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# Soybean seed quality deterioration factors and implementing effective management strategies for enhancing overall seed quality

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***Abstract***

This study explores inherent factors influencing soybean seed quality decline, encompassing genetic, physiological, and environmental aspects. A practical approach is proposed to address these challenges, integrating advanced methodologies and technologies for sustainable soybean cultivation and improved seed quality.

## Introduction

Soybean (*Glycine max*) stands as a preeminent leguminous crop with substantial economic and agronomic significance worldwide (Singh and Shivakumar, 2010). Originating from East Asia, soybean has evolved into a globally cultivated crop, recognized for its versatility and high-quality protein content. Scientifically classified within the Fabaceae family, the genus Glycine comprises several species, with *Glycine max* being the primary cultivated species. Aim of current script focusses on meticulous examination of the endogenous factors contributing to the diminution of soybean seed quality. The scope encompasses a sophisticated analysis of genetic predispositions, encompassing traits related to seed vigor, viability, and overall quality. Additionally, the study delves into the intricate interplay of physiological processes within the seed maturation phase, shedding light on the molecular and biochemical mechanisms that influence seed quality. Environmental dynamics, including climatic conditions, soil health, and agronomic practices, form integral components of this investigation, recognizing their profound impact on the inherent quality attributes of soybean seeds (Rosa and Sobral, 2008). The synthesis of these intrinsic factors within a holistic framework seeks to unravel the intricate tapestry of soybean seed quality loss, acknowledging the multifactorial nature of the phenomenon. Moreover, this scholarly endeavour extends beyond mere identification, aspiring to formulate a pragmatic and scientifically rigorous approach to address the identified challenges. The proposed methodology integrates cutting-edge advancements in seed science, biotechnology, and agronomy to devise targeted interventions.

## Seed quality deterioration factors

### *Seed morphology*

Soybean seed is nearly spherical with their thin seed coat, two fleshy cotyledons and embryonic axis. The position of embryonic axis and thin seed coat makes it vulnerable to injury during post-harvest handling. At physiological maturity seed has maximum germination and vigour and contains 40-50% moisture.

### *Seed size*

Large seeds tend to be more susceptible to mechanical damage than small seeds. Seeds that have been exposed to field weathering or that have been dried at high temperatures are more susceptible to mechanical damage. Soybean seeds have pores on the surface of seed coat. The number, size, shape and depth of pores varies among the varieties. The absence of pores on the surface protects the seed from imbibitional damage and also it makes seed coat stronger than those which are having high number of pores.

### *Environment*

The environment plays a crucial role in shaping the quality of soybean seeds. Various environmental factors influence seed development, germination, and overall seed performance. Both temperature and temperature fluctuations during the growing season can impact seed quality. Adequate humidity levels are essential for optimal seed development. Adequate and evenly distributed rainfall during the growing season is crucial for healthy seed development (Weerasekara et al. 2021). Events like storms, hail, or early frost can physically damage developing seeds and reduce overall seed quality. Drought conditions during critical growth stages can lead to smaller seeds, reduced oil content, and lower yields. Soil fertility directly influences seed quality. Soil pH influences nutrient availability.

### *Seed borne diseases*

Seed-borne diseases in soybeans are those caused by pathogens that infect and reside within the seeds themselves. These diseases can have a profound impact on the quality of soybean seeds. Seed-borne diseases in soybeans like purple seed stain, phomopsis seed decay, anthracnose diseases and soybean mosaic virus (SMV) may cause by seed-borne pathogens include different species of fungi such as Fusarium, colletotrichum, and phomopsis, as well as bacteria and viruses. Infected seeds can transmit the pathogens to the next generation of plants during germination and seedling development. Infected seeds may exhibit visible symptoms such as discoloration, deformation, or lesions on the seed coat. Seed-borne diseases often result in reduced germination rates, meaning fewer healthy plants emerge from the infected seeds. The presence of seed-borne diseases can lead to yield losses due to poor stand establishment, reduced plant vigor, and smaller seed size (Gebeyaw et al. 2020).

### *Mechanical harvesting and threshing*

Mechanical harvesting and threshing processes can significantly impact the quality of soybean seeds. Harvesting soybeans at the correct maturity stage is crucial. If harvested too early, seeds may not have reached their full size and oil content, leading to lower quality. Harvesting too late can result in shattering and seed loss. Adjusting the header height and speed of the combine is critical to ensure that the plants are harvested cleanly without excessive shattering of pods. Harvesting soybeans at the right


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moisture content is essential. Proper adjustment of the combine's threshing mechanism is essential for efficient separation of seeds from pods. Inadequate threshing can result in unthreshed pods, while excessive threshing can lead to seed breakage. The speed of the rotor or cylinder in the combine affects threshing efficiency.

***Quality loss during storage***

The height of the stack significantly contributes to germination loss, particularly during handling and transport due to the height of fall. Storage conditions, including temperature and relative humidity, play a crucial role, with high temperatures in April-May-June (approximately 40°C) potentially causing biochemical degradation of seeds. Moreover, reducing seed moisture below 8% makes seeds more prone to mechanical damage during transport. Sowing dry seeds in high soil moisture conditions can result in imbibitional damage, leading to a high rate of abnormal or dead seeds.

**Soybean seed quality standard**

| S. No. | Item | Limit | Foundation Seed | Certified Seed |
|---|---|---|---|---|
| 1 | Pure seed | Minimum | 98% | 98% |
| 2 | Inert matter | Maximum | 2.00% | 2.00% |
| 3 | Other crops | Maximum | Nil | 10/kg |
| 4 | Weed seed | Maximum | 5/kg | 10/kg |
| 5 | Other distinguishable varieties | Maximum | 5/kg | 10/kg |
| 6 | Germination | Minimum | 70% | 70% |
| 7 | Moisture | Maximum | 12% | 12% |
| 8 | Moisture (for vapor) proof containers | Maximum | 7% | 7% |

**Figure 1**. show rupturing seed coat, purple stain seed, hilum bleeding seed borne diseases affect seed germination, YMV affected seed and high stack of seed storage.

**Maintenance of seed purity**

***Nucleus seed***

The breeder from breeder seed stock produces it by adopting plant to progeny method by selecting true to type single plant and uniform plants in the progenies.

***Breeder seed***

Produced from nucleus seed under direct supervision of the breeder and monitored by a team of experts, it provides a source for foundation seed. At breeder seed stage, the standing crop is inspected by a monitoring team consisting of breeders and officials of central/state seed corporations and seed certification agencies.

***Foundation seed***

This is the first-generation progeny of breeder seed. The standards for this class are maintained thorough periodic inspection by authorized seed certification agencies. Foundation seed bags are sealed along with white tags.

***Certified seed***

This is the progeny of foundation seed. It is accepted only if it meets the prescribed norms at various stages of production.

**Maintenance of seed quality**

***Field preparation and nutrient management***

Deep ploughing (20-30 cm) in summer should be done. After the rains (at least 10 cm) use cultivator. Integrated nutrient management i.e. chemical fertilizer (20: 60: 40: 20 kg N: $P_2O_5$: $K_2O$: S/ha) + organic manure (5 t FYM/ha or 2.5 t poultry manure/ha) + biofertilizer (rhizobium + PSB). It is generally rainfed crop but seed production requires adequate soil moisture for quality seed production. Irrigation should be provided to seed crop when there is a long dry spell of more than 10-15 days.

***Seed treatment***

Recommended chemicals and dose for seed treatment Carbendazime + Thiram: 2g + 1g per kg of soybean seeds. Bio control agent: *Trichodema viridae* (5g talcom powder/kg seeds) (Spore content $10^7$). Rhizobium culture: 5g per kg seeds. Pre-sowing Seed polymer coating of soybean nucleus seeds with Pyraclostrobin, thiophenate methyl, carboxin, thiram, thiomethoxam by mist-o-matic seed treating machine. Coating of *Trichoderma viridae* with polymer has shown endophytic growth in 100% plants as compared to 40% in case of powder treatment.

| Chemical | Dose | Beneficial effect |
|---|---|---|
| Pyraclostrobin + Thiophenate methyl (Xelora) | 2 g / kg seed | Increased plant vigour and higher nitrogen metabolism |
| Molybdenum | 1 g/kg seed | Higher quantity with better quality |

***Sowing***

The optimum planting time of soybean is onset of monsoon/third week of June to first week of July. Ensure optimum moisture in the field before planting of soybean seed. Use ferti-seed drill for proper placement of fertilizers as well as seeds. Maintain the optimum plant population: 3-4 lakh plants/ha in the field. Maintain optimum row to row and plant to plant distance. According to seed size 65-75 kg seed should be applied in a hectare area.

***Rainwater management strategies***

Efficient In-situ rainwater management strategies for high yields under rainfed conditions is required. Planting of soybean on Broad-bed furrows (BBF) and Ridge-Furrow system results in 20% yield enhancement as compared to traditional flatbed planting. BBF seed drill which can simultaneously create broad beds and plant the soybean seed should be used.

***Weed management***

From sowing to flowering period effective weed management practices are recommended which can substantially reduce the yield losses due to weeds. three and six weeks after sowing hand weeding or interculture operation by wheel how should be done to maintain the crop.



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***Rouging***

At flowering stage remove off type plants on the basis of plant characteristics and flower colour. Do final rouging at maturity stage, to rouge out off type plants on the basis of pod characteristics. If plants are affected by yellow mosaic virus and soybean mosaic virus, remove the infected plants as soon as they appear. Check further spread up to first two to three weeks.

**Foliar application of growth activators and antioxidant for quality seed production**

| Chemical | Stages of application | Beneficial effect |
|---|---|---|
| Salicylic acid: 100 ppm | Vegetative stage and pod filling stage. | Activate plant internal defense mechanism.<br>Induce abiotic stress resistance.<br>Draught or high temperature.<br>Increase seed vigour and storability of seeds.<br>Protect seeds from fungal infections. |
| Potassium phosphate 2% | Pod formation or pod filling stage. | Improve cell wall formation and seed quality.<br>Improve seed vigour and storability of seeds. |
| Alpha-Tocopherol 100ppm | 1st at vegetative stage.<br>2nd at pod filling stage. | Antioxidant act by scavenging radicals in plant system thus improve plant vigour.<br>Translocation to seed improves seed yield and seed vigour and storability. |

***Harvesting & threshing***

The crop should be harvested when seed moisture is 15-17%. The stage coincides with fall of leaves and change of pod color turns to yellow/brown/black. Delay in harvesting may cause seed losses by pod shattering. The harvested crop should be dried on the threshing floor for bringing down the seed moisture to around 13-15%. At moisture below 12% soybean seed becomes brittle prone to mechanical injury during threshing. Cylinder speed of the thresher should be adjusted between 300-400 RPM. This ensures complete threshing without splitting or breakage of seed when the seed moisture is 13-15%. The speed should be lowered to 300 RPM when the seeds are dry. If the seed has been exposed to field weathering strong mechanical force should be avoided. Such crop should be threshed at higher seed moisture (15%). Drying temperatures which are relatively safer for corresponding initial moisture content of seeds and Seed drying should be adopted in steps as given below.

| Seed Moisture Range | Safe Drying Temperature |
|---|---|
| 18% and above | 32.2ºC |
| 10 – 18% | 37.7ºC |

***Packaging & storage***

Temperature and moisture are most critical factors in storage. Soybean seeds being hygroscopic absorb moisture from atmosphere or loose moisture to surrounding air until they reach equilibrium. The relative humidity in the storehouse should be maintained at below 50%. The activity of storage insect & fungi is very low at this level. The temperature in the storage room should be between 20-25ºC. At this temperature and 50% relative humidity, seeds can be stored for 8-9 months safely. If the seed moisture is reduced to 9% or less water proof bags made of thick polythene should be used for storage otherwise jute bags can be used.


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**Figure 2** show soybean seed polymer coating, ridge farrow system, broad-bed furrows system and interculture operations.

***Protection of seeds during post-harvest storage***

Application of prophylactic fungicide spray of carbendazim (0.05%) (Bavistin) during flowering and Full Green Pod stage. The systemic carbendazim is translocated to pod and seed. The presence of systemic fungicide in seed prevents fungal growth. Protects seeds from saprophytic storage fungi like Aspergillus, Penicillium, Rhizopus etc. during dumping of harvested material with high moisture. Improve storability of seeds and better germination and field emergence during next sowing time.

**Conclusions**

In summary, the study focuses on evaluating factors that lead to the deterioration of soybean seed quality. The emphasis lies in implementing effective management strategies to counter these factors and ultimately enhance the overall quality of soybean seeds. This approach is essential for optimizing crop yields and ensuring the production of high-quality seeds in soybean farming.

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