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# Seed quality response of *Urochloa humidicola* cv. Llanero to drying surfaces and environments<sup>1</sup>

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## ABSTRACT

The drying process and storage may interfere in the quality of creeping signalgrass seeds [*Urochloa humidicola* (Rendle.) Morrone & Zuloago, syn. *Brachiaria humidicola* (Rendle.) Schweick.]. This study aimed to evaluate the physical, physiological and sanitary quality of creeping signalgrass cv. Llanero seeds submitted to drying surfaces and environments and stored for two periods (1 and 8 months). The experiment was arranged in a completely randomized design, in a  $4 \times 2 \times 2 + 2$  factorial arrangement, with four drying surfaces (soil, asphalt, concrete and ceramic floor), two drying environments (seeds exposed to the sun or shade), two seed storage periods (1 and 8 months) and two additional treatments with drying in paper bags under laboratory conditions (control) and stored for 1 or 8 months, with four replicates. The water content, viability by the tetrazolium test, electrical conductivity, germination rate, germination rate index and seed sanitary quality were measured. Drying at full sun impaired the physiological quality of the seeds due to the high temperatures (46.8-51.0 °C) of the drying surface; however, reduced the incidence of pathogens. The drying of seeds in paper bags under shade results in a higher physiological quality, but the sanitary quality is compromised. However, the pathogens present in the seeds did not inhibit their viability and vigor. The storage for eight months reduces the seed quality.

KEYWORDS: Forage grass; seed pathogens; seed sanity.

## RESUMO

Resposta da qualidade de sementes de *Urochloa humidicola* cv. Llanero a superfícies e ambientes de secagem

O processo de secagem e o armazenamento podem interferir na qualidade das sementes de braquiária humidícola [*Urochloa humidicola* (Rendle.) Morrone & Zuloago, syn. *Brachiaria humidicola* (Rendle.) Schweick.]. Objetivou-se avaliar a qualidade física, fisiológica e sanitária de sementes de braquiária humidícola cv. Llanero submetidas a superfícies e ambientes de secagem e armazenadas por 1 e 8 meses. O delineamento experimental utilizado foi o inteiramente casualizado, disposto em esquema fatorial  $4 \times 2 \times 2 + 2$ , sendo quatro superfícies de secagem (solo, asfalto, concreto e cerâmica), dois ambientes (secagem à sombra e ao sol), dois períodos de armazenamento (1 e 8 meses) e dois tratamentos adicionais com secagem natural em saco de papel em condições de laboratório (controle) e armazenado por 1 ou 8 meses, com quatro repetições. Foram avaliados o teor de água, viabilidade (teste de tetrazólio), condutividade elétrica, germinação, índice de velocidade de germinação e a qualidade sanitária das sementes. A secagem ao sol prejudicou a qualidade fisiológica das sementes devido às altas temperaturas (46,8-51,0 °C) da superfície de secagem; porém, reduziu a incidência de patógenos. A secagem de sementes em sacos de papel à sombra resulta em maior qualidade fisiológica; porém, a qualidade sanitária é comprometida. Todavia, os patógenos presentes nas sementes não inibiram sua viabilidade e vigor. O armazenamento por oito meses reduz a qualidade das sementes.

PALAVRAS-CHAVE: Gramínea forrageira; patógenos de sementes; sanidade de sementes.

## INTRODUCTION

The creeping signalgrass cv. Llanero was originally released by the Colombian Agricultural Institute (CAI), in 1987, as *Brachiaria dictyoneura* cv. Llanero, but it was recently reclassified as

*Urochloa humidicola* (Rendle) Morreno & Zuloaga [syn. *Brachiaria humidicola* (Rendle.) Schweick.] (Quattrocchi 2006).

*U. humidicola* is a tropical grass native to the east and south-east Africa, and growing plants from seeds is the main method of propagating the species.

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It is a leafy, stoloniferous and rhizomatous perennial grass, tolerant to intensive grazing and shade and easily adaptable to acidic, low-fertility and poorly drained soils (Costa et al. 2010).

Forage grasses belonging to the *Urochloa* (Poaceae) genus are widely distributed in the tropical regions of the world, and, in recent years, have been expanding in new agricultural frontiers, especially in the Savannah areas of Brazil and Africa (Cezário et al. 2015). In Brazil, the *Urochloa* genus represents about 90 % of pasture areas (Florindo et al. 2014), what shows its important role in the feeding of ruminant animals. Brazil is currently the largest world producer, consumer and exporter of tropical grass seeds, with an estimated production of 256,000 t of seeds in the 2016/2017 growing season (Carvalho et al. 2017).

During the processing phase of creeping signalgrass seeds, drying and storage should receive special attention, since, after harvest, the seeds still have a moisture content considered inadequate for a safe and effective storage, and it is, therefore, necessary to reduce seed moisture through drying. In the mechanical harvesting, vegetal impurities accompany the seeds, such as green leaves, straw, stolon and weeds, and all this vegetal material in contact with the seeds may interfere in their physiological quality, being necessary to use adequate drying systems. Therefore, the drying process is of fundamental importance for the quality of creeping signalgrass cv. Llanero seeds, especially because the harvest is carried out during the rainy season in the Central-West region of Brazil.

Studies that evaluated drying methods for *Urochloa humidicola* seeds are from the early 1990s (Magalhães & Groth 1992) and information on the cv. Llanero is scarce. Research with this forage grass has evaluated the dormancy breaking and sowing depth (Almeida & Silva 2004, Zuffo et al. 2014). Magalhães & Groth (1992) evaluated the drying of *U. humidicola* cv. Common seeds, when exposed to the sun or shade, in an artificial dryer, on asphalt or concrete surface, in an oven at 35 °C and natural drying. These authors showed that the greatest reduction in the germination rate and vigor occurred when the seeds were exposed to the sun in direct contact with heated surfaces (concrete and asphalt), resulting in drying below the appropriate moisture level for seed storage. In turn, the highest germination rate and vigor of the seeds were reported

with the use of the artificial dryer, either exposed to the sun or in the shade.

After drying, the storage plays a vital role in preserving the seed quality up to the time of its use. Therefore, the seeds should be stored under conditions that allow the preservation of their physical, physiological and sanitary qualities, or, at least, that the quality decrease is not accentuated until the sowing season (Carvalho & Nakagawa 2012). For the better conservation of orthodox seeds, such as creeping signalgrass, environments with lower relative humidity and temperature are the most appropriate, since these conditions allow a low level of metabolic activity in the seeds and the preservation of their viability and vigor (Lima et al. 2014). Oliveira et al. (1999) emphasize that the maintenance of seed quality during storage should be prioritized, because the management practices adopted during the seed production in the field can be lost, if seed quality is not preserved until the sowing season. In this context, the storage period is a determinant factor to obtain seeds of quality, and appropriate conditions during this period can prolong the viability of the seeds, delaying the deterioration process (Almeida et al. 2010).

Due to the high demand for seeds with satisfactory quality for the implantation and reform of new pasture areas in Brazil, studies that aim to evaluate and identify the best drying methods and the storage time of creeping signalgrass seeds are extremely important for agricultural research. Thus, this study aimed to evaluate the physical, physiological and sanitary quality of creeping signalgrass cv. Llanero seeds submitted to drying surfaces and environments and stored for two periods (1 and 8 months).

## MATERIAL AND METHODS

Seeds of creeping signalgrass cv. Llanero [*Urochloa humidicola* (Rendle) Morreno & Zuloaga] were mechanically harvested on January 1, 2014, with a radial flow automated harvester, in a 50-ha area destined for seed production located in Nova Xavantina, Mato Grosso state, Brazil (14°50'41"S, 52°22'49"W and altitude of 310 m). The regional climate, according to the Köppen classification, is Aw, characterized as tropical, with hot summers and a tendency toward high rainfall levels, and dry winters, with a dry season between May and September. Creeping signalgrass has been cultivated for three

years in the area and, since November 2013, this area has not been used for cattle grazing. Seed harvest began when about 10 % of the spikelets had fallen to the ground.

During the cultivation of the creeping signalgrass, in November 2013, topdressing fertilization was carried out with the application of 30 kg ha<sup>-1</sup> of N as ammonium sulfate. In December 2013, weed and pest management control were carried out with the application of 3 L ha<sup>-1</sup> of 2,4-D and 200 mL ha<sup>-1</sup> of thiamethoxam + lambda-cyhalothrin, respectively.

After harvesting, a homogeneous sample of 45 kg of seeds was removed and spread on the concrete floor, in a closed environment, where it remained during the night. On January 2, 2014, the seeds were taken to the laboratory. The initial seed water content determined by the oven drying method at 105 °C, for 24 h, was 51 % ( $\pm 1$  %). The seeds were separated into nine 5 kg sub-samples and then submitted to the drying methods for 5 days.

The experiment was arranged in a completely randomized design, in a 4  $\times$  2  $\times$  2 + 2 factorial scheme, with four drying surfaces (soil, asphalt, concrete and ceramic floor), two drying environments (seeds exposed to the sun or shade), two seed storage periods (1 or 8 months) and two additional treatments [drying in paper bags under laboratory conditions (control) and stored for 1 or 8 months], with four replicates.

The seeds were spread on the drying surfaces in a single layer of  $\pm 5.0$  cm of height. The seed layer was revolved several times during the day for a better seed exposure to the drying environment. The drying procedure was performed between January 2 and 6, 2014, from 9 a.m. to 5 p.m., and, during the night period, the seeds were collected, stored in paper bags and kept under laboratory conditions at room temperature. The seeds of the additional treatment (control) were placed in Kraft-type paper bags and dried under laboratory conditions at room temperature. The paper bags were turned sideways several times during the day.

During the seed drying period, the mean air temperature and relative humidity were 29 °C and 76 %, respectively. The temperature of the drying surfaces was measured daily at midday ( $\pm 12$  a.m.), using a digital thermo-hygrometer (ITHT 2250, Instrutemp Measuring Instruments Ltd., São Paulo, SP, BRA). Data recorded during the seed drying period are shown in Table 1.

After drying, the impurities and seeds were manually separated, in order to obtain a sample of pure seeds for each treatment. After cleaning, the seed samples were packed in Kraft-type paper bags and then kept under laboratory conditions at 25 °C ( $\pm 1.0$  °C), for 1 or 8 months. Afterwards, the physical, physiological and sanitary quality of the seeds were measured using the following tests:

- Water content: the water content (%) of the seeds was determined by the oven drying method at 105 °C ( $\pm 3$  °C), for 24 h (Brasil 2009);

- Tetrazolium test: four replicates of 50 seeds for each treatment were pre-primed on the germination paper towel previously moistened and maintained for 16 h, at 30 °C. Afterwards, the seeds were transferred to plastic cups with a 0.50 % solution of 2,3,5-triphenyl tetrazolium chloride and stained in a dark chamber at 35-40 °C, for 3 h. The seeds were then washed in distilled water and each seed was individually examined (Brasil 2009). The results were expressed as percentage of viable seeds;

- Electrical conductivity: four replicates of 50 seeds for each treatment were placed in 300 mL plastic cups and weighed in an analytical scale with accuracy of  $\pm 0.001$  g. Distilled water (75 mL) was then added to each container. The containers were placed in a biological oxygen demand (BOD) incubator, at a constant temperature of 25 °C, for 24 h (Krzyzanowski et al. 1999). Seeds were then gently agitated for the homogenization of the solution, and the electrical conductivity was measured with a conductivity meter (MS TECNOPON® - mCA150). The results were expressed as  $\mu\text{S cm}^{-1} \text{ g}^{-1}$ ;

- Germination test: the seeds were previously submitted to chemical scarification with concentrated sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) for 9 min, followed by washing in running water for 5 min. Then, four replicates of 50 seeds were evenly distributed in plastic boxes type Gerbox® (11.0 cm  $\times$  11.0 cm  $\times$  3.5 cm) with blotter paper and properly moistened with 0.2 % (m/v) of

Table 1. Mean temperature ( $\pm$  mean standard deviation) of the surfaces during the five days of seed drying, when exposed to full sun or shade.

Drying surface	Drying environment	
	Full sun	Shade
Soil	48.8 $\pm$ 2.6	27.0 $\pm$ 2.8
Asphalt	50.7 $\pm$ 3.2	28.7 $\pm$ 2.6
Concrete	51.0 $\pm$ 3.0	29.1 $\pm$ 2.7
Ceramic	46.8 $\pm$ 1.8	27.4 $\pm$ 2.0

the  $\text{KNO}_3$  solution at the proportion of 2.5 times the weight of dry paper (Brasil 2009). The boxes were then closed with lids to prevent the evaporation and maintain the relative humidity close to 100 %. Germination was carried out in a BOD incubator at the alternating temperatures of 25-35 °C, under a photoperiod of 8 h, at the higher temperature. Germinated seeds were recorded every 7 days until the 120th day after the test installation, when the germination stabilization occurred. For seeds that did not germinate, the tetrazolium test was performed to determine the percentage of dead and dormant seeds.

- Germination rate index: the number of germinated seeds in the germination test was recorded weekly up to 120 days, and the germination rate index was calculated using the Maguire's equation (Maguire 1962):  $\text{GRI} = \sum (n_i/t_i)$ , where  $n_i$  is the number of germinated seeds on a given day and  $t_i$  the time, in days, from the starting/sowing day (0);

- Seed sanitary quality: the evaluation of the seed sanitary quality was performed based on the blotter-test method, according to Machado (2000), with modifications. Four replicates of 40 seeds were placed in Petri dishes and incubated for 7 days, at 20 °C ( $\pm 1$  °C) and 12 h of photoperiod, and then evaluated for the presence of pathogens associated with the seeds. Seed health was evaluated through the confidence interval for proportions ( $P$ ), using the Poisson approximation at 5 % of significance (Ramalho et al. 2012).

Data were submitted to analysis of variance (Anova), and the means of treatments were compared by the Duncan test at 5 % of probability. The Student's t-test ( $\alpha = 0.05$ ) was used to compare the means of drying surfaces and environments with the

control treatment (natural drying in paper bags under laboratory conditions).

## RESULTS AND DISCUSSION

The analysis of variance reported that the effect of drying surfaces and environments were significant ( $p \leq 0.05$ ) for most the seed quality traits, while the effect of the storage period was significant ( $p \leq 0.05$ ) for the tetrazolium test, germination, germination rate index and presence of *Phomopsis* spp. and *Curvularia* spp. in the seeds (Table 2). The interaction among the three factors tested (drying surfaces and environments and storage periods) did not show significant effects ( $p > 0.05$ ) for any of the seed quality traits (Table 2).

The drying surfaces and environments did not significantly affect the water content of the seeds after 1 and 8 months of storage (Table 3). These results suggest that, regardless of the drying surface and environment, the seed hygroscopic equilibrium point was reached. Such inference can be proved by the non-significant effect of the storage period on the water content of the seeds (Table 1). The water contents of the seeds stored for 1 or 8 months were 10.03 % and 8.92 %, respectively. During the drying process, the establishment of the hygroscopic equilibrium moisture of the seeds with the environment is an indicative that the seeds have an adequate moisture to be stored (Carvalho & Nakagawa 2012). Magalhães & Groth (1992) evaluated distinct drying processes of *U. humidicola* cv. Common seeds and also did not find a difference in the water content for the drying surfaces and environments, in seeds stored for 30 days.

Table 2. Summary of the analysis of variance for the physical, physiological and sanitary qualities of creeping signalgrass cv. Llanero seeds submitted to drying surfaces and environments and storage periods.

Causes of variation	Probability > F								
	WC	TZ-T	EC	G	GRI	Fus.	Pho.	Cur.	Dre.
Drying surface (S)	< 0.000	0.193	< 0.000	< 0.000	< 0.000	0.001	0.001	< 0.000	0.384
Drying environment (E)	0.784	< 0.000	0.042	< 0.000	< 0.000	0.001	0.154	< 0.000	0.001
Storage period (SP)	0.365	< 0.000	0.642	< 0.000	< 0.000	0.265	0.008	0.001	0.371
Interaction S $\times$ E	0.644	< 0.000	0.021	< 0.000	< 0.000	0.016	0.290	0.001	0.957
Interaction S $\times$ SP	0.835	0.805	0.030	0.001	0.112	0.002	0.201	0.022	0.196
Interaction E $\times$ SP	0.246	0.033	0.286	0.001	< 0.000	0.894	0.608	0.010	0.001
Interaction S $\times$ E $\times$ SP	0.654	0.084	0.087	0.187	0.053	0.055	0.977	0.104	0.700
CV (%)	3.70	6.28	4.56	7.72	9.31	37.27	27.94	32.45	26.45

WC: water content; TZ-T: tetrazolium test; EC: electrical conductivity; G: germination test; GRI: germination rate index; Fus.: *Fusarium* spp.; Pho.: *Phomopsis* spp.; Cur.: *Curvularia* spp.; Dre.: *Drechslera* spp.; CV: coefficient of variation.



Table 3. Effect of drying surfaces and environments on the water content (%) of the creeping signalgrass cv. Llanero [*Urochloa humidicola* (Rendle) Morreno & Zuloaga] seeds stored for 1 or 8 months.

Drying surface	Drying environment			
	Full sun	Shade	Full sun	Shade
	Seeds stored for 1 month		Seeds stored for 8 months	
Soil	10.06 aA*	9.97 aA	9.09 aA	8.87 aA
Asphalt	10.04 aA	10.03 aA	8.98 aA	8.77 aA
Concrete	10.05 aA	10.08 aA	8.83 aA	8.85 aA
Ceramic	10.08 aA	9.90 aA	9.22 aA	8.73 aA
Control	10.05 <sup>†</sup>		9.38 <sup>†</sup>	

\* Means followed by distinct lowercase letters in the column or uppercase letters in the row show significant differences (Duncan test,  $p \leq 0.05$ ). <sup>†</sup> The seed water content of the control treatment did not differ significantly by the Student's t-test ( $\alpha = 0.05$ ), when compared to the seeds exposed to drying surfaces and environments in both storage periods.

The uniformity of the seed water content in both storage periods is extremely important to standardize the evaluations and provide consistent results (Loeffler et al. 1988). Therefore, the physiological tests used in this study were not influenced by the initial water content of the seeds during the storage periods.

The drying of creeping signalgrass seeds in the shade resulted in a higher viability percentage by the tetrazolium test on all drying surfaces, in both storage periods (Figures 1a and 1b). These results indicate that the viability of the seeds was drastically reduced with the drying in the full sun and, therefore, should not be a method recommended for the drying of creeping signalgrass seeds. Indeed, Queiroz et al. (2011) reported that seed drying exposed to high temperatures may cause irreparable damage to the membrane system, impairing their physiological quality and leading to the development of abnormal seedlings. However, the damage caused by temperature depends on the exposure time and initial seed water content, i.e., the higher the water content, the lower the initial drying temperature should be (Carvalho & Nakagawa 2012). Therefore, for creeping signalgrass seeds, slow drying seems to be a more appropriate process, because, as in other tropical forage species, after harvest, the seeds still need some time to complete the physiological maturation (Garcia et al. 2004).

After 1 month of storage, the viability of the seeds submitted to natural drying in paper bags under laboratory conditions did not differ from the drying process in the shade, on the concrete surface

(Figure 1a). At 8 months of storage, the viability of seeds dried in the shade on the ceramic or soil surfaces did not differ from those dried naturally in the laboratory (Figure 1b). On the other hand, the drying of seeds exposed to full sun resulted in a lower percentage of seed viability for all drying surfaces, when compared to seeds dried naturally under laboratory conditions, in both storage periods (Figures 1a and 1b).

The seeds dried in the sun or in the shade did not differ, with respect to the electrical conductivity test, which was higher than for those submitted to natural drying under laboratory conditions (Figures 1c and 1d). The electrical conductivity test has been used as an indirect evaluation of the physiological quality of seeds through the measurement of the electrolyte leakage for the seed imbibition solution (Vieira et al. 2002). Therefore, the increase in electrical conductivity is an indicative of the greater disorganization of the cell membranes, making the seed more susceptible to damage caused by external agents, such as extreme environmental conditions and pathogen actions, compromising the physiological quality and viability of the seeds (Ullmann et al. 2015).

Seeds drying in the shade resulted in the highest germination rate index, when compared to drying in full sun, for all drying surfaces, in the two storage periods (Figures 1e and 1f). These results indicate that the germination rate index was reduced with the exposure of the seeds to the sun. The seeds submitted to natural drying in paper bags under laboratory conditions showed a higher germination rate index, when compared to the other drying processes, in both storage periods (Figures 1e and 1f). These findings confirm the hypothesis that creeping signalgrass seeds should be exposed to a slow drying, in order to guarantee a higher physiological quality.

According to Garcia et al. (2004), high temperatures can cause, among other changes, protein denaturation. The physiological damage caused by drying can be reflected in modifications in the subcellular systems, including chromosomes and mitochondria, reduction of the starch granules amount in the embryonic axis, increases in electrolyte and sugar leakage and carotenoid production, reduction of cell membranes permeability and respiratory rate.

The drying of creeping signalgrass seeds in the shade, stored for 1 or 8 months, resulted in a higher

germination rate and viable seeds percentage on all drying surfaces (Figures 2a and 2b). On the other hand, drying in the sun provided a higher percentage of dead seeds in both storage periods (Figure 2). Similar results were reported by Alves et al. (2017), which showed that slow drying resulted in a higher germination rate of palisade grass seeds [*Urochloa brizantha* (Hochst. ex A. Rich.) R. D. Webster cv. Marandu], when compared to fast drying. This loss of germination capacity of the seeds exposed to drying

in the sun is related to the high temperatures of the surfaces in contact with the seed (Table 1), which resulted in physiological changes and increase in the number of dead seeds. Such inference can be confirmed by the high temperatures ( $> 50\text{ }^{\circ}\text{C}$ ) of the asphalt surface (Table 1), which resulted in the highest percentage of dead seeds, when exposed to the sun (Figure 2).

Seed storage for 8 months resulted in a lower germination rate and percentage of viable seeds,

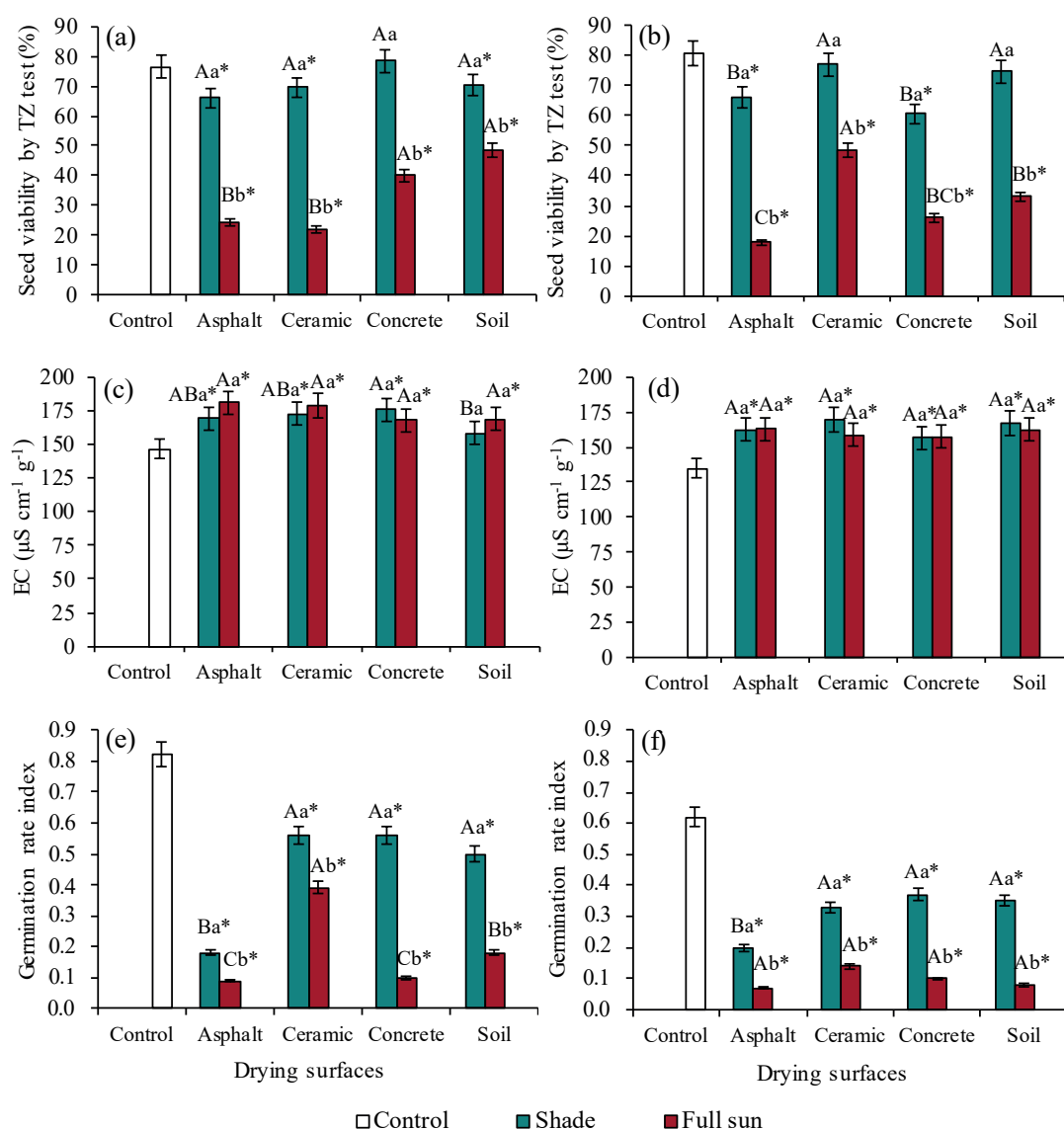


Figure 1. Seed viability by the tetrazolium test (a and b), electrical conductivity (EC; c and d) and germination rate index (e and f) of the creeping signalgrass cv. Llanero [*Urochloa humidicola* (Rendle) Moreno & Zuloaga] seeds stored for 1 month (a, c and e) and 8 months (b, d and f) and exposed to the drying surfaces and environments. Bars followed by distinct uppercase letters for the drying surfaces or lowercase letters for the drying environments show significant differences (Duncan test,  $p \leq 0.05$ ). \* Mean significantly different by the Student's t-test ( $\alpha = 0.05$ ), when compared to the control treatment (natural drying in paper bags under laboratory conditions). Data refer to mean values ( $n = 4$ )  $\pm$  standard error.

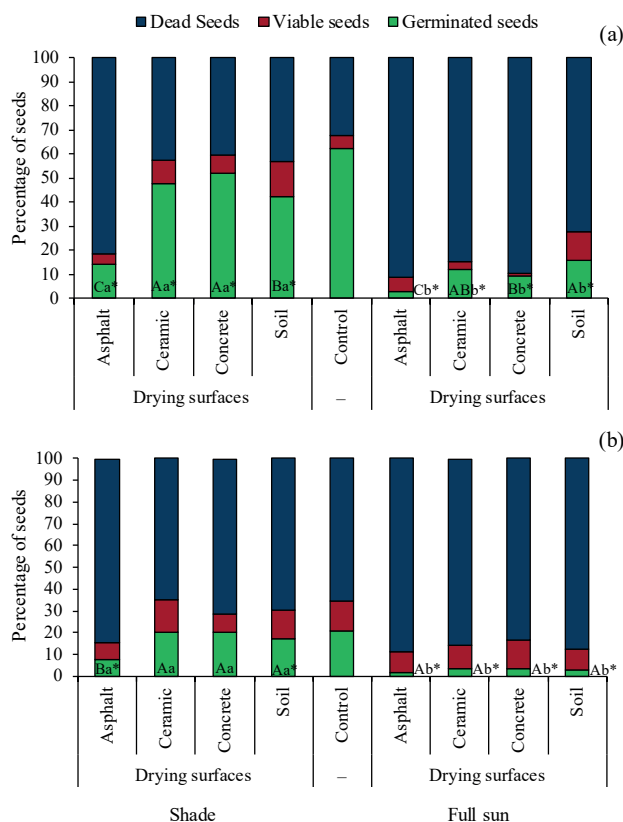


Figure 2. Germination rate and number of dead and dormant seeds at 120 days after sowing, determined by the tetrazolium test, on seeds of creeping signalgrass cv. Llanero [*Urochloa humidicola* (Rendle) Morreno & Zuloaga] stored for 1 month (a) and 8 months (b) and exposed to the drying surfaces and environments. Bars followed by distinct uppercase letters for the drying surfaces or lowercase letters for the drying environments show significant differences (Duncan test,  $p \leq 0.05$ ). \* Mean significantly different by the Student's t-test ( $\alpha = 0.05$ ), when compared to the control treatment (natural drying in paper bags under laboratory conditions).

when compared to storage for 1 month, regardless of the drying surface and environment (Figure 2b). Contrary results were reported by Magalhães & Groth (1992), who did not observe differences in the seed germination rate during the storage period of creeping signalgrass cv. Common, regardless of surface and drying environment. This fact may be related to the low water content of the seeds (Table 1), which, associated with chemical scarification with concentrated sulfuric acid, may have damaged the seeds, making them unviable. Furthermore, the rapid imbibition of the seeds in contact with the moistened substrate may have caused the rupture of the cell membranes. Silva & Villela (2011) reported

that seeds subjected to a rapid hydration could be damaged by imbibition, in which the intensity depends on the cultivar and the initial water content of the seeds.

For seeds stored for 1 month, the natural drying in paper bags in the laboratory resulted in a higher germination rate (Figure 2a), differing from all other drying processes. After 8 months of storage, the seeds submitted to natural drying showed a similar germination rate to the drying process in the shade on the ceramic and concrete surfaces (Figure 2b).

Regarding the evaluation of the seed sanitary quality, the pathogens *Fusarium* sp., *Phomopsis* sp., *Curvularia* sp. and *Drechslera* sp. were identified in creeping signalgrass seeds stored for 1 month (Figure 3a) and 8 months (Figure 3b). These are pathogens which occur widely and have a great importance in Brazil, causing significant losses in the viability and quality of creeping signalgrass seeds (Marchi et al. 2010). On the other hand, other pathogens of importance for sanitary quality, such as *Alternaria* sp., *Aspergillus* sp. and *Penicillium* sp., were not identified infecting the creeping signalgrass seeds. According to Marcos-Filho (2005), fungi of the *Fusarium* sp., *Colletotrichum* sp. and *Alternaria* sp. genera are known as field fungi, whereas *Penicillium* sp. and *Aspergillus* sp. are storage fungi, which contaminate the seeds mainly after harvest.

Among the pathogens observed in the creeping signalgrass seeds, fungi of the *Curvularia* sp. and *Phomopsis* sp. genera were those that occurred with the highest incidence, after 1 month of storage (Figure 3a), whereas, at 8 months of storage, the fungus with the highest incidence was *Phomopsis* sp. (Figure 3b). Menten (1995) reported that the presence of pathogens such as fungi of the *Fusarium* sp. and *Phoma* sp. genera can cause the seed death, even before its germination.

The natural drying of the seeds under laboratory conditions resulted in a higher incidence of pathogens, when compared to drying in the sun or shade (Figure 3c) and to the drying surfaces (Figure 3e). These results indicate that the slow drying of the seeds in a closed environment, as in the packaging of paper bags, resulted in a lower sanitary quality of the seeds. This higher incidence of pathogens under slow drying conditions may result in a rapid deterioration of the sanitary and physiological quality of the seed. On the other hand, the highest



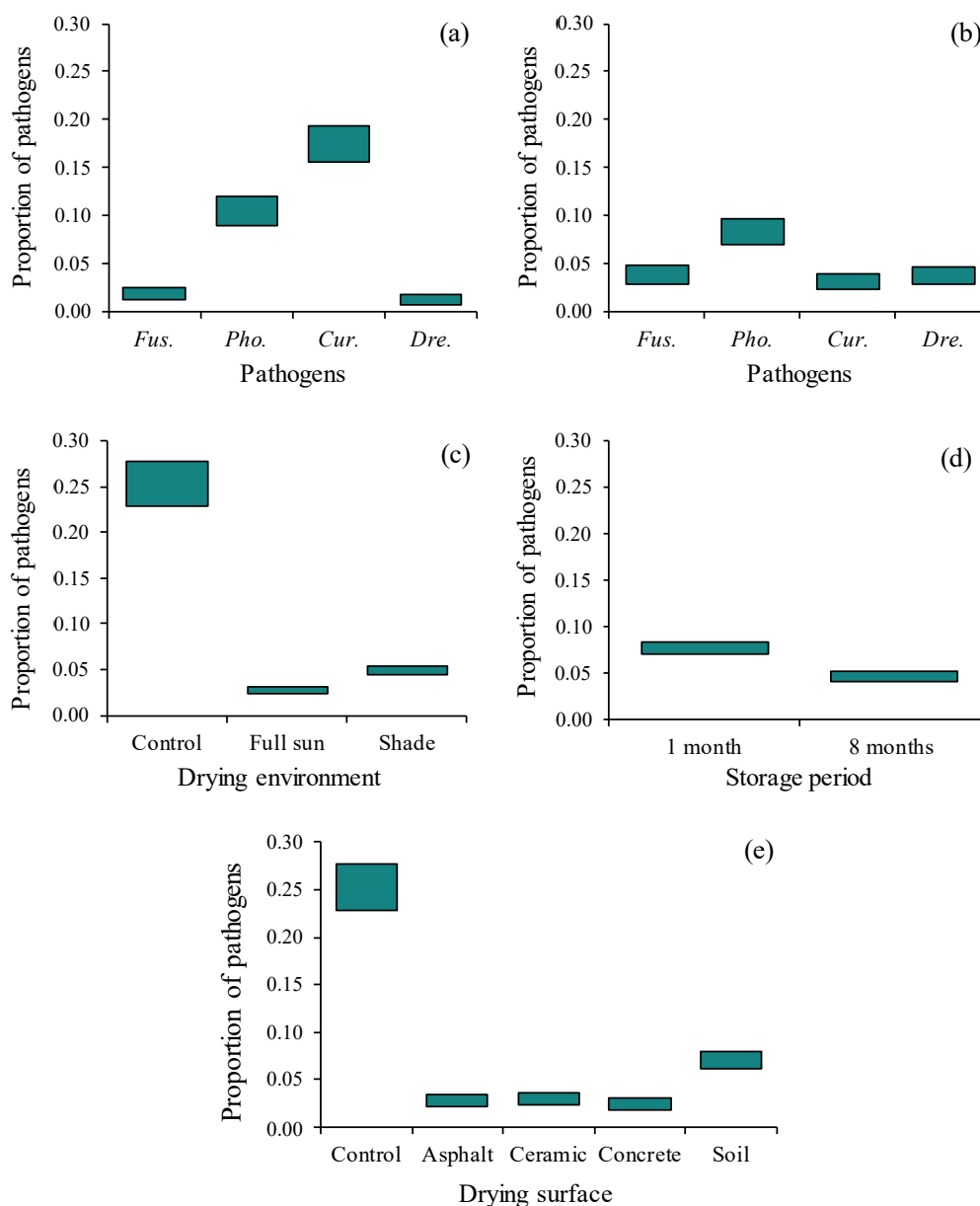


Figure 3. Confidence intervals (95 % of probability) for the proportions of pathogens (Fus.: *Fusarium* sp.; Pho.: *Phomopsis* sp.; Cur.: *Curvularia* sp.; Dre.: *Drechslera* sp.) in creeping signalgrass cv. Llanero [*Urochloa humidicola* (Rendle) Morreno & Zuloaga] seeds stored for 1 month (a) and 8 months (b), or when exposed to the drying environments (c), storage period (d) and drying surfaces (e).

incidence of pathogens was observed in the seeds stored for 1 month (Figure 3d).

The highest physiological quality of the creeping signalgrass seeds was obtained with the natural drying in paper bags in the laboratory, followed by drying in the shade, as reported by the test of viability (Figures 1a and 1b), germination rate index (Figures 1e and 1f) and germination rate (Figures 2a and 2b). Thus, despite the higher

incidence of pathogens in the seeds submitted to natural drying in the laboratory (Figure 3c), it is verified that such conditions did not reduce the seed physiological quality. Therefore, the presence of the pathogens *Fusarium* sp., *Phomopsis* sp., *Curvularia* sp. and *Drechslera* sp. (Figures 3a and 3b) did not affect the seed quality, possibly due to their low proportion of incidence. In addition, seed drying in the sun provided a reduction in the proportion of

pathogens (Figure 3c) and viability (Figure 2) for all drying surfaces. Thus, it is evident that, in this study, the pathogens present did not influence the germination capacity of the seeds. It is also noted that drying in the sun resulted in deterioration of the seed physiological quality, due to the high temperatures of the drying surface.

The creeping signalgrass cv. Llanero seeds submitted to natural drying under laboratory conditions presented a higher physiological quality. However, for the natural drying in paper bags, new studies should be carried out, since, in this experiment, a reduced seed sample was used. This is because, in field conditions, the large volume of produced seeds makes the use of this drying process impossible. The farmer, therefore, has to prioritize the drying in the shade on the ceramic surface, due to the smaller reduction of the physiological quality of the seeds, when compared to the other drying surfaces.

## CONCLUSIONS

1. Drying at full sun impairs the physiological quality of creeping signalgrass seeds, due to the high temperatures of the drying surface; however, it reduces the incidence of pathogens;
2. The drying of creeping signalgrass cv. Llanero seeds in paper bags under laboratory conditions results in a higher physiological quality, but the sanitary quality is compromised; however, the pathogens present in the seeds do not inhibit their viability;
3. Drying in the shade on the ceramic surface is the most indicated method for improving the physiological quality of creeping signalgrass seeds;
4. The storage for 8 months reduces the seed quality.

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