Agric. Rev., **29** (2) : 125 - 131, 2008

SOYBEAN SEED QUALITY DURING STORAGE: A REVIEW

V. R. Shelar, R. S. Shaikh and A. S. Nikam

Seed Technology Research Unit (NSP),
MPKV, Rahuri 413 722, Dist. Ahmednagar (MS) INDIA

ABSTRACT

Soybean seed quality is affected during pre and post harvest periods. Soybean seed reaches its maximum potential for germination and vigour at physiological maturity. The germination potential (viability) is very short lived in soybean as compared to other oilseed crops and is often reduced prior to planting time. This loss of germination is much more acute under tropical conditions like India. These environmental conditions make very difficult to maintain its viability during storage. Such deteriorated seed is one of the basic reasons for low productivity in soybean. Further, the soybean seed is highly susceptible to mechanical injury and damage occurring during post harvest handling, which affect the viability and vigour of soybean seed during storage. Besides these, large number of pathogens are also associated with soybean seed which lead to the reduction in germination and storability of the seed. However, the seed quality and viability during storage depend upon the initial quality of seed and the manner in which it is stored. The rapid seed deterioration of soybean is thought to be due to lipid peroxidation, subsequently resulting in loss of seed viability. The research on these aspects of soybean seed deterioration during storage has been reviewed in this article.

High quality seed that provides adequate plant stand is the basis for profitable production and expansion of soybean crop. In order to increase the production of soybean, a source of high quality, disease free seed must be established and maintained. 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 which is reviewed in this article.

Deterioration in soybean seed quality during storage :

Effect on Germination:

The deterioration processes begin since seed development. During seed development, anabolic processes predominate and bring about gradual decrease in dry matter including development of an embryo and food reserve. Following maturation, biochemical changes continue and eventually catabolic processes predominate and deterioration becomes apparent. Catabolic changes occur more slowly under low temperature and low relative humidity than under high temperature and high relative humidity could be the reason for fast deterioration (Justice and Bass, 1979). Changes associated with 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 the seed to germinate is reduced. Decline in viability or germination capacity does not begin immediately after maturation. Under favourable storage conditions, the initiation of decline in germination may be from few months to many years depending on storage conditions, kind of seed and conditions during seed development.

The variation in speed of seed deterioration of soybean varieties is a genetic character. Soybean genotypes differ in their ability to maintain seed longevity (Wine and Kueneman, 1981). The longevity of seeds in storage is influenced by four major factors *viz.*, i) Genetics, ii) Quality of the seed at the time of storage, iii) Moisture content of seed or ambient RH, iv) Temperature of storage environment (Gupta, 1976). Shelar (2002) carried out research on soybean seed quality during storage and reported that the germination of soybean varieties decreased during storage irrespective of varieties, threshing and processing methods and storage containers.

The decrease was more pronounced in the variety MACS-124 than the JS-335. Singh and Setia (1974) reported that smooth seeds with 8 % moisture maintained germination above 80 % till next planting season under cold storage and ambient storage temperature. The germination of seed declined with the increase in the seed moisture and storage period. But the decline in germination of seeds showing damaged seed coat was very severe at room temperature. Gupta (1976) reported that soybean seeds are short lived as compared to maize, rice, wheat etc. The seeds having only high initial germination (> 80-90 %) could be recommended for one season storage. Storing soybean seeds beyond first planting season at room temperature may not be successful even in moisture resistant containers. Upto second planting season soybean could be safely stored in cold storege (4-5° C temperature and 50-60 % RH). He stated that there is no report from India on storage of soybean seeds beyond second planting season. Indigenous varieties were found to have better storage potential than US varieties introduced in India. Vantoai (1983) stated that different soybean cultivars stored in liquid N_2 (nitrogen) for 13 months showed 10-15 % more germination as measured by the cold and accelerated ageing test. He observed lower leaching rates compared with stored in ambient condition. A decreasing trend in respiration rate with increased storage was noticed. Arulnandhy (1987) suggested that biweekly application of Benomyl and or Capton from mid flowering to maturity significantly reduced field weathering of seeds.

Tekrony *et al.,* (1993) stated that germination of soybean seed declines more rapidly during storage than other grain crops. Ellis *et al.,* (1982) prepared seed deterioration model to predict seed germination at monthly interval. The model accurately predicted germination (± 10%) after 16 months of storage for 16 of the 17 seed lots. Singh *et al.,* (1994) evaluated seeds of 20 genotypes produced under identical conditions stored in cloth bags. Adequate germinability (70 %) maintaining varieties for 16 months were classed as intermediate storer and poor storer are those with only 6 months storability. Heatherly *et al.,* (1995) observed that commercially grown soybean cultivars have a highly permeable or normal seed coat (NSC) that allows them to imbibe water rapidly. They reported that, impermeability of seeds with ISC (impermeable seed coat) did not change significantly and germination of unscarified seed of all cultivars and lines was not appreciably affected in storage environment like cold room having constant temperature of 10° C, indoor laboratory with temperature ranging from 21-27° C and in freezer with temperature of - 2° C.

Kurdikeri *et al.,* (1996) reported that the seed germination and seedlings vigour declined with increasing storage period and cv. Monetta was the best cultivar regarding storability, maintaining a high germination percentage (79 %) during 9 months of storage. Nkang and Umoh (1997) reported that germinability of cultivars harvested at different maturity periods differed significantly after six months of storage. The optimum storage conditions were found to be at 25-30° C and 55-65 % RH. The viability of soybean variety JS-335 and MACS-124 could be maintained up to certification standard for 330 and 270 days, respectively under ambient conditions of Rahuri (Shelar, 2002). This could be attributed to the smaller seed size of the variety JS-335 than MACS-124. Seed viability in storage is a genetic character and is influenced by species and varieties (Delouche *et al.,* 1973). Wien and Kueneman (1981) observed superior storability of soybean seeds of smaller size as compared to larger seeds. Larger seeds deteriorate faster than small seeds. Verma and Gupta (1975) observed that the small seeded

varieties were found to deteriorate slowly than large seed. Soybean seeds are generally short lived as compared to other species. Soybean seed maintained minimum germination for 11 months at ambient temperature. Differential storability of various species was attributed to genetics, species and varietal characters (Kurdikeri *et al.,* 2000). Delouche (1974) reported that soybean seed lots cannot be stored for two consecutive planting seasons. Singh and Dadlani (2003) reported that the germination percentage was affected by packaging materials during storage. High germination percentage can be maintained for 14 months in seeds packed in 700 guage polythene bags whereas, it fell to 3 per cent and 1 per cent, respectively in seeds packed in cloth bags by 8 months. Similarly, Gupta and Aneja (2004) reported that seeds packed in polythene bags retained seed viability for 15 months and 9 months in untreated seeds in cloth bags. Keshavulu and Krishnasamy (2005) reported that colored to soybean seeds showed differences in seed quality and insect damage. Seeds coated with *H. rosasinensis* and polykote colours showed higher per cent germination compared to control.

Effect on vigour :

The ageing or deterioration of seed, which is 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 RS length, dry matter content and vigour index of soybean seed decreased irrespective of variety, threshing and processing methods during storage. The RSL, DM and VI of seed threshed and processed by machine and stored in gunny bags was significantly lower than the seeds threshed by stick beating, processed manually and stored in polylined gunny bags (Shelar, 2002). One of the first indications of deteriorated seed is shown by the reduced rate of germination and production of weak or watery seedlings and seedlings with stunted radicles. Seedling growth is considered to be important tool that can be used for assessing the magnitude of deterioration (Toole *et al.,* 1957). Relative poor growth in terms of radicle, hypocotyls and leaf length was observed in highly deteriorated lots resulting in low vigour as seed deteriorates during storage (Srivastava and Gill, 1975). The vigour of the seeds at the time of storage is important factor that affect the storage life. Seeds of most crop species are mature when they attain maximum dry weight. Most seeds are physiologically mature at this point. When physiologically mature, the seed possesses its greatest vigour. From this point, it gradually loses vigour and eventually dies. The rate in decline is conditioned by several factors, including genetic constitution of the species or cultivar, condition of the seed, storage condition, uniformity of seed lot. Loss of vigour can be thought as an intermediate stage in the life of the seed, occurring between the onset and termination of death. Puteh *et al*., (1997) relate seed deterioration during storage to the expression of cotyledon necrosis and the performance of seedlings with cotyledon necrosis during germination. As seed vigour declined during storage, the level of cotyledon necrosis increased with the rate of deterioration. Seedlings with cotyledon necrosis emerge slower and had lower seedlings dry weight. Tiwari and Hariprasad (1997) reported that seed longevity was significantly and positively correlated with hull percentage (100 x seed coat weight / seed weight) whereas it was significantly but negatively correlated with seed weight, seed volume and seed coat weight. They further observed that the seed coat weight had the maximum direct effect towards seed longevity followed by hull percentage. They concluded that the hull percentage emerged as the most important determinant character of seed longevity in soybean and could serve as a selection criteria in breeding programme.

Effect of Moisture content

The moisture content of seed during storage is no doubt the most influential factor affecting the longevity. Barton (1961) regarded moisture content of utmost importance in seed deterioration. Seed deterioration increases as moisture content is increased. As seed deterioration is affected by moisture content, it is important to know what factor affects water absorption and retention as well as their effects. High seed mc is the most important single factor governing loss of germinability during storage. Seeds are hygroscopic. They absorb or lose moisture until the vapour pressure of seed moisture and atmospheric moisture reach equilibrium. The seed mc attained under these conditions is referred to as equilibrium moisture content. The EMC in seed at given RH decrease slowly with increasing temperature.

Gupta (1976) stated that in winter, seed is protected by low temperature and during early summer the seed is protected by low humidity. The temperature generally rises from March onwards while RH goes down making storage safe for soybean. It is only from late June or early July that the RH rises and the bulk storage become problem. The soybean seed imbibe 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) helps in more absorption of water and high oil content in seed increases deterioration of seed (Potts, 1972) by increased hydrolytic enzyme activity, enhanced respiration and an increase in free fatty acids. High temperature accelerated the rate of these biochemical processes causing more rapid deterioration that might have resulted in rapid losses in seed having high mc. The seed threshed and processed by machine was responsible for higher mechanical damage had higher mc irrespective of varieties. The moisture content of soybean seed differed significantly due to varieties, threshing and processing methods and storage container during storage. There is slow decrease in mc of seed at initial period of storage, the decrease in germination percentage of seed is also slow and increase with increase in mc irrespective of varieties, threshing methods and storage containers (Shelar, 2002). The increase in mc might be related to the loss of germination percentage of soybean. The cracks and bruises caused due to handling gave exposure of carbohydrate and proteinous material of seed to the prevailing environment which absorbs the moisture from the atmosphere. Obviously, the thickness, structure and chemical composition of the seed coat affect the rate of water absorption and retension by seeds, in hard seeds the seed coat restricts total water uptake. Of the various seed constituents, proteins are most hygroscopic (readily taking up and holding moisture) carbohydrates are slightly less so and the lipids are hydrophobic (lacking an affinity of water).

McDonald (Jr.) *et al.,* (1988) reported that after 72 hours imbibition, the embryonic axis was the most hydrated portion of the seed. The embryonic axis also hydrated more than cotyledons in a high RH environment when exposed as separated parts. Sripichitt *et al*., (1989) stated that seedling growth and length and hypocotyls respiration decreased gradually with increased storage period. Germinability decreased slightly throughout 18 months storage of seed with 6 and 8 % mc. Germinability of seeds stored at 10 and 12 % mc declined rapidly after 6-8 months of storage. Charjan and Tarar (1992) reported that seed mc decreased with storage at 32 % RH and increased with storage at 63 or 92 % RH.

Effect of Mycoflora

Siddiqui (1976) reported that fungi play an important role in deterioration. Disorders observed in infected stored seeds were i) decreased germination, ii) discolouration of parts or whole of seeds, iii)

heating and mustiness, iv) loss in weight. In addition, some species bring about certain biochemical changes in production of mycotoxins. Factors which favour infection by storage fungi and promote their infestation were i) moisture content of seed and interspace relative humidity, ii) temperature of storage, iii) pre-storage infection, iv) storage pest. He suggested that for safe storage of seed, it should be free from fungi and pests. Seed should be free from inert matter or waste material, which favour growth of storage fungi. Moisture content of stored seeds should be below 12 %, storage room temperature and relative humidity should not go beyond 10° C and 70 % RH, respectively. Shelar, (2002) reported that, the mycoflora of soybean seed increased with subsequent increase in storage period, irrespective of variety, threshing and processing methods and storage containers. The mycoflora was higher in seeds of variety MACS-124, seeds threshed by machine and stored in gunny bags. The higher mycoflora could be attributed to higher mechanical damage to these seeds. Mechanically damaged seed permit early entry of mico-organism. Damaged or broken seed coat provides easy access for mycroflora to enter the seed. At harvest, seed lots contain much extraneous material, most of which is removed by cleaning. However, certain fungi, bacteria, viruses and insects are not removed and they cause or hasten seed deterioration (Justice and Bass, 1979). The mycoflora of seeds stored in Polylined gunny bags (PGB) was significantly lower as compared to seeds stored in gunny bags (GB) irrespective of varieties during storage (Shelar, 2002). The less mycoflora in PGB could be ascribed to less fluctuation in mc of seeds. The loss of viability was also slow in the seeds stored in PGB. Storage fungi have been reported to invade and destroy soybean seeds (Milner and Geddes, 1946). They can attack almost any kind of seed under favourable environmental conditions, since these fungi can grow on most organic material. The integrity of the soybean seed coat may also influences pathogen development. Hill and West (1982) found that naturally occurring pores on the soybean seed coat surface provide a mean for fungal hyphae to penetrate the palisade layer eventually culminating invasion of the hourglass layer of the seed coat.

The higher percentage of mycoflora was noted with the seeds that had lost its viability and had higher EC and leaching of sugars (Shelar, 2002). Invasion of seeds by storage fungi may result in loss of viability, increase in free fatty acids, decrease in non reducing sugars. Among the mycoflora observed during storage of soybean seed, the *Aspergillus* spp. occupied the major percentage which is usually present in large numbers in air and on surface of seed storage areas. It is capable to invade and to destroy seed at 4-45°C and 65-100 % R.H. Its activity is largely determined by the physical condition, vitality and moisture content of the seed and the ambient temperature and R.H. of storage area. Increased susceptibility to fungal invasion can be correlated with the increased metabolites in seed leachate (Isely, 1957). Increased leaching from the seed may supply pathogen with a ready source of food for their growth (Lai *et al.,* 1968). The higher percentage of mycoflora was observed in seed which had higher deterioration, leaching, electrical conductivity and moisture content. Accumulation of free fatty acids and loss of germinability accompanied by mould growth (Christensen and Kauffman, 1969) was observed when seeds are placed under natural ageing. In these storage conditions, lipase activity was also very high. Ramkrishna and Banerjee (1951) found that lipase from fungus grown on oil seeds were more active than endogenous seed lipase.

Sangakkara (1988) reported that, the seeds threshed mechanically and dried at higher temperature showed a higher percentage of infection. This was most prominent when

the seeds were stored at high RH and was reflected by the rapid development of fungal infection leading to rapid loss of germinability. *Aspergillus* and *Phomopsis* spp. predominated. In contrast, hand threshed seeds dried at low temperature retained their germinability 12 weeks after storage and were relatively free from fungal infection. Mbuvi *et al*., (1989) reported that the physical properties of soybean seed were altered by the 3 fungi *viz*., *Alternaria* spp., *Fusarium graminearum* and *Phomopsis longicolla* but not by the virus. Density of seeds infected by this fungus was 4 % lower, volume and weight were 13 % lower and breakage susceptibility 20 times higher than those of asymptomatic seeds. Basyony *et al*., (1989) reported that irradiation of soybean seeds (mc 6.5-7.8 %) with 1000, 2000 or 3000 Gy 60 Co eliminate most of the seedborne fungi without affecting the germination even after 4 months of storage. Thomison *et al*., (1989) stated that soybean seedlots with etched (imperfect) seed coats are often associated with low seed germination and *Phomopsis* seed decay and further reported that there was little or no difference in the incidence or severity of seed infection by *Phomopsis* spp. and seed germination between seed with varying levels of seed coat etching. Franca Neto and West, (1989) observed the detrimental effects of *Phomopsis* spp. on germination of soybean seed and reported that the pathogen *Phomopsis spp.* were the fungi most frequently associated with soybean seed. (upto 77 % seed infection). Viability as obtained by the standard germination test (roller paper toweling) was drastically reduced by high (>33 %) level of *Phomopsis spp.*, whereas these effects were not observed in sand test for germination. Therefore, they concluded that rolled paper towelling was not the best substrate to evaluate germination of soybean seed infected with high level of *Phomopsis spp.* El-Kady and Youssef, (1993) assessed 100 soybean samples for growth of filamentous fungi after 4 months commercial storage and reported that the predominant species at 28° C were *Aspergillus flavus, A. fumigatus, A. niger* and *A. alutaceus*, followed by *A. terreus, Penicillum chrysogenum, P. citrinum, Mucar hiemalis, M. racemosus, Emericello nidulans, Rhizopus stolonifer, Nectria haematococea* and *Scopulariopsis brevicaulis*. At 45° C *A. fumigatus* was the predominant species followed by *Rhizomucar pusillus, Emericella nidulens* and *Neosartorya fischeri*. *Penicillum* spp. one of the most abundant genera at 28° C was absent at 45° C. Gupta *et al*., (1993) investigated the effect of *Aspergillus niger* and *A. glaucus* on seed deterioration during accelerated ageing. They observed that both fungi increased the deterioration as manifested by reduced germination in rolled paper towel and modified sand test. *A. niger* reduced germination more than *A. glaucus*. Vishwadhar and Sarbhoy, (1994) identified 38 fungal species including 10 new records for the country. Seed germination *in vitro* was directly proportional to the number of fungi on the seed surface. Relative pathogenecity of 10 dominant seed rotting fungal species confirmed *Fusarium pallidoroseum* and *F. solani*, as highly pathogenic followed by *Aspergillus flavous, Alternaria alternata, F. oxysporum* (moderately pathogenic) while *Colletotricum dematium, Curvularia, Aspergillus niger* and *Drechslera* weak pathogens. Singh *et al*., (1995) incubated one hundred seeds of 17 soybean varieties in petridish for 7 days and reported that *Aspergillus flavous, A. niger, Fusarium oxysporum* and other unidentified fungi were observed on the seedlings. Some varieties had over 25 % infection.

CONCLUSION

Soybean seed germination and vigour is high at physiological maturity. High seed moisture level increases seed mycoflora, which play an important role in deterioration of soybean seed quality and viability during storage.

REFERENCES

Arulnandhy, V. (1987). *Trop Agriculturist.* **143** : 49-60.

Barton, L.V. (1961). In: Seed preservation and longevity. *International Books & Periodicals Supply Service* 216 p. illus. London and New York.

Basyony, A.E. *et al.,* (1989. *Agril. Res. Review*. **67** (4): 619-628.

Charjan, S.K.U. and Tarar, J.L. (1992). *Annals Plant Physiol*. **6** (1): 15-20.

Christensen, C.M. and Kauffman, H.H. (1969). In: Grain Storage. Univ. of Minnesota, Minneapolis, PP. 153.

Delouche, J.C. *et al.,* (1973). *Seed Sci. and Tech*. **1** : 663-692.

Delouche, J.C. (1974). Bull 4: 69T.V.A.Muscle Shoals Alabama pp.47-62.

El-Kady, I.A. and Youssef,.M.S. (1993). *J. Basic Microbiol.* **33** :371-378.

Ellis, R.H. *et al.,* (1982). *Ann. Bot*. **50** : 69-82.

Floris, C. (1970). *J. Expt. Bot*. **21**: 462-468.

Franca-Neto, J.B. and West. S.H., (1989). *J. Seed Tech.* **13** (2): 122-135.

Gupta, A. and Aneja, K. R. (2004). *Seed Res.* **32** (1) : 26 - 32

upta, P.C. (1976). *Seed Res.* **4** (1): 32-39.

Gupta, I.S. *et al.,* (1993). *Seed Sci.& Tech*.**21**: 581-589.

Hartwig, E.E. and. Pottis, H.C. (1987). *Crop. Sci.* **27** : 506-508.

Heatherly, L.G. *et al.,* (1995). *Field Crop Res*. **40** (1): 57-62.

Hill, H.J. and. West, S.H (1982). *Crop Sci.* **22** : 602-606.

Isely, D. (1957). *Proc. Association Off. Seed Anal*. **47** : pp. 176.

Justice, O.L. and Bass, L.N. (1979). *Principals and Practices of Seed Storage.* Castle House Publication Ltd. London.

Keshavulu, K. and Krishnasamy, V. (2005). *Seed Res.* 33 (2) : 208-210

Kurdikeri, M.B. *et al.,* (1996). *J. Agric. Sci*.**9** (3) : 552-554.

Kurdikeri, M.B. *et al.,* (2000). *Seed Res.* **28** (1): 109-110.

Lai, M.T. *et al.,* (1968). *Phytopathology* **58** : 240-245.

Mbuvi, S.W *et al.,* (1989) *Trans. ASAE*. **32** (6): 2093-2096.

Mcdonald, M.B. (jr..) *et al.,* (1988). *Crop Sci.* 28 (6): 993-997.

Milner, M. and Geddes, W.P., (1946). *Cereal Chem.* **23** : 225-247.

Nkang, A. and Umoh, E.O (1997). *Seed Sci. Tech.* **25** (1): 93-99.

Potts, H.C. (1972). *Seed Techno.Lab. Bull*. Mississippi State University. Mississippi State, U.S.

Puteh, A.B. *et al.,* (1997). *Seed Sci. Tech*. **25** (1): 133-145.

Ramkrishna, C.V. and Banerjee, B.N. (1951). *J. Indian Chem. Soc.* **28** : 591-594.

Sangakkara, U.R. (1988). *J. Applied Seed Production.* **6** : 1-5.

Shelar, V.R. (2002) Ph D. Thesis MPKV, Rahuri (MS)

Siddiqui, M.R. (1976). *Seed Res.***4** (1): 66-72.

Singh, D.S. *et al.,* (1995). *Indian J. Mycology Plant Pathol.*. **25** (3): 321-322.

Singh, G. *et al.,* (1994). *Soybean Genetics News Letter.* **21** : 128-129. [Seed Abs. 1995, Vol. 18 (31)].

Singh, J.N. and Setia, R.K. (1974). *Bull. Grain Tech.* **12** (1): 3-10.

Singh, K. K. and Dadlani, M. (2003). *Seed Res.* **31** (1) : 27 - 32

Sripichitt, A. *et al.,* (1989). *Japanese J. Trop Agric.* **33** (1): 18-24.

Srivastava, A.K. and Gill, M.K. (1975). *Indian J. Expt. Biol.* 13 : 481-485.

Tekrony, D.M. *et al.,* (1993). *Seed Sci. and Tech.* **21** : 127-137.

Thomison, P.R. *et al*., (1989). *J. Seed Tech.* **13** (1): 9-18.

Tiwari, S.P. and Hariprasad, A.S.. (1997). *Trop Agric.* **74** (1): 70-72.

Toole, E.H. *et al.,* (1957). *Proc. Int. Seed. Test Ass*. **22** : 418.

Verma, RS and Gupta, P.C. (1975). *Seed Res.* **3** : 39-44.

Vantoai, T.T. (1983). Dissertation Abstract. International B. **43** (10): 3096.

Vishwadhar and Sarbhoy, A.K. (1994). *Indian J. Hill Farming.* **7** (2): 192-202.

Wine, H.C. and. Kueneman, E.A (1981). *Field Crop Res.* **4** : 123-132.