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Efficacy of different pre-sowing treatments on seed germination and growth of Karonda (*Carissa carandas* L.)

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Abstract

Karonda (*Carissa carandas* L.) is a hardy, drought-tolerant shrub with high horticultural and medicinal value, but its propagation is limited by poor seed germination due to a hard seed coat. To address this challenge of low seed germination percentage, a study was conducted with the objective to evaluate the effect of various pre-sowing treatments on germination and seedling growth for large scale production of nursery plants. The present experiment was conducted at Punjab Agricultural University, Regional Research Station, Gurdaspur during the years 2023-24 and 2024-25. Karonda seeds were extracted carefully from the freshly harvested fruits and shade dried and then subjected to different pre-sowing seed treatments viz. gibberellic acid (GA₃) (250, 500 & 1000 ppm), potassium nitrate (KNO₃) (1.0, 1.5 & 2.0%), thiourea (1.0, 1.5 & 2.0%), water soaking (24, 48 & 72 hours) and control (sown immediately after extraction without any treatment) in completely randomized design with 3 replications. After treatments, seeds were sown in polythene bags having potting mixture of soil, sand, vermicompost and cocopeat (1:1:1:1) by following recommended nursery management practices. It has been noted that karonda seeds treated with GA₃ 1000 ppm recorded early germination with maximum germination percentage. Growth parameters like plant & diameter, fresh & dry weight of stem, number of leaves, leaf length & breadth, fresh & dry weight of leaf, primary, secondary & tertiary root number, primary, secondary & tertiary root length, thick root diameter, fresh & dry weight of root and survival percentage were significantly maximum in plants raised from karonda seeds treated with gibberellic acid 1000 ppm. It is concluded that karonda seeds treated with gibberellic acid 1000 ppm gave best results in terms of all germination and plant growth parameters.

Keywords: *Carissa carandas* L., karonda, germination, gibberellic acid, plant growth, pre-sowing treatments, survival

1. Introduction

Karonda is an important minor indigenous underexploited fruit crop of India. It has recently attained importance as an arid zone horticulture crop because of its hardy nature and its nutritious fruits. It is popularly known as “Bengal currant” or “Christ’s Thorn”. It belongs to family Apocynaceae with chromosome number 2n = 22. There are about 30 species in genus the *Carissa* being native of tropics and subtropics of Asia, Africa, Australia and China (Arif *et al.*, 2016) [3]. Major natural areas of occurrence of karonda have been observed in the states of Maharashtra, Bihar, West Bengal, Chhattisgarh, Orissa, Gujarat, Madhya Pradesh, Rajasthan and Punjab (Singh *et al.*, 2014) [60]. Karonda is suitable for growing throughout subtropical and tropical climatic zones of India having commercial and medicinal value. It grows up to a height of 3-6 metres with dark green elliptic leaves, white purple or nearly black colour fruit when ripe. It is a very hardy and grown successfully on a wide range of soils, including poor soils of arid and semi-arid regions where others fruit crops fail to grow (Hasmah *et al.*, 2013) [18]. Fruits are generally harvested at immature stage for vegetable purpose, while fully ripen fruits are consumed fresh or processed (Malik *et al.*, 2010) [30]. The dried fruits are good source of iron (39.10 mg/100 g), pectin and contain fair amount of vitamin C. Fruits are used in preparation of jelly, jam, syrup, murabba and chutney (Kumar *et al.*, 2007) [27]. The unripe fruits yield milky white latex which can be used in preparing chewing gum and rubber. The fruits are traditionally used in the treatments of malaria, epilepsy, nerve disorder, relieve of pain and headache, colds, itches and leprosy

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(Rahmatullah *et al.*, 2009)^[49]. When ripe they become sweet and rich in carbohydrates, pectins, minerals, especially iron and vitamin C. The unripe fruit is sour and astringent and which is used for making pickles and chutneys. They are used in place of cherry for decoration of sweets and pastries. The ripe fruit is sweet, cooling, appetiser and antiscorbutic and is useful in controlling burning sensation, skin diseases, scabies, pruritus (Imran *et al.*, 2012)^[22] and particularly suitable for tarts and puddings. It is also used in curing anaemia. Karonda is very hardy and drought-tolerant plant and best suited as a live protective fence due to the presence of axillary spines and formation of profuse leaves on crowded branches. It has excellent potential to be used for horticultural plantations in marginal and wastelands, owing to its hardy and xerophytic nature with wide adaptability to saline sodic soils with pH up to 10 (Bankar *et al.*, 1994 ; Chundawat, 1995)^[4, 13]. The juvenile plants can also be used in the making of beautiful ornamental hedges (Sharma and Banyal, 2010)^[56]. The profuse branching in karonda roots helps in binding the soil and minimises soil erosion. The fruit type is berry and is formed in clusters of approximately 3-10 fruits. The shape of the fruit is ovoid to ellipsoid, coloured with reddish pulp on the skin and lighter near the seed. At different stages of growth, karonda fruit can be pinkish white or pinkish red. Green-fruited, white fruits with pink blush and dark purple-fruited cultivars are the three categories used to classify cultivated varieties (Chadha, 2009)^[10]. The plant exhibits wide genetic variability due to cross-pollination, leading to differences in fruit size, shape, and colour. Based on fruit colour, three types exist i.e. green, pink, and white; while based on taste, fruits can be sweet or sour (Verma and Sahu, 2018)^[65]. Leaves are opposite, small, ovate and shiny. Flowers are white in colour produced in terminal cyme. It is sometimes grown as an ornamental plant due to its beautiful cherry like fruits. Though the fruits are being used for different purposes, it has not yet been exploited on a commercial scale. As the crop is highly cross pollinated, large variability exists in natural population. It is commercially propagated by seeds, but seeds are quite hard with low germination. One major challenge in karonda cultivation is poor seed germination due to its hard seed coat, making commercial propagation difficult (Patil *et al.*, 2019)^[45]. Seeds are recalcitrant and are relatively high in moisture content and possess a characteristic feature of losing their viability within 4-5 weeks. Hence seeds of karonda should be sown just after extraction from fruits. The germination percentage and seedling growth are affected by pre-sowing seed treatments in different fruit crops. To get higher and proper germination, seed require special treatments like scarification, soaking in water, growth regulators, concentrated acid solution etc. which helps in promotion of early and higher percentage of seed germination with healthy and vigorous seedling. For example, water soaking of seeds helps soften the seed coats, remove inhibitors, and reduce the time required for germination, thereby increasing germination percentages (Bhavya *et al.*, 2017)^[5]. Plant growth regulators like gibberellic acid (GA₃) enhance the germination, growth, and survival of seedlings. GA₃ weakens the seed coat, allowing the radicle to break through. It plays a crucial role in two stages of germination: initial enzyme induction and activation of the reserve food mobilizing system, which helps enhance germination (Palepad *et al.*, 2017)^[37]. GA₃ also plays a significant role in

increasing plant height and girth due to increased cell division and elongation (Nimbalkar *et al.*, 2012)^[35]. The application of potassium nitrate (KNO₃) as a seed priming agent has demonstrated potential to improve seed performance by alleviating dormancy and stimulating metabolic processes essential for germination (Gul *et al.*, 2017; Mohammed *et al.*, 2021)^[17, 32]. Potassium nitrate (KNO₃) enhances germination by facilitating water uptake and activating enzymes involved in the early stages of seed metabolism (Yu *et al.*, 2017)^[66]. Thiourea has successfully forced germination by strongly neutralizing the inhibitors present in the seed and increasing cytokinin activity, thereby overcoming the seed coat's inhibiting effect (Hore and Sen, 1994)^[20]. Therefore, the objective of present study was to improve the seed germination with standardization of pre-sowing treatments for faster production of nursery plants of karonda.

2. Materials and Methods

The present investigation on “Efficacy of Different Pre-sowing Treatments on Seed Germination and Growth of Karonda (*Carissa carandas* L.) plant” was conducted during the years 2023-24 and 2024-25 at Punjab Agricultural University, Regional Research Station, Gurdaspur in sub-mountainous region of Punjab which is situated between 32°3' N latitude, 75°22' E longitude and has an altitude of about 257 m from mean sea level having humid subtropical and dry winter climate. The submountain zone of Punjab (Kandi region) features hilly topography with *shivalik* foothills, undulating terrains, and deep, coarse-textured sandy loam to silt loam coarse-textured soils.

2.2 Planting material

Karonda (8-10 years old plants) plants grown in the orchard of Punjab Agricultural University, Regional Research Station, Gurdaspur, were selected for this experiment on the basis of their uniformity in appearance, growth habit, and being free from visual symptoms of pests and disease occurrence.

2.3 Experimental design

The experiment was performed in a one-way analysis of variance in Completely Randomised Block Design (CRBD) with three replications.

2.4 Seed treatments and sowing

Karonda seeds were extracted carefully from the freshly harvested fruits. The seeds were washed with water to remove the mucilaginous covering over the seed surface. The seeds were shade dried and then subjected to different seed treatments for one hour viz. gibberellic acid (GA₃) (250, 500 & 1000 ppm), potassium nitrate (KNO₃) (1.0, 1.5 & 2.0%), thiourea (1.0, 1.5 & 2.0%), water soaking (24, 48 & 72 hours) and control (sown immediately after extraction without any treatment). After treatments, seeds were sown in polythene bags of size of 20x25cm, previously filled with potting mixture of soil + sand + vermicompost: cocopeat(1:1:1:1) medium by following recommended nursery management practices.

2.5 Observations recorded

The various observation i.e. days to germination initiation, days to complete germination, germination percentage, plant height, plant diameter, fresh weight of stem, dry weight of

stem, number of leaves, leaf length, leaf breadth, fresh weight of leaf, dry weight of leaf, primary root number, secondary root number, tertiary root number, primary root length, secondary root length, tertiary root length, thick root diameter, fresh weight of root, dry weight of root and survival percentage were recorded.

2.6 Statistical analysis

The recorded data were statistically analysed by using one-way analysis of variance (ANOVA) with a Completely Randomised Design (CRBD) as suggested by Gomez and Gomez (2010) [16]. Experimental data were statistically analysed using SPSS-30 software.

3. Results and Discussion

3.1 Days taken to germination initiation, germination completion and germination percentage

From Table 1, it has been reported that karonda seeds treated with GA₃ 1000 ppm and planted in garden soil + sand + vermicompost: cocopeat (1:1:1:1) medium recorded the minimum days taken for germination initiation (7.52 days), germination completion (16.02) with maximum germination (96.25%). But maximum days taken for germination initiation (30.52 days), germination completion (52.61) and minimum germination (40.35%) were observed in control. Similarly, Devkate *et al.*, (2025) [15] reported minimum days to germination in aonla seeds treated with GA₃ 750 ppm. In the current study, karonda seeds treated with GA₃ 1000 ppm emerged noticeably earlier may be due to gibberellic acid, which is crucial for encouraging enzyme activity during germination. GA₃ is known to promote the production of α -amylase, which breaks down stored starch into simple sugars that provide the energy needed for physiological and metabolic processes (Palepad *et al.*, 2017; Hota *et al.*, 2018) [37, 21]. The reason for the highest germination in GA₃ treated seeds might be that GA₃ directly relieves embryos from dormancy by encouraging protein synthesis, elongating coleoptiles and leaves, and aiding in the synthesis of ethylene. This ethylene promotes seed germination by inducing the synthesis of hydrolases, particularly amylase. These factors might have contributed to faster germination by suppressing inhibitors and improved enzymatic responses (Stewart and Freebairn, 1969) [62]. Similarly, Devkate (2025) [15] reported that aonla seeds treated with GA₃ 750 ppm taken minimum days to germination with maximum germination. Sonkar *et al.*, (2025) [61] also reported that jamun seeds treated with GA₃ at 200 ppm demonstrated the earliest initiation of germination, shortest time to achieve 50% germination with highest germination percentage. Likewise, Krishna *et al.*, (2024) [26] observed maximum seed germination of firethorn seeds treated with GA₃ 150 ppm. Bordoloi *et al.*, (2025) [6] also reported that soaking of jamun seeds in 500 ppm GA₃ was most effective for better germination percentage. Similarly, seed treatment with GA₃ 200 ppm performed best in terms of minimum days taken for germination and maximum germination percentage in sweet orange cultivar Malta (Rawat *et al.*, 2023) [51], guava Nagar *et al.*, (2025) [34], custard apple (Dahayat *et al.*, 2025) [14] and jackfruit (Mithlesh *et al.*, 2025) [31]. Likewise, Qadri *et al.*, (2021) [48] reported that rough lemon seeds treated with GA₃ 400 ppm grown in sand, silt and leaf manure mixture media showed maximum seed germination.

3.2 Plant height and diameter

Highest plant height (55.42 cm) and diameter (5.95 mm) were also recorded by the karonda seeds soaked in GA₃ 1000 ppm solution and the lowest values for these measurements were recorded in control treatment (Table 1). The enhanced seedling height in GA₃ treated seeds might be attributed to gibberellic acid role in promoting vegetative growth through increased osmotic nutrient uptake, cell multiplication, and elongation (Shweta, 2022) [58]. This aligns with the findings of work conducted in custard apple (Lawhale *et al.*, 2020; Patel *et al.*, 2016; Rawat and Pandey 2019; Pravin *et al.*, 2021) [28, 43, 52, 47]. Similarly, Bordoloi *et al.*, (2025) [6] noted soaking of jamun seeds in GA₃ 500 ppm was most effective for better seedling height and highest stem girth. This increase of seedling length in the treatment treated with gibberellic acid is due to gibberellins are well known for inter nodal cell elongation, thereby increased the seedling length. The application of growth regulator increases the seedling height and such effect might be due to increase in photosynthetic activity and also enhancement in the mobilization of photosynthates and change in membrane permeability (Shukla *et al.*, 1997) [57]. Gibberellic acid 250 ppm treated kagzi lime have maximum seedling length as reported by Kiran *et al.*, (2024) [25]. Likewise, rough lemon seeds treated with GA₃ 400 ppm grown in sand, silt and leaf manure mixture media showed highest plant height and stem diameter as reported by Qadri *et al.*, (2021) [48]. Likewise, Krishna *et al.*, (2024) [26] reported maximum shoot length and shoot diameter in firethorn plants raised from GA₃ 150 ppm treated seeds. Similarly, maximum plant height and girth were noticed in aonla seeds treated with GA₃ 750 ppm (Devkate *et al.*, 2025) [15]. Likewise, Bordoloi *et al.*, (2025) [6] reported highest seedling length and stem girth in jamun seeds treated with GA₃ 500 ppm. Jagtap *et al.*, (2024) [23] also reported GA₃ 250 ppm shown best performance of papaya in growth parameters such as shoot height and stem diameter. Likewise, seed treatment GA₃ 200 ppm resulted maximum seedling height and stem diameter in sweet orange cultivar Malta (Rawat *et al.*, 2023) [51], guava (Nagar *et al.*, 2025) [34], custard apple (Dahayat *et al.*, 2025) [14] and jackfruit (Mithlesh *et al.*, 2025) [31].

3.3 Fresh and dry weight of stem

The result of the present investigation indicated that fresh and dry weight of stem were significantly influenced by GA₃ (Table 1). The fresh weight (38.65 gm) and dry weight (27.36 gm) of stem were found maximum in GA₃ 1000 ppm treated seeds of karonda as compared to rest of treatments. Similarly, Singh and Kaur (2021) [59] reported that aonla cultivar Chakaiya seeds treated with GA₃ 500 ppm yielded plants with maximum fresh and dry weight of shoot. The increase in fresh weight and dry weight of shoot with GA₃ treatment might be due to overall growth of the seedling and increased rate of photosynthesis that led to the overall assimilation and redistribution of photosynthates within the seedling and hence, resulted in higher fresh weight of shoot. This seems to be due to the effect of mobilization of water and nutrients transported at higher rate which might have promoted more production of photosynthetic products and translocated them to various plant parts which might have resulted in better growth of seedlings and hence, more fresh and dry weight. The results are in close conformity with findings in papaya (Pratibha *et al.*, 2015) [46], mango (Muralidhara *et al.*, 2015) [33], custard apple (Parmar *et al.*,

2016)^[41] and tamarind (Rajendrakumar, 2017)^[50]. Similarly, Rawat *et al.*, (2023)^[51] noted that sweet orange cultivar Malta seeds treated with GA₃ 200 ppm resulted into maximum shoot fresh weight and shoot dry weight. This seems to be the effect of mobilization of water and nutrients transported at higher rate which might have promoted more production of photosynthetic product and translocated them to various plant parts which might have resulted in better growth of the seedlings and hence, more fresh and dry weight of shoot (Brain, 1954; Shanmugavelu, 1966)^[8, 55]. The promising effect of GA₃ on fresh weight of roots might be due to the acceleration in the translocation and assimilation of auxins, the assimilation and redistribution of materials in plants cause better growth and vegetative characters which enhance the growth attributes (Pandey *et al.*, 2011)^[30]. GA₃ might have also increased the auxin level in the roots which induces tap root length and number of secondary and fibrous roots through stimulation of more root initiation, more nutrient uptake and root cell elongation which results in more fresh and dry weight. Firethorn seeds treated with GA₃150 ppm resulted in maximum shoot fresh and dry weight Krishna *et al.*, (2024)^[26]. Similarly, Devkate *et al.*, (2025)^[15] noted maximum fresh and dry weight of shoot were observed in GA₃ 750 ppm treated aonla seeds. Likewise, Bordoloi *et al.*, (2025)^[6] reported maximum plant fresh and dry weight in jamun seeds treated with 500 ppm GA₃.

3.4 Number of leaves, leaf length and leaf breadth

The highest number of leaves (60.25), leaf length (6.15 cm) and leaf breadth (4.52 cm) were noticed in the seed treatment with GA₃ 1000 ppm as against the lowest values of number of leaves (13.26), leaf length (3.02) and leaf breadth (2.05) were observed in the treatment control (Table 1). Gibberellic acid treatment accelerates photosynthetic carbon assimilation by raising chlorophyll content and improving stomatal conductance. As a result, more photosynthates are synthesized and distributed to growing tissues like leaves. This increase in available energy and building blocks enables faster leaf primordia initiation, faster leaf expansion, and higher leaf area. Increase in number of leaves might be due to the maximum height of seedlings under treatment GA₃ 1000 ppm possibly due to the induced cell division and cell growth by the movement of gibberellic acid to the shoot apex which increase the number of young leaves (Salisbury and Ross, 1988)^[53]. This aids in the stimulation of the plants physiological process and chemical stimulatory action which form new leaves at faster rate as suggested by Shaban (2010)^[54]. The maximum leaf area might be due increased in leaf length and width, which ultimately increased in leaf area of the plant. Likewise, Devkate *et al.*, (2025)^[15] reported maximum number of leaves in GA₃ 750 ppm treated aonla seeds. Similarly, maximum number of leaves reported in plants raised from firethorn seeds treated with GA₃ 150 ppm (Krishna *et al.*, 2024)^[26] and also highest number of leaves and leaf area were noted in jamun seeds treated with GA₃ 500 ppm (Bordoloi *et al.*, 2025)^[6]. Likewise, Jagtap *et al.*, (2024)^[23] reported GA₃ 250 ppm treated seeds of papaya reported maximum number of leaves. Likewise, maximum number of leaves and leaf area reported in sweet orange cultivar Malta (Rawat *et al.*, 2023)^[51], guava (Nagar *et al.*, 2025)^[34], custard apple Dahayat *et al.*, (2025)^[14], jackfruit (Mithlesh *et al.*, 2025)^[31] plants with seed treatment with GA 200 ppm.

3.5 Leaf fresh weight and leaf dry weight

Maximum fresh (0.52 gm) and dry weight (0.27 gm) of leaf was obtained in seed treatment GA₃ 1000 ppm as compared to rest of the treatments (Table1). Similarly, Papaya seeds cultivar Barwani Red treated with GA₃ 200 ppm had highest fresh and dry weight of leaves (Anjanawe *et al.*, 2013)^[2]. Likewise, application of GA₃ 100 ppm to Bougainvillea, Ixora and Rose cuttings gave higher value leaf fresh and dry weight (Hedayatullah, 2012)^[19]. The fresh and dry weight of leaves of seedlings obtained from pre-soaked GA₃ seeds might be due to the fact that more number of leaves with GA₃ treatments and it improve the rate of photosynthesis and lead to more accumulation of photosynthates (Alvin, 1960)^[1]. Similarly, Dahayat *et al.*, (2025)^[14] reported GA₃ 200 ppm treated custard apple seeds resulted highest values of fresh and dry weight of leaves. Likewise, GA₃ 50 ppm treated seeds of guava yielded maximum fresh weight and dry weight of seedling (Brijwal and Kumar, 2014)^[9].

3.6 Primary, secondary and tertiary root number

From the table 2, it has been noted that karonda seeds treated with GA₃1000 ppm have highest primary (33.56), secondary (75.32) and tertiary (150.21) root numbers. While the lowest values of said parameters were registered under control treatment. The seed treatment with GA₃ 1000 ppm increases the number of secondary roots per seedling resulting in better growth because auxins are translocated and assimilated. The maximum number of roots per seedling might be due to the mobilization of stored nutrients within the plant and enhanced supply of soluble carbohydrates to the growing embryo, which was caused by an increase in α -amylase activity along with rapid and uniform emergence might have resulted in the root growth parameters. The increase in number of secondary roots could be due to gibberellic acid which causes cell division, supplying photosynthates to root meristem. Similarly, Kiran *et al.*, (2024)^[25] reported that maximum number of secondary roots were also observed in the pre-sowing seed treatment of GA₃ 250 ppm to Kagzi lime. Boricha *et al.*, (2020)^[7] also observed similar results in guava and Patil *et al.* (2018) in jamun. Similarly, Choudhary *et al.*, (2022)^[12] reported that plants produced from pre-soaking treatment of papaya seeds with GA₃ 200 ppm observed the maximum number of primary and secondary roots. This might be due to the fact that, vigorous root growth due to gibberellic acid might have resulted in more production of photosynthetic product and their translocation through phloem to the root zone, which might be responsible for improving the root growth. Similarly Krishna *et al.*, (2024)^[26] reported firethorn seeds treated with GA₃150 ppm produced plants with maximum number of roots. Likewise, Devkate *et al.*, (2025)^[15] observed GA₃750 ppm treated aonla seeds produced plants having maximum number of secondary roots. Rawat *et al.*, (2023)^[51] also noted that plants raised from sweet orange cultivar Malta treated seeds with GA₃200 ppm resulted maximum total number of roots.

3.7 Primary, secondary & tertiary root length and thick root diameter

From the table2, it has been observed that primary root length (22.56cm), secondary root length(14.32cm), tertiary root length (8.75 cm), thick root diameter (1.85 mm) of plants were significantly highest in GA₃ 1000 ppm treated karonda seeds as compared to rest of the treatments. Panda

et al., (2018) ^[38] also noted that significantly highest root length of kagzi lime was registered in GA₃ 100 ppm treated seeds. Similarly, Devkate *et al.*, (2025) ^[15] reported highest length of primary root in GA₃ 750 ppm treated aonla seeds. Likewise, Rawat *et al.*, (2023) ^[51] also noted that sweet orange cultivar Malta recorded maximum root length and root diameter of plants in gibberellic acid 200 ppm treated seeds. Similarly, Krishna *et al.*, (2024) ^[26] noted that firethorn seed treatment with gibberellic acid 150 ppm resulted maximum root length and root diameter. The increase in root length could be due to exogenous application of gibberellic acid induced the activity of gluconeogenic enzymes during early stages of seed germination and this could be responsible for improved germination and vigour characteristics that is reflected in terms of increase in root length (Hota *et al.*, 2018) ^[21]. Gibberellic acid treatment might have resulted into increased production of photosynthates and their translocation through phloem to the root zone might be responsible for increasing the root growth (Vachhani *et al.*, 2014) ^[63]. These results are in close agreement with Shaban (2010) ^[54] and Patel *et al.*, (2017) ^[42] in mango. Likewise, length of root per seedling was highest in GA₃ 200 ppm treated jackfruit seeds (Mithlesh *et al.*, 2025) ^[31].

3.8 Fresh and dry weight of root

Karonda plants produced from GA₃ 1000 ppm treated seeds had highest fresh weight (16.52 gm) and dry weight (11.36 gm) of root (Table 2). Likewise, Choudhary *et al.*, (2022) ^[12] also reported that plants produced from pre-soaking treatment of papaya seeds with GA₃ 200 ppm observed the highest fresh and dry weight of roots. This can be ascribed to enhanced water mobilisation, nutrient uptake, and transportation facilitated by gibberellin, which promotes the production and efficient translocation of photosynthetic products throughout the plant (Parab *et al.*, 2017) ^[40]. Thus, increased growth is a consequence of increased dry matter accumulation (Shweta, 2022) ^[58]. Similarly, Krishna *et al.*, (2024) ^[26] noted that firethorn seeds treated with GA₃ 150 ppm gibberellic acid resulted in maximum root fresh and dry weight. Devkate *et al.*, (2025) ^[15] also reported that aonla seeds treated with GA₃ 750 ppm recorded highest fresh

and dry weight root of plant. This may be due to the fact that gibberellins in roots, like in shoots, cause the cells in the sub-apical region to elongate, lengthening the roots and increasing their fresh weight. The results align with Boricha *et al.*, (2020) ^[7] in guava. This enhancement in shoot and root fresh weight is on various physiological processes, including cell division, cell elongation, auxin metabolism, cell wall plasticity, and membrane permeability, which collectively stimulate plant growth (Maheshbhai, 2019) ^[29]. Comparable findings have been reported in various crops, including Kagzi lime (Jaiswal *et al.*, 2018) ^[24] and aonla (Chiranjeevi *et al.*, 2017; Verma *et al.*, 2019) ^[11, 64]. Devkate *et al.*, (2025) ^[15] also observed that GA₃ 750 ppm treated aonla seeds produced plants having highest fresh and dry weight of root. Similarly, Rawat *et al.*, (2023) ^[51] reported sweet orange cultivar Malta treated with gibberellic acid 200 ppm recorded maximum root fresh and dry weight.

3.9 Survival

Highest survival (93.16%) of karonda plants was noticed in GA₃ 1000 ppm treated seeds and lowest (45.16%) was observed in control treatment (Table 2). The enhanced survival observed in GA₃ treated seedlings is due to initiation of growth-regulating properties, which also promote balanced root and shoot development, increase seedling vigour, and improve tolerance to environmental stress. These findings are consistent with previous research in other fruit crops. This may be due to the fact that gibberellic acid acts on embryo and causes synthesis of hydrolyzing enzymes particularly for growth of embryo and this hydrolyzed food is utilized for growth of embryo and there by enhanced the germination and survival of karonda seeds. Similarly, Devkate *et al.*, (2025) ^[15] reported highest survival percentage of plants in aonla seeds treated with GA₃ 750 ppm. Likewise, Krishna *et al.*, (2024) ^[26] observed firethorn seeds treated with GA₃ 150 ppm resulted maximum plants survival percentage. Paikra *et al.*, (2021) ^[36] also reported that papaya seeds treated with GA₃ 100 ppm had survival percentage of seedlings. Rawat *et al.*, (2023) ^[51] reported highest survival percentage of plants in sweet orange cultivar Malta seeds treated with GA₃ 200 ppm.

Table 1: Effect of pre-sowing seed treatments on germination, plant and leaf growth parameters of karonda (*Carissa carandas* L.)

Treatments	Days to germination initiation	Days to germination completion	Germination (%)	Plant height (cm)	Plant diameter (mm)	Fresh weight of stem (gm)	Dry weight of stem (gm)	Number of leaves	Leaf length (cm)	Leaf breadth (cm)	Fresh weight of leaf (gm)	Dry weight of leaf (gm)
GA ₃ 250 ppm	12.52	25.05	82.06	39.58	5.40	29.24	19.32	35.14	4.75	3.61	0.28	0.16
GA ₃ 500 ppm	10.25	22.14	88.36	46.25	5.60	32.05	22.38	45.38	5.30	3.85	0.37	0.19
GA ₃ 1000 ppm	7.52	16.02	96.25	55.42	5.95	38.65	27.36	60.25	6.15	4.52	0.52	0.27
KNO ₃ 1.0%	13.51	27.10	78.15	36.15	5.28	27.12	18.52	33.43	4.50	3.45	0.23	0.14
KNO ₃ 1.50%	11.36	24.16	85.42	42.06	5.51	30.41	20.24	40.51	4.92	3.70	0.32	0.17
KNO ₃ 2.0%	9.21	20.45	90.51	50.51	5.72	34.18	24.28	50.35	5.65	4.18	0.43	0.22
Thiourea 1.0%	18.10	31.58	68.12	29.05	4.95	24.02	14.85	25.11	4.05	3.04	0.17	0.10
Thiourea 1.50%	16.36	30.36	70.31	31.62	5.07	25.55	16.33	28.52	4.12	3.16	0.19	0.11
Thiourea 2.0%	15.21	28.18	74.12	34.46	5.15	27.34	17.45	30.15	4.32	3.31	0.21	0.13
Water soaking (24 hours)	25.64	38.45	58.16	23.05	4.50	19.25	10.56	18.32	3.41	2.31	0.12	0.06
Water soaking (48 hours)	22.15	35.26	60.61	24.18	4.65	20.10	12.10	21.55	3.70	2.50	0.13	0.07
Water soaking (72 hours)	20.26	33.15	64.15	27.02	4.80	22.46	13.48	23.07	3.85	2.76	0.15	0.09
Control	30.52	52.61	40.35	18.05	2.85	15.35	8.76	13.26	3.02	2.05	0.10	0.02
CD (p = 0.05)	3.03	3.40	3.68	3.30	1.46	3.21	2.65	3.35	0.96	0.97	0.07	0.04
SE(m)	1.04	1.16	1.26	1.13	0.50	1.10	0.91	1.15	0.33	0.33	0.02	0.01

Table 2: Effect of pre-sowing seed treatments on root growth parameters of karonda (*Carissa carandas* L.)

Treatments	Primary root number	Secondary root number	Tertiary root number	Primary root length (cm)	Secondary root length (cm)	Tertiary root length (cm)	Thick root diameter (mm)	Fresh weight of root (gm)	Dry weight of root (gm)	Survival (%)
GA ₃ 250 ppm	22.65	61.09	127.45	14.35	11.02	6.08	0.96	12.10	7.41	81.46
GA ₃ 500 ppm	26.15	66.53	135.1	16.65	12.05	7.08	1.26	13.48	9.05	85.26
GA ₃ 1000 ppm	33.56	75.32	150.21	22.56	14.32	8.75	1.85	16.52	11.36	93.15
KNO ₃ 1.0%	19.25	59.10	121.15	13.52	10.46	5.48	0.84	11.54	7.01	78.11
KNO ₃ 1.50%	24.58	64.52	133.34	15.42	11.45	6.56	1.02	12.65	8.02	83.32
KNO ₃ 2.0%	29.10	70.08	140.52	18.55	12.65	7.56	1.42	14.35	10.15	87.52
Thiourea 1.0%	14.45	52.51	103.46	9.42	8.52	4.12	0.53	10.02	5.72	70.15
Thiourea 1.5%	15.52	55.45	109.48	10.51	9.05	4.65	0.62	10.51	6.18	75.28
Thiourea 2.0%	17.22	57.10	115.18	12.54	9.85	5.06	0.71	11.05	6.65	78.06
Water soaking (24 hours)	9.55	45.05	88.54	7.53	7.03	3.04	0.26	7.48	4.36	60.48
Water soaking (48 hours)	11.62	48.18	93.24	8.02	7.51	3.42	0.35	8.10	4.70	62.27
Water soaking (72 hours)	12.51	50.16	98.1	8.68	8.16	3.86	0.41	9.15	5.14	66.10
Control	6.10	30.24	75.15	6.21	5.01	2.56	0.11	5.12	2.56	45.12
CD (p = 0.05)	3.93	4.06	5.45	2.59	2.22	1.91	0.06	1.86	1.44	4.12
SE(m)	1.34	1.39	1.86	0.89	0.76	0.65	0.02	0.64	0.49	1.41

4. Conclusion

The result of the present investigation reveals that pre-sowing seed treatment to karonda seeds with GA₃ 1000 ppm and sown in soil + sand + vermicompost: cocopeat (1:1:1:1) medium was found superior with respect to minimum days taken to germination, days to complete germination and germination percentage. Also plants developed from pre-sowing seed treatment of GA₃ 1000 ppm had maximum plant height, plant diameter, fresh weight of stem, dry weight of stem, number of leaves, leaf length, leaf breadth, fresh weight of leaf, dry weight of leaf, primary root number, secondary root number, tertiary root number, primary root length, secondary root length, tertiary root length, thick root diameter, fresh weight of root, dry weight of root and survival percentage.

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