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COMPARATIVE STUDY OF ONION (*Allium cepa* L.) SEED QUALITY IN RELATION TO STORAGE CONTAINERS AND DURATION

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Abstract

Onion (*Allium cepa* L.) is an essential bulbous vegetable and condiment crop known for having some of the shortest-lived seeds among common vegetable crops. These seeds quickly lose their viability after harvest unless special storage precautions are taken. An experiment was conducted to determine the effects of storage containers and durations on the quality of onion seeds at the Seed Technology Laboratory, Gazipur Agricultural University (GAU), Gazipur, Bangladesh from April to June 2024. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications, where two storage containers (plastic jar and cloth bag) and four storage periods (15, 30, 45, and 60 days) were used as treatments to assess the seed quality status of onions. The onion seeds stored in a plastic jar exhibited better germination capacity, as indicated by a high germination index, higher root and shoot lengths of the seedlings, seedling dry weight per plant, and a high vigor index. On the contrary, higher thousand seed weight, moisture content, and electrical conductivity were recorded in the cloth bag seed, indicating lower seed quality during the testing period. The moisture content, thousand seed weight, and electrical conductivity increased with the longer duration of storage. In addition, germination index, seedling root length, seedling shoot length, seedling dry weight per plant, and vigor index decreased with the increase in storage duration. The results suggested that the plastic jar maintained a better quality of onion seeds over the storage periods compared to the cloth bag.

Keywords: storage container, storage duration, seed moisture, germination, vigor index

Introduction

Onion (*Allium cepa* L.) is regarded as one of the major vegetables in the Amaryllidaceae family of bulb crops. It holds a significant place in the world because it has a high demand for its consumption and it is grown in most of the nations (Naik *et al.*, 2022). It is a biennial crop where the bulbs form during the first growing season, and during the second, the bulbs are used to make seeds (Kandil *et al.*, 2009). Globally, onions are widely valued for their unique flavor, taste, and aromatic qualities. The nutritional quantity of onions can vary depending on various factors. The demand for onions in Bangladesh is increasing due to the country's rapid population growth. However, the available land for

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cultivation is decreasing, posing a challenge to meet the increasing demand (Muhit *et al.*, 2024). Onion is grown both in Kharif and Rabi seasons in Bangladesh, which occupies 508 thousand acres of land with an average productivity of 4.94 MT/acre and the production of onion was 1738, 1803, 1994, 2269, and 2517 thousand MT/acre in 2018, 2019, 2020, 2021, and 2022, respectively in previous fiscal years in our country (BBS, 2022). Although onion production in the country has increased by almost 1.5 times from 2018 to 2022, this amount of production is not enough to meet the demand of the people of Bangladesh. For this reason, a large quantity of onions is imported every year. In 2021-22, Bangladesh imported onions, shallots, garlic, and fresh chilies, which cost 26.7 billion BDT (BBS, 2022). Even the cultivated onions are directly taken to the marketplace right after harvesting due to the country's insufficient storage facilities, which affects the market price on a seasonal basis. Operational storage is crucial for maintaining the availability of high-quality onions in the market and stabilizing prices between harvest seasons (Bukar *et al.*, 2023). Approximately 70 to 80% of onions are lost due to inadequate and suboptimal storage facilities (Bhasker *et al.*, 2020).

Seed germination and vigor are higher at physiological maturity than at other times (Tekrony & Egli, 1997). However, seeds are not planted immediately after harvesting, as they are stored for a variable duration and under variable conditions. Generally, onion seeds are stored for 6 to 8 months after harvesting; however, frequent fluctuations in temperature and Relative Humidity (RH) under hot and humid subtropical regions result in poor storage conditions (Rao *et al.*, 2006; Kumar *et al.*, 2021, Hasan *et al.*, 2024). Preserving profitable crops for future harvests is the main goal of seed storage. The two most crucial variables influencing seed lifetime are storage temperature and moisture content, with moisture level typically having a greater impact than temperature. (Patel *et al.*, 2012). Numerous researchers have found that factors such as storage temperature, relative humidity, seed moisture content, duration of storage, type of seed, and seed quality all influence the rate of decline in seed quality (Alhamdan *et al.*, 2011). Because onions are a poor storer, their seeds quickly lose their vitality. Its seeds have a limited lifespan in the environment (Doijode, 1987). Because seeds are living entities, their quality is impacted by various environmental stressors. Seed storage becomes problematic due to frequent fluctuations in temperature and moisture content (Suma *et al.*, 2013). Unfavorable storage conditions, such as high temperatures and high relative humidity, can result in significant fluctuations in seed germination rates (Sisman, 2005). The hygroscopic character of seeds, particularly in warm weather, is associated with a decline in germinability due to high moisture content during storage. This in turn is related to the relative humidity of the surrounding air at ambient conditions (Geetanjali *et al.*, 2019). The present investigation was conducted with the objective of determining the effect of the type of storage containers and storage duration on the quality of onion seeds.

Materials and Methods

Experimental site and materials

The experiment was conducted at the Seed Technology Laboratory of Gazipur Agricultural University (GAU), Gazipur, Bangladesh, from April to June 2024. Seed packets of BARI Piaz-5 were collected from the Bangladesh Agricultural Research Institute (BARI), Gazipur, and prepared with 100 g of seeds for each plastic jar and cloth bag under ambient conditions. The atmospheric conditions, especially the temperature and relative humidity of GAU during the 60-day storage periods, were 26-34^{0}C & 67-73%, respectively.

All packaging experiments were replicated three times and followed a Randomized Complete Block Design (RCBD). The packaging materials used in the experiments were collected from the local market. The following treatments consisting of Factor A: two storage containers: viz. i) plastic container, and ii) cloth bag; Factor B: four storage periods: viz. i) 15 DAS (days after storage), ii) 30 DAS, iii) 45 DAS and iv) 60 DAS; were used in the experiment.

Data collection

Seed samples were taken randomly from each storage container to test at the end of each storage period and the quality of onion seeds was assessed by germination (%), germination index, moisture content (%), thousand seed weight (g), seedling root length (cm), seedling shoot length (cm), seedling dry weight (mg), vigor index, electrical conductivity (µScm^{-1}g^{-1}) and observation of biotic factors as per the following procedures.

Germination test

Four hundred seeds of onion were tested for germination from each container for every storage period in the petri dishes. In a petri dish containing a hundred onion seeds, a germination test was conducted using between papers (BP) as the substrate method. The petri dishes were placed at room temperature for germination. Seedlings were counted on the 6th day and the 12th day, respectively, as per the ISTA rules (ISTA, 1999). Data on normal and abnormal seedlings, dead seeds, and shoot and root lengths, shoot and root dry weight were recorded from each replication. Germination percentage was calculated following Krishnasamy and Seshu (1990):

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{number of seeds tested}} \times 100$$

Germination index (GI)

The germination index (GI) was calculated as described in the Association of Official Seed Analysts (AOSA, 1983).

$$\text{Germination index (GI)} = \frac{\text{Number of germinated seed}}{\text{Days to first count}} + \frac{\text{Number of germinated seed}}{\text{Days to final count}}$$

Moisture content test

Moisture content was determined every 15 days during the storage period using the low-constant-temperature oven method (103°C, 18 hours), following the International Rules for Seed Testing (ISTA, 1999). The moisture content of the seed was determined in a wet basis following the formula:

$$MC\ (\%) = \frac{M2-M3}{M2-M1} \times 100$$

Where,

- M_1= weight of container + cover
- M_2= weight of container + cover + onion seed before drying
- M_3= weight of container + cover + onion seed after drying

Seedling vigor index I

Seedling vigor was calculated by determining the germination percentage and seedling length of the germinated seed. Firstly, data were recorded on germination up to 12 days of sowing, then root length and shoot length were measured from seedlings to calculate seed vigor index following the formula of Abdul-Baki and Anderson (1970):

Seedling vigor index I = Germination (%) × (Mean shoot length + Mean root length)

Seedling vigor index II

Ten plant samples from each pot were harvested on the 12th day of the germination test and dried at 70 °C for 72 hours to determine the dry matter yield. The dry weight of those samples was measured, and the seedling vigor index was calculated according to the formula (Jayraj and Karivaratharaju, 1992):

Seedling vigor index II = Mean germination (%) × Dry matter content per seedling

Electrical conductivity test:

A sample of 50 seeds was taken from each treatment and placed in a conical flask with 50 ml of deionized water for the electrical conductivity test. The sample was then incubated at 20°C for 24 hours, as done by Agrawal and Dadlani (1992); Ali *et al.* (2004) and Akter *et al.* (2014). To separate the seeds, the water in the beaker containing the seeds was decanted after 20 hours. Using a conductivity meter (Model CM-30ET), the electrical conductivity of the decanted water containing seed leachate was determined. For every seed sample, four repeat measurements were done.

Statistical analysis

Analysis of Variance (ANOVA) was performed using the R Studio software package, as described by Gomez and Gomez (1984). LSD at 5% was used to realize significant differences among means of variables, as mentioned by Snedecor and Cochran (1980). Graphical statistics were measured using R Studio and Microsoft Excel, version 2016.

Results and Discussion

Germination percent, moisture content percent, and other seed quality parameters were significantly influenced by the various storage containers and storage periods (Table 1 and 2). The reduction in germination potential under ambient storage conditions is likely due to higher temperature during storage, which enhance seed deterioration. Additionally, high seed moisture content reduces germination and vigor during prolonged storage (McDonald, 1999).

Table 1. Effect of storage containers and duration on seed quality parameters of onion

Treatments	Germination (%)	Germination index	Moisture content (%)	Thousand seed weight (g)
Containers				
C_1: Plastic Jar	83.58	10.45	9.01	3.79
C_2: Cloth Bag	80.16	9.25	10.87	3.92
$LSD_{0.05}$	1.78	0.65	0.03	0.13
Duration(days)				
D_1: 15	83.33	10.56	8.04	3.66
D_2: 30	82.33	9.99	9.04	3.79
D_3: 45	81.50	9.46	10.54	3.92
D_4: 60	80.33	9.36	12.17	4.07
$LSD_{0.05}$	2.52	0.91	0.05	0.02
Interactions				
C_1 x D_1	84.67	11.11	7.70	3.62
C_1 x D_2	84.00	10.64	8.83	3.73
C_1 x D_3	83.33	10.08	9.46	3.86
C_1 x D_4	82.33	9.97	10.58	3.98
C_2 x D_1	82.00	10.06	8.37	3.69
C_2 x D_2	80.67	9.35	9.74	3.84
C_2 x D_3	79.67	8.83	11.61	3.98
C_2 x D_4	78.33	8.74	13.76	4.16
Mean (C x D)	81.88	9.85	9.94	3.86
$LSD_{0.05}$	3.56	1.29	0.07	0.03
CV (%)	2.48	7.50	0.42	0.40

Effect of storage containers on seed quality parameters

Both storage containers significantly affected seed quality attributes during the storage period. Significantly higher germination percent (83.58) along with higher germination index (10.45), root length (3.11 cm), shoot length (6.93 cm), vigor indices viz., vigor index I (829.68), vigor index II (2240.88) as well as lower moisture content percent (9.01), thousand seed weight (3.79 g), electrical conductivity (34.25 $\mu Scm^{-1}g^{-1}$) were recorded in the plastic jar. The onion seeds stored in the cloth bag recorded lower germination percent (80.16), germination index (9.25), root length (2.79 cm), shoot length (6.22 cm), vigor indices viz., vigor index I (723), vigor index II (1675.56) with higher moisture content percent (10.87), thousand seed weight (3.92 g), electrical conductivity (45 μScm^{-1}g^{-1}) (Table 1 and 2). Storage containers had a significant effect on seed quality during storage. Here, seed quality in both of the containers was affected by the moisture. The respiratory activity, along with other physiological activities in seeds, is increased by an increasing level of moisture content, which decreases the stored food in seeds. Thus, seeds stored in a high relative humidity lose their viability and vigor more quickly than those stored in dry air (Gorechi, 1982 and Tithi *et al.*, 2010). The rapidly reduced germination percent in the cloth bag is attributed to its naturally moist nature. The higher moisture in the seed may be the primary reason for the rapid quality deterioration in the seeds of the cloth bag. The results are in concurrence with the earlier findings of Nagaveni (2005) and Tripathi (2014).

Effect of storage duration on seed quality parameters

Similarly, storage duration also significantly affected seed germination potential, moisture content and other quality attributes. In the case of storage duration, seeds stored for 15 days recorded the highest germination percentage (82.33%) and the lowest moisture content percentage (8.04%) compared to the other storage duration treatments. In addition with the highest germination percent, the highest germination index (10.56), seedling root length (3.32 cm), seedling shoot length (7.03 cm), vigor indices viz., vigor index I (862.62), vigor index II (2217.07) was recorded in 15 days storage duration followed by 30 days and 45 days storage duration, respectively. Along with the lowest moisture content percentage, the lowest thousand-seed weight (3.66g) and electrical conductivity (32.63 μS cm^{-1} g^{-1}) were recorded in the 15-day storage duration, followed by the 30- and 45-day storage durations, respectively. The lowest germination percent (80.33) with the germination index (9.36), seedling root length (2.60 cm), seedling shoot length (6.15 cm), vigor indices viz., vigor index I (704.33), vigor index II (1716.18) and the highest moisture content percent (12.17), thousand seed weight (4.07 g) and electrical conductivity (44.68 μS cm^{-1} g^{-1}) were observed when seeds were stored the longest duration of 60 days (Table 1 and 2). These results were similar to those reported earlier by Roberts (1972) and Patel *et al.* (2012). If the relative humidity of the storage is higher than that of the seed's moisture, then it will absorb moisture from the air, as the seed is a hygroscopic living material (Copeland and McDonald, 2001). Higher storage duration causes higher deterioration due to higher seed leachate and the main reason for its higher rate is seed moisture content, which results in reduced germination and vigor (Natubhai *et al.*, 2018).

Interaction effect of storage container and storage duration on seed quality parameters

The combined effect of storage containers and duration also significantly impacted germinability, moisture status and quality attributes of onion seeds. The seeds, packed in a plastic bag and preserved in ambient storage for up to 15 days, recorded the highest germination percentage (84.67). This plastic container maintained a higher germination potential of over 82 percent even after 60-day storage periods. The same treatment combination showed the highest germination index (11.11), seedling root length (3.37 cm), seedling shoot length (7.13 cm), vigor indices, viz., vigor index I (868.97), vigor index II (2466.60), due to faster germination, subsequent cell division and elongation. The lowest moisture content (7.70%), thousand seed weight (3.62 g), and electrical conductivity (30.60 µS cm^{-1} g^{-1}) were recorded in the same treatment combination. The storability and quality attributes of onion seeds in a cloth bag were significantly reduced with increased storage duration. The cloth bag stored seeds recorded the lowest seed quality due to its higher moisture content than the previous nature. A higher moisture content may have increased the respiratory activities of the seeds and shortened their life cycle, while also decreasing the quality parameters as the storage period progressed. This finding is similar to McDonald, (2004) and Patel *et al.*, (2012) finding in onion seeds. The seeds packed in a cloth bag and preserved in ambient storage for up to 60 days recorded the lowest germination percent (78.33), germination index (8.74), seedling root length (2.33 cm), seedling shoot length (5.60 cm), vigor indices viz., vigor index I (621.10), vigor index II (1424.50).

Table 2. Effect of storage containers and duration on seed quality parameters of onion

Treatments	Root Length (cm)	Shoot Length (cm)	Dry Weight (mg)	Vigor Index- I	Vigor Index- II	Electrical Conductivity (µS $cm^{-1}g^{-1}$)
Containers						
C_1: Plastic Jar	3.11	6.93	26.79	829.68	2240.88	34.25
C_2: Cloth Bag	2.79	6.22	20.88	723.00	1675.56	42.04
$LSD_{0.05}$	0.12	0.15	0.54	17.64	45.44	1.39
Duration (days)						
D_1: 15	3.32	7.03	26.57	862.62	2217.07	32.63
D_2: 30	3.07	6.68	25.00	803.60	2063.98	35.90
D_3: 45	2.82	6.43	22.5	754.82	1835.63	39.37
D_4: 60	2.60	6.15	21.30	704.33	1716.18	44.68
$LSD_{0.05}$	0.18	0.21	0.77	24.95	64.27	1.97
Interactions						
C_1 x D_1	3.37	7.13	29.13	888.97	2466.60	30.60
C_1 x D_2	3.20	7.03	28.40	859.97	2386.37	32..77
C_1 x D_3	3.00	6.87	25.23	822.23	2102.67	35.57
C_1 x D_4	2.87	6.70	24.40	787.57	2007.87	38.07
C_2 x D_1	3.27	6.93	24.00	836.27	1967.53	34.67
C_2 x D_2	2.93	6.33	21.60	747.23	1741.60	39.03
C_2 x D_3	2.63	6.00	19.70	687.40	1568.60	43.17
C_2 x D_4	2.33	5.60	18.20	621.10	1424.50	51.30
Mean (C x D)	2.95	6.58	23.83	781.34	1958.22	38.15
$LSD_{0.05}$	0.25	0.30	1.09	35.28	90.89	2.79
CV (%)	4.88	2.62	2.61	2.58	2.65	4.18

This change may occur due to damage to proteins and nucleic acids. The membrane enzyme and such degenerative changes resulted in the complete disorganization of membranes and cell organelles observed by Satishkumar and Sharnkumar (2014). The highest moisture content (13.76%), thousand seed weight (4.16 g), and electrical conductivity (51.30 µS cm^{-1} g^{-1}) were recorded in the onion seeds when stored in a cloth bag for up to 60 days. Seed leachate levels increased with the extended storage periods reported by Roberts (1972) and Rao *et al.*, 2006. The same treatment combination yielded the lowest seedling dry weight (18.20 mg) due to higher leachate of seeds and enzymatic activity throughout the storage period; however, the highest value (29.13 mg) was recorded after 15 days of storage in the plastic jar.

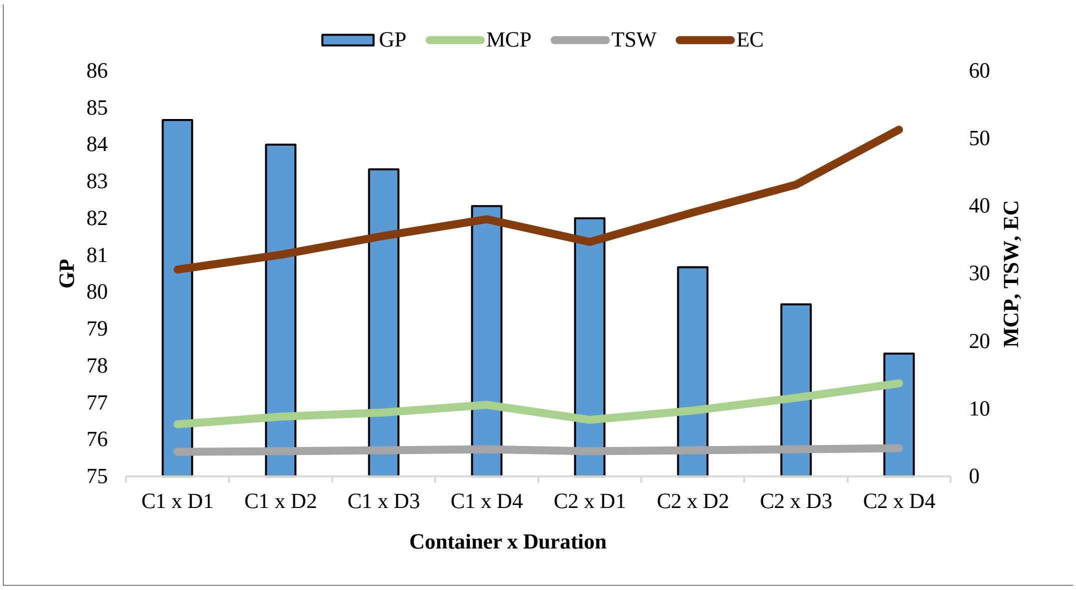

Fig. 1. Seed germination and other attributes as influenced by storage containers and duration.

Where, C_1: Plastic Jar, C_2: Cloth Bag, D_1= 15 Days, D_2= 30 Days, D_3= 45 Days, D_4= 60 Days and G = Germination percent, MCP=Moisture content percent, TSW=Thousand seed weight, EC= Electrical conductivity

Seed moisture content is the primary factor that regulates the viability of seeds and deterioration of seed quality, as evidenced by reduced germination percentages that increase with increasing moisture content in seeds (Agrawal, 2003). The germination percent (84.67) was the highest when the plastic jar was stored for 15 days. However, it gradually decreased over 30, 45, and 60 days, with increased moisture content, thousand-seed weight, and electrical conductivity, respectively. This result is similar to that of Ansari *et al.*, 1996 and Barua *et al.*, 2009, who reported that moisture absorption by seeds increased with increasing storage period. Similar trends in stored duration were seen when the onion seeds were stored in a cloth bag. The lowest germination percent (78.33) was recorded in the cloth bag stored for 60 days, with the rapid increase of moisture content, thousand seed weight, and electrical conductivity (Fig. 1). Similar findings of a decline in germination percent due to increased moisture levels among storage containers were reported by Hasna and Begum (2020).

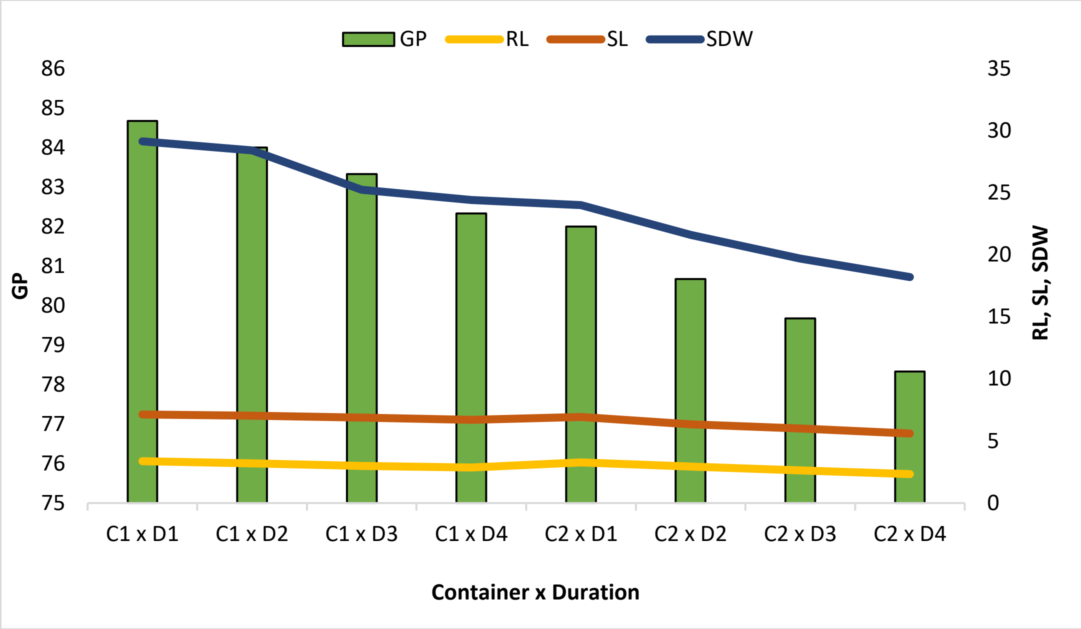

Fig. 2. Seed germination with other attributes as influenced by storage containers and duration.

Where, C_1: Plastic Jar, C_2: Cloth Bag, D_1 = 15 Days, D_2 = 30 Days, D_3 = 45 Days, D_4 = 60 Days and GP = Germination percent, RL=Root length of seedling, SL=Shoot length of seedling, SDW = Seedling dry weight.

The highest germination percent (84.67) in the plastic jar stored at 15 days, followed by 30 days, 45 days, and 60 days, resulted in lower seedling root length, seedling shoot length, and seedling dry weight, respectively. Similar trends in stored duration were seen when the onion seeds were stored in a cloth bag. The lowest germination percent (78.33) in the cloth bag stored for 60 days resulted in the lowest seedling root length, shoot length, and dry weight (Fig. 2). Similar observations had been reported by Doijode (1995) in onion seeds, Saxena *et al.*, 1974 in onion, cabbage, radish, okra, and pea, and Padma and Reddy (2000) in brinjal.

According to pearson's correlation coefficient value, germination percent was positively correlated with germination index (0.94), seedling root length (0.98), seedling shoot length (1.00), seedling dry weight (0.95), seedling index-I (1.00) and seedling index-II (0.96) when onion seeds were stored in plastic bags for different duration. Among them, the germination index and seedling dry weight were insignificant at p>0.05. However, germination percent was negatively correlated with moisture content percent (-0.99), thousand seed weight (-0.99) and electrical conductivity (-0.99) (Fig. 3).

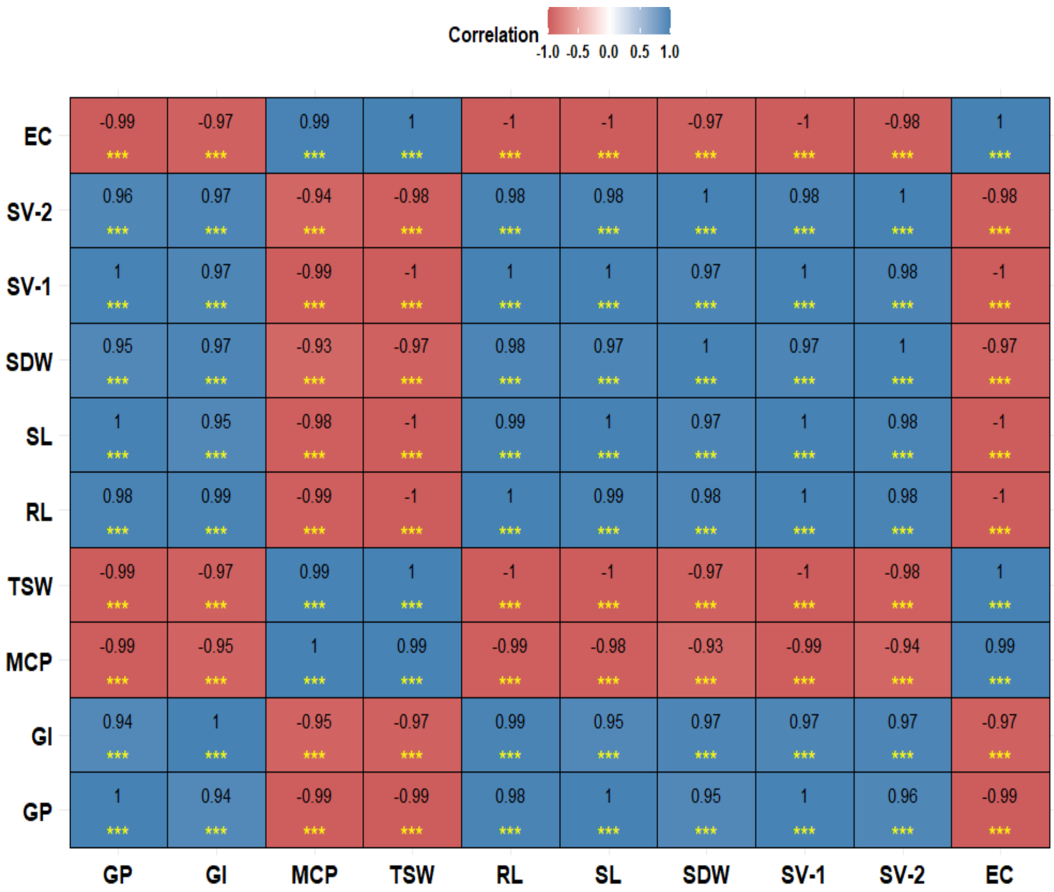

Fig. 3. Correlation coefficient analysis of seed quality attributes of plastic jar and duration.

Where, GP = Germination percent, GI = Germination index, MCP = Moisture content percent, TSW = Thousand seed weight, RL = Root length of seedling, SL = Shoot length of seedling, SDW = Seedling dry weight, SV-1= Seedling vigor index I, SV-2 = Seedling vigor index II and EC = Electrical conductivity

Similarly, pearson's correlation coefficient value for onion seeds were stored in cloth bags for different duration, germination percent was positively correlated with germination index (0.95), seedling root length (1.0), seedling shoot length (0.99), seedling dry weight seedling (0.99), Seeding index-I (1.00) and seedling index-II (0.99). Among them, the germination index was non-significant at p>0.05. But germination percent was negatively correlated with moisture content percent (-0.99), thousand seed weight (-1.00) and electrical conductivity (-0.99) (Fig. 4).

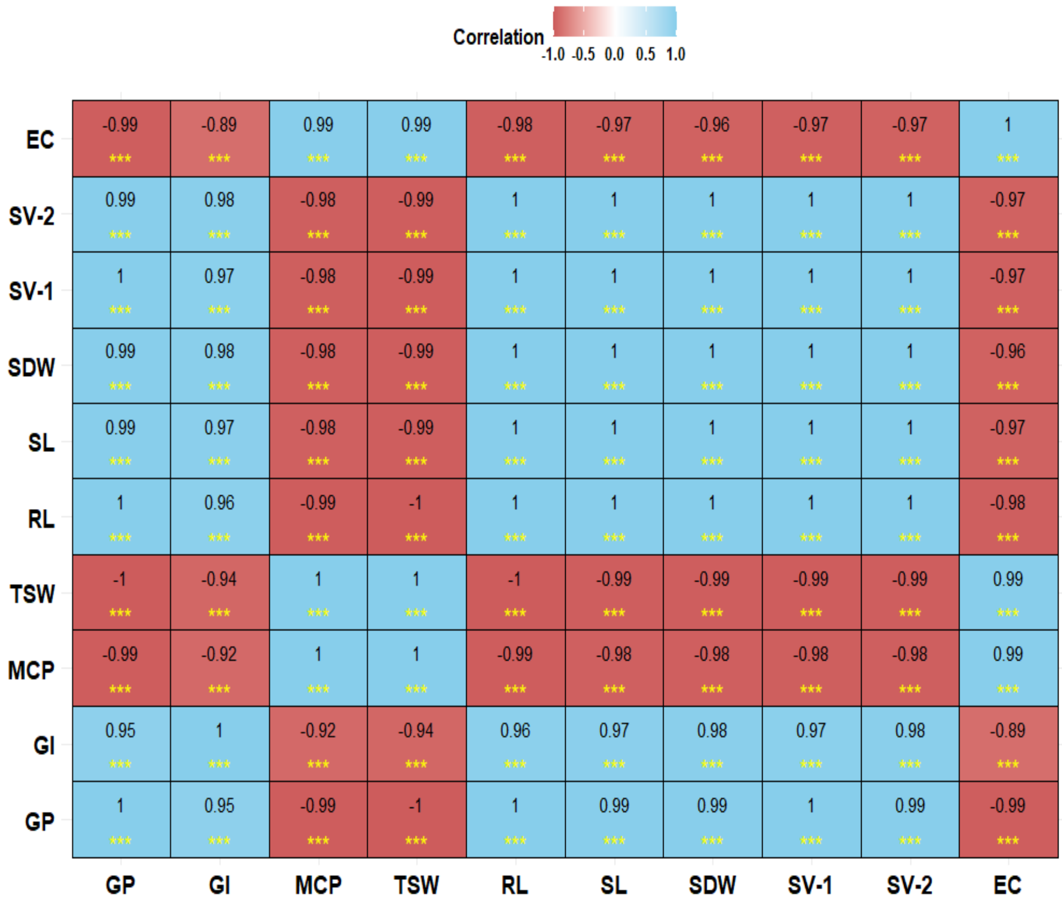

Fig. 4. Correlation coefficient analysis of seed quality attributes of cloth bag and duration.

Where, GP= Germination percent, GI= Germination index, MCP= Moisture content percent, TSW=Thousand seed weight, RL=Root length of seedling, SL=Shoot length of seedling, SDW= Seedling dry weight, SV-1= Seedling vigor index I, SV-2= Seedling vigor index II and EC= Electrical conductivity

Conclusion

This study gave an indication that plastic jars did remarkably well as compared to cloth bags in the storage of onion seeds by maintaining seed quality parameters such as germination capacity and vigor of seedlings. The result indicates an inevitable loss of quality due to higher moisture and electrical conductivity as long as the storage time is expanded as well. These findings underscore the significance of selecting suitable storage techniques and reducing storage duration to preserve onion seed viability, which ultimately contributes to enhanced crop yields and agricultural sustainability.

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