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Physical and physiological quality of soybean seeds harvested under different trial systems after storage periods

[1]Thiago Strobel, [1]Felipe Koch, [1]Geison Rodrigo Aisenberg, [1]Vinícius Jardel Szareski, [1]Ivan Ricardo Carvalho, [1]Maicon Nardino, [2]Velci Queiróz de Souza, [1]Francisco Amaral Villela, [1]Tiago Pedó, [1]Tiago Zanatta Aumonde

[1]*Universidade Federal de Pelotas*
[2]*Universidade Federal do Pampa*

Address For Correspondence:
Thiago Strobel, Universidade Federal de Pelotas

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ABSTRACT

This study aimed at evaluating physical and physiological quality of soybean seeds harvested with different trail systems after harvest and storage. The used cultivar was Syn 1059 RR (V Top), which was sown under no tillage system on 10/25/2014 with sowing density of 240,000 seeds per hectare and spacing of 0.5 m. Treatments were consisted of different trial systems for assessment: a) combine with axial trial system; b) combine with axial trial system equipped with "draper" platform; c) combine with radial trial system; d) control - manual threshing. The percentage of "bandinhas", mechanical damage by hypochlorite tests, germination, accelerated aging and field emergence were analyzed. Seeds harvested with axial and axial trial systems equipped with "draper" platform and manual trial showed no difference for germination, accelerated aging results and field emergence. Physical and physiological quality is superior when it is used harvesters with axial and axial system + "draper" without differing from manually harvested seeds.

INTRODUCTION

In Brazil, in 2013, gross domestic product (GDP) of agribusiness was responsible for the amount of 1.1 trillion Reais, being the productive chain of soybean accounted for 7.8% of the wealth produced by this sector. The grains of this species, together with derived products have high economic (Freitas, 2011) and social (Albrecht *et al*., 2009) importance. Soy is a food that shows almost complete chemical composition, being a supplier of fatty acids, vitamins, and mainly proteins (Ávila *et al*., 2007).

Brazil is in the second place in soy world production, only behind the United States. In the crop year of 2014/15, a total of 32 million hectares of this oil seed were cultivated, being 5.8% higher when compared to the previous harvest. The states of Mato Grosso, Paraná and Rio Grande do Sul have the largest cultivated areas with soybeans in Brazil, where 8.9 million ha^{-1}; 5.2 million ha^{-1} and 5.2 million ha^{-1}, respectively, were in the crop year of 2014/15. For this same crop, soybeans reached an average grain yield of 3 t ha^{-1}, corresponding to an increase of 5.7% compared to the previous harvest.

Soybean productivity can be affected by several factors, among them physiological quality of used seeds for sowing may be detached (Pádua *et al*., 2010; Schuch *et al*., 2009; Melo *et al*., 2006). In this sense, soy plants derived from seeds with high physiological quality have greater stem diameter, plant height and yield 25% higher compared to those seeds with low physiological quality Schuch *et al*., 2009).

Seeds reach the highest quality in physiological maturation stage, where occur an interruption of matrix dry matter transfer to seeds (Terasawa *et al*., 2009). When soybean seeds reach physiological maturity, these show high moisture content (50%), making it impossible to perform mechanical harvest (Pinto *et*

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al., 2007). This process is due to the difficulty of the harvester on collecting plant material and performing the trial (Terasawa *et al*., 2009). The harvest delay results in reduced germination and seed vigor (Gris *et al*., 2010; Pelúzio *et al*., 2008). The early harvest results in obtaining seeds with superior physiological quality, being this fact related with lower exposure of these unfavorable climatic factors, such as pre-harvest rain, as well the pest incidence and high relative humidity (Veiga *et al*., 2007). Thus, soybean harvest must be performed when water content reaches approximately 15% (França Neto *et al*., 2010).

During harvesting process it may have different types of losses which occur in different structures of harvester whether on the cutting platform or on trial systems, separating and cleaning (Moraes *et al*., 2005). At harvest, during the passage of plant material by the trial system, seeds are vulnerable to mechanical damage, which may be immediate or latent (Cunha *et al*., 2009a). As a result of mechanical damage, seeds are shown broken, cracked and scratched, besides having often damaged essential structures (Souza *et al*., 2009). Seeds with immediate damage present as main features the presence of cracks, cracks and/or breakage, making it unable to germinate after the damage. In contrast, despite have no change in germination, seeds with latent damage have reduced vigor and lower storage potential (Peske *et al*., 2012).

In order to minimize the mechanical damage caused to seeds, it is necessary that the trail mechanisms are correctly adjusted, thus enabling the proper trail process (França Neto *et al*., 2010). The two main trail systems present in harvesters are the axial and radial flow. In axial flow combines, the harvested plant material flows parallel to the threshing cylinder axis, which is named rotor (Veiga and Dalzoto, 2011). In the radial trail system, when plant material reaches trail system, it changes its direction and is exposed to the threshing cylinder (Moraes *et al*., 2005).

Harvesters with axial trail system presented as main differential, reduced mechanical damage compared to harvesters with radial trail system (Cunha *et al*., 2009b). By evaluating the physiological quality of soybean seeds harvested with axial and radial systems, at different speeds, it was found that the harvester with radial trail system causes more mechanical damage to seeds (Cunha *et al*., 2009a) and lower physiological quality compared to those harvested with axial trail system (Marcondes *et al*., 2010).

As an alternative to reduce losses on cutting platform, farmers have adopted in many Brazilian regions, the "draper" platform use. The "draper" platforms are characterized by having a rubber belt that performs the function of trail system supply and enables the mechanical damage reduction. However, there is a need for better knowledge of cutting platform systems.

The evaluation of seed mechanical damage on harvest can be performed by laboratory tests that allow the identification and measurement of injuries (Carvalho and Novembre, 2012). The use of tests such as X-ray, sodium hypochlorite and tetrazolium allow the measurement of mechanical damage occurred on harvest (Carvalho and Novembre, 2012). In a seed production program, the evaluation test application of seed physiological quality is employed aiming at the quality control of company. Seed quality is a result of the interaction of genetic, physical, physiological and sanitary attributes (Peske *et al*., 2012).

Germination, dormancy and vigor are physiological attributes of seed quality and are related to the metabolism of these structures (Peske *et al*., 2012). For germination assessment is employed the germination test, which is carried out under controlled conditions and expresses the maximum germination potential of the seeds under such conditions (Peske *et al*., 2012). Seed vigor involves their ability to germinate and rapidly and uniformly emerge under favorable or unfavorable environmental conditions (Dias *et al*., 2010). Various methodologies are used in the evaluation of seed vigor, among them, the first germination counting, germination speed index, seedling emergence in field, controlled deterioration, accelerated aging, electrical conductivity and tetrazolium test (Peske *et al*., 2012).

Given the above, the objective of this study was to evaluate the physical and physiological quality of soybean seeds harvested through different trail systems after harvest and storage.

MATERIAL AND METHODS

The experiment was conducted at Taipa farm, owned by Strobel Brothers S/A in municipality of Condor, in the state of Rio Grande do Sul. The property is situated at latitude 28º 06 '07 "S and longitude 53º 28' 18" W with average altitude of 518 meters above sea level. The climate in the region is subtropical of Cfa type, according to Köppen. The soil belongs to Cruz Alta mapping unit, being characterized as typical Latosol with clayey texture and undulating relief.

The soybean cultivar used was Syngenta 1059 RR (Top V), which was sown under no tillage on 10-25-2014, with sowing density of 240,000 seeds per hectare and spacing of 0.5 m. The weed control was performed from an application of glyphosate herbicide. Pest control was carried out from five applications of specific pesticides for weed pests, being the first application with chlorpyrifos at 1 L ha $^{-1}$ dose in the V2 stage; the second application was in V6 stage using clorantraniliprole at 50 mL h $^{-1}$ dose + teflubenzuron at 100 mL h $^{-1}$ dose; the third application occurred eighteen days after the second dose with triflumuron at 100 mL ha $^{-1}$ dose;

the fourth application was performed with acephate at 1.0 kg ha $^{-1}$ dose and the fifth application was performed using Thiamethoxam + lambda-cyhalothrin mixture at 200 ml h^{-1} dose.

For disease control, four fungicide applications in the interval of 18 days between one and other were performed, being used the prothioconazole products and trifloxystrobin at a dose of 400 mL ha $^{-1}$ in the V6 stage. Subsequently, two applications of benzovindiflupir + azoxystrobin at a dose of 200 g ha $^{-1}$ and one last application of prothioconazole + trifloxystrobin at a dose of 400 ml h $^{-1}$ were performed.

The harvest was carried out on 03/15/15, with samples submitted to analyses in April and September 2015, each one consisted of evaluation time (time 1 and time 2). Treatments were consisted of different trail systems, where three self-propelled harvesters and manual threshing were evaluated, as follows: a) John Deere 9770 harvester, with axial trail system and platform with belt in the place of 40 feet spiral (12.0 m); b) John Deere 9670 harvester, with axial trail system and conventional platform of 30 feet (9.0 m); c) John Deere 1550 harvester, with conventional trail system - radial and platform of 22 feet (6.6 m); d) manual.

The axial and axial more "draper" flow harvesters operated with rotor opening of 23 (50% of total opening capacity of machine) and rotor speed of 380 rpm. In radial flow harvester, concave opening was 20 (40% of total opening capacity of machine) and cylinder rotation of 600 rpm. Harvest was carried out at 17:00 p.m. and the seeds were with 13.3% of humidity.

The collection of seeds was directly carried into the grain tank, after the stabilization of harvester supply. After each collection, seeds were referred to the laboratory and subjected to cleaning with the use of 8.0 mm and 3.5 mm sieves of round hole. Then, the following variables were evaluated:

a) Percentage of bandinhas: for soybean determination, it were subjected to the evaluation process using oblong hole sieve with dimensions of 4.0 mm x 22 mm. Results were expressed as percentage of "bandinhas”.

b) Mechanical injury: for the evaluation of mechanical injury, a total of 100 seeds arranged in polyethylene cups of 200 ml containing sodium hypochlorite solution at 5%, for 10 min and ambient temperature were used. Subsequently, sodium hypochlorite solution was drained and the number of seeds with damage measured. Results were expressed as percentage of seeds with damage.

c) Germination: four subsamples of fifty seeds per treatment were used to perform the test, arranged between two germinating sheets of *"germitest"* type, wetted with distilled water in a ratio 2.5 times the weight of dry paper. Rolls were prepared, which were placed into a germinator at 25 ° C (Brazil, 2009). Evaluation was performed eight days after sowing and results expressed as a percentage of regular seedlings.

d) Accelerated aging: seeds were distributed on metal mesh fixed inside polyethylene boxes ("gerbox") containing a 40 mL blade of distilled water. Polyethylene boxes with seeds were kept in BOD at 41 ° C for 48 hours. Subsequently, seeds were arranged to germinate under the same conditions of germination test, being the germination counting performed after four days of sowing (Brazil, 2009).

e) Emergence in field: for the evaluation of field emergence four replication of 80 seeds were sown, in soil characterized as above, at 3cm depth. Irrigation was daily performed and assessment performed when seedlings were in the VC stage (first fully expanded unifoliate leaf). Results were expressed as percentage of regular emerged seedlings.

The experimental design was randomized blocks in a factorial 4 x 2 scheme (trail system *x* storage time) with four replications. Data were subjected to variance analysis and means were compared by Tukey test at 5% probability.

RESULTS AND DISCUSSION

There was no interaction among the trail system and assessment time factors (after harvest and after storage) for all analyzed variables.

The determination of mechanical injuries which was performed using sodium hypochlorite test, showed that the higher percentage of damaged seeds occurs when harvest was carried out using radial trail system (Figure 1). Harvested seeds using combined axial and axial + draper system, the percentage of mechanical damage was lower compared to that with radial trail system, however, superior to seeds manually harvested.

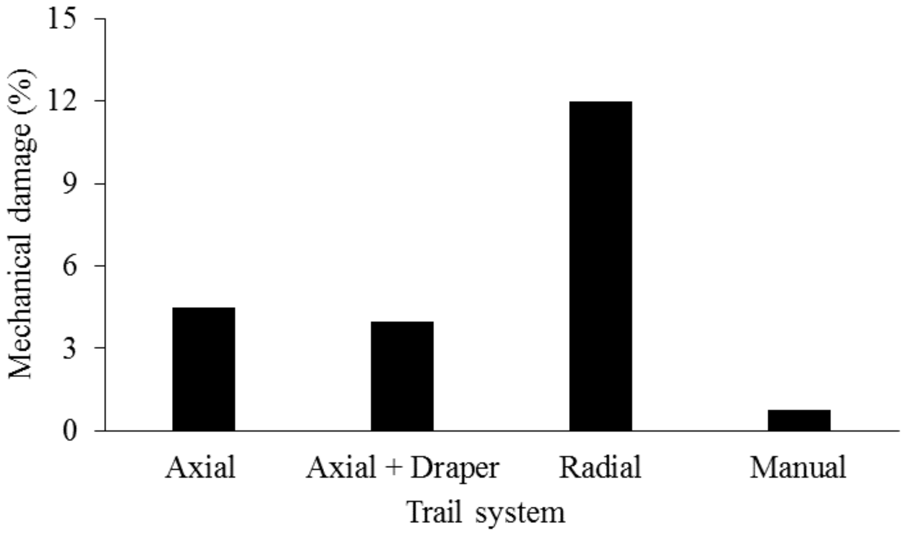

Fig. 1: Percentage of mechanical damage observed in sodium hypochlorite test applied in soybean seeds harvested under different trail systems.

The entry of material into axial flow harvesters occurs towards rotor axis, having the greater harvesting ability and allowing the reduction of damage levels caused to seeds. This is due to trail time in axial system and distance between the friction elements is higher compared to radial trail system (Cunha *et al*., 2009a). Cunha *et al*. (2009a) observed that harvesters with radial flow system and speed of 6 and 8 Km h^{-1} cause lower percentage of damages compared to harvester with radial flow in 4 and 6 Km h^{-1} speeds.

The correct adjustment of harvesters and seed humidity content at harvest are also factors to be considered by avoiding damages to seeds. When seeds are harvested with humidity content below 11%, immediate damages may occur. In contrast, seeds harvested with humidity content above 15% are subject to the occurrence of latent damages. Thus, it is important to note that soybean seeds with more than 10% of damage, after exposure to sodium hypochlorite test, should not be used as seed (Krzyzanowski *et al*., 2004).

The percentage of "bandinhas" was superior when seeds were harvested by combine with radial trail system compared to those subjected to other trail systems (Figure 2). This was probably due to seeds harvested with radial trail system that have been exposed with higher intensity to the impacts caused by threshing cylinder.

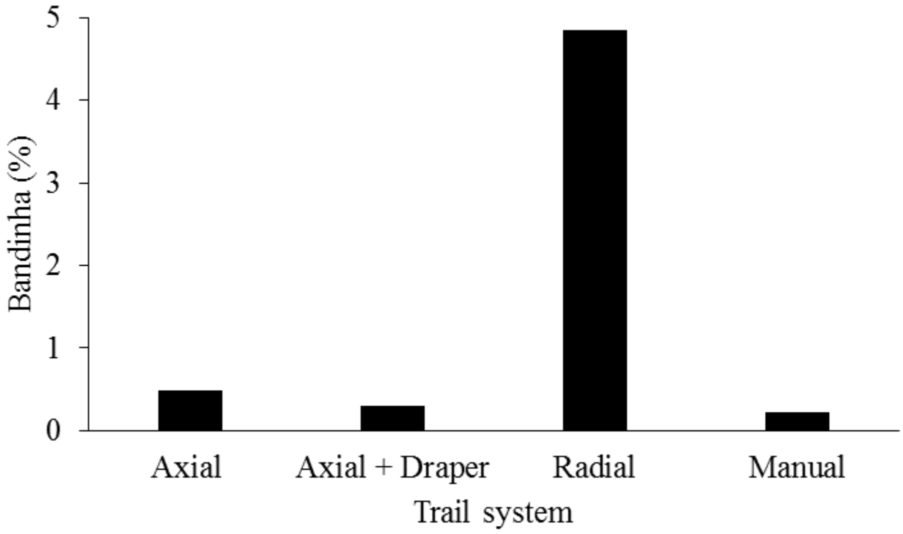

Fig. 2: Percentage of "bandinhas" in soybean seeds harvested under different trail systems.

In axial flow combines, the harvested plant material flows parallel to the axis of the threshing cylinder, wherein the path of the seeds in this system occurs due to friction between the mass of plants, concave and rotor (Veiga and Dalzoto, 2011). This trail system presents as major advantages the reduction of impurities, lower damage of the harvested product and easier maintenance (Moraes *et al*., 2005).

Furthermore, harvesters with axial trail system present as main difference the reduced mechanical damage levels of harvested seed compared to those with radial trail system (Cunha *et al*., 2009b). In radial trail system, this occurred when plant material reaches the trail system and changes its direction, thus being exposed in to the impacts caused by the threshing (Moraes *et al*., 2005).

In the assessment after harvest, the highest germination values were obtained from seeds harvested with axial trail combine, without, however, differing from seeds collected from those with axial system and equipped with "draper" platform (axial + "draper") and seeds manually harvested (Table 1). On the other hand, it should be noted that seeds harvested using combine with radial trail system reached the lowest germination values.

Table 1: Germination, accelerated aging and emergency in field of soybean seeds after harvest (AH) and after storage (AS), which were harvested under different trail systems.

Treatments	Germination		Accelerated aging		Emergence in field	
	AH	AS	AH	AS	AH	AS
Axial	98 aA*	95 aB	94 aA	93 aA	93 aA	93 abA
Axial + Draper	97 abA	95 aB	94 aA	92 aB	95 aA	95 abA
RadiaL	96 bA	94 aB	91 bA	91 aA	90 bA	89 bA
Manual	98 abA	95 aB	95 aA	93 aB	96 aA	96 aA
CV(%)	0.80		1.37		2.91	

*Means followed by the same lower letter in the column and capital in line do not differ themselvesby Tukey test p≤0.05

When seed germination was evaluated after storage in the period next to sowing, this did not differ from the different trail systems (Table 1). However, by comparing the germination values after harvest and afterstorage, it is observed a reduction of this attribute, regardless of trail system used.

Soybean seed coat is thin and has reduced protection to the vital parts of the embryo against shocks and abrasions, which occur during harvest process and result in decreased physiological quality. The germination reduction by using radial trail system, is probably due to the higher degree of mechanical damage observed in seeds of this treatment (Figure 1). Seeds that suffer damages of immediate type have cracks and breaks and become unable for germinating. Seeds submitted to latent damage have reduced vigor and lower storage potencial (Peske *et al*., 2012).

In this sense, Lopes *et al*. (2011) by evaluating the manual and mechanical harvesting methods in soybean seeds, observed germination superiority in the order of 8.5% to manually harvested seeds compared to those mechanically harvested. However, Carvalho *et al*. (2012) found no differences by evaluating soybean seed germination with lignin content 5% superior, manually and mechanically collected, with different water contents. According to Santos *et al*. (2007), lignin content in soybean seed coat direct influence over their quality due to making them less sensitive to mechanical damage. Thus, the greater or lower mechanical damage, is also a reflection of genetic load of the cultivar.

In the assessment after harvest, the lowest accelerated aging values were found on the radial trail system, axial, axial + "draper" trail and manual systems did not differ between themselves (Table 1). In the evaluation after storage, emergence values did not differ between the different trail systems.

Mechanical damage caused by impacts, cuts, abrasions or pressure can destroy the essential structures of seed and cause direct damage to germination and vigor, reducing storage potential, tolerance to insects and micro-organisms (Marcos Filho, 2005). The occurrence of mechanical damage caused by physical agents is one of the main causes of seed quality reduction during storage period. By evaluating the vigor of soybean seeds trough accelerated aging test, Lopes *et al*., (2011) found that the vigor of manually harvested seeds is higher compared to mechanically harvested seeds.

Similarly to accelerated aging results, the field emergence values were higher for soy beans harvested from the manual, axial and axial + draper trail systems, however, there was a reduction of seedling emergence values when considering seed harvested with radial trail system (Table 1). By assessing seedling emergence after storage of soybean seeds, results maintained the same trend obtained just after the harvest.

The highest values of emergence in the field indicate higher expression of seed vigor, a condition that enables the rapid establishment and initial higher performance of plants. The uniformity in seedling emergence is important to determine the initial plant population, reflecting on crop productivity (Marcos Filho, 2005).

It is important to note that the expression of seed vigor is function of environmental conditions and cultural practices employed during seed production (Peske *et al*., 2012). Thus, the harvest at certain time and with appropriate equipment is one of the determining factors for obtaining high quality seeds.

Conclusions:

Harvesters that have axial trail system, with or without "draper" platform allow obtaining seeds with better physical and physiological quality, without differentiate from manual trail system.

The radial trail system causes mechanical damage to soybean seeds capable of harming both physical and physiological quality.

Mechanical damage, determined by sodium hypochlorite tests and percent of bandinhas, are superior when radial trail system is used.

The harvest of seeds that was performed with radial trail system harvester causes reduction of germination and seed vigor.

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