HARVESTING DELAY IN PHYSIOLOGICAL QUALITY OF SOY SEEDS

RETARDAMENTO DA COLHEITA NA QUALIDADE FISIOLÓGICA DE SEMENTES DE SOJA

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ABSTRACT Soybeans are a grain-producing species of high international demand and occupy a prominent position in the Brazilian economy. The success of this crop in Brazil is due to public and private investments in production technologies and to breeding programs. It is through the seed that the genetic advances reach the producer. In this context, the success of a cultivar and high productivity depend on the quality of the seed. In view of the above, the objectives of the study were to evaluate the physiological quality of soybean cultivar seeds at different harvesting times. The experiment was conducted in an experimental area located at Fazenda Capim Branco, belonging to the Federal University of Uberlândia, in the 2016/2017 harvest. Ten soybean cultivars were evaluated (CD 2737 RR, UFUS 7415, UFUS 7910, UFUS Milionária, UFUS 7801, NA 5909 RG, UFUS 8301, TMG 7062 IPRO, UFUS Xavante and UFUS 6901) at four harvest times (R7, R8, R8+15, R8+30), constituting a 10 x 4 factorial. The experiment was carried out in a randomized complete block design with four replicates. For the evaluation of the physiological quality, germination, electrical conductivity and fresh matter and dry matter of seedlings tests were performed. In all tests the physiological quality of the seeds decreased with the harvest delay. Emphasis was placed on the cultivar NA 5909 RG, which showed the best means to delay the harvest in 15 and 30 days.

KEYWORDS: Glycine max. Seeds. Germination. Force.

INTRODUCTION

The soybean (*Glycine max* (L.) Merrill) is a grain producer species of high international demand and occupies a prominent position in the Brazilian economy. The success of this legume in Brazil is justified by favorable climatic conditions for crop development, production technologies and breeding programs that contribute to the expansion of soybeans in the regions of the country.

The soybean breeding programs stand out for the search of new genotypes that present high productive potential, long juvenile period and resistance to pests and diseases (NOGUEIRA; SEDIYAMA; GOMES, 2015). However, little emphasis has been given to the selection of characters associated with seed quality and performance (MARTINS; SILVA; MACHADO, 2014; OLIVEIRA et al., 2014; MARTINS et al., 2016). The high physiological quality of the seed directly influences the development of the crop, providing greater population uniformity, absence of seed-borne diseases, high plant vigor and high grain productivity (PESKE; VILLELA; MENEGHELLO, 2012).

The use of appropriate management, choice of cultivar, monitoring of vegetative development, cultural practices, phytosanitary treatments, harvesting season among others, are essential for the crop to express its productive potential and produce high quality seeds (SINÍCIO et al., 2009).

Harvest delay exposes seeds to unfavorable conditions, accelerating the deterioration process (TERASAWA et al., 2009; GRIS et al., 2010; DINIZ et al., 2013) and can then be used to select genotypes with physiological quality of seed.

Tests of vigor and germination have been carried out frequently by the seed industries to determine the physiological quality. The results of these tests are used to make decisions in seed companies, especially in the comparison of lots, to establish policies of storage, commercialization and quality control (MARCOS FILHO; KIKUTI; LIMA, 2009).

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In view of the above, the objective of this work was to evaluate the physiological quality of soybean seeds at different harvesting times.

MATERIAL AND METHODS

The experiment was conducted in the 2016/2017 harvest, in an experimental area located at Fazenda Capim Branco (18º52'S, 48º20'W and 805 m altitude), belonging to the Federal University of Uberlândia, in the city of Uberlândia, Minas Gerais.

Ten soybean genotypes were evaluated, being seven cultivars developed by the Soy Improvement Program of the Federal University of Uberlândia – UFU (UFUS 7415, UFUS 7910, UFUS Milionária, UFUS 8301, UFUS 7801, UFUS 6901 and UFUS Xavante) and three cultivars developed by other companies (CD 2737 RR, NA 5909 RG and TMG 7062 IPRO).

The treatments were from a 10 x 4 factorial scheme (10 soybean genotypes and four harvest seasons) and the experiment was installed in a randomized complete block design with four replicates. Each plot consisted of four rows of 5.0 m long soybean plants, spaced at 0.5 m, and the useful area was 4 m^2 from two central lines, excluding 0.5 m from each end.

The experimental area where the experiment was carried out was located on a Red Yellow Dystrophic Latosol. The area was conventionally prepared with a plowing and two gradations, followed by the groove. The fertilization of sowing was carried out with the formula NPK 02-28-18, in the dose of 400 kg ha^{-1}.

Harvesting was performed manually, taking into consideration the following stages of crop development proposed by Fehr and Caviness (1977): R7, R8, R8+15 (15 days after the R8 stadium) and R8+30 (30 days after the R8 stadium).

The useful portion and border were traced and the seeds separated from the impurities with the aid of sieves, packed in paper bags and stored in a cold room.

For the analysis of the physiological quality of soybean seeds, the following tests were carried out at the Federal University of Uberlândia Seed Laboratory:

a) Germination test: performed according to the Rules for Seed Analysis - RSA (BRASIL, 2009). Four replicates of 50 seeds of each soybean genotype were used in the four harvesting seasons, distributed evenly with the aid of a seed counter on paper towel, of the germitest type, moistened with water. The amount of water used to moisten was 2.5 times the weight of the paper. The samples were kept in germinator for five days at a constant temperature of 25 ºC. On the 5th day the amount of normal seedlings (vigorous and non-vigorous), abnormal seedlings (deteriorated, damaged and deformed) and hard, dormant and dead seeds were computed;

b) Electrical conductivity test: four samples of 50 seeds of each soybean genotype were used in the four harvesting seasons, previously weighed and immersed in 75 ml of deionized water at 25 ºC for 24 hours (LOEFFLER; TEKRONY; EGLI, 1988). After soaking the seeds for 24 hours, the electrical conductivity was read in the soaking solution in a conductivity meter, calibrated before reading. The result obtained in the conductivity meter was divided by the weight of the sample, the final result being expressed in $\mu S.cm^{-1}.g^{-1}$;

c) Fresh and dry matter of seedlings: the vigorous normal seedlings obtained in the germination test were previously weighed to obtain the fresh matter of seedlings. The seedlings were then placed in paper bags and dried in a forced air oven at constant 65 °C for 72 hours. Samples after this period were removed from the greenhouse and weighed again, determining the dry matter of the seedlings, the results being expressed in g $seedling^{-1}$ (NAKAGAWA, 1999).

The data were submitted to the analysis of homogeneity of variance between the treatments by the Levene test and normality of the residues by the Shapiro-Wilk test. When it did not meet the assumptions, the data were transformed, so, for electrical conductivity, the data were transformed into 1/y (reciprocal transformation). Analyzes of variance were performed, assuming fixed effect for cultivar and harvest season for all evaluated characters. The means were compared by the Scott-Knott test at the 5 % probability level.

All analyzes were performed using the Computational Program in Genetics and Statistics - GENES (CRUZ, 2016).

RESULTS AND DISCUSSION

Significant differences were observed at the 1 % probability level by the F test in the interaction between cultivars and harvest season (Table 1), which indicates the differential behavior of the cultivars submitted to the different harvest seasons. Xavier et al. (2015) also verified the existence of interaction between cultivars and harvest season.

Table 1. Mean interaction square and coefficient of variation evaluated in ten soybean cultivars at different harvesting times, in the 2016/2017 harvest.

Characters	QM interaction (CxE)	CV (%)
Germination	634.68**	23.49
Electric conductivity	1182.87**	24.44
Fresh matter	352.51**	41.42
Dry matter	2.18**	29.98

**: significant at the 1% probability level by the F test. CV (%): coefficient of variation.

Studying breeding programs on the physiological quality of soybean seeds is of fundamental importance, since good quality seeds are more productive, therefore, quality control should be increasingly efficient, including tests that can quickly assess their physiological potential and that allow essential differentiation between their lots (FESSEL et al., 2010).

Table 2 shows the germination data. It was observed that the cultivars CD 2737 RR, UFUS 7415, UFUS 7801 and NA 5909 RG showed germination above the acceptable minimum (≥ 80 % - Ministry of Agriculture, Livestock and Supply) when harvested at the R8 stage. The others presented germination below the recommended one, with a marked decline when harvested after the R8 stage. Focus on the cultivar NA 5909 RG, although slowing the harvest in 15 and 30 days, the germination average was 92.07 % and 59.00 %, respectively (Table 2). The maximum germination is found in the R7 stage, physiological maturity, results not observed in the present study in cultivars UFUS 7415, UFUS 7910, UFUS Milionária, UFUS 8301 and UFUS Xavante, possibly due to contamination of pathogen plots, since at this stage they were found to have higher water contents.

Table 2. Percentage of seedlings germinated (GER.) in soybean cultivars sown in the municipality of Uberlândia-MG, harvest 2016/2017 at different times of harvest.

Cultivars	GER. (%)			
	R7	R8	R8+15	R8+30
CD 2737 RR	95.04 aA	88.56 aA	17.63 dB	0.41 cB
UFUS 7415	76.41 bA	83.84 bA	28.89 cB	9.86 cC
UFUS 7910	70.47 bA	76.95 bA	51.03 bB	36.59 bB
UFUS Milionária	78.03 bA	65.88 cA	36.72 cB	21.20 cB
UFUS 7801	82.62 aA	94.31 aA	65.15 bB	37.99 bC
NA 5909 RG	88.83 aA	98.98 aA	92.07 aA	59.00 aB
UFUS 8301	69.82 bA	59.13 cA	22.14 dB	3.78 cC
TMG 7062 IPRO	88.70 aA	74.52 bA	29.16 cB	5.00 cC
UFUS Xavante	57.24 bB	74.33 bA	42.93 cB	4.67 cC
UFUS 6901	86.40 aA	42.80 dB	10.26 dC	4.46 cC

Averages followed by the same horizontal capital letter and lower case vertical letter belong to the same group by the Scott Knott test at 5 % probability.

Although the germination test does not allow an evaluation of the physiological potential of the seeds under different conditions, it provides information about the potential of a sample to germinate under optimal environmental conditions. In general, it was observed that the ten cultivars studied responded differently to the physiological quality of their seeds. Therefore, the harvest delay method, after the R8 development stage, was adequate to differentiate genotypes in function of the quality of their seeds (LIMA et al., 2007).

Low germination rates in R8, as observed in cultivars UFUS 6901, UFUS 8301 and UFUS Milionária may be due to their storage in the field, where they are exposed to unfavorable conditions, accelerating the deterioration process. The rapidity with which the seed quality decreases after the R7 stage is due to the genotype and the conditions imposed on the seeds in the field (MARCANDALLI; LAZARINI; MALASPINA, 2011).

Mathias et al. (2017) found similar results to the present work when evaluating the effect of the

harvest season on the physiological quality of soybean seeds, concluding that the delay of the harvest in 10 days provided a reduction in the germination rate of the seeds. Other authors such as Sediyama et al. (2012) and Xavier et al. (2015) also found a reduction in the germination rate with the harvest delay.

The dry matter of the plant consists, with the exception of water, of the presence of carbohydrates, proteins, lipids and mineral nutrients. Soybean growth and development can be measured by the amount of dry matter accumulated in the plant (CÂMARA, 1998) and, since water plays an essential role in cell metabolism, by fresh matter also, because cultivars with higher fresh matter, may be more able to metabolize their reserves in energy for the development of the seedling (VIEIRA et al., 2013).

Table 3 shows the values of fresh and dry matter of normal seedlings at different harvesting times. There was a decrease in the values of these two characters with harvest delay. The cultivars NA 5909 RG, UFUS 7415 and UFUS 7801 presented the highest average weights of fresh and dry matter, indicating that these cultivars are considered more vigorous. More vigorous seeds transfer more in the germination phase dry matter of their reserve tissues to the embryonic axis, giving rise to seedlings with greater weight, due to the greater accumulation of matter (NAKAGAWA, 1999).

Table 3. Fresh matter (FM) and dry matter (DM) in soybean cultivars sown in the municipality of Uberlândia-MG, harvest 2016/2017, at different times of harvest.

Cultivars	FM (g seedling^{-1})				DM (g seedling^{-1})			
	R7	R8	R8+15	R8+30	R7	R8	R8+15	R8+30
CD 2737 RR	51.93 aA	40.87 bA	6.39 bB	6.51 bB	5.57 aA	5.21 aA	2.86 bB	2.20 bB
UFUS 7415	32.88 bB	50.11 aA	12.30 bC	3.89 bC	4.65 aA	5.52 aA	2.89 bB	1.60 bB
UFUS 7910	30.14 bA	23.15 cA	15.69 bA	13.98 aA	3.64 bA	4.40 aA	3.02 bA	3.07 aA
UFUS Milionária	28.04 bA	23.09 cA	15.29 bB	9.21 bB	3.45 bA	3.30 bA	2.95 bA	2.64 aA
UFUS 7801	42.42 aA	53.77 aA	25.64 bB	20.31 aB	3.98 bB	5.39 aA	3.41 bB	3.99 aB
NA 5909 RG	49.33 aA	53.47 aA	55.07 aA	19.09 aB	5.28 aA	5.35 aA	5.54 aA	3.56 aB
UFUS 8301	23.15 bA	18.33 cA	6.53 bB	3.62 bB	3.62 bA	3.49 bA	1.85 bB	1.58 bB
TMG 7062 IPRO	46.69 aA	36.69 bA	12.17 bB	1.85 bB	4.62 aA	3.95 bA	2.68 bB	0.91 bC
UFUS Xavante	21.04 bA	26.62 cA	14.25 bA	2.64 bB	2.99 bA	3.21 bA	2.68 bA	1.50 bA
UFUS 6901	45.41 aA	10.56 cB	4.57 bB	2.91 bB	4.90 aA	2.61 bB	2.09 bB	2.21 bB

Averages followed by the same horizontal capital letter and lower case vertical letter belong to the same group by the Scott Knott test at 5 % probability.

Electrical conductivity is a test that determines the vigor of a seed lot. Researches carried out with different species have shown that the decrease in germination and vigor is directly proportional to the increase of solute leaching, indicating that the electrical conductivity is an efficient method for the evaluation of vigor (CUSTÓDIO, 2006).

The average electrical conductivity in the ten soybean cultivars evaluated at different harvest seasons ranged from 39,22 μScm^{-1} g^{-1} (NA 5909 RG) to 181,68 μS cm^{-1} g^{-1} (TMG 7062 IPRO) (Table 4). At R7 and R8 stages, the values for electrical conductivity were lower, increasing with the harvest delay. The NA 5909 RG obtained the lowest values in all evaluated harvesting seasons, indicating that it is the most vigorous cultivar. This result agrees with the germination, fresh and dry matter tests.

Table 4. Electric conductivity (EC) in soybean cultivars sown in the municipality of Uberlândia-MG, harvest 2016/2017, at different times of harvest.

Cultivars	EC ($\mu S\ cm^{-1}\ g^{-1}$)			
	R7	R8	R8+15	R8+30
CD 2737 RR	48.83 bA	57.86 cA	137.90 bB	149.49 bB
UFUS 7415	62.76 cA	63.88 cA	101.25 bB	163.29 bB
UFUS 7910	59.02 cA	62.06 cA	97.34 bB	151.03 bB
UFUS Milionária	49.84 bA	64.57 cA	91.94 bB	140.50 bB
UFUS 7801	57.39 bA	54.57 cA	82.76 bB	149.20 bC
NA 5909 RG	40.85 aA	39.22 aA	77.38 aB	105.34 aB
UFUS 8301	72.12 dA	94.24 dA	77.62 aA	109.08 aA
TMG 7062 IPRO	64.37 bA	48.12 bA	102.51 bB	181.68 bB
UFUS Xavante	94.45 dA	75.74 dA	93.25 bA	164.47 bB
UFUS 6901	57.08 cA	95.78 dB	97.52 bB	150.36 bB

Averages followed by the same horizontal capital letter and lower case vertical letter belong to the same group by the Scott Knott test at 5% probability.

The electrical conductivity estimates, with high degree of precision, the performance of soybean seeds in the field, depending on the prevailing climatic conditions (PAIVA AGUERO, 1995). The same author verified that an optimal emergence of soybean seeds can be obtained in the field with a conductivity of up to 110 $\mu S\ cm^{-1}g^{-1}$ if the field conditions are suitable for germination and emergence, but under small limitations for germination, conductivity cannot exceed 90 $\mu S\ cm^{-1}g^{-1}$.

CONCLUSION

Harvest delay allows soybean genotypes to be identified for physiological seed quality. The cultivar NA 5909 RG presented seed quality delaying the harvest in fifteen days.

RESUMO: A soja é uma espécie produtora de grãos de alta demanda internacional e ocupa posição de destaque na economia brasileira. O sucesso dessa cultura no Brasil se deve aos investimentos públicos e privados em tecnologias de produção e aos programas de melhoramento genético. É por meio da semente que os avanços genéticos chegam até o produtor. Nesse contexto, o sucesso de uma cultivar e altas produtividades dependem da qualidade da semente. Diante do exposto, os objetivos do trabalho foram avaliar a qualidade fisiológica de sementes de cultivares de soja em diferentes épocas de colheita. O experimento foi conduzido em uma área experimental localizada na Fazenda Capim Branco, pertencente à Universidade Federal de Uberlândia, na safra 2016/2017. Avaliaram-se dez cultivares de soja (CD 2737 RR, UFUS 7415, UFUS 7910, UFUS Milionária, UFUS 7801, NA 5909 RG, UFUS 8301, TMG 7062 IPRO, UFUS Xavante e UFUS 6901) em quatro épocas de colheita (R7, R8, R8+15, R8+30), constituindo um fatorial 10 x 4. Adotou-se o delineamento experimental de blocos completos casualizados com quatro repetições. Para avaliação da qualidade fisiológica foram realizados os testes germinação, condutividade elétrica, matéria fresca e seca de plântulas. Em todos os testes realizados a qualidade fisiológica das sementes diminuiu com o retardamento de colheita. Destaque para a cultivar NA 5909 RG, que apresentou as melhores médias ao retardar a colheita em 15 e 30 dias.

PALAVRAS-CHAVE: *Glycine max.* Sementes. Germinação. Vigor.

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