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Comparative evaluation of different packaging materials for field pea seed quality over various storage periods

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Abstract: **The study was conducted to determine the effect of different packaging materials for field pea seed quality over various storage periods. The experiment was carried out during 2018 to 2020 using seeds of field pea variety Tegegnch at Holetta Agricultural research center. Five types of storage materials and five storage periods were used as experimental treatments. The experiment was laid out by completely Randomized Design with four replications. Data for seed quality variables were recorded ever six months for two years and the result showed that moisture content, thousand seed weight, germination percentage, seedling length and Vigor index one was highly influenced by different packaging materials under different storage months and speed of germination, seedling dry weight, vigor index two and field emergence index are only influenced by storage months. Thousand seed weight increased proportionally with increased moisture content for seed stored by exposed storage materials. As the storage month progressed the recorded values for speed of germination, seedling dry weight, vigor index two and field emergence index are reduced and the reduction was higher for 18 and 24 months. Concerning storage fungi several fungal were associated with field pea seed. The observed fungal are Ascochyta sp, Penicillium sp, Bipolaris sp, Alternaria sp, Aspergillus sp, A.flavus, A.niger, Rhizopus, Eppiccocum nigrum, Trichoderma, Fusarium sp and Botrytis sp, Cladosporium and Phoma sp. The highest infestation of Bruchid was recorded for non-air tight storage materials and least infestation was recorded for air tight storage materials.**

Keywords: **Field pea, Packaging materials, Storage durations and Seed quality.**

1. INTRODUCTION

Seed is an important in put in agricultural production and its quality is essential in determining maximum potential crop yields. Seed quality has significant direct influence on crop productivity levels (Bewley and Black, 1998). Condition under which the seed is stored is often a major cause of poor seed quality. Good storage is a basic requirement in seed production program as the maintenance of high seed viability and vigor from the harvest to planting is of utmost important in a seed production program (Shelar *et. al*., 2008). Seeds are required to be kept in safe storage since they are harvested in the preceding season and usually used for sowing in the subsequent season often after a time gap of six months or longer. Thus, proper storage is required to keep seeds in good condition. Some varieties need air-conditioned storage. Proper packaging and ideal condition of storage are required to maintain seed quality. Rao. *et al* (2006) reported that packaging container, storage condition and duration affect seed quality (Viability and vigor).

Seed deterioration has been ascribed to physical, physiological, bio-chemical and pathological detrimental changes occurring in seeds leading to death and has been characterized as inexorable, irreversible, inevitable, and minimal at the time of physiological maturity and variable among kinds of seeds, varieties and seed lots. Seeds deterioration starts after physiological maturity in the field before and after harvesting through processing to storage until seeds become acceptable for planting (EL-Borai *et.al*., 1993). Seed quality is affected during pre- and post-harvest period (Walters *et al*., 2005). During storage, seed quality is determined by several factors like environmental conditions during seed production, pests,

diseases, seed oil content, seed moisture content, mechanical damages of seed in processing, storage longevity, packaging materials, pesticides, air temperature and relative air humidity in storage and biochemical injury of seed tissue (Tekrony *et al*., 1987; Al-Yahya, 2001; Guberac *et al*., 2003; Heatherly and Elmore, 2004). Apart from this, fungi associated with stored seeds are mainly responsible for deterioration of quality and reduction in germination potential.

It is obviously known that study improved hermetic storage is a method of using sealed, airtight units to control moisture and insects in stored dry agriculture commodities. The hermetic storage restricts gas exchanges between the internal and external environments and the stored commodity, maintaining the initial levels of moisture and controlling pests by the lack of oxygen. Apart from this there was little information about the impact of these packaging materials on seed quality (Viability and vigor) of stored seed for various storage duration in Ethiopia. So that, evaluating the performance of different packaging materials on seed physiology of a crop is important for small farmers group of Ethiopia. Therefore, this experiment was conducted with the objective of determining the effects of different packaging materials for field pea seed quality over various storage periods.

2. MATERIALS AND METHODS

The experiment was carried out during 2018 to 2020 using seeds of field pea variety Tegegnch at Holeta Agricultural research center seed laboratory. A 30 kg homogenized pre-basic seed of field pea crop produced in 2018 main cropping season were used for the experiment. For this experiment 5 x 5 factorial combination of completely randomized design in four replications was used. The factors considered were: five packaging materials (Jute bag, Polypropylene bag, Polypropylene bag with polyethylene sheet lining (Fertilizer bag), PICS bag and Grain Pro Super bag) and five storage months [0 (Initial/before packaging and storage), 6, 12, 18 and 24 months) at seed storage room of Holeta agricultural research center. Initial/ before packaging and storage data were taken as control and sample were recorded every six months for two year

2.1. Data Collected include

Moisture Content: Moisture content was determined by using the indirect moisture testing meter Granomat following international rules for seed testing in the seed technology laboratory of Holetta Agricultural Research Center.

Thousand seed weight: was determine by using seed counter machine and weighing 1000 seeds by using Sensitive balance**.**

Standard Germination test: Standard germination test was done by using Four hundred (400) seeds were randomly taken from mixed pure seed and divided in to four replicates of 100 seeds each. The seeds were sown in sterilized sand medium and kept in Seed germinator at room temperature. The first count was done on 5^{th} day after planting for field pea, 4^{th} day after planting for barely and final count was done on 8th day. Seedling was evaluated in to normal, abnormal. Seedling, Hard and dead seed. The standard germination was calculated in percentage (ISTA, 1996) as follow:

$$Germination(\%) = \frac{Total\ Number\ of\ \ normal\ Seeedling}{Total\ Number\ of\ Seeds\ Planted}\ X\ 100\%$$

Shoot and root length: The seedling shoot length and seedling root length were assessed after the final count in the standard germination test. Ten normal seedlings were randomly selected from each replicate. The shoot length was measured from the point of attachment to the cotyledon to the tip of the seedling. Similarly, the root length was measured from the point of attachment to the cotyledon to the tip of the root. The average shoot or root length was computed by dividing the total shoot or root lengths by the total number of normal seedlings measured (Fiala, 1987).

Seedling dry weight: The seedling dry weight was measured after the final count in the standard germination test. Ten seedlings randomly selected from each replicate were cut free from their cotyledons and placed in envelopes and dried in an oven at 80 ± 1 °C for 24 hours. The dried seedlings were weighed to the nearest mill-gram and the average seedling dry weight was calculated.

Vigor Index test: The seedling vigor index was calculated for each sample as per Abdul Baki and Anderson (1973) and expressed in number by using formula below. Seedling vigor index 1 was calculated by multiplying the standard germination with the average sum of shoot length and root length after 8 days of germination and vigor index 2 was again calculated by multiplying the standard germination with mean seedling dry weight (drying at temperature of 80^0c for 24

hours). The formula for these parameters: SVI1 = Standard germination × mean seedling length (Roots +Shoots length) SVI2 = Standard germination × mean seedling dry weight

Speed of germination: Speed of germination is also another indicator used for assessing the vigor of seeds. Speed of germination (GS) was calculated (Maguire, 1962) as follows:

$$SG = \frac{Number\ of\ Normal\ Seedlings + \cdots + Number\ of\ Normal\ Seedlings}{Days\ of\ First\ Count \qquad\qquad Days\ of\ Final\ Count}$$

Field Emergence Index: All treatments were sown in a pot experiment using well prepared soil for emergence. 4x100 seeds were planted from each variety. The emergence data were recorded daily until further emergence stopped. The field emergence index was calculated by dividing the number of seedlings emerged at each day with the number of days in which they were emerged (Yang *et al*., 2005).

$$EI = \frac{Number\ of\ Seedlings\ Emerged}{Days\ of\ First\ Count} + \ldots + \frac{Number\ of\ Seedling\ Emerged\ at\ Final\ Count}{Days\ of\ Final\ Count}$$

Number of Damaged Seed Per Jar: Was determined as the number of infested seeds i.e., number of seed with sting, window or hollow marks caused by the weevil per 200 grams of jar.

Number of Bruchi*d* pisorum: Was determined as the number of infested seeds i.e., number of seed with sting, window or only one hollow mark caused by the weevil per 200 grams of jar.

Number of Bruchid chenensis: Was determined as the number of infested seeds i.e., number of seed with more than one hollow mark caused by the weevil.

Seed health testing: Seed sample were studied for association of different fungal and bacterial seed- borne pathogen. The procedure for Isolation of seed borne bacteria and fungi was similar whereas the identification was different. Seed borne pathogens were tested by using agar plate method (for internal pathogens). The Seeds were treated with 1% sodium hypochlorite (NaOCl) solution for five minutes. Ten seeds were placed at equal distance on Petri-dishes which replicate four times and then incubated at a temperature of 25^0C with alternating light and dark period of 12 hours for eight days and then slides were prepared in order to identify. Identification for seed borne fungi was based on morphological traits including colony features, structures, and spores using stereo- and compound-microscopes.

$$\boldsymbol{Seed\ infection}(\%) = \frac{\boldsymbol{Number\ of\ infected\ seed}}{\boldsymbol{Total\ number\ of\ seed}} \times \mathbf{100}\%$$

2.2. Data analysis

The data obtained from each treatment were analyzed using SAS version 9.3 mean comparisons among treatments were done using the Tukey's Studentized Range (HSD) test at 5% level of significance.

3. RESULT AND DISCUSSION

3.1. Moisture, thousand seed weight, standard germination and vigor index one

Analysis of variance result showed that there was significance (P<0.01) effect among packaging materials, storage periods and their interaction effect for moisture content, thousand seed weight, germination percentage and vigor index-I of field pea seed (Table 1). The initial moisture content of field pea seed was 10.68% at the beginning of storage experiment. There was a significant increase in moisture content of seeds stored in jute bag and polypropylene bags without polyethylene sheet lining (Table 1). Hermetic bags and polypropylene bags with polyethylene sheet lining maintained the initial moisture content with slight change. According to this study as storage period is progressed moisture content was increased for field pea seed stored in Jute bag and polypropylene bag without polyethylene sheet lining this might be due to the hygroscopic nature of seed i.e seed stored in jute bag and polypropylene bag without polyethylene sheet lining can easily absorb moisture from air to it selves as compared to those of seed stored in supper grain pro bag and PICS bag acts as moisture entry barriers and also maintained the lower moisture content in the seed. Our finding is in line with the finding of (Mohammad *et al*., 2016) who found that pea seed stored on different air tight storage container namely tin and plastic container recorded lowest moisture content (9.25%) after 15-day storage duration as compared to none air tight (gunny) container which records (14%) moisture content.

According to the present study the thousand seed weight of field pea seed was also increased proportionally with increased moisture content for seed stored by exposed storage materials. The highest 253.1g and 218g thousand seed weight were recorded for field pea seed stored for eighteen months in Jute bag and polypropylene bag without polyethylene sheet lining respectively whereas, the lowest 196g and 198.7g thousand seed weight was recorded for field pea seed stored in PCIS bag and polypropylene bag polyethylene sheet lining respectively. Mohammad *et al*., 2016 also stated that 1000-seed weight was increased in gunny bag compared to poly bag and plastic container due to gaseous exchange between seed and environment.

Germination percentage of field pea seed is significantly influenced by different packaging materials under different storage months. As germination percentage is the indictor of seed viability the result showed that seed stored in different packaging materials under various storage months-maintained seed quality and field pea seed stored in jute bag for 18 and 24 months showed a rapid decrease in viability but, not below the acceptable standard level. The highest germination percentage (98.75) and (98.25) were recorded for field pea seed stored in PICS bag for 6 and 12 months respectively followed by seed stored for 6 and 12 months in polypropylene bag with polyethylene sheet lining (Fertilizer bag) and supper grain pro bag which recorded (97%) whereas, the lowest germination percentage (91.5), (87.75) and (88) were recorded for seed stored in Jute bag for 6, 18 and 24 months respectively which was at par with seed stored in polypropylene bag without polyethylene sheet lining (B) for 24 month which records (91.00%). According to this study polyethylene sheet lining (Fertilizer bag) records almost similar values with that of hermetic storage materials (PICS bag and supper grain pro bag). Result for the lowest germination percentage for seed stored in jute bag might be due to seed damaged by *Bruchids* as it feeds the germinating embryo which final reduce germination percentage. On the other hand, the highest germination percentage in case of seed stored in PICS bag might be due to air tight condition of the container makes the *bruchid*/ insect to lack the oxygen for its life. Our study is in line with the finding of Mohammad *et al*., 2016 who reported that the seed stored by hermetic storage container (plastic container) showed the highest germination 69-85%, whereas, the lowest germination found in non-hermetic (gunny bag) (56-78%) during 15, 30, 45 and 60 days of storage duration.

Concerning vigor index-I the highest (2131.30) and (2127.80) were recorded for field pea seed stored in PICS bag and polypropylene bag with polyethylene sheet lining (Fertilizer bag) for 24 month respectively followed by seed stored in polypropylene bag without polyethylene sheet lining and seed stored in supper grain pro bag for 24 months which recorded (2027.40) and (2077.60) respectively whereas, the lowest (414.20) was recorded for seed stored in supper grain pro bag stored for 6 month followed by seed stored in Jute bag for 6 and 12 months and seed stored in polypropylene bag with polyethylene sheet lining (Fertilizer bag) for 12months and seed stored in polypropylene bag without polyethylene sheet lining for 12 months which recorded (594.60), (630.90), (599.10) and (604.70) respectively whereas, the other showed an intermediate value. As vigor index-I is the summation of germination percentage and mean seedling length the increment in case of vigor index one is due to the increasing of the two parameters (variables).

Table 1: Interaction effect of packaging materials and storage period on moisture content, thousand seed weight, standard germination and vigor index one of field pea seed.

Storage period (months)	Packaging materials	Moisture content (%)	Thousand seed weight(g)	Germination percentage (%)	Vigor index - I
Initial	All	10.68defg	208.25cd	94.5abc	683.1e
6 months	Jute	12.38a	214.8bcd	91.5cd	594.6ef
6 months	PPB	11.925abcd	208.88cd	95abc	687.4e
6 months	PPBPE	10.8bcdef	198.7ef	97ab	655.4e
6 months	PICS	10.7cdefg	196f	98.75a	706e
6 months	SGB	10.35efgh	210.4bcd	97ab	414.2f
12 months	Jute	11.03bcde	214bcd	92bcd	630.9ef
12 months	PPB	10.25efgh	206.8de	95abc	604.7ef
12 months	PPBPE	9.48gh	208.3cd	97ab	599.1ef
12 months	PICS	9.5fgh	208cd	98.25a	707.9e
12 months	SGB	9.23h	209.9cd	97ab	724.9e
18 months	Jute	12abc	253.1a	87.75d	1429.2d
18 months	PPB	12.1ab	218.1b	92.25bcd	1638cd
18 months	PPBPE	11.08abcde	214.1bcd	94.75abc	1659.7cd

18 months	PICS	10.88bcde	213.1bcd	95.5abc	1697.9c
18 months	SGB	11.10abcde	215.7bc	96.25abc	1728.2c
24 months	Jute	11.25abcde	216.02bc	88.00d	1867.30bc
24 months	PPB	11.25abcde	211.59bcd	91.00cd	2027.40ab
24 months	PPBPE	10.88bcde	209.11bcd	94.50abc	2127.80a
24 months	PICS	10.68def	210.30bcd	95.25abc	2131.30a
24 months	SGB	10.70def	212.19bcd	95.25abc	2077.60ab
Std. Error		**0.24**	**1.70**	**1.00**	**44.66**
Tukey's HSD		**1.26****	**9.14****	**5.47***	**238.65****
CV (%)		**4.34**	**1.61**	**2.12**	**7.93**

Note: Jute= Jute bag, PPB= polypropylene bag without polyethylene sheet lining, PPBE= polypropylene bag with polyethylene sheet lining (Fertilizer bag), PICS= Purdue Improved Crop Storage bag and SGB= Supper GrainPro bag. Means followed by the same letter(s) at each column and row are not significantly different from each other at 0.05 level of probability.

3.2. Speed of germination, seedling dry weight, vigor index two and field emergence index

Analysis of variance showed that highly (P<0.01) significance difference among storage months and non-significant difference was observed among the packaging materials and their interaction effect for speed of germination, seedling dry weight, vigor index-II and field emergence index. As storage months are progressed the values for speed of germination, seedling dry weight, vigor index-II and field emergence index were significantly reduced for field pea seed. (Table2).

At the beginning of the experiments speed of germination recorded 28.89 and at the final storage months/ 24 months the recorded value was highly reduced and which recorded 15.32. Our present finding is in agreement with the finding of Khadtar *et al*., 2018 who stated that speed of germination of Cowpea seed was found to be decreased with advancement of storage period irrespective of packaging material. The change in seedling dry weight, vigor index-II and field emergence index were statistically non-significant from initial to 12 months storage periods but, there was a considerable reduction at 18 and 24 months and the reduction was almost by half of the initial values.

Table 2: Main effect of storage months on speed of germination, seedling dry weight, vigor index two and field emergence index of field pea seed.

Storage period (months)	Speed of germination	Seedling dry weight(mg)	Vigor index - II	Field emergence index
0(Initial)	28.89a	952.5a	90070a	13.40a
6	16.97bc	916a	87940a	13.43a
12	17.20b	1048a	100716a	12.62a
18	15.56cd	227b	21181b	7.16b
24	15.32d	581.00b	54122b	6.55b
Std. Error	0.39	48.03	4731.81	0.22
Tukey's HSD	1.51**	191.64**	18624**	0.85**
CV (%)	9.08	4.35	2.57	9.04

Note: Means followed by the same letter(s) at each column are not significantly different from each other at 0.05 level of probability.

3.3. Shoots and root length of field pea seed.

Analysis of variance result showed that highly (P<0.01) significance difference was observed among, Packaging materials, storage month and their interaction for shoot length and non-significant difference among packaging materials and highly significant difference (P<0.01) was observed among storage months and their interaction for root length of field pea seed (Table 3).

Shoot length was significantly influenced by packaging materials, storage months and their interaction effect which is presented in table 3 below. The initial shoot length of field pea seed is obtained (14.30cm). Field pea shoot length was highly reduced after 6 months storage periods for all packaging materials as compared to initial value and the reduction was almost by half of the initial value.

Concerning root length somewhat decreasing pattern was observed when the storage month progressed as compared to the recorded initial/before packaging and storage value. The recorded value for root length ranges from 6.03 cm to 11.70 cm and the highest root length (11.70 cm) was recorded for initial/before packaging and storage followed by seed stored for 6 month in supper grain pro bag and PICS bag which recorded (10.58cm) and (10.25 cm) respectively whereas, the lowest root length (6.03 cm and 6.23 cm) was recorded for field pea seed stored for 12 month in polypropylene bag without polyethylene sheet lining and polypropylene bag with polyethylene sheet lining (Fertilizer bag) respectively followed by seed stored for 24 months in PICS bag, supper grain pro bag and Jute bag which recorded (6.78 cm), (6.83 cm) and (6.95 cm) respectively whereas, the other combination showed an intermediate values.

Table 3: Interaction effect of packaging materials and storage months on shoot and root length of field pea seed.

Storage period (months)	Packaging materials	Shoot length (cm)	Root length(cm)
Initial	All	14.30a	11.70a
6 months	Jute	6.42d	7.58cdef
6 months	PPB	7.14cd	9.16bc
6 months	PPBPE	6.66cd	9.14bc
6 months	PICS	7.05cd	10.24ab
6 months	SGB	4.16e	10.58ab
12 months	Jute	6.78cd	7.68cdef
12 months	PPB	6.30d	6.03f
12 months	PPBPE	6.13d	6.23f
12 months	PICS	7.13cd	7.58cdef
12 months	SGB	7.40cd	7.30def
18 months	Jute	7.47cd	8.79bcd
18 months	PPB	9.55b	8.22cde
18 months	PPBPE	8.56bc	8.96bcd
18 months	PICS	9.43b	8.35cdf
18 months	SGB	9.79b	8.15cdf
24 months	Jute	6.28d	6.95ef
24 months	PPB	6.32d	7.25def
24 months	PPBPE	7.43cd	7.25def
24 months	PICS	7.48cd	6.78ef
24 months	SGB	7.10cd	6.83ef
Std. Error		**0.50**	**0.34**
Tukey's HSD		**1.90****	**1.81****
CV (%)		**8.03**	**7.74**

Note: Jute= Jute bag, PPB= polypropylene bag without polyethylene sheet lining, PPBE= polypropylene bag with polyethylene sheet lining (Fertilizer bag), PICS= Purdue Improved Crop Storage bag and SGB= Supper GrainPro bag. Means followed by the same letter(s) at each column and row are not significantly different from each other at 0.05 level of probability.

3.4. Effect of packaging materials and storage months on number of damage seed per jar (NDSPJ), Number of *Bruchid pisorum* and Number of *Bruchid chenensis* (NBC) of field pea seed.

Effect of packaging materials and storage months on number of damage seed per jar (NDSPJ), number of *Bruchid pisorum* and number of *Bruchid chenensis* (NBC) of field pea seed were given in figure 1. According to analysis of variance result highly ($P<0.05$) significance difference was observed among packaging materials, storage months and their interaction for both number of damage seed per Jar (NDSPJ) and number of *Bruchid. pisorum*(NBP). There was no recorded *Bruchids* infestation at initial (before packaging and storage) and also there was no recorded *Bruchid chenensis* at all storage months. After six-month storage duration the highest number of damaged seed per jar/number of *Bruchid Pisorum* was recorded for seed stored in non-air tight storage namely jute bag (7.62) and polypropylene bag without polyethylene sheet lining (7.52) followed by seed stored in polypropylene bag with polyethylene sheet lining (3.85) and PICS bag (3.34) while the lowest was recorded supper grain pro bag (1.05). Even though, there were non-significant differences between packaging materials after twelve-month storage period; Supper grain pro bag and polypropylene bag

with polyethylene sheet lining showed least infestation as compared to the other packaging materials. After eighteen-month storage both number of damage seed per Jar (NDSPJ) and number of *Bruchid. pisorum*(NBP) was dramatically higher for all packaging materials and similar to twelve month storage there was no differences between packaging materials after eighteen month storage period but, PCIS bag and supper grain pro bag showed least infestation which recorded 14.60 and 15 values respectively as compared to the other packaging materials while, the highest (20), (19.60) and (18.30) were recorded for seed stored in non-air tight storage materials namely polypropylene bag with polyethylene sheet lining, Jute and polypropylene bag without polyethylene sheet lining respectively.

Like that, of eighteen-month storage similar trend was observed after twenty-four-month storage that means the number of damaged seed per Jar/number of *Bruchid. Pisorum* (NBP) was increased for all packaging materials except, for PICS and supper grain pro bag. The highest infestation (38.30), (37.00) and (20) were recorded for non-hermetic storage materials namely polypropylene bag without polyethylene sheet lining, Jute and polypropylene bag with polyethylene sheet lining respectively while, the lowest (4.00) and (4.33) were recorded for hermetic storage materials namely PICS and supper grain pro bag respectively. According to this study at all storage months' air tight packaging materials showed promising response or lowest insect damage as compared to other exposed storage materials and as the storage month progressed the number of damaged seed per Jar/number of *Bruchid. Pisorum* (NBP) was increased. The increased insect population in the seed stored for progressed storage periods might be due to higher moisture content and aeration which enhanced seed deterioration (Monira *et al.*, 2012).

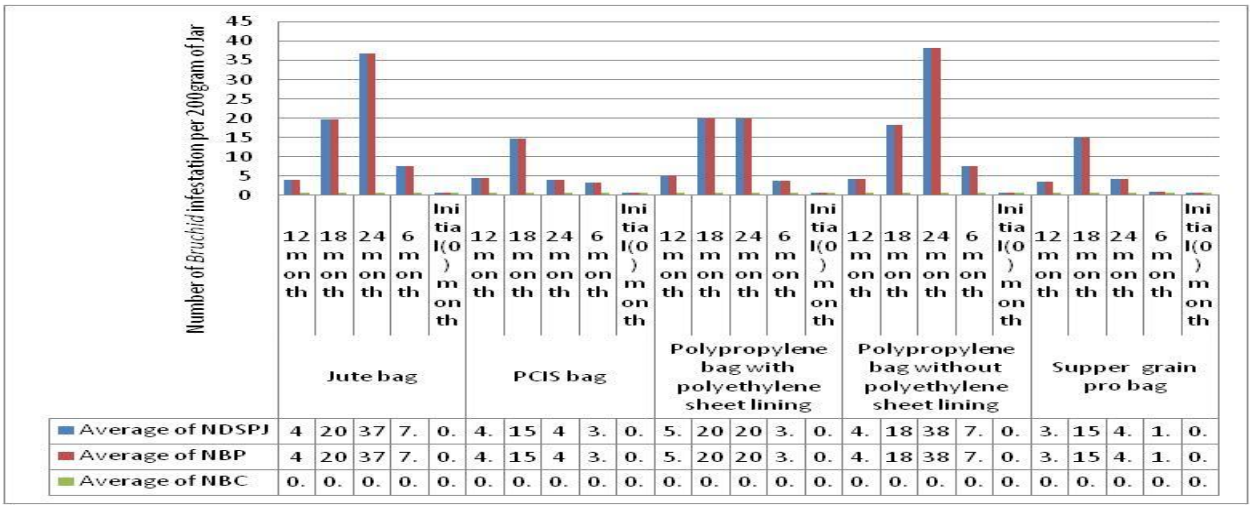

Figure 1: Interaction effect of packaging materials and storage months on number of damage seed per jar (NDSPJ) and Number of *Bruchid Pisorum* of field pea seed.

3.5. Seed health

Mean percentage of fungi associated with field pea seed stored in different packaging materials for various storage months are given in figure 2, figure 3, figure 4 and figure 5. Several fungal were associated with field pea seed stored in different storage materials for various storage months. The observed fungal are *Ascochyta* sp, *Penicillium* sp, *Bipolaris cynodentis*, *Alternaria* sp, *Aspergillus* sp, *A.flavus*, *A.niger*, *Rhizopus*, *Eppiccocum nigrum*, *Trichoderma*, *Fusarium* sp and *Botrytis* sp. From figure 2 below the highest number (13), (12.5), (12), (10.7) and (5.5) of *Ascochyta* sp was recorded for seed stored for twenty-four months in polypropylene bag with polyethylene sheet lining, PICS bag, polypropylene bag without polyethylene sheet lining, Jute bag and supper grain pro bag respectively. Also, from figure 3 below the highest number of Rhizopus *sp* (7), (4.5) and (3.2) was recorded for seed stored for 24 months in PICS bag, polypropylene bag without polyethylene sheet lining and Jute bag. Similarly, from figure 4 below the highest (4.5), (4.25) and (4) *Botrytis* sp was recorded for seed stored in polypropylene bag with polyethylene sheet lining for 24 months, for seed stored in polypropylene bag without polyethylene sheet lining for 24 months and for 12 months respectively. On the other hand at twenty four months storage periods there was no recorded *Penicillium* sp, *Bipolaris cynodentis*, *Alternaria sp*, *Aspergillus* sp, *A.niger*, *Eppiccocum nigrum* and *Trichoderma* fungus(Figure 1to 5). From Figure 5 fungus infection number range from lowest (10.00) for seed stored in supper grain pro bag for 24 months to highest (24.5) for seed stored in PICS bag for

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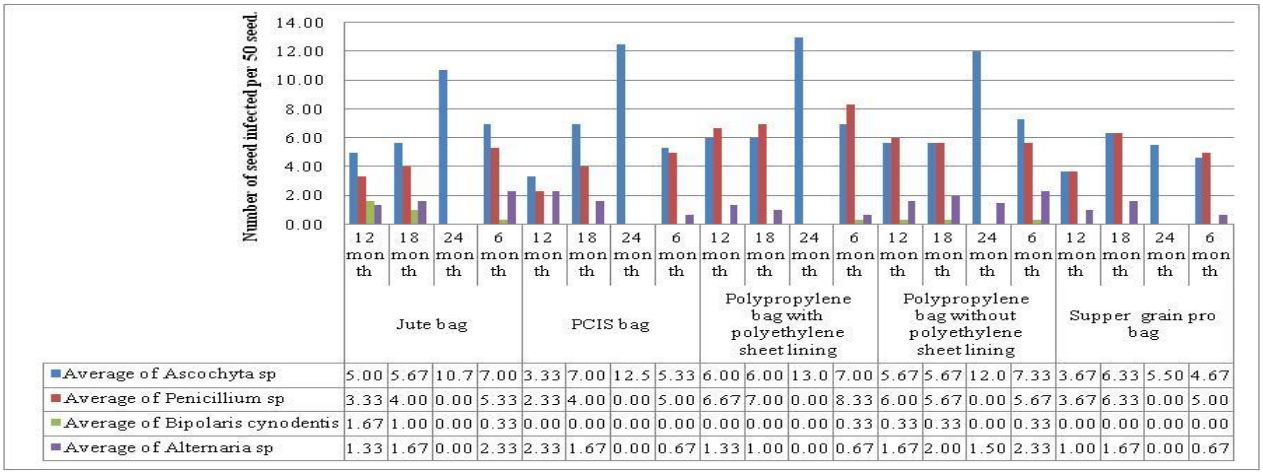
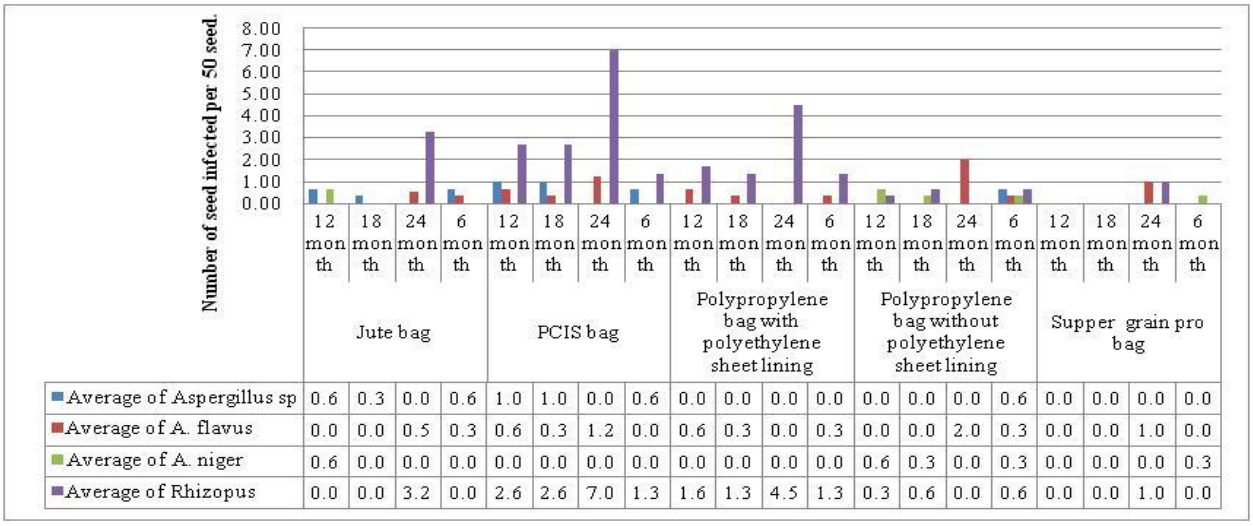
24 months. At 24 months' infection number was highest for all packaging materials than 6, 12 and 18 storage months. Concerning diseases incidence (contamination) percentage dramatically an increased infection percentage was recorded for seed stored for 24 months in all packaging materials as compared to other storage months. The highest (49%), (44%), (42%), (42%) and (40.67%) fungus contamination percentage was recorded for seed stored in PICS bag, polypropylene bag with polyethylene sheet lining, polypropylene bag without polyethylene sheet lining stored for 24 months, seed stored in polypropylene bag with polyethylene sheet lining and polypropylene bag without polyethylene sheet lining stored for 12 and 6months respectively. Seed stored in supper grain pro bag recorded lowest disease incidence as compared to other storage martials at all storage months. The lowest (10), (10.67), (11.33) and (14.67) disease incidence were recorded for seed stored in supper grain pro bag for 24, 12, 6 and 18 months respectively.

The present finding was in agreement with the finding of Mohammad *et al*., 2016 who reported *Fusarium*, *Ascochyta* and *Colletotrichum* fungus in pea seeds. He reported that 2.5, 2.7, 3.7 and 5.2 % fungal infection were observed in pea seeds at 15, 30, 45 and 60 days respectively at plastic container while 2.5, 4.5, 4.7 and 6% fungal infection at 15, 30, 45 and 60 days respectively at poly bag and 4.2, 4.6, 6.2 and 10.3% fungal infection at 15, 30, 45 and 60 days respectively at gunny bag. Mohammad *et al*., 2016 also concluded that highest fungal infections were observed in gunny bag.



	Jute bag				PCIS bag				Polypropylene bag with polyethylene sheet lining				Polypropylene bag without polyethylene sheet lining				Supper grain pro bag			
	12 month	18 month	24 month	6 month	12 month	18 month	24 month	6 month	12 month	18 month	24 month	6 month	12 month	18 month	24 month	6 month	12 month	18 month	24 month	6 month
Average of Ascochyta sp	5.00	5.67	10.7	7.00	3.33	7.00	12.5	5.33	6.00	6.00	13.0	7.00	5.67	5.67	12.0	7.33	3.67	6.33	5.50	4.67
Average of Penicillium sp	3.33	4.00	0.00	5.33	2.33	4.00	0.00	5.00	6.67	7.00	0.00	8.33	6.00	5.67	0.00	5.67	3.67	6.33	0.00	5.00
Average of Bipolaris cynodentis	1.67	1.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.33	0.00	0.33	0.00	0.00	0.00	0.00
Average of Alternaria sp	1.33	1.67	0.00	2.33	2.33	1.67	0.00	0.67	1.33	1.00	0.00	0.67	1.67	2.00	1.50	2.33	1.00	1.67	0.00	0.67

Figure 2: Mean percentage of fungi *Ascochyta* sp, *Penicillium* sp, *Bipolaris cynodentis* and *Alternaria* sp associated with field pea seed stored in different packaging materials for various storage months.



	Jute bag				PCIS bag				Polypropylene bag with polyethylene sheet lining				Polypropylene bag without polyethylene sheet lining				Supper grain pro bag			
	12 month	18 month	24 month	6 month	12 month	18 month	24 month	6 month	12 month	18 month	24 month	6 month	12 month	18 month	24 month	6 month	12 month	18 month	24 month	6 month
Average of Aspergillus sp	0.6	0.3	0.0	0.6	1.0	1.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0
Average of A. flavus	0.0	0.0	0.5	0.3	0.6	0.3	1.2	0.0	0.6	0.3	0.0	0.3	0.0	0.0	2.0	0.3	0.0	0.0	1.0	0.0
Average of A. niger	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3	0.0	0.3	0.0	0.0	0.0	0.3
Average of Rhizopus	0.0	0.0	3.2	0.0	2.6	2.6	7.0	1.3	1.6	1.3	4.5	1.3	0.3	0.6	0.0	0.6	0.0	0.0	1.0	0.0

Figure 3: Mean percentage of fungi *Aspergillus* sp, *A.flavus* sp, *A.niger* and *Rhizopus* sp associated with field pea seed stored in different packaging materials for various storage months.

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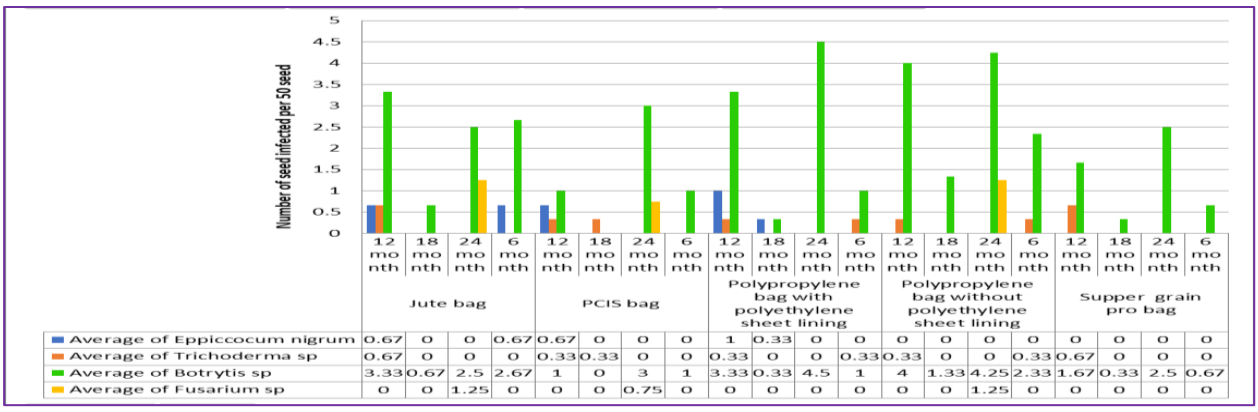

	Jute bag				PCIS bag				Polypropylene bag with polyethylene sheet lining				Polypropylene bag without polyethylene sheet lining				Supper grain pro bag			
	12 month	18 month	24 month	6 month	12 month	18 month	24 month	6 month	12 month	18 month	24 month	6 month	12 month	18 month	24 month	6 month	12 month	18 month	24 month	6 month
Average of Eppiccocum nigrum	0.67	0	0	0.67	0.67	0	0	0	1	0.33	0	0	0	0	0	0	0	0	0	0
Average of Trichoderma sp	0.67	0	0	0	0.33	0.33	0	0	0.33	0	0	0.33	0.33	0	0	0.33	0.67	0	0	0
Average of Botrytis sp	3.33	0.67	2.5	2.67	1	0	3	1	3.33	0.33	4.5	1	4	1.33	4.25	2.33	1.67	0.33	2.5	0.67
Average of Fusarium sp	0	0	1.25	0	0	0	0.75	0	0	0	0	0	0	0	1.25	0	0	0	0	0

Figure 4: Mean percentage of fungi *Eppiccocum nigrum*, *Trichoderma*, *Botrytis* sp and *Fusarium* sp associated with field pea seed stored in different packaging materials for various storage months.

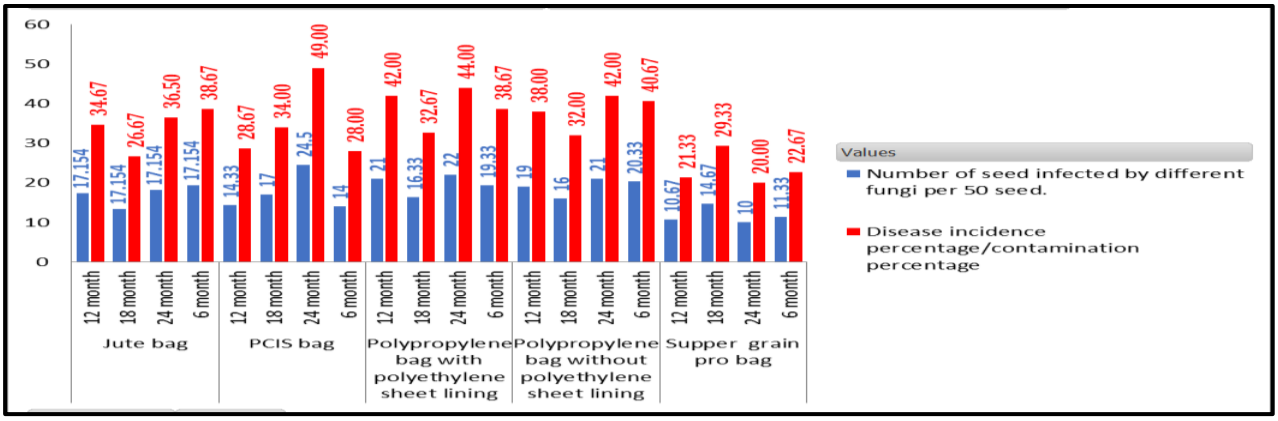

Figure 5: Number of seed infected by different fungi per 50 seed and diseases incidence percentage or contamination percentage of field pea seed stored in different packaging materials for various storage months.

3.6. Correlation coefficient (r) between disease incidence percentage, number of bruchid infestation and other laboratory seed quality parameters.

Correlation analysis between number of Bruchid infestation and the other seed quality parameters showed that highly significant associations were observed between moisture content, thousand seed weight, standard germination, speed of germination, shoot length, seedling dry weight, vigor index one, vigor index two, field emergence index and disease incidence percentage. However, non-significant associations were observed only for root length (Table 4). Strongly positive correlations were observed between *Bruchid Pisorum* with moisture content (r=0.38), thousand seed weight (r=0.33), shoot length (r=0.55), vigor index one (r= 0.63) and disease incidence percentage (r= 0.44) and Significantly negative correlations were observed among *Bruchid Pisorum* with standard germination (r= -0.60), speed of germination (r= -0.72), seedling dry weight (r = -0.48), vigor index two (r= -0.50) and field emergence index (r= -0.72).

Similarly, there were highly significant correlation between disease incidence percentage with that of speed of germination, shoot length, root length, vigor index one and field emergence index and non-significant difference were observed among disease incidence with that of moisture content, thousand seed weight, standard germination, seedling dry weight and vigor index two (Table 4). Strongly positive correlations were observed between disease incidence with shoot length (r=0.83) and vigor index one (r= 0.68). On the other hand, significantly negative correlations were observed among disease incidence with speed of germination (r= -0.31), root length (r = -0.40) and field emergence index (r= -0.55).

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Table 4: Correlation Coefficients(r) between disease incidence percentage, Number of *Bruchid. Pisorum* and laboratory seed quality parameters of field pea.

	MC	TSW	SG	SPG	SL	RL	SDW	VI1	VI2	FEI	NSI	DIP	NBP
MC													
TSW	0.40**												
SG	-0.4892**	-0.58**											
SPG	-0.2988**	-0.49**	0.74**										
SL	0.14^{NS}	0.03^{NS}	-0.26*	-0.39**									
RL	0.25*	-0.05^{NS}	0.13^{NS}	0.06^{NS}	-0.36**								
SDW	-0.38**	-0.42**	0.35**	0.45**	-0.35**	0.03^{NS}							
VI1	0.27*	0.26*	-0.29**	-0.47**	0.91**	-0.21^{NS}	-0.61^{NS}						
VI2	-0.40**	-0.44**	0.40**	0.47**	-0.36**	0.04^{NS}	0.99**	-0.62**					
FEI	-0.2606*	-0.46**	0.48**	0.63**	-0.74**	0.22*	0.66**	-0.90**	0.67**				
NSI	0.23*	-0.03^{NS}	-0.07^{NS}	-0.09^{NS}	0.41**	-0.31**	-0.14^{NS}	0.33**	-0.15^{NS}	-0.24^{NS}			
DIP	0.08^{NS}	-0.04^{NS}	-0.19^{NS}	-0.31**	0.83**	-0.4**	-0.18^{NS}	0.68**	-0.19^{NS}	-0.55**	0.74**		
NBP	0.38**	0.33**	-0.60**	-0.72**	0.55**	-0.13^{NS}	-0.48**	0.63**	-0.50**	-0.72**	0.25*	0.44**	

Note, ^{NS} **and * indicates non-significant, highly significant at 1% and significant at 5% level of probability respectively. MC= moisture contents, TSW= thousand seed weight, SG=standard germination, SPG= Speed of germination, SL= shoot length, RL=root length SDW=Seedling dry weight, SVI1= seedling vigor index 1, SVI2=seedling vigor index 2, FEI= Field Emergence index, NSI= number of seed infected by different fungi per 50 seed, DIP= Disease incidence percentage and NBP= Number of Bruchid *Pisorum*.

4. CONCLUSIONS

According to the results of this study it may be summarized that field pea seed quality was highly influenced by different packaging materials at various storage months. Generally from this study we observed that field pea seed stored in supper grain pro bag, PICS bag and polypropylene bag with polyethylene sheet lining(fertilizer bag) improved seed quality parameters at each storage months as compared to non-hermetic storage materials namely jute bag and polypropylene bag without polyethylene sheet lining so that, it was relatively good to store field pea seed in polypropylene bag with polyethylene sheet lining without losing viability for thus farmers who can't afford hermetic storage.

Seed quality was reduced for seed stored in Jute bag as compared to other packaging materials at each storage months.

The moisture content of the seeds is one of the most important factors influencing their viability in storage. As storage period is progressed both moisture content and thousand seed weight were increased for field pea seed stored in jute and polypropylene bag without polyethylene sheet lining. Concerning seed viability as germination percentage is usually the best indictor or methods of estimating seed viability field pea seed stored in jute bag and polypropylene bag without polyethylene sheet lining for 18 and 24 months showed a rapid decrease in viability/germination percentage and the recorded values are above the acceptable standards for field pea seeds. Generally according to this study as storage month progressed seed vigor testing parameters/variables are significantly reduced for field pea seed stored in all packaging materials and the reduction was highest for non-hermetic storage materials namely jute bag and polypropylene bag without polyethylene sheet lining.

Concerning Storage fungi several fungal were associated with field pea seed. The observed fungal are *Ascochyta* sp, *Penicillium* sp, *Bipolaris sp*, *Alternaria* sp, *Aspergillus* sp, *A.flavus*, *A.niger*, *Rhizopus*, *Eppiccocum nigrum*, *Trichoderma*, *Fusarium* sp and *Botrytis* sp, *Cladosporium* and *Phoma sp.* Concerning diseases incidence (contamination) percentage dramatically an increased infection percentage was recorded for seed stored for 24 months in all packaging materials as compared to other storage months for field pea seed. Concerning storage insect/ *Bruchids* for field pea seed there was no recorded infestation at initial (before packaging a storage) and also there was no recorded *Bruchid chenensis* at all storage months. According to this study at all storage months' air tight packaging materials showed promising response or lowest insect damage as compared to other exposed storage materials and as the storage month progressed the number of damaged seed per Jar/number of *Bruchid. Pisorum* (NBP) was increased. Correlation analysis between number of Bruchid infestation and the other seed quality parameters showed that highly significant associations were observed between moisture content, thousand seed weight, standard germination, speed of germination, shoot length, seedling dry weight, vigor index one, vigor index two, field emergence index and disease incidence percentage. Similarly, there were highly significant correlation between disease incidence percentage with that of speed of germination, shoot length, root length, vigor index one and field emergence index.

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