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ADEQUACY OF ELECTRICAL CONDUCTIVITY TEST FOR LENTIL SEEDS

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ABSTRACT - The electrical conductivity test stands out among the existing physiological quality tests due to its simplicity of execution, repeatability, speed, easy interpretation of results, and low cost. This study aimed to establish a methodology for the test of electric conductivity in lentil seeds (*Lens culinaris* Medik), involving the seeds' number of seeds and soaking time. The experiment was conducted at the Multidisciplinary Laboratory of the State University of Goiás, Campus Ipameri, in 2018. Lentil Silvina seeds were used, stored in the seed laboratory of the same institution. The experimental design used was completely randomized, in a 4x5 factorial scheme, with four seed lots (25, 50, 75, and 100 seeds) and five soaking times (3, 6, 9, 12, and 15 hours) at 25 ºC, with four replications. The initial seed quality was characterized (water content, first counting of germination, percentage of germination, accelerated aging and 1000-seed weight). For the electrical conductivity test, four repetitions of 25, 50, 75, and 100 seeds each were used, weighed on a digital scale with an accuracy of 0.001 g and placed in plastic cups, with a capacity of 200 mL, containing 75 mL of distilled water. Then, the plastic cups remained in a BOD chamber, adjusted at 25 °C and the measuring was performed after 3, 6, 9, 12, and 15 hours of soaking in a conductivity meter (DIGIMED DM 31), the results being expressed in µS cm^{-1} g^{-1}. There was a significant interaction when evaluating the number of seeds per repetition and the soaking time. The use of replicates with 50 seeds subjected to 12 h of soaking shows the best results for the lentil seeds' electrical conductivity test.
Keywords: *Lens culinaris* Medik, conductivity meter, vigor.

ADEQUAÇÃO DO TESTE DE CONDUTIVIDADE ELÉTRICA PARA SEMENTES DE LENTILHA

RESUMO - O teste de condutividade elétrica destaca-se dentre os testes de qualidade fisiológica existentes, por sua simplicidade de execução, repetibilidade, rapidez, fácil interpretação de resultados e baixo custo. O presente trabalho teve como objetivo estabelecer metodologia para o teste de condutividade elétrica em sementes de lentilha (*Lens culinaris* Medik), envolvendo quantidade de sementes e períodos de embebição das sementes. O experimento foi conduzido no Laboratório Multidisciplinar da Universidade Estadual de Goiás, do *Campus* Ipameri, em 2018. Foram utilizadas sementes de Lentilha Silvina, armazenadas no laboratório de sementes da mesma instituição. O delineamento experimental utilizado foi inteiramente casualizado, em esquema fatorial 4x5, sendo 4 lotes de sementes (25, 50, 75 e 100 sementes) x 5 períodos de embebição (3, 6, 9, 12 e 15 h) a 25ºC, contendo 4 repetições. Foi realizada a caracterização da qualidade inicial das sementes (teor de água, primeira contagem de germinação, percentagem de germinação, envelhecimento acelerado e peso de mil sementes). Para o teste de condutividade elétrica empregou-se quatro repetições de 25, 50, 75 e 100 sementes cada, pesadas em balança digital com precisão de 0,001 g e acondicionadas em copos plásticos, com capacidade de 200 mL, contendo 75 mL de água destilada. Em seguida, os copos permaneceram em câmara do tipo BOD, regulada a 25°C e a leitura foi realizada após 3, 6, 9, 12 e 15 h de embebição, em condutivímetro (DIGIMED DM 31), sendo os resultados expressos em µS cm^{-1} g^{-1}. Houve interação significativa ao se avaliar a quantidade de sementes por repetição e o tempo de embebição. O uso de repetições com 50 sementes submetidos a 12 h de embebição apresentam os melhores resultados para o teste de condutividade elétrica para sementes de lentilha.
Palavras-chave: *Lens culinaris* Medik, condutivímetro, vigor.

INTRODUCTION

Lentils (*Lens culinaris* Medik) have been cultivated and consumed on a large scale in many world regions. They are used as a protein source in the human diet and have about 22% to 35% protein. It has good acceptance in the Brazilian market. Although the country has favorable conditions for its cultivation, production is relatively small (BUENO et al., 2010), with yields of up to 2851 kg ha^{-1}. India, being the largest importer in the world, announced in 2016 the intention to import lentils from Brazil to supply local demand and control the country's high prices. The maximum production potential for the

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implantation of any cultivation system requires the use of quality seeds, in order to ensure, in fact, uniform and adequate plant populations (BARBOSA et al., 2012).

To determine the physiological quality of seeds, appropriate methods are used that allow the estimation of vigor, performance in the field, and the disposal of deficient lots, to reduce risks and losses since one of the main requirements for assessing the vigor of seeds refers to obtaining reliable results in a shorter period, to streamline the decision making regarding the management of batches, during the post-harvest stages of the seeds (GUEDES et al., 2009). In this case, rapid tests are used to assess the physiological quality of the seed lots accurately. The most studied rapid tests are related to the deterioration sequence's initial events, such as the degradation of cell membranes and the reduction of respiratory and biosynthetic activities (BINOTTI et al., 2008).

Electrical conductivity is considered a rapid test and is based on the premise that vigor is directly related to the cell membrane system’s integrity. The less vigorous seeds have greater difficulty in restoring cell membranes' integrity during hydration; because of this, they release greater amounts of cytoplasmic solutes into the water (MARCOS FILHO, 2005).

The electrical conductivity test has achieved satisfactory results in the separation of seed lots with different levels of vigor for some crops, such as pepper (VIDIGAL et al., 2008), pea (MACHADO et al., 2011), cocona (PEREIRA; MARTINS FILHO, 2012), black oats (MENEZES et al., 2007, NOGUEIRA et al., 2013), and ryegrass (LOPES; FRANKE, 2010). Given the above, the objective was to establish a methodology for testing electrical conductivity in lentil seeds (*Lens culinaris* Medik), through the number of seeds and soaking time.

MATERIAL AND METHODS

The experiment was conducted in a Multidisciplinary Laboratory at the State University of Goiás, Ipameri *Campus*, in 2018. Silvina lentil seeds (*Lens culinaris* Medik), from Embrapa Vegetables and stored in the seed laboratory of the same institution, were used. The seeds' initial quality was characterized, such as (water content, first counting of germination, germination, accelerated aging, and 1000-seed weight).

The water content was determined using the oven method at 105 ± 3°C according to the methodology described in the Rules for Seed Analysis - RAS (BRASIL, 2009). Two sub-samples of 20 seeds were taken per treatment. First, the oven was regulated at a temperature of 105 ± 3°C, and the containers were dried for 30 minutes, then they were weighed on a digital scale with three decimal places with their respective lids and then with the seeds. The samples remained in the oven for 24 hours, after which the samples were removed and kept in a desiccator to reduce the temperature and then weighed. The results were expressed in the percentage of water content (wet basis).

The germination test was conducted with four replications of 50 seeds; the seeds were placed on sheets of germitest paper moistened with distilled water in the proportion of 2.5 times the weight of the dry paper and placed to germinate in BOD at a constant temperature of 25°C, computing the percentage of normal seedlings on the fourth day. The evaluation was carried out following the RAS (BRASIL, 2009). The results were expressed as a percentage of normal seedlings (%). The first counting of germination was conducted together with the germination test, computing the percentage of normal seedlings on the fourth day after the test installation. The results were expressed as a percentage of normal seedlings (%). For the 1000-seed weight, eight replications of 100 seeds were used, counted manually, and evaluated on a digital scale with an accuracy of 0.001 g, according to the methodology described in the RAS (BRASIL, 2009).

In the accelerated aging test, 250 seeds were distributed on an aluminum screen, fixed in a plastic box, containing 40 mL of distilled water. The boxes with the seeds were closed and kept at 41 ºC for 48 h. At the end of each period (3, 6, 9, 12, and 15 h), the seeds were submitted to the germination test and evaluated the percentage of normal seedlings, carried out five days after sowing. The electrical conductivity test was performed with four replications of 25, 50, 75, and 100 seeds. Each weighed on a digital scale with an accuracy of 0.001g and placed in disposable plastic cups, with a capacity of 200 mL, containing 75 mL of distilled water. Then, the plastic cups remained in a BOD chamber, regulated at 25°C and the measuring was performed after 3, 6, 9, 12, and 15 h of soaking, with a conductivity meter (DIGIMED DM 31) and the results were expressed in $\mu S\ cm^{-1}\ g^{-1}$.

The experimental design used was completely randomized in a 4x5 factorial scheme with four replications. Four lots of seeds (25, 50, 75, and 100 seeds) and five soaking times (3, 6, 9, 12, and 15 h) were evaluated. The data obtained were subjected to analysis of variance. The means were compared by the Tukey test at a 5% probability of error. Also, the means were submitted to regression analysis. The Statistica software (FERREIRA, 2011) was used.

RESULTS AND DISCUSSION

The results obtained in the initial characterization of the seeds' physiological quality are shown in Table 1. The initial water content of the lentil seeds found was 11.4% (Table 1). The initial water content was not adjusted; however, the value it is within the recommended limits for evaluating the electrical conductivity of seeds is between 10 to 17% (ISTA, 2006). The seeds also showed a good percentage of germination for the first counting of germination and final germination, with 74% and 94%, respectively (Table 1). These results are corroborated by Freitas and Nascimento (2010), through the characterization of four batches of lentils, where they did not find significant differences between the studied batches, with variation from 74% to 79% in the first counting of germination and variation from 86% to 94% for the percentage of final germination. For the accelerated aging test, 65% germination was obtained (Table 1); this value is greater than those found by Freitas and Nascimento (2010), with variations between 56-62% of germination, as for the 1000-seed weight, 71 g was obtained (Table 1).

TABLE 1 - Average data of water content (WC), germination (G), first counting of germination (FC), accelerated aging (AE), and 1000-seed weight (W1000) of Silvina lentil.

WC (%)	G (%)	FC (%)	AA (%)	W1000 (g)
11.4	94	74	65	71

There was a significant interaction when evaluating the number of seeds per replication and the soaking time, as described in Table 2, which indicates that these factors directly influence the value of electrical conductivity in lentil seeds. Within the combinations of the number of seeds and soaking time, higher values of conductivity in the seeds were observed, which were soaked for 15 h, realizing that for the seeds that were soaked for 3 h in any number of seeds (25, 50, 75, and 100), there was a continuous and significant reduction in electrical conductivity, but with less effect with the increase in the number of seeds (Table 1). The increase in the number of seeds and the soaking time provides greater results in electrical conductivity (Table 1). However, it is noted that, with 6 hours of soaking, samples with 50, 75, and 100 seeds do not differ statistically.

TABLE 2 - Analysis of variance of Silvina lentil seeds according to the number of seeds per sample and soaking time in hours.

	DF*	SS	MS	FC	P
Seeds	3	11714	3904.6	107.40	0.00000**
Time (hours)	4	19030	4757.6	130.87	0.00000**
Seeds*Times	12	3115	259.6	7.14	0.00000**
Error	60	2181	36.4		
Total	79	36041			

*DF = degrees of freedom, SS = sum of squares, MS = mean square, FC = calculated F, P = p-value. ** Significant at 5% probability of error.

There is a tendency to stabilize the values of electrical conductivity, with variations between 12 and 15 h, a fact explained by Lopes et al. (2010), who states that with the soaking process, the amount of exudates released by the seeds stabilizes due to the reorganization of cell membranes.

TABLE 3 - Electrical conductivity (μS cm^{-1} g^{-1}) in Silvina lentil seeds according to the number of seeds per sample and soaking time in hours.

Number of seeds	Soaking time (hours)				
	3	6	9	12	15
25	16.03 Aa*	29.44 Ab	33.53 Ab	33.71 Ab	39.67 Ab
50	18.54 Aa	40.91 Bb	48.71 Bbc	55. 85 Bcd	64.39 Bd
75	24.94 Bab	41.24 Bb	60.01 Cc	71.14 Cc	71.36 Bc
100	35.96 Ba	46.41 Ba	66.31 Cb	76.19 Cb	95.87 Cc

*Means followed by the same uppercase letter in the columns and lowercase letters in the lines do not differ by Tukey's test, at 5% probability of error.

Analyzing the factors (Figure 1), it is noted that the data were adjusted to the increasing linear regression according to the number of seeds, obtaining the value of 63.11 μS cm^{-1} g^{-1} with 100 seeds, 52.146% higher than the electrical conductivity recorded for 25 seeds (30.00 μS cm^{-1} g^{-1}). In Figure 1B, there is also a linear increase; this is dues to the soaking time of the seeds, obtaining the value of 67.82 μS cm^{-1} g^{-1} with 100 seeds, 64.80% higher than the electrical conductivity recorded for 25 seeds (23.87 μS cm^{-1} g^{-1}).

Similar results were obtained by Ataide et al. (2012) studying peanuts from the field, Sponchiado et al. (2014), with white oats. They found higher electrical conductivity values with the increase of the period of immersion of the seeds in water. Silva et al. (2013) observed a linear increase in the number of electrolytes according to the period of seed immersion in water. This fact makes it difficult to separate the treatments. Pinto et al. (2016) state that the longer the period of soaking in water, the greater the seed's amount of leachate.

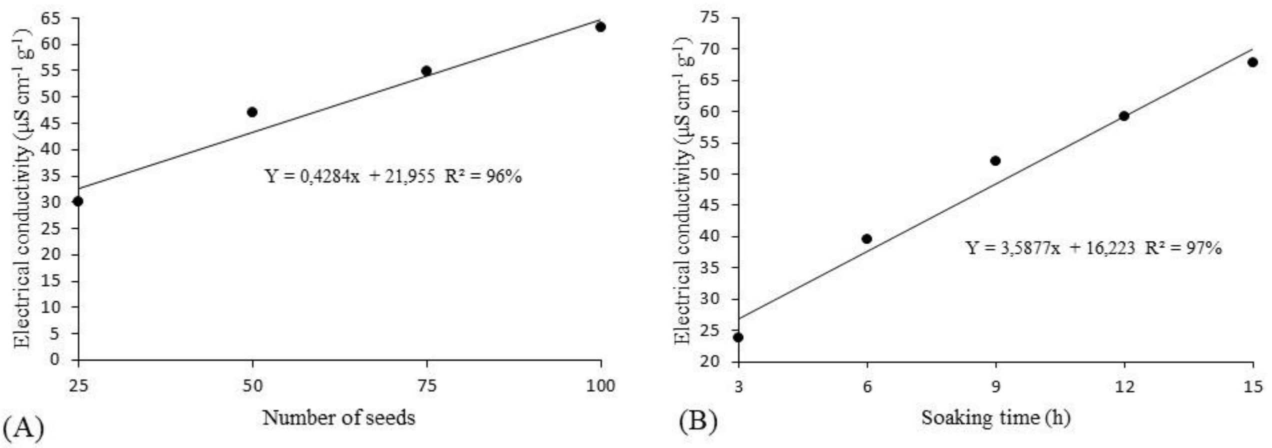

FIGURE 1 - Electrical conductivity of Silvina lentil seeds according to the soaking time and number of seeds. * Significant at 5% probability of error.

Araujo et al. (2011), Ataide et al. (2012) and Machado et al. (2011) recommend the use of samples with 50 seeds to grow peanuts, mung beans, and peas, respectively, the same number of seeds recommended by the International Seed Testing Association (ISTA, 2006). The 24 hours of immersion of the seeds in water is recommended for the electrical conductivity test in general; however, the reduction of this period is advantageous for the industry and seed laboratories, which seek quick information about the vigor of the lots (MILANI et al., 2012). Based on the time savings and greater practicality of the electrical conductivity test, it is recommended to perform it with samples of 50 seeds and measure after 12 h of soaking.

CONCLUSION

The use of replicates with 50 seeds submitted to 12 h of soaking shows the best results for the lentil seeds' electrical conductivity test.

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