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Effect of different storage containers on electrical conductivity and moisture content of soybean seeds in four verities under tropical storage conditions

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Abstract
In Vidarbha region of Maharashtra State, soybean crop is harvested in October-November. The seeds of soybean crops are stored for 7-8 months prior to sowing. Through sun drying after harvest, followed by storage, has been found to reduce the problem of loss of viability. Here the greater part of storage period is covered by the dry and cool winter months. Even keeping the seeds under ambient conditions in ordinary gunny bags would result in significant loss of viability. Electrical conductivity test is one of the most significant tests to estimate the leakage of electrolytes from the seed coat with respect to age, storage life, and environmental factors such as temperature, humidity and mother plant nutrition. Also, during storage high seed moisture level increases seed mycoflora, which play an important role in deterioration of soybean seed quality and viability during storage. In the present work study of effect of storage materials such as Polyethylene bag, Cloth bag and Jute bag on electrical conductivity and moisture content during 540 days of storage of four different verieties such as JS-335, AMS-99-33, TAMS-38 and TAMS-98-21. Electrical conductivity was found higher in the variety TAMS-98-21 (2.288 mmoh/cm) as compared to TAMS-38, AMS-99-33 and JS-335 as 2.217 mmoh/cm, 2.126 mmoh/cm and 1.945 mmoh/cm respectively after storage of 540 days in Jute bag. The seeds stored in Polyethylene bag showed minimum variation in electrical conductivity as compared to Cloth and Jute bag. The moisture content of seeds increased or decreased according to the atmospheric relative humidity and temperature. It was found that when seeds were stored in Cloth and Jute bags, it showed higher moisture content than those stored in Polyethylene bags. The least amount of moisture increase (9.1%) was found in seeds stored in Polyethylene bag at the end of 540 days of storage. In the present investigation, the corresponding moisture content values of soybean varieties JS-335, AMS-99-33, TAMS-38 and TAMS-98-21 when stored in Polyethylene, Cloth and Jute bags were different. Variety JS-335 seeds recorded lower moisture content (9.1%) as compared to AMS-99-33, TAMS-38 and TAMS-98-21.

Keywords: soybean, storage containers, electrical conductivity studies, moisture content

1. Introduction

One of the major problems encountered in the soybean production in India is the lack of good quality seeds. The desirable attributes of quality seeds is uniformity in seed size. The poor-quality seeds lead to poor and erratic field emergence and failure of seedling establishment in the field which subsequently results into low productivity of the soybean (Charjan *et al*. (2006) [7] and Charjan *et al*. (2011) [8]. By the time of next sowing in June-July, the loss in vigour and viability of carry over seeds, may adversely affect field emergence and productivity (Basu, *et al*.; 1978, Charjan and Tarar; 1992, and Abdullah M. Alhamdan *et al*.; 2011) [9, 8, 1]. The oil seeds are poor storer and loose its viability very fast in adverse conditions of temperature and humidity.

Many researchers reported that decay in food reserve in seeds may results into the loss of vigour in seeds. Whereas, experiments on non-viable seeds proved that, there is sufficient food reserve remaining behind in the seed for further growth and development (Jyoti and Malik, 2013; Shelar *et al*., 2008) [19, 31]. Some changes in chemical composition during deterioration were also observed (Vasileva, 2014) [34].

The modern germination test demonstrates the capacity of population of seeds to produce plants in the field. This is done by exposing them to conditions in the laboratory which are optimum for germination. In such species, the emergence percentage showed a fairly constant relationship to germination capacity, others are more sensitive to differences in soil conditions. In particular cases, supplementary tests, such as electrical conductivity, may be needed to detect specific weaknesses in the seeds producing normal seedlings in the laboratory. However, it is unlikely that such tests can replaced the germination test in large-scale screening for sowing quality.

Brooks, (1923) [6] stated that the increase in electrical conductivity is due to increased membrane permeability of the dyeing tissues. For example, unicellular organisms such as yeast, bacteria, progress towards death, their permeability increases and allow more leaching of inorganic and organic salts into the surrounding water thus increase its electrical conductivity. Fick and Hibbard, (1925) [15] adopted the method of measuring the relative outwards diffusion of electrolytes as an index of seed viability. Rovira, (1956) [29] conducted a test for electrolyte exudation. He concluded that peas exude not only sugar but also amino acids and other substances which conduct electricity in solution.

According to Delouche, (1965) [11], the permeability of seed increases as deterioration progresses. Pollock and Toole, (1966) [26] reported that leakage of metabolites in comparatively large in deteriorated and injured seeds than vigourous and less in lima bean. *Matthews and* Brandnock, (1968) [22] explained that the conductivity test is based on the concept that when seeds are soaked in water, low vigour seeds release more electrolytes in to the solution than do high vigour seeds. Edje and Burris, (1970) [13] proved that aged soybean seeds became 'leaky' because of increased permeability of the membrane and seed coat when rehydrate. Agrawal and Siddiqui, (1973) [2] reported that the loss in germinability of soybean seed (14% moisture content) was because increased metabolic activity. Verma and Gupta, (1975) [5, 36] reported that the measurements of electrical conductivity in leachate were found to be an estimation of soybean seed deterioration during storage. Electrolytes in leachate increased with increase in storage period. Bhanumurthy and Gupta, (1981) [36] reported that electrical conductivity of leachate showed a negative correlation with germinability and seedling vigour. Gidrol *et al*., (1988) [16] reported that electrolytes leakage may results from membrane degradation in seeds. Meena *et al*., (2017) [23] observed the soybean seeds stored in vacuum packed bags maintained the seed electrical conductivity with least deterioration compared to seeds stored in gunny bags and high-density polythene bags.

Razzak *et al*., (2013) [28] studied effect of storage containers on the seed quality attributes of tossa jute and found that Moisture content of the seeds of tin container increased significantly to 12.9% from initial moisture content 12.2%. Tatipata, (2009) [33] reported that soybean seeds stored in Aluminium foil bags showed high phospholipids and protein content of mitochondria inner membrane, germination, coefficient velocity of germination and keep moisture content in low level could delay seed deterioration followed by polyethylene and wheat bags. Ali *et al*., (2014) studied effect of initial seed moisture content and storage container on soybean seed quality and found that germination index, vigour index and seedling dry matter decreases with increase in initial seed moisture content irrespective of storage containers used. Khan *et al*., (2018) [20] observed the correlation between container and seed moisture level, the highest germination and lowest seed-borne fungal infection was recorded in seeds stored in aluminum foil bag with 7% moisture content. Maina *et al*., (2017) [21] found that seeds stored in clay pots, brown paper bags, plastic transparent jars and freezer had higher seed quality than those stored in polythene bags. Rani *et al*., (2013) [27] suggested that the seeds at higher moisture contents (16, 18, and 20%) must be dried to lower levels before 8, 5, and 3 weeks, respectively for prolonged storage.

Verma and. Verma, (2014) [35] observed that cloth bag is not perfect for soybean seed storage for long time as compared to tin container and polyethylene bag; because the rate of moisture absorbance was higher in bag than in container and polythene bag. Islam *et al*., (2018) [18] revealed that in maintaining seed quality higher moisture content in the seed stored in air leaked container, over a longer storage period, accelerated the respiration rate and infestation of microorganisms, consequently the germination potential of seeds reduced.

2. Material and Methods

Seeds of the two kinds and varieties i.e.JS-335 and AMS-99-33 (Denoted by V1, and V2 respectively) were obtained from "All India Co-ordinate Oil Seed project, College of Agriculture, Nagpur.

The seed samples were packed in the respective containers Polyethylene bag 700 gauge (moisture vapour proof), Cloth bag (moisture pervious) and Jute bag (moisture pervious). Polyethylene bag, Cloth bag and Jute bag, are denotes by C1, C2 and C3 respectively. All the three bags will be of 20 cm x 30 cm. The respective containers were then stored in wire mesh almirah in mesonary building having cemented walls, roof and floor under ambient temperature and relative humidity for a period of 18 months. Portion of the seeds from each container were removed after 3 months (90 days) and examined for Physiological observations.

0 Days, 90 Days, 180 Days, 270 Days, 360 Days, 450 Days, and 540 Days intervals are denoted by T1, T2, T3, T4, T5, T6 and T7 respectively.

Electrical conductivity test was done with the help of conductivity meter and Moisture content was determined with the help of following formula

$$Moisture\ \% = \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

Here, M_1-Weight of empty container with lid

M_2- Weight of container with lid and seed before drying

M_3-Weight if container with lid and seed after drying and cooling.

Statistical analysis

The data obtained from the experiments were statistically analyzed by using factorial CRD. (Complete Randomized Design), Using Web Portal of CCS Hariyana Agricultural University, Hisar: http://14.139.232.166/opstat/default.asp. The critical differences between the parameters like Soybean seed Varieties, containers and storage period were worked out at five per cent significance.

3. Results

a. Electrical conductivity (mmhos/cm)

The effect of container and storage period on Electrical Conductivity in all four varieties V1, V2, V3 and V4 is presented in Table 1.

Table 1: Effect of Varieties (V), Storage Containers (C) and Storage Periods (T) and three factor interaction on Electrical Conductivity (mmhos/cm) of soybean seeds during storage.

VxCxT	V1			V2			V3			V4		
	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3
T1	0.120	0.120	0.120	0.170	0.170	0.170	0.189	0.189	0.189	0.238	0.238	0.238
T2	0.172	0.223	0.227	0.181	0.241	0.281	0.197	0.285	0.301	0.276	0.298	0.398
T3	0.240	0.432	0.445	0.249	0.544	0.601	0.275	0.662	0.781	0.291	0.670	0.856
T4	0.387	0.527	0.706	0.401	0.643	0.836	0.571	0.739	0.889	0.623	0.789	0.916
T5	0.530	0.831	0.817	0.570	0.949	1.201	0.633	0.993	1.287	0.734	1.109	1.302
T6	0.732	1.150	1.292	0.951	1.312	1.471	0.997	1.422	1.512	1.147	1.562	1.581
T7	1.135	1.881	1.945	1.154	1.990	2.126	1.178	2.189	2.217	1.199	2.198	2.288
Mean	0.474	0.738	0.793	0.525	0.836	0.955	0.577	0.926	1.025	0.644	0.981	1.083

SE (m)	0.012
CD(P=5%)	0.033

In variety JS-335 (V1), the electrical conductivity significantly increased with the increase in storage period. However, the rate of increase in electrical conductivity varied with the type of container used. Seeds stored in Polyethylene bag (C1) showed significantly lower electrical conductivity (1.135 mmhos/cm) as compared to those stored in Cloth bag (C2) (1.881 mmhos/cm) and Jute bag (C3) (1.945 mmhos/cm) up to 540 days (T7) days of the storage. Among the containers Polyethylene bag (C1) showed significantly lower electrical conductivity (0.474 mmhos/cm) as compared to Cloth bag (C2) (0.738 mmhos/cm) and Jute bag (C3) (0.793 mmhos/cm) throughout the storage period.

In variety AMS-99-33 (V2), seed stored in Polyethylene bag (C1) showed significantly lower electrical conductivity (1.154 mmhos/cm) as compared to those stored in Cloth bag (C2) (1.990 mmhos/cm) and Jute bag (C3) (2.126 mmhos/cm) up to 540 days (T7) days of storage. Among the containers Polyethylene bag (C1) showed significantly lower electrical conductivity (0.525 mmhos/cm) as compared to Cloth bag (C2) (0.836 mmhos/cm) and Jute bag (C3) (0.955 mmhos/cm) throughout the storage period.

In variety TAMS-38 (V3), seed stored in Polyethylene bag (C1) showed significantly lower electrical conductivity (1.178 mmhos/cm) as compared to those stored in Cloth bag (C2) (2.189 mmhos/cm) and Jute bag (C3) (2.217 mmhos/cm) up to 540 days (T7) days of storage. Among the containers Polyethylene bag (C1) showed significantly lower electrical conductivity (0.577 mmhos/cm) as compared to Cloth bag (C2) (0.926 mmhos/cm) and Jute bag (C3) (1.025 mmhos/cm) throughout the storage period.

Similarly, in variety TAMS-98-21 (V4), the seed stored in Polyethylene bag (C1) showed significantly lower electrical conductivity (1.199 mmhos/cm) as compared to those stored in Cloth bag (C2) (2.198 mmhos/cm) and Jute bag (C3) (2.288 mmhos/cm) up to 540 days (T7) days of storage. Among the containers Polyethylene bag (C1) showed significantly lower electrical conductivity (0.644 mmhos/cm) as compared to Cloth bag (C2) (0.981 mmhos/cm) and Jute bag (C3) (1.083 mmhos/cm) throughout the storage period.

Table 1 shows that, among the four varieties of soybean, seeds stored in Polyethylene bag (C1) exhibited significantly lower electrical conductivity as compared to Cloth bag (C2) and Jute bag (C3). The variety JS-335 (V1) exhibited significantly lower electrical conductivity (0.668 mmhos/cm) as compared to AMS-99-33 (V2) (0.772 mmhos/cm), TAMS-38 (V3) (0.843 mmhos/cm) and TAMS-98-21 (V4) (0.902 mmhos/cm), irrespective of storage containers up to 540 days (T7) days.

b. Moisture Content (%)

The effect of container and storage period on Moisture Content in all four varieties V1, V2, V3 and V4 is presented in Table 2.

Table 2: Effect of Varieties (V), Storage Containers (C) and Storage Periods (T) and three factor interaction on Moisture Content (%) of soybean seeds during storage.

VxCxT	V1			V2			V3			V4		
	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3
T1	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
T2	9.0	8.9	9.0	9.1	8.8	9.2	9.0	9.0	9.1	9.1	8.9	9.2
T3	9.2	10.8	11.2	9.1	11.0	11.4	9.2	10.8	11.4	9.0	11.1	11.5
T4	9.1	10.2	10.4	9.0	10.4	10.5	9.1	10.1	10.6	9.0	10.3	10.6
T5	9.0	10.1	10.2	9.0	10.2	9.9	9.1	10.2	10.4	9.0	10.3	9.8
T6	9.0	9.3	9.4	9.0	9.5	9.5	9.0	9.6	9.8	9.0	9.4	9.6
T7	9.1	11.2	11.6	9.1	11.4	11.8	9.2	11.1	11.7	9.1	11.3	11.9
Mean	9.1	9.9	10.1	9.0	10.0	10.2	9.1	10.0	10.3	9.0	10.0	10.2
SE (m)	0.193											
CD (P=5%)	NS											

*NS-Non-Significant

In variety JS-335 (V1), Polyethylene bag (C1), Cloth bag (C2) and Jute bag (C3) showed fluctuations in moisture content of seeds during storage according to temperature and relative humidity of the atmosphere. A significant minimum fluctuation of moisture content was observed in Polyethylene bag (C1). Seed stored in Polyethylene bag (C1) showed significantly lower moisture content (9.0%) as compared to those stored in Cloth bag (C2) (11.2%) and Jute bag (C3) (11.6%) up to 540 days (T7) days of the storage. Among the containers Polyethylene bag (C1) showed significantly lower mean moisture content (9.1%) as compared to Cloth bag (C2) (9.9%) and Jute bag (C3) (10.1%) throughout the storage period.

In variety AMS-99-33 (V2), Polyethylene bag (C1), Cloth bag (C2) and Jute bag (C3) showed fluctuations in moisture content of seeds during storage according to temperature and relative humidity of the atmosphere. A significant minimum fluctuation of moisture content was observed in Polyethylene bag (C1). Seed stored in Polyethylene bag (C1) showed significantly lower moisture content (9.0%) as compared to those stored in Cloth bag (C2) (11.4%) and Jute bag (C3) (11.8%) up to 540 days (T7) days of the storage. Among the containers Polyethylene bag (C1) showed significantly lower mean moisture content (9.1%) as compared to Cloth bag (C2) (10.00%) and Jute bag (C3) (10.2%) throughout the storage period.

In variety TAMS-38 (V3), Polyethylene bag (C1), Cloth bag (C2) and Jute bag (C3) showed fluctuations in moisture content of seeds during storage according to temperature and relative humidity of the atmosphere. A significant minimum fluctuation of moisture content was observed in Polyethylene bag (C1). Seed stored in Polyethylene bag

(C1) showed significantly lower moisture content (9.2%) as compared to those stored in Cloth bag (C2) (11.1%) and Jute bag (C3) (11.7%) up to 540 days (T7) days of the storage. Among the containers Polyethylene bag (C1) showed significantly lower mean moisture content (9.1%) as compared to Cloth bag (C2) (10.00%) and Jute bag (C3) (10.3%) throughout the storage period.

Similarly, in variety TAMS-98-21 (V4), Polyethylene bag (C1), Cloth bag (C2) and Jute bag (C3) showed fluctuations in moisture content of seeds during storage according to temperature and relative humidity of the atmosphere. A significant minimum fluctuation of moisture content was observed in Polyethylene bag (C1). Seed stored in Polyethylene bag (C1) showed significantly lower moisture content (9.1%) as compared to those stored in Cloth bag (C2) (11.3%) and Jute bag (C3) (11.9%) up to 540 days (T7) days of the storage. Among the containers Polyethylene bag (C1) showed significantly lower mean moisture content (9.0%) as compared to Cloth bag (C2) (10.00%) and Jute bag (C3) (10.2%) throughout the storage period.

Table 2 shows that, in four varieties of soybean, seeds stored in Polyethylene bag (C1) exhibited significantly lower moisture content as compared to Cloth bag (C2) and Jute bag (C3). The variety JS-335 (V1) exhibited significantly lowest moisture content (9.7%) as compared to AMS-99-33 (V2) (9.8%), TAMS-38 (V3) (9.8%) and TAMS-98-21 (V4) (9.8%), irrespective of storage containers and storage period.

4. Discussion

a. Electrical conductivity *(mmhos/cm)*

In the present investigation (Table 1) the electrical conductivity of seed leachate increased with increase in storage period in all four varieties of soybean. The seeds stored in Cloth (C2) and Jute (C3) bags, showed significantly higher values for electrical conductivity of seed leachate compared to those stored in Polyethylene bag (C1). This state of affair might be due to increase in permeability of seed coat which was more pronounced in Cloth (C2) and Jute (C3) bags respectively in prolonged storage.

Colete *et al*., (2004) [10]; Panobianco and Vieira, (2007) [25] and Salinas *et al*., (2010) [30] reported that, the measurements of electrical conductivity in seed leachate were found to give an estimate of seed deterioration during storage. They also concluded that the electrolytes in seed leachate increased with increase in storage period.

Gidrol *et al*., (1988) [17] reported that electrolytes leakage resulting from membrane degradation in seeds.

Varietal differences were observed regarding electrical conductivity of seed leachate. The leachate of JS-335 (V1) recorded significant lower values for electrical conductivity as compared to AMS-99-33 (V2), TAMS-38 (V3) and TAMS-98-21 (V4) under studies during storage. Edje and Burris, (1971) [14] and Vyas *et al*., (1990) reported varietal differences in electrical conductivity of seed leachate during storage.

The results obtained from measurement of electrical conductivity have been illustrated graphically in Figure 1.

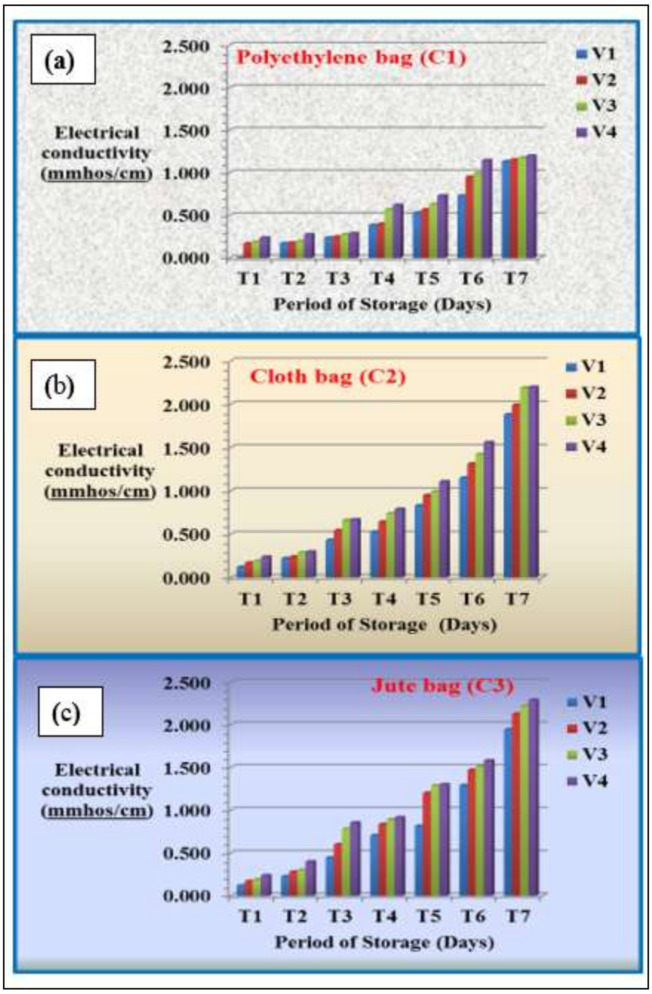

Fig 1: Effect of storage containers on Electrical Conductivity (mmoh/cm) in Soybean seed varieties. (a) Polyethylene bag (C1), (b) Cloth bag (C2) and (c) Jute bag (C3).

b. Moisture Content

In the present investigation (Table 2), the moisture content of the seeds does not adopt any trend either of decrease or rise continuously with the increase of storage period in all four varieties of soybean. The moisture content of seeds increased or decreased according to the atmospheric relative humidity and temperature. The moisture content of seeds was directly related to the relative humidity of the atmosphere (Delouche *et al*., 1973) [12].

It was also found that when seeds were stored in Cloth (C2) and Jute (C3) bags, it showed higher moisture content than those stored in Polyethylene bags (C1). The least amount of moisture increase was found in seeds stored in Polyethylene bag (C1) during storage. This increase in moisture content of seeds stored in Cloth (C2) and Jute (C3) bags may be due to moisture pervious nature. While in Polyethylene bag it is primarily due to resistance to moisture penetration. Nahar *et al*. (2009) [24] investigated that, Cloth and Jute sacks offer no resistance to moisture penetration. The moisture content of seeds stored in open weave, cotton or Jute sacks will eventually reach a value which is in equilibrium with the atmospheric relative humidity in the store. Ali *et al*., (2014) reported that seed stored in Polyethylene packets is considered to be the best because humidity cannot pass through it.

In the present investigation, the corresponding moisture content values of soybean varieties JS-335 (V1), AMS-99-33 (V2), TAMS-38 (V3) and TAMS-98-21 (V4) when stored in Polyethylene (C1), Cloth (C2) and Jute (C3) bags were different. The seeds of soybean varieties absorb more moisture comparatively. This may be due to bulk protein constitution of soybean seeds. The present findings are in agreement with those of Snow, (1944) [32] and Allerup, (1958).

Wang *et al*., (2010) [38] reported high moisture holding capacity of proteineous legume seeds. Significant varietal differences in soybean crop were not found in regard to moisture content of seeds during storage.

The results obtained from determination of moisture content have been illustrated graphically in Figure 2

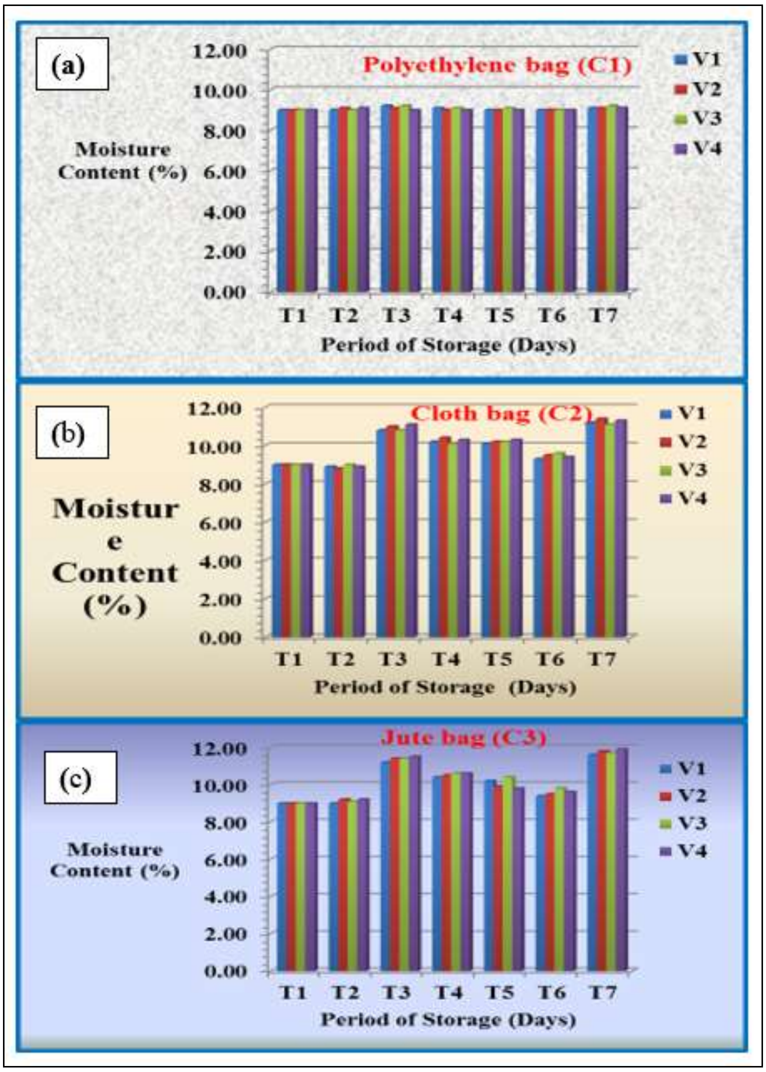

Fig 2: Effect of storage containers on Moisture Content (%) in Soybean seed varieties. (a) Polyethylene bag (C1), (b) Cloth bag (C2) and (c) Jute bag (C3).

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