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Influence of seed treatments on germination and seedling vigour of karonda (*Carissa carandas* L.) under shade net condition

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Abstract
A field experiment was done during the year 2024-25 and the seed treatments were used individually. The treatment T_6 (KNO_3 1.5%) were the outstanding treatment for enhancing seed germination and seedling vigour of karonda. Earliest initiation of seed germination (6.33 days), 50% of seed germination (11.02 days) and maximum germination percentage fruit (83.11%) was recorded superior under the treatment T_6 (KNO3 1.5%). Also, the same treatment has been recorded maximum total seedling height (33.98 cm), number of leaves/seedling (50.87), collar diameter (2.67 mm), fresh weight of shoots (2.64 g), dry weight of shoots (1.12 g), root: shoot ratio (0.34), seedling vigour index-I (2268.68), seedling vigour index-II (107.17) and survival percentage (81.74%) under shade net condition. Root parameters of karonda seed were registered highest for root length (31.19 cm), number of roots per seedling (118.66), fresh weight of roots (0.78 g) and dry weight of roots (0.35 g) under the treatment T_6 (KNO3 1.5%).

Keywords: Karonda, seed treatments, germination, survival, seedling vigour & collar diameter

Introduction
Karonda (*Carissa carandas* L.) is Indian origin and grows wild in Maharashtra, Rajasthan, Uttar Pradesh, West Bengal and Bihar. It is popularly known as "Bengal currant" or "Christ's Thorn". Other names are Karamanda, Karavanda, Kaunda, Kalivi, Natal plum in India. In Kannada it is called as 'Kavalikayi'. 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) [2]. 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.

Karonda can be cultivated in all sub-tropical and tropical climatic regions of India. Karonda has been observed to occur naturally in significant areas across the states of Maharashtra, Bihar, West Bengal, Chhattisgarh, Orissa, Gujarat, Madhya Pradesh, and Rajasthan (Singh *et al.*, 2014) [11]. This shrub is quite robust; it thrives in high-temperature environments and on various soil types. It can also thrive on marginal and wastelands successfully. Though Karonda can withstand drought, it does not thrive under heavy rainfall and water-logged conditions. The plant has heavily branched roots that make it suitable for stabilizing slopes that are eroding. A wide variety of soils, including saline and sodic soils, can support its growth.

The terminal cyme produces white flowers. In Gujarat and Punjab, it is greatly favored as a protective hedge. Its lovely cherry-like fruits mean that it is occasionally cultivated as an ornamental plant. Due to the presence of axillary spines and the formation of abundant leaves on crowded branches, Karonda is most suitable for use as a live protective fence. Due to its robustness and xerophytic characteristics, as well as its ability to adapt to saline sodic soils with a pH of up to 10, it has great potential for use in horticultural plantations on marginal and wastelands (Chundawat, 1995) [5]. Fruits are usually picked while still immature for use as vegetables, whereas fully ripened fruits are eaten fresh or processed (Malik *et al.*, 2010) [7].

When ripe they become sweet and rich in carbohydrates, pectin, minerals, especially iron and vitamin-C. The unripe fruit is sour and astringent and which is used for making pickles and chutneys. Karonda natural product is wealthy in iron (Dry weight 3.91Â°) and contains bounty of vitamin-C. Hence, it is valuable within the treatment of diabetes and has antiscurvy properties. The vitamin A substance of the natural product is 1619 IU/ 100 g eatable parcel and 87% to 90% mash, 13% to 14% add up to solvent solids and 4% to 6% acid (Bhavya *et al*., 2017) [3]. It can be made on a trade scale as the natural products of the trade economy within the changing world commerce demonstrate. Therefore, under the changing world trade scenario, it can be exploited on a commercial scale as a fruit for the processing industries.

Due to the high level of cross-pollination in this crop, there is significant variability within its natural population. Though seeds are used for commercial propagation, they are difficult and have a low germination rate. Fruit senescence and seed dissemination are caused by specific physical and chemical changes that occur during the fruit's maturation and ripening processes. The desiccation of the pericarp tissues is one of the changes that stand out the most.

In certain species, this leads to dehiscence and the discharge of the seeds from the fruit. Seeds of most species dehydrate at ripening and prior to dissemination, when moisture content drop to 30 per cent or less. The seed dries further during harvest, usually to about 4-6 percent for storage. Germination cannot take place at this level of dryness which is important basis for maintaining viability and controlling germination (Chin, 1981). Hence seeds of karonda should be sown just after extraction from fruits. It is commercially propagated by seeds but seeds are quite hard with low germination. Information on seed germination behaviour, viability and longevity of seeds under ambient conditions is needed to ascertain their storability. Storage potential of seed is mainly genetical factor but is influenced by several other factors like environment, cultivar differences (Singh and Gill, 1994) [11] and period of storage. The planning for seed storage also requires information on relative storability of seeds of particular species under ambient conditions. However, a little information is available regarding effect of seed storage and pre-sowing treatments on seed germination, seedling growth and longevity of Karonda. 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. Keeping in view the above facts, the present experiment was conducted to enhance seed germination by standardizing pre-sowing treatments for crop cultivation.

Material and Methods

- **Experimental site:** The present experiment was led at Horticulture Nursery Farm, Department of Fruit Science, College of Agriculture, IGKV, Raipur (C.G.) during the year 2024-25.
- **Experimental materials:** The investigation was laid out using a Completely Randomized Design (CRD) and 3 replications. In this research, karonda seeds were soaked separately in water soaking 12 hours, water soaking 24 hours, GA_3 50 ppm, GA_3 100 ppm, KNO_3 1.0%, KNO_3 1.5%, PSB (Phosphate Solubilizing Bacteria) 5%, PSB (Phosphate Solubilizing Bacteria) 10%, Cow urine 10% and Cow urine 20%. Growing medium for all the treatments are composed of sand, soil and FYM in the ratio of 1:1:1 under shade net condition.
- **Treatment details:** The study has been done in completely randomized design with 3 replications. The treatments were *viz.* T_0-Control, T_1-Water soaking 12 hours, T_2-Water soaking 24 hours, T_3-GA_3 50 ppm, T_4-GA_3 100 ppm, T_5-KNO_3 1.0%, T_6- KNO_3 1.5%, T_7-PSB 5%, T_8- PSB 10%, T_9- Cow urine 10% and T_{10}-Cow urine 20%.

Results and Discussion

Germination attributes

The earliest mean value of seed germination (6.33 days) was observed under the treatment T_6 (KNO_3 1.5%), which was closely followed by the treatment T_5 (KNO_3 1.0%) having 6.98 days. The treatments T_1, T_2, T_3 & T_4 and T_7, T_8, T_9 & T_{10} having respective values of 9.97, 9.11, 8.99 & 7.88 and 10.55, 10.32, 9.01 & 9.26 days were found non-significant differences among each other. While, the highest days taken to initiation of seed germination (11.01 days) was perceived under the treatment T_0 (control). The minimum days taken to 50% of seed germination (11.02 days) was gathered under the treatment T_6 (KNO_3 1.5%), which was equivalent with the treatment T_5 (KNO_3 1.0%) having 11.44 days under the present trial. However, the treatments T_1 & T_2 and T_3 & T_4 and T_7 & T_8 having respective values of 15.53 & 15.17 and 12.48 & 12.12 and 17.92 & 17.22 days were found non-significant differences among each other. While, the highest days taken to 50% of seed germination (18.36 days) was recorded under the treatment T_0 (control). The treatment KNO_3 1.5% (T_6) registered the maximum germination percentage (83.11%), which was followed by T_5 (KNO_3) having the germination percentage of 80.02% under the present investigation. Yet, the treatments T_1 & T_2 and T_3 & T_4 and T_7 & T_8 having respective values of 66.65 & 68.33 and 73.64 & 75.68 and 66.25 & 65.36% showed statistically similar among each other at 5% level of significance. Whereas, the minimum germination percentage (58.27%) was verified under the treatment T_0 (control). The earliest germination of seed, 50% seed germination and maximum germination percentage might be due to removal of hard seed coat which increase the permeability of water and gases through seed which cause early germination. Both hydro-priming and priming with KNO_3 enhanced germination rates. The beneficial impact of chemical stimulators like KNO_3 on seed germination is linked to achieving a balance in hormonal ratios within the seed and diminishing the presence of growth inhibitors such as ABA (Ali *et al.*, 2010) [1]. Similar findings were also reported by Bhavya *et al*. (2017) [3], Pal *et al*. (2019) [9], Mistry and Sitapara (2020) [8] in Karonda seed germination.

Table 1: Influence of seed treatments on days taken to initiation of seed germination, days taken to 50% of seed germination & germination percentage of Karonda under shade net condition

Notations	Treatments	Days taken to initiation of seed germination (Days)	Days taken to 50% of seed germination (Days)	Germination percentage (%)
T_0	Control	11.01^{c}	18.36^{c}	58.27^{a}
T_1	Water soaking 12 Hours	9.97^{bc}	15.33^{bc}	66.65^{b}
T_2	Water soaking 24 Hours	9.11^{abc}	15.17^{bc}	68.33^{bc}
T_3	GA_3 50 ppm	8.99^{abc}	12.48^{ab}	73.64^{ef}
T_4	GA_3 100 ppm	7.88^{abc}	12.12^{ab}	75.68^{f}
T_5	KNO_3 1.0%	6.98^{ab}	11.44^{a}	80.02^{gh}
T_6	KNO_3 1.5%	6.33^{a}	11.02^{a}	83.11^{h}
T_7	PSB 5%	10.55^{c}	17.92^{c}	66.25^{b}
T_8	PSB 10%	10.32^{bc}	17.22^{c}	65.36^{b}
T_9	Cow urine 10%	9.01^{abc}	13.26^{ab}	72.45^{de}
T10	Cow urine 20%	9.26^{abc}	13.56^{ab}	70.29^{cd}
	Se(m) ±	1.15	1.16	1.12
	C.D. at 5%	3.38	3.31	3.27

Note: The letters in superscript indicate that treatment means with the same letters are comparable at a 5% significance level, whereas those with different letters differ significantly at the same level. The placement of these letters is a result of comparing the CD values of treatment means.

Shoot attributes

The treatment T_6 (KNO_3 1.5%) retained the maximum seedling height (33.98 cm), which showed non-significant relation with the T_5, T_4, T_3 & T_{10} having seedling height of 33.92, 33.76, 33.72 & 32.64 cm evaluated under the present investigation after 120 days of sowing. Moreover, the minimum seedling height (29.34 cm) was perceived in treatment T_0 (control).

The treatment T_6 (KNO_3 1.5%) retained the highest No. of leaves/seedling (50.87), which showed non-significant relation with the treatments T_5, T_4 & T_3 having number of leaves per seedling of 50.40, 49.70 & 49.31 evaluated under the present investigation at 120 DAS. Though, the lowest No. of leaves/seedling (34.65) was perceived under the treatment T_0 (control).

After 120 days of sowing, the treatment T_6 (KNO_3 1.5%) retained the maximum collar diameter (2.67 mm), which showed statistically parallel with the treatments T_5 & T_4 having collar diameter of 2.62 & 2.59 mm. However, the lowest collar diameter (2.15 mm) was perceived under the treatment T_0 (control).

The treatment T_6 (KNO_3 1.5%) retained the maximum fresh weight of shoots (2.64 g), which was seen statistically equal among treatments T_5 with fresh weight of shoots of 2.61 g under the present investigation. Similarly, the treatments T_3 & T_4 with respective fresh weight of shoots of 2.51 & 2.53 g were statistically equivalent among each other. Whereas, the lowest fresh weight of shoots (1.86 g) was perceived under the treatment T_0 (control).

Treatment T_6 (KNO_3 1.5%) retained the highest shoots dry weight (1.12 g), which showed non-significant difference among T_5, T_4 & T_3 having dry weight of shoots of 1.09, 1.00 & 0.95 g under the present research. However, the lowest dry weight of shoots (0.35 g) was perceived under T_0 (control).

At 120 days after sowing, the treatment T_6 (KNO_3 1.5%) retained the maximum root:

shoot ratio (0.34), which was found non-significant difference with the treatments T_5 & T_7 having root: shoot ratio of 0.33 & 0.31 under the present investigation. Moreover, the minimum root: shoot ratio (0.21) was perceived under the treatment T_0 (control) under the present trial.

The maximum seedling height, number of leaves per seedling, collar diameter, fresh weight of shoots, and dry weight of shoots may be attributed to hydro-priming's improvement of the seedling emergence rate through an enhanced supply of soluble carbohydrates to the growing embryo, resulting from increased α-amylase activity. Seed priming results in a quick and consistent sprouting of seedlings, which allows the plants to make effective use of resources at hand. This contributes to greater biomass and yield (Ghassemi *et al.*, 2014) [6]. The seedlings that sprouted early are robust. Given that the germination percentage, seedling length, and seedlings' fresh weight were found to be highest, this would account for the increased shoot growth. The results are in close agreements with the findings of Bhavya *et al.* (2017) [3], Pal *et al.* (2019) [9], Mistry and Sitapara (2020) [8] in Karonda.

The treatment T_6 (KNO_3 1.5%) retained the maximum seedling vigour index-I (2268.68), which was found excellent from rest of the other treatments and followed by the treatments T_5 (KNO_3 1%) having seedling vigour index-I of 2260.52 under the present investigation. However, the minimum seedling vigour index-I (1475.76) was perceived under the treatment T_0 (control) under the present trial.

At 120 days after sowing, the treatment T_6 (KNO_3 1.5%) retained the maximum seedling vigour index-II (107.17), which was found outstanding from rest of the other treatments tested under the present trial and followed by the treatments T_5 (KNO_3 1%) having seedling vigour index-II of 104.10 under the present investigation. However, the lowest seedling vigour index-II (33.62) was perceived under the treatment T_0 (control) under the present trial.

The treatment T_6 (KNO_3 1.5%) retained the maximum survival percentage (81.74%), which was found excellent from rest of the other treatments tested under the present trial and followed by the treatments T_5 (KNO_3 1%) having survival percentage of 79.68% under the present investigation. However, the minimum survival percentage (52.21%) was perceived under the treatment T_0 (control) under the present trial.

The maximum seedling vigour index and survival percentage with KNO_3 might be due to the vigorous growth, greater seedling emergence ability, cotyledonary photosynthesis and maximum germination percentage. This also might be due to enhanced uptake of nitrogen, potassium, water and nutrients and resulted in better root and shoot growth which might have resulted in maximum vigour index. The results of the present experiment were comparable with the findings recorded by Bhavya *et al*. (2017) [3], Pal *et al*. (2019) [9], Mistry and Sitapara (2020) [8] in Karonda.

Table 2: Influence of seed treatments on seedling height (cm), number of leaves per seedling & collar diameter (mm) of Karonda at 30 days interval under shade net condition

Notations	Treatments	Seedling height (cm)				Number of leaves per seedling				Collar diameter (mm)		
		30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
T$_0$	Control	4.11^{a}	12.67^{a}	23.97^{a}	29.34^{a}	4.01^{a}	13.93^{a}	21.49^{a}	34.65^{a}	1.43^{a}	1.91^{a}	2.15^{a}
T$_1$	Water soaking 12 Hours	4.83^{ab}	13.60^{b}	24.61^{ab}	30.67^{ab}	5.02^{abcd}	14.78^{abc}	29.40^{b}	46.34^{bcd}	1.74^{c}	2.08^{bc}	2.29^{bcd}
T$_2$	Water soaking 24 Hours	4.88^{ab}	13.64^{b}	24.71^{ab}	30.76^{abc}	5.08^{bcd}	14.86^{abcd}	29.71^{b}	47.11^{cd}	1.78^{d}	2.11^{cd}	2.37^{cde}
T$_3$	GA$_3$ 50 ppm	5.02^{b}	14.00^{bc}	25.74^{cde}	33.72^{d}	5.88^{bcd}	15.26^{bcd}	32.38^{de}	49.31^{ef}	1.89^{f}	2.33^{f}	2.52^{fgh}
T$_4$	GA$_3$ 100 ppm	5.05^{b}	14.07^{bc}	25.78^{de}	33.76^{d}	5.97^{cd}	15.29^{bcd}	32.44^{de}	49.70^{ef}	1.91^{fg}	2.34^{f}	2.59^{ghi}
T$_5$	KNO$_3$ 1.0%	5.08^{b}	14.70^{c}	25.83^{e}	33.92^{d}	6.02^{d}	15.82^{cd}	32.66^{e}	50.40^{f}	1.94^{gh}	2.37^{f}	2.62^{hi}
T$_6$	KNO$_3$ 1.5%	5.14^{b}	14.76^{c}	25.89^{e}	33.98^{d}	6.04^{d}	15.85^{d}	32.72^{e}	50.87^{f}	1.96^{h}	2.38^{f}	2.67^{i}
T$_7$	PSB 5%	4.78^{ab}	13.48^{ab}	24.44^{ab}	30.43^{a}	4.91^{ab}	14.65^{ab}	29.15^{b}	44.60^{b}	1.65^{b}	1.96^{a}	2.23^{ab}
T$_8$	PSB 10%	4.81^{ab}	13.55^{ab}	24.49^{ab}	30.53^{a}	4.98^{abc}	14.74^{ab}	29.20^{b}	45.32^{bc}	1.68^{b}	2.03^{b}	2.26^{abc}
T$_9$	Cow urine 10%	4.98^{ab}	14.28^{bc}	24.94^{bcd}	32.71^{cd}	5.42^{bcd}	14.99^{abcd}	31.54^{cd}	47.92^{de}	1.88^{ef}	2.18^{e}	2.47^{efg}
T10	Cow urine 20%	4.96^{ab}	13.91^{bc}	24.92^{bc}	32.64^{bcd}	5.38^{bcd}	14.96^{abcd}	31.29^{c}	48.00^{de}	1.85^{e}	2.16^{de}	2.42^{def}
	Se(m) ±	0.30	0.32	0.29	0.36	0.35	0.36	0.37	0.61	0.01	0.02	0.05
	C.D. at 5%	0.88	0.92	0.85	1.07	1.02	1.06	1.08	1.81	0.03	0.05	0.13

Note: The letters in superscript indicate that treatment means with the same letters are comparable at a 5% significance level, whereas those with different letters differ significantly at the same level. The placement of these letters is a result of comparing the CD values of treatment means.

Table 3: Influence of seed treatments on fresh weight of shoots (g), dry weight of shoots (g), root: shoot ratio, seedling vigour index-I, seedling vigour index-II and survival percentage of Karonda after 120 DAS under shade net condition

Notations	Treatments	Fresh weight of shoots (g)	Dry weight of shoots (g)	Root: shoot ratio	Seedling vigour index-I	Seedling vigour index-II	Survival percentage (%)
T$_0$	Control	1.86^{a}	0.35^{a}	0.21^{a}	1475.76^{a}	33.62^{a}	52.21^{a}
T$_1$	Water soaking 12 Hours	2.23^{d}	0.60^{abc}	0.25^{ab}	1929.00^{d}	75.75^{d}	59.58^{d}
T$_2$	Water soaking 24 Hours	2.28^{e}	0.66^{bcd}	0.24^{ab}	1938.36^{e}	77.90^{e}	61.57^{e}
T$_3$	GA$_3$ 50 ppm	2.51^{h}	0.95^{def}	0.22^{a}	2234.28^{h}	101.34^{g}	75.61^{h}
T$_4$	GA$_3$ 100 ppm	2.53^{h}	1.00^{ef}	0.27^{abc}	2245.78^{i}	101.80^{g}	77.90^{i}
T$_5$	KNO$_3$ 1.0%	2.61^{ij}	1.09^{f}	0.33^{de}	2260.52^{j}	104.10^{h}	79.68^{j}
T$_6$	KNO$_3$ 1.5%	2.64^{j}	1.12^{f}	0.34^{e}	2268.68^{k}	107.17^{i}	81.74^{k}
T$_7$	PSB 5%	1.93^{b}	0.40^{ab}	0.31^{cde}	1860.56^{b}	66.44^{b}	53.48^{b}
T$_8$	PSB 10%	1.98^{c}	0.75^{cde}	0.24^{ab}	1867.48^{c}	69.58^{c}	55.83^{c}
T$_9$	Cow urine 10%	2.41^{g}	0.85^{cdef}	0.22^{a}	2146.34^{g}	88.47^{f}	69.57^{g}
T$_{10}$	Cow urine 20%	2.33^{f}	0.78^{cde}	0.28^{bcd}	2128.24^{f}	86.78^{f}	67.09^{f}
	Se(m) ±	0.01	0.10	0.02	1.73	0.71	0.34
	C.D. at 5%	0.03	0.29	0.05	5.17	2.11	1.01

Note: The letters in superscript indicate that treatment means with the same letters are comparable at a 5% significance level, whereas those with different letters differ significantly at the same level. The placement of these letters is a result of comparing the CD values of trea tment means.

Root attributes

The treatment T$_6$ (KNO$_3$ 1.5%) retained the maximum root length (31.19 cm), which showed statistically similar with T$_5$, T$_4$ & T$_3$ having root length of 30.76, 30.46 & 30.37 cm under the present trial at 120 DAS. Moreover, the lowest root length (23.43 cm) was perceived under T$_0$ (control) under present trial. At 120 days after sowing, the treatment T$_6$ (KNO$_3$ 1.5%) retained the highest number of roots per seedling (118.66), which showed statistically superior as compared to other. However, the lowest number of roots per seedling (70.52) was perceived under T$_0$ (control) under the present trial. The treatment T$_6$ (KNO$_3$ 1.5%) retained the maximum fresh weight of roots (0.78 g), which showed statistically equivalent to T$_5$ with fresh weight of roots of 0.72 g under the present trial. However, the minimum fresh weight of roots (0.29 g) was perceived under the treatment T$_0$ (control) under the present trial after 120 days of sowing. At 120 days after sowing, the treatment T$_6$ (KNO$_3$ 1.5%) retained the maximum dry weight of roots (0.35 g), which was found statistically superior from rest of the other treatments tested under the present investigation and followed by the treatment T$_5$ (KNO$_3$ 1%) having dry weight of roots of 0.31 g under the present trial. However, the minimum dry weight of roots (0.12 g) was perceived under the treatment T$_0$ (control) under the present trial. The maximum root length, number of roots per seedling, fresh weight of roots and dry weight of roots 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 a-amylase activity along with rapid and uniform emergence might have resulted in the root growth parameters with increase in length of root. The results of the present study were corroborated with the findings testified by Bhavya *et al.* (2017) [3], Pal *et al*. (2019) [9], Mistry and Sitapara (2020) [8] in Karonda.

Benefit: Cost ratio

The highest B:C ratio (4.02) was gathered under the superiority of the T_6 (KNO_3 1.5%), which was closely followed by the treatment T_5 (KNO_3 1%) having the benefit: cost ratio of 3.99. While, the lowest B:C ratio (2.55) was registered under control (T_0).

Table 4: Influence of seed treatments on root length (cm), number of roots per seedling, fresh weight of roots (g) and dry weight of roots (g) of Karonda after 120 DAS under shade net condition

Notations	Treatments	Root length (cm)	Number of roots per seedling	Fresh weight of roots (g)	Dry weight of roots (g)	B:C ratio
T_0	Control	23.43^{a}	70.52^{a}	0.29^{a}	0.12^{a}	2.55
T_1	Water soaking 12 Hours	27.49^{cd}	96.79^{d}	0.44^{bc}	0.15^{abc}	3.30
T_2	Water soaking 24 Hours	27.68^{d}	99.11^{e}	0.49^{cd}	0.16^{bcd}	3.54
T_3	GA_3 50 ppm	30.37^{efg}	108.79^{h}	0.62^{ef}	0.21^{e}	3.74
T_4	GA_3 100 ppm	30.46^{fg}	111.37^{i}	0.67^{fg}	0.27^{f}	3.75
T_5	KNO_3 1.0%	30.76^{g}	115.56^{j}	0.72^{gh}	0.31^{g}	3.99
T_6	KNO_3 1.5%	31.19^{g}	118.66^{k}	0.78^{h}	0.35^{h}	4.02
T_7	PSB 5%	25.46^{b}	86.59^{b}	0.36^{ab}	0.13^{ab}	2.98
T_8	PSB 10%	26.66^{c}	89.11^{c}	0.39^{b}	0.14^{abc}	2.79
T_9	Cow urine 10%	29.70^{ef}	102.81^{g}	0.60^{ef}	0.19^{de}	3.41
T_{10}	Cow urine 20%	29.45^{e}	101.79^{f}	0.57^{de}	0.17^{cd}	3.10
	Se(m) ±	0.33	0.32	0.03	0.02	
	C.D. at 5%	0.96	0.94	0.08	0.03	

Note: The letters in superscript indicate that treatment means with the same letters are comparable at a 5% significance level, whereas those with different letters differ significantly at the same level. The placement of these letters is a result of comparing the CD values of treatment means.

Conclusion

The results of the current study allow for the conclusion that different seed treatments significantly influenced the germination attribute, seedling growth and seedling vigour of Karonda. The 1.5% KNO_3 treatment (T_6) proved to be the most effective for promoting germination and growth of Karonda seedlings during the study conducted under shade net conditions.

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