

Seed Longevity of Carrot (*Daucus carota* L.) as Affected by Different Temperatures and Containers during Storage

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ABSTRACT: Seeds of carrot (*Daucus carota* L.) cv. Punjab Carrot Red were stored at three different temperatures (ambient, cold room and refrigerator) in four different packaging materials (cloth bag, plastic bag 700 gauge, desiccator with silica gel and desiccator with drying beads) for 12 months. The longevity and viability of the stored seeds was tested by determining per cent germination, moisture content per cent (MC), vigour index I, vigour index II and speed of germination. Seeds stored at cold room temperature (~15°C) maintained the Indian Minimum Seed Certification Standards (IMSCS) after 12 months of storage period when packed at MC 5.56±1% and 5.64±1% in desiccator containing desiccants (drying beads and silica gel) respectively. It was at par with that kept in refrigerator (~5.9°C) when kept in desiccator containing drying beads and silica gel at MC of 5.56±1% and 5.87±1% respectively. Under ambient temperature conditions, cloth bag maintained the IMSCS after 12 month of storage with 6.7±1% of moisture content.

Keywords: Carrot, Packaging materials, Seed longevity, Seed quality, Storage temperature

INTRODUCTION

Seed deterioration is the alterations occurring with storage time that increase the seeds exposure to external challenges and decreases the ability of the seed to survive. Storability of seeds is influenced by quality of the seed at the time of storage, pre-storage history of seed, moisture content of seed, relative humidity, temperature of storage environment, duration of storage and biotic factors [1-2]. Seed moisture content and storage conditions are the important factors to control for ensuring safe seed storage. The seed storage environment highly influences the period of seed survival. The deteriorative reactions take place in the seed more readily when moisture content is higher and thus it imposes a threat to survival and longevity [3-4]. As investigated by Lin [5] in cucumber, seeds with initial moisture content was stored at 70% relative humidity and 20°C for up to 12 months and germination percentage remained high throughout the storage

period, while vigour decreased. Seeds stored at high moisture content exhibit increased respiration, heating and fungal invasion resulting in reduced seed vigour and viability. Thus moisture content of seed during storage is the most significant factor affecting the longevity. Seed deterioration causes loss of seed quality with time. As the seed germinability decreases, the speed of germination also decreases causing loss of vigour and seeds become less viable sometimes resulting in loss of seed quality. Thus the process of seed deterioration could be associated with progressive decrease in germinability, increased mean time of germination, increase in the number of abnormal seedlings and lower tolerance to adverse storage conditions [6]. Low quality of seeds can potentially decrease the rate and percentage of germination and seedling emergence, leading to poor stand establishment in the field and consequently yield loss in many crops. Carrot

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seeds can be stored at low moisture and low temperature for few years, but difficult for long-term storage [7]. However, availability of an adequate supply of high quality seed is essential for a successful seed production programme and the maintenance of a viable and productive agriculture [8]. Keeping this in view, an experiment was conducted during 2015 and 2016 at Seed Technology Centre, Punjab Agricultural University Ludhiana to evaluate and determine seed longevity of carrot (*Daucus carota* L.) seed using different temperature regimes and containers.

MATERIAL AND METHODS

The foundation seeds of carrot (*Daucus carota* L.) cv. Punjab Carrot Red, harvested during May 2015 were used for the experiment. The seeds were packed in different packaging materials and then stored for 12 months under different temperature regimes from 15th June 2015 to 15th June 2016. The different packaging materials were cloth bag, 700 gauge plastic bag, desiccator with silica gel and desiccator with drying beads. The different storage conditions were ambient (~29.4°C), cold storage (~15°C) and refrigerator (~5.9°C). Samples were drawn bimonthly from respective containers kept at different temperatures and observations with respect to physiological seed quality parameters were conducted. Initial seed quality status was tested with respect to germination, moisture content, vigour index I, vigour index II and speed of germination. The extent and evaluation of seed longevity was determined for each treatment using the following laboratory tests:

The germination was tested with "Between the Paper" method as per Rules of International Seed Testing Association [9] in triplicate of 100 seeds each at 25±1°C in a germinator. The carrot seeds were sown between two layers of moistened rolled germination paper which were then wrapped in wax paper to retain its moisture and put into transparent polyethylene bags. The bags were kept in a germinator in an upright position. After final count day i.e. after fourteen days, germination per cent was computed as the percentage of normal seedlings. The seed moisture content was determined as per methods

of ISTA [9]. One gram (fresh weight) of the seeds of each treatment was kept in an oven at 130°C ± 5°C for 1 hour. The seeds were removed from the oven and cooled over CaCl₂ in a desiccator. The dry weights of the seeds were recorded and moisture content was determined. For determining seedling dry weight, 10 normal seedlings, selected at random, were dried at 110°C for 17h and weighed. Vigour index I and Vigour index II were computed as per formulae suggested by Abdul-Baki and Anderson [10]. Speed of germination was computed using "Top of Paper" method in three replicates in tight fitting Petri dishes, using 50 seeds each. Daily observations of emerged seedlings were recorded till the final count day. The speed of germination was calculated as suggested by Maguire [11].

RESULTS AND DISCUSSION

Seed germination data (Table 1 and Figs. 1-4) revealed that after 12 month, seeds stored in desiccator with drying beads with relative humidity (RH) of 56.76±5% showed highest per cent germination 69.3% and was at par with that kept in desiccator with silica gel with per cent germination of 68.3%. After 12 month of storage period the least germination per cent was observed in polythene bag (48.67%) at RH of 37.2±5% and with MC of 6.72±1%. The initial germination per cent, moisture content, vigour index I, Vigour Index II and speed of germination was regarded as control (Table 1). It was observed that the seeds in the cold room temperature (~15°C) at RH (56.76±5%) showed the best results. Germination per cent of seeds which were kept in refrigerator (~5.9°C) were at par with that of the cold room. Elias and Copeland [12] studied the effect of temperature in lettuce seeds and stated that lowering storage temperature progressively increased longevity. First count of germination per cent (after 7 days) also revealed the same trend.

Table 1: Initial seed quality of carrot seed before storage

Germination%	Moisture content % (MC)	Vigour index I	Vigour index II	Speed of Germination
78.0	6.90	805.74	0.936	16.73

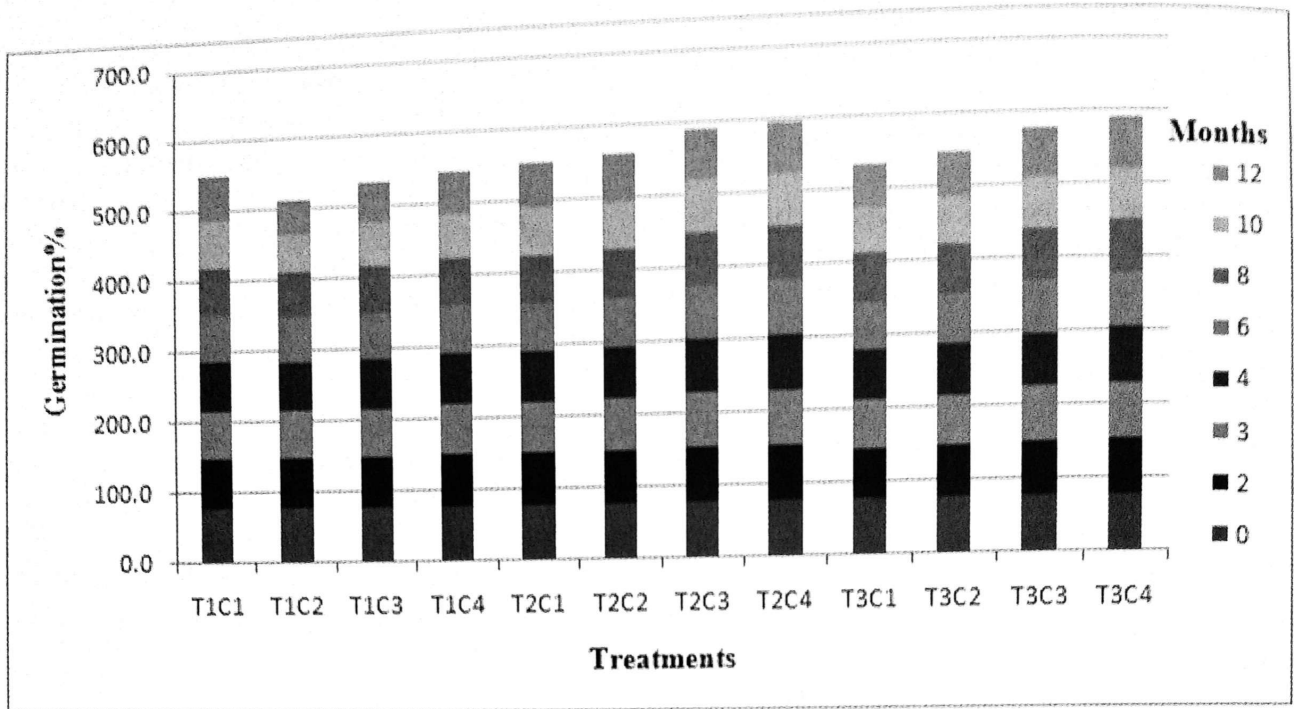


Fig. 1: Effect of temperature and containers on germination per cent of carrot seed during 12 month of storage. T1= ambient temperature, T2= cold room temperature, T3= refrigerator temperature, C1= cloth bag, C2= plastic bag, C3= desiccator with silica gel, C4= desiccator with drying beads

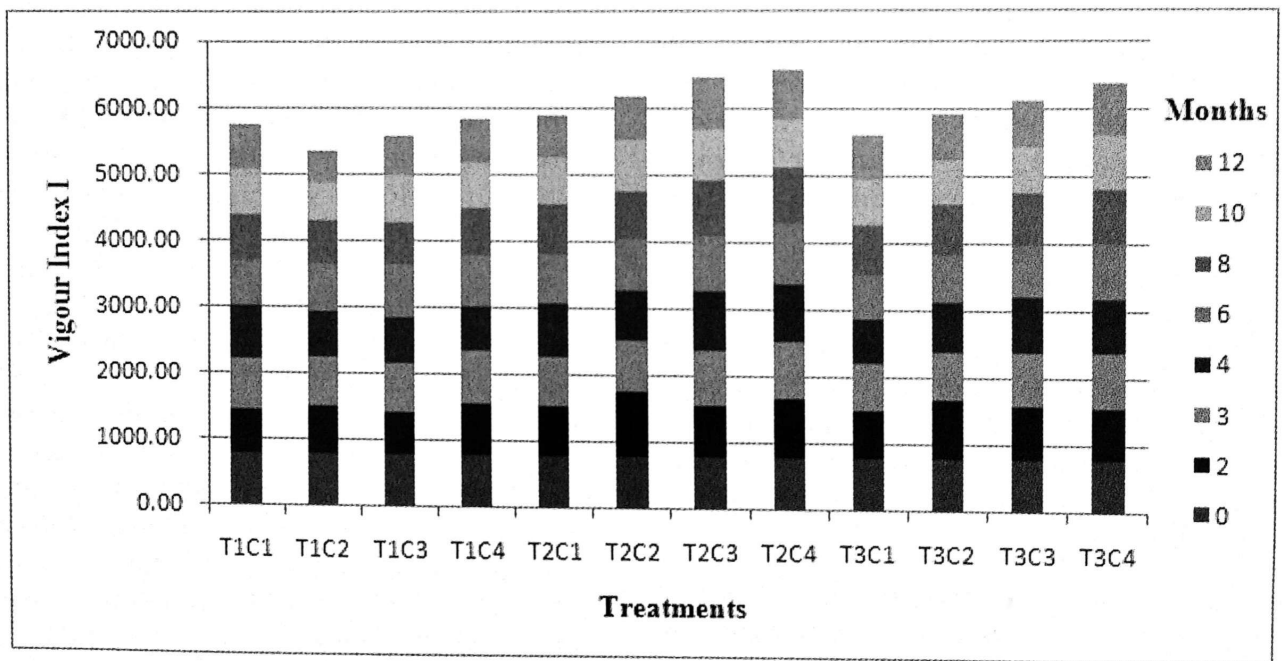


Fig. 2: Effect of temperature and containers on vigour index I of carrot seed during 12 month of storage. T1= ambient temperature, T2= cold room temperature, T3= refrigerator temperature, C1= cloth bag, C2= plastic bag, C3= desiccator with silica gel, C4= desiccator with drying beads

Seeds kept in desiccator with drying beads and silica gel at the cold room temperature having moisture content (MC) of $5.56 \pm 1\%$ with relative humidity (RH) of $56.76 \pm 5\%$ maintained the IMSCS up to 12 months with maximum per cent germination (69.3% and 68.3%) respectively.

Moreover, it was also founded that when these desiccants were kept at refrigerator, at par results were obtained with cold room. Findings of Shelar *et al.* [13] were similar to our results. In his study the onion seeds were dried to 5 per cent moisture content and stored in cloth bags, plastic bag and

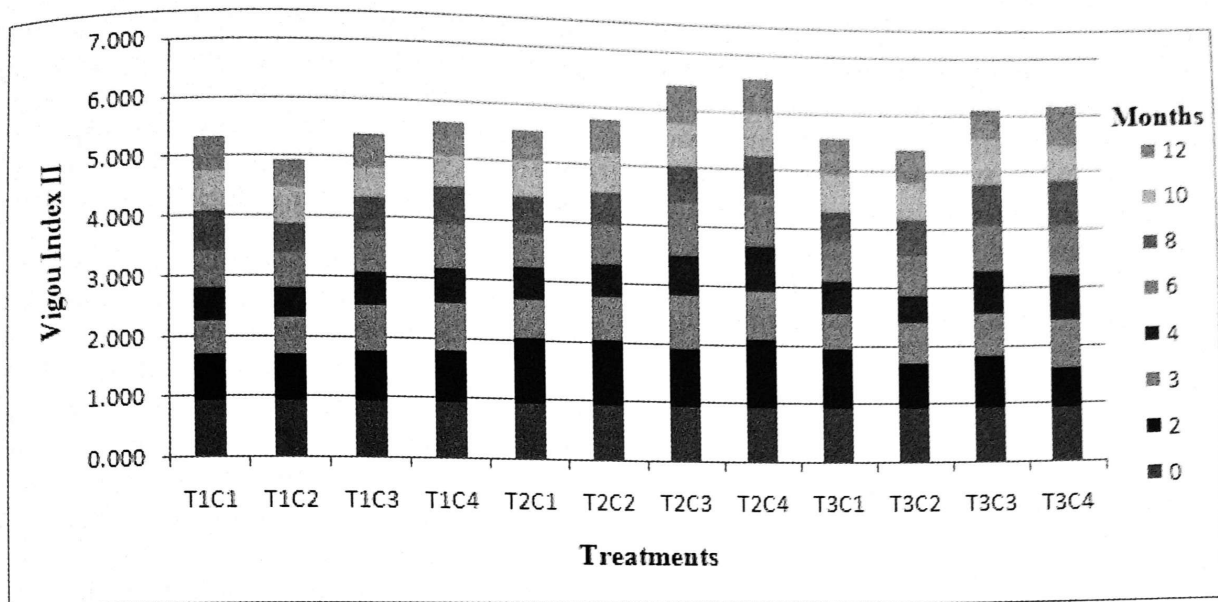


Fig. 3: Effect of temperature and containers on vigour index II of carrot seed during 12 month of storage. T1= ambient temperature, T2= cold room temperature, T3= refrigerator temperature, C1= cloth bag, C2= plastic bag, C3= desiccator with silica gel, C4= desiccator with drying beads

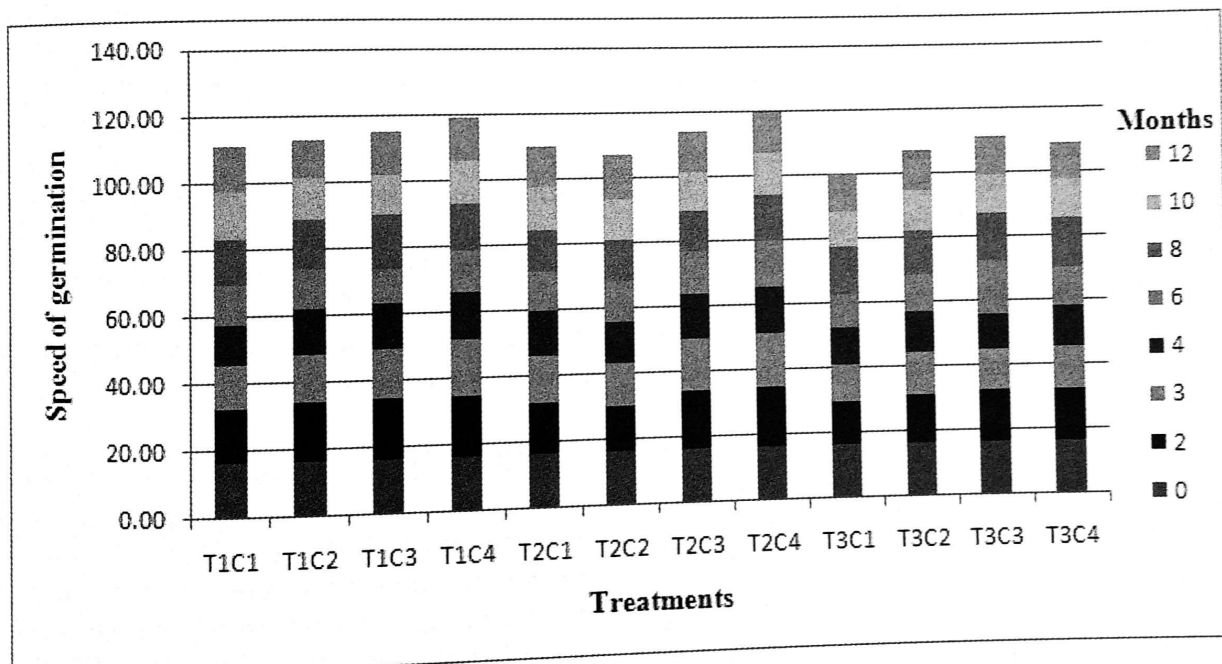


Fig. 4: Effect of temperature and containers on speed of germination of carrot seed during 12 month of storage. T1= ambient temperature, T2= cold room temperature, T3= refrigerator temperature, C1= cloth bag, C2= plastic bag, C3= desiccator with silica gel, C4= desiccator with drying beads

aluminium foil bags. In plastic and aluminium foil bags the seeds survived for a longer duration than that in cloth bags. Thus in the present study it is founded that temperature and packagings has a greater influence on seed deterioration. It was also observed that after 12 months of storage, in the cloth bag kept at ambient temperature at

RH of $30.36 \pm 5\%$ with MC of $6.7 \pm 1\%$, the seeds maintained the IMSCS. Toole [14] observed in his study that most crop seeds lose their viability at relative humidity approaching 80% and temperatures of 25°C to 30°C but can be stored for longer duration at relative humidity of 50% or less and a temperature of 5°C lower.

Seed moisture content is the important factor which affects the viability of seed. In the present study initial seed moisture was 6.90%. The cloth bag which was kept in cold storage and refrigerator showed maximum moisture content, 7.32 and 8.00 respectively after 12 month of storage. It was observed that moisture impervious containers (Desiccator with drying beads and silica gel) showed the maximum seed germination and vigour as compared to the plastic bag and cloth bag. This was because low moisture content is beneficial for the storage of the seeds of most agricultural crops. More moisture allows them to respire, subsequently shortening their storage life, causes spoilage through extraneous water and also by the metabolic water produced in respiration. The hygroscopic nature of seeds is associated with high moisture content leading to decline in germinability [15].

Vigour is the first component of seed quality, which is lost, followed by a loss of germination capacity and viability. It was observed that vigour index I decrease significantly with increase in storage period. Desiccator with silica gel showed maximum value of vigour index-I (771.79) followed by desiccator with drying beads (751.30), while the plastic bag packaging showed the minimum value (487.00) after 12 month of storage period and data revealed that desiccator with silica gel and drying beads was having maximum vigour index-II (0.683), whereas the minimum value was observed in plastic bag (0.438). Vigour index-II was observed to decreasing with the passage of time. Moreover, it was also obtained that the maximum value of vigour index-I and vigour index-II was in the cold room temperature ($\sim 15^{\circ}\text{C}$) i.e. 771.79 and 0.683 respectively after 12 month of storage. The refrigerator temperature was at par with that of cold room. Vigour index-I is shown by figure 2. Similarly, in combination of temperature and packaging the maximum value of vigour index-I and vigour index-II was obtained in desiccator with silica gel kept at cold room temperature i.e. 771.79 and 0.683 respectively. Figure 3 shows data on vigour index-II. The minimum value of vigour index-I and vigour index-II was found in plastic bag kept at ambient temperature after 12 month of storage period. Basu *et al* [16] in his study revealed that

the vigour index-I and vigour index-II decreased as the quality of seed became poor due to duration of storage period in maize. Similar findings were obtained in the rapeseed and mustard were seedling vigour decreased with increased age of seeds during storage [17].

Speed of germination is one of the best methods for determining seed vigour. Seed lots with similar total germination per cent often vary in their rate of germination and growth. Higher speed of germination implies quicker and more uniform germination. Present study indicated that speed of germination decreased with the chronological age. Seeds stored in cloth bag kept at ambient temperature showed the highest speed of germination (13.92). However, the minimum speed of germination after 12 month of storage period was observed in plastic bag packaging placed at ambient temperature (11.40). Effect of various packagings was prominent. The speed of germination was reduced with the passage of time. In a study done by Khan *et al.* [18] it was observed that accelerated ageing also decreased the germination speed of seed material. Significant differences were observed in all treatments. Germination speed of control was maximum (16.8) followed by 3, 5 and 7 days of ageing (15.2, 12.15 & 10.12, respectively). Results demonstrated that ageing slowed down the process of germination.

CONCLUSION

Based upon the results of current study, it was inferred that if the carrot seeds are kept at refrigerator and cold room in the packaging of desiccator with drying beads and silica gel at RH of $56.76 \pm 5\%$ and $30.36 \pm 5\%$ with MC of $5.5 \pm 1\%$ to $5.8 \pm 1\%$ respectively, the seeds can be stored safely for one year. Further it was also concluded that, under ambient temperature conditions at RH of $37.2 \pm 5\%$ with MC of $6.7 \pm 1\%$, the carrot seeds can be stored for 12 months if kept in cloth bag packaging. The results thus emphasize the importance of storage temperature, moisture content of the seeds, relative humidity, packaging material and storage period on the quality and longevity of carrot seeds.

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