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Assessment of seed storability parameters of seed moisture, test weight & seed germination 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 show that, the seed moisture content differed non significantly across the months of storage. Initial months showed highest seed moisture content in T_1 (10.48%), P_3 (10.41%) and T_1P_3 (10.53%) and the lowest seed moisture content was recorded in T_3 (10.25%), P_1 (10.31%) and T_3P_1 (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 T_1 (10.00 g), P_3 (9.95 g) and T_1P_3 (10.11 g) while significantly lowest 100 seed weight was recorded in T_3 (9.78 g), P_1 (9.84 g) and T_3P_1 (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 T_1 (75.11%), P_3 (73.66%) and T_1P_3 (77.33%) while significantly lower seed germination was recorded in T_3 (70.55%), P_1 (71.11%) and T_3P_1 (69.66%).

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

Introduction: Soybean seed is regarded as a poor storer and it loses its viability and vigour at a faster rate due to loss of membrane permeability of seeds. Presence of high lipid content and high level of polyunsaturated oleic acid, linolenic and linoleic acid is the main reason for short shelf life of soybean seed. Soon after harvest, soybean seed is subjected to several post-harvest operations like threshing, drying, grading, transportation and other handling operations. During this loss of soybean seed quality is mainly due to mechanical damage, it is because of its very thin seed coat and low lignin content leads to little protection to the fragile radical which lies in a vulnerable position directly beneath the seed coat so soybean seed is regarded as a poor store and it loses its viability and vigour at a faster rate due to loss of membrane permeability of seed (Alvarez *et al.*, 1997, Prakobbon, 1982, Puteh *et al.*, 1997) [2, 13, 14]. The quality of seeds gets altered during these post-harvest operations like threshing and grading which further have impact on storability of seeds. Storability of seed is mainly a genetic character and it is influenced by pre storage history of seeds, seed maturation and environmental factors during pre and post-harvest stages and storage conditions. The storage becomes successful depending upon quality of seeds to be stored. These methods directly influence on seed quality during storage. Keeping this in view the present experiment on influence of different threshing methods and processing operations on storability of soybean seed [*Glycine max* (L.) Merrill] cv. DSb-21 was carried out.

Material and methods
The seeds obtained by use of different threshing methods *viz.*, T_1, Multi-crop thresher with 300 rpm; T_2, Multi-crop thresher with 500 rpm and T_3, 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

Seed moisture content (%)

The seed moisture content differed non significantly across the months of storage as presented in Table 1. The seed moisture content depends on prevailing conditions of climate during storage. However, initial months showed highest seed moisture content in T_1 (10.48%), P3 (10.41%) and T1P3 (10.53%) and the lowest seed moisture content was recorded in T_3 (10.25%), P1 (10.31%) and T3P1 (10.16%). At the end of nine months of storage period, highest seed moisture content was recorded in T_1 (9.46%), P3 (9.40%) and T1P3 (9.50%) while significantly lowest seed moisture content was recorded in T_3 (9.25%), P1 (9.31%) and T3P1 (9.17%).

The seed moisture content rises with subsequent rise in storage period irrespective of threshing methods and processing operations. However, the moisture content fluctuates according to conditions of storage that prevail. The soybean seed imbibes high amount of water to create equilibrium inside and outside the seed. The hydrophilic nature of high protein content of soybean (Hartwig and Potts, 1987) [5] helps in more absorption of water and high oil content in seed increases deterioration of seed (Potts, 1972) [12] by increased hydrolytic enzyme activity, enhanced respiration and increase in free fatty acids. High temperature accelerates the rate of these biochemical processes causing more rapid deterioration that might have resulted in rapid losses in seeds having high moisture content. Tubic *et al.* (2011) [17] also reported that different moisture content was observed in different genotypes which might be due to the genetic factors and seed chemical composition. Because of its hygroscopic nature, seed absorbed the moisture when the relative humidity was high in the storage conditions. Similar results were observed in findings of Gadhave (2018) [3] who reported that moisture content increases with storage period.

100 seed weight (g)

The 100 seed weight differed non significantly across the months of storage. The 100 seed weight depends on the moisture content. Therefore, there was no visible trend observed during storage with respect to 100 seed weight as presented in Table 2. However, initial months showed highest 100 seed weight in T_1 (11.08 g), P3 (11.02) and T1P3 (11.20) and the lowest 100 seed weight was recorded in T3 (10.84 g), P1 (10.90 g) and T3P1 (10.80 g). At the end of nine months of storage period, highest 100 seed weight was recorded in T_1 (10.00 g), P3 (9.95 g) and T1P3 (10.11 g) while significantly lowest 100 seed weight was recorded in T_3 (9.78 g), P1 (9.84 g) and T3P1 (9.75 g).

The highest 100 seed weight in P3 might be due to its larger seed size and more reserve food in seed as compared to rest of treatments. As good graded seeds are passed through specific gravity separator it separates or processes seeds based on weight and specific gravity, so heavy seeds collected at first fraction have higher test weight than collected at next two fractions (medium and light). As the screen size increases during grading test weight increases indicating the positive association of seed size and seed weight [Ganiger *et al.* (2016) in green gram and Kausal *et al.* (2008) in soybean] [4, 6].

The decline in hundred seed weight with the advancement of storage period is predominantly due to chemical effects, activities of fungi and higher respiration rate of seeds stored in gunny bag that might have resulted in loss in hundred seed weight. The similar reduction in hundred seed weight was found in sunflower hybrids KBSH-53 and KBSH-55 (Nataraj, 2008) [11].

Table 1: Effect of threshing methods and processing operations on seed moisture content (%) in soybean variety DSb-21 during storage

Treatment	Months after storage									
	Initial Nov 2022	1 Dec 2022	2 Jan 2023	3 Feb 2023	4 Mar 2023	5 April 2023	6 May 2023	7 June 2023	8 July 2023	9 Aug 2023
Threshing methods (T)										
T_1	10.48 (18.89)*	10.61 (19.01)	10.73 (19.12)	10.84 (19.22)	10.30 (18.72)	9.58 (18.03)	9.19 (17.65)	9.06 (17.52)	9.26 (17.72)	9.46 (17.91)
T_2	10.36 (18.78)	10.48 (18.89)	10.61 (19.01)	10.71 (19.10)	10.18 (18.61)	9.46 (17.91)	9.09 (17.55)	8.95 (17.41)	9.15 (17.61)	9.35 (17.80)
T_3	10.25 (18.67)	10.37 (18.79)	10.49 (18.90)	10.60 (19.00)	10.07 (18.50)	9.36 (17.81)	8.99 (17.45)	8.85 (17.31)	9.05 (17.51)	9.25 (17.71)
Mean	10.36 (18.78)	10.49 (18.90)	10.61 (19.01)	10.72 (19.01)	10.18 (18.61)	9.47 (17.92)	9.09 (17.55)	8.95 (17.41)	9.15 (17.61)	9.35 (17.80)
S.Em±	0.13	0.13	0.13	0.13	0.13	0.12	0.11	0.11	0.11	0.12
CD @1%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Processing operations (P)										
P_1	10.31 (18.37)	10.43 (18.84)	10.56 (18.96)	10.66 (19.06)	10.13 (18.56)	9.42 (17.87)	9.05 (17.51)	8.91 (17.37)	9.11 (17.57)	9.31 (17.77)
P_2	10.36 (18.78)	10.48 (18.89)	10.61 (19.01)	10.72 (19.11)	10.18 (18.61)	9.47 (17.92)	9.09 (17.55)	8.95 (17.41)	9.15 (17.61)	9.35 (17.80)
P_3	10.41	10.54	10.66	10.77	10.23	9.52	9.14	9.00	9.20	9.40

	(18.82)	(18.94)	(19.06)	(19.16)	(18.65)	(17.97)	(17.60)	(17.46)	(17.66)	(17.85)
Mean	10.36 (18.78)	10.49 (18.90)	10.61 (19.01)	10.72 (19.11)	10.18 (18.61)	9.47 (17.92)	9.09 (17.55)	8.95 (17.41)	9.15 (17.61)	9.35 (17.80)
S.Em±	0.13	0.13	0.13	0.13	0.13	0.12	0.11	0.11	0.11	0.12
CD @ 1%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (T×P)										
T_1P_1	10.44 (18.85)	10.57 (18.97)	10.69 (19.08)	10.80 (19.19)	10.26 (18.68)	9.54 (17.99)	9.16 (17.62)	9.02 (17.48)	9.22 (17.68)	9.42 (17.87)
T_1P_2	10.47 (18.88)	10.60 (19.00)	10.72 (19.11)	10.83 (19.21)	10.29 (18.71)	9.57 (18.02)	9.19 (17.65)	9.05 (17.51)	9.25 (17.71)	9.45 (17.90)
T_1P_3	10.53 18.94)	10.66 (19.06)	10.78 (19.17)	10.89 (19.27)	10.35 (18.77)	9.62 (18.07)	9.24 (17.70)	9.10 (17.56)	9.30 (17.76)	9.50 (17.95)
T_2P_1	10.33 (18.75)	10.45 (18.86)	10.58 (18.98)	10.69 (19.08)	10.15 (18.58)	9.44 (17.89)	9.06 (17.52)	8.93 (17.39)	9.12 (17.58)	9.32 (17.78)
T_2P_2	10.36 (18.78)	10.48 (18.89)	10.61 (19.01)	10.72 (19.11)	10.18 (18.61)	9.47 (17.92)	9.09 (17.55)	8.95 (17.41)	9.15 (17.61)	9.35 (17.80)
T_2P_3	10.38 (18.79)	10.50 (18.91)	10.63 (19.03)	10.74 (19.13)	10.20 (18.63)	9.49 (17.94)	9.11 (17.57)	8.97 (17.43)	9.17 (17.63)	9.37 (17.82)
T_3P_1	10.16 (!8.59)	10.28 (18.70)	10.41 (18.82)	10.51 (18.92)	9.98 (18.42)	9.29 (17.75)	8.91 (17.37)	8.78 (17.24)	8.97 (17.43)	9.17 (17.63)
T_3P_2	10.25 (18.67)	10.37 (18.79)	10.50 (18.91)	10.60 (19.00)	10.07 (18.50)	9.37 (17.82)	8.99 (17.45)	8.86 (17.32)	9.05 (17.51)	9.25 (17.71)
T_3P_3	10.33 (18.75)	10.45 (18.86)	10.58 (18.98)	10.69 (19.08)	10.15 (18.58)	9.44 (17.89)	9.06 (17.52)	8.93 (17.39)	9.12 (17.58)	9.32 (17.78)
Mean	10.36 (18.78)	10.49 (18.90)	10.61 (19.01)	10.72 (19.11)	10.18 (18.61)	9.47 (17.92)	9.09 (17.55)	8.95 (17.41)	9.15 (17.61)	9.35 (17.80)
S.Em±	0.22	0.23	0.23	0.23	0.22	0.20	0.20	0.19	0.20	0.20
CD @ 1%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*Figures in the parenthesis indicate the angular transferred values

Table 2: Effect of threshing methods and processing operations on 100 seed weight (g) 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	11.08	11.21	11.35	11.46	10.89	10.13	9.72	9.57	9.79	10.00
T_2	10.93	11.06	11.20	11.31	10.74	9.99	9.59	9.45	9.66	9.87
T_3	10.84	10.97	11.10	11.21	10.65	9.90	9.51	9.36	9.57	9.78
Mean	10.95	11.08	11.21	11.33	10.76	10.01	9.61	9.46	9.67	9.88
S.Em±	0.13	0.13	0.14	0.14	0.13	0.12	0.12	0.11	0.12	0.12
C.D. @ 1%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Processing operations (P)										
P_1	10.90	11.03	11.16	11.27	10.71	9.96	9.56	9.42	9.63	9.84
P_2	10.93	11.06	11.19	11.30	10.74	9.99	9.59	9.44	9.65	9.86
P_3	11.02	11.16	11.29	11.40	10.83	10.07	9.67	9.53	9.74	9.95
Mean	10.95	11.08	11.21	11.33	10.76	10.01	9.61	9.46	9.67	9.88
S.Em±	0.13	0.13	0.14	0.14	0.13	0.12	0.12	0.11	0.12	0.12
C.D. @ 1%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (T×P)										
T_1P_1	11.00	11.13	11.27	11.38	10.81	10.05	9.65	9.51	9.71	9.93
T_1P_2	11.04	11.17	11.31	11.42	10.85	10.09	9.69	9.54	9.75	9.96
T_1P_3	11.20	11.33	11.47	11.59	11.01	10.24	9.83	9.68	9.89	10.11
T_2P_1	10.90	11.03	11.16	11.27	10.71	9.96	9.56	9.42	9.63	9.84
T_2P_2	10.92	11.05	11.18	11.30	10.73	9.98	9.58	9.44	9.64	9.86
T_2P_3	10.98	11.11	11.25	11.36	10.79	10.03	9.63	9.49	9.70	9.91
T_3P_1	10.80	10.93	11.06	11.17	10.61	9.87	9.48	9.33	9.54	9.75
T_3P_2	10.82	10.95	11.08	11.19	10.63	9.89	9.49	9.35	9.56	9.77
T_3P_3	10.89	11.02	11.15	11.26	10.70	9.95	9.55	9.41	9.62	9.83
Mean	10.95	11.08	11.21	11.33	10.76	10.01	9.61	9.46	9.67	9.88
S.Em±	0.23	0.23	0.24	0.24	0.23	0.21	0.20	0.20	0.20	0.21
C.D. @ 1%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Effect of threshing methods and processing operations on seed germination (%) in soybean variety DSb-21 during storage

Treatment	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	88.55	88.44	88.11	87.44	86.11	84.77	82.77	80.00	77.44	75.11

	(70.22)*	(70.12)	(69.83)	(69.24)	(68.12)	(67.03)	(65.47)	(63.43)	(61.64)	(60.07)
T_2	84.33 (66.68)	84.00 (66.42)	83.55 (66.07)	83.11 (65.73)	81.78 (64.73)	80.11 (63.51)	78.00 (62.03)	75.66 (60.44)	73.33 (58.91)	71.44 (57.70)
T_3	80.22 (63.59)	80.00 (63.43)	79.44 (63.04)	78.77 (62.56)	77.55 (61.72)	76.33 (60.89)	74.66 (59.78)	72.99 (58.69)	71.55 (57.77)	70.55 (57.13)
Mean	84.37 (66.71)	84.15 (66.54)	83.70 (66.19)	83.11 (65.73)	81.81 (64.75)	80.40 (63.72)	78.48 (62.36)	76.22 (60.81)	74.11 (59.41)	72.37 (58.29)
S.Em±	0.12	0.12	0.13	0.13	0.13	0.12	0.12	0.10	0.09	0.08
CD @1%	0.49	0.50	0.52	0.52	0.51	0.50	0.49	0.42	0.37	0.31
Processing operations (P)										
P_1	83.11 (65.73)	82.78 (65.48)	82.22 (65.06)	81.66 (64.64)	80.33 (63.67)	79.00 (62.72)	77.11 (61.42)	74.88 (59.92)	72.66 (58.47)	71.11 (57.49)
P_2	84.11 (66.51)	84.00 (66.42)	83.55 (66.07)	83.00 (65.65)	81.66 (64.64)	80.44 (62.73)	78.33 (62.26)	76.11 (60.74)	74.22 (59.49)	72.33 (58.26)
P_3	85.89 (67.94)	85.66 (67.75)	85.33 (67.48)	84.66 (66.94)	83.44 (65.99)	81.77 (63.75)	80.00 (63.43)	77.66 (61.79)	75.44 (60.29)	73.66 (59.12)
Mean	84.37 (66.71)	84.15 (66.54)	83.70 (66.19)	83.11 (65.73)	81.81 (64.75)	80.40 (63.72)	78.48 (62.36)	76.22 (60.81)	74.11 (59.41)	72.37 (28.29)
S.Em±	0.12	0.12	0.13	0.13	0.13	0.12	0.12	0.10	0.09	0.08
CD @ 1%	0.49	0.50	0.52	0.52	0.51	0.50	0.49	0.42	0.37	0.31
Interaction (T×P)										
T_1P_1	86.33 (68.30)	86.00 (68.03)	85.66 (67.75)	85.00 (67.21)	83.66 (66.16)	82.00 (64.90)	80.66 (63.91)	78.33 (62.26)	75.33 (60.22)	73.00 (58.69)
T_1P_2	88.33 (70.02)	88.66 (70.32)	88.33 (70.02)	87.66 (69.43)	86.33 (68.30)	85.66 (67.75)	83.33 (65.90)	79.66 (63.19)	77.33 (61.57)	75.00 (60.0)
T_1P_3	91.00 (72.54)	90.66 (72.20)	90.33 (71.88)	89.66 (71.24)	88.3 (70.02)	86.66 (68.58)	84.33 (66.68)	82.00 (64.90)	79.66 (63.19)	77.33 (61.57)
T_2P_1	83.66 (66.16)	83.33 (65.90)	82.66 (65.39)	82.33 (65.14)	81.00 (64.16)	79.33 (62.96)	77.00 (61.34)	74.66 (59.78)	72.33 (58.26)	70.66 (57.20)
T_2P_2	84.33 (66.68)	84.00 (66.42)	83.66 (66.16)	83.33 (65.90)	82.00 (64.90)	80.33 (63.67)	78.33 (62.26)	76.00 (60.67)	73.66 (59.12)	71.33 (57.63)
T_2P_3	85.00 (67.21)	84.66 (66.94)	84.33 (66.68)	83.66 (66.16)	82.33 (65.14)	80.66 (63.91)	78.66 (62.49)	76.33 (60.89)	74.00 (59.34)	72.33 (58.26)
T_3P_1	79.33 (62.96)	79.00 (62.73)	78.33 (62.26)	77.66 (61.79)	76.33 (60.89)	75.66 (60.44)	73.66 (59.12)	71.66 (57.84)	70.33 (57)	69.66 (56.58)
T_3P_2	79.66 (63.19)	79.33 (62.96)	78.66 (62.49)	78.00 (62.03)	76.66 (61.11)	75.33 (60.22)	73.33 (58.91)	72.66 (58.47)	71.66 (57.84)	70.66 (57.20)
T_3P_3	81.66 (64.64)	81.67 (64.65)	81.33 (64.40)	80.66 (63.91)	79.66 (63.19)	78.00 (62.03)	77.00 (61.34)	74.66 (59.78)	72.66 (58.47)	71.33 (57.63)
Mean	84.37 (66.71)	84.15 (66.54)	83.70 (66.19)	83.11 (65.73)	81.81 (64.75)	80.40 (63.72)	78.48 (62.36)	76.22 (60.81)	74.11 (59.41)	72.37 (58.29)
S.Em±	0.21	0.21	0.22	0.22	0.22	0.21	0.21	0.18	0.16	0.13
CD @ 1%	0.86	0.87	0.90	0.89	0.89	0.87	0.85	0.74	0.65	0.54

*Figures in the parenthesis indicate the angular transferred values

Seed germination (%)

The results on seed germination percentage as influenced by different threshing methods, processing operations and their interaction effects at different months of storage period are presented in Table 3. The per cent seed germination decreased with the advancement of storage period in all the treatments. Whereas, initially higher seed germination was recorded in T_1 (88.55%), P3 (85.89%) and T1P3 (91.00%) and lower seed germination was recorded T_3 (80.22%), P1 (83.11%) and T3P1 (79.33%). At the end of nine months of storage period, highest seed germination was recorded in T_1 (75.11%), P3 (73.66%) and T1P3 (77.33%) while significantly lower seed germination was recorded in T_3 (70.55%), P1 (71.11%) and T3P1 (69.66%).

This may be due to the fact that the crop threshed by combine harvester suffer more mechanical damage due to high drum speed. Murata *et al.* (1991) [10] reported that the seed coat cracking in soybean increased with increasing machine speed. These results are in conformity with Saini *et al.* (1982), Kausal *et al.* (1991), Zdradzisc and Urbaniak (1993), Addo *et al.* (2004) and Vieira *et al.* (2006) in soybean. Vishwanath *et al.* (2019) [1, 7, 15, 18, 19] reported that seeds processed using seed grader followed by spiral separator resulted in higher seed recovery with good seed quality parameters. The combinations of processing operations resulted in improvement of physiological qualities of seed lot. This was supported by various findings by Misra *et al.* (1985) and Moreano *et al.* (2018) [8, 9] in soybean. Changes associated with the seed deterioration are depletion in food reserve, increased enzyme activity, increased fat acidity and membrane permeability. As the catabolic changes continue with increasing age, the ability of seeds to germinate is reduced

It was noticed that seedling length and dry matter content 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 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) [16].

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