ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

STUDY THE EFFECT OF MECHANICAL DAMAGE AT PROCESSING ON SOYBEAN SEED GERMINATION AND VIGOR

Divsalar Maryam and Bita oskouie
Seed and plant Registration and Certification Institute (SPCRI), Karaj, Iran
E-Mail: divsalarmaryam@yahoo.com

ABSTRACT

Planting high quality seed is important in efficient soybean production system. One factor that reduces seed quality is mechanical damage. Soybean seed is very fragile and susceptible to mechanical damage that occurs at harvest, processing, drying and handling. Care should be taken to prevent seed damage and injuries during processing because mechanical damage reduces seed germination and vigor. So this research was conducted to evaluate the effect of mechanical damage on soybean seeds germination and vigor after processing. This study was completed as factorial on the basis of completely randomized design with three replications. The treatments were cultivar at three levels (Sahar, Williams and D.P.X) and the moisture percentage at three levels (12-14, 14-16 and 16-18 percent) and the measured characters were mechanical damage percentage and germination percentage. Also the electrical conductivity test and accelerated aging test were conducted to evaluate seed vigor. The variance analysis results showed there was a significant difference in mechanical damage and germination percentage between cultivars in a way that the cultivar of Sahar had the maximum mechanical damage and the highest amount of electrical conductivity and minimum germination percentage. Also there was a significant difference between three moisture levels in measured characters. The moisture of 12-14 percent had the lowest amount of mechanical damage and maximum germination percentage and 16-18 percent had the highest mechanical damage and the lowest germination ability.

Keywords: soybean seed, mechanical damage, processing, germination, vigor.

INTRODUCTION

Soybean seed quality and viability during storage depend on the primary quality of seed and conditions of the storage. The soybean seed is very susceptible to mechanical damage that occurs during handling and processing after harvest and the type and extent of mechanical damage affect soybean seed viability and vigor during storage (Sosnowski, Kuzniar, 1999).

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. One of the factors reduce seed quality is mechanical damage. 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).

Khazaei and colleagues (2008), Sosnowski and his colleagues (1992) mentioned the soybean seeds undergo sever pressures especially during threshing which results in broken seeds, seed coat cracks and also invisible internal damage. The structure and extent of damage depend on not only to the threshing machine designing properties and effectiveness but also to the threshing conditions and cultivar properties (Khazaei *et al*., 2008, Sosnowski *et al*., 1992).

Segio Carbonell (2001) reported that the soybean seed is very susceptible to mechanical damage and the vital sections of embryonic axis (radicle and hypocotyls) are placed under very thin seed coat (Segio Carbonell and Natal, 2001).

Kashaninejad and colleagues (2007) at their research on four soybean cultivars founded that the seed moisture content has significant effect on all the seed's physical damages (Kashaninejad *et al*., 2007).

Francisco dubbern (2001) remarked the seeds whit damaged seed coat usually have less vigor and viability (Francisco dubbern and Marcos-Filho, 2001).

Jahufer and Borovoi (1992) reported that in maize after processing there were different rates of mechanical damage to seed coat in 89 percent of seeds. This damage affects seed germination, seedling growth and development and grain yield. Seedling emergence and quality is affected by the place of damage in a way that embryo and central parts of seed are more susceptible (Jahufer and Borovoi, 1992).

Schenidt (2000) stated more fragile seed is more susceptible to damage and the seeds with thin seed coats or large cotyledons will damage easily. Even little damages to seed during processing may rapidly affect seed viability and cause seed vigor decrease and increase of abnormal seedlings.

Verasilpa and his colleagues (2001) also at their studies on two soybean cultivars, Chiang Ma60 and SJ.5, found significant difference in mechanical damage and broken seeds after processing and handling between two cultivars. The cultivar with less mechanical damage showed better results at germination test. Also there was a significant difference between two cultivars in electrical conductivity test and the cultivar with less mechanical damage had much better vigor. They concluded the cultivar which had more mechanical damage had larger seed size and thinner seed coat in comparison with other cultivar (Verasilpa *et al*., 2001).

Cain (1977) reported 11 percent moisture content is the moisture that causes less mechanical damage in

Soybean. Misra (1985) reported soybean seed lots with 12-14 percent moisture content suffer less mechanical damage after processing and retained their germination ability (Misra, 1985).

Van Utrecht and colleagues (2000) also remarked since embryonic axis in soybean is placed at surface the seed is very susceptible to the injuries of impacts and bruising. The moisture content less than 10 percent prone seeds to split however high moistures may result in seed crushing and bruising that decrease seed germination by accelerating deterioration (Van Utrecht *et al*., 2000).

Rahman and colleagues (2004) at their research observed the mechanical damage cause seed vigor reduction. When the soybean harvested with 11-14 percent moisture content had germination above 90 percent and its vigor was 82 percent in accelerated aging test which was the best results compare to the moistures above 14 percent (Rahman *et al*., 2004).

The purpose of this experiment is evaluation of mechanical damage on soybean cultivars seed germination ability and vigor at processing.

MATERIALS AND METHODS

This study was completed in seed quality analysis laboratory of seed and plant registration and certification institute (SPCRI), Karaj-Iran, during 2009 and 2010. The experiment was conducted as factorial on the basis of completely randomized design with three replications. The treatments were variety at 3 levels (Williams, Sahar and D.P.X) and moisture content of seed at three levels (12-14percent, 14-16 and 16-18 percent) and the measured characters were mechanical damage and germination percentage. Also the electrical conductivity test and accelerated aging test were done to assessment seed vigor. The results were analyzed by SAS software and the means were compared by Duncan multiple test.

The moisture measurement: the seed lot moisture was measured by portable electrical moisture meter.

Mechanical damage determination

The hypochlorite sodium test was used to detect cracked and damaged seeds, in a way that three replications of 100 seeds were soaked in 1% hypochlorite sodium 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 (Henning *et al*., 2006, Van Utrecht *et al*., 2000)

The standard germination test

3 replications of 100 seeds were selected from each sample in laboratory, samples were placed between paper as towel method in germinator with 76-86% moisture and 20ºc temperature. After 7 days the number of normal and abnormal seedlings, decayed and un-germinated seeds was counted (ISTA, 2008).

Electrical conductivity test

3 replications of 50 seeds with equal weight from each seed lot were counted and soaked in distilled water and kept at 20ºC for 24 hours, then the electrical conductivity of solute which contained seeds was measured in micro siemens on centimeter on gram and finally this value was calculated for each gram of sample.

Accelerated aging test

3 replications of 100 seeds from each treatment and replication was counted; the seeds were placed on net which installed on the water containing boxes. The containers were kept at 41ºC for 72 hours then the standard germination test was done and the numbers of normal seedlings were counted (ISTA, 2008).

Data were analyzed by SAS software and means were compared by Duncan multiple test in 1% level.

RESULTS

Mechanical damage percentage

Regarding to variance analysis results (Table-1), there was a significant difference at 1% level probability between tested cultivars in mechanical damage percentage. The cultivar of Sahar with the maximum mean (22.77%) showed significant difference with other two cultivars. Williams's cultivar with 19.22 percent mean didn't show a significant difference in mechanical damage with D.P.X cultivar with 18.77 percent mean three moistures showed a significant difference (1% level error of probability). 16-18 percent seed moisture showed the maximum mechanical damage (25.22 percent mean) and the moisture of 12-14 percent with 16% mean had the minimum mechanical damage percentage which had the significant difference with other two levels. The moisture of 14-16 percent with 19% also had significant difference with other two moisture levels (Table-3).

The germination percentage

There was a significant difference between cultivars in seed germination at 1% level of error probability (Table-1). Sahar cultivar with 55.66 percent mean showed a significant difference with D.P.X and Williams and the cultivar of D.P.X with 80 percent mean had a significant difference with Williams (78% mean) (Table-2). Also there was a significant difference between moisture levels at 1% percent level of error probability. The moisture of 12-14 percent with 86.22 percent mean showed the maximum germination percentage which had significant difference with other two levels of moisture. The moisture of 14-16 percent with 75 percent mean had a significant difference with 16-18 percent moisture (73% percent mean) (Table-3).

The electrical conductivity

Regarding to variance analysis the cultivars showed a significant difference in electrical conductivity rate at 1% level of probability. Sahar cultivar with mean of 67.836 us/g had the highest amount of electrical conductivity. The cultivar of Williams with mean of 51.449µs/cm/g and DPX cultivar with the minimum amount of electrical conductivity (43.198µs/cm/g mean)

ARPN Journal of Agricultural and Biological Science

www.arpnjournals.com

had a significant difference. A significant difference also was observed between three moisture levels at 1% level probability. In away that 16-18 % moisture had the highest amount of electrical conductivity (mean of 60.146 µs/cm/g)and 12-14% moisture had the lowest amount of electrical conductivity(47.368 µs/cm/g) and the moisture of 14-16 percent with 54.969 µs/cm/g mean also had a significant difference with other two moisture levels (Table-3).

The accelerated aging test

The variance analysis results showed there was a significant difference between tested cultivars at level of 1% error probability. The maximum amount of germination after accelerated aging test was for cultivar of D.P.X (62 percent mean) and the lowest amount was for Sahar cultivar (mean of 28.556 percent).

The moisture levels also showed a significant difference at 1% level (Table-1). The interaction of cultivar and moisture was also significant at level 1% probability, as in cultivar of Sahar the moisture content of 12-14 percent with 52.66 percent mean of germination had a significant difference with other two moisture levels. The moistures of 14-16 percent and 16-18 percent with germination means of 20.33 percent and 12.66 percent respectively, showed a significant difference. In cultivar of Williams at 12-14 percent moisture (61.66 percent mean) better germination percentage was observed after accelerated aging test in comparison with other moisture levels. The moisture of 14-16 percent with 55.33 percent mean of germination had a significant difference with 16-18 percent moisture (40.66 percent mean).

In cultivar of D.P.X, three levels of moisture also showed a significant difference in germination percentage after accelerated aging test as 12-14 percent moisture with 72.23 percent mean had the highest percentage of germination rather other moisture levels. The moisture of 14-16% also with mean germination of 63.33 percent showed a significant difference with 16-18 percent moisture with 50.33 percent mean of germination (Figure-1).

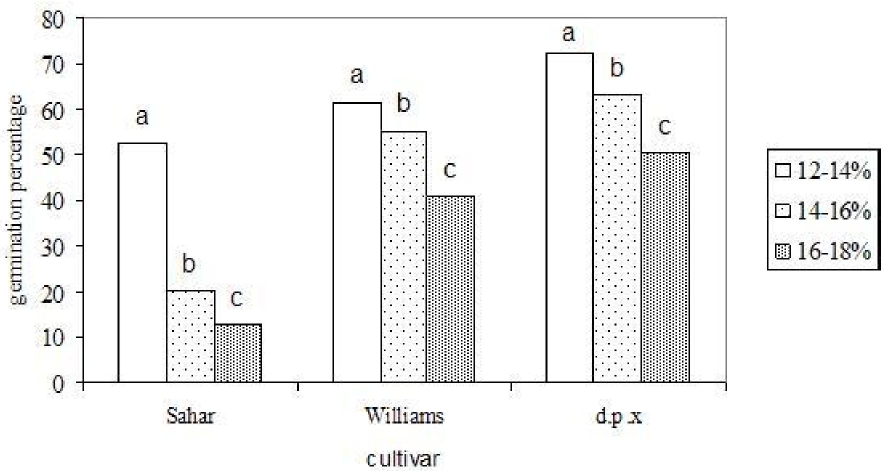

Figure-1. The mean comparison of cultivar and moisture percent interaction on germination percentage in accelerated aging test.

Table-1. The mean squares of some measured characters of soybean cultivars at different moisture after processing.

S.O.V	df	Mechanical damage percentage	Germination percentage	Electrical conductivity (µs/cm/g)	Germination percentage in accelerated aging test
Cultivar	2	43.259**	**43.814	**1415.435	2675.592**
Moisture	2	194.703**	**457.148	**371.769	1734.925**
Cultivar*moisture	4	0.814 ns	0.815 ns	27.515ns	166.148**
Error	18	2.777	2.259	25.372	8.888
Total	26				
Coefficient of variance		8.226	1.925	9.300	6.249

ns = non significant; ** significant at 1% level; * significant at 5%level of error probability

Table-2. Mean comparison of measured characters at three tested cultivars after processing.

Cultivar	Mechanical damage percentage	Germination percentage	Electrical conductivity (μs/cm/g)
Sahar	22.777 a	80.00 a	67.836 a
Williams	19.222 b	78.556 a	51.449 b
D.P.X	18.777 b	75.667 b	43.198 c

The different letters show significance at 5% level of Duncan test

Table-3. Mean comparison of measured characters at three moisture levels after processing.

Moisture percentage	Mechanical damage percentage	Germination percentage	Electrical conductivity
12-14%	16.00 c	86.222 a	47.386 c
14-16%	19.555 b	75.00 b	54.969 b
16-18%	25.222 a	73.00 c	60.146 a

The different letters show significance at 5% level of Duncan test

DISCUSSIONS

The results which implied the significant difference between studied cultivars to mechanical damage show the character of mechanical damage is one of the traits related to cultivar. In fact this character is related to seed coat characteristics that the more integrated seed coat and more lignin content, is more resistant to mechanical damage and if the seed coat be more thin and fragile, the susceptibility to mechanical damage will increase. Also the cultivar with larger seed size has more probability of mechanical damage. The results of many researchers studies particularly Verasilpa and colleagues (2001), Kryzanowski and colleagues (1995) also confirm this subject. On the other hand the extent of mechanical damage directly relate to seed moisture content. In fact there is an optimum level of moisture which causes the minimum mechanical damage. At moistures higher and lower than optimum level the extent of damage as seed crushing and bruising or breakage and cracks will be more. It can be concluded that on optimum moisture the soybean seed physical properties such as seed size, porosity and density are in the best condition for reducing mechanical damage. The results of Kashaninejad and colleagues (2007), Sosnowski and Kuzenyar (19910), Khazaie *et al*., (2009) studies also verify it.

Also the effect of mechanical damage on seed germination and vigor reduction can be attributed to damage to embryo of soybean seed which placed near to seed coat and is very susceptible. Whatever the damage is close to embryonic axis the probability of producing abnormal seedlings will be more but if the damage occurs far from embryonic axis the possibility of producing normal seedlings will be more. The decrease of seed vigor due to mechanical damage is also caused from damage to embryo and vital sections of seed. In electrical conductivity test which evaluate seed vigor and viability, the damaged seed coat allows seed matters to exit and damaged seed has more exudation and higher rate of electrical conductivity. Verasilpa *et al*., (2001) and Rahman (2004) also verify this subject.

At accelerated aging test when seeds undergo high temperatures and moisture, the seeds with intact seed coat and without internal damage tolerate this sever condition better and show better germination result in comparison with damaged seeds. Rahman and colleagues (2004) and Francisco Dubbern (2001) also found similar results.

The intact seeds are able to adjust the rate of water uptake at germination and vigor tests and protect the embryo from eventual damages of fast water uptake, however seeds with damaged seed coat are not able to regulate water uptake rate that result in increasing of spoiled seeds and weak results of germination tests.

Regarding to above subjects and the results of this study it can be concluded there is a considerable difference between soybean cultivars in resistance to mechanical damage which in this study the cultivar of D.P.X had the highest resistance and Sahar cultivar had the lowest resistance, also the seed moisture content is important to determine the extent of mechanical damage and 12-14 percent moisture content of seed is the best moisture content to minimize the mechanical damage.

REFERENCES

Francis Cain, D. 1977. Evaluation of soybean seed damage. M. Sc thesis. The Ohio State University, USA.

Francisco Dübbern, H. De Souza and Marcos-Filho J. 2001. The Seed Coat as a Modulator of Seed-Environment Relationships in Fabaceae. Rev. bras. Bot. São Paulo Dec. 24(4).

Henning A. Krzyzanowski, Francisco C. França Neto, José B. and P. Costa Nilton. 2006. Technologies That Add Value to Soybean Seed. Seed News, The International Seed Magazine. www. seed News. Inf. Br.

International rules for seed testing Anony mous. 2008. International Seed Testing Association (ISTA), Zurrich, Switzerland.

Jahufer M.Z.Z. and Borovoi V.V. 1992. The effect of mechanical damage to maize (*Zea mays* L.) seed germination, seed morphology and subsequent grain yield. Journal of Applied Seed Production. 10: 67-77.

Kashaninejad M., Ahmadi M., Daraei A. and Chabr D. 2008. Handling and frictional characteristics of soybean as a function of moisture content and variety. Powder Technology. 188(1): 1-8.

Khazaei J. 2009. Influence of Impact Velocity and Moisture Content on Mechanical Damages of White Kidney Beans Under Loadings. Cercetări Agronomice în Moldova. 42(1): 137.

Khazaei J., Shahbazi F. and Massah J. 2007. Evaluation and modeling of physical and physiological damage to wheat seeds under successive impact loadings: mathematical and neural networks modeling. J. Crop Sci. 48(4): 1532-1544.

Krzyzanowski F. C., França Neto J.B. and Nilton P. Costa. 2006. Technologies that add value to soybean seed news, the international seed magazine.
www. seed news.inf.br.

Krzyzanowski F. C. 1998. Relationship between seed technology research and federal plant breeding programs. Sci. agric. Vol. 55 special issue Piracicaba. Print version ISSN 0103-9016.l.scientia@esalq.usp.br.

Mesquita C. M., Hanna M. A., Costa N. P. 2007. Crop and harvesting operation characteristics affecting physiological qualities of soybeans. Part II. Applied Engineering in Agriculture. 23(4): 433-438.

Misra M. 1985. Soybean Seed Quality during Conditioning. Am S of Ag Eng. pp. 576-79.

Rahman M.M, Hampton J.G, Hill M.J. 2004. Effect of seed moisture content following hand harvest and machine threshing on seed quality of cool tolerant soybean. Seed Science and technology. 32(10): 149-158.

Schenidt L. 2000. Guide to Handling of Tropical and Subtropical Forest Seed. part 6, Seed Processing. Danida Forest Seed Centre. Denmark.

Sérgio Carbonell A.M. and Natal Vello A. 2001.Genetic Analysis of Soybean Seed Response to Mechanical Damage. Crop Breeding and Applied Biotechnology. 1(1): 35-43.

Shreekant R. Pardea, Rameshwar T. Kausalb, Digvir S. Jayasa, Noel D.G. White. 2002. Mechanical damage to soybean seed during processing. Journal of Stored Products Research. 38: 385-394.

Sosnowski S., Kuzniar P. 1999. Effect of Dynamic Loading on the Quality of Soybean. Department of Agricultural Product. Int. Agrophysics. 13: 125-132.

Van Utrecht D., C. J. Bern, I. H. Rukunudin. 2000. Soybean Mechanical Damage Detection. Applied Engineering in Agriculture. pp. 137-141.

Vearasilpa S., Somchai P., Nattasak K., Sa-nguansak Th., Sangtiwa S., Elke P. 2001. Assessment of Post Harvest Soybean Seed Quality Loss. Conference on International Agricultural Research for Development, Institute for Agricultural Chemistry, Georg-August University, Göttingen, 37075 Germany.