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Studies on Effect of Seed Treatment on Seed Germination and Subsequent Growth of Karonda (*Carissa carandas* L.) Seedlings

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ABSTRACT

The present experiment was carried out at Department of horticulture, College of agriculture, VNMKV, Parbhani. During the year 2023-2024 with the objective to determine the best treatment for seed germination of karonda seedlings. and effect of different treatments on seedling growth parameters of karonda. The experiment was laid out in randomized block design involved 12 different treatments including control. Among various treatment applied. The results of the present investigation revealed that, The effect of seed treatment indicated that, the treatment (T_{11}) seed soaking in water for 8 hour recorded maximum seed germination (82.50), fresh weight (3.47 gm), dry weight (1.37 gm) and seedling vigour index II (128.84 gm). while, seeds soaked in GA_3 100 mg/l for 24 hours improved various growth parameters viz., seedling length (15.46, 24.13 and 30.21 cm), length of main root (8.23, 12.60 and 16.27cm) number of primary roots (22.07, 28.33 and 34.70 cm) number of secondary roots (25.24, 31.60, and 38.37) at 30, 60 and 90 DAS respectively. Seedling vigour index I (2828 cm) at 90 DAS and GA_3 treatments resulted in the highest survival percentage (83.52%) and the lowest mortality rate (16.48%). andGA_3 at 100 mg/litre resulted in the lowest incidence of damping off at 33.33 percent. Soaking of seeds in Thiourea at the rate 2% for 2 hours (T_9) shows that the highest number of leaves (12.11, 20.00 and 29.01) at 30, 60 and 90 DAS respectively. While seed soaked in $KNO_3$1% for 1 hours and 2% for 2 hours gave significantly maximum diameter of seedlings (2.63 and 2.73 mm) at 90 days after sowing.

Introduction

Karonda (*Carissa carandas* L.), also known as the ‘Christ Thorn Tree’ is a large, dichotomously branched, evergreen shrub with a short stem and strong thorns growing in pairs. It belongs to the family Apocynaceae and thrives in tropical and subtropical climates. The hardy, evergreen, spiky, native karonda shrub is widely grown in India. It can be found in the wild in South India, West Bengal, and Bihar. Karonda is a non-traditional fruit crop that grows well under rainfed conditions and is frequently cultivated as a hedge plant.

Once established, the plant requires little maintenance and produces a good crop yield. The native Indian shrub known as "karonda" is commonly grown for its fruit, which flourishes in marginal and waste soils where other economically valuable crops would not thrive.

Karonda is a woody, evergreen, dichotomously branched, spiny shrub that grows to a height of 10-15 feet. The leaves are opposite, small, ovate, and shiny. The flowers are white and produced in terminal cymes. It is highly preferred as a protective hedge in Gujarat and Punjab. Sometimes, it is grown as an ornamental plant due to its beautiful cherry-like fruits. Karonda is best suited as a live protective fence due to the presence of axillary spines and the formation of profuse leaves on crowded branches. It has excellent potential 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 (Chundawat, 1995).

Though karonda fruits are used for various purposes, the crop has not yet been exploited on a commercial scale. There is significant variation in the size, shape, and colour of the fruits. Based on fruit colour, three types are available: green, pink, and white (Singh, 1967). Based on taste, it can be further grouped into two types: sweet and sour. As the crop is highly cross-pollinated, large variability exists in natural populations. Despite the hard seeds and low germination rates, karonda is still commercially propagated by seeds.

Various propagation methods can be successfully employed for karonda. All species of karonda (*Carissa spp*.) are multiplied through seeds. In addition to seeds, vegetative methods such as cutting, budding, air layering, stooling, and grafting can also be utilized. However, seeds are the most common commercial propagation method. The seeds are recalcitrant, with relatively high moisture content, and lose viability within 4-5 weeks. Therefore, they should be sown immediately after extraction from the fruits.

Karonda seeds germination percentage and seedling growth are affected by pre-sowing seed treatments. To achieve higher and proper germination, seeds require special treatments like scarification, soaking in water, growth regulators, and concentrated acid solutions. These treatments help overcome dormancy and promote early and higher seed germination percentages with healthy and vigorous seedlings. Pre-sowing treatment with growth regulators and scarification could lead to increased seed germination and enhanced seedling growth. 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). Scarification treatment with sulfuric acid has proven effective in removing the hard seed coat, allowing water and gases to penetrate the seed, resulting in enzymatic hydrolysis and transforming the embryo into a vigorous seedling.

Plant growth regulators like GA_3 enhance the germination, growth, and survival of seedlings. GA_3 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). GA_3 also plays a significant role in increasing plant height and girth due to increased cell division and elongation (Nimbalkar *et al.,* 2012).

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). It increases the number of leaves and total leaf area (Patel *et al.,* 2016). Auxins, compounds found in cow dung and urine, are known to promote growth and have been linked to increased seedling germination rates and overall growth (Shirol *et al.,* 2005).

Materials and Methods

The experiment was conducted in the net house of department of horticulture Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during monsoon season 2023-2024. The experiment involves various pre-sowing treatments aimed at enhancing seed germination and seedling growth of karonda (*Carissa carandas* L.).

The treatments include potassium nitrate (KNO_3) solutions at two different concentrations and durations, specifically 1% for 1 hour (T_1) and 2 hours (T_2). Additionally, gibberellic acid (GA_3) is used in three concentrations: 50 mg/litre (T_3), 75 mg/litre (T_4), and 100 mg/litre (T_5), all soaked for 24 hours. Thiourea is also tested in varying concentrations and durations, with treatments at 1% for 1 hour (T_6) and 2 hours (T_7), and 2% for 1 hour (T_8) and 2 hours (T_9). A hot water treatment at 50°C for 10 minutes (T10) is included to assess thermal effects on germination. Water soaking for 8 hours (T_{11}), while the control group (T_{12}) involves no treatment, providing a baseline for comparison. Each treatment aims to determine the optimal conditions for improving germination rates and seedling vigour in karonda. These treatments were replicated thrice in randomized block design. The fully ripe karonda fruits of sweet type were collected from Agriculture produce market committee, Market yards Parbhani in the month of July, 2023.

The seeds were extracted carefully. And the seeds were shade dried. treated seeds sown in plastic bags having size 22 x 9 cm. and then filled with the potting mixture having One part well fertile soil, one-part cocopeat, and one part sand were combined to create the potting mixture (4:2:1 proportion).

Weeding and watering were done at regular intervals whenever needed. For protection during the experiment, 10 g of Bavistin (Carbendazim 50% WP) was dissolved in 10 litre of water. This solution was applied twice to the immature karonda plants to protect them from fungal infections. The observation regarding germination percentage, seedling length, seedling diameter, number leaves, main root length, primary and secondary root length, fresh as well as dry weight, and seedling vigour index, survival and mortality percentage, and incidence of damping off were taken at regular intervals.

Results and Discussion

Seed Germination

The data presented in table 1 revealed that seed sown in water for 24 hour (T_{11}) recorded significantly the maximum seed germination (82.50) indicating superior efficacy compared to other methods which was statistically on par with treatment (T_5) gibberellic acid (GA_3) 100 mg/litre for 24 hours germination (81.67%), GA3 at 75 mg/litre (T_4) for 24 hours (80.83%) and GA_3 at 50 mg/litre (T_3) for 24 hours (80.00%). The result in the present experiment is in agreement with the findings of Chandra and Govind (1990) in guava, Nimbalkar *et al.,* (2012) in karonda and Bhavya *et al.,* (2017) in karonda.

Seedling length (cm) at 30, 60, 90 DAS

Table 1 revealed that the seedlings subjected to GA_3 treatments exhibited superior growth compared to other treatments. Specifically, soaking seeds in GA_3 at 100 mg/litre for 24 hours (T_5) resulted in the highest seedling lengths at all three stages of measurement: 15.46 cm at 30 DAS, 24.13 cm at 60 DAS, and 30.21 cm at 90 DAS. In contrast, the control treatment exhibited lowest growth overall of seedling lengths, with seedling lengths of 6.98 cm, 11.03 cm, and 16.21 cm at 30, 60, and 90 DAS, respectively.

This is might be due to GA_3 increase osmotic uptake of nutrients thereby causing cell division and cell multiplication. GA_3 is well known for promotion of internodal cell elongation, there by leading to increase in seedling length. Similar results were also obtained by Lay *et al.,* (2013) in papaya, Vasantha *et al.,* (2014) in tamrind and Yadav *et al.,* (2018) in custard apple.

Number of leaves at 30, 60, 90 DAS

The table 1 summarizes the effects of different treatments on the number of leaves per seedling measured at 30, 60, and 90 days after sowing (DAS). Among the treatments, those involving thiourea showed the highest number of leaves at all three measurement periods. Specifically, soaking seeds in thiourea at 2% for 2 hours (T_9) resulted in the statistically significant highest leaf count 12.11, 20.00 and 29.01 at 30, 60 and 90 DAS leaves respectively. Which was statistically at par with T_8, T_7, T_6 and T_5. In contrast, the control treatment (T12) showed the lowest number of leaves (6.13) at 30 DAS.

These results indicate that thiourea treatments were most effective in increasing the number of leaves, while the hot water treatment and control showed markedly lower leaf counts. The result in the present experiment is in agreement with the findings of Patel *et al.,* (2017) in mango and Mane *et al.,* (2018a) in custard apple.

Seedling diameter at 30, 60, 90 DAS

It is evident from Table 1 the results reveal that potassium nitrate (KNO_3) treatments generally promoted greater seedling diameter compared to other treatments. Specifically, soaking seeds in KNO_3 at 1% for 2 hours (T_2) yielded the significantly largest diameter (1.95 mm) measurement at 30 DAS which was on par T_1, T_5 T_4, T_3 and T_{11}. This was closely followed by the KNO_3 at 1% for 1 hour (T_1), and GA_3 at 100 mg/litre for 24 hours (T_5). Whereas the control treatment yielded smallest seedling diameter (1.32 mm). These findings indicate that KNO_3 treatments were most effective in increasing seedling diameter, while thiourea and hot water treatments had less favourable effects. These results are in accordance with findings of Aatla *et al.,* (2013) in mango and Ramteke *et al.,* (2015) in papaya.

Length of main root (cm) at 30, 60, 90 DAS

The table 2 details the impact of various treatments on the length of the main root measured in centimeters at 30, 60, and 90 days after sowing (DAS). The results indicate that GA_3 treatments significantly enhanced root growth compared to the other treatments. Notably, soaking seeds in GA_3 at 100 mg/litre for 24 hours (T_5) resulted in the longest main roots (8.23 cm) at 30 DAS, which was on par with T_4 and T 11. 12.60 cm at 60 DAS, and 16.27 cm at 90 DAS. This was followed by the GA_3 treatments at 75 mg/litre (T4) and 50 mg/litre (T_3), which also exhibited substantial root elongation.

These findings underscore the effectiveness of GA_3 treatments in promoting root development, while the hot water treatment and control conditions were associated with reduced root growth. These results are in accordance with Shinde and Malse (2015) in khirni, Patel (2015) in mango and Pamei *et al.,* (2017) in teak.

Length of primary roots (cm) at 90 DAS

The table 2 show that the effects of various pre-sowing treatments on the primary root length of seedlings measured at 90 days after sowing (DAS). The treatment with GA_3 at 100 mg/litre for 24 hours (T_5) yielded the significantly longest primary root length (8.13 cm) which was on par with the treatment (T_4) of GA_3 at 75 mg/litre for 24 hours (7.68 cm).these findings highlights GA_3 effectiveness in enhancing root growth, probably because it stimulates cell division and elongation, Conversely control treatment (T_{12}) had the shortest root length (4.08 cm) serving as a baseline for evaluating the efficacy of the other treatments.

Length of secondary roots at 90 DAS

The data presented in the table 2 illustrates the effect of various seed treatments on the secondary root length of the plants measured at 90 days after sowing (DAS). Among the treatments, soaking seeds in GA_3 at a concentration of 100 mg/litre for 24 hours (T_5) resulted in the significantly greatest secondary root length (4.07 cm) which was on par with the treatment (T_4) of soaking seeds in GA_3 at 75 mg/litre for 24 hours (3.84 cm). On the other hand, the shortest secondary root length (2.04 cm) was recorded in (T_{12}) control.

Number of primary roots at 30, 60, 90 DAS

The effect of various treatments on the number of primary roots at different days after sowing (DAS) was assessed as shown in table 2. Among the treatments, the treatment with GA_3 at 100 mg/litre for 24 hours (T_5) showed maximum number of primary roots (22.07 and 28.33) followed on par with GA_3 at 75 mg/litre (T_4) for 24 hours at 30 DAS and at 60 DAS (21.87 and 26.67) respectively.

On the other hand, the control exhibited the lowest number of primary roots, with 6.21 at 30 DAS and 11.87 at 60 DAS. At 90 DAS, the GA_3 at 100 mg/litre for 24 hours (T_5) resulted in the only significant highest number of primary roots (34.70). In contrast, the control showed the lowest number of primary roots 18.70 at 90 DAS.

Overall, the results demonstrate that treatments with GA_3 significantly enhance primary root formation, while hot water treatment and the control group are less effective. This information is crucial for optimizing seed treatment protocols to improve root development in plants. Similar results are in line with the findings of Patel *et al.,* (2017) in mango.

Number of secondary roots at 30, 60, 90 DAS

The table 1 summarizes the effects of different treatments on the number of secondary roots per seedling at 30, 60, and 90 days after sowing (DAS). At 30 DAS, the significantly maximum number of secondary roots (25.24) were found in the treatment (T_5) GA_3 at 100 mg/litre for 24 hours which was on par with the treatment (T_9) of soaking of seeds in thiourea 2% for 2 hours, the treatment (T_8) of soaking of seeds in thiourea 2% for 1 hours, the treatment (T_4) of soaking of seeds in GA_3 75 mg/litre for 24 hours and the treatment (T_2) of KNO_3 1% for 2 hours. On the other hand, control (T_{12}) exhibited the lowest number of secondary roots (24.07).

Table.1 Effect of seed treatment on germination and growth parameters of karonda seedlings

Treatment	Germination %	Seedling length(cm)			Number of leaves			Seedling diameter(mm)		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	66.67	9.26	19.14	24.26	9.40	15.7	22.59	1.87	2.35	2.63
T_2	70.00	10.63	20.19	25.20	10.33	16.23	23.14	1.95	2.42	2.73
T_3	80.00	11.93	19.77	26.08	8.93	17.20	25.75	1.49	1.93	2.15
T_4	80.83	13.30	22.45	28.05	9.03	18.57	26.66	1.69	1.98	2.21
T_5	81.67	15.46	24.13	30.21	10.90	19.27	28.03	1.80	2.27	2.35
T_6	57.50	8.87	18.10	23.01	11.15	19.49	28.21	1.24	1.66	2.08
T_7	58.33	9.74	19.03	24.33	11.85	19.63	28.55	1.17	1.55	1.99
T_8	60.83	10.23	20.60	25.15	11.96	19.91	28.74	1.13	1.65	2.19
T_9	55.83	9.19	19.03	24.03	12.11	20.00	29.01	1.14	1.54	1.94
T_{10}	61.67	7.29	11.33	17.28	6.50	13.83	16.96	1.43	1.60	1.79
T_{11}	82.50	11.29	19.16	24.85	7.03	15.80	20.67	1.51	1.91	2.01
T_{12}	43.33	6.98	11.03	16.21	6.13	14.13	16.13	1.32	1.59	1.77
S.Em :	2.69	0.24	0.69	0.90	0.46	0.68	1.00	0.13	0.13	0.12
C.D. at 5% :	7.88	0.71	2.03	2.63	1.34	2.00	2.94	0.37	0.38	0.34
C.V.%:	6.99	4.05	6.41	6.46	8.26	6.74	7.07	14.85	12.09	9.31

Table.2 Effect of seed treatments on root growth of karonda seedlings

Treatment	Length of main root (cm)			Primary root length(cm)	Secondary root length(cm)	Number of primary roots			Number of secondary roots		
	30 DAS	60 DAS	90 DAS	90 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	7.00	9.97	12.63	6.32	3.16	14.80	19.07	23.27	22.60	26.83	30.13
T_2	7.42	10.17	12.77	6.38	3.19	15.23	19.63	23.00	23.17	27.20	31.57
T_3	7.13	10.50	14.00	7.00	3.50	19.07	23.60	28.17	21.91	27.63	34.87
T_4	7.83	11.40	15.37	7.68	3.84	21.87	26.67	31.43	23.20	29.30	36.57
T_5	8.23	12.60	16.27	8.13	4.07	22.07	28.33	34.70	25.24	31.60	38.37
T_6	6.10	9.27	11.77	5.88	2.94	14.33	18.20	22.07	22.13	26.00	29.30
T_7	6.40	9.63	11.80	5.90	2.95	14.37	18.53	22.80	22.32	26.43	29.80
T_8	5.73	8.50	11.33	5.67	2.83	15.33	19.23	23.07	23.33	26.97	30.80
T_9	5.27	8.40	11.00	5.50	2.75	15.87	19.40	23.47	23.73	27.37	31.13
T_{10}	3.83	6.33	9.07	4.53	2.27	6.89	12.30	19.67	15.60	21.87	25.80
T_{11}	7.83	9.77	11.27	5.63	2.82	14.43	17.87	21.30	19.33	22.83	27.67
T_{12}	4.83	6.77	8.17	4.08	2.04	6.21	11.87	18.70	14.80	20.63	24.07
S.Em :	0.27	0.36	0.39	0.18	0.11	0.55	0.61	0.93	0.85	0.89	1.15
C.D. at 5% :	0.78	1.06	0.39	0.54	0.34	1.62	1.80	2.72	2.50	2.60	3.38
C.V.%:	7.14	6.62	1.15	5.26	6.56	6.37	5.44	6.62	6.89	5.86	6.46

Table.3 Effect of seed treatments on biomass and vigour of karonda seedlings

Treatment	Fresh weight of plant(gm)	Dry weight of plant(gm)	Seedling vigour index I of plant(cm)	Seedling vigour index II of plant (gm)
	90 DAS	90 DAS	90 DAS	90 DAS
T_1	3.20	0.98	1600	65.34
T_2	3.28	1.01	1708	70.80
T_3	2.92	1.15	2305	91.95
T_4	2.96	1.17	2533	94.74
T_5	3.18	1.21	2828	98.88
T_6	2.85	0.69	1622	39.88
T_7	2.82	0.71	1748	41.43
T_8	2.89	0.72	1551	43.78
T_9	2.81	0.74	1517	32.11
T_{10}	2.45	0.57	660	34.88
T_{11}	3.47	1.37	1654	128.84
T_{12}	2.27	0.51	548	28.29
S.Em :	0.12	0.04	80.04	3.18
C.D. at 5% :	0.34	0.12	234.75	9.32
C.V.%:	6.83	7.99	8.21	8.57

Table.4 Effect of seed treatments on survival percentage, mortality percentage and incidence of damping off karonda seedlings.

Treatment	Survival percentage	Mortality percentage	Incidence of damping off
T_1	63.45	36.55	57.94
T_2	64.84	35.16	62.56
T_3	81.20	18.80	45.00
T_4	81.48	18.52	38.33
T_5	83.52	16.48	33.33
T_6	75.05	24.95	71.67
T_7	74.03	25.97	60.00
T_8	76.42	23.58	66.67
T_9	78.89	21.11	61.00
T_{10}	61.67	38.33	55.56
T_{11}	70.94	29.06	53.33
T_{12}	55.19	44.81	75.00
S.Em :	2.34	1.45	4.70
C.D. at 5% :	6.88	4.24	13.79
C.V.%:	5.62	9.02	14.36

Among the treatments, the treatment with GA_3 at 100 mg/litre for 24 hours (T_5) showed highest number of secondary roots (31.60 and 38.37) followed on par with GA_3 at 75 mg/litre (T_4) for 24 hours at 60 DAS and 90 DAS (29.30 and 36.57) respectively. Conversely, the control treatment showed lowest number of secondary roots (20.63 and 24.07) respectively at 60 DAS and 90 DAS. Overall, the findings suggest that GA_3 treatments are highly effective in enhancing secondary root formation compared to other treatments and the control. These results are in line with Anjanawe *et al.,* (2013) in papaya and Dilip *et al.,* (2017) in rangpur lime.

Fresh weight of plant (gm) at 90 DAS

The data present in table 3 revealed that at 90 DAS, the control group exhibited the lowest fresh weight of 2.27 grams, indicating limited growth. Among the treatments, water soaking for 8 hours (T_{11}) resulted in the highest fresh weight of 3.47 grams. This was on par with soaking seeds in KNO_3 1per cent for 2 hours (T_2) and GA_3 100 mg/litre for 24 hours (T_5), which yielded fresh weights of 3.28 grams and 3.18 grams, respectively. Overall, the findings suggest that water soaking is the most effective treatment for enhancing plant fresh weight, while hot water treatment negatively impacts growth, and GA_3 and KNO_3 treatments offer moderate improvements. Similar results were also obtained by Bhavya *et al.,* (2017) in karonda.

Dry weight of plant (gm) at 90 DAS

The table 3 summarizes the dry weight of plants at 90 days after sowing (DAS) across various treatments. The data shows that the control treatment had the lowest dry weight at 0.51 grams, indicating minimal growth and biomass accumulation. Among the treatments, only water soaking for 8 hours (T_{11}) exhibited the significantly highest dry weight of 1.37 grams, suggesting it significantly enhanced biomass accumulation. Overall, the results suggest that water soaking is the most effective treatment for increasing plant dry weight, while hot water treatment negatively affects biomass accumulation, and GA_3 and KNO_3 treatments offer moderate benefit. Similar results were also obtained by Bhavya *et al.,* (2017) in karonda.

Seedling vigour index I (length)

The table 3 presents the Seedling Vigour Index I at 90 days after sowing (DAS) for various pre-sowing treatments. Among the treatments, soaking seeds in GA_3 was notably effective in promoting seedling vigour. The only treatment, GA_3 at 100 mg/litre for 24 hours (T_5) exhibited significantly highest Seedling Vigour Index of 2828. The control treatment, which received no special treatment, recorded the lowest Seedling Vigour Index of 548, reflecting minimal seedling vigour. These results are in accordance with Gurung *et al.,* (2014) in passion fruit.

Seedling vigour index II (mass)

The data presented in table 3 revealed that Among the treatments, water soaking seeds for 8 hours (T_{11}), is the only treatment which significantly enhanced the Seedling Vigour Index II with 128.84. conversely, The control treatment showed he minimum Seedling Vigour Index II at 28.29, indicating minimal plant vigour.

Overall, the findings highlight that water soaking and GA_3 treatments are highly effective in enhancing seedling vigour, while hot water treatment and thiourea treatments have relatively lower impacts on plant performance. Similar results were also obtained by Bhavya *et al.,* (2017) in karonda.

Survival percentage

The table 4 shows the survival percentage of seedlings at the end of the experimental period, illustrating the impact of various pre-sowing treatments on seedling establishment. Among the treatments, treatments involving GA_3 demonstrated notable improvements in seedling survival. Soaking seeds in GA_3 at 100 mg/litre for 24 hours (T_5) resulted in the significantly maximum survival percentage of 83.52%, followed by GA3 at 75 mg/litre (T_4) with 81.48% and GA_3 at 50 mg/litre (T_3) with 81.20% and Soaking of seeds in thiourea 2% for 2 hours (T_9) with 78.89 %. The control group, which did not receive any specialized treatment, exhibited the lowest survival percentage at 55.19 %, suggesting limited effectiveness in enhancing seedling survival. These results are in accordance with Manekar *et al.,* (2011) in anola and Dhawale (2015) in tamrind.

Mortality percentage

The data present in table 4revealed that among the treatments, treatments involving GA_3 demonstrated significantly lower mortality rates, reflecting improved seedling resilience. Significantly the lowest mortality percentage was observed with GA_3 at 100 mg/litre for 24 hours (T_5) at 16.48%, which was on par with GA_3 at 75 mg/litre (T_4) with 18.52% and GA_3 at 50 mg/litre (T_3) with 18.80%. These results indicate that GA_3 treatments are highly effective in reducing seedling mortality.

In contrast. The control treatment displayed the highest mortality percentage at 44.81%, indicating poor seedling survival under standard conditions. Overall, GA_3 treatments were most effective in minimizing seedling mortality, while KNO_3 and thiourea treatments also contributed to lower mortality rates, and hot water treatment had a relatively adverse effect on seedling survival.

Incidence of damping off

The data concerning to the incidence of damping off of karonda seedling as influenced by different seed treatments are presented Table 4. Within the various treatments, treatments involving GA_3 proved to be particularly effective in reducing damping-off incidence. Significantly minimum incidence was observed with GA_3 at 100 mg/litre for 24 hours (T_5), at 33.33%, which was on par with GA_3 at 75 mg/litre (T_4) with 38.33% and GA_3 at 50 mg/litre (T_3) with 45.00%. These results indicate that GA_3 treatments significantly lower the incidence of damping-off compared to other treatments. In contrast, the control treatment had the highest incidence of damping-off at 75.00%, highlighting a substantial level of disease occurrence under standard conditions.

Author Contributions

D. S. Sonkamble: Investigation, formal analysis, writing—original draft. R. V. Bhalerao: Validation, methodology, writing—reviewing. A. M. Bhosale:—Formal analysis, writing—review and editing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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