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Seed quality and seed health of field pea cultivars as influenced by storage containers

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Abstract

An experiment was conducted to assess the influence of storage containers on seed quality and seed health of field pea (*Pisum sativum* L.). The study comprised of three cultivars *viz*., BARI Motor-1, BARI Motor-3 and BADC Motor-1 and three containers *viz*., plastic container, polybag, earthen pot and two durations *viz*., before storage in container and after 90 days storage. The results revealed that among the three cultivars BARI Motor-1 seeds recorded lowest moisture content (10.97%), lowest electrical conductivity (164.1µS/cm/g), maximum germination (72.67%), vigor index (2926.81), shoot length (24.93 cm), root length (13.95 cm) and minimum incidence of seed borne fungi. Before storage, the seed showed lowest moisture content (9.29%), 1000-seed weight (79.53 g), electrical conductivity (100.9 µS/cm/g), highest germination percentage (91.67%), vigor index (4464.87), shoot length (26.79 cm), root length (21.85 cm) and minimum incidence of fungi *Aspergillus flavus* (1.81%), *Fusarium oxysporum* (5.76%), *Rhizopus* spp. (0.27%), *Colletotrichum* spp. (5.55%) and *Aspergillus niger* (0.11). Among the three containers, plastic container noticed lowest moisture content (10.06 %), electrical conductivity (174.5 µS/cm/g), maximum germination percentage (73.22%), vigor index (3086.32) and minimum incidence of fungi *Aspergillus flavus* (2.872%), *Fusarium oxusporum* (7.358%), *Rhizopus* spp. (1.278%), *Colletotrichum* spp. (6.228%) and *Aspergillus niger* (0.750%). Thus, it can be concluded that the quality and health of field pea seed decreased with increase in period and plastic container was suitable for field pea seed preservation. Stored seeds had low germination, high moisture content and incidence of seed borne pathogen than before storage.

Keywords: Moisture content, Electrical conductivity, Vigor index, Seed borne pathogen, Field pea

1. Introduction

Seed is one of the most crucial inputs for growing crops, often known as the building blocks of agriculture. Field pea (*Pisum sativum* L.) belonging to the Fabaceae family is a crop with significant commercial importance for food and feed. Field pea, a species from the Middle East, is a cool-season legume and demonstrates excellent adaptation, high productivity, relatively low disease attack and a favorable response to irrigation [1]. In Ethiopia, it has an important role in the highlands as it plays a significant role to improve soil fertility in cereal-based cropping systems [2]. Peas are also popular in Brazil, and it has commercial cultivation as it is used as dry grains for freezing [3]. It is a highly valuable pulse crop grown worldwide for its high protein seed and other benefits for restoring the soil [4]. Pea seeds are highly nutritious and contain protein (23-25%), starch (50%), sugars (5%). It is also a good source of essential minerals and fibre [5].

Average yield of field pea is very low in Bangladesh, average dry seed yield is only 0.75 t/ha which is lower than other countries such as USA 3.94 t/ha and France 3.23 t/ha [6]. Presently pea is grown in very small amounts and its annual production is about 8051.97 MT under 18501 acres area in our country [7]. Due to poor-quality seed use, production was reduced by about 10-15%. [8]. In Bangladesh, storage of seed is difficult, and the storing methods are still poor [9-10]. In our country most of the people store their seeds as they stored their food grain which ultimately increases the moisture content of seed. But it is extremely dangerous to have seed moisture above safe life. The respiration of seeds that are being stored is increased by higher temperatures and greater moisture percentages [11]. Due to that, the quality of seed is reduced, and it became somewhat unusable for crop production. Physiological potential of stored pea seeds significantly affected by initial physiological quality, seed water content, relative humidity and temperature, microorganisms and insects, and the storage period [12]. A seed lot having pathogens may disrupt germination, can cause disease in seedlings and growing plants [13]. Quality seed must have genetical pure with higher germination percentage and yield potentiality [14]. An uninfected seed may be infected seeds having pathogens as pathogen has long distance spreading capacity [15]. It has been found that seed vigor and viability reduce rapidly when pea seed is kept at high temperature and high moisture content near to 13%, as this condition creates favorable environment for microorganisms [16].

During seed storage in Bangladesh, weather condition favors degrading seed quality which ultimately affect seed vigor and seed respiration [17]. There is a severe lack of knowledge on storing methods of seeds to keep their quality. Information relating pea seed storage and effects of biotic and abiotic factors on quality of pea seed storage are crucial [9-10]. Considering the above factors, the present study was undertaken to measure the effects of storage containers (plastic container, poly bag and earthen pot) on pea seed quality and identify the best storage container for storing field pea cultivars.

2. Materials and methods

2.1 Location and duration

The experiment was conducted during June 2017 to March 2018 at the Seed Laboratory, Department of Agronomy, Bangladesh Agricultural University (BAU) and at Professor Golam Ali Fakir Seed Pathology Center, BAU. The minimum and maximum experimental temperature and relative humidity of the storage room were 24.0 to 33.5°C; and 65 to 98%, respectively.

2.2 Experimental material and layout

Three field pea cultivars such as BARI Motor-1, BARI Motor-3 and BADC Motor-1 and three storage containers such as plastic (PET plastic bottle), poly bag (transparent zip lock poly bag) and earthen pot (clay pot) were used as experimental material. BARI Motor-1 and BARI Motor-3 were developed by the pulse division of Bangladesh Agricultural Research Institute (BARI) and released in 2013. Both are long duration cultivar and can be grown in *Rabi* season. The average seed yield BARI Motor-1 is 1.2 t/ha and BARI Motor-3 is 1.0-1.2 t/ha (Figure 1). BADC Motor-1 was released by the Bangladesh Agricultural Development Corporation (BADC). This variety can also be grown in *Rabi* season. The plant height is 95-100 cm and generally requires 110-115 days to mature. Seed yield is about 0.8-1.0 t/ha (Figure 1). The experiment was laid out in the Completely Randomized Design (CRD) with three replications.

Figure 1 Field pea cultivars used in the trial (A) BARI Motor-1, (B) BARI Motor-3, and (C) BADC Motor-1.

2.3 Data recording

Two times sampling was performed from each container. For assessing seed quality and overall health of the stored seeds, two samples were taken: one before storage and another one 3 months later. The samples were stored in Seed pathology Centre in the selected containers - plastic, poly bag and earthen pot with proper labeling for later research. About 300 g of seeds were used per containers and made the containers air tight. Seed germination (%), seed water content (%), shoot and root ratio of seedling, vigor index, electrical conductivity (µS/cm/g) and incidence of storage fungi (%) were studied as quality of field pea cultivars.

Moisture content was also determined before storage and after 90 days storage during experimental period by using constant temperature oven method (103°C, 18 h) following International Rules for Seed Testing [18]. The sand method (using sterilized sand) was followed to measure seed germination. The number of normal seedlings, abnormal seedlings and dead seeds were recorded respectively as per International Seed Testing Association (ISTA) rules [19]. Data for germination was recorded after 8 days.

Germination tests of seeds were done in sand Petridis method using sterilized sand. The number of normal seedlings, abnormal seedlings and dead seeds were recorded respectively as per ISTA rules (2003). After 8 days, germination percentage was recorded. For root and shoot length, ten (10) normal seedlings were randomly selected and the root and shoot length of them were measured. Then, the mean root and shoot length were expressed in centimeters. Seedling vigor was measured by using the following formula [20]:

$$\text{Vigor index} = (\text{Mean root length} + \text{Mean shoot length}) \times \text{Germination (\%)} \quad (1)$$

A digital conductivity meter (Digimed DM-32) was used to measure conductivity [21]. Seed borne pathogens associated with the seeds were detected using blotter method [19,22-24]. Individual incubated seed was observed under stereomicroscope at 16 × and 25 × magnifications in order to record the incidence of seed borne fungi.

The experiment followed CRD and was replicated thrice. ANOVA was conducted using MSTATC (version 2.6) for different parameters, and the means were compared by Duncan's Multiple Range Test (DMRT).

3. Results

3.1 Seed quality parameters

3.1.1 Effects of cultivar

No significant difference was found between cultivars for seed moisture content measured after 90 days storage in different containers (Table 1). The lowest moisture content was recorded in cultivar BARI Motor-1 (10.97%) and the highest moisture content was in BADC Motor-1 (11.09%). The lowest 1000- seed weight was recorded in cultivar BARI Motor-1 (62.33). Significant differences were observed among the cultivars for electrical conductivity. It was less in BARI Motor-1 (164.1 µS/cm/g) and more in BADC Motor-1 (175.9 µS/cm/g). A significant difference was observed between the cultivars for germination percentage and dead seed percentage but not significant for ungerminated seedling percentage. Maximum germination percentage (72.67%) was recorded in BARI Motor-1 and the lowest germination (68.75%) was recorded in BADC Motor-1. The lowest dead seed (10.58%) was found in BARI Motor-1. Maximum normal seedlings (72.67%) and abnormal seedlings (10.08%) percentage were recorded in BARI Motor-1. Numerically, the highest shoot length (24.93 cm), root length (13.95 cm), vigor index (2926.81) was recorded from BARI motor-1 (Table 1).

3.1.2 Effects of storage container

Storage containers showed a significant effect on seed water content which increased with increasing storage period (Table 2). The highest moisture content (13.45%) was recorded in earthen containers compared to other containers at 90 days after storage. 1000-seed weight was different for all storage containers significantly. The maximum thousand seed weight (83.38 g) was recorded in earthen pot (Table 2). Before storage in container minimum value of electrical conductivity was recorded from C_0 (100.9 µS/cm/g) and more (216.9 µS/cm/g) in earthen pot (C_3). The effect of storage condition and container on germination percentage, ungerminated seed percentage, percentage of normal and abnormal seedlings, shoot length, root length and vigor index were found significant at 90 days after storage (Table 2). The highest germination (91.67%), normal seedlings (91.67%), shoot length (26.79 cm), root length (21.87 cm) and vigor index (4464.87) were recorded before storage in container (C_0). Dead seed percentage showed substantial differences to various storage containers. The lowest dead seed percentage (10.44%) was observed in plastic containers (C_1) when compared with other containers (Table 2).

Table 1 Effect of cultivars on moisture content (%), 1000-seed weight, EC, germination (%), ungerminated seed (%), dead seed (%), normal and abnormal seedlings (%), shoot and root length, vigour index of field pea seeds after 90 days storage.

Cultivars	Moisture Content (%)	1000-SW (g)	EC (µS/cm^{-1}/g^{-1})	Germination (%)	Ungerminated seed (%)	Dead seed (%)	Normal seedlings (%)	Abnormal seedlings (%)	Shoot length (cm)	Root length (cm)	Vigor index
V_1	10.97	62.33^{c}	164.1^{c}	72.67^{a}	6.75	10.58^{b}	72.67^{a}	10.08	24.93^{a}	13.95^{a}	2926.81^{a}
V_2	11.02	119.4^{a}	166.8^{b}	71.08^{a}	6.25	11.92^{ab}	71.08^{a}	9.92	24.54^{b}	13.30^{c}	2807.72^{b}
V_3	11.09	64.14^{b}	175.9^{a}	68.75^{b}	7.91	14.00^{a}	68.75^{b}	9.33	24.72^{c}	13.75^{b}	2739.08^{c}
$LSD_{(0.05)}$	0.159	0.321	1.91	2.165	2.969	2.155	2.165	2.905	0.571	1.482	203.8
Level of sig.	NS	**	**	**	NS	**	**	NS	NS	NS	NS
CV	1.12	0.3	0.87	2.35	32.78	13.63	2.35	22.87	1.78	8.35	5.55

The same letters or without letters within the same column do not differ significantly, *= Significant at 5% level of probability, **= Significant at 1% level of probability, NS= Non Significant, V_1= BARI Motor-1, V_2= BARI Motor-3, V_3= BADC Motor-1, SW= Seed weight, EC= Electrical conductivity.

Table 2 Effect of storage container on moisture content (%), 1000-seed weight, EC, germination (%), ungerminated seed (%), dead seed (%), normal and abnormal seedlings (%), shoot and root length, vigour index of field pea seeds after 90 days storage.

Storage containers	Moisture Content (%)	1000-SW (g)	EC (µS/cm^{-1}/g^{-1})	Germination (%)	Ungerminated seed (%)	Dead seed (%)	Normal seedlings (%)	Abnormal seedlings (%)	Shoot length (cm)	Root Length (cm)	Vigor index
C_0	9.29^{d}	79.53^{c}	100.9^{d}	91.67^{a}	1.77^{c}	3.222^{d}	91.67^{a}	3.33^{d}	26.79^{a}	21.87^{a}	4464.87^{a}
C_1	10.06^{c}	82.31^{b}	174.5^{c}	73.22^{b}	6.44^{b}	10.44^{c}	73.22^{b}	9.11^{c}	25.70^{b}	16.50^{b}	3086.32^{b}
C_2	11.31^{b}	82.56^{b}	183.4^{b}	64.56^{c}	9.11^{a}	13.22^{b}	64.56^{c}	13.22^{b}	23.98^{c}	10.10^{c}	2201.86^{c}
C_3	13.45^{a}	83.38^{a}	216.9^{a}	53.89^{d}	10.56^{a}	21.78^{a}	53.89^{d}	13.44^{a}	22.46^{d}	6.19^{d}	1545.08^{d}
$LSD_{(0.05)}$	0.141	0.285	1.688	1.932	2.636	1.913	1.923	2.579	0.507	1.316	181
Level of sig.	**	**	**	**	**	**	**	**	**	**	**
CV	1.12	0.3	0.87	2.35	32.78	13.63	2.35	22.87	1.78	8.35	5.55

The same letters or without letters within the same column do not differ significantly, *= Significant at 5% level of probability, **= Significant at 1% level of probability, NS= Non Significant, C_0 = Before storage in container, C_1 = Storage in plastic containers after 90 days storage, C_2 = Storage in plastic bag after 90 days storage, C_3 = Storage in earthen pot after 90 days storage, SW= Seed weight, EC= Electrical conductivity.

Table 3 Interaction effect of cultivars and storage containers on moisture content (%), 1000-seed weight, EC, germination (%), ungerminated seed (%), dead seed (%), normal and abnormal seedlings (%), shoot and root length, vigour index of field pea seeds after 90 days storage.

Cultivars	Storage Containers	Moisture Content (%)	1000-SW (g)	EC (µS/ cm^{-1}/g^{-1})	Germination (%)	Ungerminated seed (%)	Dead seed (%)	Normal seedlings (%)	Abnormal seedlings (%)	Shoot length (cm)	Root length (cm)	Vigor index
V_1	C_0	9.26^{d}	56.73^{g}	97.00^{i}	93.33^{a}	1.67^{e}	2.33^{f}	93.33^{a}	2.67^{f}	26.77^{a}	21.54^{a}	4518.30^{a}
	C_1	10.01^{c}	63.63^{f}	173.2^{g}	74.67^{c}	6.33^{cd}	9.33^{e}	74.67^{c}	9.67^{cd}	25.45^{bc}	17.16^{b}	3192.00^{b}
	C_2	11.18^{b}	64.17^{e}	180.2^{e}	66.67^{e}	11.00^{ab}	10.00^{de}	66.67^{e}	12.67^{abc}	24.77^{c}	10.67^{c}	2362.75^{c}
	C_3	13.43^{a}	64.77^{d}	206.2^{b}	56.00^{g}	8.00^{bcd}	20.67^{b}	56.00^{g}	15.33^{a}	22.74^{e}	6.44^{d}	1634.17^{d}
V_2	C_0	9.26^{d}	118.5^{c}	102.2^{h}	93.00^{a}	1.67^{e}	2.67^{f}	93.00^{a}	2.67^{f}	26.93^{a}	21.89^{a}	4541.77^{a}
	C_1	10.07^{c}	119.2^{b}	173.7^{g}	74.00^{c}	4.67^{de}	11.33^{de}	74.00^{c}	7.67^{de}	25.77^{b}	15.23^{b}	3054.20^{b}
	C_2	11.37^{b}	119.4^{b}	183.7^{d}	63.67^{f}	8.33^{bcd}	13.00^{d}	63.67^{f}	15.00^{a}	23.53^{d}	9.70^{c}	2116.07^{c}
	C_3	13.39^{a}	120.3^{a}	207.7^{b}	53.67^{gh}	10.33^{abc}	20.67^{b}	53.67^{gh}	14.33^{ab}	21.93^{f}	6.37^{d}	1518.83^{d}
V_3	C_0	9.35^{d}	63.33^{f}	103.4^{h}	88.67^{b}	2.00^{e}	4.67^{f}	88.67^{b}	4.67^{ef}	26.65^{a}	22.18^{a}	4334.53^{a}
	C_1	10.12^{c}	64.13^{e}	176.6^{f}	71.00^{d}	8.33^{bcd}	10.67^{de}	71.00^{d}	10.00^{cd}	25.87^{b}	17.10^{b}	3012.77^{b}
	C_2	11.36^{b}	64.07^{e}	186.4^{c}	63.33^{f}	8.00^{bcd}	16.67^{c}	63.33^{f}	12.00^{abc}	23.63^{d}	9.94^{c}	2126.77^{c}
	C_3	13.52^{a}	65.03^{d}	237.0^{a}	52.00^{h}	13.33^{a}	24.00^{a}	52.00^{h}	10.67^{bcd}	22.71^{e}	5.79^{d}	1482.25^{d}
$LSD_{(0.05)}$		0.206	0.416	2.466	2.809	3.851	2.795	2.809	3.768	0.74	1.922	264.4
Level of sig.		*	**	**	*	*	*	*	*	*	*	*
CV		1.12	0.3	0.87	2.35	32.78	13.63	2.35	22.87	1.78	8.35	5.55

The same letters or without letters within the same column do not differ significantly, *= Significant at 5% level of probability, **= Significant at 1% level of probability, V_1= BARI Motor-1, V_2= BARI Motor-3, V_3= BADC Motor-1, C0 = Before storage in container, C_1 = Storage in plastic containers after 90 days storage, C_2 = Storage in plastic bag after 90 days storage, C_3 = Storage in earthen pot after 90 days storage, SW= Seed weight, EC= Electrical conductivity.

3.1.3 Interaction effects of cultivar and storage container

1000-seed weight and moisture content were significant throughout the storage condition, V_1C_0 (56.73 g) maintained the lower 1000-seed weight before storage and after 90 days from storage pea seed maintained higher seed weight in V_2C_3 (120.3 g). By comparing storage containers at 3 months intervals from storage the lowest moisture content was found in V_1C_1 (9.26%), and the highest moisture content was found in V_3C_3 (13.52%) (Table 3).

Before and after storage V_1C_0 (97.00 µS/cm/g) had maintained lower electrical conductivity and V_3C_3 (237.0 µS/cm/g) had maintained higher electrical conductivity. At the end of storage plastic container (V_1C_1) showed lower electrical conductivity (173.2 µS/cm/g). V_1C_0 (93.33%) had maintained higher germination in storage condition and V_1C_1 (74.67%) had higher germination at the end of storage. The lowest germination was observed in V_3C_3 (52.00%) throughout the storage condition and containers. Before storage, V_1C_0 (93.33%) showed the highest normal seedling. After storage, comparing only storage containers, V_1C_1 (74.67%) showed the highest percentage of normal seedling. The percentage of abnormal seedling, ungerminated seed and dead seed increased in V_1C_3 (15.33%), V_3C_3 (13.33%) and V_3C_3 (24.00%), respectively and abnormal seedling percentage decreased in V_1C_0 (2.67%) followed by V_2C_0 (2.67%). After three months of storage, a decrease in dead seed was seen in V_1C_1 (9.33%) when compared between cultivars and containers. During storage condition V_1C_0 showed highest shoot length (26.77 cm), root length (21.54 cm) and vigor index (4518.30) and lowest shoot length (21.93 cm), root length (5.79 cm) and vigor index (1482.25) were observed in V_3C_2, V_3C_3 and V_3C_3, respectively and after 90 days duration form storage in plastic container showed higher shoot length (V_3C_1), root length (V_1C_1) and vigor index (V_1C_1) when compared with polybag and earthen pot (Table 3).

3.2 Seed health

3.2.1 Effects of cultivar

The cultivars were found significant for incidence of fungi except *Aspergillus flavus* and *Colletotrichum* spp. (Table 4). A total number of 5 fungal species were associated with field pea seeds. The fungi encountered were *Aspergillus flavus*, *Fusarium oxysporum*, *Rhizopus* spp., *Colletotrichum* spp. and *Aspergillus niger*. Incidence of *A. flavus*, *F. oxysporum*, *Rhizopus* spp., *Colletotrichum* spp. and *A. niger* in BARI Motor-1 seeds are 2.86%, 7.72%, 1.47%, 6.68% and 0.98%, respectively. On the other hand, the incidence of *A. flavus*, *F. oxysporum*, *Rhizopus* spp., *Colletotrichum* spp. and *A. niger* in BARI Motor-3 seeds are 2.88%, 7.77%, 1.54%, 6.78% and 0.97%, respectively. In addition, the incidence of *A. flavus*, *F. oxysporum*, *Rhizopus* spp., *Colletotrichum* spp. and *A. niger* in BADC Motor-1 seeds are 3.08%, 8.30%, 1.96%, 6.95% and 1.26%, respectively (Figure 2).

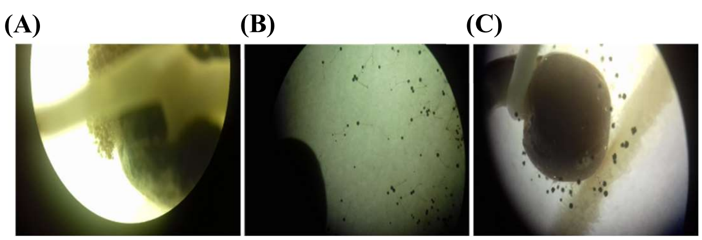

Figure 2 Stereomicroscopic view of seed borne pathogens (A) *A. flavus*, (B) *Rhizopus* spp., and (C) *A. niger.*

3.2.2 Effects of container

A total number of 5 fungal species were recorded from field pea seeds during storage in containers (Table 4). Before storage, the incidence of fungus was lowest as expected, but after 90 days storage, the lowest incidence (among the storage treatment) of fungi *A. flavus* (2.87%), *F. oxysporum* (7.35%), *Rhizopus* spp. (1.27%), *Colletotrichum* spp. (6.22%) and *A. niger* (0.75%) were recorded from the plastic container (C_1) (Table 4). The results indicate that plastic containers were better than earthen pot.

3.2.3 Interaction effects of cultivar and storage container

For *A. flavus*, the highest incidence observed in V_3C_3 (3.80%) is statistically similar with V_2C_3, V_1C_3 and V_1C_2 (Table 5). The lowest incidence observed in V_1C_1, which is statistically similar with V_2C_1, V_3C_1. For *F. oxysporum*, the highest incidence observed in V_3C_3 (10.82%) is statistically similar with V_1C_3, V_2C_3. The lowest incidence observed in V_2C_0, which is statistically similar with V_1C_0, V_3C_0. The lowest incidence of *R.* spp. observed in V_1C_0 (0.00%), which was statistically similar with V_2C_0 (0.16%). The lowest incidence of *Colletotrichum* spp. recorded in V_1C_0 (5.33%), which was statistically similar with V_2C_0 (5.56%). The lowest incidence of *A. niger* recorded in V_1C_0 and V_2C_0 with same value of (0.00%) (Table 5). The incidence of fungi increased with increasing storage period, moisture percentage, temperature, and relative humidity.

3.2.4 Seed health status/infection percentage of different seed

In this study, the collected seed samples showed significant variation in seed infection by different seed borne fungi (Table 6). The maximum seed infection by seed borne pathogens (21.55%) was found in BADC Motor-1 seed sample followed by the BARI Motor-3 (19.94%) and BARI Motor-1 seed (19.71%). These findings indicate that the seed health status of BARI Motor-1 seeds is better than other seeds.

Table 4 Effect on cultivars and storage containers for incidence of storage fungi percentage in field pea seed.

Cultivars	*Aspergillus flavus*	*Fusarium oxysporum*	*Rhizopus* spp.	*Colletotrichum* spp.	*Aspergillus niger*
V_1	2.86	7.72^b	1.47^b	6.68	0.98^b
V_2	2.88	7.77^b	1.54^b	6.78	0.97^b
V_3	3.08	8.30^a	1.96^a	6.95	1.26^a
$LSD_{(0.05)}$	0.299	0.439	0.368	0.285	0.232
Level of sig.	NS	**	**	NS	**
CV	7.8	4.25	17.03	3.23	16.56
Storage containers					
C_0	1.81^d	5.76^d	0.27^d	5.55^d	0.11^d
C_1	2.87^c	7.35^c	1.27^c	6.22^c	0.75^c
C_2	3.34^b	8.17^b	2.06^b	7.13^b	1.32^b
C_3	3.74^a	10.40^a	3.02^a	8.31^a	2.10^a
$LSD_{(0.05)}$	0.266	3.29	0.326	0.253	0.206
Level of sig.	**	**	**	**	**
CV	7.8	4.25	17.03	3.23	16.56

The same letters or without letters within the same column do not differ significantly, **= Significant at 1% level of probability, NS = Non significant, V_1= BARI Motor-1, V_2= BARI Motor-3, V_3= BADC Motor-1, C_0 = Before storage in container, C_1 = Storage in plastic containers after 90 days storage, C_2 = Storage in plastic bag after 90 day storage, C_3 = Storage in earthen pot after 90 days storage.

Table 5 Interaction effect on cultivars and storage containers for incidence of storage fungi percentage in field pea seed.

Cultivars	Storage containers	*Aspergillus flavus*	*Fusarium oxysporum*	*Rhizophus* spp.	*Colletotrichum* spp.	*Aspergillus niger*
V_1	C_0	1.50^g	5.76^e	0.00^e	5.33^e	0.00^h
	C_1	2.76^e	7.10^d	1.00^d	6.21^c	0.75^{ef}
	C_2	3.38^{abc}	7.80^c	1.95^{bc}	6.93^b	1.25^c
	C_3	3.80^a	10.25^a	2.95^a	8.25^a	1.95^a
V_2	C_0	1.86^{fg}	5.63^e	0.16^e	5.56^{de}	0.00^h
	C_1	2.83^{de}	7.33^{cd}	1.16^d	6.16^c	0.58^{fg}
	C_2	3.20^{bcd}	7.83^c	1.93^{bc}	7.21^b	1.15^{cd}
	C_3	3.63^a	10.3^{0a}	2.91^a	8.18^a	2.15^a
V_3	C_0	2.08^f	5.88^e	0.66^d	5.75^d	0.33^g
	C_1	3.01^{cde}	7.64^{cd}	1.66^c	6.30^c	0.91^e
	C_2	3.45^{ab}	8.88^b	2.30^b	7.25^b	1.53^b
	C_3	3.80^a	10.82^a	3.21^a	8.51^a	2.21^a
$LSD_{(0.05)}$		0.388	0.569	0.477	0.396	0.302
Level of sig.		*	**	*	*	*
CV		7.8	4.25	17.03	32.78	13.63

The same letters or without letters within the same column do not differ significantly, *= Significant at 5% level of probability, **= Significant at 1% level of probability, V_1= BARI Motor-1, V_2= BARI Motor-3, V_3= BADC Motor-1, C_0 = Before storage in container, C_1 = Storage in plastic containers after 90 days storage, C_2 = Storage in plastic bag after 90 day storage, C_3 = Storage in earthen pot after 90 days storage.

Table 6 Seed health status/percent seed infection of different seed samples.

Name of seed sample	Name of the crop variety	Chemically treated /Non treated	% Seed infection by seed borne pathogens	% Healthy seed
BARI Motor-1	Field pea	Non-treated	19.71	80.29
BARI Motor-3	Field pea	Non-treated	19.94	80.06
BADC Motor-1	Field pea	Non-treated	21.55	78.45

4. Discussion

The objective of seed storage is to preserve the planting material from one season to the next sowing season and to maintain the seed quality for the longest possible duration. Storage condition had various effects on the seed physiological characteristics: seed weight, moisture content percentage, germination percentage, and vigor index and seed health status. Amount of moisture, the most important factor influencing seed viability during storage and the rate of deterioration. In this experiment the lower moisture content helps to maintain the seed quality before storage in container (9.29%) and after storage such seeds stored in plastic container (10.06%) accumulate lower moisture. The seeds stored in earthen pot bag highly affected by moisture than other storage containers (before storage in container, plastic container, plastic bag), which ultimately reduced the seed longevity. These findings are supported by [25-28]. Before storage in container field pea seed had lower moisture content. As seed is a highly hygroscopic living material, it absorbs moisture from air if it is stored in an environment where relative humidity is higher than seed moisture content. The rate of absorbance was higher in earthen pot because of storage period and earthen pot is not air tight container but plastic container are moisture proof, increasing rate was lower in air tight container and plastic container moisture this is due to the storage period and impervious nature of the containers which prevented the entry of moisture from outer environment [29]. Shoot and root length data indicated that seedling shoot, and root length was reduced in earthen pot throughout the storage period and condition, which might be due to low vigor of seeds for long storage periods, high moisture, and fungi infestation [30]. In earthen pot the rate of abnormal seedling, ungerminated seed and dead seed was observed higher, due to high moisture and fungal activities in field pea seed. Seed quality deterioration during storage was due to the damage to membrane, enzyme, proteins, and nucleic acid. Seed quality deterioration occurred as a result of damage to the membrane, enzyme, proteins and nucleic acid. With the accumulation of time, such degenerative changes result in complete disorganization of membranes and cell organelles and ultimately causing death of the seed [31].

The seed moisture content had a significant effect on seed germination and vigor. The germination percentage and vigor index, in this study, was highest in BARI Motor-1 compared with BARI Motor-3 and BADC Motor-1 for cultivars difference. Plastic containers were more suitable containers compared with earthen pots and plastic bags. On the other hand, EC of seeds showed a very negative relationship with the rate of germination. The negative correlation between EC and seed germination suggested that more cells leached out of poor-quality seed and reduced the ability of field pea seeds to germinate, which is in agreement with the findings of [32] in onion seeds. High EC of seed is assumed due to membrane deterioration during the imbibition period of lower quality seeds. In plastic container, the leachate leak of good quality seed was minimum whereas it was maximum from the low-quality seeds stored in earthen pot. After storage in container the lowest incidence of fungi found in plastic container for all varieties. A total number of 5 fungal species (*A. flavus, F. oxysporum*, *Rhizopus* spp., *Colletotrichum* spp. and *A. niger*) were associated with field pea seeds. The highest incidence of *Colletotrichum* spp. (8.517%) and *A. niger* (2.217%) was recorded in earthen pot throughout the storage condition and containers in BADC Motor-1. The maximum seed infection by seed borne pathogens (21.55%) was found in BADC Motor-1 followed by the BARI Motor-3 (19.94%) and BARI Motor-1 seed (19.71%). This may be due to the high moisture percentage in storage seed. The incidence of fungi increased with increasing storage period, moisture percentage, temperature, and relative humidity [33].

5. Conclusion

Studies with the seed sample revealed that the quality and health of field pea cultivar decreased gradually in all storage containers compared with before storage in container. It may be recommended that BARI Motor-1 of field pea cultivar is better than BARI Motor-3 and BADC Motor-1 in plastic container, because BARI Motor-1 having high germination percentage and good quality seed having lower amount of seed moisture and for genetically or unknown characters. Among the three containers, plastic container was the best and the earthen pot was least effective storage containers for field pea seed for up to 90 days of storage. Therefore, it may be concluded that plastic containers were suitable to maintain seed quality and health of field pea seeds of BARI Motor-1, BARI Motor-3 and BADC Motor-1. However, further study is needed to confirm the efficiency of plastic containers as storage material on different climatic condition.

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