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Assessment of viability, quality and deterioration in stored groundnut seeds

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Abstract
In India, particularly in Karnataka, more land is now being used for the cultivation of groundnut seeds. Seeds of ggroundnut (*Arachis hypogaea* L.) are inherently less viable because of high oil content and more hygroscopic. Additionally, storing groundnut seeds in poor or unfavourable environmental conditions causes a major issue known as seed degradation or deterioration, which is characterised by a loss of viability, vigour and quality of the seed. As a result, there is a considerable demand in the supply for high quality groundnut seeds. The literature on groundnut seed viability, quality, deterioration and improvements under storage has therefore been examined in this article. The studies concluded that groundnut seeds viability and vigour may be preserved for more than a year under proper storage materials and conditions.

Keywords: Hygroscopic, seed quality and vigour

Introduction
Groundnut (*Arachis hypogaea* L.) is an annual legume which is also commonly known as monkeynut, peanut and earthnut. It is the world's 13th most significant food crop and 4th most important oilseed crop. Among oilseed crops in India, groundnut seeds accounts for about 50 percent of area and 45 percent of oil production (Worthington and Hammons, 1971) [55]. Vitamin E, niacin, dalacin, calcium, phosphorus, magnesium, zinc, iron, riboflavin, thiamine, and potassium are all nutrients found in groundnut seeds (Asibuo *et al.*, 2008) [2]. Raw, roasted, or boiled groundnut seeds are eaten straight away, and the oil derived from the seeds is utilized in cooking. Animal feed (oil pressings, seeds, green material, and straw) and industrial raw materials are further uses for it (oil cakes and fertilizer). Because of its many use, the groundnut plant is a valuable cash crop for both internal and international industry in a number of developing and advanced countries.
Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, and Maharashtra account for the majority of the countries groundnut output. About 86% of the total land used for groundnut farming is spread throughout these five states. One of the poorest stores is groundnut. For successful seed production, after harvest, seeds must be stored without compromising quality until the next crop season. When groundnuts are harvested in the summer, the problem of seed viability loss is more severe and after 4-5 months of storage in such products, roughly 50% viability might be lost (Vijayalakshm and Malabasari, 2018) [52]. Seeds containing high levels of oil tend to lose their germination and vigour in a short period of time despite the precautions taken while harvesting and drying (Nautiyal *et al*., 1990) [31]. The viability and vigour of groundnut seeds quickly deteriorate under high temperatures and high relative humidity. That is widely known that the viability and vigour of the seeds in storage are positively impacted by the selection of proper seed forms, storage containers, and storage conditions.

Seed viability in groundnut
In general, during storage, key factors such as the heritable genetic make-up of the varieties, initial seed quality (i.e., seeds free from weathering damage or mechanical injury), moisture content, relative humidity, and temperature (which controls the biological activity of the seeds, insects, and moulds, etc.), provenance (i.e., factors operating before and during harvest), activity of organisms associated with the them and so on, have a significant impact on the seed viability and seed longevity. As the seed is hygroscopic in nature, seed quality is affected by variation in moisture content, relative humidity, temperature *etc*. Roberts (1972) [39] suggested that, the most oblivious sign of seed deterioration is that as the seeds aged they take longer period to germinate and the growth of the seedlings is slower and more variable which indicates the loss of seed vigour.

For mitigate these variables, it is preferable to store the seeds in moisture-and Vapour-proof containers, either with or without a desiccating agent, in order to prolong the seed's quality by lowering the moisture content to a suitable level. A further obstacle to maintaining seedling germination of summer seed crop's potential to be stored is excessive temperatures that prevail throughout the drying process and subsequent storage during the kharif season, where high humidity speeds up the seed degradation. Begum *et al*. (2013) [6] studied that the initial storage conditions and seed quality are important to prolong the shelf life of seeds, the invasion of fungal pathogen also play a vital role in decreasing the viability of a seed lot in groundnut.

Factors affecting the seed deterioration in storage

The two most crucial elements influencing the seed life are seed moisture content and storage temperature. In comparison to temperature, seed moisture content is more harmful. Although it does not appear to be a governing factor within the typical range of biological activity of seed, temperature changes cause an increase in insect moulds, which is another essential factor in the life of seed. The higher moisture temperature has a detrimental effect on them. The best way to preserve seed quality in storage is to lower the temperature and reduce seed moisture content.

Effect of storage temperature, moisture content and relative humidity

The insufficient supply of high quality seeds at the time of sowing is one of the main challenges faced by groundnut producers. To maintain seed viability the moisture content and temperature are critical factors. Low moisture content and low temperature are beneficial to increasing seed longevity; however, these two factors are negatively correlated; at freezing temperatures, if relative humidity is high, it has an adverse effect that contributes to an increase in the moisture content of the seed, which causes seed degradation. It has been documented that a seed moisture content of 6-8 percent is optimal for maximum crop longevity (Shelar, 2008, Mahjabin *et al*., 2015) [42, 26]. Some of the investigator found that the ideal conditions for storage of peanut seed are 10 ºC and 65% RH. The resulting seed moisture content is approximately 6% (Smith and Davidson, 1982, Navarro *et al*., 1989 and Ketring, 1992). Thirusendura and Saraswathy, (2018) [32, 45, 22, 48] investigations also showed that temperature and moisture content of seed are the two main variables impacting seed lifespan in which moisture content often being more crucial than temperature.

The impact of storage environment on seed quality in different packaging material

A protected environment is required for seed storage that is both safe and long term. To keep seeds alive for long periods of time, controlled storage is required especially in tropical and subtropical regions. It is quite challenging to keep these environmental conditions throughout the storage. The length of seed survival is significantly influenced by the storage environment. When damaged seeds are planted, seedling emergence could be poor and disease transfer to the new crop may take place and storage conditions may affect seed quality (Thirusendura and Saraswathy, 2018, Meena *et al*., 2022(b)) [48, 29]. By reducing temperatures and humidity we can reduce the deterioration process of seeds. Harrington (1973) found that a package which is moisture proof or moisture resistant would be more valuable in prolonging germination and vigour of the seed. Meena *et al.* (2017) [28] revealed that groundnut seeds which was stored at 6 ± 1% seed moisture and stored at 25 ± 2 °C in ambient and 4 ± 1 °C in cold conditions under moisture impervious containers i.e vacuum packaging which expressed better seed storability. While the more fluctuation was seen in moisture pervious containers throughout storage period but it was constant for vacuum packaging and also demonstrated that biochemical and physiological parmeters are slow down under 4 ± 1 °C in vacuum packed bags but higher deterioration was oberved in cloth and HDPE bags. Ellis and Hong (2007) [15] confirmed that hermetic packaging is preferable for long term seed storage. Numerous studies have investigated the connection between seed quality, storage time, and temperature (Table 1).

Table 1: Effect of storage environment on seed quality in different packaging material

Groundnut cultivar	Teperature, relative humidity and moisture content	Container/Conditions	Storage duration	Change in seed quality	Reference
KRG-1	7% seed moisture content	Ambient condition, Polylined gunny bag	8 months	Maintained 70% germination	Basave Gowda. and Nanja Reddy (2008) and Rashmireddy *et al*. (2010) [5]
Giza 1 and 2	10 ± 0.5%	Ambient condition, Polypropylene bag and aluminium bag	18 months	Maintained 75% germination	El-Deriny *et al.* (2018) [14]
TMV-2	8.5% seed moisture content, 25 ± 2 ºC room temperature and 4 ± 1 ºC cold storage	Vacuum packed bag	18 months	Higher seed Vaibility	Meena *et al.* (2017) and Meena *et al.* (2022) [28, 27]
K-9	7% seed moisture content	Purdue improved crop storage	9 months	70% germination	Patil *et al.* (2018) [34]
G2-52	Ambient temperature	Purdue improved crop storage	8 months	80% germination	Vijayalakshmi and Malabasari (2018) [52]
TMV-2	60% N_2 + 40% CO_2 + 0% O_2	700 gauge polyethylene bag	10 months	maintained better quality	Guillaumin (1928), Rathi *et al.*, (2000) and Vasudeven *et al.* (2014) [18, 38]
Groundnut	8% seed moisture content	PET/AL/PA/PE composite bags	24 months	High germinability	Fu *et al.* (2018) and cheng *et al.* (2012) [16]
ICGS-11	1.7 to 3.4% moisture content at 35 ºC	sealed air or vacuum	288 weeks	High Vaibility	Sastry *et al*. (2007) [40]
Fuhua 20 and 24	40 ºC and 100% RH	Accelerated ageing	4, 6, 8 days	Due to prolonged ageing, the germination percentage decreased.	Parmil Singh and Khatra (1984), Sung and Jeng (1994), Vasudevan *et al.* (2012), Wang *et al.* (2016) and, Wang *et al.* (2019) [33, 47, 50, 54]

Manifestation of deterioration

- Changes in colour of seed coat and/or embryo
- Delay of radicle emergence and seedling growth
- Reduced total germination of seed population
- Increase in the number of abnormal seedlings
- Lower tolerance to adverse storage conditions
- Higher sensitivity to radiation treatment
- Increased heat production during germination
- Loss of vigour

Improvement of seed quality

Genotypic Factors: There's absolutely no question that genetic factors have a role in seeds' longevity traits, and it has genetic basis more than 50 years ago (Lindstrom, 1942) [25]. Due to variation in their genetic makeup, certain varieties of seeds have an innately longer life span, while others have a shorter lifespan and in diverse cultivars and harvests of the same species may and commonly show varied viability when kept under the same conditions (Bewley and Black, 1982 and Diojode, 1990) [7].

Choosing of genotype: Plant breeders are now considering quality and longivity of seed as an essential attribute in their breeding strategies and it is largely controlled and influenced by genetic factors. It might be difficult to choose genotypes that offer both high production and great in seed quality. Using superior genetics and safeguarding plants from disease and pests are the first steps in optimising productivity. The Quality of the seed varies within the genotype and also between the species and cultivars. Even with small sample of groundnut germplasm, genotype diversity to ambient conditions indicates that there is genetic potential to increase the stability of field emergence and the quality and longivity of seeds during storage (Ketring, 1992) [22] and also it is essential to planting in suitable locations and at the right times, using good crop management practises, adopting proper harvesting and drying techniques, especially cautious processing and handling to reduce mechanical damage and unintended seed mixing with other accessions, and ensuring minimal deterioration before reaching the designated storage are all ways to obtain seeds of high quality (Kameswara *et al.*, 2017) [21]. The selection of genotype is essential and significant because plant adaptability to specific climatic conditions and seed quality are crucial for cultivar performance (Boyhan *et al.*, 2009) [10].

Ideal seed storage environment

The seed quality at the time of storage, seed moisture content, ambient relative humidity, storage environment temperature, storage duration and biological agents all are impact on seed ability to survive (Khatun *et al*, 2009 and Biabani *et al*, 2011) [24, 9]. As per the initial seed quality and storage conditions are crucial for extending the shelf life of seeds, the invasion of fungal pathogens also significantly reduces the viability of a groundnut seed. In poor storage conditions, seeds kept in a variety of conventional containers, such as gunny bags, are particularly vulnerable to infestation by storage pests and fungus (Bhattacharya and Raha, 2002) [8]. Groundnut pods infested with *Aspergillus flavus* + Bruchids were packed in PICS bags and non-infested pods were packed in cloth bags and kept for 4 months in ambient conditions. Interestingly, higher germination was observed in PICS bags even though pods are infested and it was because of low O_2 levels that prevailed in the storage bags (Slay *et al.*, 1985, Murdock *et al.*, 2012, Baoua *et al.*, 2014, Sudini *et al.*, 2015 and Patil *et al.*, 2018) [44, 30, 46, 34]. Patra *et al.* (2000) [35] revealed that groundnut seeds stored in gunny bags lost viability with advancement of storage period and became nil after 9 months of storage compared to seeds stored in polythene bag. According to Gavrielit (1970) [17], groundnut seeds stored at 5% moisture content degraded quickly over the course of two years. Although seed storage at 7–12 °C and 60–65% RH resulted in considerable degeneration after 2 years, such seed was still appropriate for planting. However, seed remained viable at 4 °C and 30% RH for 3 years. Meena *et al.* (2017) [28] reported that a vacuum packing is the best material for storing of groundnut seed for up to 18 months. Similar results were reported by many researchers (Wang *et al.*, 2018; Ramya *et al.*, 2018; Ashok *et al.*, 2019 and Meena *et al.*, 2022(a)) [55, 36, 1, 27].

Seed treatments

Groundnut seeds are categorised as micro-biotics due to their quick deterioration because of their oil content, making it important to preserve the seeds quality. In order to enhance the seed quality and germination potential of viable seeds, a number of controlled seed hydration procedures which includes seed priming. The choice of an effective seed priming strategy, which varies from crop to crop. According to several researches, pre-treating or hydration-dehydration of seeds can help them to produce better seeds under normal or accelerated ageing conditions (Bailly *et al.*, 1998; Demir & Oztokat, 2003; Khan *et al.*, 2017; Thirusendura and Saraswathy., 2018) [3, 12, 23, 48].

Rashmireddy (2006) [37] demonstrated that groundnut seeds stored in gunny bag lined with polythene with silica gel and calcium chloride recorded significantly higher values for all the seed quality parameters followed by high density polythene bags. While, the seeds stored in gunny bag recorded lower values for seed quality parameters. If the rabi or summer produce is used for seed purpose, farmers may be advocated to dry the produce to 7% seed moisture content and store in the gunny bags lined with polythene bag (300 gauge) with desiccant, either silica gel (30g kg^{-1} pod) or calcium chloride (10g kg^{-1} pod) to achieve proper crop stand and productivity (Basavegowda and Nanja Reddy, 2008) [5]. Hydration and dehydration treatments have been recomended for healthy seedling. The priming of groundnut seeds with the application of $CaCl_2$ (1%) solution for 12 hours and GA_3 (50 ppm) increase the germination and gives good germinations and healthy seedlings (Shafiya *et al.*, 2021) [41].

When the seeds of groundnut variety VRI-2 were treated with nanoparticle of ZnO (1000 mg Kg^{-1}) enhanced germination (77%) after 12 months of storage. In case of organic nano-powder of FSP (2 g) and CLP (3 g Kg^{-1}) had higher germination (75 and 75%) (Shyla and Natarajan, 2016) [43]. Jeammuangpuk *et al.* (2020) [20] subjected the peanut seeds to low temperature of 15 °C with priming of salicyclic acid (50 mg L^{-1}) and ascorbate (50 mg L^{-1}) for 12 hours which improve seed quality.

Conclusion

Groundnut seed degradation is an unpleasant and damaging aspect of groundnut cultivation. Negative storage circumstances make it challenging to keep viability while being stored. This review makes it evident that temperature and seed moisture are the main determinants of groundnut seed viability. The findings highlight the crucial roles that

variables like storage temperature, relative humidity and ageing time play in maintaining seed quality and lengthening the seed life of groundnut seeds. The seed germinability of groundnut stored in moisture impervious containers was greater than that of seeds stored in gunny and cloth bags (moisture pervious containers).

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