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Impact of Seed Moisture Content at Harvesting and Threshing Methods on Seed Quality Soybean (*Glycine max* (L.) Merrill)

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ABSTRACT: The major constraint in soybean seed production is the rapid loss of seed viability during storage. The seed quality in soybean is affected by harvesting stages, threshing methods, storage conditions and mechanical damage etc. The present experiment was carried out at Central Seed farm, Seed Technology Research Unit and Department of Agriculture Botany, Mahatma Phule Krishi Vidyapeeth, Rahuri-413-722, Dist. Ahmednagar, Maharashtra, during kharif of 2021 and 2022. The soybean seed was collected from kharif season of 2021 and 2022 from Central seed farm. The harvesting was carried out at physiological maturity (H1 -MC ≥15%) and at harvest maturity (H2- MC <15%) and threshing was done with the help of multi-crop thresher with 400 rpm (T1), combine harvester with 700-750 rpm (T2) and steak beating (T3). Among the different threshing methods, the seed threshed by steak beating (T3) followed by seed threshed by multicrop thresher (T1) and among the harvesting stages, the seed harvested at physiological maturity (H1- MC ≥15%) recorded the better initial seed quality with higher seed germination, while lower mechanical damage, seed mycoflora and electrical conductivity. The study indicates that good quality soybean seed can be obtained by harvesting at physiological maturity (H1- MC ≥ 15%) and threshing with steak beating (T3).

Keywords: Seed moisture at harvesting, manual threshing, machine threshing, mechanical damage, soybean seed quality.

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) soybean is an important commercial crop. Many referred the soybean as a "Golden bean" and it has emerged as a 20th-century wonder crop. It is a crop with three benefits: it is a special food, an excellent feed, and a potentially very useful industrial raw resource. Soybean is widely acknowledged as one of the best pulses for getting high-quality protein and oil. It has 19.5% oil and 43.2% protein (Halwankar *et al*., 1992). Vitamins A, B, and D, as well as amino acids, are abundant in soybean. The sprouted seeds are a greater source of phosphorus and sulphur, in addition to having vitamin C. Because of its high protein content, the crop is known as "poor man's meat". Soybean oil is extracted and utilized for food purposes. Soybean with 40% protein, 18–20% fat, 30% carbs, saponins (0.4%), fibre (0.5%), lecithin (0.5%), and isoflavonoids like genistein and daidzein, it has a high nutritional value however, isoflavones are non-nutritive compounds with anti-ageing properties (Radhakrishnan, 2009).

The challenges in soybean production are becoming more apparent, particularly those related to issues with seed quality, which depend on how the seeds are managed during harvesting, threshing, processing, and storage. The loss of seed viability during storage and subsequent poor stand are the primary limitations in soybean production in tropical and subtropical countries, largely due to the prevalent high temperatures and relative humidity (Wine and Kueneman 1981). A primary obstacle for soybean cultivation in the subtropics is the quick deterioration of seed viability and vigour when stored under ambient conditions. It has been noted that germination in particular and seed quality in general are impacted by storage under ambient conditions (Nkang and Umho 1996). Since seed quality and longevity depend on both the initial quality of the seed and the storage method (Shelar, 2008), the type and extent of mechanical damage incurred during postharvest handling significantly impact the viability and vigor of soybean seeds during storage (Wilson and McDonald 1992). The foundation for profitable soybean production and its expansion lies in high-quality seeds that ensure sufficient plant stand. To boost soybean production, it's crucial to establish and maintain a source of disease-free, high-quality seeds. Seed yield and quality largely depend upon the stage of maturity of crop. Therefore, harvesting of seeds at the optimum stage of maturity is an important factor as harvesting either at early or late-stage results in lower yields with poor quality seeds (Tutu, 2014). Lopes *et al.* (2000) studied the physiological seed quality in ten soybean genotypes and found that seed quality was highest at physiological maturity stage.

Soybean seed is subjected to several post-harvest operations like threshing, drying, grading, transportation and other handling operations. Threshing involves the rubbing action for separating the seed, during this loss of soybean seed quality is mainly due to mechanical damage. Mechanical damage is a significant factor contributing to the deterioration of seed quality. Even with damage that may not be immediately visible, seeds can experience reduced vigour, leading to decreased yields. Soybean seeds, inherently fragile in structure, are highly vulnerable to mechanical injury, which accelerates their deterioration and compromises seed quality during postharvest handling (Tekrony *et al.,* 1987; Lori *et al.,* 2001). The thin coat of the seed is delicate and if excessively dry, it may develop cracks during handling, hastening deterioration. These cracks can subsequently multiply during storage, exacerbating the problem (Parde *et al.,* 2002). Compared to manual threshing, mechanical threshing methods cause more damage to the seeds (Saini *et al.,* 1982). Research has shown that hand threshing results in higher laboratory germination percentages, minimal physical damage, and lower electrical conductivity in soybean seeds compared to beating them on a cement floor (Reddy *et al.,* 1995). Another study found that soybean seeds threshed by hand beating exhibited higher germination rates and experienced less deterioration during storage compared to machine threshing or tractor treading, regardless of storage conditions (Jha *et al.,* 1996). The mechanical damage, seed quality aspects and period of storage among threshing methods. Significantly higher mechanical damage was recorded in multicrop thresher as compared to beating with stick. The longevity of seed threshed by beating with stick was prolonged, whereas multicrop thresher used seeds could retained only for short duration of time (Ujjinaiah and Shreedhara 1998). The soybean threshed by tractor treading or by multicrop thresher at 500 rpm showed the least mechanical damage along with the maximum germination percentage and seed vigour index. The use of thresher at 720 rpm lead to reduced seed quality associated with mechanically damaged seeds. In view of the above circumstances, the present investigation was undertaken to study for optimizing the harvesting stages and threshing methods for improving seed quality of soybean.

MATERIAL AND METHODS

The present investigation was carried out in field at Central Seed farm and Seed Technology Research Unit (STRU), Mahatma Phule Krishi Vidyapeeth, Rahuri-413722, Dist. Ahmednagar (M.S) during kharif 2021 and 2022. The harvesting was carried out at physiological maturity (H1 -MC ≥15%) and at harvest maturity (H2- MC <15%) and threshing was done with the help of multi-crop thresher with 400 rpm (T1), combine harvester with 700-750 rpm (T2) and steak beating (T3).

Mechanical damage. Sodium Hypochlorite Test: The mechanical damage was detected by sodium hypochlorite test as per Henning *et al*. (2006); Van Utrecht *et al*. (2000). Four replications of 100 seeds were soaked in 1 % sodium hypochlorite solution for 10 minutes. The damaged seeds swell and their size became larger than their normal size. By counting the swollen seeds, the mechanical damage percentage was calculated.

Mechanical damage (%) =

$$\frac{\text{Total number swollen seeds counted after conduct of test}}{\text{Total number of the seed put for conduct of test}} \times 100$$

Seed mycoflora

Standard blotter method: Three pieces of filter paper was properly soaked in sterilized water and placed at the bottom of a 9 cm well labelled plastic petri dishes. Twenty (20) seeds per petri dish was placed using a forceps and making sure that seeds was placed equidistantly under aseptic conditions. The lids of each petri dish were held in place with gummy cello tape. The Petri dishes containing seeds was incubated at room temperature (25° ± 20°C) for 7 days under alternating cycles of light and darkness of 12 hours each. The incidence of fungi on seed performed under these methods was expressed in percent as follows:

$$\%\ \text{incidence} = \frac{\text{Number of seed infected}}{\text{Number of plated seeds}} \times 100$$

Seed germination : The germination percentage was tested according to ISTA Rule (Anonymous, 1999) 100 seeds from each treatment were kept for germination in four replications in germinator at 25°C temperature and at 95% relative humidity for 7 days using between paper method. Accordingly, germination percentage was computed on normal seedling with the formula given below

$$\text{Germination}\ (\%) = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds}} \times 100$$

Electrical conductivity. Fifty seeds of each treatment replicated three times, were soaked in 75 ml of distilled water for 24 hrs at 25ºC in incubator. After soaking gently swirling the solution and seeds were discarded and the leachate were used for measuring the electrical conductivity. Electrical conductivity was determined by conductivity meter and expressed as $\mu S.cm^{-1}\ g^{-1}$ (Loeffler *et al.,* 1988).

RESULTS AND DISCUSSION

Mechanical damage: The mechanical damage (%) indicated significant effect due to the different threshing methods. The steak beating threshing method (T3) recorded the lowest mechanical damage (7.83, 8.90 and 8.37 %) followed by multi-crop thresher (T1) (14.37, 16.00 and 15.18 %) during the year 2021, 2022 and on pooled basis, respectively. While the highest mechanical damage was recorded for the seed threshed by combine harvester (T2) (17.62, 18.95 and 18.28 %) during the year 2021, 2022 and on pooled basis, respectively.

The mechanical damage (%) of soybean indicated significant effect due to the harvesting stages viz., at physiological maturity (H1 -MC ≥15%) and at harvest maturity (H2- MC <15%) during both years and on pooled basis. The harvesting of soybean at physiological maturity (H1 -MC ≥15%) recorded the lowest mechanical damage (12.91, 14.07 and 13.49 %), while the harvesting of soybean at harvest maturity (H2- MC <15%) recorded the highest mechanical damage (14.13, 15.69 and 14.91 %) during the year 2021, 2022 and on pooled basis, respectively.

Gagare *et al.* (2014) reported that the soybean seed threshed by stick beating recorded lower mechanical damage than other two threshing methods **viz.**, multi crop thresher and combine harvester irrespective of varieties. Mechanical damage was directly proportional to moisture content in seed reported by Mamicpic and Caldwell (1963). Sonowski and Kuzniar (1999) observed that the cultivar differed greatly in their susceptibility to mechanical damage at low moisture content range of 7-14%. The optimum moisture content at which the damage was below 5 % was 13.1 %. Initial seed moisture content is another major factor which affects storage life of seed through its effects on mediating damage by threshing and processing machinery and handling.

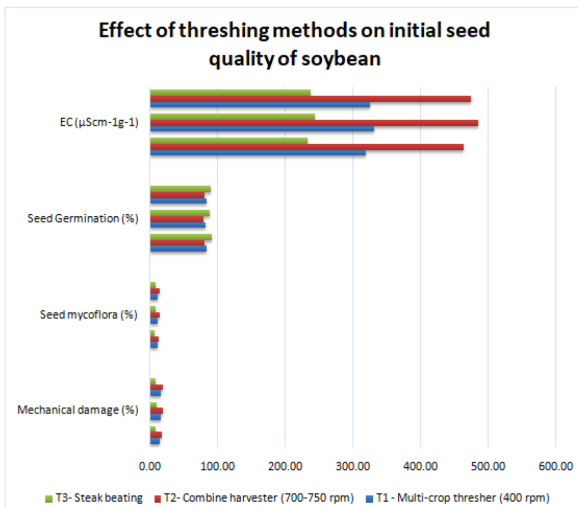

Fig. 1. Effect of threshing methods on initial seed quality of soybean.

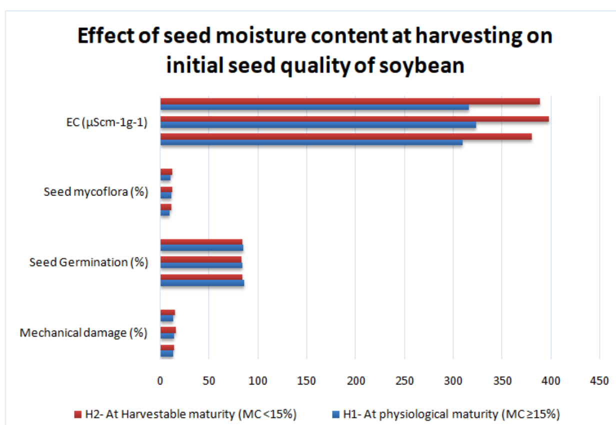

Fig. 2. Effect of seed moisture content at harvesting on initial seed quality of soybean.

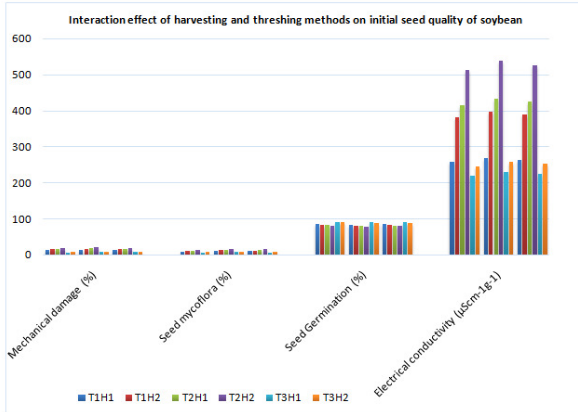

Fig. 3. Interaction effect of harvesting and threshing methods on initial seed quality of soybean.

Seed mycoflora. The significant effect of the different threshing methods on soybean seed mycoflora (%) was observed. The lowest soybean seed mycoflora (7.00, 8.45 and 7.73 %) was recorded for the steak beating threshing method (T3), followed by multi-crop thresher (T1) (10.48, 11.85 and 11.17 %), while the highest seed mycoflora (13.00, 14.47 and 13.73 %) was recorded for the seed threshed by the combine harvester (T2) during the year 2021, 2022 and on pooled basis, respectively irrespective of harvesting stages.

It was found that there was significant effect on soybean seed mycoflora (%) due to the harvesting stages. The lowest soybean seed mycoflora (9.49, 10.91 and 10.20 %) was recorded with seed harvested at physiological maturity (H1- MC ≥15%), while the highest seed mycoflora (11.26, 12.64 and 11.95 %) was recorded which was harvested at harvest maturity (H2- MC <15%) during the year 2021, 2022 and on pooled basis, respectively irrespective of threshing methods.

Mechanically damaged or broken seed coats permit early entry and easy access for mycoflora to enter in to the seeds. 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 higher mechanical damage might have lead to more fungal invasion, which has been reflected in higher fungal infection (Gupta *et al.,* 1993) and electrical conductivity during storage. The higher percentage of mycoflora was noted with the seeds that had lost its viability and had higher EC.

Seed Germination. The significant effect on soybean seed germination (%) due to the different threshing methods was found. The highest soybean seed germination (91.13, 89.00 and 90.07 %) was recorded with the steak beating threshing method (T3), followed by multi-crop thresher (T1) (84.28, 82.60 and 83.44 %), while the lowest seed germination (81.17, 79.52 and 80.34 %) was recorded for the seed threshed by the combine harvester (T2) during the year 2021, 2022 and on pooled basis, respectively irrespective harvesting stages.

There was significant effect on soybean seed germination (%) due to the harvesting stages. The highest soybean seed germination (86.21, 84.18 and 85.19 %) was recorded for seed harvested at physiological maturity (H1- MC ≥15%), while the lowest seed germination (84.39, 82.74 and 83.57 %) was recorded in seed which was harvested at harvest maturity (H2- MC <15%) during the year 2021, 2022 and on pooled basis, respectively irrespective of threshing methods.

The seeds threshed by combine harvester suffer more for mechanical damage due to high drum speed than seeds threshed by tractor operated thresher which retained its viability in storage better due to less damage to seed embryo (Nagawade, 2012). Murata *et al.* (1991) reported that the seed coat cracking in soybean increased with increasing machine speed. Germination of seed threshed manually was significantly higher than that of seeds harvested by machine irrespective of varieties reported by Kausal *et al.* (1992). Results are in conformity of Jha *et al.* (1995); Shelar (2002); Nagawade (2012); Gagare (2014); Maheshwari (2019); Vishwanath *et al.* (2023). Isaac *et al.* (2016) found in soybean harvesting at physiological maturity stage resulted in high germination percentage, significantly different from the other harvesting stages. Harvesting two weeks after physiological maturity registered the lowest germination percentage. Current findings confirmed the report by Mahesha *et al.* (2001); Hirpara *et al.* (2020) stated that at physiological maturity, soybean seed shall have maximum viability and vigour.

Electrical conductivity. The significant effect on soybean electrical conductivity ($\mu Scm^{-1}g^{-1}$) due to the different threshing methods was observed. The lowest electrical conductivity (232.98, 243.88 and 238.43 $\mu Scm^{-1}g^{-1}$) was recorded for the steak beating threshing method (T3), followed by multi-crop thresher (T1) (319.13, 332.12 and 325.62 $\mu Scm^{-1}g^{-1}$), while the highest electrical conductivity (464.23, 486.51 and 475.37 $\mu Scm^{-1}g^{-1}$) was recorded for the seed threshed by the combine harvester (T2) during the year 2021, 2022 and on pooled basis, respectively irrespective of harvesting stages.

The data revealed that there was significant differences in soybean seed electrical conductivity ($\mu Scm^{-1}g^{-1}$) due to the harvesting stages. The lowest soybean electrical conductivity (309.25, 322.96 and 316.11 $\mu Scm^{-1}g^{-1}$) was recorded for seed harvested at physiological maturity (H1- MC ≥15%), while the highest electrical conductivity (380.03, 397.91 and 388.97 $\mu Scm^{-1}g^{-1}$) was recorded which was harvested at harvest maturity (H2- MC <15%) during the year 2021, 2022 and on pooled basis, respectively irrespective of threshing methods.

The soybean seed threshed by combine harvester had significantly higher electrical conductivity than seeds threshed by stick beating (Gagare, 2014). The seeds harvested at physiological maturity were more vigorous and had good seed coat integrity than seeds harvested one and two weeks after physiological maturity (Isaac *et al.,* 2016). Ali *et al.* (2018) reported that Electrical conductivity values indicate the level of membrane integrity of seed. High values of electrical conductivity show high electrolyte leakage from the membrane which lead to low quality of seed. Seed deterioration was positively correlated with electrical conductivity of seed. Seed that produces a high amount of electrolyte leaked into the deionized water is said to be the low vigour seed. The electrical conductivity of seed was significantly increased after physiological maturity (Gaikwad and Bharud 2017).

CONCLUSIONS

The seed threshed by steak beating (T3) followed by multicrop thresher (T1) recorded the better seed quality with higher seed germination and lower mechanical damage, seed mycoflora and electrical conductivity. The seed harvested at physiological maturity (H1- MC ≥15%) recorded better seed quality with higher seed germination and lower mechanical damage, seed mycoflora and electrical conductivity than the seed harvested at harvest maturity (H2- MC <15%).

FUTURE SCOPE

It is indeed need to investigate on limitation of manual harvesting and threshing due to labour availability and have broad scope for improvising machine harvesting and threshing and their optimization for getting high quality soybean seed.

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Conflict of Interest. None.

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