

STORAGE CONDITIONS ON GERMINATION AND SEEDS VIGOR OF CONVENTIONAL AND TRANSGENIC SOYBEAN CULTIVARS

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ABSTRACT: *The soybean seeds storage in Brazil is growing concern by affecting their quality depending on the conditions which they are submitted. Thus, this study aimed at evaluating the seeds quality of three soybean cultivars recommended for western Paraná, CD 215, CD 202 and CD 233RR, from harvest and during storage in: environmental conditions (warehouse) and cooling (20 °C ± 2) for verifying its effect on the maintenance of vigor and storage potential. Evaluations were performed immediately after harvest and during eight months, every sixty days by the germination tests, cold and accelerated aging. The experimental design was completely randomized and means were compared statistically by the Tukey test at 5% probability. The accelerated aging test detected significant differences between cultivars in relation to vigor in both conditions after 120 days of storage. The CD 202 cultivar had the worst performance from beginning to end of storage. It was concluded that cooling keeps the quality of the cultivars considered vigorous up to 240 days of storage and the cultivar 233RR CD has great potential for storage, being indicated as most resistant to storage in western Paraná.*

KEYWORDS: *accelerated aging; seeds quality; cooling.*

CONDIÇÕES DE ARMAZENAMENTO NA GERMINAÇÃO E VIGOR DAS SEMENTES DE CULTIVARES DE SOJA CONVENCIONAL E TRANSGÊNICA

RESUMO: *O armazenamento de sementes de soja é preocupação crescente no Brasil por afetar a qualidade das mesmas dependendo das condições as quais são submetidas. Assim, o presente trabalho teve como objetivo avaliar a qualidade de sementes de três cultivares de soja recomendadas para a região Oeste do Paraná, CD 215, CD 202 e CD 233RR, desde a colheita e durante o armazenamento em: condição ambiente (armazém) e resfriamento (20 °C ± 2) para verificar seu efeito sobre a manutenção do vigor e potencial de armazenamento. As avaliações foram realizadas logo após a colheita e durante oito meses, a cada sessenta dias, por meio dos testes de germinação, frio e envelhecimento acelerado. O delineamento experimental foi inteiramente casualizado e as médias comparadas estatisticamente pelo teste de Tukey a 5% de probabilidade. O teste de envelhecimento acelerado detectou diferenças significativas entre as cultivares em relação ao vigor nas duas condições após 120 dias de armazenamento. A cultivar CD 202 obteve o pior desempenho do início ao fim do armazenamento. Conclui-se que o resfriamento mantém a qualidade das cultivares consideradas vigorosas até 240 dias de armazenamento e que a cultivar CD 233RR apresenta maior potencial de armazenamento, sendo indicada como mais resistente ao armazenamento na região Oeste do Paraná.*

PALAVRAS-CHAVE: *envelhecimento acelerado; qualidade de sementes; resfriamento.*

INTRODUCTION

Brazil is the second largest producer of soybeans and according to the survey conducted by Conab, it is estimated the season 2011/2012 domestic production of 69.23 million tons, down by 8.1% (96.10 million tons) to the volume of 75,320,000 tons produced in 2010/2011. Such result is due solely to adverse weather conditions, characterized by drought in major producing states in the South region of the country. 24.76 million hectares were cultivated, 2.4% or 583,400 hectares superior to the cultivated area in 2010/11 which was 24.18 million hectares, becoming the largest soybean crop cultivated in the country (Conab, 2012).

It is known that the soybean producer regions in Brazil are mostly present in tropical and subtropical regions; it has been difficult the conservation of grains and seeds in storage for these regions presenting high temperature during the storage cycle.

The storage seed quality is growing concern in the country; since its effort to export is also necessary having conditions that allow meet international standards in this segment. If storage conditions are not adequate, certainly part of soybean production may not be exported or even sold in the domestic market, since the sanitary inspection agencies are increasingly more stringent in their criteria (Maciel et al., 2005).

Soybean seeds suffer physic-chemical and biological changes during storage; thus the main factors affecting the storage capacity of soybean include: environment, relative humidity, water content, temperature and storage period. The general conditions of the product and the amount of impurities also affect the storage capacity (Kong et al., 2008).

To Nakagawa et al. (2004), the capacity of preserving seeds of a species or cultivar depends on the factors that define the initial quality of seeds and environmental conditions of storage. Storage under controlled conditions of temperature or relative humidity is a technically feasible alternative for seed quality preservation (Villela e Menezes, 2009).

Thus, the germination test is the most used to evaluate the physiological quality of seeds, but it does not always have good correlations with seedlings emergence in the field (Schuab et al., 2002). This stimulated the development of vigor concepts and consequently new tests to increase the evaluation efficiency of seeds quality.

The vigor tests have different purposes from the germination test, which are developed to identify possible differences in the degree of deterioration of seeds that have similar germination potential, they can estimate its storage capacity and seedling emergence in the field (Franzin et al ., 2004)

The vigor is reflection of a set of characteristics or properties that determine the seed's physiological potential. Thus, the result of a test or a set of tests indicates the batches more or less likely to present good performance; the most vigorous lots are more likely to succeed under adverse conditions (Marcos Filho, 1994).

Vigor tests, as the cold test and accelerated aging tests are stress tests; the seeds show their ability to emerge under adverse field conditions. The cold test for instance exposes seeds to low temperatures, and the accelerated aging to elevated temperatures and humidity (Vieira e Carvalho, 1994).

In this sense, this study aimed at evaluating the seed quality of conventional and transgenic soybean cultivars for germination and vigor and the effect of storage conditions on them, stored in the western region of Paraná under ambient conditions (Stock) and cooling ($20\text{ }^{\circ}\text{C} \pm 2$) for eight months, every 60 days, by the standard germination test, cold and accelerated aging.

MATERIAL AND METHODS

The study was conducted at the Laboratory for Evaluation of Seeds and Plants - LASP, Center for Science and Technology, State University of Paraná - UNIOESTE, Cascavel-PR, and in the Cooperativa Agroindustrial Lar, municipality of Medianeira-PR from April to December 2010. Seeds were produced and supplied by the aforementioned cooperative. Tests for assessing seeds quality were performed at LASP. Seeds storage was in the Seeds Laboratory of Cooperativa Agroindustrial Lar, in which is located in the cooling room and its Seed Processing Unit (BHU) - warehouse in the city of Medianeira, PR; being packed in 40-kg paper bags. It was used seeds of the cultivars CD 215, CD 202 (conventional) and CD 233RR (GM) from 2009/2010 crop, produced in the city of Xanxerê, west of Santa Catarina, Lar seeds producer, where its UBS located.

Analyzes were conducted immediately after harvest (time 0) and every 60 days during 240 days of storage, being collected two samples of each cultivar: one for each storage condition.

Germination: conducted with four replications of 50 seeds for each sample, germinated in paper substrate ("germitest"), previously soaked in water, using 2.5 times the mass of dry paper soaked in water, wrapped and brought into a germinator set at $25\text{ }^{\circ}\text{C}$. The evaluation was performed eight days after assembly the test, by computing the percentage of normal and

abnormal seedlings and dead seeds according to criteria established by the Rules for Seed Analysis - RAS (Brasil, 2009).

Cold Test: According to Vieira e Carvalho (1994), it was performed the same installation procedure for the germination test, with four replications of 50 seeds for each sample, the rolls were placed into plastic bags and kept in camera (BOD) set at 10 °C for seven days. After this period, the rolls were removed from plastic bags and transferred to a germinator at 25 °C where they remained for eight days, when the number of normal and abnormal seedlings and dead seeds were evaluated.

Accelerated aging: conducted with 250 seeds on an aluminum screen fixed in plastic boxes and kept in accelerated aging chamber at 41°C for 48 h. The maintenance of relative humidity inside each plastic box was performed by adding 40 mL water (100% relative humidity), as described by Marcos Filho et al. (1987) and França Neto et al. (1999). At the end of each period, seeds were submitted to germination test with four replications of 50 seeds according to the RAS (2009). The results were expressed as percentage of normal seedlings on the eighth day (considering normal and abnormal seedlings and dead seeds).

The statistical design was completely randomized (CRD), with four replications, in 3 x 2 factorial arrangement (3 cultivars and 2 storage conditions) in each period. The statistical analysis was performed by analysis of variance (ANOVA) using the statistical software SISVAR (Ferreira, 2008). The results of seeds quality expressed as percentages were transformed into arcsine $\sqrt{x/100}$ before being subjected to analysis of variance (Banzatto e Kronka, 2006).

In case of significant interactions, it was performed the necessary developments and means comparisons were carried out through the Tukey test at 5% probability.

RESULTS AND DISCUSSION

It was not possible to identify significant differences among cultivars by the germination test, since all had good performance, being the average germination percentage above 90% (Table 1).

In the cold test, cultivars CD 215 and CD 233RR showed statistically equal means, classified as very high vigor, differing only from the CD 202 with the lowest value, representing average vigor over the others.

When subjected to the accelerated aging test, CD 215 and CD 233RR had very high and high vigor, respectively; being similar between each other but different from the CD 202,

with medium vigor. This shows that this variety is more sensitive when exposed to stress conditions, both low or high temperature and humidity.

Table 1 - Mean percentage of normal seedlings of three soybean cultivars, determined by the germination test, cold test and accelerated aging after harvest. Cascavel - PR (2010)

Cultivars	Tests		
	GER	COLD	AA
CD 215	96 a	90 a	86 a
CD 202	90 a	74 b	72 b
CD 233 RR	94 a	92 a	84 ab
Average	93	85	81
CV (%)	7.14	5.06	7

Lower case in column indicate equal means among cultivars at 5% probability by the Tukey test.

In the germination test (Table 2), there was difference among cultivars in all storage periods. At 60 days of storage cultivars CD 215 and CD 233RR showed statistically equal means under environmental conditions, differing from the CD 202. Under cooling there was no difference among cultivars. The CD 202 cultivar differed statistically from the other cultivars in all storage periods in both conditions, except at 60 days, with the lowest mean, which was obtained at 240 days of storage at ambient condition, this being below the minimum standard set for marketing Seab (2005).

Regarding the storage conditions, they differed at 120 days for CD 215 and CD 233RR, especially the cooling condition with 6 and 5% higher than the ambient condition, respectively and the cultivar 233RR CD at 240 days, especially at the ambient conditions, with 9% more than cooling.

It is observed that the cultivars CD 215 and CD 233RR maintained their germination until the end of the storage period, both in the ambient and cooling condition, which does not corroborate with results obtained by Martins Filho (2001) that evaluated the physiological quality seeds of ten soybeans cultivars stored under conditions of natural environment in the region of Alegre-ES, analyzed monthly for eight months through the germination test and first germination count, and none of the cultivars maintained the germination capacity after 210 days of storage.

Table 2 - Mean percentage of normal seedlings of soybean, determined by the germination test at 60, 120, 180 and 240 days of storage under ambient conditions (A) and cooling (R). Cascavel - PR (2010)

Cultivars	Period (days)							
	60		120		180		240	
	Storage conditions							
	A	R	A	R	A	R	A	R
CD 215	95 aA	97 aA	91 aB	97 aA	95 aA	96 aA	93 bA	92 aA
CD 202	83 bA	90 aA	78 bA	77 bA	79 bA	80 bA	80 cA	75 bA
CD 233RR	89 aA	94 aA	89 abA	94 aBA	92 aA	95 aA	98 aA	89 aB
CV%	6.99		7.44		4.99		4.46	

Equal lower case in column indicate equal means among cultivars and capital letters in the row indicate equal means among the storage conditions at 5% probability by the Tukey test.

Simoni (2003) working on maize seeds reported that with the increased storage period, germination was decreasing due to the reduced physiological quality; with three months of storage has been possible to observe a significant decrease in seeds germination (72.3 to 66.9%) which was not observed in this work since the germination remained constant throughout the storage period.

It is observed that all coefficients of variation (CV%) were less than 20%, being considered low and indicating homogeneous data, according to Pimentel Gomes (2000).

In the cold test (Table 3), the three cultivars showed different means to each other at 60 days of storage under cooling condition. However, the cultivars CD 215 and CD 233RR, classified as very high vigor, and CD 202 classified as medium vigor. At ambient conditions, the cultivars CD 215 and CD 233RR presented statistically equal means, differing from the CD 202, with the lowest mean; however, still classified as high-vigor, according to the classification described by França Neto et al. (1999).

The same occurred in the other periods and in both conditions. The storage conditions differ at 60 days for CD 215 and CD 233RR, especially for cooling the CD 215 and ambient condition for CD 233RR. However, in both conditions, cultivars had very high vigor. At 180 days differed for CD 215, with emphasis on cooling, with 6% more than the ambient condition, but both with very high vigor. The same occurred for CD 233RR at 240 days.

Table 3 - Mean percentage of normal seedlings of soybean, determined by the vigor test - accelerated aging of seeds of three soybean cultivars at 60, 120, 180 and 240 days of storage under ambient conditions (A) and cooling (R). Cascavel - PR (2010)

Cultivars	Period (days)							
	60		120		180		240	
	Storage conditions							
	A	R	A	R	A	R	A	R
CD 215	90aB	96aA	90aA	94aA	92aA	98aB	95aA	94aA
CD 202	77bA	68cA	74bA	68bA	83bA	82bA	74bA	78bA
CD 233RR	94aA	88bB	93aA	94aA	97aA	99aA	91aB	97aA
CV%	8.01		6.88		5.32		5.88	

Equal lower case in column indicate equal means among cultivars and capital letters in the row indicate equal means among the storage conditions at 5% probability by the Tukey test.

When exposed to accelerated aging test (Table 4) is noted at 60 days that CD 215 and CD 233RR presented statistically equal means differing from the CD 202 in both conditions. The same was observed at 120 days; however, with lower mean values but cultivars CD 215 and CD 233RR still with high vigor, showing reduced vigor the cultivar CD 202, classified as very low vigor.

Table 4 - Mean percentage of normal seedlings of soybean, determined by the vigor test - accelerated aging of seeds of three soybean cultivars at 60, 120, 180 and 240 days of storage under ambient conditions (A) and cooling (R). Cascavel - PR (2010)

Cultivars	Period (days)							
	60		120		180		240	
	Storage conditions							
	A	R	A	R	A	R	A	R
CD 215	92aA	94aA	77aA	80aA	65bB	82aA	53bB	81aA
CD 202	81bA	76bA	44bA	46bA	43cA	50bA	50bA	49bA
CD 233RR	93aA	94aA	81aB	90aA	80aA	83aA	79aA	84aA
CV%	5.3		9.47		7.72		8.48	

Equal lower case in column indicate equal means among cultivars and capital letters in the row indicate equal means among the storage conditions at 5% probability by the Tukey test.

At 180 days there was vigor reduction in cultivar CD 215 (medium vigor) under ambient conditions, differing from the others. In the cooling condition, the CD 233RR cultivar presented the highest mean, being equal to CD 215. The CD 202 showed low vigor.

At 240 days there was also vigor reduction for CD 215 in ambient conditions, being statistically equal to CD 202, with low vigor. The CD 233RR differed from the others, with high vigor. In the cooling, CD 215 cultivar maintained high vigor differing only from CD 202, which remained its very low vigor, according to the classification of França Neto et al. (1999).

Regarding the storage conditions, there was difference at 120 days for the cultivar CD 233RR, at 180 and 240 days for CD 215 cultivar, with emphasis on the three periods under cooling condition, with 9, 17 and 28% more than the ambient condition, respectively.

Minuzzi et al. (2010) also worked on soybean cultivars, BRS 133, BRS 206, BRS 239 and CD 202 in Dourados - MT and observed that CD 202 showed inferior results to the others in the accelerated aging test, as observed in this work, which had reduced vigor of the cultivar CD 202 from 120 days of storage, both in ambient and cooling conditions.

The seed storage in ambient conditions negatively affected the seeds quality of CD 215 and CD 202 from 120 days of storage, reducing their vigor when exposed to stressful conditions at high temperatures and humidity, simulating adverse conditions in the field environment, showing that these cultivars are more sensitive to these situations promoted by the accelerated aging test. However, under cooling condition, CD 215 retained its high vigor by the end of the storage period. According to Abba e Lovato (1999), the storage of seeds under natural conditions in tropical regions presents major problems due to temperature and relative humidity conditions compared to temperate or cold climate regions.

It is noteworthy that CD 202 showed low seed vigor in the analysis of initial seed quality, is, already proving to be more sensitive when exposed to adverse conditions and low storage potential. According to Lazarini et al. (2001), it should be selected soybean seeds with appropriate values of germination and vigor, especially for storage conditions to allow some depressing effect of storage is bearable.

Dutra e Vieira (2004) used the accelerated aging test as vigor tests for soybean seeds and obtained satisfactory results for determining the vigor difference among lots, which agrees with this work, whose accelerated aging test was more sensitive to detect differences in vigor among cultivars from 120 days.

CONCLUSIONS

There was significant interaction between cultivars and storage conditions. Soybean seeds stored in different conditions exhibited different behavior on vigor after 120 days of storage.

The cooling keeps the quality of cultivars considered vigorous up to 240 days of storage. The transgenic cultivar, CD 233RR, showed greater storage potential, it indicated as being more resistant to storage in western Paraná.

ACKNOWLEDGEMENTS

The authors thank the Cooperativa Agroindustrial Lar for the support and supply of seeds and the National Council for Scientific and Technological Development (CNPq) for financial assistance for developing the project.

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