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# Effect of Packaging Materials on Seed Quality Attributes of Basmati Rice during Seed Storage under Ambient Environmental Conditions

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**ABSTRACT:** The present study was conducted to evaluate the effect of packaging materials on seed quality parameters of Pusa Basmati 1121 variety of basmati rice (*Oryza sativa* L.) during seed storage under ambient environmental conditions. The seeds (four months after harvest) were desiccated to 13, 10 and 8% moisture levels and were stored at room temperature in laminated and non-laminated polypropylene bags for 10 months. The seeds with 13% moisture content stored in jute bags served as control. All seed storage treatments recorded a gradual decrease in germination, seedling vigour index and speed of germination with increase in seed storage duration from 5 to 14 months; however electrical conductivity and moisture content of seeds recorded a gradual increase with increased storage duration. The results indicated that seeds stored in laminated and non-laminated polypropylene bags as well as jute bags complied with germination standard as per IMSCS (80%) upto 12 months of seed storage. The seeds with different moisture content stored in any of the packaging materials did not met IMSCS after 12 months of seed storage. Thus, polypropylene bags either laminated or non-laminated can be used as cost effective packaging material in place of jute bags as the cost of polypropylene bags is approximately half the cost of jute bags.

**Keywords:** Germination, Polypropylene, Speed of germination, Electrical conductivity, Vigour

There is increasing demand of basmati rice due to its long grain size and aroma than non-basmati rice. The area under basmati rice production in India is about 7 million hectares and its productivity is 11 million metric tons. India is the leading producer and exporter of basmati rice to global market [1]. In India, the highest area under basmati rice is in Haryana (44%) followed by Punjab (28%) and Uttar Pradesh (24%).In Punjab, area under cultivation of basmati rice was around 5.50 lakh ha in *kharif* 2019 [2]. There are many basmati varieties recommended for cultivation in Punjab viz., Pusa Basmati 1637, Punjab Basmati 5, Punjab Basmati 4, CSR 30, Punjab Basmati 3, Pusa Basmati 1509, Basmati 370, Punjab Basmati 2 and Pusa Basmati 1121. The most widely cultivated basmati variety in Punjab is Pusa Basmati 1121 as it has highly aromatic and long slender grains and has high yield (13.7 quintals per acre) [2]. But viability of Pusa Basmati 1121 seeds is a major issue when stored under ambient storage conditions.

The production of quality seeds is the main factor governing production and productivity of crops. In India, 80 per cent of the crop seeds are kept under storage conditions for minimum one planting season and the remaining 15-20 per cent is carried over for subsequent sowing [3]. The two important factors that influence seed longevity are storage temperature and seed moisture content [4].At the time of harvesting of Basmati rice (first fortnight of November), temperature starts declining and thus seeds have relatively higher moisture content than recommended moisture content of 13% for safe seed storage. High moisture content of seeds may impair their viability during storage. For safe and long term seed storage, seeds have to be desiccated to low seed moisture content and kept at low relative humidity and low temperature [5,6]. The maintenance of low temperature for storage of seeds is quite expensive, as cost of installation and maintenance of refrigeration and dehumidification equipments is very high [7]. Temperatures exceeding 25°C are deleterious to retain the physiological attributes of seeds due to physiological and biochemical changes occurring at high temperature [8].

Under ordinary storage conditions, seed desiccation upto 10 per cent moisture content seems to be suitable for 12 to 18 months storage of cereal seeds [9]. The increase in seed moisture content increases the rate of seed deterioration. In most cases farmer's stored seeds are severely infested with pests and moulds that usually exhibit poor germination [10]. Seed moisture content fluctuates and retains equilibrium with prevailing relative humidity because of hygroscopic nature of seeds under ambient storage conditions. Hence, to retain seed viability for long duration, desiccated seeds must be kept in appropriate containers/packaging materials to escape direct interactions between storage environment and seed materials. Many storage bags such as purdue improved crop storage (PICS) bags, polypropylene (PP) bags, cloth bags, hermetic bags, jute bags etc. are used for storage of seeds. Polypropylene bags are prepared by fusing together flat and long sheets of polypropylene fibres. Molecular formula of polypropylene is $(C_3H_6)_n$. Melting point of polypropylene is about 320°Fahrenheit. Once the chemicals have been bonded, they are melted and pressed through tight rollers for making a thin fabric. This process is termed extrusion and moulding. Unlike cotton or other natural fibres like jute that are woven, polypropylene is not woven and is termed as "non-woven" in the fabric industry. Two types of polypropylene bags are available in the market- laminated and non-laminated based on presence and absence of laminated sheath having variable thickness. These bags are tough, durable, porous and cost effective. For the purpose of seed sale, jute bags are commonly used for seed packaging. The polypropylene bags either laminated or non-laminated if used as packaging material in place of jute bags can reduce the cost of seed packaging as their cost is less than half of jute bags (Table 1). But information regarding seed quality of Pusa Basmati 1121 is not available w.r.t seeds desiccated to different moisture contents followed by their storage in laminated and non-laminated polypropylene bags. So, present study was conducted to evaluate the seed quality attributes of Pusa Basmati 1121 variety of basmati rice after seed desiccation to different moisture levels followed by their packaging in laminated and non-laminated polypropylene bags.

## MATERIALS AND METHODS

The seeds of Pusa Basmati 1121 (three months after harvest) were procured from Office of Director (Seeds), Punjab Agricultural University, Ludhiana during March 2019 (crop was harvested in the month of November 2018). Initial germination of seed lot as well as its seedling vigour index was determined. The seeds were desiccated to three moisture levels viz., 13, 10 and 8% using fused $CaCl_2$ as a desiccant and stored separately in laminated and non-laminated polypropylene bags having capacity of 24kg. Seeds with 13% moisture content stored in 24 kg jute bags is the recommended practice for seed sale and was taken as control. The dimensions of jute bags and laminated/non-laminated polypropylene bags were 55x85cm and 55x87.5cm, respectively. The thickness of polyethylene sheet used for lamination was 50 gauge in laminated polypropylene bags. There were seven seed storage treatments and details are given in Table 1. Following seed quality parameters were recorded at monthly intervals after seed storage for 10 months starting from 5 months after seed harvest.

### Germination (%)

The germination studies were conducted in the laboratory using 'between paper' method as per International Rules for Seed Testing [11]. Four replications with one hundred seeds per replication were placed on germination paper

**Table 1.** Seed storage treatments

| S. No. | Treatments | Price of one 24 kg capacity bag (Rs.) | Cost of 4.58 lakh bags* (Rs) |
|---|---|---|---|
| $T_1$ | Seeds with 13% moisture content stored in jute bags (control) | 53 | 2,42, 74,000 |
| $T_2$ | Seeds with 13% moisture content stored in laminated polypropylene bags | 25 | 1,14, 50,000 |
| $T_3$ | Seeds with 10% moisture content stored in laminated polypropylene bags | 25 | 1,14, 50,000 |
| $T_4$ | Seeds with 8% moisture content stored in laminated polypropylene bags | 25 | 1,14, 50,000 |
| $T_5$ | Seeds with 13% moisture content stored in non-laminated polypropylene bags | 21 | 96, 18,000 |
| $T_6$ | Seeds with 10% moisture content stored in non-laminated polypropylene bags | 21 | 96, 18,000 |
| $T_7$ | Seeds with 8% moisture content stored in non-laminated polypropylene bags | 21 | 96, 18,000 |

*In Punjab, an area of 5, 50,000 ha was under basmati rice cultivation in *kharif* 2019. As 20 kg seed is required per hectare area; thus 1,10, 000 quintal seed is required for which approximately 4.58 lakh bags of 24kg capacity are required.

and the rolled germination papers held in vertical direction were incubated in a BOD incubator maintained at 25°C. The final germination data was recorded on 14$^{th}$ day. The germinated seedlings were evaluated on 14th day and the germination was expressed in terms of per cent based on normal seedlings using the formula: [No. of seeds germinated/ total seed number] x 100

### Seedling vigour index (SVI)

For vigour index, ten germinated seedlings per replication were assessed on 14th day. The seedlings were measured for their root as well as shoot length using centimeter scale. The SVI I was estimated in accordance with [12]

SVI I = Germination (%) × average seedling length (cm)

### Speed of germination

For determining speed of germination, seeds were kept in moist Petri dishes for 14 days and number of seeds germinated each day were recorded as described by Association of Official Seed Analyst[13] using the following formula:

$$\text{Speed of germination} = \left(\frac{n1}{d1} + \frac{n2}{d2} + \frac{n3}{d3} + \ldots\right)$$

Where, n = number of seeds germinated

d= number of days.

### Mean germination time

The mean germination time (MGT) was calculated for each lot using the formula given by [14]

$$\text{MGT} = \left(\frac{n1 \times d1 + n2 \times d2 + n3 \times d3 + \ldots..}{\text{Total no. of seeds germinated}}\right)$$

Where, n= no. of seeds germinated, d = no. of days

### Seed moisture content

5g of seed sample was grounded and seed moisture content was measured by using moisture analyser and MX-50.

### Electrical conductivity

Electrical conductivity was determined as described by [15]. For determining electrical conductivity, seeds were washed with distilled water. After washing, three replications with 25 seeds per replication were added in the test-tube containing 30 ml distilled water and the samples were incubated at 25°C in an incubator. The seed leachates was collected after 24 hours in a separate beaker. Electrical conductivity was measured using digital Systronics Conductivity Meter 304.

### Statistical analysis

The experiment was conducted in factorial completely randomized design with two factors namely- storage treatments and storage durations. The data were subjected to analysis of variance (ANOVA) using CPCS1 software and treatments were compared at five per cent level of significance [16].

## RESULTS AND DISCUSSION

Data presented in Table 2 revealed that different seed storage treatments did not have any significant effect on germination; but there was significant decrease in

**Table 2.** Effect of different seed storage treatments on germination (%) of Pusa Basmati 1121variety of basmati rice after different seed storage durations

| Treatments | Seed storage duration (months) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Mean |
| $T_1$ | 90.3 | 88.3 | 86.3 | 84.0 | 84.0 | 81.3 | 79.3 | 78.0 | 76.3 | 75.3 | 82.3 |
| $T_2$ | 91.3 | 89.3 | 84.7 | 82.7 | 82.0 | 81.3 | 80.3 | 80.3 | 75.7 | 73.7 | 82.1 |
| $T_3$ | 86.0 | 85.0 | 82.7 | 82.3 | 82.3 | 81.7 | 81.0 | 81.3 | 76.7 | 76.7 | 81.6 |
| $T_4$ | 85.3 | 84.3 | 84.0 | 82.7 | 82.3 | 82.0 | 81.3 | 81.0 | 76.3 | 75.7 | 81.5 |
| $T_5$ | 92.7 | 90.3 | 86.3 | 82.3 | 82.0 | 81.3 | 81.0 | 80.3 | 77.3 | 77.3 | 83.1 |
| $T_6$ | 86.7 | 83.7 | 83.3 | 83.3 | 82.7 | 82.3 | 81.7 | 80.7 | 77.7 | 77.7 | 82.0 |
| $T_7$ | 87.3 | 83.7 | 83.0 | 82.0 | 81.7 | 81.0 | 81.0 | 81.0 | 78.7 | 78.3 | 81.7 |
| Mean | 88.5 | 86.4 | 84.3 | 82.8 | 82.4 | 81.6 | 80.8 | 80.4 | 76.9 | 76.4 | |
| SEm(±) | Storage treatments: 0.43 | | | | Storage durations: 0.52 | | | Interaction: 1.36 | | | |
| LSD (p=0.05) | Storage treatments: NS | | | | Storage durations: 1.44 | | | Interaction: NS | | | |

NS: Non Significant

**Table 3.** Effect of different seed storage treatments on seedling vigour index I of Pusa Basmati 1121 variety of basmati rice after different seed storage durations

| Treatments | Seed storage duration (months) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Mean |
| $T_1$ | 2536 | 2274 | 2143 | 2085 | 2020 | 1899 | 1658 | 1568 | 1522 | 1131 | 1884 |
| $T_2$ | 2619 | 2571 | 2372 | 2249 | 2177 | 2072 | 1719 | 1753 | 1556 | 1482 | 2057 |
| $T_3$ | 2659 | 2475 | 2388 | 2313 | 2253 | 2077 | 1747 | 1720 | 1583 | 1267 | 2048 |
| $T_4$ | 2537 | 2427 | 2360 | 2302 | 2268 | 2271 | 1812 | 1800 | 1616 | 1206 | 2060 |
| $T_5$ | 2658 | 2513 | 2410 | 2188 | 2060 | 1959 | 1773 | 1647 | 1544 | 1263 | 2001 |
| $T_6$ | 2842 | 2716 | 2272 | 2278 | 2020 | 2035 | 1852 | 1781 | 1648 | 1384 | 2083 |
| $T_7$ | 2626 | 2501 | 2340 | 2278 | 2307 | 2203 | 1880 | 1798 | 1714 | 1304 | 2095 |
| Mean | 2639 | 2496 | 2326 | 2242 | 2158 | 2074 | 1777 | 1724 | 1598 | 1290 | |
| SEm (±) | Storage treatments: 18.8 | | | | Storage duration: 22.5 | | | Interaction: 59.5 | | | |
| LSD (p=0.05) | Storage treatments: 52.7 | | | | Storage duration: 63.0 | | | Interaction: 166.6 | | | |

NS: Non Significant

germination of Pusa Basmati 1121 seeds with increase in seed storage duration from 5 to 14 months. The interaction effect was found to be non-significant. As per Indian Minimum Seed Certification Standards (IMSCS), the minimum germination standards recommended for paddy seeds is 80%. The seeds with different moisture contents stored in any of the packaging materials did not met IMSCS after 12 months of seed storage. All seed storage treatments maintained higher SVI I as compared to jute bags (control). There was gradual decline in seedling vigour index I (SVI I) with the increase in storage period. The interaction effect between seed storage treatments and storage duration was significant. SVI I of seeds with 13% moisture content stored in jute bags at the end of 12 months of seed storage was statistically at par to seeds with 13% moisture content stored in laminated polypropylene bags at the end of 11 months of seed storage (Table 3).

Different seed storage treatments recorded statistically similar germination speed. However, there was gradual decrease in speed of germination with increase in seed storage duration from 5 to 14 months. The interaction effect was non-significant (Table 4). There was gradual increase in mean germination time with the increase in seed storage period; however different seeds storage treatments recorded statistically similar mean germination time. The interaction effect was non-significant w.r.t mean germination time (Table 5).

Seadh *et al.* [17] reported that the germination (%) of rice var. Giza 178 decreased with increasing storage periods from 3 to 12 months after harvesting. They recorded highest germination (%) of seeds stored in metal packages, followed by those stored in polyethylene bags; while the lowest germination percentage was recorded of seeds stored in paper packages. Raja and Sasikala

**Table 4.** Effect of different seed storage treatments on speed of germination of Pusa Basmati 1121 variety of basmati rice after different seed storage durations

| Treatments | Seed storage duration (months) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Mean |
| $T_1$ | 9.64 | 9.40 | 8.67 | 8.33 | 7.88 | 7.73 | 7.58 | 7.24 | 6.57 | 6.35 | 7.94 |
| $T_2$ | 10.47 | 9.52 | 8.67 | 8.54 | 8.18 | 7.99 | 7.73 | 7.65 | 7.36 | 6.54 | 8.27 |
| $T_3$ | 9.76 | 8.65 | 8.16 | 8.09 | 7.99 | 7.90 | 7.78 | 7.30 | 7.28 | 6.80 | 7.97 |
| $T_4$ | 9.73 | 8.64 | 8.32 | 8.12 | 8.12 | 7.58 | 7.58 | 7.15 | 6.98 | 6.86 | 7.91 |
| $T_5$ | 9.63 | 8.62 | 8.28 | 8.05 | 7.67 | 7.60 | 7.50 | 7.45 | 7.38 | 6.85 | 7.90 |
| $T_6$ | 9.53 | 8.62 | 8.28 | 8.12 | 7.96 | 7.86 | 7.53 | 7.34 | 7.34 | 6.83 | 7.94 |
| $T_7$ | 9.74 | 9.32 | 8.71 | 8.69 | 7.73 | 7.72 | 7.69 | 7.52 | 7.45 | 7.39 | 8.20 |
| Mean | 9.79 | 8.97 | 8.44 | 8.27 | 7.93 | 7.77 | 7.63 | 7.38 | 7.19 | 6.80 | |
| SEm (±) | Storage treatments: 0.12 | | | | Storage duration: 0.14 | | | Interaction: 0.37 | | | |
| LSD (p=0.05) | Storage treatments: NS | | | | Storage duration: 3.93 | | | Interaction: NS | | | |

NS: Non Significant

**Table 5.** Effect of different seed storage treatments on mean germination time of Pusa Basmati 1121 variety of basmati rice after different seed storage durations

| Treatments | Seed storage duration (months) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Mean |
| $T_1$ | 2.85 | 2.95 | 3.59 | 5.12 | 6.70 | 7.19 | 7.22 | 7.59 | 8.53 | 8.93 | 6.07 |
| $T_2$ | 2.54 | 2.88 | 3.75 | 4.40 | 6.19 | 7.39 | 7.13 | 7.40 | 7.79 | 8.61 | 5.81 |
| $T_3$ | 2.80 | 3.43 | 3.77 | 5.42 | 6.21 | 7.37 | 7.47 | 8.77 | 8.27 | 7.99 | 6.15 |
| $T_4$ | 2.81 | 3.51 | 3.80 | 5.37 | 6.53 | 7.33 | 7.30 | 8.87 | 7.72 | 7.85 | 6.11 |
| $T_5$ | 2.85 | 3.56 | 4.11 | 5.76 | 7.06 | 7.21 | 7.89 | 8.26 | 7.84 | 8.46 | 6.30 |
| $T_6$ | 2.91 | 3.56 | 4.11 | 4.67 | 6.88 | 7.46 | 7.41 | 7.62 | 8.03 | 8.02 | 6.07 |
| $T_7$ | 3.02 | 3.26 | 3.54 | 4.36 | 6.58 | 7.50 | 7.81 | 8.13 | 7.78 | 8.45 | 6.04 |
| Mean | 2.83 | 3.31 | 3.81 | 5.01 | 6.59 | 7.35 | 7.46 | 8.09 | 7.99 | 8.33 | |
| SEm (±) | Storage treatments: 0.21 | | | | Storage duration: 0.25 | | | Interaction: 0.67 | | | |
| LSD (p=0.05) | Storage treatments: NS | | | | Storage duration: 0.70 | | | Interaction: NS | | | |

NS: Non Significant

[18] recorded that germination of rice var. ADT (R) 46 was reduced drastically to 39% (initial germination was 97%) during 10 months of rice seed storage irrespective of treatments and containers. The seeds stored in polylined gunny bags recorded higher germination percentage up to 6 months of seed storage. The viability and vigour of the seeds decreased slowly upto six months and drastic decline was recorded thereafter irrespective of the storage treatments. Naing *et al*.[19] recorded that seeds of rice variety Manawthukha had highest seedling vigor index at the end of 4 months of seed storage when stored in woven plastic bags followed by tight tin bin and bamboo basket. Padhi *et al.* [20] recorded the highest germination percentage and speed of germination in seeds of paddy cv. Naveen which were stored in polythene bags as compared to cloth bags at the end of 7$^{th}$ month of seed storage. In present study, the highest germination percentage, SVI I and speed of germination were recorded at 5 months of seed storage; and gradual decrease in these parameters was observed with increase in seed storage duration. The decrease in seedling vigour index and speed of germination with increased storage duration may be attributed to age induced variation in germination percentage.

There were no significant differences in electrical conductivity of Pusa Basmati 1121 seeds stored in different packaging treatments. The interaction effect was non-significant. However, all seed storage treatments exhibited an increase in electrical conductivity of seeds with increase in storage period (Table 6). The seeds of rice cv. Mugad sugandha recorded higher electrical conductivity when stored in cloth bags as compared to polythene bags for 20 months of seed storage [21].

**Table 6.** Effect of different seed storage treatments on electrical conductivity (µS cm$^{-1}$ g$^{-1}$) in seeds of Pusa Basmati 1121 variety of basmati rice after different seed storage durations

| Treatments | Seed storage duration (months) | | | | |
|---|---|---|---|---|---|
| | 5 | 8 | 11 | 14 | Mean |
| $T_1$ | 61.1 | 77.8 | 122.2 | 138.9 | 100.0 |
| $T_2$ | 94.4 | 122.2 | 144.5 | 166.7 | 131.9 |
| $T_3$ | 94.4 | 122.2 | 133.3 | 161.1 | 127.8 |
| $T_4$ | 105.6 | 111.1 | 144.4 | 166.7 | 131.9 |
| $T_5$ | 105.6 | 116.7 | 144.5 | 155.5 | 130.5 |
| $T_6$ | 111.1 | 111.1 | 133.3 | 161.1 | 129.2 |
| $T_7$ | 100.0 | 116.7 | 133.3 | 161.1 | 127.8 |
| Mean | 96.0 | 111.1 | 136.5 | 158.7 | |
| SEm (±) | Storage treatments: 7.70 | | Storage duration: 5.82 | Interaction: 15.4 | |
| LSD (p=0.05) | Storage treatments: NS | | Storage duration: 16.5 | Interaction: NS | |

NS: Non Significant

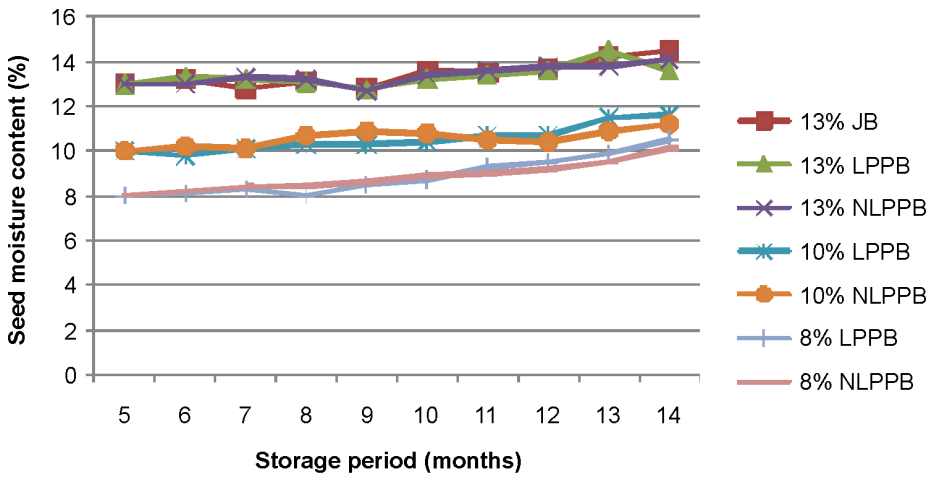


**Figure 1.** Effect of different seed storage treatments on seed moisture content of Pusa Basmati 1121 variety of basmati rice after different seed storage durations (JB: jute bags, LPPB: laminated polypropylene bags, NLPPB: non-laminated polypropylene bags)

Khadtar *et al.* [22] observed that seeds of cowpea var. Konkan Sadabahar stored in aluminium foil bags recorded low electrical conductivity than seeds stored in polylined jute canvas (PLJC), polylined HDPE bags (PLHDPE), polylined cotton bags (PLC), storage bins and control (gunny bags) at 11 months of seed storage. The seeds of rice cv. 'MAS 946-1' stored in 700 gauge polythene bags had lower electrical conductivity than seeds stored in cloth bags at 9 months of storage period[23]. The increase in electrical conductivity can be attributed to the reason that as seed ages, many constituents like sugars, free amino acids and organic acids leach out in the presence of water and cause the disruption of membrane integrity. Loss of membrane integrity during storage is the main reason for increased electrical conductivity and is considered one of the important cause of decreased germination with increased storage duration [24].

There was gradual increase in seed moisture content with increase in seed storage duration irrespective of the seed storage treatments. Increase in moisture content of seeds stored in non-laminated as well as in laminated polypropylene bags clearly indicated the porous nature of these bags. The maximum increase in moisture content was recorded in seeds stored in jute bags (Fig. 1).The seeds of paddy cv. Naveen recorded faster rise in seed moisture content when seeds were stored in cloth bags than seeds stored in polythene bags [20]. Azam *et al*. [25] recorded progressive increase in moisture content with the increase in storage period in seeds of wheat var. BARI Gom-24. They recorded the highest increase in seed moisture content in seeds stored in gunny bags than plastic containers and tin pots at 60 days after storage. Seed germination of Pusa basmati 1121 seeds desiccated to different moisture contents and stored in laminated and non-laminated polypropylene bags was statistically at par with seeds stored in jute bags during 5 to 14 months of seed storage. All seed storage treatments were able to meet Indian Minimum Seed Certification Standards (IMSCS) upto 12 months. But the seedling vigour index was higher of seeds stored in either laminated or non-laminated polypropylene bags than jute bags. The area remains variable from 5-6 lakh hectares in Punjab under basmati rice cultivation. During *kharif* 2019, the area under basmati rice was about 5, 50,000 ha in Punjab. Thus, 1, 10, 000 quintal seed is required for this area @ 20 kg seed rate/ha which needs approximately 4.58 lakh bags of 24 kg capacity. As given in Table 1, the price of one jute bag, laminated polypropylene bag and non-laminated polypropylene bag is Rs.53, Rs. 25 and Rs. 21, respectively. So, cost of 4.58 lakh jute bags comes around Rs 2, 42, 74,000; while it will cost about Rs 1, 14, 50,000 and Rs 96, 18,000 by using laminated polypropylene bags and non-laminated polypropylene bags, respectively. Thus, polypropylene bags either laminated or non-laminated can be used as cost effective packaging material as alternatives of jute bags.

## REFERENCES

1. ANONYMOUS (2018). Package of Practices for Kharif Crops. Punjab Agricultural University, Ludhiana, pp: 18-19.
2. ANONYMOUS (2019). Basmati Crop Survey Report (APEDA), Vol.**1**, pp: 27.

3. PATIL PR (2013). Studies on impact of packaging materials and desiccants on seed quality and storability of hybrid paddy (*Oryza sativa* L.). *M.Sc. Thesis*, Univ. of Agric. Sci., Bangalore, India.

4. AHMED AS AND SM MOHAMMED (2014). Effect of storage types on seed moisture content and germination of *Acacia senegal*, *Acacia mellifera* and *Acacia laeta*. *Journal of Natural Resources and Environmental Studies,* **6**:36-41.

5. ELLIS RH AND TD HANG (2007). Quantitative response of the longevity of seed of twelve crops to temperature and moisture in hermetic storage. *Seed Science and Technology,***35**: 432-444.

6. HAY FR, F DE GUZMAN, D ELLIS, H MAKAHIYA, T BORROMEO AND NR SACKVILLE HAMILTON (2013). Viability of *Oryza sativa* (L.) seeds stored under gene bank conditions for up to 30 years. *Genetic Resources and Crop Evolution,* **60**: 275-296.

7. STRELEC I, R POPOVIC, I IVANISIC, V JURKOVIC, Z JURKOVIC, Z UGARCIC-HARDI AND M SABO (2010). Influence of temperature and relative humidity on grain moisture, germination and vigour of three wheat cultivars during one year storage. *Poljoprivreda,***16**: 20-24.

8. MARINI P, CL MORAES, N MARINI, DM MORAES AND L AMARANTE (2012). Physiological and biochemical changes in rice seeds subjected to thermal stress. *Review of Agronomy,* **43**: 722-730.

9. ILIEVA V, I KAROV, L MIHAJLOV, NM RUZDIK AND M ILIEVSKI (2014). Effect of rice moisture at harvest and rough rice storage time on milling yield and grain breakage. *International Scientific Conference of Breeding and Technologies field crops* 27, 28 Nov 2014 Karnobat, Bulgaria.

10. VANGE T, F IKYELEVE, AND JO OKOH (2016). Effect of packaging materials and storage condition on soybean germination and seedling vigour in Makurdi. *Research Journal of Seed Science*, **9**: 1-4.

11. ISTA (2015). International rules for seed testing. International Seed Testing Association, Baassersdorf, Switzerland.

12. ABDUL-BAKI AA AND JD ANDERSON (1973). Vigour determination in soybean seeds by multiple criteria. *Crop Science,***13**:630-633.

13. ASSOCIATION OF OFFICIAL SEED ANALYSIS (1983). Rules for testing seeds. *Journal of Seed Technology,***16**:1-113.

14. ELLIS RA AND EH ROBERTS (1981). The quantification of ageing and survival in orthodox seeds. *Seed Science and Technology,* **9**: 373-409.

15. Presley JT(1958). Relation of protoplast permeability to cotton seed viability and predisposition to seedling disease. *Plant Disease Reporter*, **42**: 842.

16. CHEEMA HS AND B SINGH (1991). Software Statistical Package CPCS-1. Department of Statistics, Punjab Agricultural University, Ludhiana, India.

17. SEADH SES, MAEA BADAWI AND MMM EL-DENASORY (2019). Some factors affect storage efficacy and germination parameters of rice. *Journal of Applied Sciences,***19**: 392-399.

18. RAJA K AND K SASIKALA (2018). Effect of seed treatments and storage containers on viability and vigour of rice (*Oryza sativa* L.) variety ADT (R) 46 seeds. *International Journal of Current Microbiology and Applied Sciences,* **7**: 3087-3096.

19. NAING AA, KT ONE, TS MYINT, EI HAY MAN AND KK WIN (2019). Grain and seed quality of manawthukha rice (*Oryza sativa* L.) as affected by different storage containers and storage durations. *Journal of Agricultural Research,* **6**: 79-88.

20. PADHI SK, S BEHERA, SP MISHRA, AK PADHIARY AND B NAYAK (2017). Effect of seed coating materials on seed quality during storage of paddy. *Journal of Pharmacognosy and Phytochemistry,* **6**: 1263-1279.

21. RAIKAR SD, BS VYAKARNAHAL, DP BIRADAR, VK DESHPANDE AND BS JANAGOUDAR (2012). Effect of seed source, containers and seed treatment with chemical and biopesticide on storability of scented rice cv. Mugad sugandha. *Karnataka Journal of Agricultural Science,* **24**: 448-454.

22. KHADTAR UM, AK SHINDE, PP PATIL AND SG BHAVE (2018). Physiological studies on effect of different packaging material for storage of cowpea seed. *Journal of Advanced Agricultural Research and Technology,* **2**: 202-205.

23. CHOUDHURY MM, CM RAJANNA, JAT SILVA AND BALAKRISHNA (2011). Influence of packaging materials and seed treatments on physiological attributes during storage of rice (*Oryza sativa* L.). *Seed Science and Biotechnology,***5**: 15-20.

24. UMESHA U, BC CHANNAKESHAVA, K BHANUPRAKASH, D NUTHAN, R SIDDARAJU AND J LAKSHMI (2017). Influence of seed treatment and packaging materials on seed longevity of cluster bean [*Cyamopsistetra gonoloba* (L.) Taub.]. *Journal of Applied and Natural Science,* **9**: 482-491.

25. AZAM MG, MS ISLAM, K HASAN, MK CHOUDHURY, MJ ALAM, MO SHADDAM AND A EL SABAGH (2018). Effect of storage containers and lengths of storage on the germination, moisture content and pest infestation of wheat seed. *Cercetari Agronomice in Moldova,* **51**: 13-23.