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Effect of seed ageing on seed quality parameters of soybean cultivars [*Glycine max* (L.) Merrill]

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Abstract
The three cultivars *viz.,* NRC 37, JS 20-34 and JS 335 were chosen for the study of effect of artificial ageing on seed quality parameters. The cultivar JS 335 showed significantly higher germination percentage, seedling root length, shoot length, seedling length, seedling fresh weight & dry weight, seed vigour indices and seed viability and low electrical conductivity as compared to other cultivars. Among the aged treatments control group was found significant for all characters as compared to the other ageing treatments. The cultivar JS 335 has retained its germination capacity and vigour after ageing treatment hence, this variety can be effectively utilized for further investigation regarding the storability and longevity of the soybean seeds.

Keywords: Artificial seed ageing, electrical conductivity, seed vigour indexes, seed viability

Introduction
Soybean [*Glycine max* (L.) Merrill, 2n=2x=40] is an important oilseed crop known as “Golden bean” which belongs to the family *Leguminosae* along with many essential food legume crops such as chickpea, peanut, alfalfa, faba bean, lentil and pea.

To grow a healthy crop, a healthy seed is the prime requirement. Soybean seeds are structurally weak, inherently short-lived and easily subjected to damage during harvesting and threshing (Delouche *et al*., 1973) [1]. Seed storage life is influenced by the genotype as well as the storage conditions. Seed deterioration is affected due to high temperature, moisture and relative humidity are most important for viability, vigour and germination. Most importantly, deterioration is an irreversible catabolic process that, once occurred, cannot be reversed. However, the seed potential storage life as well as the deterioration rate are greatly subjected to both species and genotype dependency.

Seeds from many field crops are kept in storage after harvest for a few days, weeks, months or years. Seed vigour potential and germination characteristics can be affected by seed storage conditions (Mc Donald, 1999) [9]. The vigour of seeds can be determined by a number of variables, including the weather during the seed-producing stage, pests and diseases, seed oil and moisture content, mechanical damage, storage season, duration and relative humidity of storage (Krishnan *et al*., 2003; Marshal and Levis, 2004) [7, 8]. Not only does time affect seed ageing, but also temperature and moisture (Ellis and Roberts, 1981) [2]. As a result, the environment in which seeds are stored has a significant impact on the time that seeds survive (Ellis *et al*., 1982) [3]. The decrease of seed quality, viability and vigour in seeds that results from ageing or the impact of unfavourable environmental variables is known as seed degradation.

Seed ageing is directly associated with the seed moisture content and temperature thus, their manipulation provides a means of technically inducing the seed deterioration process. Under storage conditions, seeds typically lose their viability within a few days or weeks (Murthy *et al.,* 2003) [11]. It has been evidenced that accelerated ageing causes a remarkable decrease in germination percentage and vigour (Rastegar *et al.,* 2011) [12] while, at the same time, ageing seed is characterized by loss of germination, reduced germination rate and poor seedling development (Tatic *et al.,* 2012). In soybean, it has been confirmed that the accelerated ageing test provides the possibility of predicting the actual seed germination rate during natural ageing (Fabrizius *et al.,* 1999) [4]. There are many circumstances under which it is important to predict the environmental effects on seed longevity, ranging from the rapidly occurring loss of viability due to the hot air-drying of wet seeds to slowly occurring deterioration as a result of long-term storage for genetic conservation purposes.

Such equations allow for an accurate prediction of the expected percentage of seed viability formed at any given period of medium-term storage and any combination of temperature and moisture content (Ellis *et al.*, 1982) [3]. When either the seed moisture content or storage temperature rises, the rate of deterioration increases quickly (Kapoor *et al.*, 2010) [6]. Reduced seed vigour results from lower seed quality, yield, percentage, rate of germination and susceptibility to environmental stress (Tekrony *et al*., 1989) [15].

Materials and Methods

The experimental material consists of three soybean cultivars named NRC 37, JS 20-34 and JS 335 were procured from ICAR-Indian Institute of Soybean Research, Indore, Madhya Pradesh. The seeds were subjected to accelerated ageing treatment at 45 °C temperature and >95% relative humidity for 1, 2, 3, 4 and 5 days and compared with control. The germination test was conducted for all the treatments in four replicates and the data for various parameters *viz.*, germination per cent, seedling root length, seedling shoot length, seedling length, seedling fresh weight, seedling dry weight, seed vigour indices, electrical conductivity and viability. The data for germination percentage, electrical conductivity and viability was considered upto 5th day of seed ageing and for remaining characters the data upto 3rd day of seed ageing was taken since there was no germination in NRC-37 and JS-20-34 varieties studied.

Results

All the varieties showed significant effect of ageing on seed physiological parameters. In case of germination percentage the control group (69.50%) showed significantly higher germination as compared to the other ageing treatments. Among the varieties JS 335 (47.05%) showed significantly higher germination followed by JS 20-34 (32.57%) and NRC 37 (22.57%). A significant per cent loss of germination was found in all the cultivars with 78.30%, 79.85% and 46.73% in NRC 37, JS 20-34 and JS 335 respectively (Fig. 1). Decreasing in germination in aged seeds might be due to the lipid peroxidation, mitochondrial dys-function and less ATP production.

The seedling root length, shoot length and seedling length was severely affected by seed ageing, as the aged seeds showed less seedling length with control being the highest. NRC 37 (6.20 cm, 7.94 cm and 14.14 cm) showed least seedling root length, seedling shoot length, seedling length and JS 335 (10.25 cm, 10.89 cm and 21.14 cm) being the cultivar having higher seedling root length, seedling shoot length and seedling length (Fig. 2).

The artificial seed ageing affected seedling fresh and dry weight in all the three cultivars of soybean. As compared to the aged treatments control (6.53 g and 0.26 mg for 10 seedlings) has significantly higher seedling fresh and dry weight. The cultivar NRC 37 (3,31 g and 0.12 mg for 10 seedlings) had lowest seedling fresh and dry weight however, JS 335 (5.64 g and 0.23 mg for 10 seedlings) had significantly higher seedling fresh and dry weight.

The seedling vigour indices was affected severely with seed ageing in all the cultivars. Control group (1639 and 19.03) showed higher seedling vigour index I and seedling vigour index II in comparison with aged treatments. The cultivar JS 335 (1448 and 15.50) showed higher vigour indices and NRC 37 (584 and 6.05) showed least vigour indices.

The electrical conductivity showed drastic changes in the control and aged seeds. Highest leachate content was found in aged seeds and lowest seed leachate in control (0.81 ds/m). Among the cultivars, JS 335 (3.14 ds/m) has lowest seed leachate and NRC 37 (4.56 ds/m) had highest seed leachate.

The seed viability was tested among all the treatments and compared with the control. The control group (99.67%) had highly viable seed but as the ageing progress seed viability was lost upto 42.67% in 5th day aged seeds. Cultivar NRC 37 (Fig. 3) had lost its viability early as compared to JS 335 (Fig. 5) and JS 20-34 (Fig. 4). This indicated that the after ageing also JS 20-34 and JS 335 retained maximum viability.

Table 1: Effect of artificial seed ageing on germination (%), EC and Seed viability of soybean cultivars

Treatments	Germination percentage				Electrical conductivity (ds/m)				Seed viability (%)			
Cultivars (V) Ageing period (A)	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean	V_1	V_2	V_3	Mean
A_1	57.26	77.58	73.65	69.50	1.10	0.82	0.51	0.81	99.00	100.00	100.00	99.67
A_2	49.22	67.55	77.84	64.87	1.80	1.21	0.62	1.21	86.33	99.00	97.33	94.22
A_3	16.41	34.65	67.55	39.54	3.00	2.03	1.60	2.21	72.00	94.67	87.33	84.67
A_4	12.42	15.66	39.23	22.44	3.73	2.70	2.46	2.96	45.33	73.67	84.00	67.67
A_5	0.00	0.00	14.15	4.72	4.08	3.96	3.02	3.68	24.33	66.00	74.67	55.00
A_6	0.00	0.00	9.88	3.29	4.56	4.28	3.14	3.99	18.33	52.33	57.33	42.67
Mean	22.55	32.57	47.05		75.87	80.84	83.75		57.56	80.94	83.44	
(%) loss	78.30	79.85	46.73		3.04	2.50	1.89		81.48	47.67	42.67	
For comparing the means of	S.Em. ±			CD (p=0.05)	S.Em. ±		CD (p=0.05)		S.Em. ±		CD (p=0.05)	
A	0.41			1.19	0.01		0.04		0.47		1.34	
V	0.59			1.68	0.02		0.05		0.66		1.90	
A × V	1.02			2.92	0.03		0.09		1.14		3.20	
	5.16				2.32				2.68			

Table 2: Effect of artificial seed ageing on seedling root length, shoot length, seedling length and seedling fresh weight of soybean cultivars

Treatments	Seeding root length (cm)				Seedling shoot length (cm)				Seedling length (cm)				Seedling fresh weight (g)			
Cultivars (V) Ageing period (A)	**V_1**	**V_2**	**V_3**	**Mean**	**V_1**	**V_2**	**V_3**	**Mean**	**V_1**	**V_2**	**V_3**	**Mean**	**V_1**	**V_2**	**V_3**	**Mean**
A_1	8.98	12.09	13.23	11.43	10.12	12.56	12.12	11.60	19.86	24.65	25.35	23.29	4.85	7.38	6.53	6.53
A_2	9.02	11.24	12.55	10.94	10.83	10.69	11.88	11.13	19.10	21.92	24.43	21.82	4.20	6.33	6.40	5.62
A_3	4.71	7.70	10.84	7.75	5.36	9.76	12.46	9.19	10.07	17.46	23.30	16.94	2.01	4.95	6.07	3.97
A_4	2.08	4.20	4.40	3.56	5.46	7.95	7.09	6.83	7.54	12.15	11.49	10.39	2.16	3.92	3.40	3.33
Mean	6.20	8.81	10.25		7.94	10.24	10.89		14.14	19.05	21.14		3.31	5.64	5.64	
(%) loss	76.94	65.26	66.74		49.58	36.70	41.50		62.03	50.70	54.67		55.46	46.88	47.93	
For comparing the means of	S.Em. ±			CD (p=0.05)	S.Em. ±		CD (p=0.05)		S.Em. ±		CD (p=0.05)		S.Em. ±		CD (p=0.05)	
A	0.08			0.23	0.12		0.34		0.15		0.43		0.07		0.20	
V	0.09			0.27	0.13		0.39		0.17		0.49		0.08		0.23	
A × V	0.16			0.46	0.23		0.68		0.29		0.86		0.14		0.41	
	3.32				4.13				2.81				5.00			

Table 3: Effect of artificial seed ageing on seedling dry weight and seed vigour indices of soybean cultivars

Treatments	Seedling dry weight (mg)				Seedling vigour index I				Seedling vigour index II			
Cultivars (V) Ageing period (A)	**V_1**	**V_2**	**V_3**	**Mean**	**V_1**	**V_2**	**V_3**	**Mean**	**V_1**	**V_2**	**V_3**	**Mean**
A_1	0.22	0.32	0.26	0.26	1138	1913	1867	1639	12.62	25.08	19.39	19.03
A_2	0.21	0.32	0.25	0.26	940	1480	1901	1440	10.51	20.96	19.46	16.97
A_3	0.04	0.19	0.25	0.15	165	605	1574	782	0.66	6.35	16.89	7.97
A_4	0.04	0.05	0.16	0.08	94	189	451	245	0.42	0.78	6.28	2.49
Mean	0.12	0.21	0.23		584	1047	1448		6.05	13.29	15.50	
(%) loss	81.81	84.37	38.46		91.73	90.12	75.84		96.67	96.88	67.61	
For comparing the means of	S.Em. ±			CD (p=0.05)	S.Em. ±		CD (p=0.05)		S.Em. ±		CD (p=0.05)	
A	0.005			0.013	14		47.00		0.21		0.76	
V	0.006			0.015	16		54.27		0.24		0.88	
A × V	0.011			0.026	27		93.99		0.42		1.52	

Cultivars Treatment	**NRC-37**	**JS-20-34**	**JS-335**
Control			
1 day ageing			
2 day ageing			

Fig 1: Effect of artificial seed ageing on seedling length in different cultivars of soybean

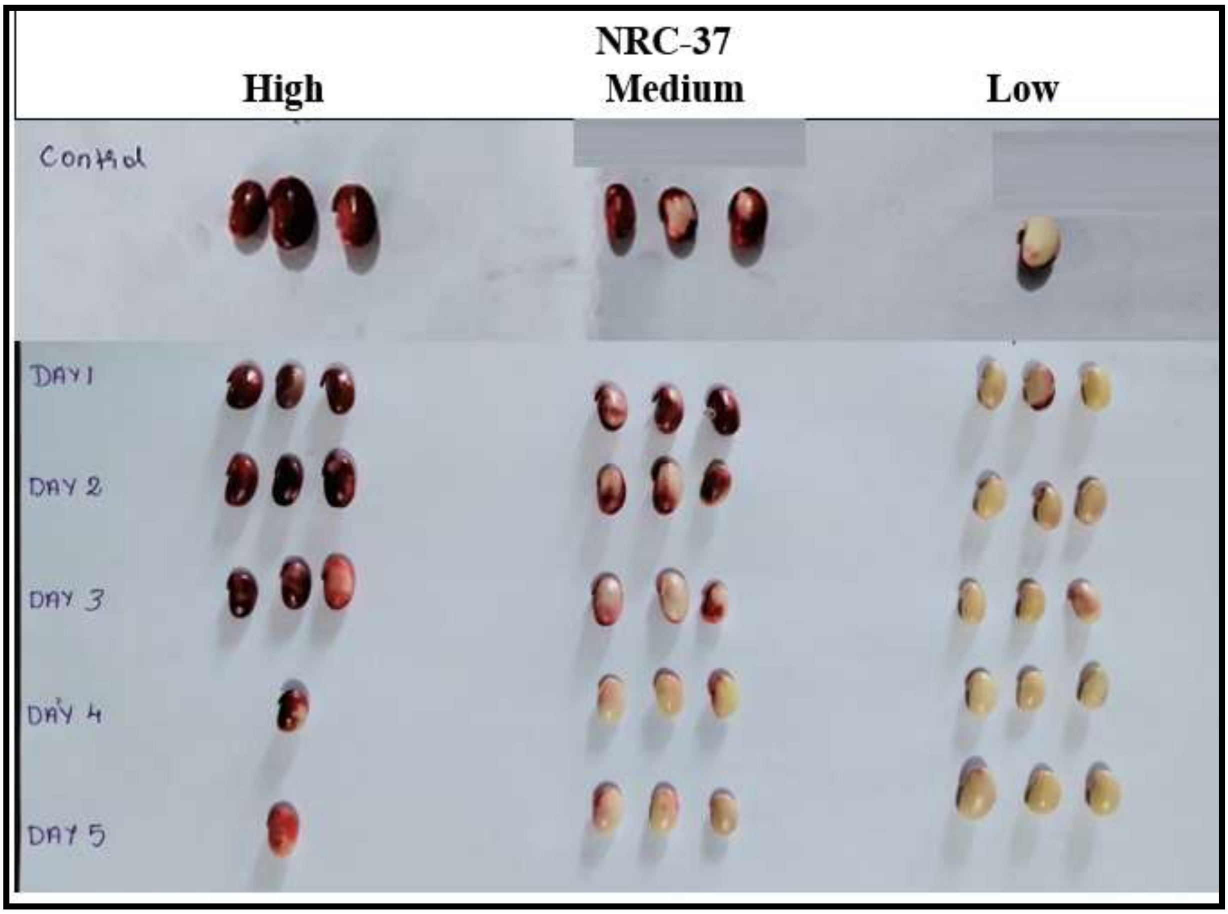

Fig 2: Effect of artificial seed ageing on seed viability in NRC 37

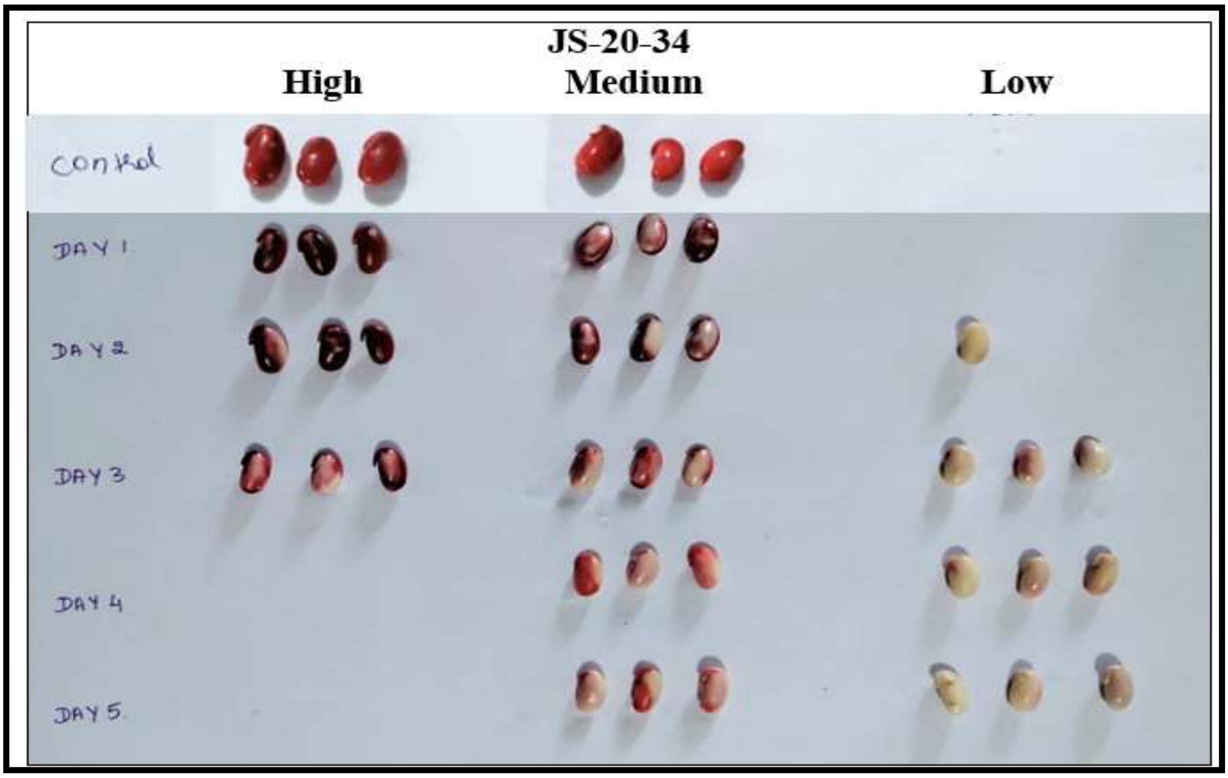

Fig 3: Effect of artificial seed ageing on seed viability in JS 20-34

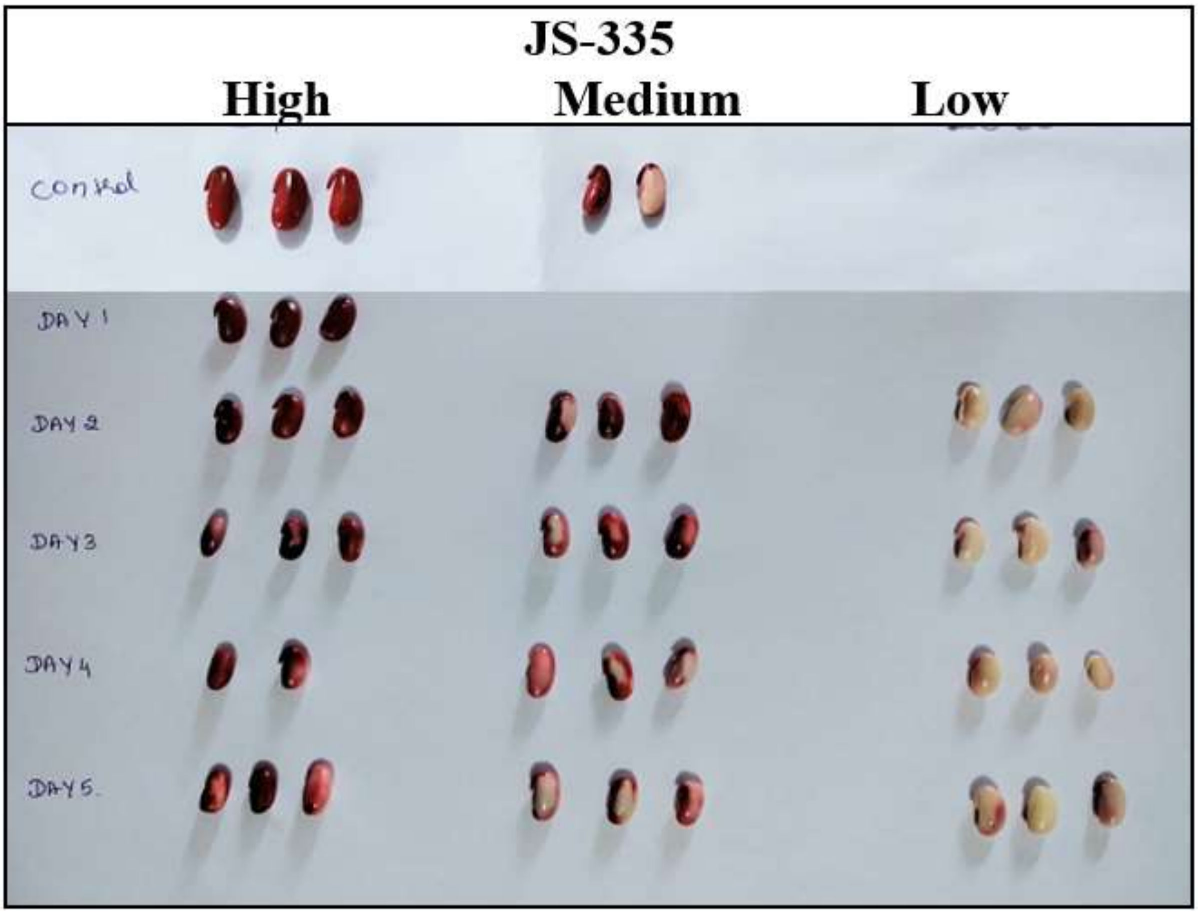

Fig 5: Effect of artificial seed ageing on seed viability in JS 335

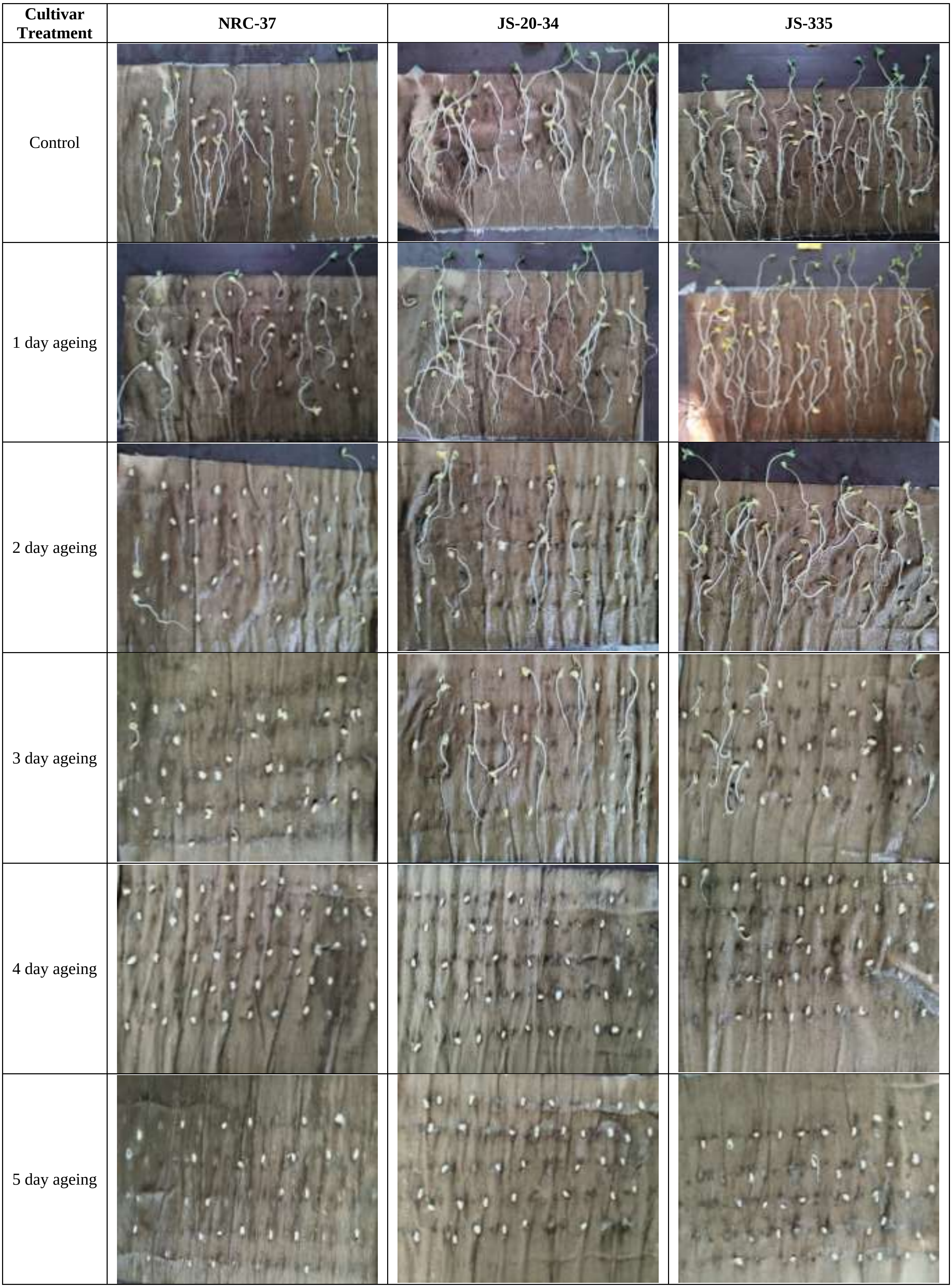

Plate 1: Effect of artificial seed ageing on germination in different cultivars of soybean

Discussions

High temperature and relative humidity are among the major storage stresses that confronts seed during storage. Accelerated ageing technique has been widely used to access the ability of seeds to resist storage stress. In this study, the effect of accelerated ageing on seed physiological parameters of three soybean cultivars. The physiological parameters of soybean was consistently decreased with ageing duration. This implied that soybean seeds are sensitive to changes in storage temperature and relative humidity. Germination percentage of soybean seeds were affected at high RH irrespective of the species.

A similar results of decreasing germination percent and other physiological parameters was also observed by Ju-Ian *et al.* (2011) [5] who reported the decline in the vigour and germinability of soybean with increased ageing duration. Similarly, Mohammadi *et al.* (2011) [10] observed loss of germination in deteriorated seeds and decreased percentage of normal seedlings in soybean seeds. Tatic *et al*. (2012) [14] observed that intensive decrease of germination and vigour of soybean seeds after artificial ageing and they concluded that storage conditions *viz*., temperature and relative humidity were highly important factors that affects the ability of seeds to germinate and seed viability along with the duration of storage.

Conclusion

The mean values of each parameter showed significant difference among cultivars, different ageing periods and interaction among the cultivars and ageing periods. Among all the treatments the control treatment showed significantly higher germination percentage, root length, root length, seedling length, seedling fresh weight, seedling dry weight, seedling vigour indices and viability. Among all the cultivars the cultivar JS 335 showed significantly superior for all the characters except electrical conductivity. NRC 37 showed highest electrical conductivity indicated the poor integrity of cell membrane. After ageing also JS-335 retained its physiological capacity and showed significantly higher germination percentage as compared to other two cultivars hence this cultivar can be exploited for further breeding studies.

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