Communications in PLANT SCIENCES

http://cpsjournal.org
e-ISSN 2237-4027
Volume 12 (2022)

RESEARCH ARTICLE

Quality of bean seeds submitted to doses of desiccant herbicides at application periods

Camile Tais Castoldi, **Leandro Galon***, **Lauri Lourenço Radünz**, **Josiel Ricardo Toni**, **Francisco Wilson Reichert Júnior**, **Mauricio Albertoni Scariot**, **Daniel de Oliveira e Souza** and **Gismael Francisco Perin**

Universidade Federal da Fronteira Sul, Erechim, RS, Brasil.
Correspondence to: leandro.galone@gmail.com

Submitted on December 01, 2021
Accepted on August 31, 2022
Early View on September 01, 2022
Final Publication on September 02, 2022

Authors declare no conflict of interest

KEYWORDS:
Phaseolus vulgaris
Seed desiccation
Ripening seeds

ABSTRACT

Harvesting seeds at physiological maturity is characterized by preserving the quality of the seeds and preventing them from being exposed to deterioration, but the high humidity makes mechanized harvesting unfeasible at this stage. The objective of this work was to verify the feasibility of applying desiccant herbicides in reduced doses, at different times, to the physical and sanitary quality of carioca bean seeds. The experiment was carried out in a randomized complete block design, in a 2x3x4+1 factorial arrangement, with four replications. The carioca bean plants, cultivar BRS Pérola, were desiccated when the seeds had 42 and 30% water content, with ammonium-glufosinate, saflufenacil and diquat, at doses of 0, 50, 75 and 100% in relation to the average dose recommended for seed desiccation. The additional treatment without application of the desiccant was harvested with 18% water content. Analyzes of thousand seed weight, hectoliter weight, electrical conductivity and sanity test were performed. The use of desiccant herbicides and the increase in their doses, at both times of application, reduces the hectoliter weight, increases the electrical conductivity and increases the incidence of *Penicillium* spp., *Aspergillus* spp. and *Fusarium* spp, however, with minimized values when applying desiccants in reduced doses (50 and 75% of the recommended dose). It is feasible to apply ammonium-glufosinate, saflufenacil and diquat with 30 and 42% of water, to anticipate the harvest when using 50% of the recommended average dose. Harvesting seeds with moisture close to 18% is indicated when there is low rainfall and reduced relative humidity between physiological maturity and harvest.

Highlighted Conclusion

1. Harvesting bean seeds with water contents of 30 and 42% and without the application of desiccants provided the best physical and sanitary quality of the seeds.
2. The desiccation in bean seeds using the recommended average dose increases electrical conductivity, reduces the hectoliter weight, and causes a loss in sanitary quality of the seeds.
3. It is feasible the application glufosinate-ammonium, saflufenacil, and diquat for anticipating harvest when 50% of the recommended average dose is used.

INTRODUCTION

The bean seed harvest should preferably be carried out at physiological maturity (Guimarães et al. 2012). When performed at this stage, in addition to preserving the characteristics responsible for the physiological quality, the early harvest prevents the seeds from remaining in the field for a long period, exposed to fluctuations in temperature, precipitation and relative humidity, which makes them susceptible to deterioration and attack. of fungi, factors that compromise its quality and, consequently, the yield (Daltro et al. 2010; Marcos Filho 2015).

Harvesting bean seeds at the appropriate time, as close as possible to physiological maturity, is essential to preserve their quality. Physiological maturity corresponds to the stage in which the plants have yellow leaves, most of the pods are dry and the seeds are at their maximum development. (Kappes et al. 2012). However, to anticipate the harvest, it is necessary to use techniques that favor this procedure, because the closer to the physiological maturity, the higher the water content of the seeds, in addition to the plants having a high number of branches and green leaves, aspects that make mechanized harvesting unfeasible (Castoldi et al. 2019).

Desiccation, with the use of herbicides appropriate for this procedure, results in rapid drying of all parts of the plant, allowing for early harvest (Kappes et al. 2012), since the seeds will reach the indicated water content for mechanical harvesting in a shorter period when compared to those in which the loss of water occurs naturally. When properly carried out, the application of desiccant promotes uniformity of crop maturation, allows for an earlier harvest, reduces yield losses and also maintains the physical, physiological and sanitary characteristics of the seeds, even when submitted to storage (Lamego et al. 2013; Castoldi et al. 2019). This technique can also eliminate weeds that are eventually infesting the crop, favoring the harvesting process (Pereira et al. 2015; Krenchinski et al. 2017).

However, several aspects must be considered before carrying out the desiccation of the seeds. Among them, are the correct moment of application, mode of action and doses of the herbicide used, in addition to the possibility of remaining product residues in the seed. These factors can compromise seed quality and, consequently, crop yield (Lacerda et al. 2005; Kappes et al. 2009). In view of the above, there is an alternative to reduce the doses of herbicides, in order to anticipate the harvest and preserve the quality of the seeds.

The feasibility of using herbicides for desiccation, in order to anticipate harvest, has been studied by several authors, in crops such as soybean [*Glycine max* (L.) Merill] (Daltro et al. 2010; Botelho et al. 2019), beans (*Phaseolus vulgaris* L.) (Coelho et al. 2012; Kappes et al. 2012) and wheat (*Triticum aestivum* L.) (Tarumoto et al. 2015; Fipke et al. 2018). However, there are few studies that have evaluated the efficiency of using low doses to desiccate carioca bean seeds (Castoldi et al. 2019). Still, few studies used the water content as a parameter to define the times of herbicide application, mainly for the bean crop.

The herbicides used in the present study, ammonium-glufosinate, saflufenacil and diquat are recommended for use as pre-harvest desiccants in common bean (Agrofit 2022). However, the research seeks to evaluate different doses and volumes of water for the application of herbicides to obtain better quality seeds.

In this sense, the objective of this work was to verify the feasibility of applying desiccant herbicides in reduced doses, at different times, on the physical and sanitary quality of carioca bean seeds.

MATERIAL AND METHODS

The research was carried out at the Federal University of Fronteira Sul (UFFS), Erechim/RS campus, in the 2015/16 harvest, and the work was divided into two stages. The first stage was constituted by the installation of the experiment and application of herbicides in the field, and the second by the execution of the physical and sanitary analyses, carried out at the Seeds and Grains Laboratory of UFFS.

The area used for bean sowing was previously desiccated with the herbicide glyphosate, at a dose of 3.0 L ha^{-1}, in order to control the vegetation present in the area. The fertilization of the area was carried out according to the physical-chemical analysis of the soil with pH in water of 5.1; OM = 3.0%; P= 5.2 mg dm^{-3}; K= 118.0 mg dm^{-3}; Al^{3+}=0.3 cmolc dm^{-3}; Ca^{2+}= 5.5 cmolc dm^{-3}; Mg^{2+}= 3.0 cmolc dm^{-3}; CEC(t)= 7.4 cmolc dm^{-3}; CEC (pH=7.0)= 16.6 cmolc dm^{-3}; H+Al= 7.7 cmolc dm^{-3}; BS= 53% and Clay= 60%, following the technical recommendations for the cultivation of carioca beans (Rolas 2004), together with sowing, using 260 kg ha^{-1} of 05-30-15 NPK formulation.

Each experimental unit (plot) consisted of an area of 15 m² (2.5 x 6.0 m). The sowing of carioca beans, cultivar BRS Pérola, was carried out in the no-tillage system, using a seeder/fertilizer, with six rows, spaced at 0.50 m. The sowing density was 14 viable seeds per linear meter, with an estimated final population of 280,000 plants ha^{-1}. The average temperature, precipitation and relative humidity values recorded during the growing season are shown in Figure 1 (INMET 2022).

The experimental design adopted was randomized blocks, in a 2 x 3 x 4 + 1 factorial arrangement (seed water content x herbicide x dose + additional) with four replications, totaling 25 treatments. The application of the desiccants occurred when the seeds had 42 and 30% of water, denoted as conditions 1 and 2, respectively, defined based on the determination of the water content by the oven method at 105 ± 3 °C (Brasil 2009). Three herbicides were used for desiccation, composed of the active ingredients (ammonium-glufosinate, saflufenacil and diquat), applied in four percentage doses of 0 (water only), 50, 75 and 100%, to the average dose recommended for desiccation (Table 1). The herbicides ammonium-glufosinate, saflufenacil and diquat belong to the mechanisms of action inhibitors of glutamine synthase - GS, protoporphyrinogen oxidase - PROTOX and photosystem I - PS I, respectively, with recommendation for the desiccation of bean (Agrofit 2022). Also, an additional treatment was included, without application of desiccant, harvested with seed water content close to 18%.

The herbicides were applied in both conditions, with the aid of a precision backpack sprayer, Névoa, model NV-02, pressurized with CO_2, equipped with four spray tips type DG 110.02, under constant pressure of 2.0 kgf cm^{-2} and displacement speed of 3.6 km ha^{-1}, with a flow of 150 L ha^{-1} of spray solution.

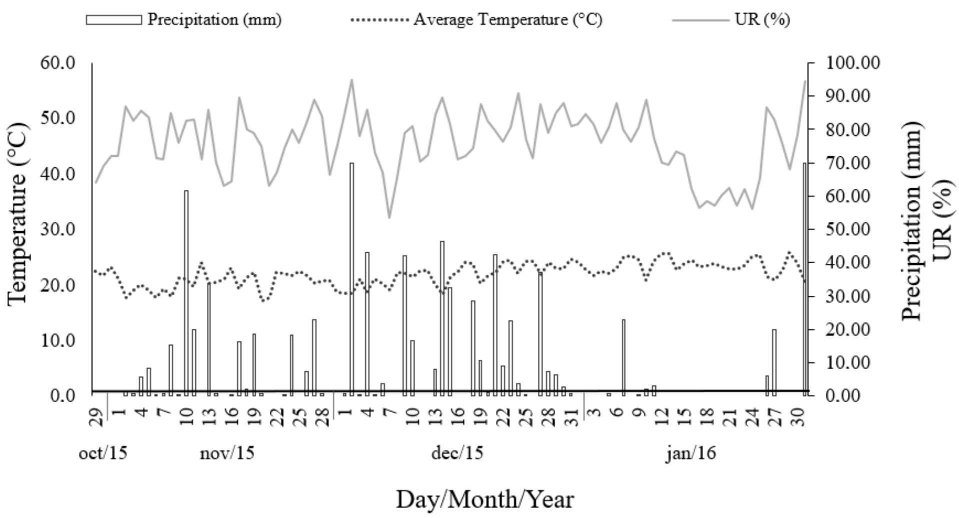

Figure 1. Meteorological conditions during the bean growing period, 2015/16 crop, in Erechim/RS. Arrows represent the period between the first desiccation (FD) and the last harvest (LH) respectively. Source: INMET, 2022.

The harvest of each experimental unit was carried out manually, in a useful area of 11 m², disregarding the borders of 0.50 m. The control treatment (0% dose) was harvested on the same date as the herbicides were applied and subjected to drying in an oven with forced air circulation and a temperature of 35 °C until they reached a water content close to 18%. The harvest of the plants submitted to desiccation was carried out only when the seeds presented a water content of approximately 18% in the field.

Table 1. Specification of herbicides used for bean desiccation and their respective average doses

Herbicide[1]	Average recommended dose	
	Commercial product L/kg ha^{-1}	Active ingredient (g ha^{-1})
Amonio-glufosinate	1.900	380.0
Saflufenacil	0.105	73.5
Diquat	1.750	350.0

[1] Herbicides authorized and registered by the Ministry of Agriculture, Livestock and Supply, for bean crop desiccation (Agrofit 2022).

After harvesting, the plants of each experimental unit were threshed separately, using a plot thresher, and then the seeds of each replication were submitted to oven drying, with forced air circulation and air temperature of 35 °C until they reach a water content of approximately 11%. These operations were performed in the same way for all treatments.

In the second stage of this study, carried out at the Laboratory of Sustainable Management of Agricultural Systems at UFFS, determinations of the physical and sanitary quality of the seeds were carried out, through the following analyses:

Thousand seed weight (TSW): was performed by counting 8 repetitions of 100 seeds per treatment, weighed separately on an analytical balance. The average result was multiplied by 10 and expressed in grams (Brasil 2009).

Hectoliter weight (PH): Determined through the weight of a quarter of a liter of seeds, obtained using the hectoliter balance, followed by adjusting the value for the water content of 13%. The result was expressed in kg hl^{-1} (Brasil 2009).

Electrical conductivity (EC): eight samples of 50 seeds, physically pure, were used for each treatment. The samples were weighed on a precision balance and then placed for imbibition in plastic cups containing 75 mL of distilled water, kept in BOD at 25 ºC for 24 h, according to the method described by AOSA (2002). After this period, the electrical conductivity was determined by reading a digital conductivity meter, Digimed, with results expressed in µS cm^{-1} g^{-1}.

Sanity test: performed using the "*Blotter test*" method, following the recommendations of Brasil (2009), using 400 seeds per treatment. The seeds were previously disinfected with a 1% sodium hypochlorite solution for 3 minutes. Afterward, they were placed on germitest paper, moistened in a 2,4-D salt solution (2,4-dichlorophenoxyacetate of sodium), at a concentration of 5 ppm, to prevent germination, and then submitted to

DOI: 10.26814/cps2022005 | 9 pages

incubation in B.O.D with a photoperiod of 12 hours, for 7 days, at a temperature of 20±2 °C. After incubation, the visual identification of the fungi was performed with the aid of a table stereomicroscope. Results were expressed as the percentage of infested seeds.

The data were submitted to analysis of variance, using the F test ($p \leq 0.05$) and, later, when there was a significant effect, the qualitative variables were compared using the Tukey and Dunnett test ($p \leq 0.05$) and the quantitative variables submitted the regression analysis. The models were selected based on the significance of the regression coefficients, the "t" test, the coefficient of determination value (r^2) and the biological behavior.

RESULTS AND DISCUSSION

It was observed that during the carioca bean cycle the climatic conditions required for the crop were favorable (Figure 1). However, at the time of application of desiccants and harvest of seeds, there was a period of drought, contributing to the rapid drying of plants in the field, with the interval between the first desiccation and the last harvest of six days.

According to the statistical analysis of the data, through the F test ($p \leq 0.05$), significant interactions were observed between the treatment factors for the variables, electrical conductivity, incidence of *Aspergillus* spp, *Penicillium* spp., *Fusarium* spp. and other fungi. As for the hectoliter weight, a significant interaction between times and doses was observed, while the weight of one thousand seeds had no significant effect (Table 2).

Table 2. Summary of the analysis of variance, by the F test (p≤0.05), of the data referring to the thousand seeds weight (TSW), hectoliter weight (HW), electrical conductivity (EC), *Aspergillus* spp. (ASP), *Penicillium* spp. (PEN), *Fusarium* spp. (FUS) and other fungi (OF) and their respective coefficients of variation, obtained as a function of the time of application, type of herbicide and doses.

Sources of Variation	DF[6]	*p* value						
		TSW	HW	EC	ASP	PEN	FUS	OF
TM[1]	1	0.6512	0.3793	0.0529	0.0009	0.0001	<0.0001	<0.0001
HB[2]	2	0.3006	0.1100	0.0001	0.0199	0.1372	0.0380	<0.0001
DS[3]	3	0.3986	0.0662	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EPxHB	2	0.5079	0.9908	0.0013	0.0010	<0.0001	<0.0001	0.0099
EPxDS	3	0.5179	0.0002	<0.0001	0.1056	<0.0001	<0.0001	0.0067
HBxDS	6	0.6679	0.1353	0.2017	0.0052	0.0005	<0.0001	<0.0001
EPxHBXDS	6	0.9330	0.7260	0.0497	<0.0001	0.0010	0.0055	<0.0001
T[4] x ADT[5]	1	0.0778	0.1702	<0.0001	0.3062	<0.0001	0.4610	<0.0001
C.V. (%)		2.71	1.12	9.07	9.11	11.47	21.37	19.19

[1]Time; [2]Herbicide; [3]Dose.[4]Treatments; [5] Additional; [6] Degrees of freedom.

Table 3 shows the averages of each treatment, compared with the average of the additional treatment, obtained by Dunnett's test ($p \leq 0.05$). There was no difference between the averages of the treatments for the weight of one thousand seeds and hectoliter weight. For most treatments with desiccation, the electrical conductivity was lower than that obtained in the additional treatment. The incidence of fungi, in general, was superior to the additional treatment in those seeds that received the highest doses of herbicide in the desiccation.

The weight of 1000 seeds did not vary significantly between treatments, according to the F test ($p \leq 0.05$), with an average of 226.15 g. This result can be attributed to the small difference between the times of harvest of the seeds, even the one that was not submitted to desiccation.

Kamikoga et al. (2009) also found no significant difference between treatments, when applying desiccant herbicides at 28 and 43 DAF (days after flowering), for the weight of 1000 black bean seeds. However, Santos et al. (2004) when applying the herbicide carfentrazone-ethyl in pre-harvest of carioca bean, cultivar BRSMG Talismã, found that the weight of 1000 seeds was influenced by the time of application and also by the dose of the desiccant, with lower weights at higher doses. The use of various ripening herbicides of the carioca bean cultivar, IAC Imperador, caused differences in the weight of 1000 seeds according to the time of application and the product applied, with diquat being the best among those tested (Silva et al. 2017).

Figure 2 shows the results for hectoliter weight (A) and electrical conductivity (B). There was a reduction in hectoliter weight with increasing doses, regardless of the herbicide applied (Figure 2A). For electrical conductivity (Figure 2B) an increase was observed with increasing doses for all herbicides and times.

The hectoliter weight showed differences between the times of application of desiccant herbicides, and those carried out in condition 2 (30% water) provided lower values than those obtained in applications in condition 1 (42% water), suffering a reduction with the increase of the dose, regardless of the herbicide used (Figure 2A). Scariot et al. (2017) obtained higher hectoliter weight in black bean seeds harvested with higher water contents, observing values similar to those verified in this work.

Table 3. Results obtained by Dunett's test (p≤0.05), for the variables thousand seed weight (TSW), hectoliter weight (HW), electrical conductivity (EC), and incidence of *Aspergillus* spp. (ASP), *Penicillium* spp. (PEN), *Fusarium* spp. (FUS) and other fungi (OF), obtained as a function of time of application, type of herbicide and doses compared to the additional treatment.

Treatments			Averages						
TM¹	HB²	DS³	TSW	HW	EC	ASP	PEN	FUS	OF
1	1	0	226.73	79.16	71.45*	38.25*	33.50	0.00*	5.00
1	1	50	226.73	77.33	79.27*	44.00	38.00	15.08	8.04**
1	1	75	219.87	78.18	97.65*	46.34	59.75**	15.33	14.67**
1	1	100	221.29	78.21	88.09*	57.25	70.00**	20.50**	34.50**
1	2	0	226.73	79.16	71.45*	38.25*	33.50	0.00*	5.00
1	2	50	231.09	77.43	82.71*	50.75	39.50	8.00	21.33**
1	2	75	224.76	77.97	87.33*	56.50	56.25**	9.75	8.75**
1	2	100	228.62	76.80	94.19*	60.75**	66.50**	22.00**	6.78**
1	3	0	226.73	79.16	71.45*	38.25*	33.50	0.00*	5.00
1	3	50	225.19	77.89	91.60*	40.00	50.00**	11.75	11.00**
1	3	75	225.20	77.79	95.20*	62.00**	47.25**	15.50	9.00**
1	3	100	224.78	78.26	97.35*	74.50**	55.50**	28.00**	10.33**
2	1	0	225.72	77.70	69.06*	38.25*	25.75	5.00*	3.44
2	1	50	229.33	78.16	70.18*	46.33	50.33**	10.33	6.56**
2	1	75	223.60	77.89	75.36*	60.50**	52.00**	11.00	3.83
2	1	100	225.63	78.60	106.53	71.50**	73.25**	11.00	5.75
2	2	0	225.72	77.70	69.06*	38.25*	25.75	5.00*	3.44
2	2	50	226.76	78.43	88.17*	54.00	41.75	5.92*	9.00**
2	2	75	228.84	77.16	98.51	64.25**	51.75**	12.67	2.83
2	2	100	225.25	77.47	125.29	65.25**	84.50**	13.50	5.52
2	3	0	225.72	77.70	69.06*	38.25*	25.75	5.00*	3.44
2	3	50	226.23	77.71	81.27*	50.25	60.00**	6.58	6.33**
2	3	75	228.78	78.00	99.40	58.25	64.50**	7.17	5.75
2	3	100	222.97	78.93	114.46	62.00**	84.50**	10.67	5.70
Additional			231.51	77.41	114.84	49.75	30.50	11.25	3.00
General average			226.15	78.01	88.36	51,48	50.13	10.44	8.20
CV (%)			2.71	1.12	9.07	11.84	13.59	48.06	84.84

* and ** Lower and higher averages to additional treatment, respectively. ¹Times 1 and 2: (42 and 30% of water content, respectively); ²Herbicides: (1: amonio-glufosinate, 2: saflufenacil, 3: diquat); ³ Percentage doses in relation to the average recommended dose for each product.

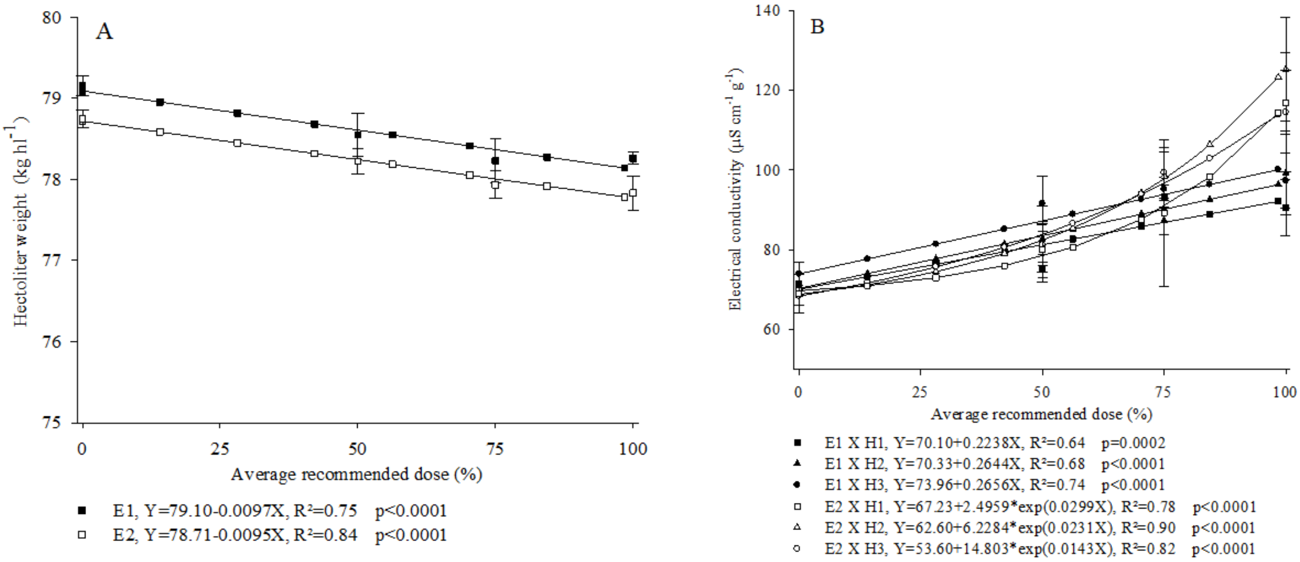

Figure 2. Hectoliter weight (A) and electrical conductivity (B) of carioca bean seeds, depending on the application of different percentage doses, in relation to the recommended average of desiccant herbicides (H1: ammonium-glufosinate; H2: saflufenacil; H3: diquat) in the conditions (E1 and E2, respectively with 42 and 30% of water in the seeds).

Scariot et al. (2017) also found a reduction in hectoliter weight due to the delay in harvesting black beans, cultivar BRS Campeiro. On the other hand, Santos and Vicente (2009) obtained lower values of hectoliter weight in the early application of herbicides in the wheat crop (milky grain) when compared to the other application times and the control with natural maturation. It is noteworthy that the longer the crop remains in the field, the greater the degradations that occur with it, reducing the dry mass of the seeds, as occurred with the control with natural maturation in the present study. Lacerda et al. (2005) also describe a result similar to that observed in the present work.

There was an increase in electrical conductivity values with increasing herbicide doses, and the average difference between the lowest dose (0%) and the highest dose (100%) was 26% for condition 1 (42% of water) and 42% for condition 2 (30% water), for the three herbicides (Figure 2B). This result is similar to that reported by Marcos Filho (2005), where he describes that after the physiological maturity of the seeds, the seed membrane system may be disrupted, causing greater release of solutes. The seeds from the additional treatment (harvested with 18% of water) also showed a higher value of electrical conductivity when compared to the control treatment (0% dose) (Table 3). Kappes et al. (2012) when using the herbicide paraquat for desiccation of carioca beans, at doses of 50, 100 and 150% (200, 400 and 600 g ha^{-1}) in relation to the maximum recommended dose (400 g ha^{-1} or 2.0 L ha^{-1}), observed lower electrical conductivity with increasing desiccant doses and higher electrical conductivity in the absence of desiccation (dose 0 g ha^{-1}). High doses of paraquat promoted a reduction in the vigor of bean seeds and, thus, seeds with low vigor tend to present disorganization in the structure of cell membranes, allowing an increase in the leaching of solutes, such as sugars, amino acids, organic acids, proteins and phenolic substances and inorganic ions (Kappes et al. 2012).

When applied at condition 1 (42% water), all herbicides, regardless of the dose used, showed lower electrical conductivity than the additional treatment (Table 3). This result is similar to that verified by Coelho et al. (2012), who, when applying paraquat desiccant at the recommended dose (400 g ha^{-1}) in different bean genotypes (two landraces and one commercial), observed that this herbicide favored the physiological quality of seeds in the electrical conductivity evaluations compared to non-drying plants (harvested after natural drying of the plants). However, Kappes et al. (2009) verified that soybean seeds from the control treatment, without the application of diquat and paraquat desiccants (400 g ha^{-1}), harvested at the R9 stage (harvest maturation point), showed lower electrical conductivity.

The lowest electrical conductivity values occurred for the two conditions, when there was no use of desiccant herbicides, in treatments harvested on the same date of herbicide application (0% dose), (Figure 2B and Table 3) indicating that seeds from this treatment have greater integrity of cell membranes and, consequently, showed less release of solutes. According to Marcos Filho (2005), when there is a low release of solutes, there is less loss of cell compartmentalization, and this characteristic in the field can minimize the growth of harmful microorganisms to the emergence of seedlings.

The EC test principle indicates that less vigorous or more deteriorated seeds have a slower rate of cell membrane repair during the absorption of water from the seed for germination and, therefore, release greater amounts of solutes to the external environment, such as sugars, amino acids, fatty acids, proteins, enzymes and inorganic ions (K^+, Ca^{+2}, Mg^{+2}, Na^+, Mn^{+2}), which are leached into the seed soaking water (Marcos Filho 2015). As shown in Table 3, the highest EC values were observed in the additional treatment and in seeds harvested with a water content of 30% and with the application of doses of 75 and 100% of the herbicides saflufenacil and diquat, indicating a higher degree of deterioration of these seeds. Right at the beginning of storage, seeds harvested with 42% water content showed higher EC value (Figure 2B), but during storage, seeds harvested with 30% water content showed the highest values, despite all treatments having provided an increase in electrical conductivity. It is assumed that the higher electrical conductivity, manifested at the end of storage in the seeds that were desiccated with 30% water, occurred because they had a greater potential for deterioration due to the longer time spent in the field and potentiated by the use of herbicides. The increase in EC during storage, for all treatments, is indicative of seed deterioration, as mentioned above, in agreement with results obtained by other authors (Paraginski et al. 2015; Scariot et al. 2017; Zuffo et al. 2017).

In the sanitary analysis of the bean seeds (Figure 3) the presence of the fungi *Penicillium* spp., *Aspergillus* spp. and *Fusarium* spp., in addition to *Trichoderma* spp. and *Macrophomina phaseolina*, the last two being called other fungi. There was an increase in the incidence of the mentioned fungi with increasing doses of herbicides.

It was observed in Table 3 that the additional treatment provided a higher incidence of *Aspergillus* spp. and *Fusarium* spp. compared to control treatment, harvested on the same herbicide application date (0% dose). The incidence of *Fusarium* spp. was lower in the additional treatment (harvested with 18% moisture) only when compared to the use of 100% of the dose, for all tested herbicides, at condition 1 (42% water). The incidence of

Penicillium spp. was lower in the additional treatment compared to the application of doses 75 and 100%, for all herbicides and times, not differing from the control treatments (dose 0%), also, for both times (Table 3).

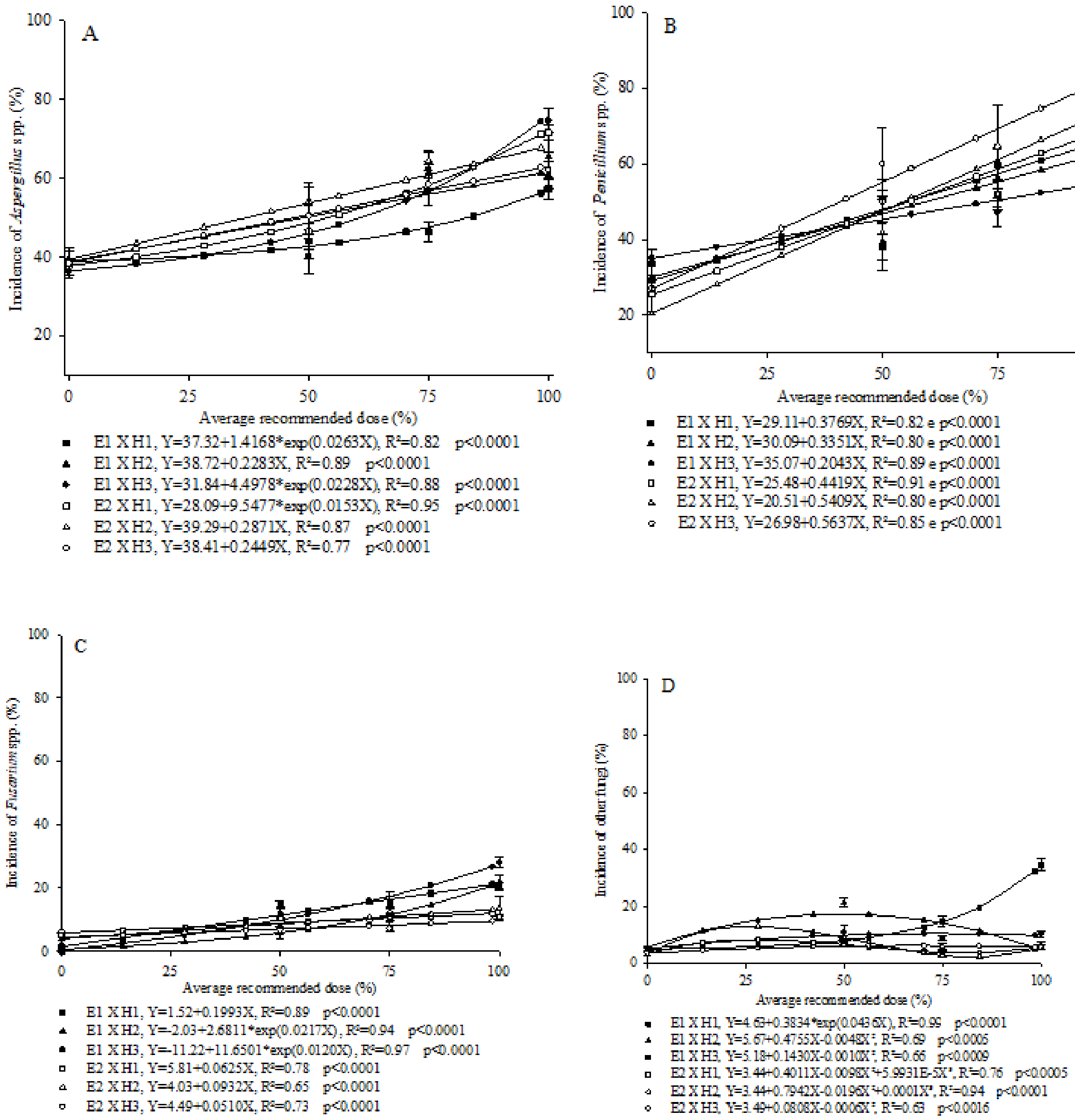

Figure 3. Incidence of *Aspergillus* spp. (A), *Penicillium* spp. (B) and *Fusarium* spp. (C) and other fungi (D) present in carioca bean seeds, depending on the application of percentage doses, in relation to the recommended average dose of desiccant herbicides (H1: ammonium-glufosinate; H2: saflufenacil; H3: diquat) in the conditions (E1 and E2, respectively with 42 and 30% water in the seeds).

As for the incidence of the other fungi, the additional treatment did not differ from the control treatments (0% dose), in both conditions, being lower for condition 1 (42% water), at doses 50, 75 and 100%, and for the condition 2 (30% water) when 50% of the average dose recommended for all herbicides was applied (Table 3).

The incidence of the fungus *Aspergillus* spp. showed linear growth with increasing herbicide dose. Tavares et al. (2015), when testing different doses of saflufenacil for desiccation in the physiological maturity of adzuki bean plants, also found a linear increase in the incidence of *Aspergillus* spp. with the increase of the doses of this herbicide in the evaluations carried out soon after the harvest. Seeds from desiccation carried out in condition 2 (30% water) had a higher incidence compared to condition 1 (42% water) (Figure 3A).

For *Penicillium* spp. the presence was lower when there was no application of desiccants for both conditions. Lacerda et al. (2003) also found lower rates of *Penicillium* spp. in the absence of desiccation compared to soybean seeds that received application of desiccants. Fungi of this genus are usually present on poor quality seeds. Marques et al. (2009) found a lower incidence of the *Aspergillus* and *Penicillium* genera at higher moisture corn seeds, while the *Fusarium* genus showed an increase in this condition, corroborating the results of the present

DOI: 10.26814/cps2022005 | 9 pages

study. This fact may be related to the ease of development of *Penicillium* spp. in lower humidities, unlike *Fusarium* spp. which preferentially needs higher moisture contents to infect and colonize.

The results show that in the first time of application (42% water), the herbicide diquat resulted in less contamination of the seeds by *Penicillium* spp. difference of 23% between conditions (Figure 3B). This was the opposite for *Fusarium* spp, in which the incidence of fungi at condition 1 (42% water) was 65% higher than at condition 2 (30% water) (Figure 3C).

It was observed that the incidence of *Fusarium* spp. (Figure 3C) was lower than the fungi *Penicillium* spp., (Figure 3B) and *Aspergillus* spp. (Figure 3A), when comparing all treatments. This fact may be related to the rapid loss of water content in plants, which makes it difficult for this fungus to survive (Tavares et al. 2015). This is in line with what happened in the present study, since in the days before the harvest there was no rain, which allowed the plants to dry quickly and restricted the development of *Fusarium* spp. The increase in doses considerably favored the incidence of *Fusarium* spp. (Figure 3C). The average difference between the control treatment (0% dose) and the recommended mean dose (100%) was 96% for condition 1 (42% water) and 58.3% for condition 2 (30% water). This may have occurred due to the high incidence of rainfall during the development of the bean crop, in the 2015/16 crop year (Figure 1), conditions that allowed the infestation of this fungus, and the application of herbicides in the pre-harvest, especially in the largest doses, may have potentiated the damage already present in the seeds, further favoring the development of *Fusarium* spp.

Regarding the presence of other fungal genera (*Trichoderma* spp. and *Macrophomina phaseolina*) in the seeds, it was observed that the highest incidence occurred in condition 1 (42% water), due to the application of ammonium-glufosinate at the highest doses, with a difference between the other herbicides saflufenacil and diquat of 85 and 73%, respectively.

For the herbicide diquat, the behavior was similar for both conditions, with a higher incidence in condition 1 (42% of water), being 42% higher in relation to condition 2 (30% of water). In general, the applications carried out in condition 2 (30% water) for the three herbicides favored the incidence of fungi, compared to condition 1 (42% water), at the highest dose (100%).

The increase in the incidence of fungi in seeds with increasing doses may be related to the results verified in electrical conductivity. At the highest doses, all herbicides used harmed the integrity of seed membranes, which may have facilitated the entry of fungi. Bento et al. (2012) report that the presence of *Aspergillus* and *Penicillium* genera is indicative of the deterioration of seeds and grains of agricultural crops, promoting embryo damage, discoloration, nutritional changes and loss of dry mass.

The presence of fungi in the seeds is worrying, in view of the damages caused by them. Storage fungi, *Aspergillus* spp. and *Penicillium* spp., can impair germination, produce toxins and reduce seed dry weight. They also cause diseases, such as fusarium wilt and root rot, manifested after infestation by *Fusarium* spp.

In conclusion, the physical quality of bean seeds was not affected by any of the factors studied. The harvest of bean seeds with water contents of 30 and 42% and without the application of desiccants showed better sanitary quality. The use of desiccant herbicides and the increase in their doses, at both times of application, reduces the hectoliter weight, increases the electrical conductivity and increases the incidence of *Penicillium* spp., *Aspergillus* spp. and *Fusarium* spp, however, with minimized values when applied in reduced doses (50 and 75% of the recommended dose). Due to the results obtained in the present study, it is expected that the application of ammonium-glufosinate, saflufenacil and diquat, at both application times (30 and 42% of water), to anticipate the harvest, when using 50% of the dose recommended average for each of these herbicides, being 1.9 L ha^{-1}, 105 g ha^{-1} and 1.75 L ha^{-1}, respectively. The harvest of seeds with humidity of approximately 18% is indicated when the climatic conditions between physiological maturation and harvest period are favorable, with little rainfall and air with low relative humidity. However, it causes high electrical conductivity and allows greater infestation of field fungi, such as *Fusarium* spp.

Acknowledgements

To CNPq, FAPERGS, UFFS and FINEP for the financial support to the research and for the granting of scholarships.

References

Agrofit. 2022. Ministério da Agricultura, Pecuária e Abastecimento. Available at: http://agrofit.agricultura.gov.br/agrofit_cons/principal_agrofit_cons. Accessed on: 11 fev. 2022.

AOSA - Association of Official Seed Analysts. 2002. Seed vigor testing Handbook. Lincoln, NE, USA. (Contribuition, 32).

Bento LF et al. 2012. Ocorrência de fungos e aflatoxinas em grãos de milho. Revista Instituto Adolfo Lutz 71: 44-49.

Brasil - Ministério da agricultura, pecuária e abastecimento. 2009. Regras para análise de sementes. Brasília. p. 395. Available at http://www.agricultura.gov.br. Accessed on May 10, 2020.

Botelho FJ et al. 2019. Quality of soybean seeds with different lignin content obtained from desiccated plants. Revista Brasileira de Ciências Agrárias 14:e5674.

Castoldi CT. et al. 2019. Physiological quality of carioca bean seeds submitted to the application of desiccant herbicides in two periods. Planta Daninha 37:e019215688.

Coelho CMM. et al. 2012. Ação de dessecante na pré-colheita sobre a produtividade e a qualidade fisiológica de sementes crioulas de feijoeiro. Semina: Ciências Agrárias 33:2973-2980.

Daltro FMF. et al. 2010. Aplicação de dessecantes em pré-colheita: efeito na qualidade fisiológica de sementes de soja. Revista Brasileira de Sementes 32:111-122.

Fipke GM. et al. 2018. Application of non-selective herbicides in the pre-harvest of wheat damages seed quality. American Journal of Plant Sciences 9:107-123.

Guimarães VF. et al. 2012. Produtividade e qualidade de sementes de soja em função de estádios de dessecação e herbicidas. Planta Daninha 30:567-573.

INMET - Instituto Nacional de Meteorogia. 2022. Dados meteorológicos. Município de Quatro Irmãos, RS. Available at: http://www.inmet.gov.br/portal. Accessed on Apr. 04, 2022.

Kamikoga ATM. et al 2009. Efeito de diferentes épocas de aplicação de três herbicidas dessecantes na produção e qualidade fisiológica de sementes de feijão. Ciências Exatas e da Terra, Ciências Agrárias e Engenharias 15:53-61.

Kappes C et al. 2009. Potencial fisiológico de sementes de soja dessecadas com diquat e paraquat. Scientia Agraria 10:001-006.

Kappes C et al. 2012. Qualidade fisiológica de sementes e crescimento de plântulas de feijoeiro, em função de aplicações de paraquat em pré-colheita. Pesquisa Agropecuária Tropical 42:9-18.

Krenchinski FH et al. 2017. Yield and physiological quality of wheat seeds after desiccation with different herbicides. Journal of Seed Science 39:254-261.

Lacerda ALS et al. 2003. Armazenamento de sementes de soja dessecadas e avaliação da qualidade fisiológica, bioquímica e sanitária. Revista Brasileira de Sementes 25:97-105.

Lacerda ALS et al. 2005. Efeitos da dessecação de plantas de soja no potencial fisiológico e sanitário das sementes. Bragantia 64:447-457.

Lamego FP et al. 2013. Dessecação pré-colheita e efeitos sobre a produtividade e qualidade fisiológica de sementes de soja. Planta Daninha 31:929-938.

Marcos-Filho J. 2005. Fisiologia de sementes de plantas cultivadas. Piracicaba: FEALQ. 495p.

Marcos-Filho J. 2015. Seed vigor testing: an overview of the past, present and future perspective. Scientia Agricola 72:363-374.

Marques OJ. et al. 2009. Incidência fúngica e contaminações por micotoxinas em grãos de híbridos comerciais de milho em função da umidade de colheita. Acta Scientiarum. Agronomy 31:667-675.

Paraginski RT et al. 2015. Qualidade de grãos de milho armazenados em diferentes temperaturas. Revista Brasileira de Engenharia Agrícola e Ambiental 19:358-363.

Pereira T et al. 2015. Chemical desiccatin for early harvest in soybean cultivars. Semina: Ciências Agrárias 36:2383-2394.

ROLAS - Rede oficial de laboratórios de análise de solo e de tecido vegetal. 2004. Manual de adubação e calagem para os estados do Rio Grande do Sul e Santa Catarina. 10.ed. Porto Alegre: Sociedade Brasileira de Ciência do Solo, 2004. 400p.

Santos JB et al. 2004. Qualidade de sementes de feijão (*Phaseolus vulgaris*) após aplicação do carfentrazone-ethyl em pré-colheita. Planta Daninha 22:633-639.

Santos PRR, Vicente D. 2009. Momento fisiológico das plantas de trigo para a dessecação e seus efeitos no rendimento de grãos. Cultivando o Saber 2:52-62.

Scariot MA. et al. 2017. Moisture content at harvest and drying temperature on bean seed quality. Pesquisa Agropecuária Tropical 47:93-101.

Silva PV et al. 2017. Desection of bean culture through herbicides for harvest anticipation. Revista Ensaios Pioneiros 1:14-25.

Tavares CJ et al. 2015. Qualidade de sementes de feijão-azuki dessecadas com saflufenacil e submetidas ao armazenamento. Revista Brasileira de Engenharia Agrícola e Ambiental 19:1197-1202.

Tarumoto MB et al. 2015. Dessecação em pré-colheita no potencial fisiológico de sementes e desenvolvimento inicial de trigo. Cultura Agronômica 24:369-380.

Zuffo AM et al. 2017. Qualidade fisiológica e sanitária de sementes de soja colhidas em diferentes épocas e submetidas a armazenamento. Pesquisa Agropecuária Tropical 47:312-320.

DOI: 10.26814/cps2022005 | 9 pages