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# Effect of nano-DAP and nano-urea on Karonda (*Carissa carandas* L.) grafts Cv. Konkan Bold

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**Abstract**
This study aimed to determine the effect of application of foliar spray and drenching of nano-DAP and nano urea on growth and survival of karonda grafts cv. Konkan Bold. The experiment was laid out in Randomized Block Design with two replication and fifteen treatments to assess various concentrations of nano DAP and nano urea at college of horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India. Treatments applied as a foliar spray and drenching of nano-DAP and nano urea at different rates in which drenching of nano urea at 2000 ppm showed best performance in survival (100%), graft height (52.31 cm), number of leaves (46.00), leaf area (280.84 cm$^2$), Girth of graft (8.20 mm), fresh and dry weight of shoot (27.00 g and 8.50 g) and also $T_{14}$ (drenching of nano-DAP at 2000 ppm) had shown best performance in, fresh and dry weight of root (25.91 g and 8.50 g), length of tap root (30.25 cm). Treatment–$T_{13}$ showed maximum B:C ratio (1.10) and followed by treatment $T_{15}$ and $T_{11}$ reported with B:C ratio (1.09). Among all the nano-DAP and nano urea treatments drenching of nano urea at 2000 ppm was best to highest survival and better growth of karonda grafts cv. Konkan bold and also $T_{13}$-drenching of nano urea 1500 ppm also at par with the best treatment and give maximum B:C ratio.

**Keywords:** Karonda grafts, nano-DAP, nano urea, foliar spray, Drenching

## 1. Introduction
Karonda (*Carissa carandas* L.) belongs to family Apocynaceae. It is an underutilized fruit crop also known as "Christ thorn" that is an exotic and important minor fruit crop. It is an evergreen, spiny flowering shrub that thrives in bushes over India. It thrives in arid tropics and subtropics and is valued for its colourful edible fruits. It is a spreading semi-vine shrub indigenous to India (Bankar *et al*., 1994) [3].

It's poor man's meal. In the Konkan region, it is popularly known as "Dongarchi Kali Maina" (Jadhav, 1996) [6]. Karonda grows well in India's subtropical and tropical climates. Karonda is most commonly found in the states of Maharashtra, Bihar, West Bengal, Chhattisgarh, Orissa, Gujarat, Madhya Pradesh, Rajasthan, and the Western Ghats. In Maharashtra, the majority of this crop is grown in submountain areas such as Kolhapur, Ratnagiri, and Pune districts (Sawant *et al*., 2002) [15].

In 2004, Dr. Balasaheb Sawant of Konkan Krishi Vidyapeeth in Dapoli released the variety "Konkan Bold" for commercial growing in the Konkan region. Fruits are dark black, spherical, and clustered, with 92(%) pulp and 361mg of vitamin C per 100 grams. The average weight of the fruit is 12-16 grams. Seeds are soft and can be swallowed. The average yield is between 3 and 5 kg/tree. Seeds are the most common and simplest way of Karonda propagation. The seeds are seeded immediately following extraction. Karonda can also be propagated vegetatively by methods such as air layering, stem cutting, inarching, and soft wood grafting. Softwood grafting has recently become a widely utilized commercial process. Karonda is an evergreen shrub that ranges in size from small to large, typically reaching 2-4 metres tall.

The stem is rich in white latex, and the branches have sharp spines. Flowers are white in colour and are 3-5 cm in diameter. The fruit is a berry, which grows in clusters of 3-10 fruits. The fruit is globose to broad-ovoid in form. Young fruits are pinkish white, but mature fruits range in colour from white, green, and pinkish red according on the genotype. Each fruit has 3-5 blackish brown seeds that are flat and elliptical in shape and light in weight. Flowering begins in January February, and the fruits mature in May-June. Fruits are often picked at immature stages for vegetable purposes, whereas fully ripened fruits are consumed fresh or processed (Malik *et al*., 2010) [9]. Karonda is a hardy, drought-tolerant plant that thrives in hot climates and a variety of soil types. It can be cultivated to create a beautiful juvenile hedge, and because of the presence of auxiliary spines, it can also serve as an excellent bio-fence (Sharma and Banyal, 2010) [16].

The high demand for healthy and robust karonda grafts, observed for their good survival rates in the field. It is thought that the application of nano-DAP and nano-urea may lead to improved growth of grafts due to potential benefits such as better nutrient absorption, stronger graft union, Improved plant health, reduced fertilizer usage

Nano DAP is a high-end in-house designed and manufactured product based on cutting-edge nanotechnology. It is a peculiar liquid fertilizer solution containing diammonium phosphate nanoparticles (DAP). It contains supplies of nitrogen and phosphorus, two essential minerals for crop growth and development. Plant leaves absorb nano DAP efficiently due to its small size (100nm) and large surface area. Improved crop growth and production, reduced environmental impact, and increased farmer profitability are all benefits of these unique and nano forms. Nano DAP is a foliar, opalescent, white aqueous Nano fertilizer. It contains DAP micro particles with N-2% (w/v) and $P_2O_5$-5% (w/v). Because of its small size and huge surface area, it can absorb nutrients more efficiently. It includes the most effective stabilizers for product efficiency and stability.

Nano urea is a urea alternative that meets the crop's nitrogen requirements, particularly during critical growth stages. Nano urea (liquid) contains 4% nanoscale nitrogen particles (Koneru *et al*., 2022) [7]. Nano urea reduces the need for traditional urea by 50% or more. It improves the nutritional value of produce, agricultural yield, and soil health. Nitrogen in nano urea successfully meets crop nitrogen requirements for optimal growth (Kumar *et al*., 2023) [8].

It promotes early root development, increases cellular activity in the mid-growth phases, and improves overall plant health, resulting in higher graft survival rates. Nano DAP and nano urea promote nutrient uptake while lowering stress, resulting in vigorous, resilient plants. Its antibacterial qualities lessen the need for chemical inputs, in line with sustainable farming techniques. A valuable tool for Karonda growers.

Farmers' enthusiasm for it may be limited by a lack of research and local trials. The hypothesis proposes that there is a great demand for healthy and vigorous karonda grafts, which have a high survival rate in the field. The use of nano DAP and nano urea has been suggested to increase the development of grafts due to potential benefits such as improved nutrient uptake, reduced environmental impact, and enhanced plant health. Controlled experiments are necessary to confirm the hypothesis and achieve robust development and survival of karonda grafts in the region could satisfy the demands of farmers interested in cultivating karonda. A viable and sustainable technique for future cultivation protocols.

## 2. Materials and Methods

### 2.1 Site and weather

The experiment was done during the year 2024-2025 from July to March at Nursery No. 10, Department of Fruit Science, College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri. Maharashtra, India. Dapoli is a town in Ratnagiri district, Maharashtra's west coast, at an elevation of 240 meters above mean sea level. It has a tropical climate, with hot and humid weather all year. It is located at 17˚45" North and 73˚12" East longitude. The soil in this region is lateritic, permeable, and acidic, with a pH range of 5.6 to 6.5. The yearly average maximum and lowest temperatures are 30.4˚C to 31.8˚C and 17˚C to 20.2˚C, respectively. The average annual rainfall is around 3600 mm, which is generally dispersed from July to March.

### 2.2 Experimental Details

The current study investigated the effect of nano-DAP and nano urea on karonda (*Carissa carandas* L.) grafts cv. Konkan Bold. The randomized block designed was used in that experiment, with fifteen treatments and two replications. The experimental planting material consists of Konkan Bold karonda grafts obtained from Nursery no. 10, College of Horticulture, Dapoli. Grafting procedures for Konkan Bold karonda took place in june. The experiment used grafts that were one month old. All treatments are given 30, 60, and 90 days after grafting.

### 2.3 Observations Recorded

Total five seedlings from each treatment were selected for the observation of morphological characters. The following observation regarding graft height (cm), stem girth (mm), number of shoots per grafts, number of leaves per graft, Total leaf area ($cm^2$) were recorded at 30 days interval upto 270 days from the first application. Whereas, the observations regarding, tap root length (cm), Fresh weight of roots (g), dry weight of roots (g), Fresh weight of shoots (g), dry weight of shoots (g), absolute growth rate (cm/day), relative growth rate (cm/cm/day) and survival percentage were recorded at the end of the experiment i.e. after 270 days after 1st application.

**Table 1:** Treatment Details

| Treatment | Treatment details | |
|---|---|---|
| $T_1$ | Absolute Control | ---- |
| $T_2$ | Urea (2 g/plant) | Soil application |
| $T_3$ | DAP (2 g/plant) | Soil application |
| $T_4$ | 500 ppm @ Nano-DAP | Foliar Spray (At 30, 60, 90, days After grafting) |
| $T_5$ | 500 ppm @ Nano Urea | |
| $T_6$ | 1000 ppm @ Nano-DAP | |
| $T_7$ | 1000 ppm Nano -Urea | |
| $T_8$ | 1500 ppm@ Nano-DAP | |
| $T_9$ | 1500 ppm @ Nano- Urea | |
| $T_{10}$ | 2000 ppm @ Nano-DAP | |
| $T_{11}$ | 2000 ppm @ Nano-urea | |
| $T_{12}$ | 1500 ppm @ Nano-DAP | Drenching (At 30, 60, 90, days After grafting) |
| $T_{13}$ | 1500 ppm @ Nano- Urea | |
| $T_{14}$ | 2000 ppm @Nano-DAP | |
| $T_{15}$ | 2000 ppm @ Nano- Urea | |

### 2.4 Statistical Analysis

The data collected in this study was statistically evaluted using the method suggested by Panse and Sukhatme (1995) [11]. The standard error (S.E.) of means was worked and a critical difference (CD) at 5(%) i.e. p=0.05 was also worked out whenever the result was significant.

## 3. Results and Discussion

### 3.1 Survival Percentage

The data on the effect of nano urea on survival percentage in karonda grafts are given in Table 2 and fig 1. The results demonstrated that survival percentage at 270 DAT (Days after treatment) was significantly impacted by the nano-DAP and nano urea. As a result, it was discovered that survival rate varied between 90.00 per cent ($T_1$) to 100.00 per cent ($T_{15}$) among all the treatments. Thus, treatment ($T_{15}$), ($T_{13}$), ($T_{14}$), ($T_{11}$) showed superior i.e. (100%) results over other treatments. The use of nano-DAP and nano-urea provided an additional supply of nitrogen and phosphorous in a highly absorbable form. Phosphorous is essential for root growth and energy transfer and its improved uptake through nano-DAP further contributed to increased survival rates and overall growth performance of karonda grafts, Kumar *et al*., (2023) [8].

### 3.2 Graft Height (cm)
The data on graft height of karonda cv. Konkan Bold after application of various nano-DAP and nano-urea treatments are presented in Table 3 and Fig. 3. At 270 DAT, graft height was significantly highest in treatment $T_{15}$ (52.31 cm) which was found superior over rest of the treatments followed by treatment $T_{13}$ (51.35 cm). The lowest graft height was observed in treatment $T_1$ (41.55 cm). Effect of nano-DAP and nano urea in karonda grafts cv. Konkan Bold was found to be superior in treatment $T_{15}$(Drenching of nano urea 2000 ppm). The slow release property of nano urea improves nutrient uptake efficiency and reduced leaching losses, ensuring sustained availability to plant (Ramesh and Reddy, 2011) [12]. Increase nitrogen from nano-urea likely enhanced auxin production. Auxin boosts cell division and shoots growth, enhancing plant height. Similar effects of nano-urea were noted by Al-Gym and Al-Asady (2020) [1] in sunflower and corn.

### 3.3 Graft Girth (mm)
The data regarding to the girth of grafts as influenced by different nano-DAP and nano urea treatments are presented in Table 3. At 270 DAT, graft girth was significantly affected by from 120 DAT. The highest graft girth was noticed in treatment $T_{15}$ (8.20 mm) (Drenching of nano urea 2000 ppm) which was at par with treatments $T_{13}$ (7.80 mm) and $T_{11}$ (7.75 mm) and significantly superior over the remaining treatments. Whereas the lowest graft girth was observed in treatment $T_1$ (6.63 mm) which was at par with treatments $T_2$ (6.95 mm), $T_4$ (6.85 mm), $T_5$ (6.85 mm), $T_6$ (7.15 mm), $T_7$ (7.07 mm) and $T_8$ (7.15 mm) significantly inferior to all other treatments. Treatment $T_{15}$(Drenching of nano urea at 2000 ppm) recorded superior results over remaining treatments. can be attributed to the gradual and efficient nutrient release of nano-urea, which enhanced nitrogen availability and improved overall plant metabolism and stem development. Similar results have been reported in other crops Bhatti *et al.* (2023) [4] observed increased stem growth in guava, Al-Gym and Al-Asady (2020) [1] reported greater stem diameter in yellow maize and Augustus and Domingo (2023) [2] noted increased stem thickness in banana (cv. Cavendish).

### 3.4 Number of Shoots
The data on effect of nano-DAP and nano urea on number of shoots per graft were recorded at 30 days interval from 30 to 270 DAT and are given in Table 3. At 270 days after treatment, the highest number of shoots were observed in treatment $T_{15}$(4.30) Drenching of Nano-Urea at 2000 ppm. Whereas the lowest number of shoots were found in the control $T_1$(3.55). Due to the slow and controlled nitrogen release from Nano-urea, enhancing nutrient uptake efficiency and promoting better vegetative growth. These results align with findings by Bhatti *et al*. (2023) [4] in guava and Augustus and Domingo (2023) [2] in banana, where nano-urea application stimulated shoot proliferation. Similar observations were made by Al-Gym and Al-Asady (2020) [1] in yellow maize.

### 3.5 Number of Leaves
The data on the effect of nano-DAP and nan- urea on number of leaves karonda grafts cv. Konkan Bold are presented in Table 3. There was a significant difference observed in the number of leaves due to various treatments. At 270 DAT, the maximum number of leaves (46.00) were observed in the treatment $T_{15}$ and it was at par with the treatments $T_{13}$(42.00) and $T_{11}$(41.50). The minimum number of leaves (29.00) was recorded in the treatment $T_1$. It was at par with the treatments $T_2$(31.00), $T_4$(30.60), $T_5$(29.35), $T_6$ (32.50) and $T_7$(31.07) From the above context, results indicated that treatment $T_{15}$(Drenching of nano urea at 2000 ppm) recorded with the better number of leaves. The increase in the leaves might be attributed to a nano fertilizer that stimulates cell division and expansion, particularly in leaf cells which was positively reflected in increasing photosynthesis. Where, nitrogen has positive role in increasing various activities of grafts. Similarly, the results were found identical with the findings obtained by Rathod *et al.*, (2022) [13] in French basil and Sathyan D., (2022) [14] in field pea.

### 3.6 Total Leaf Area (cm2)
Another important parameter in determining the size of the photosynthetic site is leaf area. The leaf area which was recorded at 30 days interval up to 270 DAT significantly affected by the different nano-DAP and nano urea treatments on karonda grafts. The data regarding total leaf area is shown in Table 3. At 270 days after treatment, the statistically maximum total leaf area was recorded in treatment $T_{15}$(280.84 $cm^2$) (Drenching nano-urea at 2000 ppm) which was at par with the treatment $T_{13}$(265.58 $cm^2$), $T_{11}$ (265.32 $cm^2$). The minimum total leaf area was recorded in treatment $T_1$(256.06 $cm^2$). The increase in leaf area may be due to drenching and foliar operations that accelerated metabolic and physiological activities, particularly photosynthesis, which leads to higher photosynthate accumulation and significantly increases leaf chlorophyll and mineral contents compared to the control. The plant's nutrient availability and absorption promotes growth by taking in a greater quantity of nitrogen, resulting in an increase in leaf area. Mustafa *et al*., (2022) [10].

### 3.7 Absolute Growth Rate (cm/day) and Relative Growth Rate (cm/cm/day)
The data regarding absolute growth rate of karonda grafts cv. Konkan Bold with respect to height (cm/cm/day) are given in Table 3. As the growth progressed, from 0–120 to 0–270 DAA, treatment $T_{15}$ (Drenching of Nano-Urea @ 2000 ppm) maintained the highest AGR, reaching 0.141 cm/day at 270 DAA. This consistent increase indicates that nano-urea at 2000 ppm via drenching had a sustained positive effect on graft growth over time. Treatment $T_{13}$ also showed stable and high growth throughout, with AGR values reaching 0.135 cm/day at 270 DAA.

The data regarding relative growth rate of karonda grafts cv. Konkan Bold with respect to height (cm/cm/day) are given in Table 3. At 240–270 DAA, the average relative growth rate was

0.00369 cm/cm/day. The highest relative growth rate was recorded in $T_2$ (0.00539 cm/cm/day). The lowest was recorded in treatment $T_3$ (0.00284 cm/cm/day).

The reason for the nano nitrogen fertilizer promotes auxin synthesis, which in turn encourages cell elongation and proliferation throughout the vegetative plant. The height of the plant and other growth characteristics are directly impacted by this (Bhatti *et al*., 2023) [4].

### 3.8 Fresh and dry weight of shoot (g)

The data on effect of nano-DAP and nano urea on fresh and dry weight of shoot (g) of karonda grafts cv. Konkan Bold are presented in Table 4.

The fresh weight of shoot was recorded at 270 DAT. There was significant variation observed among the various treatments. At 270 days after treatment, the highest fresh weight of shoot was recorded in treatment $T_{15}$(27.00 g) which was at par with the treatment $T_{11}$(25.00 g) and treatment $T_{13}$ (24.25g) However, the lowest fresh weight of the shoot was found in control (15.05 g) which was at par with the treatment $T_3$ (16.75). significantly inferior over remaining treatments. Thus, it was found that fresh weight of shoot was varied from 15.05 g ($T_1$) to 27.00 g ($T_{15}$).

The data on effect of nano-DAP and nano urea on fresh and dry weight of shoot (g) of karonda grafts cv. Konkan Bold are presented in Table 4. The dry weight of shoot was recorded at 270 DAT. There was significant variation observed among the various treatments. At 270 days after treatment, the highest dry weight of shoot was recorded in treatment $T_{15}$(8.50 g) which was at par with the treatment $T_{11}$(8.00 g) and treatment $T_{13}$ (7.50 g) However, the lowest dry weight of the shoot was found in control (4.95 g) Thus, it was found that dry weight of shoot was varied from 4.95 g ($T_1$) to 8.50 g ($T_{15}$). The nano-scale size of the particles facilitates faster and more targeted nitrogen uptake compared to conventional urea, thereby promoting vigorous growth and greater shoot biomass accumulation. Similar findings were reported by Augustus and Domingo (2023) [2] who observed a significant increase in fresh and dry biomass of banana cv. Cavendish following soil application of nano-urea in comparison to traditional urea treatments.

### 3.9 Fresh and dry Weight of Root (g)

The data on effect of nano-DAP and nano urea on fresh and dry weight of root (g) of karonda grafts cv. Konkan Bold are presented in Table 4.

The fresh weight of root was recorded at 270 DAT. There was significant variation observed among the various treatments. At 270 days after treatment, the highest fresh weight of root was recorded in treatment $T_{14}$(25.91 g) which was at par with the treatment $T_{12}$(24.73 g), treatment $T_{10}$ (23.81 g) and treatment $T_{15}$ (23.75 g). However, the lowest fresh weight of the root was found in control (14.50 g) which was at par with the treatment $T_2$ (16.00 g). significantly inferior over remaining treatments. Thus, it was found that fresh weight of root was varied from 14.50 g ($T_1$) to 25.91 g ($T_{14}$).

The dry weight of root was recorded at 270 DAT. There was significant variation observed among the various treatments. At 270 days after treatment, the highest dry weight of root was recorded in treatment $T_{14}$(8.50 g). However, the lowest dry weight of the root was found in control (4.95 g). Thus, it was found that dry weight of root was varied from 4.95 g ($T_1$) to 8.50 g ($T_{14}$). Nano fertilizer which contains phosphorus enhances the availability and absorption of nutrients, particularly nitrogen and phosphorus, by increasing their mobility in the soil, lowering fixation losses and boosting root elongation. This leads to increased root growth and dry biomass. Auxins are necessary for the development and structuring of the root system. They promote root development, resulting in a stronger and wider network and more dry matter in the roots. As nutrient absorption increases, the plant may develop and store more root tissue, increasing root dry weight. These findings are consistent with Augustus and Domingo (2023) [2].

### 3.10 Tap root Length (cm)

The data on the effect of nano-DAP and nano-urea on tap root length as influenced by various nano-DAP and nano urea treatments are given in Table 3 and Fig 2. Significant difference was observed among the various treatments in karonda grafts cv. Konkan Bold with respect to tap root length. At 270 DAT, the highest tap root length was noted in the treatment $T_{14}$(30.25 cm) which was significantly superior over all other treatments and it was followed by treatments $T_{10}$(27.50), $T_9$(25.75 cm), $T_{13}$(27.97 cm), $T_{12}$(28.94 cm), and $T_{15}$ (28.20 cm). The lowest tap root length was observed in treatment $T_1$(21.00 cm) which was at par with the treatment $T_2$ (22.50 cm), $T_3$ (23.00 cm), $T_5$ (23.50 cm), $T_4$ (23.75 cm). significantly inferior over remaining treatments. Thus, it was observed that the tap root length ranged between 21.00 ($T_1$) to 30.25 cm ($T_{14}$) among all the treatments. Treatment $T_{14}$ i.e. Drenching of nano-DAP at 1500 ppm showed good result regarding to tap root length. Hagag *et al.* (2018) [5] reported positive results in olives when nano-urea was used. Nano fertilizer which contains phosphorus enhances the availability and absorption of nutrients, particularly nitrogen and phosphorus, by increasing their mobility in the soil, lowering fixation losses, and boosting root elongation.

**Table 2:** Effect of nano-DAP and nano-urea on survival percentage of karonda grafts cv. Konkan Bold

| Treatment no. | Treatment Details | Survival percentage |
|---|---|---|
| $T_1$ | Absolute Control | 90.00 |
| $T_2$ | Soil application (2g urea/plant) | 95.00 |
| $T_3$ | Soil application (2g DAP/plant) | 95.00 |
| $T_4$ | Foliar spray Nano-DAP @ 500 ppm | 92.50 |
| $T_5$ | Foliar spray Nano-urea @ 500 ppm | 92.50 |
| $T_6$ | Foliar spray Nano-DAP @ 1000 ppm | 95.00 |
| $T_7$ | Foliar spray Nano-urea @ 1000 ppm | 95.00 |
| $T_8$ | Foliar spray Nano-DAP @ 1500 ppm | 92.50 |
| $T_9$ | Foliar spray Nano-urea @ 1500 ppm | 97.50 |
| $T_{10}$ | Foliar spray Nano-DAP @ 2000 ppm | 95.00 |
| $T_{11}$ | Foliar spray Nano-urea @ 2000 ppm | 100.00 |
| $T_{12}$ | Drenching Nano-DAP @ 1500 ppm | 97.50 |
| $T_{13}$ | Drenching Nano-urea @ 1500 ppm | 100.00 |
| $T_{14}$ | Drenching Nano-DAP @ 2000 ppm | 100.00 |
| $T_{15}$ | Drenching Nano-urea @ 2000 ppm | 100.00 |
| | Mean | 95.83 |
| | Range | 90.00-100.00 |
| | S.E m (±) | 2.00 |
| | CD at 5 (%) | 6.06 |
| | ‘F’ test | SIG |

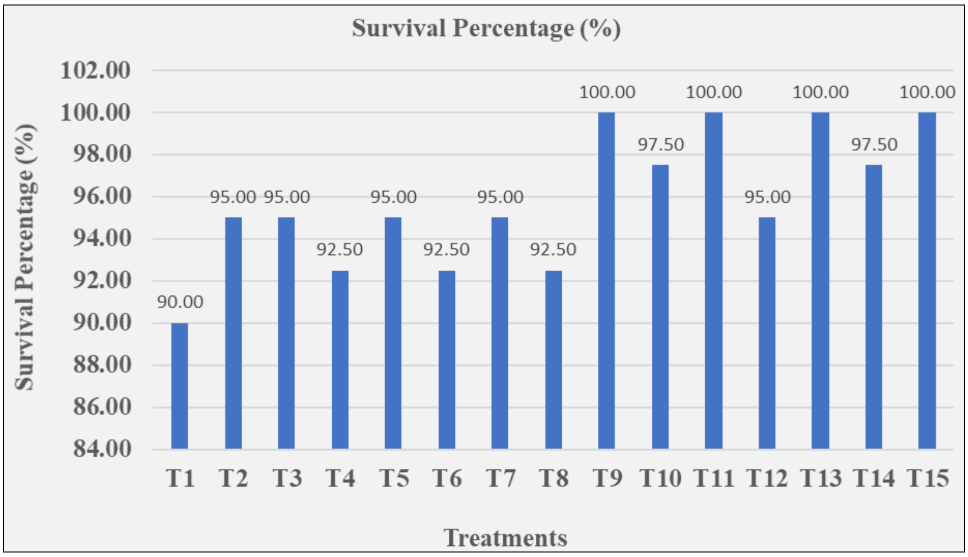


**Fig 1:** Effect of nano-DAP and nano-urea on survival percentage of karonda grafts cv. Konkan Bold

**Table 3:** Effect of nano-DAP and nano urea on graft height, stem girth, number of shoots, number of leaves, total leaf area, absolute growth rate and relative growth rate of karonda grafts cv. Konkan Bold.

| Treatment No. | Graft* Height (cm) | Stem* girth (mm) | Number* of shoots | Number* of Leaves | Total* leaf area (cm$^2$) | Absolute* growth rate (cm/day) | Relative* growth rate (cm/cm/day | Tap* root Length (cm) |
|---|---|---|---|---|---|---|---|---|
| $T_1$ | 41.55 | 6.80 | 3.55 | 29.00 | 240.9 | 0.099 | 0.00378 | 21.00 |
| $T_2$ | 42.55 | 6.95 | 3.75 | 31.00 | 260.6 | 0.104 | 0.00539 | 22.50 |
| $T_3$ | 44.55 | 7.30 | 3.90 | 37.50 | 260.5 | 0.112 | 0.00285 | 23.00 |
| $T_4$ | 42.50 | 6.85 | 3.65 | 30.60 | 242.0 | 0.103 | 0.00286 | 23.75 |
| $T_5$ | 41.85 | 6.85 | 3.60 | 29.35 | 247.1 | 0.100 | 0.00335 | 23.50 |
| $T_6$ | 45.70 | 7.15 | 3.70 | 32.50 | 254.0 | 0.112 | 0.00432 | 25.32 |
| $T_7$ | 42.00 | 7.07 | 3.75 | 31.07 | 252.9 | 0.101 | 0.00405 | 24.75 |
| $T_8$ | 42.00 | 7.15 | 3.75 | 33.50 | 254.6 | 0.104 | 0.00364 | 26.83 |
| $T_9$ | 43.70 | 7.35 | 3.85 | 36.50 | 257.2 | 0.109 | 0.00354 | 25.75 |
| $T_{10}$ | 45.15 | 7.35 | 3.85 | 37.50 | 259.3 | 0.113 | 0.00346 | 27.50 |
| $T_{11}$ | 46.40 | 7.75 | 3.95 | 41.50 | 265.3 | 0.119 | 0.00328 | 27.00 |
| $T_{12}$ | 43.80 | 7.30 | 3.80 | 34.00 | 255.6 | 0.109 | 0.00500 | 28.94 |
| $T_{13}$ | 51.35 | 7.80 | 4.05 | 42.00 | 265.5 | 0.135 | 0.00346 | 27.97 |
| $T_{14}$ | 45.85 | 7.55 | 3.95 | 39.50 | 260.5 | 0.116 | 0.00316 | 30.25 |
| $T_{15}$ | 52.31 | 8.20 | 4.30 | 46.00 | 280.8 | 0.141 | 0.00327 | 28.20 |
| Mean | 44.75 | 7.29 | 3.82 | 35.30 | 156.0 | 0.112 | 0.00369 | 25.75 |
| Range | 41.55-52.31 | 6.80-8.20 | 3.55-4.30 | 29.00-46.00 | 240.9-280.8 | --- | ---- | 21.00-30.25 |
| S.E m (±) | 1.55 | 0.15 | 0.21 | 1.67 | 5.28 | --- | ---- | 0.97 |
| CD at 5% | 4.70 | 0.47 | 0.65 | 5.08 | 16.02 | --- | ---- | 2.95 |
| 'F' test | SIG | SIG | NS | SIG | SIG | --- | ---- | SIG |

(* observation taken on 270 days after 1st application)

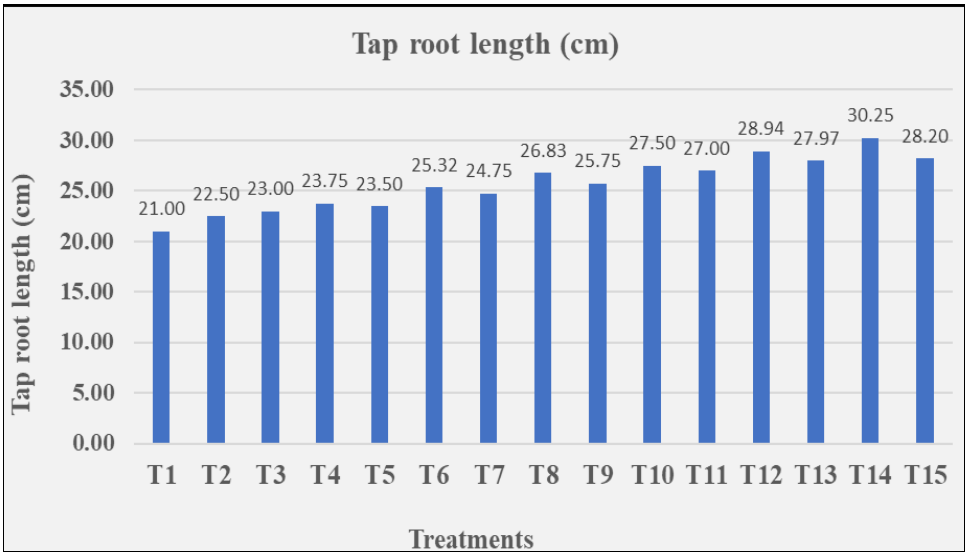


**Fig 2:** Effect of nano-DAP and nano urea on tap root length (cm) in karonda grafts cv. Konkan Bold

**Table 4:** Effect of nano-DAP and nano urea fresh and dry weight of shoot and root (g) of karonda grafts cv. Konkan Bold.

| Treatment No. | Fresh weight of shoot (g) | Dry weight of shoot (g) | Fresh weight of root (g) | Dry weight of root (g) |
|---|---|---|---|---|
| $T_1$ | 15.05 | 4.95 | 14.50 | 4.95 |
| $T_2$ | 17.25 | 5.75 | 16.00 | 5.20 |
| $T_3$ | 16.75 | 5.45 | 18.00 | 5.35 |
| $T_4$ | 18.50 | 5.85 | 20.50 | 5.55 |
| $T_5$ | 20.00 | 6.00 | 18.62 | 5.45 |
| $T_6$ | 20.50 | 6.15 | 21.80 | 6.10 |
| $T_7$ | 21.75 | 6.37 | 20.62 | 5.65 |
| $T_8$ | 21.00 | 6.11 | 22.50 | 6.25 |
| $T_9$ | 23.95 | 7.21 | 21.00 | 5.85 |
| $T_{10}$ | 22.21 | 6.65 | 23.81 | 7.40 |
| $T_{11}$ | 25.00 | 8.00 | 21.56 | 6.00 |
| $T_{12}$ | 22.58 | 6.90 | 24.73 | 7.50 |
| $T_{13}$ | 24.25 | 7.50 | 22.66 | 7.00 |
| $T_{14}$ | 23.25 | 7.00 | 25.91 | 8.50 |
| $T_{15}$ | 27.00 | 8.50 | 23.75 | 7.30 |
| Mean | 21.27 | 6.56 | 21.06 | 6.27 |
| Range | 15.05-27.00 | 4.95-8.50 | 14.50-25.91 | 4.95-8.50 |
| S.E m (±) | 0.94 | 0.40 | 0.76 | 0.27 |
| CD at 5% | 2.85 | 1.22 | 2.29 | 0.81 |
| 'F' test | SIG | SIG | SIG | SIG |

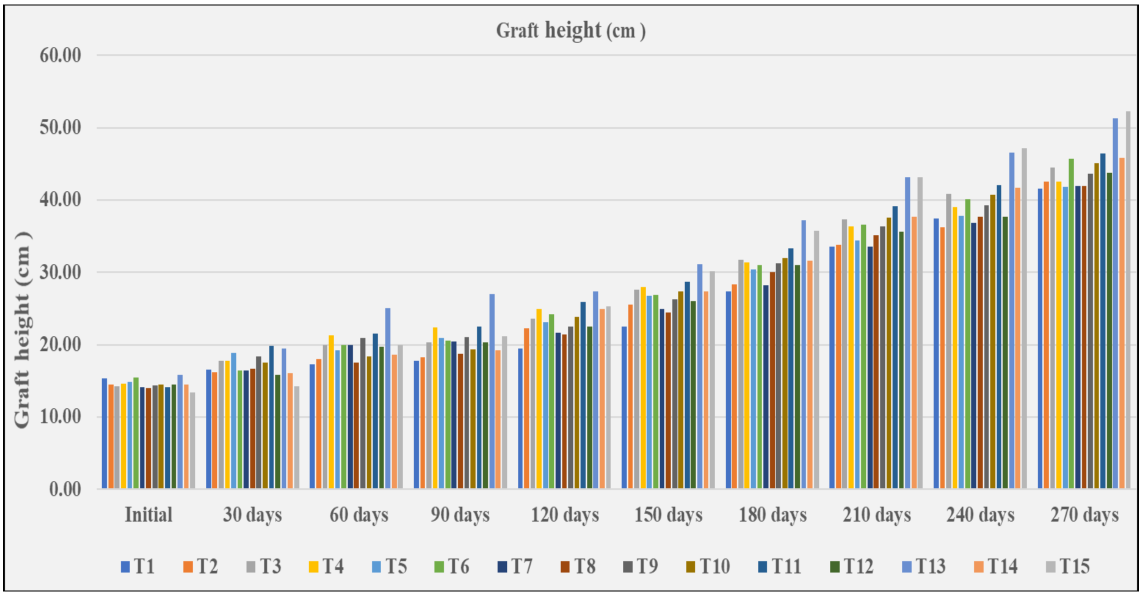


**Fig 3:** Effect of nano-DAP and nano urea on height (cm) of karonda grafts cv. Konkan Bold

## Conclusion

The present experimentation on effect of nano-DAP and nano urea treatment on karonda grafts (*Carissa carandas* L.) cv. Koranda indicated that the treatments influenced the survival and growth parameters significantly. However, this effect was not consistent with respect to foliar application, drenching and various concentrations of nano-DAP and nano urea. The survival, graft height, number of leaves, leaf area ($cm^2$), Girth of graft, absolute growth rate, fresh and dry weight of shoot, and was the best in treatment $T_{15}$. Treatment $T_{14}$ had shown best performance in relative growth rate, fresh and dry weight of root, length of tap root. Treatment–$T_{13}$ showed maximum B:C ratio (1.10) and followed by treatment $T_{15}$ and $T_{11}$ reported with B:C ratio (1.09). Thus, on the basis of the results obtained from above investigation, it can be concluded that treatment $T_{15}$ – drenching of nano-urea at 2000 ppm enhanced the growth, vigour and survival of karonda grafts and at par with $T_{13}$- drenching of nano urea at 1500 ppm have also maximum B:C ratio.

## Disclaimer (Artificial Intelligence)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing this manuscript.

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## Competing interests

Authors have declared that no competing interests exist.

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