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Postharvest deterioration dynamics in soybean seed quality

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Abstract

Seed quality in soybean is strongly influenced by the methods of harvesting, processing, and handling. In this context, the present study was conducted at AICRP on Seed (Crops), Dr. PDKV, Akola during 2019-20-2023-24 to assess stage-wise postharvest losses in seed germination and other quality parameters.

Five seed lots with moisture contents ranging from 12-15% and 15-17% were used for experimentation. The selected seed lots were threshed using a multicrop thresher under both the farmers' practice (500-800 rpm) and the recommended practice. All seeds were subsequently processed in a modern seed processing plant. Observations were recorded from harvesting through storage, and seed samples were collected after each operation. The samples were evaluated for key seed quality parameters.

The results of the investigation indicated that threshing at higher drum speeds (farmers' practice) resulted in an 8-12% reduction in seed germination, whereas threshing at the recommended speed of 350-450 rpm minimized the losses to 3-7%. Seed lots with higher moisture content (15-17%) recorded 3.5% greater losses in germination compared to seed lots with lower moisture content (12-15%) under both threshing speeds. Germination assessed prior to processing further revealed additional declines due to transportation and handling. Seed lots with 12-15% moisture exhibited an additional 4.4% reduction in germination, while those with 15-17% moisture showed a 6.5% reduction.

Keywords: Soybean, threshing, cleaning, grading, seed germination, moisture content

Introduction

Post-harvest losses in seeds represent a critical constraint in maintaining seed quality, viability, and overall agricultural productivity. Seeds, being living entities, undergo continuous physiological and biochemical changes from the time of harvest until sowing. These changes are highly influenced by handling practices, drying methods, processing operations, storage conditions, and packaging materials.

Soybean seed is most delicate and possesses a fragile seed coat. Due to slight impact it loses its quality. Post-harvest operations found to be most critical operations causing maximum damage to seed resulting into loss of seed quality. The quality control in all processes of pre harvest at farm to processing and final stage of seed storage plays an important role in assuring the production of high quality seed. The seed injuries are caused from the weathering, fungi, insects, artificial drying and mechanical damage during harvest, handling, threshing and storage (Henning *et al.*, 2006) [2].

Mundhe (2005) [5] notified the effect of moisture content (MC) and mechanical processing on seed quality (mechanical damage, germination percent, vigour index, seed coat cracking, recovery and physical purity) of processed soybean (cv. JS-335) seeds and noticed that, seed moisture content (initially 14.0%) was reduced to 11.7, 9.7 and 8.2% by drying. With increase in moisture content, mechanical damage decreased at all the stages.

The soybean seed is highly susceptible to mechanical injury and damage occurring during post-harvest handling. Seeds may receive internal fractures from impactation. These injuries were produced due to mechanical shock to the seeds and were greater with reduced seed moisture (Shelar, 2008) [10].

Previous studies have highlighted the influence of threshing methods on seed quality. Lower mechanical damage (15.92%) and seed infection (28.37%) were observed in soybean seeds

processed by hand shelling compared to those threshed by beating with sticks on a cement floor (33.93% and 28.80%, respectively) (Pavankumar, 2000) ^[7]. Similarly, Prakobban (1982) ^[8] reported higher germination and a lower percentage of abnormal seedlings in hand-threshed seeds compared to beaten and machine-threshed seeds.

Seed quality is also significantly affected during processing, where seeds are conveyed at high speeds and subjected to repeated impacts against metal surfaces, bends, and other seeds. These conditions often result in increased breakage and mechanical damage compared to manual handling. In most handling operations, seeds are accelerated and discharged onto stationary surfaces or other seeds, further increasing the risk of injury (Paulsen *et al.*, 1981).

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) ^[11].

Quantifying losses at each stage of post-harvest operations provides a scientific basis for improving technologies and minimizing quality deterioration. Therefore, a systematic study of stage-wise post-harvest losses in seed germination and associated quality parameters, along with the optimization of post-harvest practices, is essential for developing efficient seed management strategies. Such efforts will contribute to improved seed performance, better crop establishment, and enhanced agricultural productivity. Accordingly, the present investigation was carried out at AICRP on Seed (Crops), Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during 2019-20-2023-24 to assess stage-wise post-harvest losses in seed germination and associated quality parameters.

Methodology

The present investigation was conducted under the All India Coordinated Research Project (AICRP) on Seed (Crops) at Dr. Panjabrao Deshmukh Krishi Vidyapeeth (Dr. PDKV), Akola, during 2019-20-2023-24 to assess stage-wise post-harvest losses in seed germination and quality parameters in soybean. The experiment was carried out using soybean variety JS 335. A minimum of three independent seed lots were included to ensure reliability of results. The harvested seeds were categorized into two groups based on their moisture content at the time of threshing, i.e., Category I (12-15%) and Category II (15-17%), with moisture content determined using a standard moisture meter. Two threshing methods were evaluated, namely farmer's practice of threshing using a multicrop thresher operated at 500 - 800 rpm drum speed under field conditions and threshing using a multi-crop thresher at a controlled drum speed of 350-450 rpm under recommended conditions.

Seed samples were collected at different post-harvest stages, including immediately after harvesting, immediately after threshing, just prior to processing operations, and during various stages of processing such as after cleaning, after size grading, and after gravity grading. Further, the processed seeds were stored under ambient godown conditions, and samples were drawn at 30-day intervals upto end of March. At each stage, seed quality parameters were evaluated following standard ISTA procedures, including germination percentage, seedling vigour index, seedling length, seedling dry weight, test weight, physical purity, moisture content, and electrical conductivity to assess

membrane integrity. The data generated were used to quantify stage-wise losses in germination and other quality parameters by calculating the percentage reduction between successive stages. Statistical analysis of the data was performed using appropriate experimental designs, and treatment means were compared through analysis of variance to identify significant differences. The stage exhibiting maximum deterioration in seed quality was considered as the critical control point for optimizing post-harvest operations.

Results

The data presented in Table 1 clearly indicate that post-harvest operations significantly influenced seed quality parameters of soybean seed (JS-335) in seed lot No. 511. The control sample recorded the highest germination (91.3%), vigour index I (3106), vigour index II (39.3), and 1000-seed weight (117.6 g) with no mechanical damage, representing the initial quality before any post-harvest handling.

A marked deterioration in seed quality was observed immediately after threshing, particularly under the farmer's practice (500-800 rpm). This treatment recorded the highest mechanical damage (9.0%), which resulted in a substantial reduction in germination (81.7%) and vigour indices (2587 and 34.0). The higher drum speed likely caused severe impact and abrasion damage to seeds, leading to loss of viability and seedling vigour. In contrast, threshing at a controlled speed (350-450 rpm) significantly reduced mechanical damage (3.7%) and maintained higher germination (87.7%) and vigour, indicating that optimization of threshing speed is critical to minimize seed deterioration. These findings are in agreement with earlier and recent studies by Paulsen *et al.* (1981), Shelar (2008) ^[10], Khodabakhshian *et al.* (2019) ^[3], Kumar *et al.* (2021) ^[4], and Patil *et al.* (2022) ^[6], who reported that higher threshing speeds and mechanical impacts significantly increase seed damage, resulting in reduced germination and vigour in soybean. Further handling prior to processing showed a slight increase in damaged seeds (4.0%) and a decline in germination (84.7%) and vigour, suggesting that handling and transportation also contribute to quality loss. However, subsequent processing operations, particularly cleaning and grading, effectively reduced the proportion of damaged seeds to 0.7%, and completely eliminated visibly damaged seeds after gravity separation. Despite this improvement in physical quality, a gradual decline in germination (84.3% to 83.7%) and vigour indices was observed, possibly due to cumulative mechanical stress and removal of heavier, more vigorous seeds during grading.

During storage under ambient conditions, a progressive decline in all quality parameters was evident. Germination decreased from 83.7% after gravity grading to 83.0% in February and further to 82.0% in March. Similarly, vigour index I decreased from 2454 to 2132 and vigour index II from 32.6 to 30.6. The reduction in seed quality during storage can be attributed to natural aging processes, including membrane degradation and biochemical changes. Test weight also showed a consistent decline from 117.6 g (control) to 107.1 g (March storage), indicating loss of seed reserves over time.

The data in Table 2 reveal a clear and progressive impact of post-harvest operations on seed quality of soybean (JS-335) under higher initial moisture conditions (15-17%). The control recorded relatively high germination (89.3%), vigour index I (2831), vigour index II (36.9), and test weight (130.3 g), indicating good initial seed quality at higher moisture content.

A sharp decline in seed quality was observed immediately after

threshing, particularly under the farmer's practice (500-800 rpm). This treatment resulted in the highest mechanical damage (8.0%), which corresponded with a substantial reduction in germination (77.7%) and vigour indices (2283 and 30.3). The adverse effect is more pronounced compared to lower moisture conditions (Table 1), suggesting that seeds at higher moisture are more susceptible to mechanical injury during high-speed threshing. Threshing at controlled speed (350-450 rpm) reduced damage (6.7%) and maintained comparatively higher germination (82.7%) and vigour, though still lower than the control, confirming that even optimized threshing cannot fully prevent losses at elevated moisture levels.

At the stage prior to processing, seed quality deteriorated further, with damaged seeds increasing to 7.3% and germination dropping to 75.3%. This indicates that handling, transport, and delays before processing contribute significantly to quality loss, especially when seeds have higher moisture content. Processing operations such as cleaning and grading drastically reduced visible mechanical damage (down to 0.3%), demonstrating their

effectiveness in improving physical purity. However, germination (74.3%) and vigour indices continued to decline, indicating that physiological damage caused earlier could not be reversed through processing. After gravity separation, although damaged seeds remained minimal (0.3%), germination (74.0%) and vigour indices (1845 and 25.9) further decreased. This suggests that removal of lighter seeds improves uniformity but may also reduce overall vigour if already deteriorated seeds dominate the lot.

During ambient storage, a steady decline in all seed quality parameters was observed. Germination decreased from 74.0% after gravity grading to 73.7% in February and 72.3% in March, while vigour index I declined from 1845 to 1635 and vigour index II from 25.9 to 24.1. This deterioration is attributed to accelerated aging processes, which are more severe in seeds initially harvested at higher moisture content. Moisture content decreased gradually from 16.8% to 11.1% across stages, which is favourable for storage.

Table 1: Effect of post-harvest operations on seed quality of soybean seed. Seed Lot. No.511. Shri. Mohan Namdev Deshmukh, Titawa, and Akola (JS-335, MC: 12-15%)

S. No	Treatment	Moisture content, %	Percent of damaged seed, %	1000 seed weight, g	Germination, %	Vigour index I	Vigour index II
1	*Control	14.33	0.0	117.6	91.3	3106	39.3
2	Farmers practice of threshing (500 to 800 rpm)	13.20 (21.3)	9.0 (17.4)	113.8	81.7 (64.6)	2587	34.0
3	After threshing (350 to 450 rpm)	13.17 (21.2)	3.7 (11.0)	114.4	87.7 (69.6)	2805	36.5
4	Prior to processing (at seed processing plant)	12.53 (20.7)	4.0 (11.4)	111.8	84.7 (66.9)	2624	33.6
5	After cleaning cum grading	12.27 (20.4)	0.7 (3.82)	110.7	84.3 (66.6)	2556	33.2
6	After gravity	12.13 (20.3)	0.0	109.8	83.7 (66.1)	2454	32.6
7	Feb Storage	11.93 (20.2)	0.0	108.7	83.0 (65.6)	2241	31.8
8	March Storage	11.73 (20.0)	0.0	107.1	82.0 (64.8)	2132	30.6
	SEm ±	0.066	1.01	0.44	0.61	58.1	0.50
	C. V.	0.55	15.9	0.69	1.60	4.04	2.62
	C.D at 5%	0.20	3.56	1.38	1.91	181.0	1.56

Table 2: Effect of post-harvest operations on seed quality of soybean seed. Seed Lot. No.853. Haribhau Dnyandeve Tekade (JS-335, MC: 15-17%)

S. No	Treatment	Moisture content, %	Percent of damaged seed, %	1000 seed weight, g	Germination, %	Vigour index I	Vigour index II
1	*Control	16.8	0.0	130.3	89.3	2831	36.9
2	Farmers practice of threshing (500 to 800 rpm)	15.7 (23.3)	8.0 (16.4)	117.8	77.7 (61.7)	2283	30.3
3	After threshing (350 to 450 rpm)	15.8 (23.4)	6.7 (14.8)	118.1	82.7 (65.4)	2499	32.3
4	Prior to processing (at seed processing plant)	12.6 (20.8)	7.3 (15.6)	116.3	75.3 (60.2)	2085	28.6
5	After cleaning cum grading	12.0 (20.2)	0.3 (1.91)	114.4	74.3 (59.5)	1928	27.3
6	After gravity	11.7 (19.9)	0.3 (1.91)	113.2	74.0 (59.3)	1845	25.9
7	Feb Storage	11.3 (19.6)	0.0	112.1	73.7 (59.1)	1717	24.6
8	March Storage	11.1 (19.4)	0.0	111.2	72.3 (58.2)	1635	24.1
	SEm ±	0.15	1.34	0.42	0.65	25.7	0.65
	Variance	1.29	22.8	0.63	1.88	2.23	4.13
	C.D at 5%	0.48	4.43	1.31	2.05	80.2	2.05

() Figures in parenthesis are arcsin values.

*Not consider for statistical analysis

Conclusion

Post-harvest operations significantly affect the seed quality of soybean (JS-335), with threshing identified as the most critical stage causing mechanical damage and loss of viability. High drum speed (500-800 rpm) resulted in maximum seed injury and reduced germination and vigour, whereas controlled threshing (350-450 rpm) minimized damage and preserved seed quality. Although processing operations improved physical purity by removing damaged seeds, they could not restore physiological deterioration incurred during earlier stages. Seed quality decline was further aggravated during storage due to natural aging, particularly in seeds harvested at higher moisture content (15-

17%). Overall, maintaining optimum moisture at harvest, reducing mechanical stress, and ensuring timely processing are essential to minimize post-harvest losses and sustain seed quality. These findings provide a scientific basis for improving post-harvest management practices to reduce quality losses and enhance seed performance.

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