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Assessment of seed storability parameters: Vigour Index-I, Vigour Index-II, electric conductivity and enzyme activities of soybean as influenced by different methods of threshing and processing

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Abstract

The seed storability of soybean is influenced by different methods of threshing and processing was studied at the Department of Seed Science and Technology, College of Agriculture, Raichur under ambient conditions. The experiment was conducted in laboratory using Factorial Completely Randomized Design with three replications. The findings shows that, the seed moisture content differed non significantly across the months of storage. Initial months showed highest seed moisture content in T₁ (10.48%), P₃ (10.41%) and T₁P₃ (10.53%) and the lowest seed moisture content was recorded in T₃ (10.25%), P₁ (10.31%) and T₃P₁ (10.16%). Further, The 100 seed weight differed non significantly across the months of storage. The 100 seed weight depends on the moisture content. The findings shows that, at the end of nine months of storage period, highest 100 seed weight was recorded in T₁ (10.00 g), P₃ (9.95 g) and T₁P₃ (10.11 g) while significantly lowest 100 seed weight was recorded in T₃ (9.78 g), P₁ (9.84 g) and T₃P₁ (9.75 g). Further, the findings shows that, The results on seed germination percentage as influenced by different threshing methods, processing operations and their interaction effects at different months of storage period. Highest seed germination was recorded in T₁ (75.11%), P₃ (73.66%) and T₁P₃ (77.33%) while significantly lower seed germination was recorded in T₃ (70.55%), P₁ (71.11%) and T₃P₁ (69.66%).

Keywords: Seed processing, seed length, design, factorial, threshing

Introduction

Soybean (*Glycine max* L.) is a globally important annual crop, often called the “wonder crop” due to its high nutritional and economic value. It contains about 40–45% protein and 19–20% oil, making it a major source of edible oil and plant-based protein, especially for vegetarians. Because of its affordability, it is popularly known as the “poor man’s meat.” Soybean is widely used in food products such as soya milk, flour, biscuits, and snacks, as well as in industrial products like paints and varnishes. It also improves soil fertility by fixing atmospheric nitrogen, benefiting subsequent crops.

Globally, countries like Brazil, the United States, and Argentina dominate soybean production. In India, soybean is mainly grown during the rainy season in states like Madhya Pradesh, Maharashtra, and Rajasthan, contributing significantly to farmers’ income and cropping intensity.

Seed quality plays a crucial role in soybean productivity, with good quality seeds increasing yields by 15–20%. However, soybean seeds have poor storability due to high oil content and sensitivity to environmental conditions.

Proper harvesting at the right stage of maturity is essential to maintain seed viability and ensure better germination and overall crop performance.

Materials and Methods

The seeds obtained by use of different threshing methods viz., T₁, Multi-crop thresher with 300 rpm; T₂, Multi-crop thresher with 500 rpm and T₃, Threshing by combine harvester and same seeds as per assigned treatments subjected to processing operations viz., P₁, Air screen cleaner; P₂, Air screen cleaner followed by gravity separator; and P₃, Air screen cleaner followed by gravity separator and spiral separator were stored in small gunny bags and placed in the seed storage cabinet at the Department of Seed Science and Technology, College of Agriculture, Raichur under ambient conditions. These seeds were used for further testing of seed quality parameters. The experiment was conducted in laboratory using Factorial Completely Randomized Design with three replications. The seeds were used for recording parameters viz., 100 seed weight, bulk density, seed germination, shoot length, root

length, seedling dry weight, seedling vigour index – I, seedling vigour index – II, electrical conductivity, dehydrogenase enzyme activity and peroxidase activity. All of the above parameters were recorded for every month, with the exception of peroxidase and dehydrogenase enzyme activity, which were recorded every three months.

Results and Discussion

Seedling vigour index I

The results of seedling vigour index I as influenced by different threshing methods, processing operations and their interaction effects at different months of storage period are presented in Table 1. The seedling vigour index decreased with the advancement of storage period in all the treatments. Whereas, initially higher seedling vigour index I was recorded in T₁ (3037), P₃ (2840) and T₁P₃ (3159) and lowest was in T₃ (2396), P₁ (2631) and T₃P₁ (2310). At the end of nine months of storage period, highest seedling vigour index I was recorded in T₁ (2121), P₃ (2005) and T₁P₃ (2211) while, significantly lowest seedling vigour index I was recorded in T₃ (1734), P₁ (1851) and T₃P₁ (1670).

Seedling vigour index II

The results of seedling vigour index II as influenced by different threshing methods, processing operations and their interaction effects at different months of storage period are presented in Table 2. The seedling vigour index decreased with the advancement of storage period in all the treatments. Whereas, initially higher seedling vigour index II was recorded in T₁ (54460), P₃ (52535) and T₁P₃ (56284) and lower was in T₃ (48094), P₁ (50282) and T₃P₁ (47257). At the end of nine months of storage period, highest seedling vigour index II was recorded in T₁ (44368), P₃ (43275) and T₁P₃ (45939) while, significantly lower seedling vigour index II was recorded in T₃ (40627), P₁ (41315) and T₃P₁ (39857).

Differences in vigour index among the processed seeds may be due to the difference in seed size and extent of mechanical injury. This was supported by various findings by Hesse and Peske (1981)^[14], Moreano *et al.* (2018)^[18] in soybean. The soybean crop threshed by multi-crop thresher with 300 rpm and seeds processed using air screen cleaner followed by gravity separator, and spiral separator (T₁P₃) recorded significantly highest seedling length, dry matter content and vigour index than other combinations. This could be attributed to less percentage of mechanical damage to these seeds. Mechanical damage to the seed may be one of the causes for reduction in length of seedlings of soybean. The threshing produces breaks, cracks, bruises and abrasions in seeds which in turn results in abnormal seedlings of questionable planting value. These results are in conformity with the findings of Kausal *et al.* (2006)^[16] in soybean.

It was noticed that seedling length, dry matter content and vigour index were decreased as the storage period advanced. The decrease in length of seedlings could be ascribed to the ageing or deterioration of seed, which is progressive process, accompanied by accumulation of metabolites and progressively decrease germination and growth of seedlings with increased age (Floris, 1970)^[12] and ultimately reducing the dry matter and vigour of soybean seed during storage. Seedling growth is considered to be an important tool that

can be used for assessing the magnitude of deterioration (Toole *et al.*, 1957)^[25].

Electrical conductivity (dS/m)

The data on electrical conductivity of seed leachate as influenced by different threshing methods, processing operations and their interaction effects at different months of storage period are presented in Table 3. Electrical conductivity of seed leachate was increased gradually as the storage period advanced. Initially, Lowest EC of seed leachates was observed in T₁ (0.396 dSm⁻¹), P₃ (0.459 dSm⁻¹) and T₁P₃ (0.379 dSm⁻¹) and highest EC of seed leachates was observed in T₃ (0.539 dSm⁻¹), P₁ (0.496 dSm⁻¹) and T₃P₁ (0.569 dSm⁻¹). At the end of storage period significantly lowest EC of seed leachates was observed in T₁ (1.407 dSm⁻¹), P₃ (1.632 dSm⁻¹) and T₁P₃ (1.347 dSm⁻¹) and highest EC of seed leachates was observed in T₃ (1.916 dSm⁻¹), P₁ (1.762 dSm⁻¹) and T₃P₁ (2.023 dSm⁻¹).

The electrical conductivity of soybean increased progressively with the advancement in storage period. A significant difference in electrical conductivity due to processing operations was observed throughout the storage period. The electrical conductivity increased with subsequent increase in storage period irrespective of processing operations. Lower electrical conductivity in seeds processed using air screen cleaner followed by gravity separator, and spiral separator (P₃) may be due to higher test weight, less mechanical damage and more physical purity. Increase in electrical conductivity along storage period might be caused by increase in permeability of membrane of deteriorated seed. Loss of membrane integrity of deteriorated seeds leaks more substances into the medium. This could be attributed to the high mechanical injury, poor membrane structure and leaky cells. These results in greater loss of electrolytes such as sugars, amino and organic acids from seeds and increased conductivity in the soak water and are in conformity with findings of Abdul Baki and Anderson, 1973^[1] and Agrawal, 1977^[2] in soybean.

Dehydrogenase enzyme activity

The data on dehydrogenase enzyme activity as influenced by different threshing methods, processing operations and their interaction effects at different months of storage period are presented in Table 4. Dehydrogenase enzyme activity decreased gradually as the storage period advanced. Initially, highest dehydrogenase enzyme activity was observed in T₁ (1.009 OD), P₃ (0.945 OD) and T₁P₃ (1.032 OD) and lowest dehydrogenase enzyme activity was observed in T₃ (0.833 OD), P₁ (0.895 OD) and T₃P₁ (0.815 OD). At the end of storage period significantly lowest dehydrogenase enzyme activity was observed in T₃ (0.434 OD), P₁ (0.466 OD) and T₃P₁ (0.424 OD) and highest dehydrogenase enzyme activity was observed in T₁ (0.525 OD), P₃ (0.492 OD) and T₁P₃ (0.537 OD).

These results are in agreement with findings of Radha *et al.* (2014)^[24] in maize, Chauhan *et al.* (2011)^[8] in wheat and Pallavi *et al.* (2003)^[21] in sunflower who observed reduction in dehydrogenase activity with the advancement of storage period, which could be due to enzymes undergo compositional changes by losing or gaining certain functional groups, by oxidation of sulf-hydral groups or by conversion of amino acids within the protein structure. The

enzymes may also undergo configurational changes such as partial folding or unfolding of ultra structure, condensation to form polymers and degradation to sub units.

The continual accumulation of free fatty acids culminates in reduction of cellular pH and is detrimental to normal cellular metabolism (Copeland and McDonald, 1995) [9]. Further, it denatures enzymes resulting in their loss of activity. A high level of correlation between was reported between the decrease in dehydrogenase activity and loss of seed viability by Mustafa *et al.* (2010) in onion. The amount of dehydrogenase activity in storage decreases with the progress in ageing as reported by Verma *et al.* (2003) [26] in Brassica spp.

Peroxidase enzyme activity

The data on peroxidase enzyme activity as influenced by different threshing methods, processing operations and their interaction effects at different months of storage period are presented in Table 4. Peroxidase enzyme activity decreased gradually as the storage period advanced. Initially, highest peroxidase enzyme activity was observed in T₁ (1.415 μ moles ml⁻¹min⁻¹), P₃ (1.254 μ moles ml⁻¹min⁻¹) and T₁P₃ (1.511 μ moles ml⁻¹min⁻¹) and lowest peroxidase enzyme activity was observed in T₃ (0.966 μ moles ml⁻¹min⁻¹), P₁ (1.109 μ moles ml⁻¹min⁻¹) and T₃P₁ (0.915 μ moles ml⁻¹min⁻¹). At the end of storage period significantly lowest peroxidase enzyme activity was observed in T₃ (0.400 μ moles ml⁻¹min⁻¹), P₁ (0.460 μ moles ml⁻¹min⁻¹) and T₃P₁ (0.379 μ moles ml⁻¹min⁻¹) and highest peroxidase enzyme activity was observed in T₁ (0.586 μ moles ml⁻¹min⁻¹), P₃ (0.519 μ moles ml⁻¹min⁻¹) and T₁P₃ (0.626 μ moles ml⁻¹min⁻¹).

The decreased activity of peroxidase is due to accumulation

of H₂O₂ and this accumulation of hydrogen peroxide itself is detrimental to seeds (Gidrol *et al.*, 1989) [13] reported that similar results were reported by Bhanuprakash *et al.* (2010) [6] in bell pepper and Demirkaya *et al.* (2010) [10] in onion seeds.

The ageing period had a significant effect on peroxidase activity. The decline in scavenging enzymes particularly peroxidase could be due to lipid peroxidation and sugar hydrolysis (formation of reducing sugars) was coupled to the Maillard reactions during seed ageing. Carbonyl intermediates as a result of Millard reaction may attack the enzyme complex and modify the native structure of enzyme either by adding or drawing the certain functional groups from enzyme structure. Thus, alter the macromolecular structure and reduces the efficiency of peroxidases as described by Narayanamurthy and Sun (2000) [20]. Cyanide production is often associated with deleterious mechanisms. It will inhibit the activity of heme proteins from peroxidases (Ellis and Dunford, 1968; Job and Ricard, 1975) [11, 15] and make it inefficient. Demirkaya *et al.* (2010) [19] studied that a high level of correlation between loss in seed viability and the decreases that occurred in antioxidant enzyme activity in onion, Bhanuprakash *et al.* (2010) [6] recorded change in enzyme activity due to ageing in bell pepper. Cakmak *et al.* (2010) [7] studied the decrease germination ability of aged legume seed were correlated with decrease in activity of enzymatic antioxidant studies. These results support the hypothesis of Bailly *et al.* (1996) [4] that a decrease in antioxidant enzymes is linked to an increased lipid peroxidation and accelerated ageing. Subsequently, Bailly *et al.* (2000 and 2002) [5] proposed a positive relationship between antioxidant enzyme capacity and the vigour of the seed.

Table 1: Effect of threshing methods and processing operations on seedling vigour index-I in soybean variety DSb-21 during storage

Treatments	Months after storage									
	Initial Nov 2022	1 Dec 2022	2 Jan 2023	3 Feb 2023	4 March 2023	5 April 2023	6 May 2023	7 June 2023	8 July 2023	9 Aug 2023
Threshing methods (T)										
T ₁	3037	3015	2983	2925	2820	2709	2576	2415	2264	2121
T ₂	2752	2725	2691	2645	2548	2436	2310	2174	2040	1919
T ₃	2396	2375	2342	2295	2212	2125	2025	1920	1821	1734
Mean	2728	2705	2672	2622	2526	2423	2304	2170	2042	1925
S.Em±	2	2	2	2	2	2	2	2	2	2
C.D. @ 1%	10	10	10	10	9	9	9	8	7	6
Processing operations (P)										
P ₁	2631	2604	2569	2521	2428	2330	2216	2087	1960	1851
P ₂	2713	2694	2662	2612	2517	2420	2295	2161	2039	1919
P ₃	2840	2816	2786	2731	2634	2520	2401	2261	2126	2005
Mean	2728	2705	2672	2622	2526	2423	2304	2170	2042	1925
S.Em±	2	2	2	2	2	2	2	2	2	2
C.D. @ 1%	10	10	10	10	9	9	9	8	7	6
Interaction (T×P)										
T ₁ P ₁	2939	2909	2878	2821	2719	2601	2492	2347	2185	2045
T ₁ P ₂	3013	3006	2975	2917	2813	2724	2580	2392	2249	2107
T ₁ P ₃	3159	3129	3096	3036	2928	2803	2657	2507	2357	2211
T ₂ P ₁	2643	2617	2577	2537	2443	2335	2208	2076	1947	1838
T ₂ P ₂	2783	2756	2726	2682	2584	2470	2347	2209	2072	1938
T ₂ P ₃	2830	2801	2771	2716	2616	2502	2377	2237	2100	1983
T ₃ P ₁	2310	2287	2253	2206	2123	2054	1948	1838	1746	1670
T ₃ P ₂	2344	2320	2284	2239	2153	2065	1959	1883	1797	1711
T ₃ P ₃	2533	2518	2490	2440	2359	2255	2168	2039	1921	1821
Mean	2728	2705	2672	2622	2526	2423	2304	2170	2042	1925
S.Em±	4	4	4	4	4	4	4	3	3	3
C.D. @ 1%	17	17	17	17	16	16	15	13	12	11

Table 2: Effect of threshing methods and processing operations on seedling vigour index-II in soybean variety DSb-21 during storage

Treatments	Months after storage									
	Initial Nov 2022	1 Dec 2022	2 Jan 2023	3 Feb 2023	4 March 2023	5 April 2023	6 May 2023	7 June 2023	8 July 2023	9 Aug 2023
Threshing methods (T)										
T ₁	54460	54227	53904	53228	52155	51090	49635	47730	45975	44368
T ₂	51330	50973	50591	50070	49023	47782	46291	44682	43087	41767
T ₃	48094	47821	47383	46750	45795	44848	43651	42460	41411	40627
Mean	51295	51007	50626	50016	48991	47907	46525	44957	43491	42254
S.Em±	25	25	25	25	25	24	23	21	19	16
C.D. @ 1%	100	101	103	102	101	99	95	84	75	64
Processing operations (P)										
P ₁	50282	49932	49486	48908	47869	46836	45489	43956	42436	41315
P ₂	51067	50849	50469	49884	48838	47868	46379	44829	43494	42173
P ₃	52535	52240	51923	51257	50266	49016	47709	46086	44543	43275
Mean	51295	51007	50626	50016	48991	47907	46525	44957	43491	42254
S.Em±	25	25	25	25	25	24	23	21	19	16
C.D. @ 1%	100	101	103	102	101	99	95	84	75	64
Interaction (T×P)										
T ₁ P ₁	52791	52432	52109	51449	50385	49138	48094	46471	44467	42877
T ₁ P ₂	54305	54345	54024	53345	52274	51608	49954	47515	45895	44289
T ₁ P ₃	56284	55905	55579	54891	53806	52525	50857	49205	47562	45939
T ₂ P ₁	50798	50446	49931	49483	48440	47204	45589	43982	42396	41210
T ₂ P ₂	51315	50960	50643	50190	49143	47902	46475	44867	43269	41690
T ₂ P ₃	51876	51513	51199	50538	49486	48240	46809	45195	43596	42400
T ₃ P ₁	47257	46919	46419	45791	44783	44167	42785	41415	40443	39857
T ₃ P ₂	47581	47242	46740	46116	45097	44093	42707	42106	41318	40538
T ₃ P ₃	49445	49303	48990	48343	47505	46283	45461	43859	42470	41485
Mean	51295	51007	50626	50016	48991	47907	46525	44957	43491	42254
S.Em±	43	43	44	44	43	42	41	36	32	27
C.D. @ 1%	174	175	179	178	175	171	165	146	130	111

Table 3: Effect of threshing methods and processing operations on electrical conductivity (dSm⁻¹) in soybean variety DSb-21 during storage

Treatments	Months after storage									
	Initial Nov 2022	1 Dec 2022	2 Jan 2023	3 Feb 2023	4 March 2023	5 April 2023	6 May 2023	7 June 2023	8 July 2023	9 Aug 2023
Threshing methods (T)										
T ₁	0.396	0.400	0.420	0.457	0.526	0.615	0.732	0.886	1.108	1.407
T ₂	0.499	0.504	0.529	0.577	0.663	0.776	0.924	1.118	1.397	1.774
T ₃	0.539	0.544	0.572	0.623	0.717	0.838	0.998	1.207	1.509	1.916
Mean	0.478	0.483	0.507	0.552	0.635	0.743	0.884	1.070	1.338	1.699
S.Em±	0.002	0.002	0.002	0.002	0.003	0.003	0.004	0.005	0.006	0.007
C.D. @ 1%	0.008	0.009	0.009	0.010	0.011	0.013	0.016	0.019	0.024	0.030
Processing operations (P)										
P ₁	0.496	0.501	0.526	0.573	0.659	0.771	0.917	1.110	1.388	1.762
P ₂	0.479	0.484	0.508	0.554	0.637	0.745	0.887	1.073	1.341	1.703
P ₃	0.459	0.464	0.487	0.531	0.610	0.714	0.850	1.028	1.285	1.632
Mean	0.478	0.483	0.507	0.552	0.635	0.743	0.884	1.070	1.338	1.699
S.Em±	0.002	0.002	0.002	0.002	0.003	0.003	0.004	0.005	0.006	0.007
C.D. @ 1%	0.008	0.009	0.009	0.010	0.011	0.013	0.016	0.019	0.024	0.030
Interaction (T×P)										
T ₁ P ₁	0.409	0.413	0.434	0.473	0.544	0.636	0.757	0.916	1.145	1.454
T ₁ P ₂	0.399	0.403	0.423	0.461	0.530	0.621	0.738	0.894	1.117	1.419
T ₁ P ₃	0.379	0.383	0.402	0.438	0.504	0.589	0.701	0.849	1.061	1.347
T ₂ P ₁	0.509	0.514	0.540	0.588	0.677	0.792	0.942	1.140	1.425	1.810
T ₂ P ₂	0.499	0.504	0.529	0.577	0.663	0.776	0.924	1.118	1.397	1.774
T ₂ P ₃	0.489	0.494	0.519	0.565	0.650	0.761	0.905	1.095	1.369	1.739
T ₃ P ₁	0.569	0.575	0.603	0.658	0.756	0.885	1.053	1.274	1.593	2.023
T ₃ P ₂	0.539	0.544	0.572	0.623	0.717	0.838	0.998	1.207	1.509	1.916
T ₃ P ₃	0.509	0.514	0.540	0.588	0.677	0.792	0.942	1.140	1.425	1.810
Mean	0.478	0.483	0.507	0.552	0.635	0.743	0.884	1.070	1.338	1.699
S.Em±	0.004	0.004	0.004	0.004	0.005	0.006	0.007	0.008	0.010	0.013
C.D. @ 1%	0.015	0.015	0.016	0.017	0.020	0.023	0.027	0.033	0.041	0.052

Table 4: Effect of threshing methods and processing operations on enzyme activities in soybean variety DSb-21 during storage

Treatments	Months after storage								
	Dehydrogenase enzyme activity (OD value)				Peroxidase enzyme activity (μ moles $\text{ml}^{-1}\text{min}^{-1}$)				
	Initial November 2022	3 February 2023	6 May 2023	9 August 2023		Initial November 2022	3 February 2023	6 May 2023	9 August 2023
Threshing methods (T)					Threshing methods (T)				
T ₁	1.009	0.938	0.750	0.525	T ₁	1.415	1.202	0.902	0.586
T ₂	0.918	0.854	0.683	0.478	T ₂	1.158	0.985	0.738	0.480
T ₃	0.833	0.775	0.620	0.434	T ₃	0.966	0.821	0.616	0.400
Mean	0.920	0.856	0.684	0.479	Mean	1.180	1.003	0.752	0.489
S.Em $\pm$	0.039	0.001	0.000	0.000	S.Em $\pm$	0.101	0.001	0.001	0.001
C.D. @ 1%	NS	0.002	0.002	0.001	C.D. @1%	NS	0.006	0.004	0.003
Processing operations (P)					Processing operations (P)				
P ₁	0.895	0.832	0.666	0.466	P ₁	1.109	0.943	0.707	0.460
P ₂	0.920	0.855	0.684	0.479	P ₂	1.176	1.000	0.750	0.487
P ₃	0.945	0.879	0.703	0.492	P ₃	1.254	1.066	0.799	0.519
Mean	0.920	0.856	0.684	0.479	Mean	1.180	1.003	0.752	0.489
S.Em $\pm$	0.039	0.001	0.000	0.000	S.Em $\pm$	0.101	0.001	0.001	0.001
C.D @ 1%	NS	0.002	0.002	0.001	C.D. @1%	NS	0.006	0.004	0.003
Interaction (T$\times$P)					Interaction (T$\times$P)				
T ₁ P ₁	0.983	0.914	0.731	0.512	T ₁ P ₁	1.325	1.126	0.845	0.549
T ₁ P ₂	1.011	0.940	0.752	0.527	T ₁ P ₂	1.408	1.197	0.898	0.583
T ₁ P ₃	1.032	0.960	0.768	0.537	T ₁ P ₃	1.511	1.284	0.963	0.626
T ₂ P ₁	0.887	0.825	0.660	0.462	T ₂ P ₁	1.088	0.925	0.694	0.451
T ₂ P ₂	0.914	0.850	0.680	0.476	T ₂ P ₂	1.133	0.963	0.722	0.469
T ₂ P ₃	0.953	0.886	0.709	0.496	T ₂ P ₃	1.254	1.066	0.799	0.520
T ₃ P ₁	0.815	0.758	0.606	0.424	T ₃ P ₁	0.915	0.778	0.583	0.379
T ₃ P ₂	0.834	0.776	0.620	0.434	T ₃ P ₂	0.988	0.840	0.630	0.409
T ₃ P ₃	0.851	0.791	0.633	0.443	T ₃ P ₃	0.996	0.847	0.635	0.413
Mean	0.920	0.856	0.684	0.479	Mean	1.180	1.003	0.752	0.489
S.Em $\pm$	0.067	0.001	0.001	0.001	S.Em $\pm$	0.175	0.003	0.002	0.001
C.D. @ 1%	NS	0.004	0.003	0.002	C.D. @1%	NS	0.010	0.008	0.005

References

- Abdul-Baki AA, Anderson JD. Vigour determination in soybean seed by multiple criteria. *Crop Sci.* 1973;13(6):630-633.
- Agrawal PK. Germination, fat acidity and leaching of sugars from five cultivars of paddy (*Oryza sativa*) seeds during storage. *Seed Sci Technol.* 1977;5(1):489-498.
- Alvarez PJC, Krzyzanowski FC, Mandarino JMG, Franca-Neto JB. Relationship between soybean seed coat lignin content and resistance to mechanical damage. *Seed Sci Technol.* 1997;25(2):209-214.
- Bailly C, Benamar A, Corbineau F, Come D. Changes in malondialdehyde content and in superoxide dismutase, catalase and glutathione reductase activities in sunflower seeds as related to deterioration during accelerated ageing. *Plant Physiol.* 1996;97(1):104-110.
- Bailly C, Benamar A, Corbineau F, Come D. Antioxidant systems in sunflower (*Helianthus annuus* L.) seeds as affected by priming. *Seed Sci Res.* 2000;10:35-42.
- Bhanuprakash K, Yogeesh HS, Arun MN. Physiological and biochemical changes in relation to seed quality in ageing bell pepper seed. *Indian J Agric Sci.* 2010;80(9):777-780.
- Cakmak T, Atici O, Agar G, Serap S. Natural ageing related biochemical changes in alfalfa seeds stored for 42 years. *Int Res J Plant Sci.* 2010;1(1):1-6.
- Chauhan DS, Deswal DP, Dahiya OS, Punia RC. Change in storage enzymes activities in natural and accelerated aged seed of wheat (*Triticum aestivum*). *Seed Res.* 2011;48(1):23-29.
- Copeland LO, McDonald MB. Principles of seed science and technology. New York, USA: Chapman and Hall; 1995.
- Demirkaya M, Dietz KJ, Sivritepe HO. Changes in antioxidant enzymes during ageing of onion seeds. *Not Bot Horti Agrobot.* 2010;38(1):49-52.
- Ellis WD, Dunford HB. The kinetics of cyanide and fluoride binding by ferric horseradish peroxidase. *Biochemistry.* 1968;7(6):2054-2062.
- Floris C. Ageing in Triticum durum seeds: behavior of embryos and endosperm from aged seeds as revealed by the embryo transplantation technique. *J Exp Bot.* 1970;21:462-468.
- Gidrol X, Serghini H, Noubhani A, Mocoquot B, Mazliak P. Biochemical changes induced by accelerated ageing in sunflower seeds. I. Lipid peroxidation and membrane damage. *Plant Physiol.* 1989;76:591-597.
- Hesse SR, Peske ST. Spiral separator for removal of small bean seeds in soybean seeds. *Seed Technol.* 1981;1(2):118.
- Job D, Ricard J. Kinetic and equilibrium studies of cyanide and fluoride binding to turnip peroxidases. *Arch Biochem Biophys.* 1975;170(2):427-437.
- Kausal RT, Jagtap AP, Patil BN, Pavitrakar NRA, Rathod TH. Management of mechanical damage to soybean seeds during threshing. *Ann Plant Physiol.* 2006;20(1):74-77.
- Mahesha CR, Channaveeraswami AS, Kurdikeri MB,

- Shekhargouda M, Merwade MN. Seed maturation studies in sunflower genotypes. *Seed Res.* 2001;29(1):95-97.
18. Moreano TB, Marques OJ, Braccini AL, Scapim CA, Franca-Neto JDB, Krzyzanowski FC. Evolution of the physical and physiological quality of soybean seeds during processing. *J Seed Sci.* 2018;40:313-322.
19. Demirkaya M, Dietz KJ, Sivritepe HO. Changes in antioxidant enzymes during ageing of onion seeds. *Not Bot Horti Agrobot Cluj-Napoca.* 2010;38(1):49-52.
20. Narayanamurthy UM, Sun WQ. Protein modification by amadori and millard reactions during storage: roles of sugar hydrolysis and lipid peroxidation. *J Exp Bot.* 2000;51(348):1221-1228.
21. Pallavi M, Sudheer SK, Dangi KS, Reddy AV. Effect of seed ageing on physiological, biochemical and yield attributes in sunflower (*Helianthus annuus* L.) cv. MORDEN. *Seed Res.* 2003;31(2):161-168.
22. Prakobbon N. Role of mechanical damage in deterioration of soybean seed quality during storage: a review. *Agric Rev.* 1982;29(3):177-184.
23. Puteh AB, Tekrony DM, Egli DB. Expression of cotyledon necrosis in deteriorating soybean [*Glycine max* (L.)] seed. *Seed Sci Technol.* 1997;25(1):133-145.
24. Radha BN, Channakeshava BC, Hullur N, Bhanuprakash K, Vishwanath K, Umesha BD, *et al.* Change in storage enzymes activities in natural and accelerated aged seed of maize (*Zea mays* L.). *Int J Plant Sci.* 2014;9(2):206-211.
25. Toole EH, Toole VK, Borthwick HA. Growth and production of snap beans stored under favourable and unfavourable conditions. *Proc Int Seed Test Ass.* 1957;22:418.
26. Verma SS, Verma U, Tomer RPS. Studies on seed quality parameters in deteriorating seed in Brassica (*Brassica campestris*). *Seed Sci Technol.* 2003;31(2):389-396.