meristems. GA₃ enhances hydrolytic enzyme activity such as alpha-amylase, promoting cell wall loosening and internodal extension. These findings accord with Chavan (2014) [12] in karonda and Malshe *et al.* (2016) [13] in *Manilkara hexandra* L., who documented comparable growth stimulation following exogenous GA₃ application.

Collar Girth (mm) serves as a vital index of rootstock sturdiness and graft compatibility. Application of 6-Benzylaminopurine (BAP) at 30 ml (T₉) produced the maximum stem girth (6.40 mm), which was statistically at par with BAP at 20 mg L⁻¹ (T₈, 6.16 mm), while control seedlings (T₁) registered the lowest stem thickness (4.83 mm). The radial thickening driven by BAP highlights the classic physiological function of cytokinins in promoting lateral meristem activity, cambial cell division, and sink strength, thereby directing assimilate partitioning toward the primary stem axis. Similar cytokinin-mediated radial expansion was reported by Halder *et al.* (2023) [14].

Leaf count per seedling differed significantly ($p \leq 0.05$) among treatments at 240 DAS. Foliar spray of BAP at 30 mg L⁻¹ (T₉) yielded the highest leaf number (57.90), performing at par with T₁₀ (BAP 40 mg L⁻¹, 57.13), T₈ (BAP 20 mg L⁻¹, 57.07), T₃ (NAA 50 mg L⁻¹, 56.03) and T₂ (NAA 25 mg L⁻¹, 55.50). Minimum leaf accumulation occurred in control (46.17). BAP delays leaf senescence and promotes auxiliary bud outgrowth, enhancing photosynthetic canopy formation. These results corroborate the findings of Pavhane (2016) [15] in *Garcinia indica* Choisy.

Accelerating rootstock readiness is essential for shortening the nursery production cycle. High concentration cytokinin treatment (T₁₀: BAP 40 mg L⁻¹) required the minimum duration (207.33 days) to achieve graftable stem diameter (> 5.5 mm) remaining at par with T₉ (210.33 days), T₄ (210.33 days), and T₃ (213.00 days). Conversely, control seedlings required the longest duration (222.00 days). The accelerated attainment of graftable age in BAP-treated plants stems from synchronized radial thickening and rapid tissue maturation.

The overall proportion of seedlings reaching graftable readiness was significantly highest under T₉ (BAP 30 mg L⁻¹) at 92.67%, significantly outperforming all other treatments, whereas control (T₁) yielded the lowest graftable proportion (80.00%). The superior graftable recovery in T₉ is the culmination of balanced collar thickness, optimal leaf area, and physiological vigor. Similar enhancements in graftable seedling recovery following cytokinin application were reported by Muralidhara *et al.* (2014) [16] in *Mangifera indica* L.

Table 1. Effect of foliar application of plant growth regulators on growth performance and graftability of Karonda (*Carissa carandas* L. cv. Konkan Bold) rootstock seedlings at 240 days post-treatment

Treatment Code	Treatment Details	Plant Height (cm)	Collar Girth (mm)	Leaves Seedling ⁻¹	Days to Graftable Size	Graftable Seedlings (%)
T ₁	Control (Distilled water)	27.07 ^c	4.83 ^e	46.17 ^c	222.00 ^a	80.00 ^f (63.43)
T ₂	NAA 25 mg L ⁻¹	29.20 ^{cd}	5.52 ^{bc}	55.50 ^{ab}	218.00 ^{ab}	84.67 ^{c-e} (66.95)
T ₃	NAA 50 mg L ⁻¹	27.83 ^{de}	5.81 ^b	56.03 ^a	213.00 ^{b-d}	88.67 ^{b-d} (70.33)
T ₄	NAA 75 mg L ⁻¹	28.33 ^{de}	5.77 ^b	52.67 ^b	210.33 ^{cd}	83.33 ^{de} (65.91)
T ₅	GA ₃ 50 mg L ⁻¹	31.00 ^{bc}	5.62 ^b	52.47 ^b	219.67 ^a	85.33 ^{c-e} (67.48)
T ₆	GA ₃ 75 mg L ⁻¹	31.80 ^b	5.42 ^{cd}	52.93 ^b	215.33 ^{a-c}	86.67 ^{b-e} (68.58)
T ₇	GA ₃ 100 mg L ⁻¹	34.43 ^a	5.16 ^{de}	52.17 ^b	213.67 ^{b-d}	82.00 ^{ef} (64.90)
T ₈	BAP 20 mg L ⁻¹	30.00 ^c	6.16 ^a	57.07 ^a	216.33 ^{a-c}	90.67 ^{ab} (72.21)
T ₉	BAP 30 mg L ⁻¹	30.60 ^{bc}	6.40 ^a	57.90 ^a	210.33 ^{cd}	92.67 ^a (74.30)
T ₁₀	BAP 40 mg L ⁻¹	29.10 ^{cd}	5.46 ^{cd}	57.13 ^a	207.33 ^d	86.00 ^{c-e} (68.03)
	S.Em. (±)	0.79	0.15	1.56	2.51	0.61
	CD (<i>p</i> ≤ 0.05)	2.34	0.44	4.65	7.45	1.82

Figures in parentheses represent arc-sine transformed values.

Note: Means followed by different superscript letters within a column differ significantly at *p* ≤ 0.05.

Conclusion

Exogenous foliar application of plant growth regulators significantly improved rootstock seedling growth and graftability in Karonda (*Carissa carandas* L. cv. Konkan Bold). Foliar application of BAP at 30 mg L⁻¹ (T₉), applied twice at a 30 day interval, proved effective for nursery production by recording the maximum collar girth of 6.40 mm, highest number of leaves of 57.90 leaves per seedling, and highest proportion of graftable seedlings of 92.67 percent. BAP at 40 mg L⁻¹ (T₁₀) and 30 mg L⁻¹ (T₉) reduced the time required to attain graftable stem diameter of more than 5.5 mm by 14.67 and 11.67 days, respectively, compared with the untreated control. Overall, foliar application of BAP at 30 mg L⁻¹ improved key nursery growth and graftability attributes and reduced the time required for production of graftable Karonda rootstocks, indicating its potential for improving nursery propagation efficiency.

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