Indian Journal of Agricultural Sciences **88** (7): 1063–9, July 2018/Article

Efficacy of storage duration and pre-sowing treatments on seed germination, seedling growth and longevity of karonda (*Carissa carandas*)

JAYA BARMAN[1], ARKENDU GHOSH[2], KOYEL DEY[3], BIKASH CHANDRA DAS[4] and SATYA NARAYAN GHOSH[5]

Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal 741 252

Received: 19 June 2017; Accepted: 17 April 2018

ABSTRACT

Considering germination problem in karonda (*Carissa carandas* L.) the present experiment was carried out in factorial randomized block design with 3 stages of seed storage condition and 12 levels of pre-sowing treatments coupled with 36 treatment combinations. Investigation revealed that freshly shown seeds were superior in respect of germination percentage (64.12%), fresh and dry shoot weight and root weight, seedling vigour index (1411.72) and root-shoot ratio (0.27) also. In case of several pre-sowing treatments, P_8 (KNO_3) gave the maximum germination percentage (55.37%), seedling vigour index (1148.49) with minimum time taken for germination (11.74). The interaction between different storage duration and pre-sowing treatments was statistically significant with respect to germination percentage of Karonda. Among different treatment combination, T_8 (D_1P_8) recorded best in respect minimum time taken for germination (8.20) and other morphological parameters whereas T_{36} gave the lowest results in all the parameters observed.

Key words: Germination, Karonda, Longevity, Seedling growth, Seed treatment

Karonda (*Carissa carandas* L.) is one of the important perennial shrub in India belongs to the family Apocynaceae. It is commonly known as 'Karaunda' in India and 'Bengal Currant' or 'Christ's thorn' in South India. It grows up to a height of 3-6 m with dark green elliptic leaves, white-fragnant-bisexual flower and purplish-red turning dark-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 fails to grow (Hasmah *et al*. 2013). The fruits are traditionally used in the treatments of malaria, epilepsy, nerve disorder, relieve of pain and headache, fever, blood purifier, myopatic spams, dog bite, cough, colds, itches and leprosy (Rahmatullah *et al*. 2009). 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. It is commercially propagated by seeds but seeds are quiet 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 a genetical factor but is influenced by several other factors like environment, cultivar differences (Singh and Gill 1994) 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. Keeping in view the above facts, the present experiment was conducted.

MATERIALS AND METHODS

The field experiment was conducted at Instructional Farm of Bidhan Chandra Krishi Viswavidyalaya, Jaguli, Nadia, West Bengal, India during 2015 and 2016. The ripe fruits were soaked in water for overnight to allow the fruit pulp to become soft and were separated by rubbing the seeds against hard surface. The seeds were washed with water to remove the mucilaginous covering over the seed surface and shade dried. The required seeds were kept in brown paper bags and stored at ambient temperature except first treatment where seeds were sown immediately after extraction. These stored seeds were taken for further seed germination studies.

The experiment was laid out in two factorial randomized block design with 36 treatment combinations. First factor was seed storage duration having 3 levels, viz. D_1 – Seed sowing at 0 days of seed extraction (Fresh seeds), D_2 – Seed sowing at 30 days of seed extraction, D_3 – Seed sowing at

[1,2,3]Ph D Research Scholar (jayabarmancob@gmail.com, arkofruits@gmail.com, koyelfruits@gmail.com), [4,5]Professor (e mail: , bikash.das2511@gmail.com, profsnghosh@yahoo.co.in)

60 days of seed extraction. Second was pre-sowing chemical treatments, viz. P_1 – GA_3 (25 ppm), P_2 – GA_3 (50 ppm), P_3 – GA_3 (100 ppm), P_4 – NAA (25 ppm), P_5 – NAA (50 ppm), P_6 – NAA (100 ppm), P_7 – KNO_3 (0.5%), P_8 – KNO_3 (1%), P_9 – KH_2PO_4 (0.5%), P_{10} – KH_2PO_4 (1%), P_{11} – Soaking in water and P_{12} – Control. Treatment combinations were T_1 –D_1P_1, T_2 – D_1P_2, T_3 – D_1P_3, T_4 – D_1P_4, T_5 – D_1P_5, T_6 – D_1P_6, T_7 – D_1P_7, T_8 – D_1P_8, T_9 – D_1P_9, T_{10} – D_1P_{10}, T_{11} – D_1P_{11}, T_{12} – D_1P_{12}, T_{13} – D_2P_1, T_{14} – D_2P_2, T_{15} – D_2P_3, T_{16} – D_2P_4, T_{17} – D_2P_5, T_{18} – D_2P_6, T_{19} – D_2P_7, T_{20} – D_2P_8, T_{21} – D_2P_9, T_{22} – D_2P_{10}, T_{23} – D_2P_{11}, T_{24} – D_2P_{12}, T_{25} – D_3P_1, T_{26} – D_3P_2, T_{27} – D_3P_3, T_{28} – D_3P_4, T_{29} – D_3P_5, T_{30} – D_3P_6, T_{31} – D_3P_7, T_{32} – D_3P_8, T_{33} – D_3P_9, T_{34} – D_3P_{10}, T_{35} – D_3P_{11} and T_{36} – D_3P_{12}.

GA_3 treatment was done according to the method of Banik *et al*. (2015). The seeds were dipped in aqueous solution of different concentrations of GA_3 (25 ppm, 50 ppm and 100 ppm) separately. NAA treatment was done according to the method of Ghosh *et al*. (2003). The seeds were dipped in aqueous solution of different concentrations of NAA (25 ppm, 50 ppm and 100 ppm) separately. KNO_3 treatment was done according to the method of Dey *et al*. (2016). The seeds were dipped in aqueous solution of different concentrations of potassium nitrate (0.5% and 1%) separately. KH_2PO_4 treatment was done according to the method of Ghosh and Sen (1988). The seeds were dipped in aqueous solution of different concentrations of potassium dihydrogen phosphate (KH_2PO_4) (0.5% and 1%) separately.

Treated earthen pots were filled with potting mixture of soil, FYM and soil at a proportion of 1:1:1 along with 1g of carbendazim per cubic meter of potting mixture was added as a prophylactic measure to prevent the disease occurrence. Seeds were sown treatment wise in earthen pots containing potting mixture at 1 cm depth. Each treatment was replicated thrice with 100 seeds per replication.

Germination percentage was worked out after the final germination, i.e., after stoppage of germination. It was calculated by dividing the total number of seeds sown with the number of seeds germinated and multiplied by 100.

Germination (%) = (Number of seeds germinated / Number of seeds sown) × 100.

Initiation of germination was recorded from the date of sowing till first seed germinated. The days taken for attainment of complete germination from date of sowing till no further germination were recorded daily till constant germination number. Morphological observations were recorded on five randomly selected and tagged seedlings in each replication in a treatment at 90 days after sowing. Shoot length was recorded and measured from a marked point just above the crown region upto the tip and was expressed in centimeters. Number of leaves on seedlings was counted. The length of the longest root was measured from the morphological base to the morphological top with the help of vernier callipers and is expressed in centimeters. Vigour index of seedling was calculated by multiplying seedling length (root length + shoot length) with germination percentage (Abdual-baki and Anderson 1973).

Analysis of variance (one way classified data) for each parameter was performed using op stat software (online version). The statistical analysis was done by following randomized block design (RBD) as per Gomez and Gomez (1983). The significance of different sources of variation was tested by error mean square by Fischer-Snedecor's 'F' test at probability level of 0.05%.

RESULTS AND DISCUSSION

Experimental results on germination percentage (%) showed significant variation under different storage duration and pre-sowing treatments (Table 1 and 2). Maximum germination % (64.12) was recorded in D_1 (0 days of seed extraction) whereas the minimum result was observed in D_3 (29.31). The significantly highest germination % (55.37) was recorded in P_8 followed by P_7 (53.81). The minimum germination % result was recorded in P_{12} (39.21). The interaction between different storage duration and pre-sowing treatments was statistically significant with respect to germination percentage of Karonda. Data revealed that T_8 gave the maximum germination % (72.36) followed by T_7 (70.58), whereas the lowest result was found in T_{36} (20.62).

The data pertaining to days taken for initiation of germination that all the data were statistically significant under different storage duration and pre- sowing treatments (Table 1 and 2). Minimum days taken for initiation of germination was found in D_1 (9.78) and maximum days taken for initiation of germination was found in D_3 (16.88). In case of pre-sowing treatments the minimum days taken for initiation of germination was found in P_8 (11.74) followed by P_7 (12.03). The maximum days taken for initiation of germination was recorded in P_{12} (14.97). The interaction effect between different storage duration and pre-sowing treatments was highly significant with respect to days taken for initiation of germination. It revealed that T_8 gave the minimum days (8.20) taken for initiation of germination followed by T_7 (8.42) whereas the maximum days taken for initiation of germination in T_{36} (18.42).

Observations on days taken for completion of germination were statistically significant under different storage duration and pre-sowing treatments (Table 1 and 2). Maximum days (28.75) taken for completion of germination was observed in D_3 (60 days of seed extraction) whereas the minimum result was observed in D_1 (21.72). The significantly highest days (26.84) taken for completion of germination was recorded in P_{12} followed by P_{11} (26.55). The minimum days taken for completion of germination was observed in P_8 (23.62). The interaction between different storage duration and pre-sowing treatments was statistically significant with respect to days taken for completion of germination of Karonda. Data revealed that T_{36} (30.36) took maximum days followed by T_{35} (30.08) whereas the lowest result was found in T_8 (20.15).

Experimental results on shoot length (cm) showed significant variation under different storage duration and pre-sowing treatments (Table 3 and 4). Maximum shoot length (10.60 cm) was recorded in D_1 (0 days of seed extraction)

Table 1 Effect of seed storage duration and pre-sowing treatments on germination of karonda

Treatment	Germination percentage	Days taken for initiation of germination (DAS)	Days taken for completion of germination (DAS)
D_1 (0 days of seed extraction)	64.12 (53.22)	9.78	21.72
D_2 (30 days of seed extraction)	47.65 (43.63)	13.46	25.22
D_3 (60 days of seed extraction)	29.31 (32.67)	16.88	28.75
S.Em. (±)	0.004	0.006	0.007
CD (P≤0.05)	0.011	0.017	0.021
P_1 (GA_3 25 ppm)	46.19 (42.69)	13.58	25.38
P_2 (GA_3 50 ppm)	47.52 (43.50)	13.22	25.09
P_3 (GA_3 100 ppm)	48.99 (44.36)	12.92	24.79
P_4 (NAA 25 ppm)	42.07 (40.20)	14.44	26.25
P_5 (NAA 50 ppm)	43.37 (40.98)	14.03	25.94
P_6 (NAA 100 ppm)	44.69 (41.80)	13.79	25.65
P_7 (KNO_3 0.5%)	53.81 (47.25)	12.03	23.95
P_8 (KNO_3 1%)	55.37 (48.20)	11.74	23.62
P_9 (KH_2PO_4 0.5%)	50.58 (45.32)	12.67	24.51
P_{10} (KH_2PO_4 1%)	51.96 (46.14)	12.37	24.24
P_{11} (Water soaking)	40.52 (39.24)	14.77	26.55
P_{12} (Control)	39.21 (38.41)	14.97	26.84
SEm (±)	0.008	0.012	0.015
CD (P≤0.05)	0.022	0.033	0.041

**Values in parenthesis are angular transformed value. DAS – Days after sowing.

Table 2 Effect of seed storage duration and pre-sowing treatments on germination of karonda

Treatment	Germination percentage	Days taken for initiation of germination (DAS)	Days taken for completion of germination (DAS)
T_1 (D_1P_1)	63.16 (52.65)	10.09	21.85
T_2 (D_1P_2)	64.45 (53.43)	9.51	21.54
T_3 (D_1P_3)	65.58 (54.09)	9.25	21.25
T_4 (D_1P_4)	59.47 (50.48)	10.79	22.75
T_5 (D_1P_5)	60.22 (50.89)	10.36	22.44
T_6 (D_1P_6)	61.58 (51.71)	10.19	22.14
T_7 (D_1P_7)	70.58 (57.17)	8.42	20.44
T_8 (D_1P_8)	72.36 (58.31)	8.20	20.15
T_9 (D_1P_9)	67.27 (55.12)	9.13	20.96
T_{10} (D_1P_{10})	68.86 (56.11)	8.88	20.72
T_{11} (D_1P_{11})	58.08 (49.66)	11.16	23.07
T_{12} (D_1P_{12})	57.82 (49.49)	11.42	23.35
T_{13} (D_2P_1)	46.74 (43.11)	13.49	25.33
T_{14} (D_2P_2)	48.05 (43.91)	13.27	25.07
T_{15} (D_2P_3)	49.96 (44.94)	13.13	24.77
T_{16} (D_2P_4)	42.26 (40.57)	14.48	26.25
T_{17} (D_2P_5)	44.67 (41.96)	14.22	25.96
T_{18} (D_2P_6)	45.15 (42.25)	13.92	25.65
T_{19} (D_2P_7)	54.44 (47.52)	12.22	23.95
T_{20} (D_2P_8)	55.91 (48.39)	11.82	23.64
T_{21} (D_2P_9)	51.45 (45.86)	12.66	24.52
T_{22} (D_2P_{10})	52.86 (46.66)	12.31	24.24
T_{23} (D_2P_{11})	41.08 (39.87)	14.94	26.51
T_{24} (D_2P_{12})	39.20 (38.76)	15.08	26.81
T_{25} (D_3P_1)	28.65 (32.39)	17.17	28.95
T_{26} (D_3P_2)	30.08 (33.27)	16.82	28.65
T_{27} (D_3P_3)	31.42 (34.08)	16.39	28.35
T_{28} (D_3P_4)	24.49 (29.67)	18.05	29.75
T_{29} (D_3P_5)	25.21 (30.13)	17.52	29.42
T_{30} (D_3P_6)	27.35 (31.50)	17.25	29.15
T_{31} (D_3P_7)	36.42 (37.11)	15.45	27.44
T_{32} (D_3P_8)	37.85 (38.00)	15.19	27.07
T_{33} (D_3P_9)	33.03 (35.06)	16.22	28.07
T_{34} (D_3P_{10})	34.15 (35.79)	15.92	27.77
T_{35} (D_3P_{11})	22.41 (28.25)	18.22	30.08
T_{36} (D_3P_{12})	20.62 (26.99)	18.42	30.36
SEm (±)	0.013	0.020	0.025
CD (P≤0.05)	0.037	0.058	0.072

**Values in parenthesis are angular transformed value.

and the minimum result (8.30 cm) was recorded in D_3 (60 days of seed extraction). In case of pre-sowing treatments the maximum shoot length was observed in P_8 (9.96 cm) followed by P_7 (9.80 cm). The minimum shoot length was recorded in P_{12} (8.90 cm). The interaction effect between different storage duration and pre-sowing treatments was statistically at par with respect to shoot length proved that treatment combination had no effect on this parameter. Data revealed that T_8 gave the maximum shoot length (11.15 cm) followed by T_7 (11.04 cm), whereas the lowest result was found in T_{36} (7.77 cm).

Table 3 Effect of seed storage duration and pre-sowing treatments on shoot and root length of karonda

Treatment	Shoot length (cm)	Root length (cm)
D_1 (0 days of seed extraction)	10.60	11.35
D_2 (30 days of seed extraction)	9.41	8.95
D_3 (60 days of seed extraction)	8.30	6.56
S.Em. (±)	0.004	0.005
CD (P≤0.05)	0.012	0.014
P_1 (GA_3 25 ppm)	9.39	8.85
P_2 (GA_3 50 ppm)	9.48	9.05
P_3 (GA_3 100 ppm)	9.58	9.26
P_4 (NAA 25 ppm)	9.11	8.26
P_5 (NAA 50 ppm)	9.21	8.45
P_6 (NAA 100 ppm)	9.30	8.65
P_7 (KNO_3 0.5%)	9.86	9.85
P_8 (KNO_3 1%)	9.96	10.05
P_9 (KH_2PO_4 0.5%)	9.68	9.45
P_{10} (KH_2PO_4 1%)	9.76	9.63
P_{11} (Water soaking)	9.00	8.05
P_{12} (Control)	8.90	7.86
SEm (±)	0.008	0.010
CD (P≤0.05)	0.023	0.028

Experimental results on root length (cm) showed significant variation under different storage duration and pre-sowing treatments (Table 3 and 4). Maximum root length (11.35 cm) was observed in D_1 and the minimum result was observed in D_3 (6.56 cm). The significantly highest root length was recorded in P_8 (10.05) followed by P_7 (9.85 cm). The minimum root length was recorded in P_{12} (7.86 cm). The interaction effect between different storage duration and pre-sowing treatments was statistically at par with respect to root length proved that treatment combination had no effect on this parameter. It revealed that T_8 gave the maximum root length (12.42 cm) followed by T_7 (12.25 cm), and the lowest result was observed in T_{36} (5.43 cm)

Observations on number of leaves were statistically significant under different storage duration and pre-sowing treatments (Table 5 and 6). Maximum number of leaves was recorded in D_1 (7.71) and the minimum result was observed in D_3 (6.18). In case of pre-sowing treatments the highest number of leaves was observed in P_8 (7.33) followed by P_7 (7.24). The lowest number of leaves was recorded in P_{12} (6.61). The interaction between different storage duration and pre-sowing treatments was statistically significant with respect to number of leaves of karonda. Data revealed that T_8 gave the highest number of leaves (8.05) followed by T_7 (7.94), and the lowest number of leaves was observed in T_{36} (5.82).

Experimental results on seedling vigour index showed significant variation under different storage duration and pre-sowing treatments (Table 5 and 6). Maximum seedling vigour index was recorded in D_1 (1411.72) and the minimum result was recorded in D_3 (440.70). The significantly highest seedling vigour index was observed in P_8 (1148.49) followed by P_7 (1101.40). The minimum seedling vigour index was recorded in P_{12} (700.83). The interaction effect between different storage duration and pre-sowing treatments was statistically significant with respect to seedling vigour index.

Table 4 Effect of seed storage duration and pre-sowing treatments on shoot and root length of karonda

Treatment	Shoot length (cm)	Root length (cm)
T_1 (D_1P_1)	10.56	11.25
T_2 (D_1P_2)	10.65	11.47
T_3 (D_1P_3)	10.74	11.67
T_4 (D_1P_4)	10.25	10.66
T_5 (D_1P_5)	10.36	10.84
T_6 (D_1P_6)	10.45	11.02
T_7 (D_1P_7)	11.04	12.25
T_8 (D_1P_8)	11.15	12.42
T_9 (D_1P_9)	10.86	11.84
T_{10} (D_1P_{10})	10.94	12.01
T_{11} (D_1P_{11})	10.13	10.46
T_{12} (D_1P_{12})	10.03	10.26
T_{13} (D_2P_1)	9.33	8.85
T_{14} (D_2P_2)	9.43	9.04
T_{15} (D_2P_3)	9.53	9.24
T_{16} (D_2P_4)	9.09	8.26
T_{17} (D_2P_5)	9.18	8.44
T_{18} (D_2P_6)	9.27	8.65
T_{19} (D_2P_7)	9.85	9.84
T_{20} (D_2P_8)	9.93	10.05
T_{21} (D_2P_9)	9.63	9.45
T_{22} (D_2P_{10})	9.75	9.62
T_{23} (D_2P_{11})	8.98	8.04
T_{24} (D_2P_{12})	8.89	7.88
T_{25} (D_3P_1)	8.27	6.46
T_{26} (D_3P_2)	8.37	6.63
T_{27} (D_3P_3)	8.47	6.87
T_{28} (D_3P_4)	7.98	5.85
T_{29} (D_3P_5)	8.09	6.07
T_{30} (D_3P_6)	8.17	6.27
T_{31} (D_3P_7)	8.69	7.47
T_{32} (D_3P_8)	8.78	7.67
T_{33} (D_3P_9)	8.54	7.07
T_{34} (D_3P_{10})	8.59	7.25
T_{35} (D_3P_{11})	7.89	5.65
T_{36} (D_3P_{12})	7.77	5.43
SEm (±)	0.014	0.017
CD (P≤0.05)	0.040	NS

Table 5 Effect of seed storage duration and pre-sowing treatments on number of leaves and seedling vigour index of karonda

Treatment	Number of leaves	Seedling vigour index
D_1 (0 days of seed extraction)	7.71	1411.72
D_2 (30 days of seed extraction)	6.97	879.66
D_3 (60 days of seed extraction)	6.18	440.70
SEm (±)	0.004	0.359
CD (P≤0.05)	0.012	1.015
P_1 (GA_3 25 ppm)	6.91	883.13
P_2 (GA_3 50 ppm)	7.00	921.33
P_3 (GA_3 100 ppm)	7.05	963.05
P_4 (NAA 25 ppm)	6.72	771.82
P_5 (NAA 50 ppm)	6.77	806.88
P_6 (NAA 100 ppm)	6.85	841.96
P_7 (KNO_3 0.5%)	7.24	1101.40
P_8 (KNO_3 1%)	7.33	1148.49
P_9 (KH_2PO_4 0.5%)	7.13	1008.06
P_{10} (KH_2PO_4 1%)	7.19	1048.57
P_{11} (Water soaking)	6.67	732.82
P_{12} (Control)	6.61	700.83
SEm (±)	0.008	0.718
CD (P≤0.05)	0.024	2.031

Data revealed that T_8 gave the maximum (1705.45) seedling vigour index followed by T_7 (1644.04) whereas the lowest result was found in T_{36} (272.07).

Deepika and Yadav (2014) reported the days taken for initiation and completion of germination were 9.28 – 15.45 DAS and 23.67 - 31.33 DAS respectively. It was little different with the present investigation. This could be attributed to the seed deterioration during storage, leading to reduction in vigour, germination rate, enzymatic activity, respiration, increase in permeability and susceptibility in stresses, decrease in seedling growth rate, reproductive processes and yield as reported by Verma *et al*. (2003). Oxidative enzymes are essential for conversion of stored food reserves in seed into simpler substances and for translocation of these simpler substances into the embryo for emergence of radical and plumule and thereby promoting the rapid germination. These results were also in accordance with Yalleshkumar *et al*. (2007) in mango and Abbas *et al*. (2003) in jamun. The highest germination percentage of fresh seeds might be due to the presence of moisture and absence of dormancy, even a small decrease in moisture content will lead to a decrease significantly in seed germination (Pangou *et al*. 2011). Various internal as well as external factors affect the viability of the seeds during storage. Aging is a natural, irreversible phenomenon which affects viability

Table 6 Effect of seed storage duration and pre-sowing treatments on number of leaves and seedling vigour index of karonda

Treatment	Number of leaves	Seedling vigour index
T_1 (D_1P_1)	7.67	1377.59
T_2 (D_1P_2)	7.76	1425.42
T_3 (D_1P_3)	7.79	1469.43
T_4 (D_1P_4)	7.51	1243.45
T_5 (D_1P_5)	7.55	1276.46
T_6 (D_1P_6)	7.62	1322.05
T_7 (D_1P_7)	7.94	1644.04
T_8 (D_1P_8)	8.05	1705.45
T_9 (D_1P_9)	7.86	1527.10
T_{10} (D_1P_{10})	7.89	1580.87
T_{11} (D_1P_{11})	7.47	1195.67
T_{12} (D_1P_{12})	7.41	1173.10
T_{13} (D_2P_1)	6.93	849.79
T_{14} (D_2P_2)	7.01	887.42
T_{15} (D_2P_3)	7.10	937.85
T_{16} (D_2P_4)	6.72	733.44
T_{17} (D_2P_5)	6.74	787.23
T_{18} (D_2P_6)	6.84	808.94
T_{19} (D_2P_7)	7.29	1071.68
T_{20} (D_2P_8)	7.38	1117.20
T_{21} (D_2P_9)	7.16	981.49
T_{22} (D_2P_{10})	7.24	1024.14
T_{23} (D_2P_{11})	6.67	699.45
T_{24} (D_2P_{12})	6.60	657.31
T_{25} (D_3P_1)	6.14	422.01
T_{26} (D_3P_2)	6.21	451.15
T_{27} (D_3P_3)	6.27	481.88
T_{28} (D_3P_4)	5.94	338.57
T_{29} (D_3P_5)	6.02	356.94
T_{30} (D_3P_6)	6.07	394.89
T_{31} (D_3P_7)	6.49	588.48
T_{32} (D_3P_8)	6.56	622.81
T_{33} (D_3P_9)	6.35	515.60
T_{34} (D_3P_{10})	6.43	540.71
T_{35} (D_3P_{11})	5.86	303.31
T_{36} (D_3P_{12})	5.82	272.07
SEm (±)	0.015	1.244
CD (P≤0.05)	0.041	3.518

and vigour of stored seeds. Under hot, dry conditions, seeds lose viability rapidly as a result of water loss from the endosperm. The decline in per cent germination with advance in storage period might be attributed to the phenomenon of aging, depletion of food reserves, decline in synthetic activity (Nair 1966), cytoplasmic or physiological changes in subcellular system (membrane, mitochondria, protein synthesis, ribosomes and DNA) and enzyme machinery during storage with preceding age of the seed resulting in slow germination rate of embryo, which intended to continue its ontogenetic effect on the developing seedling (Heydecker 1972, Chauhan *et al*. 1984). Freshly harvested seeds showed maximum plant height which might be due to a higher germination capacity of the fresh seed, which resulted in normal seedlings with longer shoot. A trend of decrease in plant height was observed with delay in sowing of seeds after extraction. Aging decreased plant height. This might be due to decreased mobilization of reserve substances during germination of the stored seeds (Dhakal and Pandey 2001). This decreased trait by aging might cause loss of membrane integrity due to lipid peroxidation which causes loss in vigour of seedlings (Eisvand *et al*. 2010). Priya and Rao (2008) reported that gradual increase of the storage period resulted in the gradual decline in number of leaves. This might be due to decreased mobilization of reserve substances during germination of the stored seeds. The superior root growth of freshly harvested seeds could indicate that they have better initial nutrient reserves (proteins, lipids and starch) which, through storage under adverse conditions, were gradually depleted in the older seed lots as reported by Kalsa *et al*. (2011). Earlier reports have shown that storage under adverse conditions could cause depletion of important nutrient reserves (Murthy *et al*. 2003). The vigour index was maximum in seeds sown at zero days of extraction i.e. freshly harvested seeds and it decreased during prolonged storage period. The rapid depletion of the carbohydrates and protein reserves in the seeds might be responsible for the loss in vigour. The decline in seedling vigour index after 9 months of seed storage was also reported by Dhakal and Pandey (2001) in Niger. This might be due to decreased mobilization of reserve substances during germination of the stored seeds (Shrivastava and Knoor 1974). Vigour index indicated that, freshly harvested seeds were more vigorous at all durations of storage, than the remaining seed lots (Kalsa *et al*. 2011). Murthy *et al*. (2003) reported a decline in vigour of *Vigna radiata* (L.) Wilczek as the seed-storage period increased from zero to several days. These authors indicated that loss of seed vigour was associated with biochemical deterioration during seed ageing. Seed age during storage and eventually lose their viability or germinability. The decrease in physiological quality (emergence, rate of emergence, vigour, seedling growth rate) traits by aging may cause loss of membrane integrity due to lipid peroxidation (Eisvand *et al*. 2010). Decrease in the activity of enzyme system during storage of seed cause decline of seed vigour. The superiority in germination of KNO_3 seed was related to more nitrogen and potassium accumulation in seeds. The increase in germination might be due to the activity of α-amylase. Amylases are key enzymes that play a vital role in hydrolyzing the seed starch reserve, thereby supplying sugars to the developing embryo (Banik *et al*. 2015). Overall, for most traits under study, seeds primed with KNO_3 showed better germination parameters than those primed with distilled water (Ghobadi *et al*. 2012). One reason for the positive effect of chemical stimulators such as KNO_3 on seed germination is related to creating a balance between hormonal ratios in seed and reducing the growth preventable materials, like ABA (Ali *et al*. 2010).

From the above experiments it can be concluded that, using of freshly harvested seeds (D_1) improved the overall germination process instead of storing them for longer periods. Among different pre-sowing treatments, KNO_3 1% (P_8) proved best in terms of highest germination percentage, seedling vigour index, number of leaves and other growth parameters along with least time taken for germination. Besides, among interaction effect between different storage duration and pre-sowing treatments, T_8 (D_1P_8) was superior in the overall germination process of Karonda than rest of the treatments. Hence freshly extracted seeds treated with Potassium nitrate 1% may be recommended for this region for better germination of Karonda.

ACKNOWLEDGEMENT

The work was supported by Department of Fruits and Orchard management, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, West Bengal.

REFERENCES

Abbas M, Khan M M, Iqbal M J and Fatima B. 2003. Studies on Jaman (*Syzygium cuminii* L. Skeels) seed storage behaviour. *Pakistan Journal of Agricultural Sciences* **40**: 164–69.

Abdul-baki A and Anderson J D. 1973. Vigour determination in soybean seed by multiple criteria. *Crop Science* **13**: 630–33.

Ali T, Hossein P, Asghar F, Salman Z and Ali Z C M. 2010. The effect of different treatments on improving seed germination characteristics in medicinal species of *Descurainia sophia* and *Plantago ovate*. *African Journal of Biotechnology* **9**(39): 6588–93.

Banik B C, Dey A N, Pradhan S, Thapa N and Bhowmick N. 2015. Seed germination of karonda (*Carissa carandas* L.). *Acta Horticulturae* **1074**: 23–26.

Chauhan K P S, Negi H C S and Verma M M. 1984. The effect of thiram treatment on the incidence of ageing induced changes in seed. *Seed Research* **12**: 110–19.

Deepika V and Yadav A. 2014. Effect of seed storage on seed viability, germinability and morphological characteristics of Karonda (*Carissa carandas*) seedlings. *Asian Journal of Advanced Basic Sciences* **2**(3): 1–6.

Dey K, Ghosh A, Dey A N, Bhowmick N and Bauri F K. 2016. Studies on seed germination and seedling behaviour of Indian hog-plum (*Spondias pinnata*) in response to different pre-sowing treatments. *Seed Science and Technology* **44**(3): 1–5.

Dhakal M R and Pandey A K. 2001. Storage potential of Niger (*Guizotia abyssinica*) seeds under ambient conditions. *Seed Science and Technology* **29**: 205–13.

Eisvand H R, Alizadeh M A and Fekri A. 2010. How hormonal

priming of aged and non aged seeds of Bromegrass affects seedling physiological characters. *Journal of New Seeds* **11**: 52–64.

Ghobadi M, Shafiei-Abnavi M, Jalali-Honarmand S, Mohammad-Eghbaland G and Gholam-Reza M. 2012. Does KNO_3 and hydro priming improve wheat (*Triticum aestivum* L.) seeds germination and seedlings growth? *Annals of Biological Research* **3**(7): 3156–60.

Ghosh S N, Manna S and Mathew B. 2003. Effect of pre-sowing seed treatments on germination, seedling growth and viability of Custard Apple (*Annona squamosa*) seeds. *Environment and Ecology* **21**(1): 4–7.

Ghosh S N and Sen S K. 1988. Effect of seed treatment on germination, seedling growth and longevity of Ber (*Ziziphus mauritiana* Lank.) seeds. *South Indian Horticulture* **36**(5): 260–61.

Gomez K A and Gomez A A. 1983. Problem data. *(In) Statistical Procedures for Agricultural Research* (2nd edition), Wiley-Inter Science Publication (John Wiley and Sons), New York, USA, pp. 275–315.

Hasmah S N, Bhatt A and Keng L C. 2013. Micropropagation of Asam Karanda (*Carissa carandas* Linn.). *Pertanika Journal of Tropical Agricultural Science* **36**: 89–98.

Heydecker W. 1972. *Vigour in viability of seeds*. E.H. Roberts (Ed.). Chapman Hall, London.

Kalsa K K, Tomer R P S and Abebie B. 2011. Effects of storage duration and hydro-priming on seed germination and vigour of common vetch. *Journal of Science and Development* **1**(1): 65–73.

Murthy U M N, Kumar P P and Sun W Q. 2003. Mechanisms of seed ageing under different storage conditions for *Vigna radiata* (L.) Wilczek: lipid peroxidation, sugar hydrolysis, maillard reactions and their relationship to glass transition. *Journal of Experimental Botany* **54**: 1057–67.

Nair C V. 1966. Effect of provenance on seed quality and halogenations treatment to control seed deterioration. M.Sc. Thesis, Tamil Nadu Agricultural University, Coimbatore.

Pangou V S, Zoysa D N, Maury G, Massanga A and Yoka P F M C. 2011. Seed storage behaviour of some indigenous values tropical trees species from Congo (Africa). *International Research Journal of Agricultural Science and Soil Science* **1**(8): 307–13.

Priya S V and Rao J V S. 2008. Effect of storage period in seed and seedling vigour of *Entada pursaetha* an endangered gigantic medicinal liana. *Seed Science and Technology* **36**: 475–80.

Rahmatullah M, Noman A, Hossan M S, Harun-Or-Rashid M, Rahman T, Chowdhury M H and Jahan R. 2009. A survey of medicinal plants in two areas of Dinajpur District, Bangladesh including plants which can be used as functional foods. *American-Eurasian Journal of Sustainable Agriculture* **3**: 862–76.

Shrivastava A and Kooner N K. 1974. Effect of osmotic potential on the mobilization of nitrogenous substances in the germinating seeds of *Phaseolus aureus*. *Indian Journal of Experimental Biology* **12**: 278–81.

Singh G and Gill S S. 1994. Evaluation of soybean genotypes of seed storability. *Seed Research*. **22**: 137–40.

Verma S S, Verma U and Tomer R P S. 2003. Studies on seed quality parameters in deteriorating seeds in Brassica (*Brassica campestris*). *Seed Science and Technology* **31**: 389–96.

Yelleshkumar H S, Swamy G S K, Kanamadi V C, Patil C P, Kumar P and Athani S I. 2007. Studies on viability of mango stones and its effect on germination and rootstock vigour. *Journal of Asian Horticulture* **3**(3): 205–7.