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GERMINATION AND DORMANCY IN SEEDS OF *Sorghum halepense* AND *Sorghum arundinaceum*[1]

Germinação e Dormência em Sementes de ***Sorghum halepense*** *e Sorghum arundinaceum*

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ABSTRACT - Light, temperature and dormancy are factors that influence the germination of seeds and are strictly linked to the emergence of weeds. The objective of this work was to assess the germination of *Sorghum arundinaceum* and *Sorghum halepense* subjected to different conditions of temperature and luminosity, as well as assessing seed dormancy breaking mechanisms. For this, two experiments were conducted, both arranged in a completely randomized design. Experiment 1 was installed in a 2 x 5 double factorial design. The first factor was the absence or presence of light for 12 hours, and the other was composed of five constant temperatures: 15, 20, 30, 40 and 45 °C. In experiment 2, the efficiency of nine treatments used for breaking dormancy of seeds was assessed. The variables analyzed for both experiments were germination percentage and germination speed index (GSI). For the statistical analysis were performed an analysis of variance (ANOVA) and all the necessary consequences, as well as regression, when relevant. In experiment 1 for both species greater germination occurred in the presence of light. For *S. arundinaceum* the temperatures at which there was the highest percentage of germination were 33.13 and 31.24 °C for presence and absence of light respectively. As for *S. halepense* these temperatures were 31.98 and 29.75 °C for presence and absence of light respectively. As for the treatments for breaking dormancy, the mechanical scarification of seeds with sandpaper presented the highest germination and GSI. It is concluded that the *Sorghum* species studied are neutral photoblastic seeds and present mechanical type dormancy.

Keywords: johnsongrass, false johnsongrass, dormancy, seeds.

RESUMO - A luz, a temperatura e a dormência são fatores que influenciam a germinação das sementes e estão estritamente ligados à emergência de plantas daninhas. Objetivou-se com este trabalho avaliar a germinação de ***Sorghum arundinaceum*** *e* ***Sorghum halepense*** *submetidas a diferentes condições de temperatura e luminosidade, bem como avaliar mecanismos de quebra de dormência das sementes. Para isso, foram realizados dois experimentos, ambos dispostos em delineamento inteiramente casualizado. O experimento 1 foi instalado em esquema fatorial duplo de 2 x 5. O primeiro fator consistiu na ausência ou na presença de luz durante 12 horas; e o segundo, em cinco temperaturas constantes: 15, 20, 30, 40 e 45 °C. No experimento 2, avaliou-se a eficiência de nove tratamentos utilizados para quebra de dormência das sementes. As variáveis analisadas nos dois experimentos foram: porcentagem de germinação e índice de velocidade de germinação (IVG). Para a análise estatística, foram realizados a ANOVA e todos os desdobramentos necessários, bem como regressões, quando pertinentes. No experimento 1, em ambas as espécies ocorreu maior germinação na presença de luz. Para* ***S. arundinaceum****, as temperaturas em que houve maior porcentagem de germinação foram 33,13 e 31,24 °C, para presença e ausência de luz, respectivamente. Já para* ***S. halepense****, essas temperaturas foram de 31,98 e 29,75 °C, na presença e ausência de luz, respectivamente. Quanto aos tratamentos para a quebra da dormência, as sementes escarificadas mecanicamente com lixa foram as que apresentaram a maior germinação e IVG. Conclui-se que as espécies de* ***Sorghum*** *estudadas são fotoblásticas neutras e apresentam dormência do tipo mecânica.*

Palavras-chave: capim-massambará, capim-falso-massambará, dormência, sementes.

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INTRODUCTION

Among the weed species that occur in the main economic crops of the world, about 44% belong to the Poaceae family (Cobb, 1992). Within this family, genus *Sorghum* presents weed species that infest and cause serious damage to agriculture and livestock. Johnsongrass (*Sorghum halepense*) is one of the most popular weeds in the world for its infestation potential on pastures and crops. Together with *S. halepense*, *S. arundinaceum*, (false johnsongrass) has great infestation potential in the crops of corn, sugarcane, cotton, soybeans, among others (Nóbrega Júnior et al., 2006).

According to Concenço et al. (2012), *S. halepense* is a perennial plant with reproduction by seeds and rhizomes. This species is adapted to hot and rainy regions, and in Brazil it tends to spread in various agricultural areas. *S. arundinaceum* differs from *S. halepense* by reproducing only by seeds and can reach up to 4 m high. The particles are loose (open) and large (20 to 60 cm long), producing large quantities of seed.

Weeds such as *S. halepense* and *S. arundinaceum* depend directly on the germination to infest and compete with the cultivated species (Roberts, 1999). In general, the germination of seeds is defined as a series of metabolic and morphological processes that transform the embryo in seedling (Taiz & Zeiger, 2009; Camargo et al., 2002). Germination is influenced by several factors such as light, temperature, phytohormones action and humidity (Takahoshi, 1995).

The temperature directly affects the seed germination, and can inhibit or stimulate the germination process. Furthermore, the alternating temperatures may be used as a method for breaking or overcoming dormancy in species of *Poaceae* (Ikeda et al., 2012).

Light is responsible for causing a number of changes in the physiology of seeds, such as the accumulation of active forms of phytochromes, which is bound to break dormancy in seeds of some species (Hilhorst & Karssen, 1988). Thus, light is required for seed germination of some species, which are called positive photoblastic; others are negative photoblastic, i.e., they germinate best when there is light limitation; and there are the ones that are indifferent or neutral, they do not have sensitivity to light (Lopes et al., 2005).

Several weed species have seed dormancy, directly implying the determination of the emergence flow of seedlings in the field (Rodrigues & Pitelli, 1994). According to Marcos Filho (2005), dormancy is a seed adaptation mechanism against environmental variations; thus, it is a mechanism to ensure seed survival and perpetuation of some species in their natural dispersal. In this sense, knowledge and efficiency of techniques to overcome or break dormancy and knowledge about the germination flow effectively contribute with management tactics of weeds (Santos et al., 2001; Brighenti et al., 2003; Vivian et al., 2008). For Ogunwenmo & Ugborogho (1999) and Azania et al. (2003), methods for overcoming seed dormancy, such as mechanic scarification, soaking seeds in sulfuric acid, treatment with phytohormones and hot water, were responsible for increasing the percentage of germination in seeds of certain weed species.

Thus, the aim of this work was to study the germination of *S. halepense* and *S. arundinaceum* under different conditions of temperature and light, and to assess some treatments that are used to break dormancy.

MATERIALS AND METHODS

Experiment 1

Experiment 1 was carried out in BOD (Biochemical Oxygen Demand) type germination chamber in order to test the behavior of the species of *Sorghum* when subjected to different temperatures in the presence and absence of light.

The experiment was arranged in a completely randomized design in a 2 x 5 factorial, with five replications. The first factor refers to the presence and absence of light, considering for the presence of light a photoperiod of 12 hours, and the second factor consisted of five constant temperatures: 15, 20, 30, 40 and 45 °C.

In the treatments in the absence of light, assessments were made exclusively under safety green light conditions (Noronha et al., 1978).

Data were subjected to analysis of variance and all necessary developments ($p < 0.05$) (Pimentel-Gomes & Garcia, 2002). The averages for the light factor were compared by the F test ($p < 0.05$), and the regression analysis was used for data obtained at the temperatures ($p < 0.05$).

Experiment 2

Experiment 2 was conducted in BOD type germination chamber to assess different dormancy breaking treatments in seeds of *S. halepense* and *S. arundinaceum*.

The experiment was arranged in a completely randomized design with five replicates. The treatments shown in Table 1 were tested at a constant temperature of 30 °C with a photoperiod of 12 hours of light per day. The control treatment did not show any form of dormancy breaking. In mechanical scarification with sandpaper, all the palea and lemma were removed, exposing the embryo and the reserve tissue.

Data were subjected to analysis of variance and all necessary developments ($p < 0.05$) (Pimentel-Gomes & Garcia, 2002). The means were grouped by the Scott-Knott test ($p < 0.05$).

Plant material and tests

For experiments 1 and 2, the seeds of the species *Sorghum* were collected 30 days prior to conducting the experiments, in production areas located in the Brazilian city of Palotina (west region of Paraná State), shade dried and stored at 14% moisture. In both experiments, fifty seeds were sown in five replicates per treatment, in gerbox type plastic boxes (11.0 x 11.0 x 3.0 cm), transparent for the treatments in the presence of light and for the experiment of dormancy breaking, and dark for the seeds that remained in the absence of light. Seeds were placed on three sheets of filter paper (germitest type) moistened with water equivalent to 2.5 times their weight. The moisture content of the substrate was monitored daily, and when necessary it was moistened with 3 mL of distilled water.

The variables analyzed in both experiments were: germination percentage and germination speed index (GSI). To calculate the percentage used, the following equation was used: $G(\%) = (N/A) \times 100$, where: N = number of germinated seeds; A = total number of seeds placed to germinate. As for the germination speed index, this equation was used: $GSI = ((N_1/D_1) + (N_2/D_2) + (N_N/D_N))$, where: GSI = germination speed index; N = number of seeds germinated on the day; D = days for germination to occur (Maguire 1962). The assessments were performed daily until the species had constant germination, which occurred at 21 days. In both experiments the seeds that were considered germinated were those with root length equal or higher than 2 mm (Rehman et al., 1996).

RESULTS AND DISCUSSION

Experiment 1

There was no significant interaction between the light and temperature factors. Isolating the light effect, one can see that for both species, *S. arundinaceum* (Table 2) and *S. halepense* (Table 3), in general, the highest germination averages occurred in the presence of light.

For *S. arundinaceum* (Table 2), germination values in the presence of light significantly differed from germination in the absence of light at temperatures of 20, 30, 40 and 45 °C, with a difference in the percentage of germination around 12, 26, 26.5 and 22.5 percentage points, respectively, for the above temperatures. In general, for *S. halepense* (Table 3) there was a low germination percentage, but in the presence of light higher germination values were obtained at temperatures of 30, 40 and 45 °C compared to the absence of light, with a difference of 4.75, 8.5 and 6 percentage points, respectively. The low percentage of germination obtained for these seeds can be explained by the fact that no treatment was used to break dormancy; only the effects of temperature and light were assessed.

Table 1 **-** Description of the treatments used in the second experiment

Acronym	Description
T1	Control;
T2	Soaking in diluted gibberellic acid at a concentration of 0.1% for 1 minute;
T3	Soaking in diluted gibberellic acid at a concentration of 0.05% for 1 minute;
T4	Chemical scarification with sulfuric acid with total concentration for 3 minutes;
T5	Chemical scarification with sulfuric acid with full concentration for 5 minutes;
T6	Chemical scarification with sulfuric acid with a concentration of 70% for 15 minutes;
T7	Immersion in water at 50 ^{o}C for 30 minutes;
T8	Immersion in water at 50 ^{o}C for 30 minutes, after addition of ice water (heat shock);
T9	Mechanical scarification with a sandpaper.

Table 2 **-** Germination and germination speed index of *Sorghum arundinaceum* seeds in the presence and absence of light at different temperatures

Temperature (^{o}C)	Germination (%)		GSI (sprouted seeds / day)	
	Presence of light	Absence of light	Presence of light	Absence of light
15	0.001 a	0.002 a	0.00 a	0.00 a
20	29.00 a	17.00 b	0.78 a	0.62 a
30	52.25 a	26.25 b	5.52 a	3.50 b
40	40.50 a	14.00 b	2.43 a	0.60 b
45	34.00 a	11.50 b	1.93 a	0.36 b
Average	31.15	13.75	2.13	1.01
CV %	32.13	32.13	22.36	22.36
DMS	10.47	10.47	0.51	0.51

Same letters in the rows do not differ by F test ($p < 0.05$).

Table 3 **-** Germination and germination speed index of *Sorghum halepense* seeds in the presence and absence of light at different temperatures

Temperature (^{o}C)	Germination (%)		GSI (sprouted seeds / day)	
	Presence of light	Absence of light	Presence of light	Absence of light
15	0.003 a	0.001 a	0.00 a	0.00 a
20	7.00 a	7.00 a	0.95 a	0.30 b
30	18.50 a	13.75 b	1.43 a	1.25 a
40	11.50 a	3.00 b	1.17 a	0.24 b
45	7.50 a	1.50 b	0.59 a	0.06 b
Average	8.90	5.05	0.83	0.37
CV %	38.71	38.71	41.21	41.21
DMS	1.75	1.75	0.16	0.16

Same letters in the rows do not differ by F test ($p < 0.05$).

Even with the greater germination in the presence of light, the two species showed significant percentages of germination in the absence of light. This is important in the study of these species within the crops of economic interest, whose germination can occur early or late regarding the closure of the crop, which guarantees them the ability to compete and consequently reduce the productive aspects of the crops. Furthermore, the control by means of straw deposition can be compromised for these species. Other species belonging to the Poaceae family have also shown higher rates of germination in the presence of light than in its absence, including *Digitaria ciliaris* and *Digitaria insularis* (Mondo et al., 2010).

For both species, it is observed that germination was greater as the temperature increased to some extent. With the increase

of the constant temperatures, it is observed that the seeds in the absence of light had a more pronounced reduction in germination rates compared to seeds in the presence of light.

According to Concenço et al. (2012), *S. halepense* seed can germinate at a depth of 15 cm, and seeds found above 22 cm in the soil may have viability of up to two years, that is, the seeds of this species germinate even in the absence of light.

The GSI data for *S. arundinaceum* (Table 2) have shown a trend similar to the one of the percentage of germination. Only at temperatures of 15 and 20 °C difference in values between treatments with and without light was not observed (Table 2). In the other temperatures, GSI in the presence of light was higher. GSI for *S. halepense* (Table 3) was higher at temperatures 20, 40 and 45 °C in the presence of light.

Regarding temperature, one can see that for *S. arundinaceum* (Figure 1A) it was possible to adjust a quadratic regression model, both in the presence and absence of light. In the presence of light the ideal temperature for germination was 33.13 °C, with maximum germination of 52.63%. As for the absence of light, temperature 31.24 °C was found, with the maximum germination of 25.38%.

For *S. halepense* (Figure 1B), a quadratic regression model was also adjusted, both in the presence and absence of light. In the presence of light, the ideal temperature 31.98 °C was found and in the the absence of light 29.75 °C, with maximum germination of 17.09 and 11.93%, respectively.

Hamada et al. (1993), assessing genotypes of *S. arundinaceum*, found that they are able to germinate at temperatures 10-35 °C, showing to be similar to the results of this work, whose germination occurred between temperatures 20 and 45 °C, but having as ideal 33.13 °C. These data demonstrate the high capacity that the seeds of this species have to germinate even in adverse temperature conditions.

For the GSI variable in both species it was possible to adjust a quadratic curve (Figure 2). For *S. arundinaceum*, higher GSI was found in the presence of light (4.43) in temperature 32.04 °C. As for the absence of light, the highest GSI (2.63) occurred at 30,33 °C. For *S. halepense* it was possible to observe, in the presence of light, higher GSI (1.53) at a temperature of 31.62 °C, and in the absence of light at 30.04 °C the highest GSI was found (0.98).

The temperatures of maximum germination and maximum GSI were very similar for both species. It was noted that *S. arundinaceum*, when numerically compared, presented germination and GSI higher than in *S. halepense*, both in the presence and absence of light. These results may be related to the differential degree of numbness for each species.

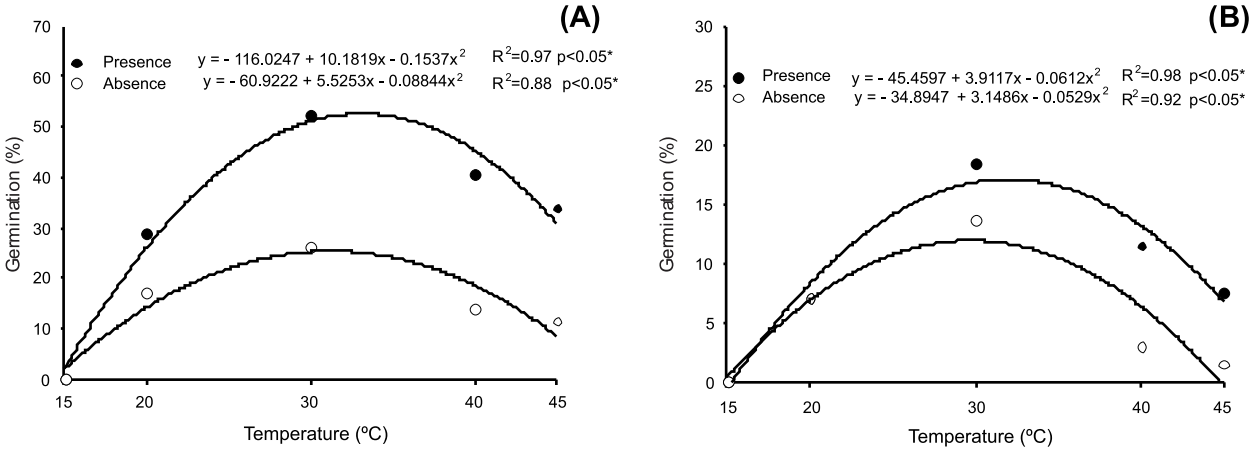

Figure 1 - Germination of *Sorghum arundinaceum* (A) and *Sorghum halepense* (B) in different temperatures in the presence and absence of light.

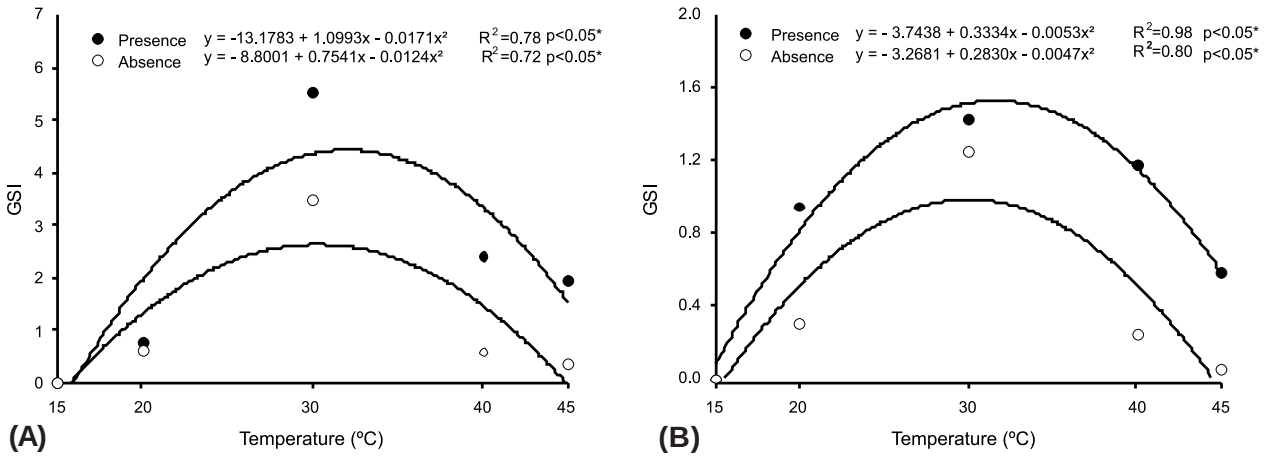

Figure 2 - Germination speed index of *Sorghum arundinaceum* (A) and *Sorghum halepense* (B) at different temperatures in the presence and absence of light.

Experiment 2

For *S. arundinaceum* (Table 4), the highest percentage of germination occurred when seeds were subjected to treatment of mechanical scarification with sandpaper (T9). This treatment showed a difference of 53.6 percentage points compared to the germination of the control (T1). The chemical scarification treatments with sulfuric acid for three minutes (T4), chemical scarification with sulfuric acid for five minutes (T5) and chemical scarification with sulfuric acid at 75% for 15 minutes (T6) had germination lower to the control. In these treatments, treatment with sulfuric acid was used, which may have adversely affected the embryos by preventing germination. GSI for *S. arundinaceum* was higher in the treatment of mechanical scarification with sandpaper. According to Mayer & Poljakoff-Muayber (1989), this may be related to the removal of the bales, which improves water permeability, and induces increased sensitivity to light and temperature and allows gas permeability, factors that are related to overcoming seed dormancy. Treatment of chemical scarification with sulfuric acid for five minutes (T5) presented GSI zero because germination has not occurred.

For *S. halepense* (Table 5), the mechanical scarification treatment with sandpaper (T9) was the one which presented the highest percentage of germination (64.80%). In the chemical scarification treatments with sulfuric acid for three minutes (T4), chemical scarification with sulfuric acid for five minutes (T5) and chemical scarification with sulfuric acid at 75% for 15 minutes (T6) germination was not observed. Sulfuric acid was used in these treatments, which may have negative effects even at lower concentrations or in shorter exposure time on the seeds of *S. halepense*. The mechanical scarification treatment with sandpaper (T9) was the one which showed higher GSI.

For both species, the highest germination and GSI values were observed for treatment with mechanical scarification of the seeds with sandpaper (T9), demonstrating that the seeds of these species have mechanical dormancy. According to Hamada et al. (1993), the species *S. halepense* also has chemical type dormancy, i.e., due to the presence of substances internal or external to the seed and when in contact with the embryo, they inhibit germination. The species *S. arundinaceum* also has physiological dormancy (Martins et al., 2012). This may explain why, even with mechanical scarification, the maximum germination values were below 75%. According to Vivian et al. (2008), dormancy of weed seeds ensures survival for months and even years, which facilitates its dissemination capacity.

In conclusion, *S. arundinaceum* and *S. halepense* have seeds that are considered

Table 4 - Germination and germination speed index of *Sorghum arundinaceum* seeds under different dormancy breaking treatments

Treatment	Germination (%)	GSI (sprouted seeds/day)
T1	20.80 d	1.75 b
T2	18.00 d	2.01 b
T3	26.40 b	2.53 b
T4	13.20 e	1.84 b
T5	0.00 f	0.00 c
T6	12.00 e	1.46 b
T7	23.60 c	1.64 b
T8	22.40 c	1.42 b
T9	74.40 a	16.32 a
Average	23.42	3.22
CV %	9.43	20.00

Same letters in the same column were not significantly different by the Scott-Knott test ($p < 0.05$).

Table 5 - Germination and germination speed index of *Sorghum halapense* seeds under different dormancy breaking treatments

Treatment	Germination (%)	GSI (sprouted seeds/day)
T1	12.80 b	1.05 b
T2	7.20 d	0.77 b
T3	14.00 b	1.19 b
T4	0.00 e	0.00 c
T5	0.00 e	0.00 c
T6	0.00 e	0.00 c
T7	11.60 c	0.69 b
T8	7.20 d	0.47 b
T9	64.80 a	11.75 a
Average	13.07	1.77
CV %	9.18	23.34

Same letters in the same column were not significantly different by the Scott-Knott test ($p < 0.05$).

neutral photoblastic. The best temperature for germination and GSI were close to 30 °C in both species. As for breaking dormancy, mechanical scarification with sandpaper showed the highest germination and GSI values for both species.

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