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Effect of Cultivars and Processing Stages on Soybean Seed Quality

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Authors' contributions

This work was carried out in collaboration between all authors. Authors BM and HS analyzed data and wrote the manuscript. Authors SS and HG managed field and laboratory evaluations. The outcomes of calculated data were commented under consideration of authors FP and BM. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Aims: The objective of this research was to assess the effect of cultivars and processing stages on soybean seed quality as well as determining the step that exacerbates mechanical damage to seeds.
Study Design: Losing soybean seed quality under effect of processing stages accomplished through an experiment in factorial arrangement (6×3) with 18 treatments based on completely randomized design with three replications.
Place and Duration of Study: This study carried out in Agriculture and Natural Resources Research Institute of Sari- Iran (2011-12).
Methodology: The experiment proceeded with two separate factors, the first factor consisted of six different seed Processing stages: before cleaning, after elevator, after pre-cleaning, after cleaning, after drying and after packaging, and the second factor involved three cultivars of soybean, Telar, Sari and Line 033.
Result: Cultivar effect on germination percentage, cracked seed coat percentage, mean germination time, germination after accelerated aging test, electrical conductivity test and seedling vigor index was significant. However these parameters were significantly affected by different processing stages.

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Conclusion: The lowest value of germination percentage, the highest value of broken seed percentage and the greatest value of cracked seed coat percentage caused after elevator stage while the rest of processing stages led to maximum quality of seed.

Keywords: Cultivar; electrical conductivity; elevator; processing; seedling vigor index.

1. INTRODUCTION

Soybean seed (*Glycine max* L.) is very susceptible to mechanical damage that occurs during processing and packaging at the time of post-harvest, thus the velocity and type of mechanical damage both affect viability and seed vigor during storage [1]. The Presence of lignin in seed coat invigorates seed tolerance to mechanical damage and preserves cell walls against microorganisms' destruction [2]. Soybean seed coat is very thin and weak in lignin content so that makes less protection of fragile radical which has located in vulnerable position right below the seed coat. Due to this fact, mechanical damage has the most important factor that reduces soybean seed quality at harvesting and processing time [3]. Lignin is an amorphous polymer related to cellulose that provides rigidity and together with cellulose forms the woody cell walls of plants and the cementing material between them [4]. Primarily peroxidase as an enzyme in lignin construction contribute to metabolize of Isodi-Tyr bridges which set up the cross-linking of protein inside the cell walls on the one hand, and the cross-linking of pectin by frolic bridges on the other hand, further it catalyzes Cinnamyl alcohol oxidation prior to polymerization during lignin and Suberin formation [5]. Soybean seed processing involves harvest stage and seeded products as well as sorting, gravity separator, disinfectant, bagging and storing steps through which mechanical damage to seeds amplifies by threshing system during these different steps [6]. Cracking of seeds and splitting of cotyledons are the most important mechanical damages to seeds coat that has been reported on maize and soybean with this explanation that seed humidity highlighted mechanical damage percentage [5]. The mechanical and physiological damages have sophisticated interactions on seeds and grains as they achieved with other effective agents such as seed variety, seed size besides the number of loading time, so that each one of these agents deteriorates final seed quality by disturbing seed humidity content at harvest and process time [7]. Consequently this issue underlines designation an advanced automatic system for driving seed process. In fact projecting an advanced machine minimizes costs, amends the quality of products and removes previous imperfections. Further, automatic control needs to have more powerful simulated model to be able of accommodating the effects of some independent variables with the capability of turning into some other dependent variables [8,9,10]. The outcomes of an experiment by working on soybean seeds in different levels of moisture disclosed that incoming strokes on seeds by metal surfaces caused the lowest value of germination percentage by 41% as well as cracked seed coat percentage and broken seed percentage by 54%, while the lowest value of germination percentage by 87% apart from cracked seed coat percentage concluded by seeds under impacts velocity by Polyurethane surfaces [11]. Also it was recognized that the percentage of injured seeds increased by rising of impacts velocity from 10 to 40m/s. on the one hand the number of injured seeds reduced by raising up the seeds moisture from 7.2% to 16.2% under effect of metal surfaces, on the other hand the usage of polyurethane surfaces enhanced the percentage of injured seeds. The breakage of legumes' seeds makes a substantial predicament as they dried through warm air [8]. This research performed with the purpose of investigating the effect of cultivars and various processing stages on soybean seeds and determining the step through which the most mechanical damage appeared on seeds as well as regarding progressive procedures to avoid of likely deficiencies by processing machine.

2. MATERIALS AND METHODS

Assessment of mechanical damage to soybean seeds quality under effect of cultivar during processing time aimed through an experiment in factorial arrangement (6 × 3) with 18 treatments based on completely randomized design with three replications. The first factor involved different processing stages consisted of six steps: Before cleaning, after elevator, after pre-cleaning, after cleaning, after drying and after packaging and the second factor involved three soybean cultivars: Telar, Sari and Line 033. The experiment carried out in Agriculture and Natural Resources Research Institute, located in Mazandaran Province (Sari) - Iran, during (2011 and 2012) seasons. As soybean seeds reached approximately of 14% moisture content the seeds harvested and cleaned by Air screen separator (Fig. 1), [12]. After sampling of each mentioned step the samples immediately were taken to the seed laboratory and after determining humidity percentage using standard method by means of oven at the temperature of 103±2 around 17±1 hour, a number of 100 hale seeds cultured on the top of paper (TP) at 20-30°C.

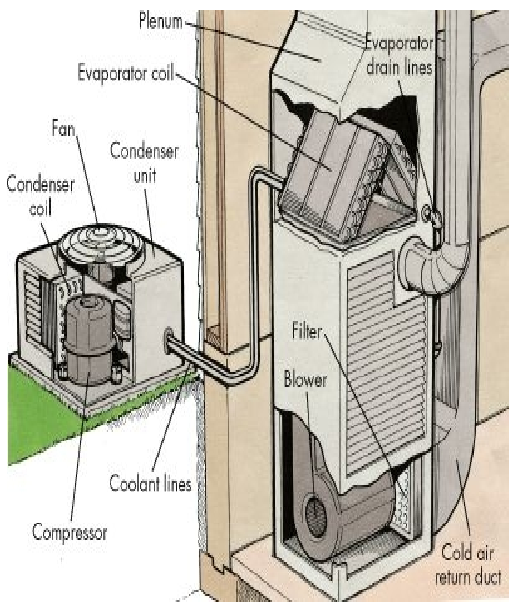

Fig. 1. Schematic diagram of Air screen separator

After 8 days the number of germinated seeds recorded as final germination [13]. Due to manage electrical conductivity test (EC), a-four-sample of 50 seeds were drawn at random from the pure seed fraction of each sample then put into 250ml glass bottles containing 50ml de-ionized water. Each bottle was gently swirled to ensure complete immersion of all seeds and was covered with aluminum foil and then kept at 20°C for 24h. At the end of 24h soaking period, the bottles were swirled, the aluminum foil removed and the conductivity was determined by immersing a dip-type EC meter cell (model – HI 8820 N) into the seed water solution with due care to avoid direct placement of cell on the seed. After testing, the dip-cell was rinsed twice using de-ionized water prior to test the next sample. The EC per gram of seed weight for each sub-sample was calculated by formula (1) [14].

$$(1) \quad EC\ (mscm^{-1}g^{-1}) = \frac{\text{Conductivity rate for each flask}}{\text{Weight of seed sample (g)}}$$

To achieve accelerated aging test (AAT), 42g of soybean seeds placed in the chamber of AAT device under temperature of 41°C for 72h, then after lasting 1h seeds cultured for determining germination standard test, also seedling vigor index (SVI) was measured by formula (2), [15].

(2) SVI= Seedling Dry Weight × Seed Viability.

In order to specify the mechanical damage to seed coat, a number of 100 seeds were soaked in solution of $Nacl_2H_2o$ (1%) around 10min. After creating damage to seed coat, they swelled. The amount of created mechanical damage was calculated in percentage, also due to compute of cracked seed coat percentage (CSCP) after each stage, about 200g seed of each sample sifted manually with a size of 4mm sieve. The seeds that passed through the sieve weighed as broken seeds and computed in percentage [16]. Analysis of statistical data done using SAS (V., 9) and MSTAT-C (V., 2.1) software programs and significant difference of means compared using Duncan's Multiple Range Test.

3. RESULTS AND DISCUSSION

The results revealed that cultivar and different stages of processing had significant effect on germination percentage (GP), (Table 1). Regarding the effect of different processing stages on GP, the highest value of GP (83.5%) allocated to cultivar 033 rather than cultivars Telar and Sari (81.21%, 81.08%), (Table 2). In addition, the influence of different processing stages on GP specified that the lowest value of GP (77.52%) appeared after elevator which revealed approximately a reduction by (4.32%) compare to step before cleaning (81.84%), but the others of processing stages amended seed quality and GP, (Table 2). It presumed that the reason of this issue either might be due to imperceptible mechanical damage to seeds or associated with the effect of strokes on seeds by elevator that resulted in minority of seed viability. The effect of cultivar on broken seed percentage (BSP) was not significant although BSP was significantly affected by the type of processing stage (Table 1). Also the greatest value of BSP (16.72%) was observed after elevator step which showed an increase by (6.9%) in comparison with the step of before cleaning (9.85%).

In the next processing stages, BSP decreased and resulted in better quality of seeds, (Table 2). Perhaps as seeds lifted up to the height of 4.5m from the ground level and then entered into the processing machine under gravity force, seed coat weakened because of striking which came on seeds by elevator device, and when seeds transferred into the processing machine under gravity force at the height of 4m for the second time, again because of impacts velocity which appeared on seeds, seeds hull split and resulted in seeds breakage.

Table 1. Analysis of Variance (Mean Squares) of investigated traits

		Mean Squares (MS)						
S.O.V	**df**	**NSP (%)**	**BSP(%)**	**CSCP (%)**	**MGT (%)**	**NSP after AAT (%)**	**EC ($mscm^{-1}g^{-1}$)**	**SVI**
Cultivar	2	33.28**	0.017ns	21.407**	0.047ns	25.80*	26.09*	11.01**
Processing steps	5	86.11**	14.22**	44.41**	6.43**	75.18**	628.29**	77.91**
Cultivar× Processing steps	10	1.08ns	0.036ns	2.16ns	0.662ns	0.08ns	50.09ns	0.983ns
Error	36	2.001	0.070	1.37	0.087	7.48	7.97	1.16
C.V		1.72	10.71	11.03	8.81	3.9	6.54	9.07

*ns = Non significant, * and ** Significant at P = 0.05 and P < 0.01 levels. NSP= normal seedling percentage. BSP= broken seed percentage. CSCP= cracked seed coat percentage. MGT= mean germination time. NSP after AAT= normal seedling percentage after accelerating aging test. EC= electrical conductivity. SVI= seedling vigor index*

Table 2. Means comparison of cultivars and processing stages interactions on investigated traits

S.O.V	**NSP (%)**	**BSP (%)**	**CSCP (%)**	**MGT (%)**	**NSP after AAT (%)**	**EC ($mscm^{-1}g^{-1}$)**	**SVI**
Cultivar							
033	83.5a	6.0017a	8.5b	3.39a	71.6a	41.73b	12.76a
Sari	81.08b	5.866a	10.35a	3.36a	69.18b	43.87a	11.58b
Telar	81.21b	6.157b	10.38a	3.29a	69.31b	43.76a	11.27b
Processing steps							
Before cleaning	83.1b	9.85b	7.77c	3.27b	69.94b	43.43b	12.11b
After elevator	78.36c	16.72a	13.55a	4.51a	65.62c	48.53a	7.83c
After pre-cleaning	79.73c	5.12c	10.55b	4.26a	67.00c	46.57a	8.64c
After cleaning	86.68a	1.11d	7.77c	2.74c	72.52ab	39.60c	14.17a
After drying	86.25a	1.43d	8.55bc	2.55c	72.94a	40.07c	14.38a
After stacking	85.50a	1.75d	10.33b	2.74b	72.15ab	40.51c	14.09a

Means within the same column, followed by the same letters are not significantly different at P=0.05

The value of BSP increased by (0.32%) in the stage of after stacking by (1.75%) relative to stage after drying by (1.43%). As before in this stage the value of broken seeds increased because of striking which appeared on seeds during transferring and stacking, but this enhancement was not significant. In spite of genetic diversity, the percentage of tolerance against mechanical damage was variable among soybean seeds of various cultivars [3].

According to the results, the effect of cultivar on CSCP was significant, (Table 1). Regarding mean comparison, the lowest value of CSCP (8.5%) allocated to cultivar 033, while cultivars Sari and Telar with greater value of CSCP (10.35%, 10.38%) appeared in the same category respectively, (Table 2). Cultivar 033 with the lower value of cracked seeds under effect of incoming strokes not only related to more rigidity of seed coat, but also associated with the greater amount of lignin in seed hull. The susceptibility to mechanical damage depends on the rate of lignin in seeds hull which may causes genetic disorders as well as alternative reactions in various cultivars [3].

The effect of processing stages on CSCP was significant. Moreover in after elevator stage the percentage of cracked seeds (13.55%) compare to before cleaning stage (7.77) represented an increase by (5.78%), (Table 2). Hence seeds under effect of elevator presses during loading time along with the striking which appeared on them over centrifugal force during unloading time led to augmentation of cracked seeds [17]. The percentage of cracked seeds decreased just after pre-cleaning and cleaning stages so that resulted in higher seed quality while drying and stacking stages together caused maximum percentage of cracked seeds which likely occurred due to inconvenient conditions of drying, storing and stacking stages. Our findings are in agreement with the observations of other researchers [18,19].

According to analysis of variance the effect of cultivars and different stages of processing on GP after AAT were significant (P =0.05, P<0.01). The greatest value of GP (72.94%, 71.6%) devoted to the stage after drying by cultivar 033. It represented that GP value raised up to (69.94%) right after last step in comparison with before cleaning stage. Conversely GP reduced after elevator step rather than the first step owing to the successive strokes on seeds under effect of elevator. When seeds remained in long terms of humidity and thermal condition at AAT stage which is known as severe and inconvenient condition, the seeds with healthier hull and without inner injuring had better capability to bear this severe condition and indicated better germination behavior compare to impure and vulnerable seeds. The similar results were found by numerous studies [20].

The effect of cultivar on mean germination time (MGT) was not significant (Table 2). But the effect of processing stages on MGT was significant, (Table 1). The greatest value of MGT (4.51%) concluded in after elevator step relative to before cleaning step by EC test about (3.27%) that increased MGT up to (38%). Significant differences observed among cultivars with EC test, so that the minimum value of EC by (41.73$mscm^{-1}g^{-1}$) allocated to cultivar 033 while cultivars Telar and Sari with the values of (43.76, 43.87$mscm^{-1}g^{-1}$) appeared in the next categories respectively (Table 2). These significant differences arisen from the potential ability of various cultivars apart from injuring neither by seeds hall nor cells membrane during processing. According to International Seed Testing Association (ISTA), if EC value is less than 25 ($mscm^{-1}g^{-1}$) seeds considered with high potential vigor and if this value is 25 to 29 ($mscm^{-1}g^{-1}$), seed vigor is acceptable and proper for cultivation in the early season, but cultivation in adverse condition causes minimum emergence and feeble seedlings establishment. Still If EC value is 30 to 43 ($mscm^{-1}g^{-1}$), seeds have minor vigor and not appropriate for early cultivation in severe condition. Ultimately if EC value is more than 43.0 ($mscm^{-1}g^{-1}$), seed vigor is low and not appropriate for cultivation [21]. Therefore, regarding the results of this research also concerning many other findings, it clarified that cultivar 033 could be able to endure the severe condition much better compare to other cultivars during processing. According to previous study, the quality of small seeds was superior to large seeds in different cultivars. From this respect cultivar 033 with small seeds had higher ability to endure severe condition during processing [22]. Further different stages of processing had significant effect on EC so that the greatest value of EC by (48.53$mscm^{-1}g^{-1}$) allocated to stage after elevator and showed an increase by (11.5%) compare to previous stage of cleaning by (43.43$mscm^{-1}g^{-1}$), (Table 2).This finding is in agreement with the studies by [16,18]. SVI was affected by cultivar and processing stage, (Table 1). The greatest of SVI (12.76), allocated to cultivar 033. The highest and lowest values of SVI appeared on the stages of drying and after elevator respectively. Seed vigor reduction under effect of mechanical damage has been announced by many researches [23,24,25,16,17].

4. CONCLUSION

In consequence, based on the results of this experiment, there found significant differences among soybean cultivars under effect of mechanical damage so that cultivar 033 exhibited the greatest tolerance against compressor. Also among different stages of processing the elevator stage reduced seed quality drastically. Virtually, in this stage as seeds lifted up to the height of 4.5 m from ground level and then entered into the processing machine under gravity force being under impacts velocity by means of elevator device, seeds hull weakened during this process, and when seeds entered into the processing machine under gravity force at the height of 4 m for the second time again because of striking which came on seeds, seeds hull split and caused seeds breakage. Subsequently, it is vital to reform the imperfections in elevator system as well as using advanced equipment which develop the capability of processing machine in order to select the best method for processing soybean seed.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Stephens LE, Foster GH. Reducing damage to corn handled through gravity spouts. Trans. A.S.A.E. 1977;20(2):367 71.
2. Schoorl D, Holt JE. Mechanical Damage in Agricultural Products: A Basis for Management. Agricultural Systems. 1983;11:143-157.
3. França Neto JB, Henning AA. Qualidades fisiológica e sanitária de sementes de soja. (Physiological and pathological qualities of soybean seed). EMBRAPA – National Soybean Research Centre. Circular Técnica 09, 39p. Londrina, Paraná, Brazil; 1984.
4. Campbell MM, Sederoff RR. Variation in lignin content and composition. Plant Physiol. 1996;110:3-13.
5. Quiroga M, Guerrero C, Botella MA, Barceló A, Amaya I, Medina MI, Alonso FJ, Forchetti SM, Tigier H, Valpuesta V. A tomato peroxidase involved in the synthesis of lignin and suberin. Plant Physiol. 2000;122:1119-1127.

6. Krittigamas N, Vearasilp S, Thanapornpoonpong S, Suriyong S, Pa-oblek S, Pawelzik E. Investigation of Post-harvest Soybean Seed Storability after Passing the Different Steps of Processing. Conference on International Agricultural Research for Development. Deutscher Tropentag – Bonn. 2001;9-11.
7. Khazaei j, Shahbazi F, Massah J, Nikravesh M, Kianmehr MH. Evaluation and modeling of physical and physiological damage to Wheat seeds under successive impact loading: mathematical and neural networks modeling. Crop Sci Vol. 2008;48:1532- 1544.
8. Krzyzanowski F, José B, França Neto C, Costa Nilton P, 1989. Technologies that add value to soybean seed seed news,The international seed magazine; 1989. Available: (http://www.seed news.inf.br).
9. Khazaei J. Mechanical strength of chickpea pods and grains under static and dynamic forces. PhD. Diss. Univ. of Tehran; 2003.
10. Baryeh EA. A simple grain impact damage assessment device for developing countries. Journal of Food Engineering. 2002;56:37–42.
11. Evans MD, Holmes RG, McDonald MB. Impact damage to soybean seed as affected by surface hardness and seed orientation. Trans- ASAE. 1990;33:234-240.
12. Available: http:// www. Hvacatx. Com/services/ac-system-diagram.
13. Anonymus. Hand book for seedling evaluation. International Seed Testing Association (ISTA), Jan 1, 2012 - ISTA Ordinary Meeting 2011, held at Zurich, Switzerland. Available: http//www. seedtest.org/upload/cms/user/PubCat_2012-2013_web.pdf.
14. Hossain MM, Khan MAA, Tofail Hosain MD, Fazle Bari ASM, Hasanuzzaman M. Germination and electrical conductivity of two species of Jute seed as affected by different sowing and production methods. International Journal of Agriculture and Crop Sci. Available online at Available: www.ijagcs.com IJACS/2013/6-12/861-865.
15. Abdul – Baki AA, Anderson JD. Vigor determination in soybean by multiple criteria. Crop science. 1973;13:630-633.
16. Henning A, Krzyzanowski F, França Neto C, José B, Costa Nilton P. Technologies That Add Value To Soybean Seed. Seed News, the International Seed Magazine; 2006. Available: (http://www.Seed News.Inf.Br).
17. Shrivastava PK, Ojha TP. Features of material handling in case of soybean. Proceedings of the National Seminar on Soybean Processing and Utilization in India. CIAE. Bhopal, MP, November 22–23; 1986.
18. Vearasilpa S, Somchai P, Nattasak K, Sa-nguansak TH, Sangtiwa S, Elke P. Assessment of Post-Harvest Soybean Seed Quality Loss. Conference on International Agricultural Research for DevelopmentInstitute for Agricultural Chemistry, Georg-August University, Göttingen 37075 Germany; 2001.
19. Sosnowski S, Kuzniar P. Effect of dynamic loading on the quality of soybean. Int. Agrophysics. 1999;13:125-132.
20. Rahman MM, Hampton JG, Hill MJ. Effect of seed moisture content following hand harvest and machine threshing on seed quality of cool tolerant soybean. Seed Science and technology. 2004;32:149-158(10).
21. Dehghanshoar M, Hamidi A, Mobasser S. Handbook of vigour test methods. Agricultural Education Press. (In Persian). 2006;193.
22. Keng Feng Chen SH, Lai STC. Shanmugasundaram S. Vegetable Soybean Seed Production Technology in Taiwan. Asian Vegetable Research and Development Center. P.O. BOX 42, Shanhua, Tainan 74199, Taiwan. 1991;45-52.

23. Sérgio Carbonell AM, Natal Vello A. Genetic Analysis of Soybean Seed Response to Mechanical Damage.Crop Breeding and Applied Biotechnology. 2001;1(1):35-43.
24. Herbek JH, Bitzer MJ. Soybean production in kentucky PART II: Seed Selection, Variety Selection And Fertilization Issued., 1-88, Agr-129 .University Of Kentucky Publications; 2001.
25. Berglund DR, Helms TC. Soybean Production. A-250 (Revised), North Dakota State University; 2003. Available: (http://www.ag.ndsu.nodak.edu).

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