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Studies on impact of threshing methods and processing operations on moisture content, test weight, physical purity, and electrical conductivity of soybean

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Abstract

The present study was conducted to evaluate the impact of different threshing methods and processing operations on seed quality parameters of soybean (*Glycine max* L. Merrill) variety DSb-21. The experiment was carried out during Kharif 2022 using a factorial completely randomized design with three replications. Three threshing methods, namely multi-crop thresher at 300 rpm, multi-crop thresher at 500 rpm, and combine harvester, were combined with three processing operations comprising air screen cleaner, air screen cleaner followed by gravity separator, and air screen cleaner followed by gravity separator and spiral separator. The effects of these treatments were assessed on seed moisture content, 100-seed weight, physical purity, and electrical conductivity. Results revealed that threshing methods and processing operations had no significant influence on seed moisture content and 100-seed weight. However, significant differences were observed for physical purity and electrical conductivity. The highest physical purity (99.33%) was recorded in seeds threshed by combine harvester and processed through air screen cleaner, gravity separator, and spiral separator, whereas the lowest physical purity (96.66%) was observed in seeds threshed by multi-crop thresher at 300 rpm and processed through air screen cleaner alone. Electrical conductivity, an indicator of seed vigour and membrane integrity, was lowest (0.379 dSm⁻¹) in seeds threshed using a multi-crop thresher at 300 rpm and processed through air screen cleaner, gravity separator, and spiral separator, indicating minimal mechanical damage. The highest electrical conductivity (0.569 dSm⁻¹) was observed in seeds threshed by combine harvester and processed through air screen cleaner alone. The study concludes that low-speed threshing combined with advanced processing operations helps maintain superior soybean seed quality by minimizing mechanical injury and improving seed purity.

Keywords: Soybean, threshing methods, seed processing, physical purity

Introduction

Soybean [*Glycine max* (L.) Merrill] is a significant leguminous crop that is a member of the genus *Glycine* and family Leguminosae. According to Caldwell and Howell (1973) [3], soybeans are thought to have originated in Southeast Asia and were widely grown in China as early as 2838 B.C. 1880 A.D. saw its introduction to India. Since 1953, this crop has received a lot of attention because of its high value and greater tolerance to Indian conditions. Soybeans are known to be a great source of high-quality protein and oil among the different types of pulses. It has 19.5% oil and 43.2% protein (Halvankar *et al.*, 1992) [5]. Because of its high protein content, it is known as "poor man's meat." Soybean oil is extracted and consumed. It is grown on 136.03 million hectares worldwide, producing 369.72 million tons with a yield of 2.72 tonnes per hectare (Anon., 2022-23). In India, it is grown on 12.91 million hectares with a production of 12.61 million tons and

a productivity of 976 kg/hectare. It is grown on 0.31 million hectares in Karnataka, yielding 0.37 million tons with a productivity of 1212 kg per hectare (Anon., 2021-22). Soybean production is facing increasing challenges due to seed quality, which is influenced by seed management during harvesting, threshing, processing, and storage. Environmental and physiological variables affect seed quality. Seed damage reduces grain value and increases storage problems, as well as affecting moisture content, test weight, physical purity, electrical conductivity, and crop output. Loss of seed viability during storage, as well as poor stand, are key restrictions in soybean production in tropical and subtropical areas, owing mostly to high temperatures and relative humidity (Wien and Kueneman, 1981) [10]. Threshing is a key post-harvest process. In India, soybean seed is traditionally threshed by pounding the pods with sticks, stomping the pods under bullocks' hooves, and using a stone roller. However, soybean seeds are now widely

threshed using tractor-operated multi-crop threshers and, in certain circumstances, combined harvesters. These methods involve rubbing the seed and threshing; during this process, soybean seed quality is primarily lost due to mechanical damage due to its very thin seed coat and low lignin content, providing little protection to the fragile radicle, which lies in a vulnerable position directly beneath the seed coat (Seema *et al.*, 2020) ^[9].

Seed processing is a significant part of the seed industry. Seed processing is done to improve the seed's planting value. The majority of soybean seeds produced are processed using various machinery such as a cleaner, grader, gravity separator, and so on. Soybean seed with a thin seed coat and embryo put outwards is subject to mechanical damage during grading operations because it is lifted by elevators and dumped into graders from the top at various stages of processing. Hence, it is necessary to identify suitable processing machines among the available ones for processing of seeds without much mechanical damage and quality deterioration.

The purpose of this study is to determine the effects of various threshing methods and processing activities on seed moisture content, 100 seed weight, physical purity and electrical conductivity.

Materials and Methods

During *kharif* 2022 the seeds of soybean variety DSb-21 were sown for the experimental purpose at farmer's field of Koutha (B) village of Aurad taluka of Bidar district, Karnataka. The crop was raised in field in a Factorial Randomized Block Design with three replications to further use the seeds for experimental analysis. Recommended agronomic practices were followed for ensuring normal growth and development of plants.

The pods were threshed to separate the seeds from pods as per the designated treatments viz., T₁, multi-crop thresher with 300 rpm; T₂, multi-crop thresher with 500 rpm and T₃, threshing by combine harvester. After threshing, the seeds from each respective thresher were sun-dried for 2 days on a tarpaulin sheet laid out on a cemented floor.

The same seeds (*i.e.*, threshed as per assigned treatments T₁, T₂ and T₃) after sun drying were carried to the processing unit for further processing operations as per the designated treatments viz., P₁, Air screen cleaner; P₂, Air screen cleaner followed by gravity separator; and P₃, Air screen cleaner followed by gravity separator and spiral separator, with the aim to study the effect of threshing methods and processing operations on seed quality of soybean. This has yielded interactions viz., T₁P₁, T₂P₁, T₃P₁, T₁P₂, T₂P₂, T₃P₂, T₁P₃, T₂P₃ and T₃P₃. The experiment was laid out in factorial completely randomized design in three replications. The seeds after processing were used for recording seed quality parameters viz., seed moisture content, 100 seed weight, physical purity and electrical conductivity.

Results and Discussion

Effect of threshing methods and processing operations on seed quality of soybean

Seed moisture content

There was non-significant difference with respect to seed moisture content due to threshing methods presented in Table 1. The crop threshed by multi-crop thresher with 300

rpm (T₁) recorded numerically highest seed moisture content (10.48%) and the crop threshed by combine harvester (T₃) recorded lowest seed moisture content of 10.25 per cent.

Seed moisture content was found to be non significant with respect to processing operations. Among the different stages of processing, seeds processed using air screen cleaner followed by gravity separator, and spiral separator (P₃) recorded maximum seed moisture content (10.41%) and the seeds processed using air screen cleaner (P₁) recorded lowest seed moisture content of 10.31 per cent.

The interaction effect of the two factors taken for the investigation *i.e.*, threshing methods and processing operations with respect to seed moisture content were found to be non-significant. Among the interaction the crop threshed by multi-crop thresher with 300 rpm and seeds processed by air screen cleaner followed by a gravity separator, and a spiral separator (T₁P₃) recorded maximum seed moisture content (10.53%). However, the crop threshed by combine harvester and seeds processed using air screen cleaner (T₃P₁) recorded lowest seed moisture content (10.16%).

100 seed weight

No significant differences were noticed with respect to 100 seed weight due to threshing methods presented in Table 1. The crop threshed by multi-crop thresher with 300 rpm (T₁) recorded highest 100 seed weight (11.08 g) and the crop threshed by combine harvester (T₃) recorded lowest 100 seed weight (10.84 g).

Hundred seed weight was found to be non significant with respect to processing operations. The seeds processed using air screen cleaner followed by gravity separator, and spiral separator (P₃) recorded highest 100 seed weight (11.02 g), whereas, the seeds processed using air screen cleaner (P₁) recorded lowest 100 seed weight (10.90 g).

The interaction effect of threshing methods and processing operations were found to be non-significant. Among the interaction the crop threshed by multi-crop thresher with 300 rpm and seeds processed using air screen cleaner followed by gravity separator and spiral separator (T₁P₃) recorded maximum 100 seed weight (11.20 g). However, the crop threshed by combine harvester and seeds processed using air screen cleaner (T₃P₁) recorded lowest 100 seed weight (10.80 g).

Physical purity

Statistically significant differences were observed with respect to physical purity due to threshing methods presented in Table 1. The crop threshed by combine harvester (T₃) recorded maximum physical purity (98.55%) and the lowest physical purity (97.88%) was recorded when seeds were threshed by multi-crop thresher with 300 rpm (T₁).

Statistically significant differences were observed with respect to physical purity due to processing operations. Among the different treatments, seeds processed using air screen cleaner followed by gravity separator, and spiral separator (P₃) recorded maximum physical purity (99.00%) and the seeds processed using air screen cleaner (P₁) recorded lowest physical purity (97.00%).

Statistically significant differences were observed with

respect to physical purity due to threshing methods and processing operations. Among the interactions the crop threshed by combine harvester and seeds processed using air screen cleaner followed by gravity separator, and spiral separator (T_3P_3) recorded maximum physical purity (99.33%). However, the crop threshed by multi-crop thresher with 300 rpm and seeds processed using air screen cleaner (T_1P_1) recorded lowest physical purity (96.66%). The variations in physical purity may be attributed to the removal of shrivelled seeds, immature seeds, broken seeds and other inert matters like soil, sand, crop thrashes and other particles, during processing. This removal process might not have been possible during threshing. As good seeds obtained in seed grader are processed here, the seed which are heavy has higher physical purity whereas, more impurities i.e., less physical purity observed in rejected, medium and light seed lots. Similar observations of improved physical purity have been reported by Ganiger *et al.* (2016) [4] in green gram.

Electrical conductivity

Statistically significant differences were observed with respect to electrical conductivity due to threshing methods as presented in Table 1. Among the treatments crop threshed by multi-crop thresher with 300 rpm (T_1) recorded lowest electrical conductivity (0.396 dSm^{-1}), followed by T_2 (0.499 dSm^{-1}) whereas, the crop threshed by combine harvester (T_3) recorded maximum electrical conductivity (0.539 dSm^{-1}).

The crop threshed by combine harvester recorded significantly highest electrical conductivity values as compared to crop threshed by multi crop thresher at 300 and 500 rpm. The higher electrical conductivity in crop threshed

by combine harvester could be ascribed to rapid loss in viability, due to more mechanical damage to seeds. This threshing damage was due to high speed of threshing drum leading to seed coat injury which facilitates more leaching and ultimately resulted into higher electrical conductivity. The above results are in conformity with Murata *et al.* (1991) [8] in soybean.

Statistically significant differences were observed with respect to electrical conductivity due to processing operations. The seeds processed using air screen cleaner followed by gravity separator, and spiral separator (P_3) recorded lowest electrical conductivity (0.459 dSm^{-1}). Whereas, the seeds processed using air screen cleaner (P_1) recorded maximum electrical conductivity (0.496 dSm^{-1}). This was supported by various findings by Hesse and Peske (1981) [6] and Moreano *et al.* (2018) [7] in soybean.

Interaction effect of threshing methods and processing operations with respect to electrical conductivity differed significantly. Among the interaction the crop threshed by multi-crop thresher with 300 rpm and seeds processed using air screen cleaner followed by a gravity separator, and a spiral separator (T_1P_3) recorded lowest electrical conductivity (0.379 dSm^{-1}). However, the crop threshed by combine harvester and seeds processed using air screen cleaner (T_3P_1) recorded maximum electrical conductivity (0.569 dSm^{-1}).

The use of combine harvester has recorded highest electrical conductivity due more amount of mechanical damage to seeds. In addition, it might be due to increased membrane permeability and the cause of membrane degradation likely due to lipid peroxidation which is detrimental at the intracellular level and also due to the mechanical damage.

Table 1: Effect of threshing methods and processing operations on seed moisture content, 100 seed weight, physical purity and Electrical conductivity in soybean variety DSB-21

Treatment	Seed moisture content (%)				100 seed weight (g)				Physical purity (%)				Electrical conductivity (dSm^{-1})			
	P ₁	P ₂	P ₃	Mean	P ₁	P ₂	P ₃	Mean	P ₁	P ₂	P ₃	Mean	P ₁	P ₂	P ₃	Mean
T ₁	10.44 (18.85)	10.47 (18.88)	10.53 (18.94)	10.48 (18.89)*	11.00	11.04	11.20	11.08	96.66 (79.47)	98.33 (92.57)	98.66 (83.35)	97.88 (81.63)*	0.409	0.399	0.379	0.396
T ₂	10.33 (18.75)	10.36 (18.78)	10.38 (18.79)	10.36 (18.78)	10.90	10.92	10.98	10.93	96.66 (79.47)	98.00 (81.87)	99.00 (84.26)	97.89 (81.65)	0.509	0.499	0.489	0.499
T ₃	10.16 (18.59)	10.25 (18.67)	10.33 (18.75)	10.25 (18.67)	10.80	10.82	10.89	10.84	97.67 (81.22)	98.66 (83.35)	99.33 (83.35)	98.55 (83.08)	0.569	0.539	0.509	0.539
Mean	10.31 (18.73)	10.36 (18.78)	10.41 (18.82)		10.90	10.93	11.02		97.00 (80.03)	98.33 (82.57)	99.00 (84.26)		0.496	0.479	0.459	
	S. Em±		C.D. @ 1%		S. Em±		C.D. @ 1%		S. Em±		C.D. @ 1%		S. Em±		C.D. @ 1%	
T	0.13		NS		0.13		NS		0.03		0.12		0.002		0.008	
P	0.13		NS		0.13		NS		0.03		0.12		0.002		0.008	
T×P	0.22		NS		0.23		NS		0.05		0.21		0.004		0.015	

*Figures in the parenthesis indicate the angular transferred values

Legend

T₁: Multi-crop thresher with 300 rpm

P₁: Air screen cleaner

T₂: Multi-crop thresher with 500 rpm

P₂: Air screen cleaner followed by gravity separator,

T₃: Threshing by combine harvester

P₃: Air screen cleaner followed by gravity separator and spiral separator

NS: Non Significant

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