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# Intrinsic Factors of Soybean Seed Quality Loss and Practical Approach to Tackle the Problems

**Soybean occupies first position among the oil seed crops in terms of acreage and production in India. Besides contributing substantially to the edible oil needs of the country, it earns valuable foreign exchange by way of export of soy meal. Soybean has changed the economic status of the farmers who are growing soybean; still farmers are struggling with the problem of loss of seed quality of soybean. Good field emergence is being a problem due to one or other reasons. Soybean seed is very delicate in nature due to its structural limitations. Chemical composition high protein and high oil content also makes it vulnerable to biochemical degradation during maturity and storage. Maintaining the quality of seed produced during month of Oct-Nov up to the next sowing time in the month of June-July is a difficult task in tropical and subtropical countries like India. The climatic variability leading to delay in monsoon, drought spells of different duration at various growth stages, water logging conditions and above normal temperatures particularly at seed fill stage are the main reasons of low productivity of soybean in India. Poor germination potential of soybean seed and faster deterioration of its seed quality under ambient storage are major problem. In this article, intrinsic factors of soybean seed quality loss and practical approach to tackle the problems have been explained.**

## INTRODUCTION

Soybean commonly known as "Miracle bean" occupies first position

among the oil seed crops production in India since 2006. Besides contributing substantially to the edible oil needs of the country, it earns valuable foreign exchange by way of export of soy meal. Soybean has changed the economic status of the farmers who are growing soybean; still farmers are struggling with the problem of loss of seed quality of soybean. Good field emergence is being a problem due to one or other reasons. Soybean seed is very delicate in nature due to its structural limitations. Chemical composition – high protein and high oil content also makes it vulnerable to biochemical degradation during maturity and storage. Maintaining the quality of seed produced during month of October - November up to the next sowing time in the month of June-July is a difficult task in tropical and subtropical countries like India. During previous years the degrees of climatic adversities add severe negative impact on soybean productivity and production of quality seeds. The climatic variability leading to delay in monsoon, drought spells of different duration at various growth stages, water logging conditions and above normal temperatures particularly at seed fill stage are the main reasons of low productivity of soybean in India. Poor germination potential of soybean seed and faster deterioration of its seed quality under ambient storage are major problem.

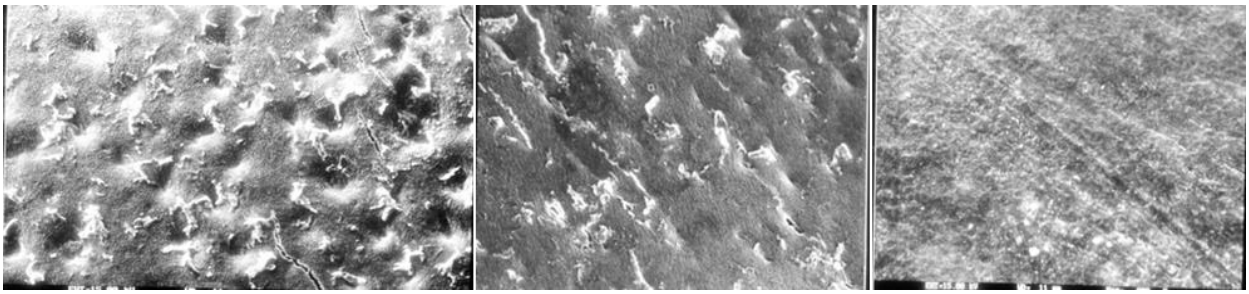
The major intrinsic factors responsible for deterioration of soybean seed quality during harvesting, processing, transportation and storage are:

## 1) STRUCTURAL LIMITATIONS OF SEED MORPHOLOGY

Soybean seed has structural limitation towards mechanization and large scale handling. The seed coat of soybean is very thin as compared to other leguminous crops. The position of radical axis is also quite raised on the cotyledons. Due to thin seed coat soybean seed is very prone to mechanical injury. Breakage on seed coat occurs during threshing and processing and mishandling during transportation. Soybean seeds are prone to damage that if 1 quintal seed bag is thrown from a height of 5 feet the seed losses its viability due to mechanical injury even the seed looks normal from outer appearance. The extreme of mechanical injury lead to splitting of seed thus producing "Dal' (single cotyledons) i.e. Is no longer define as seed. The seed moisture content also influences the degree of mechanical damage to soybean seed. Physical damage increases as the seed moisture decreases below 12%. At higher moisture level (≥ 14%), seeds may be damaged internally and the germination be reduced Singh and Singh, 1981, Prakoboon, 1982). Seed moisture content is greatly correlated to the seed damage during mechanical harvesting and threshing. The safe moisture for mechanical harvesting and threshing of seed had been recommended to be 13-14%. After threshing the seed should be finally dried in thin layer on cemented floor or tarpaulin. Large seeds are 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. Genetic variability in seed for resistanceto mechanical damage among different soybean cultivars had been demonstrated (Carbonell and Kryzanowski, 1995, Kuchlan et al., 2010a and Kuchlan et al., 2010b). Strength of seed coat was a major concern of soybean seed researchers to improve seed quality. The resistance to mechanical damage has been reported to be a genetically governed by mostly seed coat lignin content, seed coat thickness and structure and distribution of 'Hourglass cells' in seed coat.

## 2) POSITION OF RADICAL AND SEED COAT AS REVEALED THROUGH X-RADIOGRAPHY OF SOYBEAN SEED

The vulnerability due to mechanical damage of soybean seed is mainly due to its structural limitations. The x-radiography reveals the position of



radicle which grows into root is positioned above the cotyledons. Thus, it is easily damaged during machine harvesting threshing or processing. Slight damage to this part can cause seedling abnormality or dead seed. There are slight variation among the varieties for the position of radical but there is no variety which is having sradicle is positioned exceptionally deep in to the cotyledons so that the risk of damage can be avoided. Soybean seeds have pores on the surface of seed coat. The number, size, shape and depth of pores varies among the varieties. No pores had been observed in case of black seeded varieties like Kalitur, Birsa Soya 1 etc. 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. Such a variety named PK 472 which was released for central zone have very high number of pores and the problem of 'dal' formation was so high during threshing that farmers gradually shifted to other varieties. Loss of seed germination due to mechanical damage is critical problem in quality seed production in soybean. Soybean seed coat is very susceptible to mechanical forces during harvesting –threshing and post-harvest operations dueto its thin seed coat and low lignin content as reported by several researchers.(Kuchlan et al, 2018).

## 3) SEED QUALITY DETERIORATION DURING STORAGE

The storability of seeds is highly influenced by the storage condition- the relative humidity (RH) and temperature of storage (Justice and Bass, 1978). The tendency of seed to maintain equilibrium moisture in relation to RH of storage is an unavoidable physiological phenomenon. Therefore, high RH of store increases the seed moisture and cause rapid loss of seed quality. In tropical and subtropical regions like India, the development of 'state of the art' facility where storage temperature and RH can be regulated is quite expensive. Lack of such infrastructures forces to store seeds under ambient condition. Soybean seed is being harvested in the month of Oct-Nov and stored for 8 months for next sowing in June-July. The performance of seed in storage varies with areas of storage. The seeds stored in the condition above the safe level of RH (approximately 50-60%) are deteriorated rapidly.

**The relationship between RH of storage and equilibrium seed moisture content in relation to storage temperature**

| Temperature ($^0$C) | Relative humidity (%) of seed store | | | | |
|---|---|---|---|---|---|
| | 50 | 60 | 70 | 80 | 90 |
| 15 | 9.2 | 11.0 | 13.0 | 15.5 | 19.2 |
| 20 | 9.0 | 10.7 | 12.8 | 15.2 | 19.0 |
| 25 | 8.7 | 10.5 | 12.5 | 15.0 | 18.8 |

## 4) SEED HEALTH/ SEED BORNE DISEASE

Seed health is an important parameter for determining seed quality. There are reports of as high as 30 seed borne fungi which infect soybean seed (Sinclair, 1982). Most prevalent field fungi associated with soybean seed as seed borne was found to be Phomopsis sps. Followed by Cercospora and Colletotrichum sps. Under Indian condition infection by Cercospora kikuchii (Purple stain of seed), Diaporthe phaseolorum var. sojae, Myrothecium roridum, Macrophomina phaseolina, colletotrichum truncatum are major cause of low seed quality. The incidence of seed borne diseases not only affects the seed crop, it is transmitted through the infected seed to the next crop. Diseases thus disseminated hamper the soybean production. Seed crop should be free from viral diseases like Soybean mosaic viruses. Occurrence of mycoflora on

Purple strain Soybean mosaic virus infected seeds

**Seed borne diseases of soybean**

and in seed has detrimental effect on seed quality at storage. The seed deterioration is accelerated by the infection of storage fungi – namely Aspergillus sp, Penicillium sps. and Rhizopus sps. In the tropical and sub-tropical regions where relative humidity is higher during seed crop maturity, the risk of attack of saprophytic fungi is more. Rains during seed crop maturity may cause devastating loss of seed quality. The infection of storage fungi has cumulative effect on biochemical degradation of seed.

## 5) BIOCHEMICAL DETERIORATION OF SEED

The biochemistry of seed deterioration has been documented as lipid peroxidation of the phospholipid fraction of cell membrane, disruption of cell membrane, damage to electron transport system in the mitochondrion membrane, inactivation or damage to enzyme system, damage to genetic materials of cell- DNA, mRNA. The production of highly reactive free radicals (superoxide or hydroxyl radicals) during different metabolic pathways triggers the biochemical deterioration of seeds. First and primary site of attack of free radicals are the phospholipids of cell membrane of mitochondria. The lipid peroxidation of phospholipids produces different small chain aldehydes and ketones which attack the genetic material of cell and cause damage to DNA. Damage to the cell membrane cause leaching loss of intra-cellular substances. The antioxidant enzyme system scavenges the free radicals produced in seeds. The expression and activity determine the degree of free radical scavenging. Anti-oxidant chemicals like α-tocopherol and ascorbic acids content of seed also determine the level of protection of seeds to scavenge free radicals.

## CRITICAL MEASURES IN SEED PRODUCTION STEPS TO MINIMIZE SEED QUALITY LOSS

The advanced techniques should be followed to produce seeds of better quality and prevent the chances of seed quality loss and seed damage. The measures start with proper seed treatment before sowing to storage of seeds for next sowing season.

## A) IMPROVED METHODS OF SEED TREATMENT AND ITS BENEFICIAL EFFECT

Seed treatment with recommended dose should be followed to improve seed germination and field emergence by protecting the seed from internal as well as external fungal infections. The texture of soybean seed coat is very smooth. Therefore, loss of chemical applied to seed through powder formulations is very high. Seed treatment becomes non-effective if the chemical is not fixed to seeds and it does not enter into the seed to give systemic effect. Soybean seed germination is epigeal type *i.e.* the seed comes out of the soil due to higher elongation of the seedling hypocotyl. Therefore, most of the powders applied to seed get shed out from seed surface during seedling emergence. Seed polymer coating is most advanced technique to make seed treatment most effective and economical. This polymer coating technique binds the beneficial chemicals on the surface of the seed and does not allow the chemical to get shed out of the seed neither during seed handling, sowing nor during seedling emergence. The chemical gets sufficient time to enter into the seed with the intake of moisture from soil and act systemically and check the growth of internal as well as external fungal infection. Present day seed polymers are manufactured by several firms and being used by private seed companies to improve seed quality as well as improve aesthetic value of high value low volume seeds. The polymer coating technique can be used for all purposes like seed treatment with fungicide and insecticide, application of seed invigorating chemicals, micronutrients (Boron, molebdenum, zinc, iron etc) and bicontrol agents like *Trichoderma*, *etc*. The problem of soybean seed germination and field emergence is chronic and should be tackled to some extent by this improved seed treating techniques. Soybean seed can be polymer coated with fungicides-carbendazime, carboxin, thiram; insecticide- thiomethoxam; seed invigorating chemicals – Salicylic acid; micronutrients-boric acid, ammonium molybdate.

**B) FOLIAR APPLICATION OF GROWTH ACTIVATORS AND ANTIOXIDANTS FOR QUALITY SEED PRODUCTION**

| Chemical | Stages of application | Beneficial effect |
|---|---|---|
| **Salicylic acid: 100 ppm** | i. vegetative stage<br>ii. pod filling stage | • Induce good germination and field emergence<br>• Activate plant internal defense mechanism<br>• Induce abiotic stress resistance: 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** | i. vegetative stage<br>ii. pod filling stage | • Antioxidant act by scavenging radicals in plant system thus improve plant vigour<br>• Translocation to seed improves seed yield and seed |

**C) OPTIMUM PLANT POPULATION FOR PROPER SEED GROWTH AND DISEASE AND INSECT MANAGEMENT**

To get higher production and productivity in soybean optimum plant population is must. For optimum plant population recommended row to row distance(45cm) and plant to plant (spacing 3-5cm) is very important. The seed is a living entity and should be properly grown to be able to develop a new healthy plant in the next generation. If the plant population is not maintained or uniform plant spacing is not followed there will be competition for nutrient for growth and seed development. Scarcity of nutrient may cause deficiencies of important and critical biological units e.g. enzymes and mineral co-factors of enzymes with cause failure of germinability of seed produced or abnormal growth of seedling and plant from such low quality seed. Present day improved machineries for soybean seed are developed like soybean seed drill or soybean seed planter where desired plant spacing is achieved properly. Such machines should be utilized for sowing of seed production plots. Proper spacing of plants not only desirable for proper seed development, it also helps in management of insect and diseases. Diseases are becoming alarming and reducing seed yield. Seed borne diseases cause failure of seed production programme as this menace cause loss of germination of seed and seed lots less than standard limit of germination are rejected for further sale.

**D) WATER AND NUTRIENT MANAGEMENT**

For seed production programme irrigation should be followed for proper time of sowing and protecting the seed crop from long spell of water scarcity due to lack of rain. The drought may hampers quantity of produce but the loss of quality is in much more higher magnitude than loss of quantity. The recommended nutrient doses should be followed for good quality seed production. Sulfur and Phosphorus are very essential for high protein containing soybean crop. Phosphorus is specifically important for improving storability of soybean seeds. Soybean crop S deficiency at vegetative stage to soybean crop negatively associated to seed yield but S deficiency at reproductive stage does not influence the seed yield. The 11S/7S ratio was strongly influenced by S deficiency occurring during reproductive growth, but was relatively insensitive to S availability during vegetative growth (Sexton *et al*., 1998).

**E) PRECAUTIONS DURING HARVESTING AND THRESHING TO MINIMIZE MECHANICAL DAMAGE TO SOYBEAN SEED**

The seed quality of soybean can be maintained by timely harvesting & careful threshing because harvesting at most appropriate time will minimize the effect of weathering & seed damage and careful handling during threshing can prevent mechanical injury to seeds resulting in reduced viability.

1. The crop should be harvested when seed moisture is 15-17%. The stage coincides with fall of leaves and change of pod colour to yellow/brown/black. Delay in harvesting causes seed losses by pod shattering.
2. 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.

3. 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 14-15%. The speed should be lowered to 300 RPM when the seeds are dry.
4. Seeds should frequently be checked during threshing. If any excessive damage is seen cylinder speed should be adjusted.
5. If the seed has been exposed to weathering strong mechanical force should be avoided.

## F) DRYING

After threshing the seed should be finally dried in thin layer on cemented floor or tarpaulin. The moisture should be reduced to 10% or below. In processing plants the seed can be dried either by natural air or hot air of below 30°C if the moisture content is high.

## G) CLEANING & GRADING

Seed is cleaned in three steps. A pre-cleaner is used for pre-cleaning of seeds. Pre-cleaning is a fast cleaning process and removes most of the inert matters from seed. A grader is then used to remove the under and over size seeds and soil particles, inert mater etc. Finally specific gravity separator is used for removing foreign matters which have similar size as the soybean seeds of a particular variety.

## H) PACKAGING & STORAGE

The storage of soybean seed needs special care. Temperature and moisture are most critical factors in storage. Soybean seeds being hygroscope 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 20-27°C. At this temperature and RH of 50% seeds can be stored for 8-9 months safely. If the seed moisture is reduced to 10% or less water proof bags made of thick polythene should be used for storage otherwise jute bags can be used.

## CONCLUSION

The low germination rate of soybean seed encourages high seed rate and hence high cost of cultivation. Low seed germination lead to poor plant population which ultimately affects the final production and productivity. Seed deterioration can be minimized by taking proper care of crop such as planting of soybean at proper time and with proper seed treatment resulted in good quality seeds. Harvesting at right time will be reducing loss of seed quantity due to pod shattering and loss of seed quality due to field weathering. With this pre-harvest care right post-harvest care such as maintaining safe, clean and ambient environmental condition in storage will help in achieving good seed quality in soybean crop.

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