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Germination of Sorghum Under the Influences of Water Restriction and Temperature

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Abstract: The study had the aim to evaluate the germination responses provoked by water restriction and by the effect of temperature on seeds of *S. bicolor* cultivar BR-700. The experimental design was to carried out in 3×8 factorial scheme, with 3 temperature levels (26, 30 and 34°C), combined with 8 osmotic potential levels that simulate water restriction (Ψs = 0.0, -0.1, -0.2, -0.3, -0.4, -0.5, -0.6 and -0.7 MPa). The analyzed variables were the germination percentage (%G) and the mean germination time (MGT). It was showed progressive fall in %G due to the decreased Ψs of the environment, independent of the temperature, caused by the low water conductivity and slow water absorption by the seed. MGT reduced occasioned by temperature increased, in the interval between 26-34°C, provoked by an acceleration of biochemical reactions involved in germination. Moreover, the water restriction, as well as the Ψs reduced, proportioned a maximization of MGT.

Key words: *Sorghum bicolor* L. Moench, water deficit, temperature, seed

INTRODUCTION

Sorghum (*Sorghum bicolor* L.) Moench) is an important alternative for human and animal food, especially in regions of low water availability, in which its are seeds rich in protein, vitamins, carbohydrates and minerals. Also, the plants have a high green mass and are tolerant to drought and high temperatures (Carvalho *et al*., 2000).

The critical phase in the production cycle of sorghum is the period between sowing until the plant has produced seedlings, due to the adverse environmental conditions as low or high temperatures, water excess or deficiency, salinity, soil compacting and the occurrence of microorganisms, capable of damaging the germination and growth of the seedlings (Medeiros Filho *et al*., 2000).

Temperature provokes variable effects among the seeds of several species, being divided into the ranges sub-optimum, optimum and supra-optimum. The optimum temperature range for germination is a genetic characteristic dependent on the morphology and physiology of the seed (Carvalho and Nakagawa, 2000), besides, this factor acts directly on the velocity of the biochemical reactions that occur during germination (Ferreira and Borghetti, 2004).

Water availability of the soil is considered one of the principal causes of low germination in seeds, in which dry periods can occur during sowing and decrease the environmental water potential, affecting the process of seed absorption (Mian and Nafziger, 1994).

Polyethylene Glycol (PEG) has been used in studies conducted in laboratories aiming at simulating water stress occurring in the field during seed germination, because it is a heavy polymer that cannot be absorbed by the cells of the seed and is nontoxic (Menezes *et al*., 2006; Moraes and Menezes, 2003).

The aim of this study was to evaluate the germination responses of seeds of *S. bicolor* cultivar BR-700, when cultivated under water restriction, simulated by solutions of PEG 6000 and different temperatures.

MATERIALS AND METHODS

Plant material and seed treatment: The seeds of *S. bicolor* cultivar BR-700 were obtained at the Empresa Brasileira de Pesquisa Agropecuária (Embrapa-Milho e Sorgo), from the 2006 harvest. The experiment was developed during the month of June 2007, at the Laboratory of Advanced Plant Physiology of the Instituto de Ciências Agrárias at the Universidade Federal Rural da Amazônia, Belém, Pará, Brazil.

Seed preparation consisted of obtaining, cleaning and immersing them in a solution of methyl-n-(1-(butylcarbamoil)-2-benzimidazol carbamate ($C_{14}H_{18}N_4O_3$)

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at 1 ppm for 3 min. Afterwards, they were placed to dry on a sheet of filter paper for 24 h and stored in aluminum flasks at 10°C until the experiment was carried out.

Experiment design and treatments: The experimental design was in 3×8 factorial scheme, with 3 temperature levels (26, 30 and 34°C), combined with 8 levels of osmotic potentials (Ψs = 0.0, -0.1, -0.2, -0.3, -0.4, -0.5, -0.6 and -0.7 MPa), in which were obtained with Polyethylene Glycol 6000 (Sigma Chemicals), according to the methodology preset by Michel and Kaufmann (1973) and described by Villela *et al.* (1991). For the osmotic potential of 0.0 MPa (control), only distilled water autoclaved at 120°C, 1 atm for 20 min was added. The experiment consisted of 24 treatments and 8 repetitions, in which each experimental unit was made up of 100 seeds.

The seeds were placed in transparent plastic recipients, gerbox type, with the following dimensions (length × width × height), 11×11×4 cm, previously lined with sterile filter paper, moistened with the solutions in testing (PEG and water) until reaching 2.5 times the dry paper weight. The recipients, hermetically closed and containing the seeds, were placed in germination chambers, BOD type, model TE-401 (Tecnal equipments), with the temperatures controlled and photoperiod of 12/12 h, light and dark, promoted by white light using fluorescent bulbs with 25 μmol.m^{-2}s^{-1} of irradiance.

Measurements: The readings were carried out from the 1st to the 8th day after implementing the experiment, it being considered germinates the seeds that emitting rootlets of 1cm or more of length. The observed variables were germination percentage (%G) and mean germination time (MGT), according to Edmond and Drapala (1957) and described by Silva and Nakagawa (1995).

Data analysis: The results were submitted to variance analysis and the averages of the treatments were compared according to Tukey at the level of 5% significance. These statistical analyses were carried out with SAS (SAS Institute, 1996) and based on the statistical theories suggest by Gomes (2000).

RESULTS AND DISCUSSION

Germination: The variance analysis revealed that occurred significant difference among the treatments, with the highest %G in the Ψs of 0.0 MPa (control) with 97.6, 96.8 and 95.5% of germination in the temperatures of 26, 30 and 34°C, respectively.

At 26°C, the germination percentage varied from 97.6-69.6% germination in the treatments under Ψs of 0.0 and -0.7 MPa, respectively, it being statistically equal (Table 1 and Fig. 1).

Table 1: *Sorghum bicolor* cv: BR-700 seed germination under different temperatures and osmotic potentials

Osmotic potentials (MPa)	Germination (%)		
	26°C	30°C	34°C
0.0	97.6aA[1]	96.8 aA	95.2aA
-0.1	93.6abA	94.4abA	94.2abA
-0.2	91.2bcB	93.6abcAB	94.1abA
-0.3	90.4bcB	92.8abcAB	93.3abA
-0.4	88.8cdB	92.0bcA	90.4bAB
-0.5	85.6deB	91.2bcA	82.4cC
-0.6	83.2eB	89.6cA	80.0cC
-0.7	69.6fB	84.0dA	56.0dC
CV (%)	6.72		

[1]Means followed by the same lowercase letter in the column and uppercase letter in the line, do not differ within themselves by the Tukey test at 5% probability

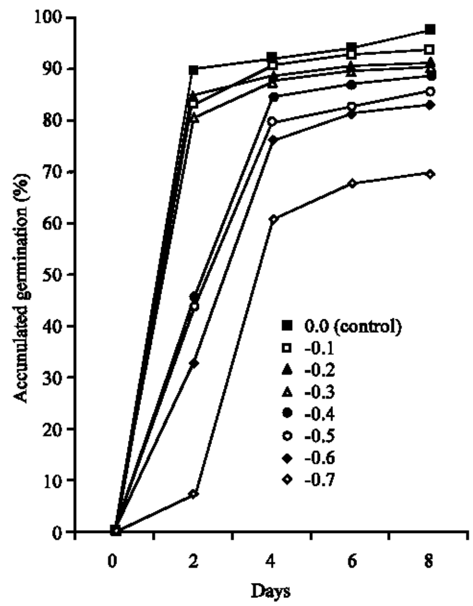

Fig. 1: Accumulated percentage of germination in seeds of *Sorghum bicolor* cv: BR-700 under the temperature of 26°C and different osmotic potentials

Under 30°C occurred progressive decrease in seed germination in the studied species, varying from 96.8- 84% in germination, in the Ψs of 0.0 MPa (control) and -0.7 MPa, respectively. Besides, it was observed that the %G of the control treatment (Ψs = 0.0 MPa) did not differ statistically from the treatments of the Ψs of -0.1, -0.2, -0.3 and -0.4 MPa and differing from the other treatments (Fig. 2).

The temperature of 34°C had a similar behavior of that observed at 26 and 30°C, with a seed germination percentage between the Ψs of 0.0 MPa (control) and -0.6 Mpa, however, it was different than the other

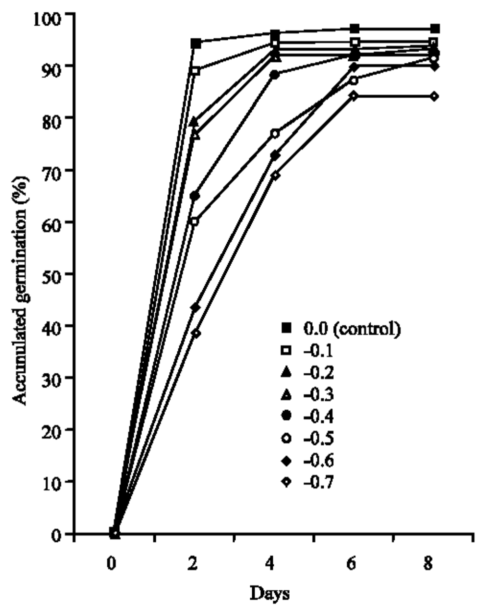

Fig. 2: Accumulated percentage of germination in seeds of *Sorghum bicolor* cv: BR-700 under the temperature of 30°C and different osmotic potentials

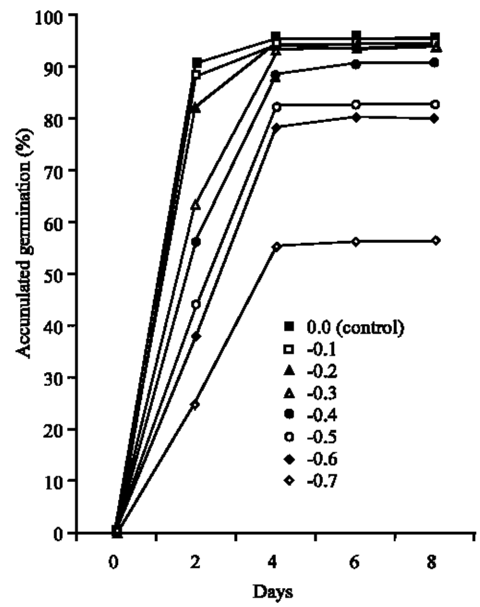

Fig. 3: Accumulated percentage of germination in seeds of *Sorghum bicolor* cv: BR-700 under the temperature of 34°C and different osmotic potentials

temperatures at the osmotic potential of 0.7 MPa, where a more drastic drop was observed, with 56% of germination, being the lowest germination observed in this experiment (Table 1 and Fig. 3).

When the Ψs of the several temperatures were compared, it was observed that the %G in the control treatments (Ψs = 0.0 MPa) and -0.1 MPa did not differ statistically among themselves, although the highest %G occurred in Ψs = 0.0 MPa (control) at 26°C.

In regards to the Ψs of -0.5, -0.6 and -0.7 MPa compared with the temperatures of 26, 30 and 34°C, a better germination performance was observed at 30°C (91.2, 89.6 and 84%), respectively (Table 1). Also, it was verified that the %G was drastically decreased in the Ψ = -0.7 MPa at 34°C, with the %G of 56%, when compared to the control treatment (0.0 MPa).

Under the Ψs of -0.5 MPa, comparing the temperatures 26, 30 and 34°C, the best germination performance was at 30°C, presenting a germination of 91.2%. Just like in the Ψs of -0.6 and -0.7 MPa, the highest %G was observed at 30°C.

The progressive fall in the germination percentage observed in this experiment, with the water potential of the environment decreased, probably caused by the low hydraulic conductivity of the environment, where the particles of PEG 6000 connect to water particles, making them unavailable to assimilate seeds, affecting the imbibition process of the seed which is fundamental for germination (Bray, 1995). Furthermore, the fact should be observed that under water restriction the velocity of water absorption is affected, where the absorption is slower and consequently the hydrolysis of carbohydrates (Taiz and Zeiger, 1998; Bradford, 1990). The results demonstrate that the seeds of *Sorghum bicolor* are more tolerant to water stress than others specie, like *Adenanthera pavonina* (Fonseca and Perez, 2003) and *Ateleia glazioviana* (Rosa *et al*., 2005), besides revealing that the germination behavior of seeds of this species under water restriction is similar to what was found by Souza Filho (2006) studying *Leucaena leucocephala* and Stefanello *et al.* (2006) working with *Pimpinella anisum.*

Mean germination time: Table 2 reveals the results obtained on the mean germination time (MGT) on differents Ψs and studied temperatures, in which it was showed significant difference among the treatments, according to ANOVA, having a similar behavior among 26, 30 and 34°C, observing the increase in the MGT when the Ψs of the environments became smaller. The MGT oscillated within 1.25 days at 34°C and Ψs = 0.0 MPa and 3.56 days at 26°C and Ψs = -0.7 MPa.

At 26°C the MGT varied from 1.75-3.56 days in the treatments under Ψs of 0.0 Mpa (control) and -0.7 Mpa, respectively. The treatments under the action of the osmotic potentials of 0.0 and -0.1 MPa are statistically equal and different from the others.

Table 2: Mean time of germination *Sorghum bicolor* cv: BR-700 under different temperatures and osmotic potentials

Osmotic potentials (MPa)	Mean time (days) 26°C	30°C	34°C
0.0	1.75aB[1]	1.35aA	1.25aA
-0.1	1.80abC	1.52bB	1.39aA
-0.2	1.93bcB	1.88cAB	1.77bA
-0.3	2.03cA	2.02cA	2.29cB
-0.4	2.36dA	2.34dA	2.37cdA
-0.5	2.55eA	2.52dA	2.47eA
-0.6	2.82fA	2.80eA	2.75fA
-0.7	3.56gB	3.00fA	2.98gA
CV (%)	13.81		

[1]Means followed by the same lowercase letter in the column and uppercase letter in the line, do not differ within themselves by the Tukey test at 5% probability

At 30°C, it was observed that in the treatments that used Ψs of 0.0 and -0.7 MPa (control), the mean times of 1.35 and 3.00 days, respectively, besides revealing that this treatment is statistically different from the others, when the osmotic potentials are compared at this temperature.

The lowest MGT of the experiment was observed at 34°C under 0.0 MPa (control), with 1.25 days, it being this treatment equal at treatment that using the osmotic potential of -0.1 MPa, according to the statistical test used. When considering only the temperature of 34°C, the other treatments had a progressive increase in mean germination time when the osmotic potential of the environment decreased.

Under the Ψs of 0.0 MPa (control) and comparing the temperatures, the treatments at 30 and 34°C had the lowest MGT, besides being statistically equal. However, under the Ψs = -0.1 MPa the treatment at 34°C was the best and different from the rest. Starting from the Ψs of -0.4 to -0.7 MPa the results obtained at 30°C were statistically equal to the best results, observed at 34°C.

The MGT was positively influenced by the increase in temperature, with the temperature increase from 26-34°C, in which it was provoked reduction in the time necessary for germination. Results indicate that this interval of temperature can be considered the germination optimum besides revealing the adaptability of the evaluated cultivar seeds in conditions that present low environmental water potential, since the elevation of the temperature provoked maximization in the germination velocity, even in the treatments under strong water deficiency.

The increase in temperature provoked acceleration in the germination process, within the interval of 26-34°C evaluated in this experiment, it being showed decrease in MGT when was increase the temperature, understanding this interval as an optimum temperature range for germination of seeds of sorghum cv. BR-700, because reunites the maximum germination and lowest time needed for emitting a rootlets. Similar results about the increase in temperature in MGT was obtained by Varela *et al.* (1999) studying *Ceiba pentandra*, Eschiapati-Ferreira and Perez (1997) after scarification of the *Senna macranthera* seeds and under the same water potential with Silva *et al.* (2007) working with *Piper aduncum*.

The biochemical reactions involved in the germination are dependent on the temperature, because the enzymes involved have ranges of action that will retard or accelerate seed germination (Bewley and Black, 1994). The velocity in which the enzymes carry out their functions will interfere in the degrading of the reserved carbohydrates and ATP production, which will be used in forming proteins and other metabolites that originate tissues and cellular compounds (Mayer and Poljakoff-Mayber, 1989) that culminate with the protrusion of the rootless and consequent seedling establishment (Copeland and Mcdonald, 1995; Marcos Filho, 2005).

CONCLUSION

The experiment reveal that occurred progressive fall in %G, independent of the temperature, caused by the low water conductivity and slow water absorption by the seed, besides MGT reduced occasioned by temperature increased, in the interval between 26-34°C, provoked by an acceleration of biochemical reactions involved in germination.

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