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Qualidade fisiológica de sementes de soja em resposta a doses de pó de basalto

Physiological quality of soybean seeds in response to doses of basalt powder

Calidad fisiológica de semillas de soja en respuesta a dosis de polvo de basalto

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Resumo

A utilização e incorporação de pó de basalto no solo tem crescido a cada ano e ainda não existem trabalhos que mostrem os efeitos dele sob a qualidade fisiológica de sementes de soja. Assim, considerando a importância desta resposta no sistema produtivo, o objetivo do presente trabalho foi avaliar a qualidade fisiológica de sementes de soja após a aplicação superficial de diferentes doses de pó de basalto no solo. O delineamento experimental utilizado foi inteiramente casualizado em esquema fatorial 3 × 4, com três repetições. Os tratamentos consistiram em três cultivares de soja e quatro doses de pó de basalto (0, 1, 3 e 5 t ha^{-1}) produzidas na safra 2018/2019 na região de Chapadão do Sul, MS. Os testes realizados foram: primeira contagem de germinação, germinação, condutividade elétrica, massa seca da parte área e de raízes de plântulas e teste de tetrazólio (vigor, viabilidade, danos mecânico, umidade e percevejos). Os resultados foram submetidos ao teste de normalidade e análise de variância, seguido de comparações de médias, pelo teste de Tukey ao nível de 5% de probabilidade. Os resultados mostraram por primeira vez efeitos combinados de ambos os fatores testados apenas nas variáveis condutividade elétrica, comprimento da raiz, vigor, viabilidade e dano mecânico. A resposta obtida foi dependente das cultivares avaliadas que se diferenciaram para todas as características mesuradas.

Palavras-chave: *Glycine max*; Pó de rocha; Remineralizadores; Teste de tetrazólio.

Abstract

The use and incorporation of basalt powder in the soil have grown every year, and there are still no studies showing its effects on the physiological quality of soybean seeds. Thus, considering the importance of this response in the production system, the objective of the present research was to evaluate the physiological condition of soybean seeds after applying different doses of basalt powder in the soil. The experimental design used was completely randomized in a 3 × 4 factorial scheme, with three replications. The treatments consisted of three soybean cultivars, and four doses of basalt powder (0, 1, 3, and 5 t ha^{-1}) produced in the 2018/2019 harvest in the region of Chapadão do Sul, MS. The tests carried out were: first germination count, germination, electrical conductivity, dry mass of the upper plant and roots, and tetrazolium test (vigor, viability, mechanical damage, moisture, and bed bug damage). The results were submitted to the normality test and analysis of variance, followed by comparisons of means by the Tukey test at the level of 5% probability. The results showed for the first time the combined effects of both factors tested only on the variables: electrical conductivity, root length, vigor, viability, and mechanical damage. The response obtained was dependent on the cultivars evaluated, which differed for all measured characteristics.

Keywords: *Glycine max*; Rock powder; Remineralization; Tetrazolium test.

Resumen

El uso e incorporación de polvo de basalto en el suelo ha crecido a cada año y todavía no hay estudios que demuestren sus efectos sobre la calidad fisiológica de las semillas de soja. Por lo tanto, considerando la importancia de esta respuesta en el sistema productivo, el objetivo del presente trabajo fue evaluar la calidad fisiológica de las semillas de soja después de la aplicación superficial de diferentes dosis de polvo de basalto en el suelo. El diseño experimental utilizado fue completamente al azar en un esquema factorial 3 × 4, con tres repeticiones. Los tratamientos consistieron en tres cultivares de soja y cuatro dosis de polvo de basalto (0, 1, 3 y 5 t ha^{-1}) producidas en la zafra 2018/2019 en la región de Chapadão do Sul, MS. Las pruebas realizadas fueron: primer recuento de germinación, germinación, conductividad eléctrica, masa seca de la parte área y raíces de plántulas y prueba de tetrazolio (vigor, viabilidad, daños mecánicos, humedad e insectos). Los resultados se sometieron a la prueba de normalidad y al análisis de varianza, seguidos de comparaciones de medias, por la prueba de Tukey al nivel de probabilidad del 5%. Los resultados mostraron por primera vez efectos combinados de ambos factores evaluados, apenas en las variables conductividad

eléctrica, longitud de la raíz, vigor, viabilidad y daño mecánico. La respuesta obtenida dependía de los cultivares evaluados, que diferían para todas las características medidas.

Palavras-claves: *Glycine max*; Polvo de roca; Remineralizadores; Prueba de tetrazólio.

1. Introduction

The cultivation of soybeans in the 2019/2020 harvest was 36.8 million hectares, with a total production of 120.3 million tons (CONAB, 2020). Soybeans occupy about 59% of the grain cultivated area in Brazil, and the country is among the leading world producers, losing to the United States, which together exceed 66% with more than 231 million tons of grain production from all over the world. The planet, followed by China, according to the United States Department of Agriculture (USDA, 2020).

The high productivity of this legume depends on proper soil nutrition to achieve high production levels, generally obtained through the use of chemical fertilization, associated with good practices in the management of pests and diseases that allow seeds with high nutritional value and physiological quality. Top-quality seeds generate highly vigorous plants, allowing access to genetic advances, with guarantees of quality and adaptation technologies in the different regions, ensuring higher productivity (Prado et al., 2020). Therefore, good soil fertility is essential to maintain the physiological quality of seeds.

Maintaining soil fertility depends on the use of fertilizers. Brazil is a significant importer of fertilizers, mainly phosphorus, and potassium, generating a higher production cost and extensive international dependence (Manning & Theodoro, 2018). Therefore, alternatives are sought, such as the use of rock dust, configured as the incorporation of rocks in the soil, causing a rejuvenation for low fertility soils (Ramos et al., 2015). The rocks slowly release a set of minerals and trace elements, mainly SiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, Na_2O, K_2O and CaO (Ramos et al., 2014; Nunes et al., 2014; Ratke et al., 2020), that provide the perfect environment for natural agriculture, while improving the availability of these nutrients in the soil.

In Brazil, the effect of using ground rock powder is efficient in the development of *Theobroma cacao* L. (Anda et al., 2009); *Myrciaria dubia* (Welter et al., 2011); *Fragaria ananassa* Duch (Camargo et al., 2012); *Triticum aestivum* L. (Ramezanian et al., 2013); *Solanum tuberosum* (Santos et al., 2014); *Phaseolus vulgaris* L. (Bertoldo et al., 2015); *Zea mays* L. (Aguilera et al., 2020a) and soybean (Aguilera et al., 2020b). However, the effects on

the physiological quality of seeds produced with rock dust under field conditions were not observed.

The productive increase of the cultures due to the use of rock dust emphasized; however, the evaluation of the post-harvest quality, mainly of seeds, has still been little studied. In this sense, this research objective was to evaluate the physiological condition of seeds of soybean cultivars produced with doses of basalt powder.

2. Material and Methods

The present research is an experimental, quantitative research, which follows the fundamentals of this type of research, as recommended by Pereira et al. (2018). Quantitative data were obtained at the Seed Technology Laboratory of the Federal University of Mato Grosso do Sul (UFMS), Campus Chapadão do Sul (CPCS), Mato Grosso do Sul (MS). The seeds of different soybean cultivars for the evaluation of physiological quality in the laboratory were produced in the field, with doses of basalt powder, in the CPCS experimental area, located at 18° 46' 17.9" south latitude, 52° 37' 25.0" west longitude and the average altitude of 810 m) in the 2018/2019 cropping season.

2.1 Field experiment

During the 2018/2019 cropping season, field experiments conducted in an Oxisol, which was sampled before starting the research at a depth of 0.00-0.20 m, and the main chemical properties were determined (Table 1).

Table 1 - Main chemical properties of the soil in the field experiment.

pH	OM	P	H+Al	Al^{3+}	Ca^{2+}	Mg^{2+}	K^{+}	EC	V
$CaCl_2$	g MD^{-3}	mg MD^{-3}	----------		$cmol_c$ MD^{-3}			----------	%
4.3	22.8	12.8	5.7	0.37	2.20	0.40	0.27	8.6	33.5

OM: Organic matter. EC: Cation exchange capacity at pH 7.0. V: Base saturation. Source: Aguilera et al. (2020b).

The result of the soil analysis indicated the need to correct the acidity of the soil, which was carried out 60 days before the implementation of the experiment with the superficial application of 2.5 t ha^{-1} of limestone (CaO: 29%; MgO: 20%; total relative

neutralizing value: 90.1% compared to calcium carbonate) was performed to correct acidity and raise soil base saturation (levels of Ca^{2+}, $Mg^{2+,}$ and K^{+} present in the exchange capacity of the soil) method was used to calculate the limestone amount to 60%.

According to the Köppen classification, the climate of the region is the tropical rainy (Aw) type, with wet summers and dry winters. The main climate characteristics during field experiments described by Aguilera et al. (2020b).

2.1.1 Seed production under field conditions

In the field, the cultivars were conducted in a randomized block design, arranged in a 3 × 4 factorial scheme, with three replications. The treatments consisted of three soybean cultivars and four dose basalt powder (0, 1, 3, and 5 t ha^{-1}). The three soybean cultivars used were: Brasmax Foco IPRO - indeterminate growth habit, an average cycle of 109 days, maturity group 7.2; Brasmax Desafio IPRO - indeterminate growth habit, 113 days in between, maturity group 7.4 and Brasmax Bônus IPRO - indeterminate growth habit, the average cycle of 121 days, maturity group 7.9. The basalt powder was applied superficially one week before the experiment's installation, being distributed in the experimental plots previously identified, and the basalt powder chemical characteristics were described by Aguilera et al. (2020b).

The three soybean cultivars were sowing with the mechanically seeder-fertilizer machine, distributing 13 seeds per meter, with a row spacing of 0.45 m, generating a population of 288 thousand plants. The base fertilization was broadcast pre-plant consisted of 150 kg P_2O_5 ha^{-1}, whose source was mono ammonium phosphate (11% ammonia N and 52% P_2O_5). Throughout the crop cycle, the control of plants, pests, and harmful diseases carried out with chemicals on demand (Aguilera et al., 2020b).

Within each block, the experimental unit, consisting of six lines of three meters in length, was established, with the two external lines on each side and the 0.50 m at each end of the plot used as a border, thus constituting the useful area with the four lines from the center of the 2 m long plot. The valuable space at the end of the experiment was collected manually and tracked in a stationary tracker. The seeds obtained were standardized by size using a 6.0 mm diameter sieve and kept in a refrigerated chamber until physiological quality tests were performed.

2.2 Evaluation of the physiological quality of seeds

The seeds harvested from the three cultivars when conducting the field experiment with a dose of basalt powder were used in the laboratory's physiological quality tests. Initially, the seeds' moisture content was determined by weighing 10 g of the sample in two repetitions, placed in an oven at 105 ºC ± 1 ºC for 24 h; then, the samples were removed and placed in a desiccator for later weighing (Brasil, 2009).

The following variables were evaluated: first germination count (FGC); germination (GERM); plant length (PL); root length (RL); dry plant mass (DPM); dry root mass (DRM); electrical conductivity (EC) and tetrazolium [vigor (VIG); viability (VIA); mechanical damage (MD); moisture damage (MoD) and bed bug damage (BBD)].

For the germination test, four replicates of 50 seeds were used, distributed in rolls of germitest paper towels, moistened with distilled water in a proportion 2.5 times the mass of the non-hydrated paper, in a germinator typeset at 25 ºC ± 2 ºC. The evaluations were performed on the 5th (first count, FGC) and the 8th day (total germination, GERM) after the installation of the test by counting healthy seedlings (Brasil, 2009).

The evaluate the growth (PL and RL), and dry mass (DPM and DRM) of soybean seedlings, four replications of 20 seeds were used and placed to germinate under the same conditions as the germination test. At seven days, the seedlings were removed from the germinator, and the area (hypocotyl and cotyledon) of the root was separated, measuring the length of both parts (PL and RL) individually with the aid of a millimeter rule (cm). Afterward, the samples were placed in kraft paper packaging in a forced air oven at 65ºC for three days. At the end of this period, the samples are weighed (mg) on a precision scale (0.001 g) (Brasil, 2009).

The EC was measured in four replicates per treatment, each containing 25 seeds, weighed on a 0.001 g precision scale, placed in plastic cups with 75 mL of distilled water, and stored in BOD at 25 ºC, for 24 hours. After this period, the EC reading of the soak solution with a digital conductivity meter of the brand Conductivity Meter model CD-4301. The results were expressed in μS cm^{-1} g^{-1} according to the methodology described by Marcos Filho et al. (1987).

In the tetrazolium test, two replicates of 50 seeds were pre-moistened on germitest paper for 16 hours at 25°C and subjected to 0.075% tetrazolium solution, maintained for three hours at 35°C in the absence of light. After this period, the seeds were washed in running

water, and the variables VIG, VIA, MD, MoD, and BBD were evaluated according to the methodology established by França-Neto (1999).

2.3 Statistical analysis

The experimental data were subjected to tests to verify the assumptions of normality and homogeneity of variance. Subsequently, the analysis of variance (ANOVA) was performed and, when significant, the means were compared using the Tukey test at 5% probability, using the GENES statistical program (Cruz, 2013). The regression analysis was used for doses of basalt powder (F test, $P<0.05$) and equations with the highest significant coefficients of determination were chosen using the GENES software, and the graphs were generated in SigmaPlot 11.0 for Windows (Systat Software, Inc., San José, CA, USA) to better present and interpret the data.

3. Results

The parameters of the seeds' physiological quality showed significant differences ($P<0.001$) for soybean cultivars. However, the doses of basalt powder differed only for the VIG and MD (Table 2).

Significant interaction between cultivars and doses of basalt powder was obtained for the variables ER, RL, VIG, VIA, and MD. Parameters like FGC, GERM, PL, DPM, DRM, MoD, and BBD of soybean seeds did not show a significant interaction between cultivars and doses of basalt powder, so the means of the different characteristics for both evaluated factors were compared to the ways by the Tukey ($P<0.05$) (Table 3).

Table 2 - Analysis of variance of the physiological quality of seeds, obtained in experiments with doses of basalt powder in three soybean cultivars in the 2018/2019 harvest. Chapadão do Sul, MS, Brazil.

Variable	------ Probability > F¹ -------			CV (%)	Means	Minimum	Maximum
	Cultivars (C)	Doses (D)	Interaction (C x D)				
FGC (%)	< 0.001	0.63	0.31	9.09	88.86	52	100
GERM (%)	< 0.001	0.90	0.32	7.38	91.64	56	100
PL (cm plant^{-1})	< 0.001	0.17	0.11	11.55	5.48	2.06	8.39
RL (cm plant^{-1})	< 0.001	0.90	0.001	13.52	6.79	2.16	12.47
DPM (mg plant^{-1})	< 0.001	0.46	0.24	17.73	15.59	7.88	27.58
DRM (mg plant^{-1})	< 0.001	0.13	0.31	30.69	5.27	1.82	11.7
EC (µS cm^{-1} g^{-1})	< 0.001	0.56	0.01	10.76	97.05	74.81	148.33
VIG (%)	< 0.001	0.003	0.004	7.09	89.25	60	100
VIA (%)	< 0.001	0.06	0.04	4.15	94.79	80	100
MD (%)	< 0.001	< 0.001	0.03	150.71	1.96	0	16
MoD (%)	< 0.001	0.35	0.08	118.95	2.84	0	20
BBD (%)	< 0.001	0.55	0.16	193.79	0.45	0	4

¹Test F. CV: coefficient of variation; FGC: first germination count; GERM: germination; PL: length plant; RL: root length; DPM: dry plant mass; DRM: dry root mass; EC: electrical conductivity; VIG: vigor; VIA: viability; MD: mechanical damage; MoD: moisture damage; BBD: bed bug damage. Source: Research data.

The variation coefficients obtained showed fair values below 31%, except for variables related to seed damage (MD, MoD, and BBD), which showed values above 115%, mainly influenced by values close to zero. The low values of MD, MoD, and BBD values represent no damage to the evaluated seeds.

Behavior of the three cultivars evaluated shows similarity for the variables FGC and GERM with emphasis on the cultivars Brasmax Foco IPRO and Brasmax Desafio IPRO, which at the same time had the lowest values for MoD and BBD, and thus behaved with good germination and small damage in the seeds under the conditions tested (Table 3).

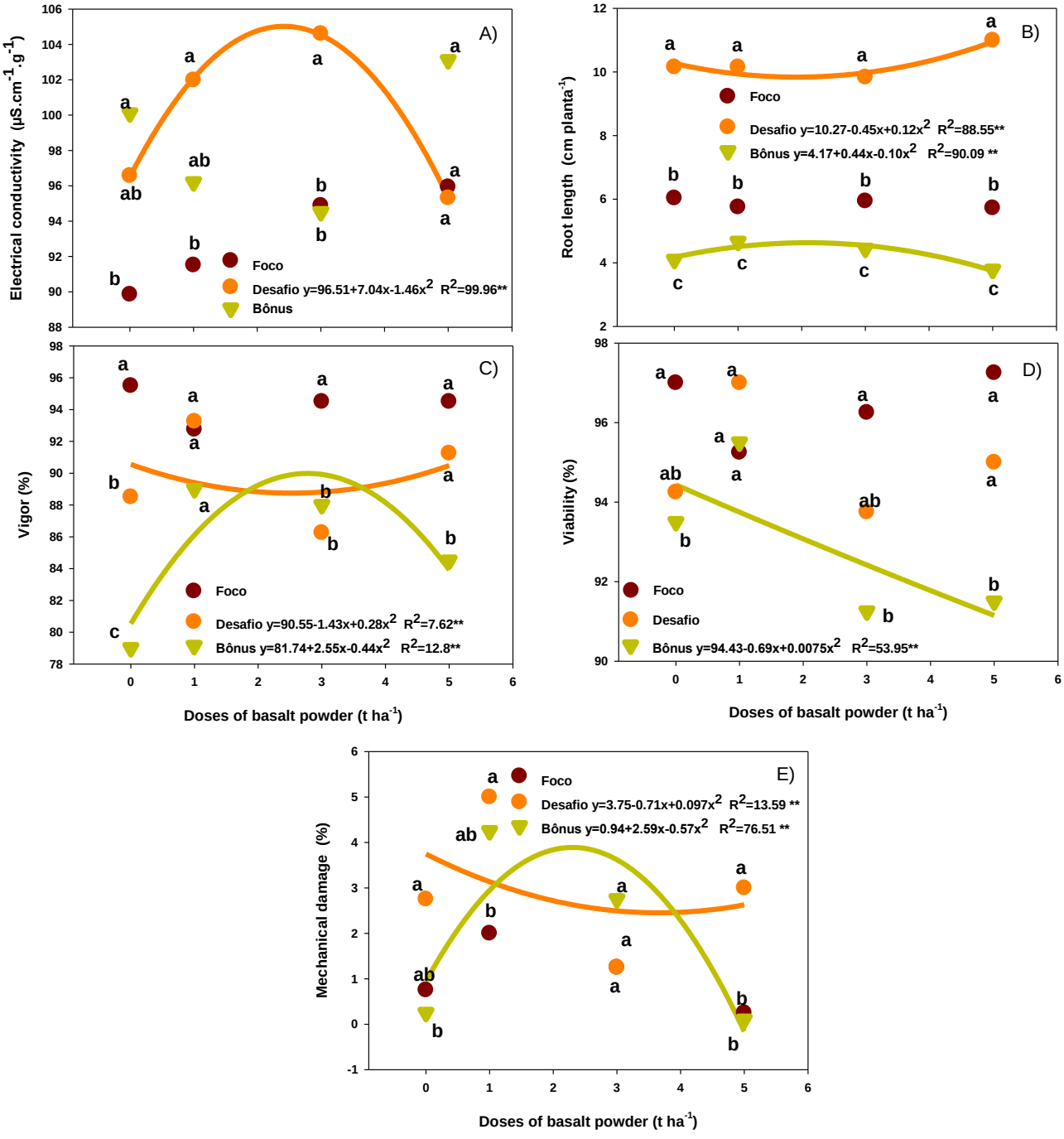
Table 3 - Means values of the variables first germination count (FGC), germination (GERM), plant length (PL), dry plant mass (DPM), dry root mass (DRM), moisture damage (MoD) and bed bug damage (BBD) obtained in experiments with doses of basalt powder in three short cycle soybean cultivars in the 2018/2019 harvest. Chapadão do Sul, MS, Brazil.

Cultivars	FGC	GERM	PL	DPM	DRM	MoD	BBD
	------ (%) ------		(cm plant $^{-1}$)	-- (mg plant^{-1}) --		------ (%) -----	
Brasmax Foco IPRO	96.0 a	97.0 a	6.07 b	14.43 b	3.55 b	2.28 b	0.25 b
Brasmax Desafio IPRO	95.0 a	97.0 a	6.91 a	15.67 a	6.08 a	1.63 b	0.25 b
Brasmax Bônus IPRO	76.0 b	81.0 b	3.45 c	16.68 a	6.17 a	4.63 a	0.88 a
Doses (t ha^{-1})	FGC	GERM	PL	DPM	DRM	MoD	BBD
0	88.0 ^{ns}	91.0 ^{ns}	5.56^{ns}	15.63^{ns}	4.89^{ns}	3.54^{ns}	0.42^{ns}
1	88.0	92.0	5.58	16.06	5.19	2.50	0.58
3	88.0	91.0	5.33	15.16	5.67	2.42	0.33
5	90.0	92.0	5.43	15.51	5.31	2.92	0.50

Means followed by the same lowercase letter in the columns do not differ by Tukey's test at the 5% significance level. Source: Research data.

The most significant development in the PL variable was obtained in the cultivar Brasmax Desafio IPRO (6.91 cm plant^{-1}). The accumulation of dry matter in the area and at the root showed the same behavior, especially for the cultivars Brasmax Bônus IPRO (16.68 and 6.17 mg plant^{-1}, respectively) and Brasmax Desafio IPRO (15.67 and 6.08 g plant^{-1}, respectively). In the doses of basalt powder, there was no statistical difference for any of the variables in Table 3, showing that the effect of basalt powder, in the conditions tested (first year of surface application), thus demonstrating that it was coincident for the variables linked to the physiological quality of soybean seeds (Table 3). The factors cultivar and doses of basalt powder showed significant interactions ($P<0.05$) for the variables shown in Figure 1.

Figure 1 - Mean values and regression equations obtained for electrical conductivity (A), root length (B), vigor (C), viability (D), and mechanical damage (E) in soybean seeds. Means followed by the same lowercase letter within each dose, do not differ by the Tukey (*P > 0.05*) probability (n = 16).



Source: Research data.

The Brasmax Bonus IPRO cultivar has lower physiological quality, verified by lower vigor (Figure 1C) and lower viability (Figure 1D) of the seeds, while showing the shortest root length (Figure 1B), among the three cultivars evaluated. The EC, RL, VIG, and MD of

the seeds were influenced by the use of doses of basalt powder in the cultivar Brasmax Desafio IPRO, presenting significant polynomial regression (Figure 1A, 1B, 1C and 1E). The seeds of the cultivar Brasmax Bonus IPRO showed significant regressions for VIG, VIA, and MD (Figure 1C, 1D, and 1E). Significant quadratic equations were obtained mainly in the cultivars Brasmax Bonus IPRO and Brasmax Desafio IPRO for the variables shown in Figure 1.

Correlation coefficients were significant ($P> 0.01$). However, they were not always of high adjustments ($R^2 >70$), such as those obtained for Figure 1C and Figure 1E for both cultivars.

4. Discussion

The search for new sources of alternative fertilizers that partly eliminate dependence on chemical fertilizers has been one of the objectives of numerous researches in Brazil (Welter et al., 2011; Theodoro et al., 2012; Hanisch et al., 2013; Ramos et al., 2014, 2015; Lopes et al., 2014; Nunes et al., 2014; Manning & Theodoro, 2018; Aguilera et al., 2020a, 2020b; Medeiros et al., 2020; Ratke et al., 2020) and in the world (Straaten, 2006; Anda et al., 2009; Ramezanian et al., 2013; Beerling et al., 2018), in which the use of rock dust (basalt, amethyst, among others) has manifested itself as a viable alternative.

In the present study, seed germination was assessed using two variables, FGC and GERM (Table 2 and Table 3), recommended by Brazil (2009). Both variables did not show a C x D interaction, and with that, it was evident that the doses of basalt powder used did not differ from the control (absence of basalt powder). However, the seeds maintained germination above 91%, a value adequate for the commercialization of soybean seeds in Brazil (Teixeira et al., 2020), which were guaranteed in the tested cultivars (Table 3).

For the cultivar Brasmax Foco IPRO, there was no significant effect on the variable's electrical conductivity, root length, vigor, viability, and mechanical damage in soybean seeds (Figure 1). On the other hand, for the cultivars Brasmax Desafio IPRO and Brasmax Bonus IPRO, there was a significant effect. This fact may be related to the cultivar maturation group, considering that the Brasmax Foco IPRO cultivar has a shorter cycle [Relative Maturation Group (GMR) 7.2]. The varieties Brasmax Desafio IPRO and Brasmax Bonus IPRO had GRM 7.4 and 7.9, respectively. These variations are related to differences in genetic potential and other intrinsic characteristics of each cultivar, determining the cycle of these cultivars employed (Felisberto et al., 2015; Soares et al., 2015).

The tests applied to take into account the upper plant and the well-developed root system as an indicator of normal seedlings. The results show that DPM and DRM did not show C x D interactions, and thus, plants that received doses of basalt powder did not respond to the increase without differing from the control. Aguilera et al. (2020b), when evaluating in the field, doses of basalt powder observed influence on plant height, the number of pods plant^{-1} and percentage of grains retained in the Ø6.5 mm mesh; with variable responses between cultivars and the doses used, without affecting the productive performance of soybean cultivars; however, they contributed to obtaining a larger seed size. The size of the grains determines in part the reserves that the plant will have once germinated, being favored the vigor or the speed with which the seeds germinate, as a consequence of this, a more accelerated growth of the area and root part is stimulated, thus benefiting the final production (Panozzo et al., 2018), is for this reason that the aim is to homogenize the size of the marketable seed lots in the companies dedicated to their production or benefit.

The soybean cultivars Brasmax Desafio IPRO and Brasmax Bonus IPRO showed higher accumulations of dry matter in seedlings (DPM and DRM), at the same time as reported by Aguilera et al. (2020b) as the cultivars that in the field showed the highest yields when subjected to doses of basalt powder, which shows the direct relationship between the development and accumulation of dry matter in soybeans with the productivity of the crop. The development of roots in field conditions determines the absorption of water and nutrients (Taiz et al., 2017), which is a favorable performance to have in a seed lot and, thus, suitable for the installation of a crop.

Mechanical, moisture, and bed bug damage were evaluated in the seeds according to the criteria defined by Brasil (2009) through the tetrazolium test. The results indicated that the combination of the tested factors influenced only the MD (Table 2, Figure 1E). Only in the cultivar Brasmax Foco IPRO there were no effects of the doses used, with values below 2%. The occurrence of MD is a severe quality problem of soybean seed, mainly associated with trail operation in mechanized harvesting (França-Neto; Krzyzanowski, 2018). According to a survey by Embrapa (2018, 2019), the mechanical damage of samples collected in the municipality of Cassilândia - MS in the 2016/2017 and 2017/2018 harvests showed 0 to 4% MD, which shows that the data obtained are among expected for soybean seeds produced in the region (Figure 1E).

The results of vigor and viability of seeds indicated that there was an interaction between factors C x D (Table 2, Figure 1). The cultivars influenced the vigor values (Figure 1C) and viability (Figure 1D), if we observe that the values for both variables maintained the

same behavior Brasmax Foco IPRO > Brasmax Desafio IPRO > Brasmax Bonus IPRO. In vigor among the cultivars, the different doses of basalt powder influenced only the cultivars Brasmax Desafio IPRO and Brasmax Bonus IPRO, however, with contrasting or inverse responses for doses of 3 t ha^{-1}. The best viability (89%) was found in the cultivar Brasmax Bonus IPRO with a dose of 3 t ha^{-1} of basalt powder. Considering the survey that Embrapa (2019) carried out in four municipalities in the state of MS, totaling 32 samples resulted in average values of 83% vigor, 93.5% viability, and 91.7% germination; we can say that the values obtained are adequate. Seeds with high vigor give rise to seedlings that emerge quickly and evenly in the field (Soltani et al., 2006), which provides them with a competitive advantage over weeds (Dias et al., 2011).

The electrical conductivity of the seed exudates was evaluated according to the recommendations of Brasil (2009), allowing the quantification of the leaching of ionizing substances, which occurs in the seeds due to mechanical damage and or temperature that alter the cellular structure. The higher the amount of leached nutrients and their magnitude (EC > 100 µS cm^{-1} g^{-1}), the greater the deterioration of cell membranes. Consequently, the lower the physiological quality (Brasil, 2009; Coradi et al., 2015). The results obtained in this research showed values from 74.81 to 148.33 µS cm^{-1} g^{-1} for CE (Table 2). The cultivar Brasmax Desafio IPRO was the only one that presented a significant quadratic polynomial regression equation with a high regression coefficient (R^2 = 99.96%) while manifesting EC > 100 µS cm^{-1} g^{-1} at doses of 1.0 and 3.0 t ha^{-1}, negatively influencing the quality of these obtained seeds (Coradi et al., 2015), about control and at doses of 5.0 t ha^{-1} that showed the lowest EC values for this cultivar.

In general, the soybean seeds obtained in the different doses of basalt powder tested did not show stimulation of their germination, growth of the aerial part, accumulation of dry matter and damage by humidity and bedbugs, however, when the electrical conductivity, root length was evaluated, vigor, feasibility, and mechanical damage, responses were obtained that were dependent on the cultivars Brasmax Desafio IPRO and Brasmax Bonus IPRO.

5. Conclusion and Suggestions

The use of basalt powder does not improve the physiological quality of soybean seeds.

The best performance of the cultivars was in the Brasmax Foco IPRO cultivar, with high values of germination, vigor and viability of the seeds associated with less electrical conductivity and less damaged by mechanical, humidity and bed bug damage.

This research is the first work that evaluates the physiological quality of seeds using basalt powder, thus contributing to the increase in the current scientific literature related to the short-term effects that can be obtained with these residue's indirect applications in agriculture national and international scenario.

The results of this research suggest that other assessments need to be made to better elucidate among the materials of the same maturation group the effect of basalt powder on the physiological quality of the seeds obtained under these conditions.

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