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RESEARCH ARTICLE

Agricultural Science Digest, Volume Issue : ()

Effect of Desiccants and Packaging Materials on Seed Storability in Soybean [*Glycine max* (L.) Merrill]

T. Ramanadane[1], S. Sathya[2], G. Hemalatha[3], R. Gnanasekar[1]

10.18805/ag.D-5837

Abstract

Background: Seeds are characterized by rapid deterioration during storage under hot and humid coastal conditions. Physiological changes that occur in seeds during storage are manifested as reduction in seedling vigour indices and percentage germination. This study aimed in prolonging the longevity of soybean seed through packaging materials with or without desiccants.

Methods: Each 10 kilograms of soybean seeds treated with Vitavax 200 (2 g/kg of seed) were stored with or without desiccants *viz*., Calcium Chloride @ 10 g/kg of seeds, Silica gel @ 10 g/kg of seeds and 'Zeolites' drying beads @ 35 g/kg of seeds, packed in two different containers *viz*., Cloth bag and Super grain bag and stored under ambient conditions of coastal environment of Karaikal district, Puducherry (UT). Seed samples were drawn at three months intervals and tested for seed vigour and viability up to nine months.

Result: The results revealed that that vitavax treated soybean seeds stored in Super grain bags with desiccants *viz*., $CaCl_2$ or drying beads exhibited the highest seed germination, seedling length, seedling dry weight, vigour index-I and II than cloth bags after nine months of storage. The loss in seed vigour during storage was only 12 per cent in Super grain bags as compared to 83 per cent in cloth bags indicated that Super grain bag has the potential to effectively contain the influence of environment on seeds stored in it. Hence, it is suggested that the vigour and viability of soybean seeds could be very well prolonged by storing fungicide treated seeds in Super grain bag instead of cloth bags under coastal environment.

Key words: Containers, Desiccants, Seed storage, Seed treatment, Soybean, Viability.

Introduction

Soybean [*Glycine max* (L.) Merrill] is one of the most important oilseed crops in the world and is a cheaper source of quality protein and edible oil. In the total edible oil production of the world, 30 per cent is contributed by soybean (Assefa, 2008). Soybean seed contains about 40-45% protein, 20-22% oil, 20-26% carbohydrate and a high amount of Ca, P and vitamins (Rahman *et al*., 2011).

High quality seed that provides adequate plant stand is the basis for profitable production and expansion of soybean crop. Loss of viability and vigour under high temperature and RH conditions is a common phenomenon in many crop seeds but it is well marked in soybean. The problems of maintaining the soybean seed viability in storage have always been an important concern; and retention of high viability over a long period is necessary for crop production. Many factors determine the longevity of seeds during storage. These includes seed moisture content, temperature, relative humidity, initial viability, stage of maturity at harvest, storage gas and initial moisture content of seed entering into storage (Tatipata, 2009). Soybean seed losses its viability in very short period of storage even when stored in good nonporous container (Woodruff, 1998).

The principle of drying using a desiccant is that the dry desiccant will take up moisture from the wet seed until the two come to equilibrium. How much water the desiccant adsorbs from the seed and how quickly it does so depends on number of factors, including the ratio of desiccant to seeds, temperature and the affinity of the desiccant for water. It may also be necessary to refresh the desiccant to ensure that seeds reach the target moisture content. Aluminium silicate ceramics are a type of molecular sieve with very small, uniform pores where water molecules can be adsorbed. Small balls of this molecular sieve material are being marketed as seed 'Drying Beads ®' with professed advantages over other desiccants including greater affinity for water, particularly at low humidity; more rapid drying; and no hysteresis effect, which reduces the amount of water

[1]All India Co-ordinated Research Project on Seed (Crops), Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaika-609 602, Puducherry (UT), India.
[2]Department of Plant Breeding and Genetics, Palar Agricultural College, Vellore-635 805, Tamil Nadu, India.
[3]Department of Plant Breeding and Genetics, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaika-609 602, Puducherry (UT), India.

Corresponding Author: T. Ramanadane, All India Co-ordinated Research Project on Seed (Crops), Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaika-609 602, Puducherry (UT), India. Email: ramanadane1971@gmail.com

How to cite this article: Ramanadane, T., Sathya, S., Hemalatha G. and Gnanasekar, R., (2024). Effect of Desiccants and Packaging Materials on Seed Storability in Soybean [*Glycine max* (L.) Merrill]. Agricultural Science Digest. doi: 10.18805/ag.D-5837.

Submitted: 11-07-2023 **Accepted:** 22-02-2024 **Online:** 17-05-2024

that can be adsorbed following regeneration. The beads can be regenerated by heating to 200°C for 3-4 hours (Hay *et al.,* 2012).

Selection of containers for storing the seeds is one of the important techniques to extend shelf life of seed according to the prevailing climatic conditions of particular area. Grain Pro Super bag (Introduced by Grain Pro Agro Pvt. Ltd, Israel is multilayered polythene bag consist inert gas in between two layer) was exploited for safe storage of seeds / dry grains of several crops. Super grain bags help in extending seed storability, most importantly, they control insect pest without any insecticides. Rice seeds stored in Super grain bag maintained its viability up to 12 months under ambient conditions (Rickman, 2004).

Proper seed treatment with fungicide will improve the germination of poor quality seed if the low quality is due to fungal infection. A fungicide treatment also protects the seeds and young seedlings from many seed borne and soil borne pathogens (Taylor *et al*., 1998). With this background, a study was undertaken to determine the effect of desiccants and packaging materials on vigour and viability of soybean seeds treated with Vitavax 200, a broad spectrum dual action (systemic and contact) polymer formulated fungicide as pre-storage seed treatment as shown in Fig1.

MATERIALS AND METHODS

The experiment was conducted on freshly harvested each 10 kilograms of soybean cv. JS 335 seeds treated with Vitavax 200 (2 g/kg of seed) and stored in Super grain bag with $CaCl_2$ (T_1): Super grain bag with silica gel (T_2): Super grain bag with drying beads (Zeolites-drying beads @ 1:0.035) (T_3): Super grain bag without desiccants (T_4): cloth bag with $CaCl_2$ (T_5): cloth bag with silica gel (T_6): cloth bag with drying beads (T_7): cloth bag without desiccants (T_8) under ambient conditions at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, the coastal district of Puducherry (UT), India during 2018-19. Seed samples were drawn at three months interval and evaluated for seed moisture content (%), seed germination (%), shoot and root length of seedlings (cm), dry weight of seedlings (g/10 seedlings), vigour index I and II up to nine months by ISTA rules (Anonymous, 2016).The analysis and interpretation of the experimental data were done as suggested by Panse and Sukhatme (1967) with level of significance used as P = 0.05.

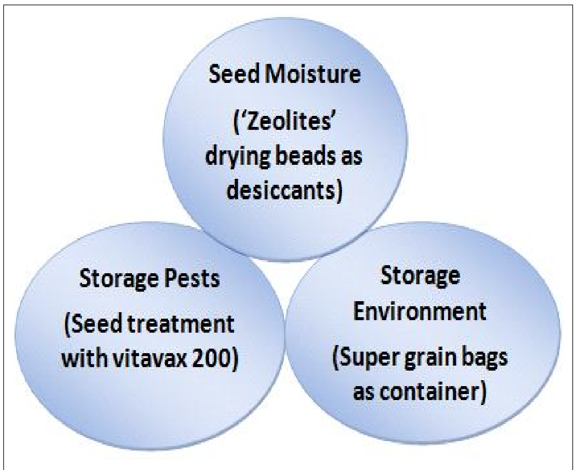


Fig 1: Three components of seed storage used in the study.

RESULTS AND DISCUSSION

Seed moisture content

Several factors may affect the quality of seeds in storage, however, the most critical among them is high seed moisture content (O'Hare *et al*., 2001). In the present study, the seed moisture content was significantly influenced by the period of storage and packaging materials used (Table 1). An initial seed moisture content of 8.40 per cent was enhanced to 11.45 per cent at 6th month of storage in cloth bags; while, it was almost maintained in the Super grain bags throughout the storage. The overall mean seed moisture content between the packaging materials indicated that nearly 2 per cent higher seed moisture content was observed in cloth bags as compared to super grain bags during storage. However, treatments with desiccants didn't differ with seed moisture content during storage. Irrespective of desiccants, a steep increase in seed moisture content was observed in cloth bags at 6th month of storage and thereafter it declined. Thus, it was found that seeds stored in cloth bags had higher moisture content than super grain bags due to moisture pervious nature of cloth bags. Similar results were observed by Baskin *et al*. (1987) and Kurdikeri (1991). These findings are also in agreement with studies of Ravi Hunje *et al*. (2007) and Barua *et al*. (2009) in Chilli. Tiwana *et al*. (2021) also opined that Super Grain bag was the only storage system that kept grain moisture content stable along the storage period.

Seed germination

Seed germination was also significantly influenced by the period of storage and packaging materials used in the present study (Fig 2). However, treatments with desiccants didn't differ in seed germination during storage. Though the germination was well above the Indian Minimum Seed Certification Standard for germination (70%) in all the treatments at 6th month of storage, a drastic reduction to the tune of 41 per cent was noticed in seeds stored in cloth bags (42.75%) at 9th month of storage. The overall mean seed germination between the packaging materials also indicated that nearly 11 per cent higher seed germination was recorded in super grain bags (86.69%) as compared to cloth bags (75.69%). Seed germination decreased with increase in storage period, as seen by Mandal and Basu (1986) in wheat; Dharmalingam (1995); Hussaini *et al.* (1988) and Ramamoorthy *et al.* (1989) in maize due to natural ageing process. Singh and Dadlani (2003) also opined that the germination per cent was affected by packaging materials during storage. Meena *et al.* (2017) also observed that seeds stored in vacuum packed bags

Table 1: Effect of seed treatment, desiccants and packaging material on seed moisture content and seed germination of seedling (%) during storage in soybean cv. JS 335.

Treatments (T)	Seed moisture content (%)					Seed germination (%)				
	Initial	3rd month	6th month	9th month	Mean	Initial	3rd month	6th month	9th month	Mean
T_1- Super grain bag with $CaCl_2$	8.2	7.6	8.1	7.9	8.0	83	91	86	80	85
T_2- Super grain bag with silica gel	8.3	8.6	8.4	8.8	8.5	84	88	88	85	86
T_3- Super grain bag with drying beads	7.5	7.8	7.4	7.9	7.7	83	91	92	85	88
T_4- Super grain bag without desiccants	7.8	7.8	8.0	8.2	8.0	83	92	93	83	88
T_5- Cloth bag with $CaCl_2$	8.6	9.0	11.5	10.4	9.9	88	89	86	37	75
T_6- Cloth bag with silica gel	8.7	9.3	11.3	10.2	9.9	82	89	93	43	77
T_7- Cloth bag with drying beads	7.6	9.3	11.7	10.1	9.7	83	87	89	39	75
T_8- Cloth bag without desiccants	8.7	9.6	11.3	10.1	9.9	83	84	85	52	76
Mean	8.2	8.6	9.7	9.2		84	89	89	63	
	T	**P**	**T×P**			**T**	**P**	**T×P**		
SEd.	0.05	0.04	0.12			0.59	0.42	1.19		
CD (P=0.05)	0.11	0.08	0.23			1.19	0.84	2.37		

maintained the seed quality with least deterioration with respect to all the seed quality parameters compared to seeds stored in gunny bags and high density polythene bags. Chin and Kieu (2006) concluded that hermetically sealed storage system using poly-ethylene bag reduced insect population in the stock of rice seeds and increases germination percentage of rice seeds as compared to the traditional method of aerobic storage by farmers.

Shoot and root length of seedlings

Seedling growth is considered as the important tool that can be used for assessing the magnitude of deterioration (Toole *et al*., 1957). The seedling vigour in terms of shoot and root length was also influenced by the period of storage and packaging materials used (Table 1). The initial shoot and root lengths of 21.44 cm and 25.83 cm were reduced to 14.19 cm and 15.13 cm, respectively at 9th month of storage. Significant reduction in shoot and root lengths to the tune of 56 per cent and 68 per cent were observed in cloth bag; while it was 11.3 per cent and 12.9 per cent, respectively in Super grain bag at 9th month of storage. Further, the shoot and root lengths in super grain bags were almost two and three fold higher than cloth bags at 9thmonth of storage. The overall mean shoot and root length of seedlings between the packaging materials indicated that nearly 2 and 4 cm longer shoot and root lengths were recorded in super grain bags (86.69%) compared to cloth bags (75.69%), respectively. Similar results were observed by Akter *et al*. (2014) in soybean and reported that storage container had significant effect on root length and shoot length; which decreased with the increase in storage period. Seeds in tin container gave the highest seedling length than cloth bags.

Dry weight of seedlings

The deterioration of seed, which is a progressive process accompanied by accumulation of metabolites, which progressively depress germination and growth of seedling with increased age (Floris, 1970), ultimately reducing the dry matter and vigour of soybean seed during storage. The dry weight of seedling an important measure of seed vigour was significantly influenced by packaging materials used (Table 2). Between packaging materials, seeds stored in super grain bags registered nearly 31 % higher dry weight of seedlings than cloth bags and indicated its superiority in the maintenance of seed vigour during storage.

Vigour indices

The computed vigour indices I and II were also significantly differed due to period of storage and packaging materials used (Table 3). A reduced vigour index I to the tune of 81 per cent was observed in cloth bag as against only 12 per cent in super grain bags. Interestingly, the super grain bags didn't show any reduction in vigour index II while it was nearly 60 per cent in cloth bags. Similar results with polythene bags of 700 gauge were reported by Tammanagouda (2002); Arati

Table 2: Effect of seed treatment, desiccants and packaging material on shoot and root length of seedling (cm) during storage in soybean cv. JS 335.

Treatments(T)	Shoot length of seedling (cm)					Root length of seedling (cm)				
	Initial	3rd month	6th month	9th month	Mean	Initial	3rd month	6th month	9th month	Mean
T_1- Super grain bag with $CaCl_2$	21.92	22.44	19.17	19.45	20.75	24.98	24.68	26.46	22.41	24.63
T_2- Super grain bag with silica gel	20.87	22.43	20.23	19.33	20.71	25.31	23.73	27.14	20.64	24.20
T_3- Super grain bag with drying beads	22.14	22.91	21.02	18.60	21.16	26.25	24.40	27.43	22.86	25.23
T_4- Super grain bag without desiccants	20.41	22.18	20.61	18.30	20.37	24.33	22.26	25.93	21.92	23.61
T_5- Cloth bag with $CaCl_2$	21.49	22.20	22.71	9.32	18.93	26.17	23.29	25.00	9.79	21.06
T_6- Cloth bag with silica gel	21.70	22.27	20.32	9.54	18.46	26.55	23.73	26.57	8.15	21.25
T_7- Cloth bag with drying beads	21.91	22.56	20.21	8.46	18.28	26.27	24.26	24.92	6.09	20.38
T_8- Cloth bag without desiccants	21.05	22.78	19.50	10.53	18.47	26.81	22.92	25.23	9.15	21.02
Mean	21.44	22.47	20.47	14.19		25.83	23.66	26.09	15.13	
	T	**P**	**T × P**			**T**	**P**	**T × P**		
SEd.	0.44	0.31	0.87			0.35	0.25	0.71		
CD (P=0.05)	0.86	0.61	1.73			0.70	0.50	1.40		

Table 3: Effect of seed treatment, desiccants and packaging material on seed vigour during storage in Soybean cv. JS 335.

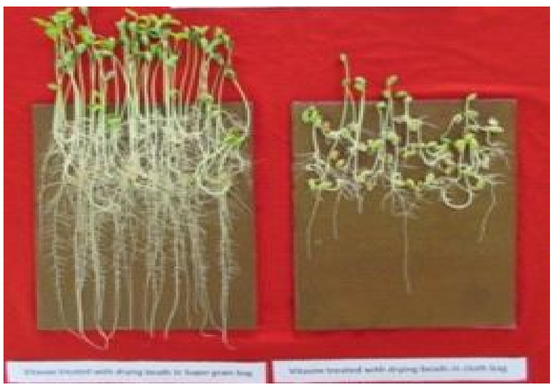
Treatments (T)	Dry weight of seedlings (g 10 seedlings^{-1})					Vigour index I					Vigour index II				
	Initial	3rd month	6th month	9th month	Mean	Initial	3rd month	6th month	9th month	Mean	Initial	3rd month	6th month	9th month	Mean
T_1- Super grain bag with $CaCl_2$	0.303	0.325	0.283	0.377	0.322	3891	4286	3927	3350	3863	25.08	29.55	24.36	30.17	27.29
T_2- Super grain bag with silica gel	0.309	0.304	0.291	0.378	0.321	3856	4037	4169	3399	3865	25.73	26.60	25.65	32.16	27.53
T_3- Super grain bag with drying beads	0.356	0.316	0.289	0.398	0.340	3992	4280	4457	3523	4063	29.32	28.60	26.57	33.80	29.57
T_4- Super grain bag without desiccants	0.341	0.295	0.299	0.373	0.327	3721	4088	4330	3315	3863	28.24	27.15	27.85	31.28	28.63
T_5- Cloth bag with $CaCl_2$	0.315	0.332	0.285	0.264	0.299	4172	4049	4086	699	3251	27.61	29.51	24.37	9.63	22.78
T_6- Cloth bag with silica gel	0.345	0.322	0.292	0.264	0.306	4026	4208	4338	738	3327	28.80	29.44	27.01	11.32	24.14
T_7- Cloth bag with drying beads	0.342	0.308	0.275	0.252	0.294	4001	4073	4016	568	3164	28.35	26.75	24.44	9.85	22.35
T_8 - Cloth bag without desiccants	0.328	0.310	0.279	0.272	0.297	3973	3841	3803	1020	3159	27.19	26.07	23.72	14.14	22.78
Mean	0.330	0.314	0.287	0.322		3954	4107	4141	2076		27.54	27.96	25.50	21.54	
		T	**P**	**T× P**			**T**	**P**	**T × P**			**T**	**P**	**T × P**	
SEd.		0.007	0.005	0.014			68	48	136			0.63	0.44	1.25	
CD (P=0.05)		0.013	0.009	0.027			135	96	270			1.24	0.88	2.48	

(2000); Dwivedi and Shukla (1990) in Pulses. Kurdikeri *et al*. (1996) reported that the seed germination and seedling vigour declined with increasing storage period. Chuansin *et al*. (2006) reported that prolonged storage life of soybean seed without the use of chemical could be attained by the use of different kinds of packaging materials. Thus, the seeds stored in super grain bag recorded significantly higher germination (83.25%), shoot length (20.42 cm), root length (21.96 cm), seedling dry weight (0.382 g) seedling vigour index I (3397) and vigour index II (31.85) as compared to the seeds stored in cloth bag (43%, 9.46 cm, 8.30 cm, 0.263 g, 756 and 11.24, respectively) after nine months of storage (Fig 2). Significantly higher seed quality parameters observed in the seeds stored in super grain bag might be due to constant seed moisture content, reduced respiration rate of seeds stored due to hermetic condition inside the bag and the cushion effect exerted by the inert gas filled in between the two layers of polythene bag protects the seeds from the influence of environment. Similar observation was made by Rickman (2004) in Rice. Wilson and McDonald (1992) observed that Polyethylene and aluminium foil materials were moderately effective in preventing moisture uptake and maintaining seed viability, while paper and cloth containers were least effective. Seeds stored in any air tight containers could retain viability for a longer period of time. Sealed plastic pot and polythene bag are more effective storage containers than cloth bag or jute bag and earthen pot, etc. (Rahman *et al*., 2010). High moisture content and presence of oxygen were the main causes for lipid autoxidation in soybean to lead rapidly seed deterioration and the quality decline (Chang *et al*., 2004). Akter *et al*. (2014) opined that the soybean seeds stored in tin container showed maximum germination capacity with high germination index, highest seedling growth, seedling dry weight per plant and vigour index. The result revealed that all the seed quality parameters under study were significantly influenced by storage materials. Ramanadane and Rettinassababady (2008) opined that rice seed quality declined with storage period, the rate of seed deterioration was higher at high moisture level and the storability differed with type of storage container. Rice seeds with low moisture content stored in super bags or poly-lined cloth bags performed better in storability under coastal area with high relative humidity. Bista *et al*. (2022) also observed that PICS bag followed by super grain bag was found to be superior in terms of seed moisture content,

Vitavax treated seeds with $CaCl_2$ in Super grain bag and cloth bag

Vitavax treated seeds with Silica Gel in Super grain bag and cloth bag

Vitavax treated seeds with drying beads in Super grain bag and cloth bag



Vitavax treated seeds without desiccants in Super grain bag and cloth bag

Fig 2: Seed germination and seedling vigour in soybean after nine months of storage in cloth bag and Super grain bag.

germination percentage and seed health throughout the storage period in rice.

CONCLUSION

Soybean seeds treated with vitavax 200 and stored in Super grain bags exhibited the highest seed germination, seedling length, seedling dry weight, vigour index-I and II than cloth bags after nine months of storage. The loss in seed vigour (VI-I) during storage was only 12 per cent in Super grain bags as compared to 81 per cent in cloth bags indicated that Super grain bag has the potential to effectively contain the influence of environment on seeds stored in it. Hence, it is suggested that the vigour and viability of soybean seeds could be very well prolonged by storing fungicide treated seed in Super grain bag instead of cloth bags under coastal environment.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the financial assistance extended by the ICAR-Indian Institute of Seed Science, Mau for conducting the research experiments under AICRP on Seed (Crops) at PAJANCOA and RI, Karaikal.

Conflict of interest

All authors declared that there is no conflict of interest.

REFERENCES

Akter, M.N.H., Islam, M. and Kondoker, A. (2014). Seed quality of stored soybean (*Glycine max* L.) as influenced by storage containers and storage periods. The Agriculturists. 12: 85-95.

Anonymous, (2016). International Rules for Seed Testing. International Seed Testing Association (ISTA). Zürichstr. CH-8303 Bassersdorf, Switzerland.

Arati, P. (2000). Influence of containers and seed treatments on storability of chickpea. [M.Sc., (Agri) Thesis, University of Agriculture Science, Dharwad, Karnataka, India].

Assefa, M.K. (2008). Effect of seed priming on storability, seed yield and quality of soybean [*Glycine max* (L.) Merrill]. [M.Sc., (Agri) Thesis, University of Agriculture Science, Dharwad, Karnataka, India].

Barua, H., Rahman, M.M. and Masud, M.M., (2009). Effect of storage Containers environment at different storage period on the quality of chilli seed. International Journal of Sustainable Crop Production. 4: 28-32

Baskin, C. and Delouche, J.C. and Carbera, E.R. (1987). The influence of packing materials, seed moisture content and storage environment on seed storability and performance of soybean. Newsletter, Association of Official Seed Analyst. 61(2): 15.

Bista, M., Ghimire, P., Khanal, D., Khatri, N. and Marasini, S. (2022). Effect of Storage Materials and Duration on Quality of Rice Seed. Agronomy Journal of Nepal. 6(1): 36-44.

Chang, S.K.C., Liu, Z.S., Hou, H.J. and Wilson, L.A. (2004). Influence of storage on the characteristics of soybean,soymilk and tofu. Proc. VII- World Soybean Res. Con., IV-In: Soybean Proc. and Util. Con., III-Congresso Brasileiro de Soja Brazilian Soybean Congress, Foz do Iguassu, PR, Brazil, 29 February-5 March, pp 977-983.

Chin, D.V. and Kieu, T.T. (2006). Study on hermetically sealed storage system for rice seeds. Omonrice. 14: 64-70.

Chuansin, S., S. Vearasilp, S. Srichuwong and E. Pawelzik, (2006). Selection of packaging materials for soybean seed storage. Proceeding of the conference on International agricultural research for development. October 11-13, 2006, Tropentag, University of Bonn, Dharmalingam, C. (1995). Halogenation of seed to control and seed declaration. Kisan World. 1: 38-39.

Dwivedi, S.N. and Shukla, T.N., (1990). Effects of methods of seed storage on germinability and mycoflora of gram (*Cicer arietinum* L.) seeds. Seed Research. 18(1): 82-85.

Floris C.(1970). Ageing in *Triticum durum* seeds: Behaviour of embryos and endosperm from aged seeds as revealed by the embryo transplantation technique. Expt. Bot. 21: 461-468.

Hay, F.R., Thavong, P., Taridno, P. and Timple, S. (2012). Evaluation of zeolite seed 'Drying Beads ®' for drying rice seeds to low moisture content prior to long-term storage. Seed Science and Technology. 40: 374-395.

Hussaini, J., Zaki, Z.H. and Jalani, G., (1998). Comparison of various organic and inorganic combination on economical rice production. Pakistan Journal of Soil Science. 6: 21-24.

Kurdikeri, M.B., (1991). Studies on Seed Quality in Hybrid Maize *(Zea mays L.).* [Ph.D., Thesis, University of Agriculture Science, Dharwad, Karnataka, India].

Kurdikeri, M.B. Basavaraj, G.T. Hiremath, M.V. and Aswathanarayan, S.C. (1996). Storability of soyabean [*Glycine max* (L.) Merill] seed under ambient condition. Karnataka Journal of Agriculture Science. 9: 552-554.

Mandal, A.K. and Basu, R.N., (1986). Vigour and viability of wheat seed treatment with bleaching power, Seeds and Farms. 21: 46-48.

Meena, M.K., Chetti, M.B. and Nawalagatti, C.M. (2017). Seed quality behavior of Soybean (*Glycine max*) as influenced by different packaging materials and storage conditions. Legume Research. 40(6): 1113-1118. doi: 10.18805/lr.v 0i0.7598.

O'Hare, T., John, B., Wu, L., and Greg, J. (2001). Storage of oriental bunching onions. Post harvest handling of fresh vegetables. In: Proceedings of a workshop held in Beijing, People's Republic of China.

Panse, V.G. and Sukhatme, P.V. (1967). Statistical Methods for Agricultural Workers, Indian Council of Agricultural Research, New Delhi. pp.167-174.

Rahman, M.M., Hagidok, B. Masood, M.M. and Islam, M.N. (2010). Effect of storage container and relative humidity on the quality of wheat seed. Bangladesh Journal Seed Science and Technology. 14: 89-94.

Rahman, M.M., Hossain, M.M., Anwar, M.P. and Juraimi, A.S. (2011). Plant density influence on yield and nutritional quality of soybean seed. Asian Journal of Plant Sciences. 10(2): 125-132.

Ramamoorthy, K., Kalavathi, D., Thiagarajan, C.P. and Jayakumar, G. (1989). Evaluation of maize inbreds and their hybrid for vigour viability and storability by accelerated ageing. Seeds and Farms. 15: 31-32.

Ramanadane, T. and Rettinassababady, C. (2008). Evaluation of different packaging materials for safe storage of paddy seeds in coastal areas. Oryza. 45(3): 202-205.

Ravi Hunje, Vyakarnahal, B.S. and Channappagoudar, B.B., (2007). Influence of containers on storability of chilli seed. Karnataka Journal of Agricultural Sciences. 20: 55-58.

Rickman, J.F. (2004). Hermetically sealed grain storage systems. IRRI Report.

Singh K.K. and Dadlani M. (2003). Effect of packaging on vigor and viability of soybean [*Glycine max*(L.) Merrill] seed during ambient storage. Seed Research. 31(1): 27-32.

Tammangouda, P. (2002). Influence of organics on seed yield, quality and storability studies in green gram cv. Chinamung. [M.Sc., (Agri) Thesis, University of Agriculture Science, Dharwad (India)].

Tatipata, A. (2009). Effect of seed moisture content packaging and storage period on mitochondria inner membrane of soybean seed. Journal of Agricultural Technology. 5(1): 51-64.

Taylor, A.G., Allen, P.S., Benett, M.A., Bradford, K.J., Burris, J.S. and Misra, M.K. (1998). Seed enhancements. Seed Science and Research. 8: 245-256.

Tivana, L.D., Nguenha, R.J., Viola, P., Monjane, I., Lungu, O., Kafwamfwa, N. (2021). Effectiveness of high-density polyethylene container and Super Grain Bag for the storage system of cowpea grain for small holder farmers. Legume Science. 3(1): 1-12.

Toole, E.H., Toole V.K. and Borthwick, H.A. (1957). Growth and production of snap beans stored under favourable and unfavourable conditions. Proceedings of the International Seed Testing Association. 22: 418.

Wilson D.O. Jr. and McDonald, M.B. Jr. (1992). Mechanical damage in bean (*Phaseolus vulgaris* L.) seed in mechanized and non-mechanized threshing systems. Seed Science and Technology. 20: 571-582.

Woodruff, M.J. (1998). Reports on the soybean: Its status, and potential for Bangladesh. Agro based Industries and Technology Development Project (ATDP). May 1998. Ministry of Agriculture and International Fertilizer Development Centre IFDC).