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Comparative Evaluation of Physiological Traits in Mung Bean [*Vigna radiata* (L.) Wilczek] Genotypes for Seed Longevity

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Abstract
A study was conducted to evaluate seed longevity of 15 mung bean [*Vigna radiata* (L.) Wilczek] genotypes, including IPM-2-3, PDM-139, IPM-2K-14-9, IPM 409-4, IPM 410-3, IPM 312-20, IPM 512-1, IPM 302-2, IPM 16-20-6, IPMD 2-802, IPMD 19-05, IPM-2-14, IPM 205-7, DGGV-2, and IPM 1604-1, which were stored under ambient conditions for six months and categorized as good, medium, and poor storers based on the observed physiological changes in seeds during the storage period. The results showed that as the storage period progressed, there was a noticeable decline in seed quality parameters, with freshly harvested seeds exhibiting higher germination and vigour. After six months of storage, good storers (IPM 205-7, IPM 512-1, IPMD 19-05, and IPM 409-4) maintained higher germination, seedling vigour indices, and lower electrical conductivity of seed leachate compared to poor storers (IPM-2K-14-9, IPM 16-20-6, and IPM 1604-1). Additionally, an increase in seed moisture content and electrical conductivity was observed due to metabolic reserve depletion, contributing to the reduction in seed vigour and viability.

Keywords: Physiological, seed germination, electrical conductivity, seed viability, seedling vigour, seed longevity

Introduction

Mung bean [*Vigna radiata* (L.) Wilczek] is an important short-duration pulse crop of the family Fabaceae, with a diploid chromosome number of 2n = 2x = 22. Commonly known as green gram or moong, it is widely cultivated in India and several tropical and subtropical countries for its highly nutritious seeds and significant contribution to food and nutritional security (Kataria *et al.*, 1989) [17]. Mung bean is valued for its short growth duration, adaptability to diverse agro-climatic conditions, and high yield potential, making it a key crop in rainfed and irrigated farming systems.

In India, mung bean is grown on 55.38 lakh hectares, producing 31.50 lakh tonnes, with an average productivity of 570 kg/ha, contributing more than 70% of global production (Anon., 2023) [5]. Major mung bean growing states include Rajasthan, Maharashtra, Madhya Pradesh, Karnataka, Odisha, Bihar, Tamil Nadu, and Gujarat. Its widespread cultivation reflects its agronomic importance and versatility as a staple legume in human diets.

Seed is a biological entity whose quality deteriorates over time. Maintaining seed viability and vigour during storage is crucial for ensuring proper seedling establishment and optimal crop performance (Pandita and Hosamani, 2025) [21]. Seed ageing is influenced by both genetic and environmental factors, including the inherent genotypic potential of the seed, initial seed quality, moisture content, relative humidity, and temperature. In tropical and subtropical regions, where high temperature and humidity prevail, seeds are particularly prone to rapid physiological deterioration (McDonald, 1999) [20].

Physiological deterioration during storage results in reduced germination, poor seedling growth, and loss of vigour. Seed vigour and germination uniformity are essential indicators of seed quality and are largely governed by genetic variability among genotypes. Different mung bean genotypes exhibit considerable variation in their ability to maintain viability and vigour under storage conditions, highlighting the importance of identifying genotypes with superior storage potential (Hosamani *et al.*, 2012; Siddaraj *et al.*, 2019) [15, 24].

Optimal storage conditions are critical for conserving seed longevity and ensuring consistent crop establishment. Understanding the genotypic differences in seed storability and physiological performance enables breeders and seed producers to select superior genotypes for cultivation and hybridization programmes. In view of the above, the present study was undertaken to evaluate the physiological changes in mung bean genotypes during natural ageing for assessing seed vigour and identifying genotypes with superior storage potential.

Materials and Methods

A laboratory experiment was conducted at the Department of Seed Science and Technology, College of Agriculture, Dharwad, UAS Dharwad, during *kharif* 2024-25 to study physiological changes during natural ageing for seed vigour assessment of 15 mung bean genotypes. The genotypes included IPM-2-3, PDM-139, IPM-2K-14-9, IPM 409-4, IPM 410-3, IPM 312-20, IPM 512-1, IPM 302-2, IPM 16-20-6, IPMD 2-802, IPMD 19-05, IPM-2-14, IPM 205-7, DGGV-2, and IPM 1604-1. Seeds were collected from the ICAR-Indian Institute of Pulses Research (IIPR), Regional Research Centre-cum-Off-season Nursery, Dharwad, and used after one cycle of multiplication. Harvested seeds were stored in cloth bags under ambient laboratory conditions, and physiological changes were recorded in fresh seeds, and after three and six months of storage.

Vigour assessment was carried out through physiological parameters such as seed germination (%) as per ISTA (2021), and seedling vigour index I and II were calculated following the formula of Abdul-Baki and Anderson (1973) [1] and expressed in number. Electrical conductivity (EC) (µS/cm/g seed fresh weight) of seed leachate was estimated as per Agrawal and Dadlani (1992) [3] with minor modifications. Seed moisture content (%) was estimated using the hot air oven method as per ISTA (2021) and expressed on a fresh weight basis.

Results

Seed germination of mung bean genotypes declined progressively with storage duration (Table 1). In freshly harvested seeds, the highest germination was observed in IPMD 19-05 (96.50%), followed closely by IPM 512-1 (95.50%) and IPM 409-4 (93.50%), while the lowest germination was recorded in IPM-2K-14-9 (78.50%). Among the 15 genotypes, ten exhibited more than 90 per cent germination, whereas five ranged between 78.50 and 89.25 per cent, with an overall mean of 88.28 per cent. After three months of storage, germination declined across all genotypes, ranging from 68.50 per cent (IPM-2K-14-9) to 90.00 per cent (IPM 512-1), and the overall mean decreased to 81.48 per cent. Good storers such as IPM 512-1 (90.00%), IPMD 19-05 (89.25%), and IPM 205-7 (89.75%) maintained relatively higher germination, whereas poor storers including IPM-2K-14-9 (68.50%) and IPM 16-20-6 (69.75%) showed a marked decline. After six months of storage, germination was further reduced, ranging from 61.75 per cent (IPM-2K-14-9) to 87.50 per cent (IPM 205-7), with an overall mean of 76.88 per cent. Good storer genotypes, including IPM 205-7 (87.50%), IPM 512-1 (86.75%), and IPM 409-4 (86.00%), consistently retained germination above 85 per cent, whereas poor storers such as IPM-2K-14-9 (61.75%) and IPM 16-20-6 (64.75%) declined to critically low levels.

Based on six-month germination, the genotypes were classified into three categories. Good storers, maintaining more than 80% germination, included IPM 205-7, IPM 512-1, IPM 409-4, IPM 302-2, IPM 312-20, IPM-2-14, and IPMD 19-05, reflecting their superior ability to retain viability. Medium storers, with germination between 70% to 80%, comprised IPM 410-3, IPMD 2-802, IPM-2-3, and DGGV-2. Poor storers, exhibiting less than 70% germination, included PDM-139, IPM 1604-1, IPM 16-20-6, and IPM-2K-14-9, which failed to meet the Indian Minimum Seed Certification Standards, whereas good storers maintained high seed viability.

Seedling vigour indices (SVI-I and SVI-II) also showed a marked decline with increasing storage duration (Table 1). Freshly harvested seeds exhibited higher vigour, which decreased significantly after three months and further deteriorated by six months. Among the genotypes, IPM 410-3 recorded the highest SVI-I (2566) at harvest, while IPM 16-20-6 had the lowest (1615). After six months, IPM-2-14 (2059) and IPM 205-7 (2052) maintained relatively higher values, whereas IPM-2K-14-9 registered the lowest (1196). Similarly, SVI-II was maximum in IPM 410-3 (22540) and DGGV-2 (21644) at harvest, while IPM 1604-1 had the lowest (16006). After six months, IPM 409-4 (16827) retained the highest SVI-II, and IPM 16-20-6 the lowest (10095). Storability grouping revealed distinct differences among genotypes. Good storers maintained higher vigour across all stages (2324, 2077 and 1892 for SVI-I; 19679, 17475 and 14335 for SVI-II at fresh, three and six months, respectively), followed by medium storers, whereas poor storers registered the lowest values (1800, 1469 and 1342 for SVI-I; 16413, 12903 and 10837 for SVI-II).

Seed moisture content showed a steady increase with advancing storage duration (Table 2). In freshly harvested seeds, IPMD 19-05 recorded the highest moisture content of 13.70 per cent, which was followed by IPM 16-20-6 (13.39%). In contrast, IPM-2K-14-9 had the lowest moisture content of 10.71 per cent. After three months of storage, seed moisture content increased in all genotypes. The highest moisture content of 14.63 per cent was observed in IPMD 19-05, while the lowest was noted in IPM-2K-14-9 that is 11.39 per cent. However, after six months of storage, seed moisture content further increased across genotypes. IPM 16-20-6 recorded the highest value of 15.80 per cent, whereas the lowest was found in IPM-2K-14-9 (12.42%). The mean seed moisture content for freshly harvested mung bean seeds was 11.91 per cent, which increased to 12.86 per cent after three months of storage and further to 13.93 per cent after six months of storage.

In freshly harvested seeds, the EC of seed leachate varied from 20.71 µS/cm/g in IPMD 19-05 to 89.15 µS/cm/g in IPM-2-3. Among the genotypes, IPM-2-3 (89.15 µS/cm/g), IPM 410-3 (63.00 µS/cm/g) and PDM-139 (62.13 µS/cm/g) recorded the highest values, whereas IPMD 19-05 (20.71 µS/cm/g) and IPMD 2-802 (21.64 µS/cm/g) exhibited the lowest values. The overall mean EC of seed leachate in freshly harvested seeds was 52.66 µS/cm/g.

After three months of storage, the EC of seed leachate increased across all genotypes. IPM 16-20-6 (116.25 µS/cm/g) exhibited the highest EC of seed leachate, which was comparable to DGGV-2 (111.32 µS/cm/g) and IPM-2-3 (110.71 µS/cm/g). In contrast, IPMD 19-05 (35.46 µS/cm/g) displayed the lowest EC of seed leachate, followed by IPM 512-1 (42.50 µS/cm/g). The mean EC of seed leachate at this stage was 74.70 µS/cm/g. This trend persisted after six months of storage, wherein genotype IPM 16-20-6 (146.90 µS/cm/g) recorded the highest EC of seed leachate in similar to DGGV-2 (139.69 µS/cm/g) and IPM-2-3 (133.74 µS/cm/g), while IPMD 19-05 (42.53 µS/cm/g) had the lowest EC of seed leachate. The overall mean EC after six months of storage was 92.87 µS/cm/g (Table 2).

Discussion

Seed germination showed a progressive decline during storage, indicating gradual loss of viability across genotypes (Table 1). In freshly harvested seeds, most genotypes exhibited more than 90% germination, with IPMD 19-05, IPM 512-1, and IPM 409-4 performing superiorly. After three months, germination decreased, though good storers such as IPM 205-7, IPM 512-1, and IPMD 19-05 maintained higher values. By six months, a marked reduction was observed, with poor storers like IPM-2K-14-9 and IPM 16-20-6 falling below the Indian Minimum Seed Certification Standards, while good storers retained germination above 85%. The overall mean reduced from 88.28% (fresh seeds) to 76.88% (six months). These results indicate distinct genotypic differences in storability, with good storers showing better retention of viability and vigour. Similar trends were reported by Chan and Mohammad Bin (2019) [7] and Lokeshwari *et al.* (2024) [18], who noted that the rate of germination decline varies with genetic constitution and storage potential of legume genotypes.

Seedling vigour indices (SVI-I and SVI-II) declined significantly with increasing storage duration. Freshly harvested seeds recorded higher vigour, which progressively decreased after three and six months of ambient storage. Among the genotypes, IPM 410-3 showed the highest SVI-I (2566) at harvest, while IPM 16-20-6 had the lowest (1615). After six months, IPM-2-14 (2059) and IPM 205-7 (2052) maintained higher SVI-I, whereas IPM-2K-14-9 recorded the minimum (1196). Similarly, SVI-II decreased from 22540 (IPM 410-3) in fresh seeds to 16827 (IPM 409-4) after six months, with the lowest in IPM 16-20-6 (10095). Good storers consistently exhibited higher mean values of both SVI-I and SVI-II at all storage intervals, followed by medium storers, while poor storers recorded the lowest vigour. The extent of decline was genotype dependent, with poor storers deteriorating faster. These findings agree with Chan and Mohammad Bin (2019) [7] in mung bean, and similar patterns were reported by Durga and Verma (2013) [9], Durga and Keshavulu (2015) [8] in horse gram, and Adebisi *et al.* (2008) [2] in sesame.

Seed moisture content increased steadily with advancing storage duration, indicating gradual absorption of atmospheric moisture under ambient conditions (Figure 1). The overall mean rose from 11.91% in freshly harvested seeds to 13.93% after six months, with IPMD 19-05 maintaining the highest and IPM-2K-14-9 the lowest values across intervals. Elevated seed moisture was associated with faster deterioration in poor storers such as IPM 16-20-6 and IPM 1604-1, whereas good storers like IPM 512-1 and IPM 302-2 retained lower moisture levels and superior quality. Comparable observations were reported by Maruthi (2006) [19], who emphasized the influence of ambient storage on seed water status and viability. High seed moisture is known to accelerate metabolic activity and reserve depletion (Bortey *et al.*, 2016; Gangambika *et al.*, 2022) [6, 10] and predispose seeds to bruchid infestation (Aidbhavi *et al.*, 2023) [4], supporting the present findings.

Electrical conductivity (EC) of seed leachate also exhibited a distinct increasing trend with storage duration, reflecting progressive loss of membrane integrity (Figure 1). The overall mean EC increased from 52.66 µS/cm/g in fresh seeds to 92.87 µS/cm/g after six months. Poor storers such as IPM 16-20-6 (146.90 µS/cm/g) and IPM 1604-1 (129.69 µS/cm/g) recorded the highest EC values, whereas good storers such as IPMD 19-05 (42.53 µS/cm/g) and IPM 512-1 (50.22 µS/cm/g) showed the lowest, indicating better membrane stability. The observed increase in EC due to solute leakage and membrane damage corroborates earlier reports in horse gram (Maruthi, 2006) [19], cotton (Goel *et al.*, 2003) [11], soybean (Hosamani *et al.*, 2013a; Hosamani *et al.*, 2013b; Hosamani *et al.*, 2020; Panobianco and Vieira, 2007) [12, 14, 13, 22], and onion (Rao *et al.*, 2006) [23]. Chan and Mohammad Bin (2019) [7] also observed similar trends in mung bean, confirming that higher EC values correspond to poor storability and reduced seed quality.

During storage, poor storer genotypes (PDM-139, IPM 1604-1, IPM 16-20-6, and IPM-2K-14-9) recorded a pronounced decline in seed germination, SVI-I and SVI-II, along with substantially higher EC of seed leachate. In contrast, good storers (IPM 205-7, IPM 512-1, IPMD 19-05, IPM 409-4) consistently maintained superior germination, vigour indices and lower EC values. Medium storers (IPM 302-2, IPM-2-14, DGGV-2 and IPM 410-3) exhibited intermediate performance, retaining moderate germination and vigour with corresponding EC levels. Seed moisture content also showed a steady increase with storage duration, with poor storers sustaining comparatively higher values, which made them more prone to rapid deterioration. These results clearly indicate that after six months of ambient storage, mung bean genotypes can be effectively classified into good, medium, and poor storers based on their viability and vigour behaviour.

Conclusion

Prolonged seed storage resulted in a progressive decline in germination and seedling vigour, attributable to both intrinsic factors, such as genetic makeup, and extrinsic factors related to storage conditions. This decline was accompanied by an increase in the electrical conductivity of seed leachate, indicating membrane deterioration and loss of cellular integrity. Significant variation among mung bean genotypes was observed, highlighting the role of genetic differences in seed storability. These findings are of practical relevance for the identification and characterization of genotypes with enhanced seed longevity and underscore the importance of adopting optimal storage practices and management strategies to maintain seed quality, ensure uniform seedling establishment, and support sustainable crop production.

Table 1: Changes in seed germination and seedling vigour indices of mung bean genotypes stored under ambient conditions

Genotypes		Seed germination (%)			Seedling vigour index I			Seedling vigour index II		
		Fresh seeds	3 MAS	6 MAS	Fresh seeds	3 MAS	6 MAS	Fresh seeds	3 MAS	6 MAS
Good storers	IPM 205-7	90.75 (72.33)*	89.75 (71.37)*	87.50 (69.36)*	2324	2153	2052	20419	19552	16458
	IPM 512-1	95.50 (77.96)	90.00 (71.60)	86.75 (68.70)	2271	1994	1744	18688	16494	11950
	IPM 409-4	93.50 (75.28)	88.25 (69.99)	86.00 (68.05)	2354	2080	1828	20443	18058	16827
	IPM 302-2	90.00 (71.62)	85.50 (67.65)	82.50 (65.28)	2216	1966	1850	18200	14954	13182
	IPM 312-20	89.00 (70.72)	83.75 (66.24)	81.75 (64.73)	2284	2014	1946	20845	17431	13855
	IPM-2-14	89.25 (70.87)	88.25 (70.05)	81.00 (64.22)	2513	2340	2059	18778	17123	13342
	IPMD 19-05	96.50 (79.31)	89.25 (70.88)	80.75 (63.99)	2308	1992	1766	20377	18713	14731
	Mean	92.07 (74.01)	87.82 (69.68)	83.75 (66.33)	2324	2077	1892	19679	17475	14335
Medium storers	IPM 410-3	91.75 (73.44)	83.00 (65.72)	78.00 (62.06)	2566	2190	2025	22540	17824	13570
	IPMD 2-802	87.25 (69.21)	81.25 (64.39)	76.00 (60.70)	2017	1741	1630	18180	13980	12276
	IPM-2-3	83.50 (66.12)	81.00 (64.20)	75.75 (60.51)	2124	1926	1743	19563	16950	15604
	DGGV-2	90.75 (72.31)	81.50 (64.53)	74.25 (59.52)	1879	1390	1201	21644	16280	12932
	Mean	88.31 (70.27)	81.69 (64.71)	76.00 (60.70)	2147	1812	1650	20482	16259	13596
Poor storers	PDM-139	87.50 (69.46)	71.75 (57.96)	69.50 (56.48)	2285	1758	1741	17451	12293	10127
	IPM 1604-1	81.25 (64.37)	70.75 (57.27)	67.00 (54.94)	1634	1391	1234	16006	12431	11054
	IPM 16-20-6	79.25 (62.96)	69.75 (56.64)	64.75 (53.59)	1615	1364	1197	16141	13236	10095
	IPM-2K-14-9	78.50 (62.41)	68.50 (55.86)	61.75 (51.80)	1666	1363	1196	16054	13653	12073
	Mean	81.63 (64.80)	70.19 (56.93)	65.75 (54.20)	1800	1469	1342	16413	12903	10837
Overall mean		88.28 (70.56)	81.48 (64.96)	76.88 (61.60)	2137	1844	1681	19022	15932	13205
S.Em (±)		1.21 (1.09)	1.17 (0.88)	1.08 (0.77)	81.7	66.4	27.8	259.1	239.4	187.5
CD @ 1%		4.60 (4.14)	4.46 (3.36)	4.11 (2.94)	310.8	252.7	105.8	985.4	910.7	713.3
Significance		S	S	S	S	S	S	S	S	S

Note: MAS - Months after storage
S - Significance
* Values in the parentheses are arc sin transformations

Table 2: Seed moisture content and electrical conductivity of seed leachate of mung bean genotypes stored under ambient conditions

Genotypes		Seed moisture content (%)			Electrical conductivity of seed leachate (µS/cm/g seed fresh weight)		
		Fresh seeds	3 MAS	6 MAS	Fresh seeds	3 MAS	6 MAS
Good storers	IPM 205-7	11.70 (20.00)*	13.05 (21.17)*	14.45 (22.34)*	36.36	50.90	68.73
	IPM 512-1	11.21 (19.56)	12.39 (20.61)	13.10 (21.22)	26.43	42.50	50.22
	IPM 409-4	10.90 (19.28)	12.17 (20.41)	13.13 (21.25)	57.95	67.45	81.13
	IPM 302-2	11.31 (19.65)	12.37 (20.59)	13.15 (21.26)	37.59	54.60	69.33
	IPM 312-20	11.61 (19.92)	12.43 (20.64)	13.13 (21.25)	51.74	68.45	89.32
	IPM-2-14	11.81 (20.10)	12.60 (20.79)	13.77 (21.79)	32.49	46.00	60.08
	IPMD 19-05	13.70 (21.72)	14.63 (22.49)	15.73 (23.37)	20.71	35.46	42.53
	Mean	11.75 (20.03)	12.81 (20.96)	13.78 (21.78)	37.61	52.19	65.91
Medium storers	IPM 410-3	10.95 (19.32)	11.83 (20.11)	12.80 (20.96)	63.00	87.51	109.71
	IPMD 2-802	13.62 (21.65)	14.01 (21.98)	15.35 (23.07)	21.64	40.33	49.68
	IPM-2-3	11.11 (19.47)	12.30 (20.53)	13.19 (21.30)	89.15	110.71	133.74
	DGGV-2	12.16 (20.40)	13.51 (21.57)	14.77 (22.60)	58.59	111.32	139.69
	Mean	11.96 (20.21)	12.91 (21.05)	14.03 (21.98)	58.10	87.47	108.21
Poor storers	PDM-139	11.25 (19.59)	12.19 (20.43)	13.18 (21.29)	62.13	87.18	102.60
	IPM 1604-1	13.11 (21.23)	14.00 (21.97)	15.01 (22.79)	73.52	102.93	129.69
	IPM 16-20-6	13.47 (21.53)	14.07 (22.03)	15.80 (23.42)	76.29	116.25	146.90
	IPM-2K-14-9	10.71 (19.10)	11.39 (19.72)	12.42 (20.63)	82.32	98.98	119.68
	Mean	12.14 (20.36)	12.91 (21.04)	14.10 (22.03)	73.57	101.34	124.72
Overall Mean		11.91 (20.17)	12.86 (21.00)	13.93 (21.90)	52.66	74.70	92.87
S.Em (±)		0.08 (0.08)	0.03 (0.02)	0.09 (0.08)	0.67	0.96	1.16
CD @ 1%		0.35 (0.32)	0.12 (0.10)	0.39 (0.32)	2.60	3.72	4.52
Significance		S	S	S	S	S	S

Note: MAS - Months after storage
S - Significance
* Values in the parentheses are arc sin transformation

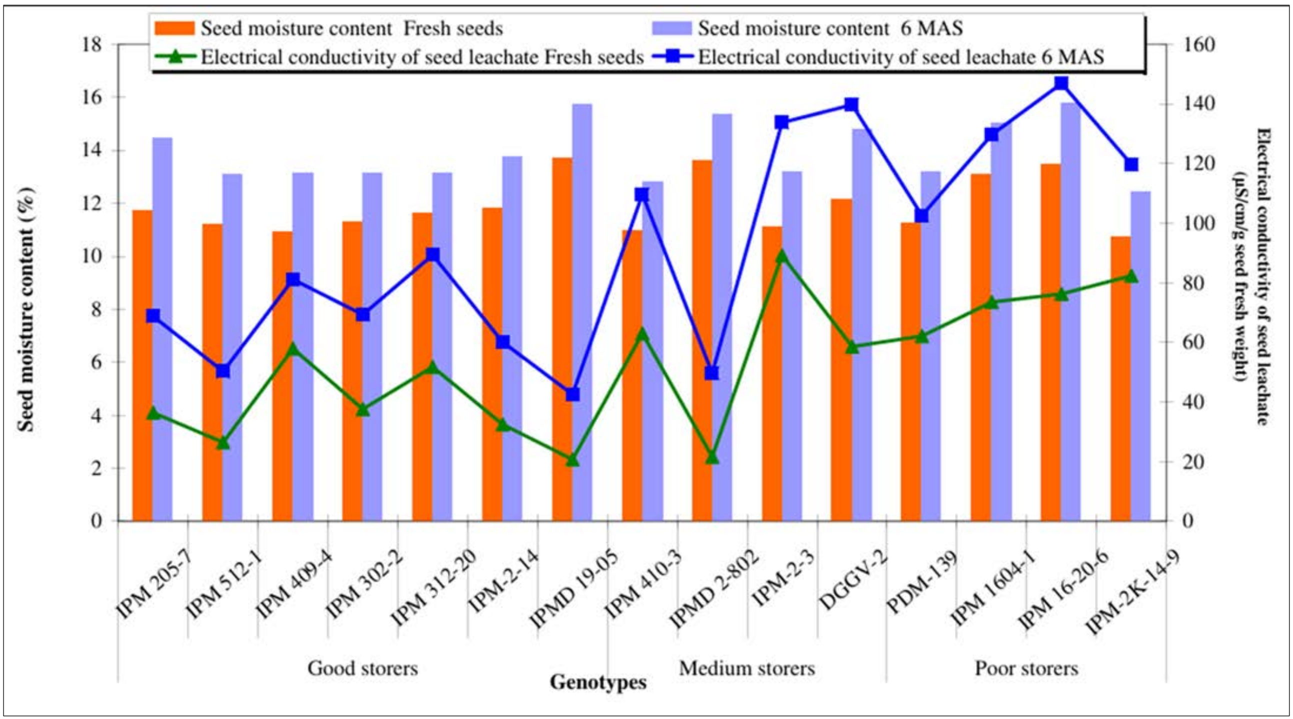

Fig 1: Seed moisture content (%) and electrical conductivity (µS/cm/g seed fresh weight) of seed leachate of mung bean genotypes stored under ambient conditions.

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