VEIGA, J. S. B.; HENNIPMAN, P. S.; CARVALHO, T. C. de; Comparison of viability and vigor tests in soybean seeds (*Glycine max* (L.) Merrill.). **Applied Research & Agrotechnology,** Guarapuava-PR, v.13: e6063, 2020.
DOI: 10.5935/PAeT.V13.e6063

Scientific Paper

Comparison of viability and vigor tests in soybean seeds (*Glycine max* (L.) Merrill.)

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Abstract

The methodologies to determine seed vigor are used in order to complement the germination test, the latter estimate the viability of the seeds. Similarly, the tetrazolium test can also make this estimate, however, presenting its results earlier, when compared with the germination test. However, the viability and vigor analysis methodologies may present differences in results. Thus, the objective of this work was to compare the relation between the viability and vigor results of the tetrazolium test with the results of the germination and accelerated aging tests, respectively, in soybean seed lots. The experiment was conducted at the Seed Analysis Laboratory of the Parana State Association of Seed and Seedlings Producers, using 19 lots of the cultivar TMG7063 IPRO analyzed by germination, accelerated aging and tetrazolium tests (viability, vigor and identification of damages caused by stinkbugs, mechanical damage and moisture deterioration). The analysis of the data and the interpretation of the results allowed to conclude that the viability has a closer relation with the germination, even taking into account, that the tetrazolium test overestimates the results. Therefore, it can be assert that, for the evaluated lots, the viability presented results compatible with the results of germination pattern test. The analysis of vigor, by tetrazolium test compared to accelerated aging, presents inferior results of vigor, probably such results are influenced by identification and interpretation, of damage caused to the seeds, as mechanical, by stinkbug and moisture.

Keywords: accelerated aging, germination, physiological quality, tetrazolium.

Comparação de testes de viabilidade e vigor em sementes de soja (*Glycine max* (L.) Merrill.)

Resumo

As metodologias para determinar o vigor de sementes são utilizadas com a finalidade de complementar o teste de germinação, sendo que este último estima a viabilidade das sementes. De maneira semelhante, o teste de tetrazólio também pode fazer esta estimativa, porém, apresentando seus resultados antes, ao comparar com o teste de germinação. Entretanto, as metodologias de análise de viabilidade e vigor, podem apresentar diferenças de resultados. Desta forma, o objetivo deste trabalho foi comparar a relação existente entre os resultados da viabilidade e vigor pelo teste de tetrazólio, com os resultados dos testes de germinação e envelhecimento acelerado, respectivamente, em lotes de sementes de soja. O experimento foi conduzido no Laboratório de Análise de Sementes da Associação Paranaense dos Produtores de Sementes e Mudas, sendo utilizados 19 lotes da cultivar TMG7063 IPRO, analisados através dos testes de germinação, envelhecimento acelerado e teste de tetrazólio (viabilidade, vigor e identificação de danos causados por percevejo, danos mecânicos e deterioração por umidade). A análise dos dados e a interpretação dos resultados permitiram concluir que a viabilidade possui uma relação mais próxima com a germinação, mesmo levando em consideração, que o teste de tetrazólio superestima os resultados. Portanto, pode-se afirmar que, para os lotes avaliados, a viabilidade obtida pelo teste de tetrazólio apresentou resultados compatíveis aos resultados do teste padrão de germinação. A análise do vigor, pelo teste de tetrazólio comparado ao envelhecimento acelerado, apresenta resultados inferiores de vigor, provavelmente tais resultados são influenciados pela identificação e interpretação, de danos causados as sementes, como mecânico, percevejo e umidade.

Palavras-chave: envelhecimento acelerado, germinação, qualidade fisiológica, tetrazólio.

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Comparación de pruebas de viabilidad y vigor en semillas de soja (*Glycine max* (L.) Merrill.)

Resumen

Las metodologías para determinar el vigor de la semilla se utilizan para complementar la prueba de germinación, esta última estima la viabilidad de las semillas. Del mismo modo, la prueba de tetrazolio también puede hacer esta estimación, sin embargo, presentando sus resultados antes, en comparación con la prueba de germinación. Sin embargo, las metodologías de análisis de viabilidad y vigor pueden presentar diferencias en los resultados. Por lo tanto, el objetivo de este trabajo fue comparar la relación entre los resultados de viabilidad y vigor de la prueba de tetrazolio con los resultados de las pruebas de germinación y envejecimiento acelerado, respectivamente, en lotes de semillas de soja. El experimento se realizó en el Laboratorio de Análisis de Semillas de la Asociación Estatal de Productores de Semillas y Plántulas de Paraná, utilizando 19 lotes del cultivar TMG7063 IPRO analizados por germinación, envejecimiento acelerado y pruebas de tetrazolio (viabilidad, vigor e identificación de daños causados por chinches, mecánica daño y deterioro de la humedad). El análisis de los datos y la interpretación de los resultados permitieron concluir que la viabilidad tiene una relación más estrecha con la germinación, incluso teniendo en cuenta que la prueba de tetrazolio sobreestima los resultados. Por lo tanto, se puede afirmar que, para los lotes evaluados, la viabilidad presentó resultados compatibles con los resultados de la prueba del patrón de germinación. El análisis del vigor, mediante la prueba de tetrazolio en comparación con el envejecimiento acelerado, presenta resultados inferiores de vigor, probablemente dichos resultados están influenciados por la identificación e interpretación, del daño causado a las semillas, como mecánico, por chinches y humedad.

Palabras-clave: envejecimiento acelerado, germinación, calidad fisiológica, tetrazolio.

Introduction

Soybean stands out for being one of the most important crops in Brazil, which justifies the search for technologies to improve the performance of seeds in the field. In recent years, seed technology has progressively advanced, driven by advances in research (NUNES et al., 2014; MARTINS et al., 2016; ESCAMILLA et al., 2017; HOWARD, 2015; MARCOS FILHO et al., 2009;). Thus, in this segment is crucial the production of seeds with satisfactory quality for the proper establishment of the culture and obtaining adequate yields (BORNHOFEN et al., 2015, KOLCHINSKI et al., 2005).

The seed quality is composed of four pillars, characterized by physiological, genetic, sanitary and physical attributes (FRANÇA NETO et al., 2016; CARVALHO and NAKAGAWA, 2000; MARCOS FILHO, 2011). There are many factors that may interfere with the physiological quality of soybean seeds, such as mechanical, stinkbugs and moisture deterioration; these damages and their severity can be identified in the tetrazolium test. For Krzyzanowski et al. (2018), the physiological quality of soybean seed may be affected by deterioration factors occurring in the field and covering the already mentioned damage, in addition to the damage caused by pathogens.

Low-quality soybean seeds, when used, may result in loss of production, being necessary to perform a new sowing causing significant losses to producers (KRZYZANOWSKI et al., 2008; PINTO et al., 2015). Good management practices in conjunction with the use of proven quality seeds, justify the use of analyses that represent the real situation of the crop so that can predict its development.

To be marketed, the seeds are grouped in lots and subjected to laboratory tests, presenting different levels of physiological quality due to the tolerable and natural variation existing among the seeds that compose the lots. Greater heterogeneity of the field, due to the edaphhoclimatic and management conditions, greater will be these differences (MARCOS-FILHO, 1999; ALI et al., 2018).

To perform the evaluation of seed quality, tests such as germination and vigor, can be used. The germination test is widely used by laboratories; however, its results do not allow to detect the progress of deterioration of the seeds, indicating only the final stages of the process (MARCOS-FILHO, 1999; MARTINS et al., 2016; AMARO et al., 2015). In this sense, seedlings with lower physiological potential are computed as normal and may contribute to increase the germination percentage or accentuate the differences with seedling emergence in the field.

The vigor tests have the purpose of generating information regarding the behavior of the seeds in view of the probable climatic conditions that occur during storage and in the field (SMANIOTTO et al., 2014; MARCOS FILHO, 2006; CARVALHO and NAKAGAWA, 2000). To select the efficient methods that determine vigor, it is necessary to be sensitive, simple, low cost and the results should be related to the emergence of seedlings in the field (MARCOS FILHO, 2006; KRZYZANOWSKI et al., 2018).

Vigor tests are more sensitive to identify less advanced stages of seed deterioration, thus facilitating the decision on the fate of seed lots, but one of the limitations of some vigor tests refers to the time required, or to the subjectivity in its evaluation (PINTO et al., 2015). Among the vigor tests that can be considered fast, it stands out tetrazolium that in 19 hours can inform the vigor of the seeds, besides the sodium hypochlorite test that allows observing the mechanical damage of immediate effect occurring in the seed (KRZYZANOWSKI et al., 2008), computerized analysis of seedling images through the Software SVIS® (MARCOS FILHO et al., 2009) and the electrical conductivity test (VIEIRA and KRZYZANOWSKI,1999). Another procedure that allows obtaining rapid results on vigor of seed lots is the quantification of the respiratory rate, based on the determination of the concentration of CO_2 (DRANSKI et al., 2013; MENDES et al., 2009).

The accelerated aging test was initially developed to determine the storage potential of seeds. However, it has been used to verify the evaluation of the emergence potential of seedlings in the field (FREITAS and NASCIMENTO, 2006). This test seeks to estimate the behavior of seeds when subjected to adverse environmental conditions, usually caused by stresses (MARCOS-FILHO, 1999).

However, the physiological quality analysis of seeds (germination and vigor tests) have methodologies that can be longer, making them unfeasible when the decision-making of commercialization needs to be fast. According to Brasil (2009) the soybean germination test has a deadline for its conduction up to eight days. Thus, to meet the demand for the verification of the quality of lots in shorter time, the tetrazolium test can be an alternative of great value, because through the germination test only the development of the seeds is verified in ideal conditions. Carvalho et al. (2009) affirmed that the use of fast, reliable and easy-to-perform methods to estimate seed viability is necessary, due to the advantages provided by the speed of results in the various production segments.

The viability results obtained by the germination and tetrazolium tests should be similar, allowing differences up to 5% among them (FERREIRA et al., 2004; FRANÇA NETO, 1999). However, the occurrence of differences greater than this value, may occur due to the difference in sampling, improper techniques of conduction and evaluation of the tests, presence of hard seeds, sanitary quality, high rates of mechanical damage or damage caused by stinkbug, and seeds lots with medium or low vigor (FRANCE NETO, 1999).

Thus, the objective of this study was to compare the existing relation between the viability and vigor results by the tetrazolium test, with the results of the germination and accelerated aging tests, respectively, in lots of soybean seeds.

Material and methods

The experiment was performed at the Seed Analysis Laboratory of the Parana State Association of Seed and Seedling Producers (LAS APASEM) located in the Ponta Grossa city, PR, in the year 2018. 19 (nineteen) soybean lots from the cultivar TMG7063 IPRO were randomly selected, produced in the region of Campos Gerais, PR, referring to the 2017/2018 crop, identified and categorized as described in Table 1.

Table 1. Lots of soybean seeds selected for conducting the research.

Lots	Identification	Seed Category
1	01/18	C2
2	02/18	C2
3	03/18	C2
4	04/18	C2
5	05/18	C2
6	06/18	C2
7	07/18	Basic
8	08/18	Basic
9	09/18	Basic
10	10/18	Basic
11	11/18	C2

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Lots	Identification	Seed Category
12	12/18	C2
13	13/18	C2
14	14/18	C1
15	15/18	C1
16	16/18	C1
17	17/18	C1
18	18/18	C1
19	19/18	C1

For conducting the research, were obtained mean samples of 19 lots seeds, which were initially homogenized and reduced to a working sample, using a centrifugal splitter, as indicated in Brasil (2009). Subsequently, the work samples belonging to each seed lot, went through the physical purity determination, according to the methodology described in the Seed Analysis Rules (BRASIL, 2009). From the pure seed portion, laboratory analyses were performed to evaluate the physiological quality of the seeds.

The seeds used for the germination test were previously distributed on aluminum screens in acrylic boxes (gerbox type) containing 40 mL of water, avoiding contact with water through the methodology of overcoming dormancy for (*Glycine Max* (L.) Merrill.) indicated by SAR pre-conditioning at 25°C for 24 hours.

Below is the description of the seed quality tests that were applied.

Germination test: 400 seeds were transferred to 8 rolls of filter paper (germitest type), moistened with 2.5 times the weight of the dry substrate paper, each roll contained 50 seeds, which after confectioned were packaged in germinators at 25°C. The evaluation of the results was performed 5 days after sowing, identifying dead seeds, hard seeds, abnormal seedlings and normal seedlings, according to SAR (BRASIL, 2009). The results were expressed as average percentage of normal seedlings, among the repetitions of each treatment (lot).

Accelerated aging test: for the conduction of the test, it was adapted to the methodology proposed by Fratin and Marcos Filho (1984), following the indicated by Krzyzanowski et al. (1999), through preheating, the seeds were exposed to a condition of temperature of 41 ^{o}c for 48 hours. After this period, 200 seeds were transferred to 4 filter paper rolls moistened with 2.5 times the weight of the dry substrate paper and placed in the germinator at 25°C for 5 days. The evaluations were performed as indicated for the germination test (BRASIL, 2009). The results were expressed as average percentage of normal seedlings, among the repetitions of each treatment (lot).

Tetrazolium test (TZ): for conduction of the test, 200 seeds were divided into two replications of 100 seeds each, and were kept wrapped in filter paper previously moistened, with volume of 2.5 times the dry weight of the paper, at 25°C for 16 hours. After this period, the seeds were immersed in 0.075% tetrazolium solution concentration, at 40°C, in the dark, for approximately 2 to 3 hours, until they reached the reddish coloration. The evaluation was carried out through levels of damage (mechanical, by stinkbug and by moisture), attributing a 1-3 to the viable and vigorous seed class, 4-5: Viable seeds and little vigorous, hard: unfeasible seeds that do not possess the ability of soaking in water, 6-8: unviable seeds, following the methodology of Brasil (2009) and França Neto et al.(1998). Through this test, seed viability (seed class 1 to 5) and vigor (seed class 1 to 3) were obtained. The results were expressed as a mean percentage of viability and vigor, between repetitions of each treatment (lot).

Through the results obtained with the tests, it was made the comparison of the results of the germination test with the viability (obtained by the tetrazolium), and accelerated aging with vigor (obtained by the tetrazolium).

The experimental design was completely randomized (CRD), with four replications, in a double factorial scheme, being the lots the first factor and the tests the second factor; being compared the viability by the tetrazolium test with the germination test and vigor by the tetrazolium test with the accelerated aging test. The data obtained were subjected to analysis of variance and the averages were compared by the Scott-Knott test at 5%. The analyses were performed using the statistical program AgroEstat (BARBOSA and MALDONADO JUNIOR, 2015).

Results and discussion

Table 2 shows the data obtained in the germination test and viability by the tetrazolium test for soybean lots of cultivar TMG7063 IPRO. It is observed that there was stratification of the lots in 4 levels, both in the germination and in the viability by tetrazolium, when comparing the lots in each test.

All soybean seed lots presented germination percentage similar or higher than the minimum established by MAPA (2013), 80% (Normative Instruction 45/2013, Annex XXIII- Patterns for production and marketing soybean seeds (*0* L.), as shown in Table 2. The seed germination variation of the lots (Table 2) was between 82 and 92%, being stratified as follows: lower germination (82 to 85%), intermediate (86 to 89%) and higher germination (90 to 92%). For seed viability by the tetrazolium test, the results ranged from 88 to 95%, with the lots ranked in: lower viability (88 to 89%), intermediate (90 to 92%), and higher viability (93 to 95%). According to the classification, for the results of the germination and viability tests (TZ), the lots 03/18, 06/18, 08/18, 13/18, 14/18, 16/18, 17/18 and 18/18, are at the same level: lower germination and viability (03/18 and 08/18), intermediate germination and viability (06/18, 13/18, 17/18 and 18/18), higher germination and viability (14/18 and 16/18). The other lots didn't present the same classification described above, and most of them (01/18, 02/18, 04/18, 05/18, 07/18, 09/18, 10/18, 11/18 and 12/18) were ranked so that the classification for viability was higher in relation to classification for germination. Lots 15/18 and 19/18 presented an inverse classification (higher germination), but according to the percentages, the first lot cited had identical results for the two variables (92%) and lot 19/18, higher results for viability (86% of normal seedlings and 89% of viable seeds).

Table 2. Average data of germination and viability by tetrazolium test (TZ) obtained in 19 lots of soybean seeds.

Lots	Germination	Viability (TZ)
	-----%-----	
01/18	89 bB	93 bA
02/18	85 cB	91 cA
03/18	83 dB	88 dA
04/18	87 bB	95 aA
05/18	88 bB	94 aA
06/18	88 bB	91 cA
07/18	89 bB	95 aA
08/18	82 dB	88 dA
09/18	85 cB	93 bA
10/18	85 cB	92 bA
11/18	86 cB	93 bA
12/18	89 bB	95 aA
13/18	87 bB	90 cA
14/18	90 aB	95 aA
15/18	92 aA	92 bA
16/18	90 aB	95 aA
17/18	89 bB	92 bA
18/18	89 bB	92 bA
19/18	86 cB	89 dA
VC(%)	1,89*	

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* Averages followed by the same lowercase letter in the column and capitalized in the row do not differ by the Scott-Knott test at 5%.

When analyzing the results of the comparison between the germination and viability within the same lot, all lots presented significant differences, except lot 15/18 (Table 2). It was verified that there were differences between the methods used to determine the viability of soybean seeds. Thus, it was verified that the tetrazolium test can overestimate the viability of the samples analyzed when compared with the germination test (Table 2). The determination of both viability and vigor by the afore mentioned test constitutes an estimation of its potentiality, not obtaining values from seedling growth (DUARTE and LOBO JUNIOR, 2011). In the case of the occurrence of dormant seeds, for example, in the tetrazolium test these are classified as viable seeds (DIAS and ALVES, 2008; DUARTE and LOBO JUNIOR, 2011) overestimating the viability results when comparing with the results of the germination test.

Generally, the results of the tetrazolium test are higher and very close to the results of the germination test (Table 2). According to Oliveira et al. (2005), this happens because in the tetrazolium test, only the embryo is evaluated, not considering the influence of the external structures of the seeds as analyzed in the germination test, as the possible infections of Pathogens to seeds. These characteristics are important for the reliability of the results, because the vigor tests should be able to detect differences in the physiological potential of lots, especially those with similar germinative power (MARTINS and SILVA, 2005; COIMBRA et al., 2009). Also, the presence of intact or early germination (symptoms of dormancy occurrence) may determine the prolongation of the test, allowing these seeds to complete the germination, but in this case, doubts may arise as to the lower speed of germination, if the cause would be dormancy or inferior physiological potential (MARCOS-FILHO, 1999).

Zagui and Neres (2018), when working with soybean seeds, verified that the viability of the seed lots analyzed did not differentiate between them in the tetrazolium test, even though there were considerable percentages of seeds that are viable in all treatments, what means that they are apt to germinate. Duarte and Lobo Junior (2011), observed in bean seeds (*Phaseolus vulgaris* L.), that the viability was nine percentage points higher than the germination; in such a way that the tetrazolium test overestimated the viability of the samples, since the viability by the afore mentioned test demonstrates an estimation of its potentiality, not obtaining values from the growth of the seedlings. Schuab et al. (2002), working with soybean seeds, were able to identify the best cultivars in relation to viability (by tetrazolium) in a similar way, correlating with the germination test. The same happens on the germination and viability values expressed in Table 2, and the lots with the highest germination percentual were the same ones that obtained superior viability in the tetrazolium test, with a mean difference of five percentage points more for viability (tetrazolium), when compared to germination; the lot 15/18 showed equal results for both tests.

Lima et al. (2010) found in cucumber seeds (*Cucumis sativus* L.) a positive correlation between the tetrazolium test and the germination test, both highlighted the same lots with the highest viability. The present study presents this characteristic for lots 14/18 and 16/18 (Table 2).

França Neto et al. (2010) expose the limitations of the germination test in soybean seeds, because in addition to the relatively long period for its execution, the test does not allow accurate identification of the factors affecting seed quality, and its results are often masked by the presence of potentially pathogenic fungi. However, the tetrazolium test is not affected by several conditions that may affect the germination pattern.

Table 3 refers to the results of the accelerated aging and vigor obtained by the tetrazolium test. The two tests were able to divide the lots into two groups, with results from 86 to 94% for normal seedlings in the accelerated aging test and 77 to 83% of seed vigor by the tetrazolium test.

Table 3. Average data of accelerated aging and vigor by tetrazolium test (TZ) obtained in 19 lots of soybean seeds.

Lots	Accelerated Aging	Vigor (TZ)
	-----%-----	
01/18	93 aA	81 aB
02/18	90 aA	77 bB
03/18	86 bA	79 bB
05/18	92 aA	83 aB
06/18	88 bA	80 bB
07/18	93 aA	80 bB
08/18	85 bA	79 bB
09/18	91 aA	84 aB
10/18	91 aA	77 bB
11/18	93 aA	83 aB
12/18	94 aA	81 aB
13/18	86 bA	80 bB
14/18	93 aA	80 bB
15/18	88 bA	84 aB
16/18	92 aA	82 aB
17/18	88 bA	79 bB
18/18	89 bA	70 bB
19/18	86 bA	77 bB
VC(%)	2,78*	

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* * Averages followed by the same lowercase letter in the column and capitalized in the row do not differ by the Scott-Knott test at 5%.

According to the values expressed in Table 3, the lots 02/18, 04/18, 07/18, 10/18 and 14/18 were stratified in a different way, classified with higher results in accelerated aging and lower in vigor by tetrazolium. When comparing the accelerated aging and tetrazolium tests within the same lot, it was verified that all the lots differed, and the values of the accelerated aging test were superior in discrepancy with the values obtained by vigor in the tetrazolium test (Table 3).

França Neto et al. (1998) characterize, in the tetrazolium test, as: very low vigor: values less than or equal to 49%; low vigor: values between 50 and 59%; average or intermediate vigor: values from 60 to 74%; high vigor: values between 75 and 84%; and very high vigor: values equal to or greater than 85%. According to the results presented in Table 3, it is verified that only lot 18/18 was characterized as medium or intermediate vigor, being all others with high vigor.

Studies conducted by Dutra and Vieira (2004) evaluating soybean seeds by the aging test, obtained satisfactory results to determine the difference of vigor between lots, agreeing with the results presented in Table 3.

Aguilera and Menezes (2000) studying the quality of different soybean cultivars, through the physical and physiological characterization of the seeds, verified that the accelerated aging test was more accurate to detect the differences of vigor between cultivars; and the tetrazolium test was more sensitive to verify the vigor changes in soybean seeds. However, it was possible to rank soybean lots according to physiological quality, with germination, accelerated aging and tetrazolium tests as good quality indicators of soybean seed lots, as can be verified through the results obtained by Tables 2 and 3.

The results of the germination and viability tests by the tetrazolium test (Table 2), have greater interaction for the analyzed lots than the accelerated aging test and vigor by tetrazolium (Table 3). According to França Neto et al. (1998), the tetrazolium test has many advantages, such as not being affected by conditions that may affect the germination pattern and focus to the physical and physiological conditions of the embryo of each individualized seed, allowing rapid evaluation of viability and vigor at different levels, providing the diagnosis of the cause of the fall in seed viability.

In the tetrazolium test, mechanical damage, damage by stinkbug and moisture deterioration are identified, as can be characterized by figures 1A, 1B, 1C, 1D, 1E and 1F. Zagui and Neres (2018) also indicate the similar classification for soybean seeds according to the methodology proposed by França Neto et al. (1998).

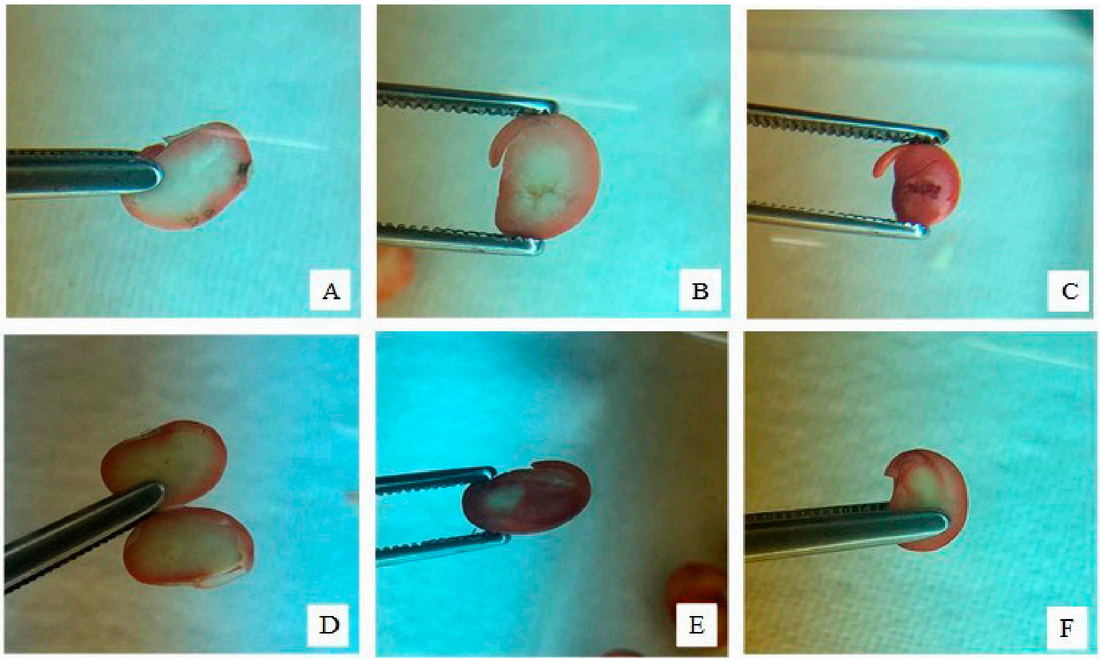

Figure 1. Soybean seeds subjected to tetrazolium test, being (A): Damage by stinkbug class 1-3 (inner face); (B): Damage by stinkbug class 4-5 (inner face); (C): Damage by stinkbug class 4-5 (outer face); (D): Mechanical damage class 6-8 (inner face: sectioned embryonic axis); (E): Moisture deterioration class 4-5 (inner face); (F): Moisture deterioration class 6-8 (inner face: embryonic axis reached).

Table 4 shows the average percentage of mechanical damage, by stinkbug and moisture, at different levels of classification, as specified in the preceding paragraph. In the classification levels (6-8), which unviable the seeds, the mechanical damage and caused by stinkbugs when accounted together, reached the average percentage of 2%, and the damage caused by moisture deterioration showed an average of occurrence of 6% for the analyzed lots, classising as intermediaries (between without restriction and serious problem), as affirmed by França Neto et al. (1998). The percentages of mechanical damage, moisture deterioration and stinkbug damage in the level (seed class of 6-8, illustrated by figures 1D and 1F), indicate the percentage of viability loss caused by the afore mentioned damages, being considered in relation the quality of seed as: without restriction: less than 6%, serious problem: between 7 to 10%, very serious problem: more than 10%.

Table 4. Average data on viability, vigor and damage different levels through the tetrazolium test (TZ), obtained in 19 lots of soybean seeds.

Lots	Mecanical Damages + Stinkbug Damages		Moisture Deterioration		
	(4-5)	(6-8)	(1-8)	(4-5)	(6-8)
	-----%-----		-----%-----		
01/18	0 a	1 a	36 a	0 a	6 b
02/18	0 a	1 a	10 e	1 a	8 a
03/18	1 a	3 a	19 d	1 a	9 a
04/18	0 a	2 a	13 e	1 a	3 c
05/18	0 a	3 a	23 d	2 a	3 c
06/18	0 a	2 a	33 c	3 a	7 b
07/18	0 a	1 a	22 d	2 a	4 c
08/18	0 a	2 a	32 c	3 a	10 a
09/18	1 a	1 a	30 c	1 a	6 b
10/18	0 a	2 a	21 d	1 a	6 b
11/18	0 a	1 a	42 b	0 a	6 b
12/18	0 a	1 a	29 c	1 a	4 c
13/18	1 a	1 a	35 c	3 a	9 a
14/18	0 a	2 a	29 c	2 a	3 c
15/18	1 a	1 a	13 e	3 a	7 b
16/18	1 a	3 a	39 b	2 a	2 c
17/18	0 a	3 a	22 d	4 a	5 c
18/18	1 a	2 a	52 a	2 a	6 b
19/18	1 a	2 a	19 d	2 a	9 a
Average	0	2	28	2	6
VC(%)	146,7*	82,4*	21,7*	57,4*	34,5*

*Averages followed by the same lowercase letter in the column do not differ from each other by the Scott-Knott test at 5%.

In the analyzed lots, the damage caused by moisture deterioration was very expressive at all levels (1-8), Table 4, so that Krzyzanowski et al. (2018) confirm the characterization effective of this damage through the tetrazolium test. Moisture deterioration may cause an increment in the deteriorating speed of the studied lots, as well as Brandelero et al. (2019), by the assert that seed damage leads to abnormal plant development, making them less apts to the environment and less productive; results similar to those obtained by França Neto et al. (2016).

Moisture deterioration can cause a very speed reduction in seed vigor when in storage conditions, since moisture may still increase the development of other damage, such as mechanical damage and damage caused by dissemination of pathogens by finding an environment with the necessary characteristics to develop. Pilon et al. (2018) and Brandelero et al. (2019), conducting studies on the influence of moisture and temperature on the vigor of soybean seeds, observed the influence that moisture exerts on the other damages; and still point the moisture deterioration as the main factor affecting the physiological behavior of the seed, through the tests of tetrazolium, emergency infield, germination, germination speed index and accelerated aging. Figures 2A and 2B evidence the high incidence of moisture damage in the seeds of the lots evaluated in this study. According to Forti et al. (2010), the quality of soybean seeds has been compromised by the high moisture deterioration rates, as in the results obtained (Table 4).

Terasawa et al. (2009) evaluating the physiological quality of soybean seeds of the cultivar FTS Cascavel RR according to the anticipation of the harvest, verified that the seeds evaluated were high vigor (between 75% and 84%) in the classification suggested by França Neto et al. (1998), even for moisture damage from track 4 (4-5 and 6-8) resulting in high physiological quality seeds.

Based on the quality information from laboratory analyses, one of the first aspects to be observed is the seed performance during the germination and emergence process in the field (KRZYZANOWSKI et al., 2018).

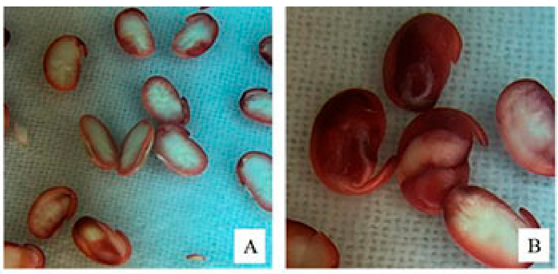

Figure 2. Soybean seeds subjected to tetrazolium test, being (A): High incidence of moisture deterioration (inner face); (B): High incidence of moisture deterioration (external face).

Even though the tetrazolium test showed results that overestimated the viability of lots when compared to the germination test, this test, in addition to its speed of execution, was important to determine the viability of soybean seeds and the nature of the damage affecting the physiological quality, as verified in this experiment.

In summary, the tetrazolium test may show results referring to the physiological potential of seeds, as well as accelerated aging, even the results of these two tests did not present similarity, as verified in soybean seeds studied lots according Table 3, where it can be verified that the vigor by tetrazolium showed lower results when compared to accelerated aging. In addition to the tetrazolium test, it is able to demonstrate the high amount of moisture damage present in the evaluated lots (Table 4).

Conclusões

The tetrazolium test can be used to quantify the viability of soybean seeds, especially when compared with the germination pattern.

To evaluate the vigor, the tetrazolium test compared to accelerated aging, showed lower vigor results, probably such results are influenced by identification and interpretation, of damage caused to the seeds, as mechanical, by stinkbug and moisture.

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