Effect of storage period on seed longevity of soybean cultivars grown in the hills of northwestern Himalayas

SHREYA SINGH[1*], ANUBHAV THAKUR[2], JEENIA THALYARI[2] and RAKESH KUMAR KAPILA[3]

[1]Department of Seed Science and Technology
Chandra Shekhar Azad University of Agriculture and Technology
Kanpur 208002 Uttar Pradesh, India
[2]Department of Seed Science and Technology, College of Horticulture
Dr YS Parmar University of Horticulture and Forestry
Nauni Solan 173230 Himachal Pradesh, India
[3]Department of Seed Science and Technology
CSK HP Krishi Vishvavidyalaya, Palampur 176062 Himachal Pradesh, India
*Email for correspondence: shreya17authentic@gmail.com

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ABSTRACT

Soybean is an important oilseed crop; however, it is classified under least storage group because its genotypes differ in their ability to maintain seed longevity. A storage experiment was carried out by packing the seeds of seven soybean varieties in high density polyethylene (HDPE) bags and storing them under ambient conditions. The cultivars were assessed for six seed quality parameters initially during January 2019 and, thereafter, at bimonthly interval up to May 2020. PS 1556 was the best performing variety in terms of all the seed quality parameters whose seed longevity was 16 months, whereas, Palam Early Soya 1 and Him Palam Hara Soya 1 were poor performing varieties with 12 months seed longevity. The study acquaints about the seed storability of soybean cultivars under temperate conditions of northwestern Himalayan region which would assist the seed producers in deciding the fate of the produced seed.

Keywords: Longevity; seed quality; soybean; storage

INTRODUCTION

Soybean [*Glycine max* (L) Merrill] is one of the principle legume crops contributing significantly as an oilseed crop. India ranks fourth in area with 11.34 million hectares (28.02 million acres) accounting for 9.41 per cent of the world area and fifth in production with 11.22 million tonnes (Anon 2021). Only about 20 per cent of the seed produced in India is carried over for subsequent sowing; the remaining 80 per cent is stored for an entire planting season (Bal 1976). Soybean seeds are naturally short-lived and their quality declines faster than other seeds in storage. The deterioration processes in soybean begin since seed development. Catabolic changes occur more slowly under low rather than high temperature and relative humidity which could be the reason for fast deterioration (Justice and Bass 1979). Under favourable storage conditions, the initiation of decline in germination may be from few months to many years depending on storage conditions, kind of seed and conditions during seed development (Shelar et al 2008). Hence, deterioration of soybean seed in storage is one of the key reasons for low productivity and non-availability of high vigour seeds at the time of sowing.

Soybean genotypes differ in their ability to maintain seed longevity (Khare et al 1996). Soybean is classified under least storable group due to its high oil content, high moisture content (Balesevic-Tubic et al 2010), high protein content, physiological decay and thin seed coat character (Delouche and Baskin 1973).

While crop improvement efforts continue, the major area of focus often remains high yield and resistance to biotic and abiotic stresses. However, seed quality attributes, that are critical for optimum productivity, often get ignored. Seed longevity is a complex and quantitative seed quality trait. Besides, it is acquired on the mother plant during the reproductive phase of seed development. Understanding what factors contribute to lifespan, is one of the oldest and most challenging questions in plant biology (Zinsmeister et al 2020). The study was, therefore, designed to establish the effect of storage period and genotypes on soybean seed quality characteristics during storage.

MATERIAL and METHODS

In order to investigate and evaluate the seed longevity, freshly harvested and well graded seeds of seven soybean varieties grown in the hills of northwestern Himalayan regions of India, namely Hara Soya, Shivalik, Palam Soya, Him Soya, PS 1556, Palam Early Soya 1 and Him Palam Hara Soya 1 were taken. These varieties were packed in high density polyethylene (HDPE) bags and kept for storage (Jan 2019 to May 2020) in four replicates under ambient conditions using completely randomized design (CRD) in the seed technology laboratory, Department of Seed Science and Technology, CSK HP Krishi Visvavidyalaya, Palampur, Kangra, Himachal Pradesh. Seeds were not treated with any chemicals or botanicals before and during storage. Temperature and relative humidity (RH) data of the storage room were recorded on daily basis. Seeds were evaluated for six seed quality parameters viz moisture content, 100-seed weight, germination percentage, field emergence, rate of germination and electrical conductivity. The data were recorded over a period of 16 months, initially in January 2019 and, thereafter, at bimonthly interval up to May 2020.

Moisture content: Moisture content was determined using a non-destructive moisture meter (PM-600: Kett, Japan). A homogeneous sample weighing 175 g was drawn randomly from the bags of each replication of all the varieties and moisture content was recorded using the moisture meter.

100-seed weight: A homogenous representative sample was drawn from four replications of each variety. One hundred seeds were counted from each sample and their weight was recorded.

Seed germination: The germination test was performed using between paper method as per ISTA procedure (Anon 2019) in four replications of 100 seeds each and germionation percentage was calculated using the following formula:

$$\text{Per cent germination} = \frac{\text{Number of seeds geminated into normal seedlings}}{\text{Total number of seeds kept for germination}} \times 100$$

Field emergence: Field emergence of stored soybean seeds was calculated as per ISTA procedures (Anon 2019) by sowing the seeds of every variety in four replications of 100 seeds each:

$$\text{Field emergence (\%)} = \frac{\text{Number of total seedlings emerged on } 8^{\text{th}} \text{ day}}{\text{Total number of seeds sown}} \times 100$$

Rate of germination: The test for calculating the rate of germination was conducted using between paper method as per ISTA procedure (Anon 2019) in four replications of hundred seeds each. The number of germinated seeds was recorded every day until the germination was completed. The index of the rate of germination was calculated by using the formula:

$$\text{Rate of germination} = n_1/d_1 + n_2/d_2 + n_3/d_3 + \ldots\ldots\ldots\ldots$$

where n = Number of germinated seeds, d = Number of days

Electrical conductivity: Five grams seeds from each replication of each variety were taken in a 100 ml beaker. These seeds were soaked in 50 ml of water for 17 hours at 25 ± 1°C. After 17 hours, the content of the beaker was gently stirred. The seeds were discarded and the leachate was used for measuring the electrical conductivity of the sample with the help of a digital conductivity meter.

The data recorded were statistically analysed using CRD as per Steel and Torrie (1960).

RESULTS and DISCUSSION

Effect of storage period on soybean seed quality parameters

The ambient conditions of the storage environment were monitored using an indoor digital humidity and temperature monitor (Fig 1). The moisture content of the seeds kept under storage varied significantly as a result of fluctuation in the RH and temperature of the storage environment (Fig 2). The seeds were stored at similar initial moisture content (10-10.3%). The moisture content decreased till six months of storage up to July 2019. Thereafter, in the month of August 2019, the RH of the storage environment increased consequently increasing the moisture content of the seeds kept under storage. Subsequently, after November 2019, the moisture content of the seeds decreased as a result of decreasing RH of the storage environment. Although, all the genotypes had a fixed 100-seed weight but the fluctuating moisture content, as a result of alternating atmospheric RH, resulted in variation in 100-seed weight during storage period (Fig 2). The variation was proportionate to the moisture content. The seed moisture content can be represented as a function of RH and temperature of the storage environment (Fang et al 1998). When RH fluctuates in the storage conditions, the seed moisture content varies in equilibrium with atmospheric water vapour. Besides, the increase in 100-seed weight could be attributed to the rise in seed moisture content, whereas, the decrease in 100-seed weight could probably be due to evaporation of moisture or due to biochemical changes resulting in the evolution of CO_2.

The germination percentage and the field emergence of seven soybean varieties kept under storage declined gradually with the advancement of storage period (Fig 3). During 16 months of storage, germination declined by 23.89 per cent and field emergence by 22.84 per cent. Many earlier researchers have identified storage duration as a major factor affecting the germination (Vishwanath et al 2019) and field emergence (Issac et al 2016) of soybean. When soybean seeds are naturally aged, seed deterioration causes damage to cell structure and function of cell membrane leading to reduced germination. Besides, low germination could also be due to depletion of food reserves or occurrence of high percentage of abnormal seedlings. In soybean, seeds with a higher vigour level produced a quick seedling emergence (Ebone et al 2020). Hence, decline in field emergence could be the result of progressive loss of vigour because as the seed quality deteriorates during storage, vigour declines before loss in standard germination. The rate of germination (Table 1) also witnessed a declining trend with the increasing storage period.

During 16 months of storage, rate of germination declined by 59.19 per cent. Monira et al (2012) reported similar results in soybean. One of the possible reasons behind decreasing rate of germination could be seed deterioration. During storage, the injured or deeply bruised areas may serve as centres for infection and result in deterioration of seeds. As deterioration further multiplies during storage, relative poor growth is observed in highly deteriorated lots resulting in low vigour.

The electrical conductivity gradually increased with the advancement of storage period (Table 2).

On an average, electrical conductivity at the beginning and at the end of the storage period was 0.142 and 0.200 m mhos/cm/g respectively. Over the period of 16 months, electrical conductivity increased by 48.36 per cent. Vishwanath et al (2019) have also reported similar results of increasing electrical conductivity in soybean. Attributing to high mechanical injury, poor membrane structure and leaky cells, seeds which lose vigour release more electrolytes. Additionally, the permeability of the membrane increases with the increase in storage period and leads to loss of electrolytes, sugars, amino acids and phenols. This results in increased conductivity in the soak water.

Seed quality parameters of seven soybean varieties as affected by storage period

The moisture content and the 100-seed weight of seed varied significantly among genotypes. The variety PS 1556 recorded the highest moisture content throughout the storage period, whereas, the lowest moisture content was recorded in variety Him Palam Hara Soya 1. Subsequently, the variety Him Palam Hara Soya 1 recorded the maximum, whereas, PS 1556 recorded the least 100-seed weight throughout the storage period. Mechanical injury causes cuts and bruises on the seed leading to exposure of seed carbohydrates and proteins to the prevailing environment which further results in absorption of moisture from the environment.

The amount of mechanical injury varies amongst genotypes; therefore, the seed moisture content varies among genotypes. Ambika et al (2014) reported that genotypic differences among seed size are the result of genetic variation. This variation results from the flow of nutrients into the seed at the mother

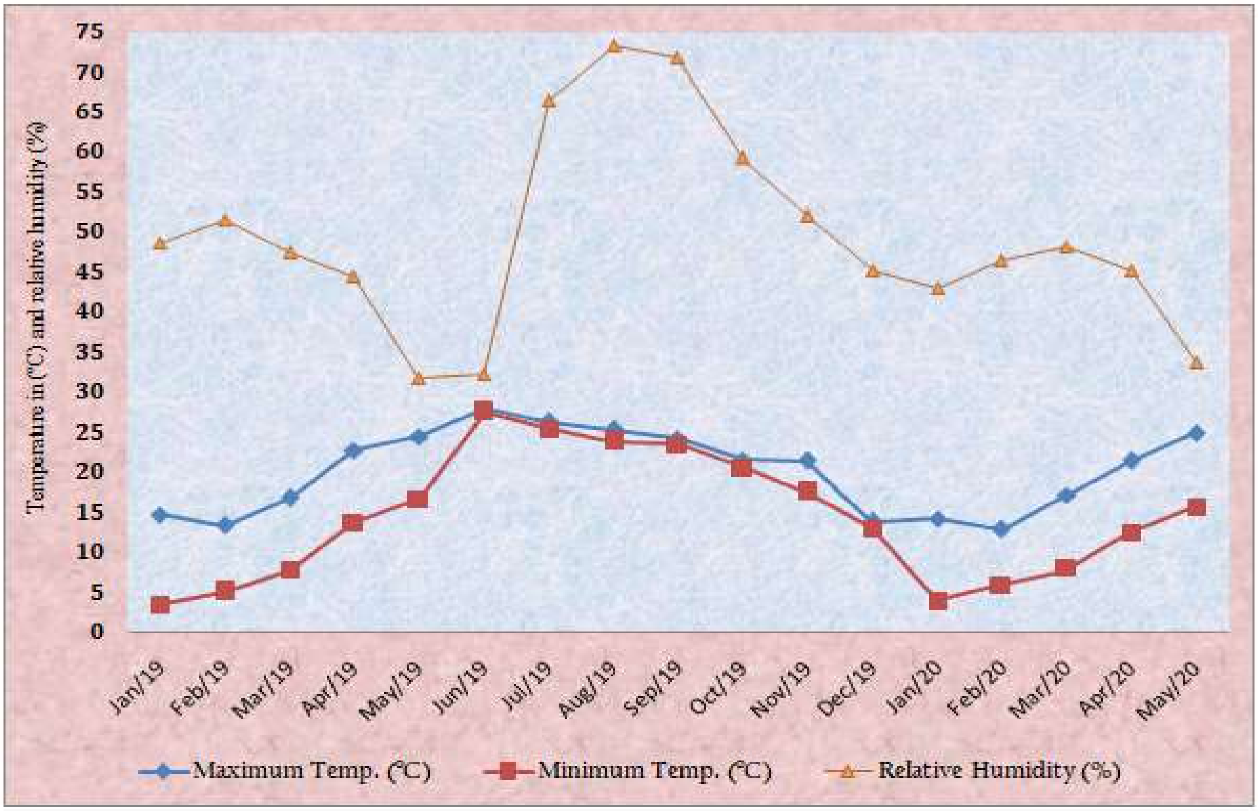

Fig 1. Mean monthly temperature and relative humidity of the storage environemnt

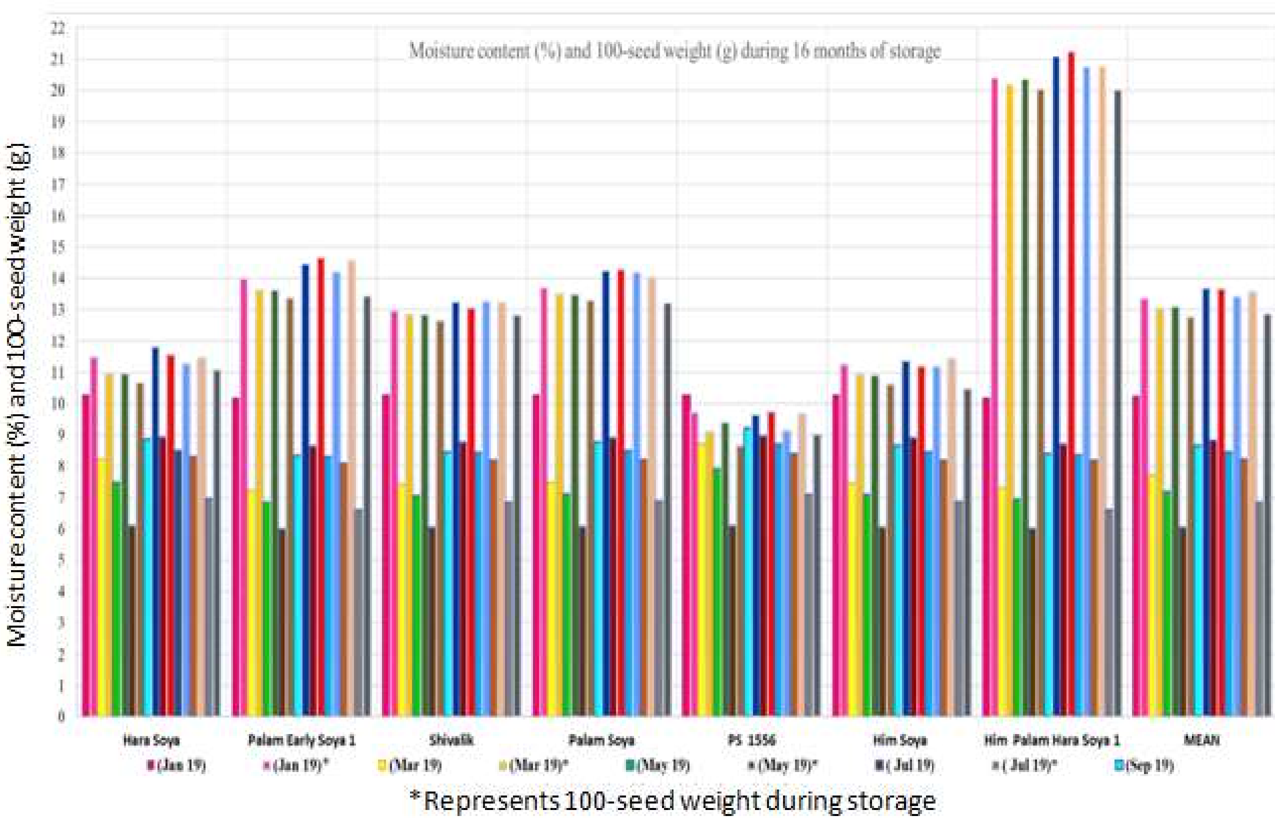

Fig 2. Moisture content (%) and 100-seed weight (g) of seven soybean varieties during 16 onths of storage

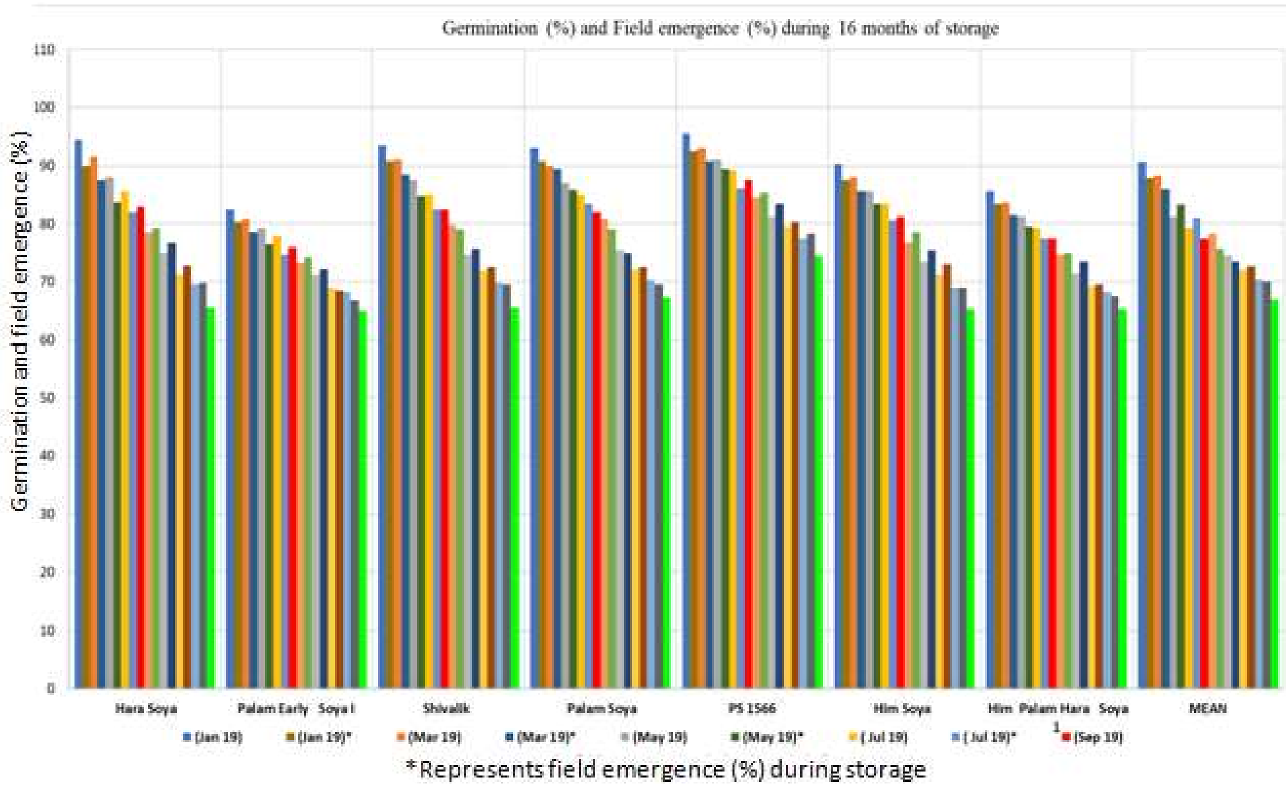

Fig 3. Germination and field emergence of seven soybean varieties during 16 months of storage

plant itself, since embryonic axis and seed coat develop first and food reserve accumulation occurs later on.

The germination percentage and the field emergence got gradually declined throughout the storage period. In the initial month of storage, variety PS 1556 recorded significantly highest germination (95.50%) and field emergence (92.50%), whereas, Palam Early Soya 1 exhibited significantly lowest germination (82.50%) and field emergence (80.25%). At the end of the storage, the germination percentage of the poorest performing variety Palam Early Soya 1 was 11.50 per cent lesser than the best performing variety PS 1556. Additionally, the field emergence of PS 1556 was 12.75 per cent greater than the field emergence of Palam Early Soya 1. Ageing can result in loss of membrane integrity which causes an increase in electrolyte leakage ultimately leading to decline in field emergence and germination percentage. Abdul-Baki and Anderson (1973) reported that large sized seeds have greater electrolyte leakage. In the present study, the largest test weight was exhibited by varieties Him Palam Hara Soya 1 and Palam Early Soya 1. These varieties exhibited the highest electrical conductivity and consequently the lowest germination percentage as well as field emergence, whereas, variety PS 1556 having lowest test weight exhibited lowest electrical conductivity, better germination percentage and field emergence.

Tentatively, Palam Early Soya 1 and Him Palam Hara Soya 1 maintained the germination percentage above the IMSCS (70%) only up to 12 months of storage and were classified under short seed longevity. The seed longevity duration clearly indicated that these varieties could be stored safely only until next growing season and can't be carried forward. On the other hand, Hara Soya, Shivalik, Him Soya and Palam Soya maintained the germination percentage above the IMSCS up to 14 months of storage and were classified under medium seed longevity. However, the highest storage life was recorded in PS 1556 as its germination percentage did not fall below the IMSCS even after 16 months of storage and, hence, it was classified under long seed longevity. The better duration of seed longevity indicated that these five varieties could be stored subsequently up to two growing seasons without any compromise in quality.

The rate of germination also witnessed a declining trend with the advance in storage period. In the initial month of storage, PS 1556 recorded the

Table 1. Rate of germination of seven soybean varieties during 16 months of storage

Variety	Rate of germination (months after storage)								
	Initial (Jan 19)	2 (Mar 19)	4 (May 19)	6 (Jul 19)	8 (Sep 19)	10 (Nov 19)	12 (Jan 20)	14 (Mar 20)	16 (May 20)
Hara Soya	24.47	23.55	21.22	20.95	17.58	15.92	13.92	11.44	10.46
Palam Early Soya 1	22.27	21.06	19.45	17.62	15.03	13.20	10.19	07.55	05.70
Shivalik	29.30	28.04	25.99	23.52	21.34	19.07	17.45	15.77	12.38
Palam Soya	25.17	23.87	23.11	21.47	20.07	18.43	16.36	15.00	11.67
PS 1556	34.97	32.32	29.98	27.50	25.02	23.35	21.33	19.84	16.62
Him Soya	23.52	22.18	21.06	20.05	18.76	15.87	13.37	11.35	09.20
Him Palam Hara Soya 1	23.35	21.28	20.18	19.24	17.00	15.03	13.75	10.81	08.67
Mean	26.15	24.61	23.00	21.48	19.26	17.27	15.20	13.11	10.67
SE(m)±	0.415	0.379	0.362	0.423	0.385	0.351	0.365	0.211	0.112
$CD_{0.05}$	1.229	1.122	1.072	1.251	1.139	1.04	1.08	0.626	0.333

Table 2. Electrical conductivity of seven soybean varieties during 16 months of storage

Variety	Electrical conductivity (m mhos/cm/g) in months after storage								
	Initial (Jan 19)	2 (Mar 19)	4 (May 19)	6 (Jul 19)	8 (Sep 19)	10 (Nov 19)	12 (Jan 20)	14 (Mar 20)	16 (May 20)
Hara Soya	0.140	0.156	0.170	0.182	0.185	0.196	0.202	0.213	0.274
Palam Early Soya 1	0.171	0.185	0.198	0.206	0.217	0.237	0.257	0.267	0.310
Shivalik Soybean	0.165	0.183	0.197	0.201	0.217	0.222	0.235	0.242	0.290
Palam Soya	0.130	0.149	0.165	0.174	0.183	0.190	0.200	0.211	0.268
PS 1556	0.073	0.083	0.098	0.107	0.114	0.130	0.153	0.168	0.215
Him Soya	0.127	0.137	0.142	0.157	0.175	0.186	0.194	0.205	0.255
Him Palam 1 Hara Soya	0.186	0.198	0.213	0.222	0.232	0.241	0.257	0.274	0.315
Mean	0.142	0.156	0.169	0.178	0.189	0.200	0.214	0.226	0.275
SE(m)±	0.003	0.001	0.002	0.001	0.002	0.002	0.002	0.003	0.004
$CD_{0.05}$	0.008	0.004	0.006	0.003	0.005	0.007	0.005	0.008	0.012

highest rate of germination (34.97), whereas, Palam Early Soya 1 recorded the lowest rate of germination (22.27) which was at par with Him Palam Hara Soya 1 (23.35). Subsequently, at the end of storage period, the rate of germination of the best performing variety PS 1556 was 65.70 per cent higher as compared to Palam Early Soya 1 which recorded the minimum rate of germination.

Unlike all the other seed quality parameters, electrical conductivity witnessed an increasing trend with the advancement of storage period. The increase in electrical conductivity was much more pronounced in Him Palam Hara Soya 1 and Palam Early Soya 1 reflecting that these varieties deteriorated faster than others when kept under storage. Him Palam Hara Soya 1 exhibited the highest electrical conductivity (0.315 m mhos/cm/g) at the end of storage period that was 31.74 per cent more as compared to PS 1556 which exhibited the lowest electrical conductivity (0.215 m mhos/cm/g). The variation in electrical conductivity between genotypes may be due to seed size and mechanical damage. Small sized seeds having lesser mechanical damage are less prone to attack of microflora and hence, have lower electrical conductivity (Abdul-Baki and Anderson 1973). In the present study, variety PS 1556 exhibited the lowest test weight and recorded the lowest electrical conductivity throughout the storage period. On the other hand, varieties Him Palam Hara Soya 1 and Palam Early Soya 1 exhibited the highest test weight and electrical conductivity. Higher electrical conductivity in large sized seeds may be due to loss of membrane integrity which increases its permeability, thus resulting in leakage of more substances into the medium.

Among the seven varieties of soybean grown in the hills of northwestern Himalayan regions of India, variety PS 1556 recorded higher seed quality parameters viz germination percentage, field emergence and rate of germination and least 100-seed weight as well as the lowest electrical conductivity. Besides, its germination percentage did not fall below IMSCS (70%) even after 16 months of storage. The study acquaints about the seed storability of seven soybean varieties and would assist the seed producers in deciding the fate of the produced seeds.

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