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Impact of Post-Harvest Operations on Seed Quality in Soybean

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The influence of threshing, cleaning and processing operations on seed quality in two varieties of soybean was studied with an objective to identify the best post-harvest operation to maintain seed viability and vigour. The two varieties *viz.* Basara and JS 335 were subjected to five different post-harvest operations and two sieve sizes of 3.75 and 4.00 mm. The mechanical damage (%), seed recovery (%), physical purity (%), germination (%), seedling vigour Index II (SVI II), field emergence, electrical conductivity, amino acids and total soluble sugars in seed leachates of processed seed were determined. Among the two varieties Basara recorded lowest mechanical damage and higher germination and field emergence compared to JS 335. The highest seed quality with lowest mechanical damage was reported in seed threshed and cleaned manually. Electrical conductivity showed a non-significant variation in all the treatments while amino acids and total soluble sugars in seed leachates were lowest in Basara. The character association studies revealed a positive association of germination and field emergence and negative association of germination and mechanical damage, amino acids and total soluble sugars in seed leachates.

Keywords: Character association; mechanical damage; post-harvest operations; seed quality; soybean.

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1. INTRODUCTION

Soybean (*Glycine max* L. Merill) is an important oilseed crop globally and popularly grown in temperate regions, however, it is gaining popularity in India also because of ease in production with high yields. The major constraint associated with soybean production in tropics is supply of quality seed due to post-harvest losses i.e., rapid loss of vigour and germination in storage. Loss of germination is more acute in tropical countries [1] as compared to temperate environment. In tropics, more than 40 % of the losses occur during post-harvest and processing operations [2]. The post-harvest losses in soybean include field weathering and impact on seed during post-harvest operations influencing seed coat integrity and thereby resulting in damage to embryonic axis. The erratic behaviour of rainfall due to climate change has led to rains at the time of soybean harvest further enhancing the damage due to field weathering and affecting the seed quality.

Manually cleaned seed retains good germination, but it is labour, intensive and time consuming, thus mechanical threshing and processing are commonly adopted. Irrespective of the extent, mechanical injuries reduce seed longevity and storability, predisposes seed to infection, reduces germination and vigour, [3,4]. Mechanical processing of seed will help in improving the physical purity, test weight, germination and vigour of seed, however mechanical damages during post-harvest operations were identified not only in soybean but also in green gram, black gram, sunflower [5] and chickpea [6]. The extent of mechanical damage varies with varieties, hence appropriate postharvest operations to attain seed of high quality with good seed recovery should be determined.

Hence there is a need to identify an appropriate feasible processing chain to reduce loss in seed quality which leads to disruption in seed multiplication chain especially during breeder and foundation stage of seed production. This information can be useful to identify the reasons associated with seed damage and intervene into new post-harvest management strategies to mitigate losses during processing.

2. MATERIALS AND METHODS

The two varieties of soybean (JS-335 and Basara) grown during *Kharif* 2021 at the Agricultural Research Station, Adilabad was harvested manually at harvest maturity and subjected to cleaning after drying. To study the influence of post-harvest operations on seed quality the two varieties of soybean seed were cleaned using two sieve sizes i.e., S1 3.75mm and S2 4.00 mm and five post-harvest methods *viz.* P1 threshed by beating with wooden sticks and hand cleaned, P2 threshed with a multi-crop thresher and hand cleaned, P3 threshed with a multi-crop thresher and cleaned in fine cleaner in Fowler Westrup make 4 TPH machine, P4 threshed with a multi-crop thresher, cleaned in fine cleaner in Fowler Westrup make 4 TPH machine and graded in Spiral Separator through conveyance by rubberized elevators and P5 threshed with a multi-crop thresher, cleaned in fine cleaner in Fowler Westrup make 4 TPH machine and graded in Spiral Separator through conveyance by normal elevators at Seed processing plant, Agriculture Research station, Adilabad, Telangana.

The seed collected by various methods was tested for seed quality parameters at the Department of Seed Science and Technology, Seed Research and Technology Centre, PJTSAU, Hyderabad. The physical parameters i.e., percent mechanical damage was calculated by Ferric chloride method suggested by Agarwal [7], percent seed recovery was estimated as per the procedure given by Vishwanath et al. [8] and physical purity as per ISTA -2019 [9]. The Seed germination and electrical conductivity was estimated as per ISTA-2019 [9], Seedling vigour index II was calculated as per the method suggested by Abdul- Baki and Anderson [10] and field emergence was determined by sowing hundred seeds in two replications.

Field emergence % = Number of seedlingsgerminated on eight day / Total number of seeds sown × 100

The total soluble sugars in seed leachates were estimated as per method of Dubois et al. [11]. To 1 ml of seed leachate, 1 ml of 5% phenol solution is added, followed by 5 ml of concentrated H2SO4 and the mixture is Shaked well, allowed to cool at room temperature and absorbance was recorded in spectrophotometer at 490 nm. The free amino acids in seed leachates is done as per ninhydrin method. To 1 ml of seed leachate, 1 ml of ninhydrin solution is added and kept in boiling water bath for 20 min followed by addition of 5 ml of diluent solvent. The intensity of the purple colour against a reagent blank is read in the calorimeter at 570 nm. The data was analysed using three-way ANOVA on Completely Randomized Block Design (CRD) as suggested by Panse and Sukathme [12] and data analysis carried out through INDOSTAT pacakage.

3. RESULTS AND DISCUSSION

The varieties showed a significant variation for all the physical parameters of the seed (Table 1) with Basara recording lowest mechanical damage and highest physical purity, while seed recovery was more in JS 335. A significant variation in seed physical parameters was observed for post-harvest treatments with lowest mechanical damage in P1, highest seed recovery in P1 and physical purity in P5. A significant variation for sieve sizes was observed for seed recovery and physical purity with highest values in S1 and S2 respectively.

The physical changes in two varieties of soybean across various post-harvest operations are given in Fig. 1. The percent mechanical damage in Basara ranged from 18% (P1S1) to 32% (P5S2), while in JS 335 from 19.5% (P1S1) to 35.5% (P5S1) and increased gradually from manual method to fine grading in both the varieties. The seed recovery was found to be significant among varieties, sieve size and post-harvest treatments and ranged from 86 (P5S2) to 94.25 (P1S1) percent in Basara and from 87 (P5S2) to 96.25 (P1S1) percent in JS335. Lowest physical purity was recorded in P1 and highest in P5 in both the varieties.

The mechanical threshing and processing operations caused significant mechanical damage in both the varieties with significantly higher damage in JS 335 compared to Basara indicating that Basara offered better resistance to mechanical operations than JS 335. These results corroborate to similar results obtained by Delouche [13], Gagare et al. [14] and Rodrigo Albaneze et al. [15] in soybean.

A significant variation was observed among varieties for all physiological parameters i.e germination, SVI II and field emergence, while post-harvest treatments showed significant variation for germination only and sieve sizes for germination and field emergence (Table 2). Basara recorded highest germination (90.05 %) and field emergence (84.70 %), while highest SVI II was observed in JS 335 (7667.85). The treatment P1 recorded highest germination of 90.25%, while P5 recorded a lowest germination of 85.88 % and among the sieves, highest germination was observed in seed cleaned using 4 mm sieve. Field emergence was more in seeds cleaned using a 4 mm sieve than in 3.75 mm sieve.

The pattern of physiological performance of two varieties of soybean at various stages of post-harvest operations is presented in Fig. 2. The germination percentage in Basara ranged from 89 % (P5S2, P3S1) to 91.5 % (P1S1) and in JS 335 from 79% (P5S1) to 91% (P1S2). The SVI was highest in V2P1S2 (8443.5) and lowest in V1P5S1 (6306.5) and decreased gradually from manual to mechanical methods. A significant variation among interactions was not observed for field emergence, however it ranged from 81.5 (P2S2) to 87% (P2S1 and P5S1) in Basara and from 71.5 (P5S1) to 82.5 (P4S2) per cent. Similar highest germination and vigour was observed by Seema and Betageri [16] in seeds threshed by stick beating. Highest germination and vigour in seeds threshed and cleaned manually is due to low mechanical damage leading to less damage and high vigour. Nagawade et al. [17] also reported that pre-processing samples recorded higher germination and vigour index-I, followed by seeds obtained after pre-cleaner in and seeds collected at the end of the processing chain.

The biochemical parameters i.e., electrical conductivity showed a non-significant variation for all the treatments, while amino acids and total soluble sugars in seed leachates was found to be significant among varieties with Basara recording lowest values compared to JS 335. The total soluble sugars in seed leachates showed a significant variation among the post-harvest treatments with lowest values in P1 (57.89 µg/ml) and highest in P5 (99.39 µg/ml). The range of biochemical parameters in two varieties across post-harvest treatments and sieves is presented in Fig. 3. The electrical conductivity in seed leachates ranged from 141.78 to 284.70 µS cm^{-1} g^{-1} in Basara and from 139.37 to 228.64 µS cm^{-1} g^{-1} in JS 335. The amino acids in seed leachates showed a non-significant variation among the treatments and ranged from 25.5 µg/ml (V1P3S2) to 23.42 µg/ml (V2P5S2). The total soluble sugars in seed leachates showed a gradual increase from manual to mechanical methods with lowest values in P1S2 in both Basara (54.88 µg/ml) and JS 335 (59.25 µg/ml) and highest values of 82.31 and 118.31 µg/ml in P5S1 in Basara and JS 335 respectively.

Table 1. The effect of post-harvest operations on the mean physical parameters ofseed after processing in soybean

Factor	Level	Mechanical Damage (%)	Seed Recovery (%)	Physical Purity (%)
Variety	Basara (V1)	24.80	89.60	98.09
	JS 335 (V2)	27.45	91.00	98.05
Post-harvest treatments	Manual threshing and Manual cleaning(P1)	19.38	94.38	97.53
	Mechanical threshing and Manualcleaning (P2)	23.13	90.94	97.96
	Mechanical threshing and Cleaning inFine cleaner (P3)	26.75	90.13	98.14
	Mechanical threshing and Cleaning inFine cleaner and grading in Spiral separator (using rubberized elevators)(P4)	29.13	89.19	98.23
	Mechanical threshing and Cleaning in Fine cleaner and grading in Spiral separator (using normal elevators) (P5)	32.25	86.88	98.49
Sieve size	3.75 mm (S1)	25.75	90.65	98.06
	4.00 mm (S2)	26.50	89.95	98.08
CD	Variety	1.396	0.443	0.164
	Post-harvest treatments	2.207	0.7	0.259
	Sieve size	NS	0.443	0.164
	V X P	NS	0.99	0.367
	V X S	NS	NS	NS
	P X S	NS	0.99	NS
	V X S X P	NS	1.4	0.519

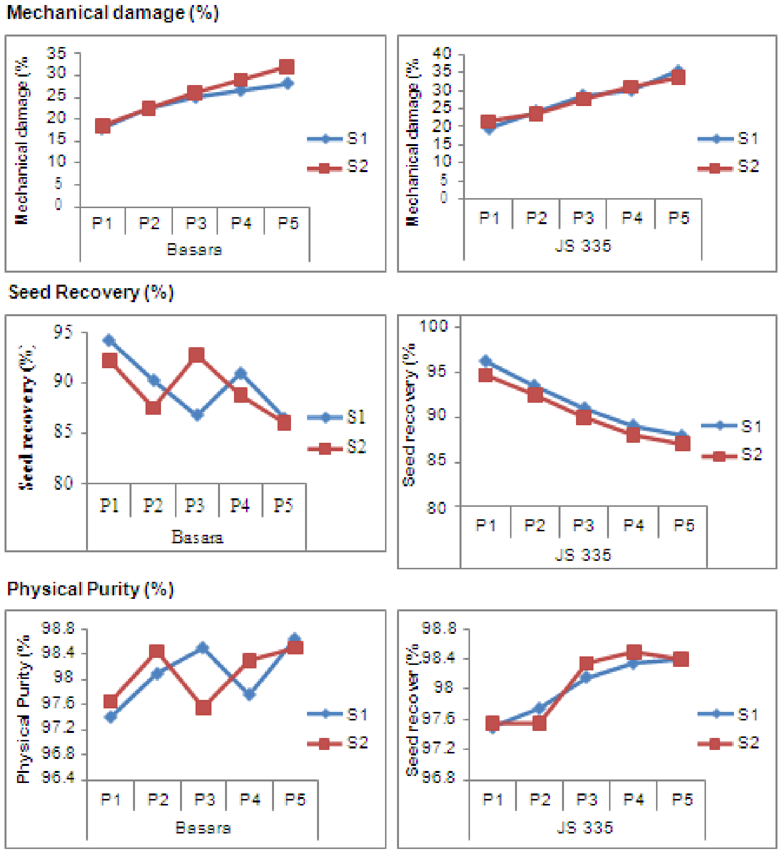

Fig. 1. The effect of various post-harvest operations and sieve sizes on thephysical parameters in soybean

Post-harvest practices

P1: Manual threshing and cleaning
P2: Mechanical threshing and Manual Cleaning
P3: Mechanical threshing and Cleaning in fine cleaner
P4: Mechanical threshing + Cleaning in fine cleaner+ grading in spiral separator (usingrubberized elevators)
P5: Mechanical threshing + Cleaning in fine cleaner+ grading in spiral separator (usingnormal elevators

Sieve sizes

S1: 3.75 mm
S2: 4.00 mm

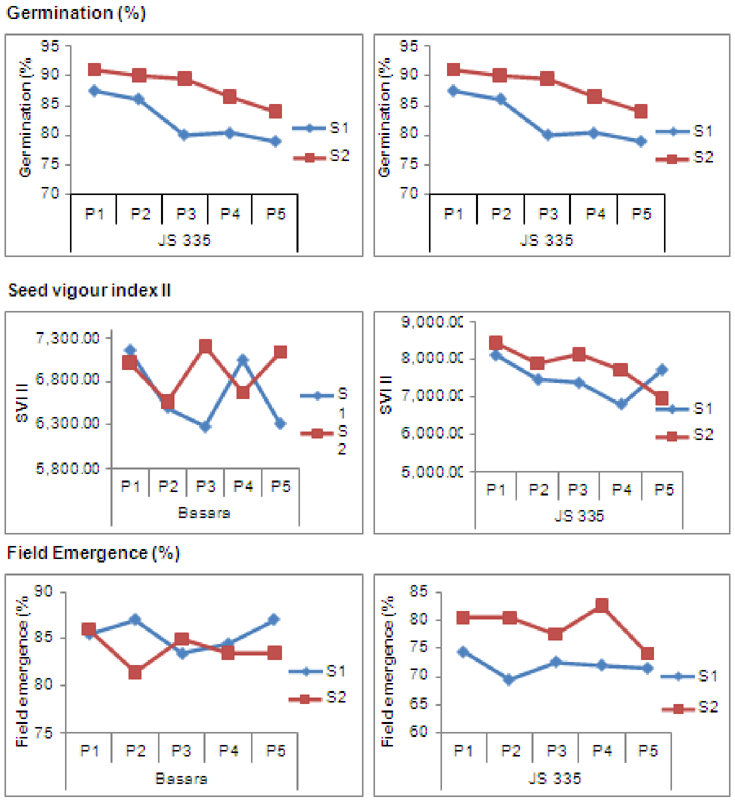

Fig. 2. The effect of various post-harvest operations and sieve sizes on thephysiological parameters in soybean

Post-harvest practices

P1: Manual threshing and cleaning
P2: Mechanical threshing and Manual Cleaning
P3: Mechanical threshing and Cleaning in fine cleaner
P4: Mechanical threshing + Cleaning in fine cleaner+ grading in spiral separator (usingrubberized elevators)
P5: Mechanical threshing + Cleaning in fine cleaner+ grading in spiral separator (usingnormal elevators

Sieve sizes

S1: 3.75 mm
S2: 4.00 mm

Table 2. The effect of post-harvest operations on the mean physiological parametersof seed after processing in soybean

Factor	Level	Germination %	SVI II	Field emergence (%)
Variety	Basara (V1)	90.05	6787.60	84.70
	JS 335 (V2)	85.40	7667.85	75.50
Post-harvest treatments	Manual threshing and Manualcleaning (P1)	90.25	7683.00	81.63
	Mechanical threshing andManual cleaning (P2)	88.88	7106.50	79.63
	Mechanical threshing and Cleaning in Fine cleaner (P3)	87.25	7257.50	79.63
	Mechanical threshing and Cleaning in Fine cleaner andgrading in Spiral separator (using rubberizedelevators) (P4)	86.88	7057.88	80.63
	Mechanical threshing and Cleaning in Fine cleaner andgrading in Spiral separator (using normal elevators) (P5)	85.38	7033.75	79.00
Sieve size	3.75 mm (S1)	86.25	7078.20	78.75
	4.00 mm (S2)	89.20	7377.25	81.45
CD	Variety	1.749	301.496	2.66
	Post-harvest treatments	2.765	NS	NS
	Sieve size	1.749	NS	2.66
	V X P	NS	NS	NS
	V X S	2.473	NS	3.761
	P X S	NS	NS	NS
	V X S X P	NS	NS	NS

Table 3. The effect of post-harvest operations on the mean biochemical parametersof seed after processing in soybean

Factor	Level	Electrical conductivity (µS cm^{-1} g^{-1})	Amino acids in seed leachates (µg/ml)	Total soluble sugars inseed leachates(µg/ml)
Variety	Basara (V1)	194	26.48	68.51
	JS 335 (V2)	176	29.45	88.94
Post-harvest treatments	Manual threshing and Manual cleaning (P1)	216	27.84	57.89
	Mechanical threshing and Manual cleaning (P2)	180	27.07	71.99
	Mechanical threshing and Cleaning in Fine cleaner (P3)	176	28.12	77.07
	Mechanical threshing and Cleaning in Fine cleaner and grading in Spiral separator (using rubberized elevators) (P4)	171	28.05	87.28
	Mechanical threshing and Cleaning in Fine cleaner and grading in Spiral separator (using normal elevators) (P5)	184	28.75	99.39
Sieve size	3.75 mm (S1)	197	27.77	78.85
	4.00 mm (S2)	173	28.17	78.60
CD	Variety	NS	2.271	4.422
	Post-harvest treatments	NS	NS	6.992
	Sieve size	NS	NS	NS
	V X P	NS	NS	9.889
	V X S	NS	NS	NS
	P X S	NS	NS	NS
	V X S X P	NS	NS	NS

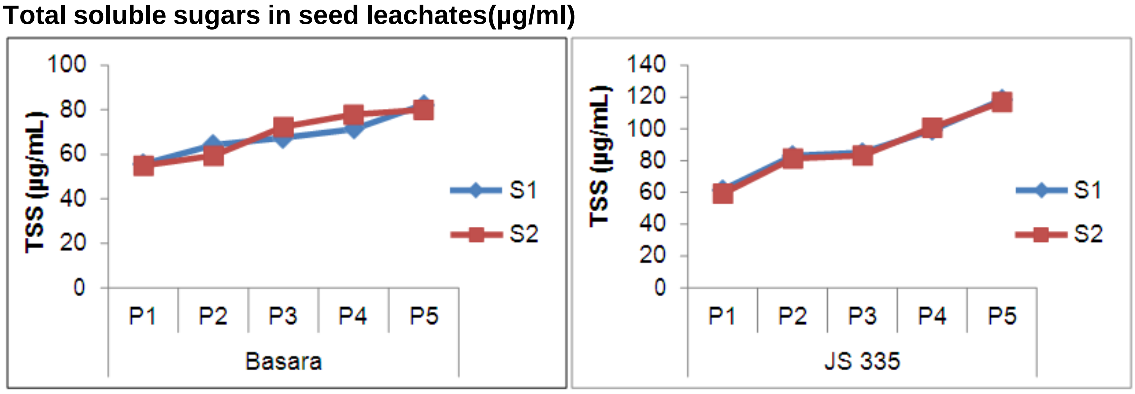

Fig. 3. The effect of various post-harvest operations and sieve sizes ontotal soluble sugars in soybean

Post-harvest practices
P1: Manual threshing and cleaning
P2: Mechanical threshing and Manual Cleaning
P3: Mechanical threshing and Cleaning in fine cleaner
P4: Mechanical threshing + Cleaning in fine cleaner+ grading in spiral separator (using rubberized elevators)
P5: Mechanical threshing + Cleaning in fine cleaner+ grading in spiral separator (usingnormal elevators

Sieve sizes
S1: 3.75 mm
S2: 4.00 mm

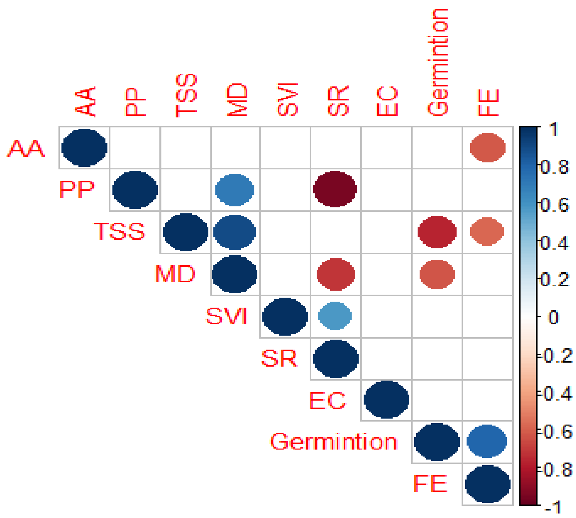

Fig. 4. Correlation of seed quality characters of seed subjected to various post-harvest operations

The studies on the association of seed quality characters revealed a significant positive association of seed germination with field emergence and a negative association with mechanical damage in seeds, while both germination and field emergence showed a negative association with amino acids and total soluble sugars in seed leachates. This reveals a possible influence of mechanical damage on seed deterioration leading to release of amino acids and total soluble sugars in seed leachates. The mechanical damage of seed had a significant positive association with total soluble sugars in seed leachates and a negative association with seed recovery. A similar negative correlation of seed germination with cracked seed coat and broken seeds was observed in peas by Karagi et al. [18]

4. CONCLUSION

The study carried out to determine the best post-harvest operation to minimize mechanical damage has indicated that, at every post-harvest operation of seed i.e., mechanical threshing, fine cleaning, grading etc., the mechanical damage has gradually increased in soybean with maximum damage in seed subjected to fine grading in spiral separator and passed through normal elevators. This damage is reflected by a decrease in seed germination, vigour and increase in electrical conductivity, amino acids and total soluble sugars in seed leachates. However marginal and non-significant variations were observed in the seed quality parameters immediately after processing, but there is a possibility for significant variations in seed quality parameters under storage as mechanical damage leads to decrease in germination, vigour and increase in EC and total soluble sugars in seed leachates which can be further hastened leading to seed deterioration. The climate change has affected the seed quality due to field weathering which has further enhanced mechanical damage during seed threshing and processing. Hence studies to arrest damage at field level and relevant corrective measures at post-harvest to rectify them should be standardized by testing them on large volumes in future.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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