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Impact of different storage containers on seed quality parameters of eggplant (*Solanum melongena*) during storage

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ABSTRACT

The present study was carried out at Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana to assess the impact of natural ageing and different storage containers on eggplant (*Solanum melongena* L.) seed quality during the 2020–21 and 2021–22 winter (*rabi)* seasons. Genetically pure seeds were used and stored in cloth and polythene bags. Seed quality parameters (germination, seedling length, seedling dry weight, and seed vigour) were monitored at various intervals (0, 3, 6, 9, 12, 15, 18 months). Freshly harvested seeds (control) exhibited superior quality, with higher germination rates, longer seedlings, greater seedling dry weight, and improved vigour indices compared to stored seeds over 18 months. Seed quality deteriorated with longer storage, reaching its lowest point at 18 months. Among storage containers, cloth bags showed a faster decline in seed quality compared to polythene bags (>700 gauge). In field experiments, one-year stored seeds from polythene bags outperformed those from cloth bags in terms of seed establishment percentage, mean emergence time, and germination speed. In conclusion, polythene bags maintained acceptable seed germination (meeting IMSCS standards) for up to 15 months, while cloth bags maintained it for up to 12 months. Therefore, polythene bags are a better choice for preserving eggplant seed quality during storage, particularly for longer durations.

Keywords: Germination percentage, Seed, Storage container, Vigour index

Eggplant (*Solanum melongena* L.) is a vital vegetable crop in India, contributing 9% of the nation's total vegetable production. While it thrives in tropical regions, it's primarily grown during the warm season in temperate areas. Asia, China, India, and Turkey are the main producers, accounting for 53, 28, and 4% of global production, respectively (Daunay *et al.* 2001). Eggplant's popularity has risen due to its appealing fruit characteristics, but its productivity remains relatively low.

Seed quality is crucial for successful crop production, encompassing germination capacity, seedling vigour, and overall plant performance (Bewley and Black 2020). Seed quality naturally degrades over time, resulting in reduced germination rates, weaker seedlings, and lower crop yields (Smith *et al.* 2017, Sunil *et al.* 2021). Practices like organic farming, integrated nutrition management, and high-quality hybrid seeds are essential to maintain productivity. Seed ageing, associated with irreversible quality degradation, is a significant concern (Kumar 2012). Prolonged seed storage leads to deterioration, diminishing both vigour and viability (Bordolui *et al.* 2015).

Proper storage containers are crucial to preserve seed quality, alongside natural ageing. Different containers vary in their ability to maintain optimal storage conditions, such as temperature, humidity, and air circulation. Inadequate storage can worsen seed deterioration (Teixeira *et al.* 2018). During storage, factors like storage pests and microflora lead to a decline in viability and vigour, with insects and fungi causing significant damage, resulting in seed degeneration and loss of storage capacity (Kumar *et al.* 2008). Seed deterioration during storage involves complex physiological and biochemical changes that reduce germination potential.

Appropriate packaging materials, like moisture-resistant containers, play a crucial role in extending seed storability by preventing moisture exchange with the surrounding air. Employing suitable storage containers and durations effectively mitigates seed deterioration, ensuring favourable germination and robust seedling growth (Rao *et al.* 2006, Chakraborty *et al.* 2020). Airtight containers like polythene bags and gunny bags lined with polythene, with or without

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a desiccant, are effective options for maintaining seed quality over time (Vijayalakshmi and Malabasari 2018). The experiment was carried out with the objective of studying the impact of different storage containers on seed quality parameters of eggplant during storage.

MATERIALS AND METHODS

The present study was carried out at the laboratory and experimental area of Department of Seed Science and Technology, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana to assess the effect of natural ageing and various storage containers on seed quality parameters of eggplant during 2020–21 and 2021–22.

Seeds of eggplant (H-8) having germination per cent more than 70% which is minimum limit of germination per cent according to Indian Minimum Seed Certification Standard (IMSCS) were collected from the Department of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar. Two containers, viz. cloth bag (C_1) and >700-gauge polythene bags (C_2) were used. Seeds were stored in these containers in ambient conditions (Supplementary Table 1).

Observations were recorded on seed quality parameters including seed germination (%), seedling length (cm), seedling dry weight (mg), vigour index-I and vigour index-II. The standard germination test, seedling length test, and vigour index assessment were carried out following established protocols. The obtained results were subjected to statistical analysis (Table 1 and 2). A factorial Randomized Block Design was employed, wherein one hundred seeds of each crop stored in polythene and cloth bag containers were sown. Field observations were meticulously recorded to ascertain the impact of different storage containers on seed performance. The acquired data was then subjected to statistical analysis (Table 3). Data analysis was done with help of OPSTAT software (Sheoran *et al.* 1998).

Standard germination (%): In three replicates, one hundred seeds of both crop seeds were placed in between sufficiently moistened rolled germination papers (BP) separately and kept at 25ºC in seed germinator. The first count was taken on the 7^{th} day and the final count on the 14^{th} day. Only normal seedlings were considered to calculate total germination per cent (ISTA 2003).

Seedling length (cm): At the time of the final count, 10 normal seedlings were selected at random from each replication and their length was measured in centimeters. These seedlings' average length was calculated.

Seedling dry weight (mg): Ten normal seedlings which were used for the measurement of seedling length were also used for seedling dry weight measurement. Seedlings were dried in a hot air oven at 80°C for 48 h, removed from the oven, and allowed to cool in desiccators for 30 min before weighing on an electronic balance. The average weight of dried seedlings from each replication was calculated and expressed in milligrams.

Seed vigour indices: Seedling vigour indices were calculated by using the formula suggested by Abdul-Baki and Anderson (1973) as follows:

Vigour index-I = Standard germination (%) × Average seedling length (cm)

Vigour index-II = Standard germination (%) × Average seedling dry weight (mg)

Seedling emergence index (SEI): In the well-prepared field, the line sowing of 100 seeds in three replications was done. The number of seedlings that emerged was counted daily up to the final seedling establishment. The seedling emergence index was calculated using a formula suggested by Maguire (1962).

Seedling emergence index (SEI) =

$$\frac{\text{No. of seedlings emerged}}{\text{Day of the first count}} + \ldots + \frac{\text{No. of seedlings emerged}}{\text{Day of final count}}$$

Seedling establishment (%): When the seedling emergence was accomplished or there was no further increase in total seedling emergence, the seedling establishment was evaluated by counting the total number of seedlings (up to 15 days).

Mean emergence time (MET): The mean emergence time was calculated for each treatment combination using the formula cited by Ellis and Roberts (1977).

$$\text{MET} = \frac{\Sigma nt}{\Sigma n}$$

Where, n, number of seeds newly germinated at the time (t); t, days from sowing; Σn, Final emergence of seedlings.

RESULTS AND DISCUSSION

This study aimed to investigate the impact of different seed storage containers on seed storability at ambient conditions. The findings of the research unveiled that moisture impermeable containers, (polythene bags with a gauge exceeding 700) exhibited superior preservation of seed viability and vigour compared to moisture-permeable containers (cloth bags) when seeds were stored at low moisture levels in ambient conditions. Significantly, the germination rate of seeds stored in polythene bags consistently outperformed seeds stored in cloth bags over the 18-month storage duration. The germination percentage of seeds stored in cloth bags consistently exceeded the minimum seed certification standards set in India for duration of up to 12 months. Conversely, seeds stored in polythene bags maintained germination percentages above the same standards for a longer period, specifically up to 15 months. Notably, seeds stored in cloth bags exhibited the most significant decline in germination percentage, decreasing from an initial value of 84.67–60.00%. These findings underscore the crucial role of selecting appropriate seed storage containers in preserving seed quality throughout the storage period. Even after nine months of storage, Baldaniya *et al.* (2018) found the same thing to be true in onion. The germination potential was maintained in the plastic bag at a level that was higher than the minimum seed certification standards required by India (70%).

Table 1 Effect of containers on seed germination per cent, seedling length (cm) and seedling dry weight (mg) of eggplant during storage

Parameters →	Germination (%)			Seedling length (cm)			Seedling dry weight (mg)		
Containers (C) → Storage period (P) ↓	Cloth bag	Polythene bag	Mean	Cloth bag	Polythene bag	Mean	Cloth bag	Polythene bag	Mean
0 month	84.67 (66.92)	84.67 (66.92)	84.67 (66.92)	13.87	13.87	13.87	26.87	26.87	26.87
3 months	82.33 (65.12)	83.00 (65.62)	82.67 (65.37)	13.57	13.73	13.65	24.20	26.35	25.28
6 months	78.33 (62.24)	80.00 (63.41)	79.17 (62.82)	12.38	13.56	12.96	22.28	25.17	23.72
9 months	74.00 (59.32)	78.33 (62.24)	76.17 (60.78)	11.37	13.14	12.26	20.77	22.77	21.77
12 months	71.33 (57.61)	77.00 (61.32)	74.17 (59.46)	10.50	12.23	11.37	18.73	20.57	19.65
15 months	67.00 (54.92)	72.33 (58.24)	69.67 (56.58)	8.67	10.30	9.48	15.63	18.97	17.30
18 months	60.00 (50.75)	64.00 (53.11)	62.00 (51.93)	6.73	8.10	7.42	13.57	17.07	15.32
Mean	73.95 (59.55)	77.05 (61.55)		11.01	12.13		20.29	22.61	
CD (P=0.5)	C=0.519, P=0.971, C×P=1.373			C=0.245, P=0.459, C×P=0.649			C=0.363, P=0.679, C×P=0.960		
SEm±	C=0.178, P=0.333, C×P=0.471			C=0.084, P=0.158, C×P=0.223			C=0.125, P=0.233, C×P=0.330		

*Values in parenthesis are angular transformed.

Similar findings were also reported by Adam *et al.* (2018) in cowpea, and Alhamdan *et al.* (2011) in four vegetable crop seeds (tomato, carrot, onion, and cucumber). Kumar *et al.* (2019) in chilli and brinjal seeds suggested that the usage of appropriate packaging material and seed treatment could help prolong the storage life of seeds.

Our investigation unveiled a notable decline in both seedling length and dried weight, attributed to the choice of storage container during the storage period. Specifically, the utilization of polythene bags exhibited a comparatively lesser reduction in seedling length (13.87–8.10 cm) in contrast to cloth bags (13.78–6.73 cm). Similarly, the polythene bag also demonstrated a less decrease in seedling dry weight (26.87–17.07 mg) to cloth bags (13.87–6.73 mg) throughout the duration of storage (Table 1). These findings distinctly emphasize the significant impact of the container type on seedling growth and survivability during storage.

The seed vigour index-I exhibited a lower reduction when stored in polythene bags (1174–486), while a higher reduction was observed in cloth bags (1174–370) throughout the storage period. Similarly, the seed vigour index-II showed a lower reduction in polythene bags (2275–1092) compared to cloth bags (2275–814) (Table 2). These results emphasize the superior performance of seeds stored in polythene bags, attributed to their moisture impervious nature. The imperviousness of polythene bags prevents the movement of moisture vapour from the surrounding environment, thereby slowing down the rate of seed deterioration. The findings of our study align with previous research highlighting the significant influence of storage containers on seed germination and vigour. Studies conducted by Doijode (2010), Barua *et al.* (2009) and Sharma *et al.* (1998) have reported similar outcomes in terms of significant variations in germination percentage, seedling length and vigour index when seeds were stored in different containers, in chilli, tomato, and brinjal seeds, respectively.

In a study on onion seeds conducted by Baldaniya *et al.* (2018), consistent with our findings, it was observed that even after nine months of storage, seeds stored in plastic bags maintained a germination percentage above the Indian minimum seed certification standard of 70%. Kartoori and Patil (2018) also investigated the effect of different storage containers on storage of onion seeds and reported that polythene bags and aluminium foil were more effective than cloth bags to retain seed quality parameters during seed storage.

Similarly, Kumar *et al.* (2014) observed that polythene bags of 700 gauge were more beneficial than paper bags for storing brinjal seeds in terms of retaining germination percentage and vigour index at the end of 12 months' storage. Quais *et al.* (2013) also reported comparable findings for radish seeds. Therefore, it could be concluded that the choice of storage container can significantly affect seed germination and vigour, with some containers proving more effective than others for particular types of seeds.

The impact of storage containers and storage duration on the speed of emergence index was assessed. Notably, freshly harvested seeds exhibited the highest field emergence index (10.467). After 12 months of storage, the seeds stored in polythene bags showed a higher field emergence

Table 2 Effect of containers on seed vigour index I and seed vigour index II of eggplant during storage

Parameters →	Seed vigour index-I			Seed vigour index-II		
Containers (C) → Storage period (P) ↓	Cloth bag	Polythene bag	Mean	Cloth bag	Polythene bag	Mean
0 month	1174	1174	1174	2275	2275	2275
3 months	1112	1151	1132	1993	2230	2111
6 months	961	1107	1034	1744	2013	1879
9 months	818	1035	927	1537	1783	1660
12 months	735	926	830	1336	1577	1457
15 months	548	677	612	1047	1372	1210
18 months	370	486	428	814	1092	953
Mean	817	936		1535	1763	
CD (P=0.5)	C=20.9, P=39.2, C×P=55.5			C=31.89, P=59.66, C×P=84.37		
SEm±	C=7.20, P=13.45, C×P=19.06			C=10.95, P=20.49, C×P=28.97		

Table 3 Effect of containers on speed of emergence index, seedling establishment and mean emergence time of eggplant during storage

	Speed of emergence index			Seedling establishment			Mean emergence time		
Containers (C) → Storage period (P) ↓	0 month	12 month	Mean	0 month	12 month	Mean	0 month	12 month	Mean
Cloth bag	10.467	7.687	9.077	78.33 (62.24)	66.33 (54.51)	72.33 (58.38)	9.592	11.343	10.467
Polythene bag	10.467	8.973	9.720	78.33 (62.24)	72.33 (58.24)	75.33 (60.24)	9.592	10.523	10.057
Mean	10.467	8.33		78.33 (62.24)	69.33 (56.38)		9.592	10.933	
CD (P=0.05)	C=0.551, P=0.551, C×P=0.779			C=1.701, P=1.701, C×P=2.406			C=0.269, P=0.269, C×P=0.381		
SEm±	C=0.156, P=0.156, C×P=0.221			C=0.514, P=0.514, C×P=0.726			C=0.076, P=0.076, C×P=0.108		

*Values in parenthesis are angular transformed.

index (7.683) compared to the seeds stored in cloth bags. The findings revealed a significant interaction between the storage container and duration, highlighting the variability in the speed of emergence index. The influence of storage containers and storage duration on seedling establishment was evaluated. The seedling establishment percentage was highest in freshly harvested seeds (78.33%), while after 12 months of storage, the polythene bag demonstrated a higher seedling establishment percentage (72.33%) compared to the cloth bag (66.33%). A significant interaction between the storage container and duration indicated variations in seedling establishment. Similar findings were also reported by Ejeta *et al.* (2018) in the field pea crop, reinforcing the consistency of the results. Effect of containers and storage period on field emergence index, seedling establishment and mean emergence time of eggplant is represented in the Table 3. The mean emergence time was increased with increase in storage period in both polythene and cloth bags. As per the result, maximum mean emergence time (95.92) was recorded in freshly harvested seeds. After 12 months of storage, the less mean emergence time (10.523) was recorded in polythene bags and more (11.343) in cloth bags. After 12 months of storage period showed significant effect on mean emergence time. Similar finding was reported in caper seeds by Pascual *et al.* (2006).

Eggplant seeds exhibit a remarkable resilience, maintaining their germination rates for up to one year, even when stored in ambient conditions using either cloth or polythene bags as storage containers. Notably, the germination rates of seeds stored in polythene bags remained consistently high for an extended duration of 15 months. While field parameters such as the speed of emergence index and seedling establishment show a decline with increasing ageing duration, the mean emergence time continues to lengthen. In comparison, seeds stored in polythene bags outperformed those stored in cloth bags in terms of field parameters.

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