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Physiological maturation of sweet sorghum seeds produced under water restriction[1]

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ABSTRACT - Sweet sorghum has been shown to be an alternative for ethanol production in several regions. Because it is sexually propagated, the use of quality seeds becomes an important factor for obtaining an adequate plant stand and, consequently, good productivity. Thus, the objective was to evaluate the production and physiological maturation of seeds of sweet sorghum cv. BRS 511, in response to the interval between irrigations during the reproductive period and harvesting period. Two experiments were carried out in a greenhouse, the experimental design adopted was in randomized blocks, with four replications in a 3 x 2 split-plot scheme, corresponding to three intervals between irrigations during the reproductive stage (0; 4 and 8 days) and two harvest times (102 and 110 days after sowing). The following parameters were evaluated from the harvested panicles: number of seeds, weight of one thousand seeds, water content, germination, first germination count, emergence in sand and emergence speed, electrical conductivity and seedling vigor. The production of seeds per panicle and the weight of a thousand seeds were significantly influenced by the increase in the interval between irrigations in the 2nd experiment, with a reduction of 50.4 and 46.3%, respectively. Water replacement every eight days caused a reduction of up to 43.4% in the first germination count and 16.3% in germination. The production and quality of sweet sorghum seeds reduces as a function of the increase in the interval between irrigations and the harvesting time, presenting germination rates below the required for commercialization.

Key words: *Sorghum bicolor* (L.) Moench. BRS 511. Germination. Intermittent irrigation. Seed production.

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INTRODUÇÃO

Sweet sorghum [*Sorghum bicolor* (L.) Moench] is considered a promising raw material for ethanol production, due to its rusticity and because it has stalks rich in fermentable sugars. The crop emerges as a viable alternative for sugarcane off-season cultivation or in times of low water availability (COLE *et al.*, 2017; RATNAVATHI *et al.*, 2011; SILVA *et al.*, 2017). Due to its sexual propagation, all stages of cultivation (implantation to harvest) can be carried out with the aid of agricultural machinery, which reduces production costs (ALMEIDA *et al.*, 2019; SOLANO *et al.*, 2018).

Currently, agricultural production is strongly affected by changes in rainfall patterns, so water availability has become a critical issue and a limiting factor for crops (ALMEIDA *et al.*, 2019). The water deficit can cause changes in the crop cycle, anticipating the maturation and dispersion of the seeds, which, therefore, promote a reduction in the production and quality of the seeds (QUAIN *et al.*, 2014).

As for qualitative aspects, the use of low quality seeds, in addition to compromising the initial stand of seedlings in the crop, reducing crop productivity and economic profitability of the activity (TAVARES *et al*., 2013), can generate individuals sensitive to abiotic stresses, as is the case of soil water deficit (OLIVEIRA; GOMES-FILHO, 2011; SILVA *et al*., 2017). Seed quality is expressed by vigor, which is considered an important factor in choosing seeds for sowing. The basic objectives of vigor tests are: to evaluate or detect significant differences in the physiological quality of lots with similar germination; safely distinguish and classify batches at different vigor levels (MARCOS FILHO, 2015).

An important point in the physiology of seeds is the maturation process, which consists of an ordered sequence of several changes, ending when the seed reaches the maximum possible dry matter content. However, seeds do not necessarily have higher quality when they reach physiological maturity, which varies between species and environmental conditions to which they are exposed (ELLIS, 2019). It should be noted that the main technological indices desired at the end of maturation are: adequate water content, higher dry matter content, high percentage of germination and high level of vigor (MARCOS FILHO, 2015).

The time for harvesting the seeds is one of the key points to increase the yield and physiological quality of the seeds, however, when the harvest is carried out at the ideal time, it reduces damage to the field due to adverse weather conditions (LESSA *et al.*, 2017; MATHIAS *et al.*, 2017).

Despite the importance that the culture of sweet sorghum has been gaining in recent years, there is still little research carried out involving its production with the purpose of obtaining seeds, as well as its offer on the market (LESSA *et al.*, 2017; MAY; DURÃES, 2012).

The effects of low water availability affect aspects of plant development and these effects may vary depending on the species, the stage of occurrence and the intensity of water availability. Thus, the objective was to evaluate the maturation and physiological quality of sweet sorghum seeds as a function of the intensity of water restriction during the reproductive stage and different harvest times.

MATERIAL E MÉTODOS

Location and characterization of the experimental area

Two experiments were carried out, both in a greenhouse. The first in 2019 at the Federal Institute of Education, Science and Technology of Ceará – Campus Umirim (IFCE-Umirim), located in the Vale do Curu region, in the municipality of Umirim in the state of Ceará. The second experiment was conducted in 2020 at the Teaching, Research and Outreach Unit (UEPE) of the Federal Institute of Education, Science and Technology of Ceará - Campus Limoeiro do Norte (IFCE- Limoeiro do Norte), located in the irrigated perimeter Jaguaribe-Apodi, in the municipality of Limoeiro do Norte in the state of Ceará.

The climate of the two locations, according to the Köppen and Geiger classification, is BSw'h', that is, semi-arid with irregular rainfall, with two well-defined seasons (ALVARES *et al.*, 2013). The mean temperatures and relative humidity of the air collected in the greenhouse under the growing conditions for the two locations are shown in Table 1.

Table 1 - Temperature (Temp.) maximum (Max), average (Avg.) and minimum (Min.); average relative humidity (UR), measured during the conduction of experiments in the greenhouses

Experiment	Period	Mean temperature (°C)			Mean RH (%)
		Max.	Med.	Min.	
1	March/2019 to July/2019	35.6	29.2	23.9	85.3
2	December/2019 to April/2020	39.4	31.2	24.5	82.4

Experimental design and treatments

The experiments were conducted in a randomized block design. The treatments were distributed in a split-plot design with 3 (irrigation frequencies during the reproductive stage) x 2 (harvest times) with four replications, totaling 24 experimental plots. The experimental plots consisted of three plants placed in pots (30 cm Ø) with a capacity of 18 liters.

For the irrigation frequency treatment, three different intervals between irrigation were adopted, with reference to soil moisture at field capacity (Mfc). The Mfc was determined, as described by Souza *et al.* (2000), where the determination method consists of the difference between the weight of wet soil after saturation and free drainage, and the weight of air-dried soil. Thus, at the reference level (L0), water was replenished daily, maintaining soil moisture at 70% of the Mfc throughout the entire experiment. The other treatments (L4 and L8) correspond to the replacement of water up to 70% of the Mfc every four and eight days, respectively. Differentiation of irrigation management between treatments was introduced at the beginning of flowering (63 days after sowing - DAS). As for the harvest, it was carried out in two periods (102 and 110 DAS).

Experimental procedure

The pots were filled with soil extracted from the 0-20 m depth layer of the soil present in the localities. The soil used in the first experiment was classified as a eutrophic Red-Yellow Argisol and the second one as eutrophic Red-Yellow Cambisol (SANTOS *et al*., 2018). For correction purposes, a composite soil sample used in the pots for both types of soil was collected and sent to the soil laboratory for determination of chemical and physical attributes (Table 2).

When filling the pots, shade and 15 kg of soil were placed at the bottom, leaving about 3 cm between the surface of the soil and the upper edge of the pot, to facilitate irrigation, seeking to avoid possible overflow of water during irrigation, which were carried out manually with the aid of a graduated cylinder (500 mL).

Before sowing, fertilization with urea (45% - N) and simple superphosphate (18% - P_2O_5) was carried out. In addition to the sowing fertilization, a top dressing with urea and powdered potassium chloride (60% - K_2O) was carried out at 21 DAS (AGUIAR; GONÇALVES; PATERNIANI, 2014). Topdressing fertilization was carried out by diluting the fertilizer in 30 mL of water and being applied two cm away from the plants after irrigation. Sowing was carried out by opening three holes and placing five seeds of Cultivar BRS 511 per hole, at a depth of 1 cm. Ten days after seedling emergence, thinning was performed, leaving three plants per pot.

The water used for irrigation came from the supply system of each location. The water supply for the plants was carried out with a daily irrigation frequency, up to the 62nd DAS for all experimental plots, from the 63rd DAS until harvest; the frequency was adopted according to each treatment. At each irrigation, a sufficient volume of water was applied to raise the soil moisture to 70% of the Mfc. Table 3 shows the variation in moisture content as a function of the period without irrigation.

Table 2 - Chemical and physical attributes of the soils used in the experiments, from the 0 to 0.20 m layer

Chemical Attributes						
Exp.	$cmol_c\ dm^{-3}$					
	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	$H^{+} + Al^{3+}$	Al^{3+}
1	3.20	2.00	0.40	0.34	2.31	0.35
2	9.53	2.09	0.11	2.64	N. D.	N. D.

Exp.	$cmol_c\ dm^{-3}$		$g\ kg^{-1}$		(%)	(H_2O)	($dS\ m^{-1}$)
	S	T	C	O. M.	V	pH	E. C.
1	5.9	8.3	4.89	8.44	72	4.7	1.75
2	14.4	14.4	10.23	17.63	100	7.6	1.34

Physical Attributes						
Exp.	Granulometric Composition ($g\ kg^{-1}$)				Texture Classification	Mfc (%)
	Coarse sand	Fine sand	Silt	Clay		
1	432	290	142	136	Sandy loam soil	24
2	248	233	261	258	Sandy clay loam soil	34

Exp. - Experiment; H+ + Al^{+3} – Potential acidity; N.D. - Anything; S – Sum of bases; T – Cation exchange capacity; O.M. - Organic matter; V – Base saturation; E.C. - Electric conductivity; C - Classification; Mfc – Soil moisture at field capacity

Table 3 - Soil moisture content observed according to different irrigation intervals in sweet sorghum cultivation

Interval between irrigation (days)	Moisture content (%)	
	1st Experiment	2nd Experiment
0*	16.4 ± 0.3	23.0 ± 0.25
4	7.9 ± 0.5	9.5 ± 0.3
8	4.8 ± 0.27	5.2 ± 0.37

*The value obtained in this treatment corresponds to the variation in soil moisture over a period of one day

To analyze the quality of the seeds, three panicles were harvested from each experimental unit and taken to the Seed Laboratory (IFCE- Limoeiro do Norte) for weighing the panicles, extracting and processing the seeds.

Variables analyzed

The seeds were submitted to the following analyses: Water content (WC) – by stove of the method, oven at 105 ºC (± 2 ºC) for 24 h, using 50 seeds per repetition; Number of seeds per panicle (NSP) – obtained from the mean number of seeds of the three panicles of each experimental plot; Weight of a thousand seeds (WTS) using eight repetitions of 100 seeds, multiplying the average value by 10 when the coefficient of variation was less than 4% (BRASIL, 2009).

The germination test was carried out using four repetitions of 50 seeds and placed between germitest paper, moistened with distilled water up to three times the weight of the dry paper, and placed in a B. O. D. adjusted to 25 °C. The counts were performed on the fourth day (first count - FGC) and on the tenth day (final germination - G), after sowing (BRASIL, 2009); root length (RL) and shoot length (SL) of the seedlings: carried out in conjunction with the germination test, the roots and respective shoots of 20 seedlings from each repetition were measured with the aid of a ruler graduated in centimeters, after the final count of the germination test; fresh mass of roots and shoots: at the end of the germination test, the roots and shoots were sectioned and weighed on an analytical scale with a precision of 0.0001 g, to determine the fresh mass.

To evaluate seedling emergence (E) four replications of 25 seeds were sown in plastic trays containing sand. Irrigations were carried out whenever necessary, aiming at providing water for seed germination and seedling emergence. The evaluations were made four DAS, counting the percentage of normal seedlings (BRASIL, 2009). The emergence speed index (ESI) was performed along with the emergence test, the number of normal seedlings being counted daily from the first count. The count continued until the stabilization of seedling emergence (MAGUIRE, 1962).

The electrical conductivity (EC) test was performed with four repetitions of 50 seeds placed to soak in test tubes (75 mL), containing 50 mL of distilled water and maintained at a temperature of 25 ºC (NUNES; PINHEIRO; DUTRA, 2019) for a period of 24 hours. After the immersion period, the electrical conductivity of the solution was measured in nine immersion periods (1, 2, 3, 4, 6, 8, 10, 12 and 24 h) with a bench conductivity meter and the results expressed in µS cm^{-1} g^{-1}. The reading of each repetition was performed shortly after removing the material from the incubator, gradually, carefully shaking each container, with the aim of uniforming the leached electrolytes in the solution.

Statistical analyses

The data were submitted to tests of normality and homogeneity, taking into account these assumptions, analysis of variance (ANOVA) was performed using the F test (5%). When significant, the Scott-Knott test (5%) was applied for the different intervals between irrigation and for different harvest times.

Variables that did not meet the assumptions were submitted to the Kruskal-Wallis non-parametric test. When significant, Dunn’s test (5%) was applied with multiple comparisons by pairs.

RESULTS AND DISCUSSION

In the 1st experiment, it was observed that the irrigation depth applied up to 110 DAS was 425.19 mm (Table 4), a value 51.7% lower than that applied in the 2nd experiment (878.27). Between the harvests, there is a difference of 38.64 and 74.02 mm respectively (equivalent to a reduction of 9.1 and 8.4%) in the 1st and 2nd experiment.

Through analysis of variance, it can be noted that in the 1st experiment, which for the WC variable, there was a significant effect ($F_{1;9}$ = 46.16; p ≤ 0.001) regarding the harvest time. A different response was observed in the 2nd experiment, in which there was a significant difference ($F_{2;9}$ = 5.584; p ≤ 0.05) regarding the interval between irrigations. For the FGC variable there was a significant interaction ($F_{2;9}$ = 7.84; p ≤ 0.05) between the factors in the 2nd experiment. The variable G showed a significant effect only in the 2nd experiment, which was isolated for the stress factor ($F_{2;9}$ = 13.69; p ≤ 0.01) and harvest ($F_{1;9}$ = 7.72; p ≤ 0. 05).

Analyzing the WC of seeds produced from sweet sorghum, it is noted that in the 1st experiment (Figure 1A) the highest mean (8.89%) was obtained at 102 DAS. In the 2nd experiment (Figure 1B) the seeds showed a lower value (8.01%) when irrigation was performed every eight days. This value is 41% lower than the maximum obtained in L0 (13.49%). This observed reduction can be attributed to the association of lower water availability and high temperatures observed. Because, due to the seeds being hydroscopic, and during the experiment the temperature reached a maximum of 39.4 ºC, it may have caused excessive water loss and, as a possible consequence, irreparable damage to the quality of the seeds (MATHIAS *et al*., 2017; OLIVEIRA *et al*., 2015).

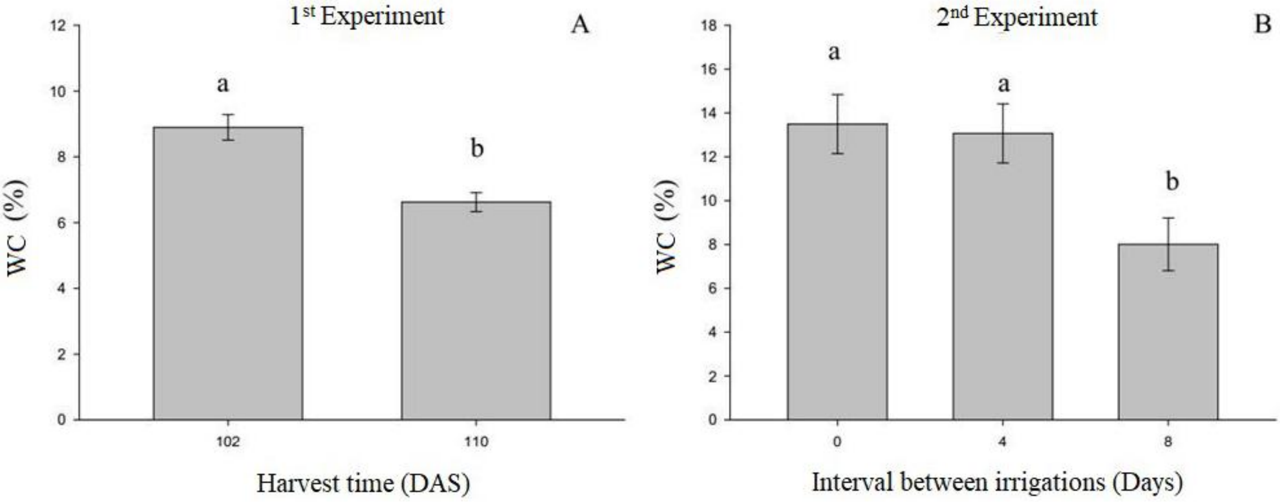
The moment of harvesting must be properly determined, because if carried out early, the harvested material may present high moisture, which is undesirable for the producer. In addition to being more susceptible to mechanical damage during harvest, seeds with a high moisture content can reduce the quality of the harvested material, increasing production costs due to the need for artificial drying (FERREIRA *et al*., 2013; SILVA *et al*., 2001). For these reasons, it is recommended that sorghum seeds be kept in the field until they reach an approximate moisture content of 18%, a value considered ideal so that less damage occurs during harvest (SILVA *et al*., 2001).

The performance of a late harvest aiming at seed production is beneficial to the producer, as the material harvested can be in conditions for storage (low moisture and high germination), or be ready for immediate use, without having to go through any drying process (LESSA *et al*., 2017). The seed reaches its physiological maturity, when it accumulates the maximum dry matter mass possible, a period that must correspond to the high germination capacity and vigor. From then on, the seed

Table 4 - Volume of water applied and irrigation depth of the sweet sorghum crop depending on the harvest time

Harvest time	Volume of water applied		Irrigation blade	
	L pot^{-1}		mm $cycle^{-1}$	
	1st Experiment	2nd Experiment	1st Experiment	2nd Experiment
102	27.31	56.82	386.55	804.25
110	30.04	62.05	425.19	878.27

Figure 1 - Water content (WC) of sweet sorghum seeds as a function of harvest time (A) and interval between irrigations (B) in two experiments



DAS - Days after sowing. Means followed by the same letter do not differ according to the Scott-Knott test (5%)

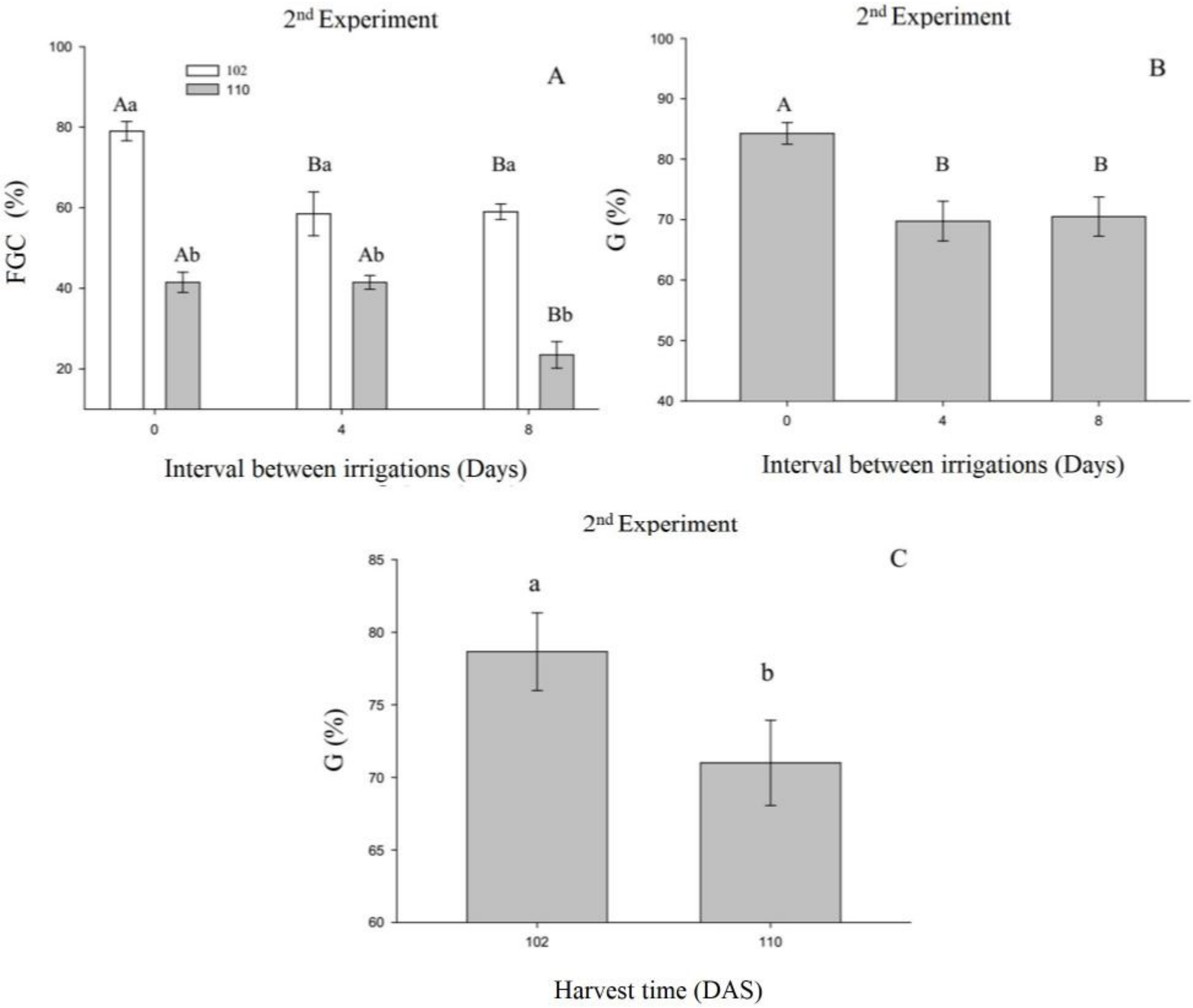
begins to lose quality, which is why it would be desirable for the harvest to be carried out soon after this point is reached (SILVA *et al*., 2001).

In the 2nd experiment, the FGC showed a reduction in values, both as a function of the harvest time and the increase in the interval between irrigations. Analyzing first the harvest times within each interval between irrigations (Figure 2A), it is noted that regardless of the frequency between irrigation, the lowest values were observed in seeds harvested at 110 DAS. This difference is up to 60.2% (L8).

As for the analysis of the intervals between irrigation in each harvesting period, a similar behavior can be observed between both, with higher means in L0 (102 = 79% and 110 = 41.5%) and a reduction in the values observed with the increase in the interval between irrigations (L8 102 = 59% and 110 = 23.5%). Considered as an important factor that can interfere with the qualitative characteristics of the seeds, the delay in harvesting after reaching physiological maturity can negatively influence the final quality of the seeds produced (GHASSEMI-GOLEZANI *et al*., 2015).

Daily replacement of water in the soil provided a higher germination rate of sweet sorghum seeds (84.3%) (Figure 2B). However, increasing the interval between irrigations reduced these values, with a

Figure 2 - Unfolding between the factors under the first germination count (FGC) of sweet sorghum seeds (A) and seed germination (G) of sweet sorghum as a function of the interval between irrigation (B) and harvest time (C)



DAS – Days after sowing. Means followed by the same letter, capital letters, do not differ from each other regarding the interval between irrigations and the same lowercase letters, for the harvest time by the Scott-Knott test (5%)

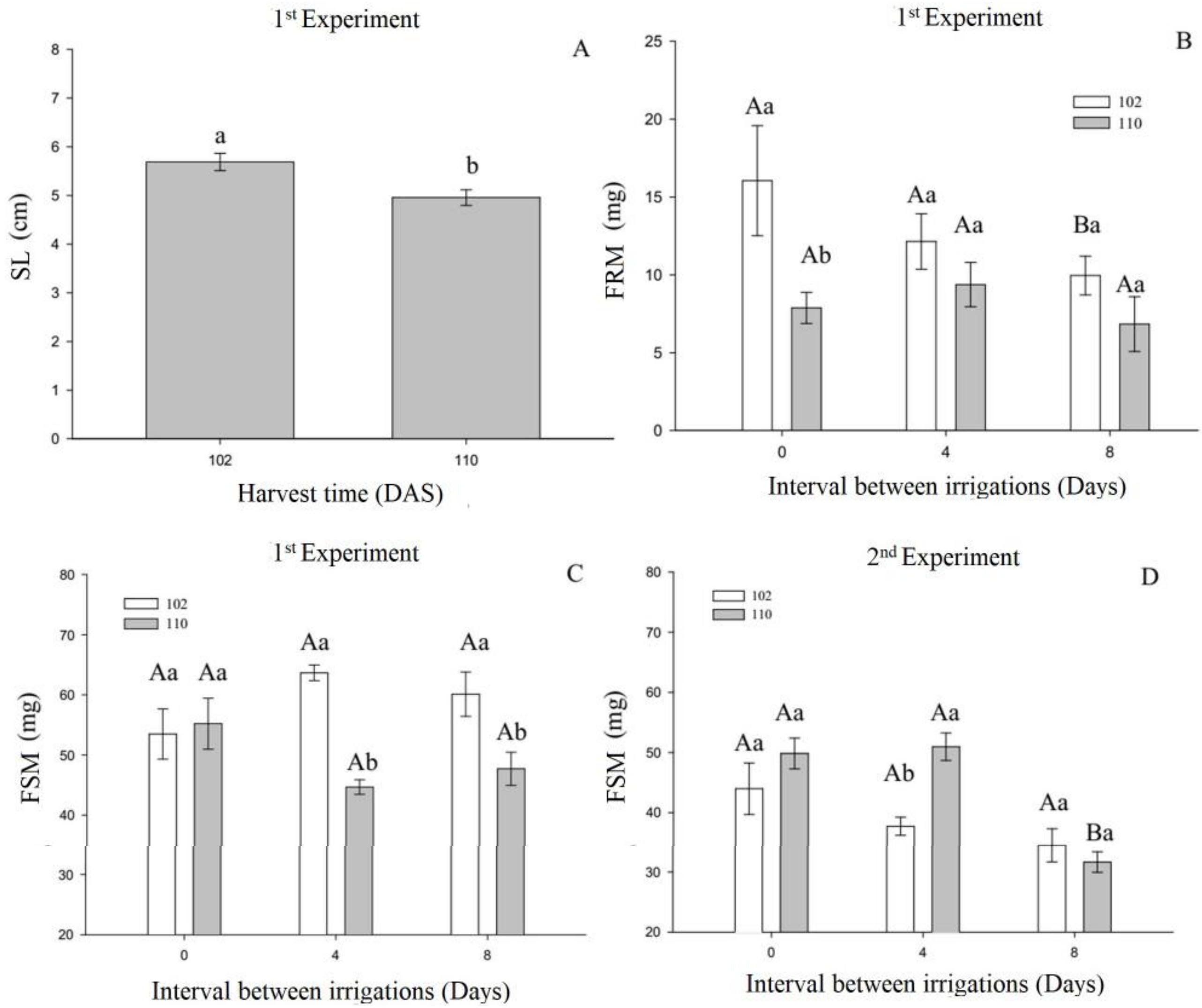
germination rate of 70.5% being observed in L8, a value 16.3% lower than that obtained in L0. As for the harvest time (Figure 2C), the highest mean was obtained at 102 DAS (78.6%).

The germination test in the 2nd experiment showed low physiological quality of the seeds produced under conditions of water restriction (G < 70%). This percentage of germination is within the limit required by the Ministry of Agriculture, Livestock and Supply, which is 70% for basic seeds and below the other categories (80%) (BRASIL, 2013). The occurrence of water deficit during the reproductive stage significantly reduces plant yield, directly impairing seed production; because, unlike the occurrence of water deficit during the vegetative stage, the plant in this phase does not have so much plasticity, to the point of recovering the dry matter lost due to stress, without affecting the final production (JUMRANI; BHATIA, 2017).

The SL showed a significant effect ($F_{1;9} = 13.78$; $p \leq 0.01$) in relation to the harvest time in the 1st experiment. For the FRM in the 1st experiment, there was a significant interaction ($F_{1;9} = 4.83$; $p \leq 0.05$) between the factors and for FSM in both experiments (1st Experiment: $F_{2;9} = 9.11$; $p \leq 0.01$/ 2nd Experiment: $F_{2;9} = 3.82$; $p \leq 0.05$).

The SL (Figure 3A) had the lowest value (4.95 cm) at 110 DAS. Analyzing the harvest time within each irrigation interval, a reduction of 50.9% in the MFR at 110

Figure 3 - Shoot length (SL) under the effect of harvest time (A) and the unfolding of the interaction between the factors for fresh root mass (FRM) (B) and fresh shoot mass (FSM) (C and D)



DAS – Days after sowing. Means followed by the same letter, capital letters do not differ from each other regarding the interval between irrigations and the same lowercase letters, for the harvest time by the Scott-Knott test (5%)

DAS in L0 is observed. As for the harvest time in relation to the intervals between irrigations, a lower value (9.9 cm) is observed in L8 at 102 DAS, a value 37.9% lower than the highest value obtained (L0 = 16.1 cm).

For FSM it can be seen in Figure 3C that in the 1st experiment there was a reduction in the values observed in seeds harvested at 110 DAS when irrigation was carried out at intervals of four and eight days. In the 2nd experiment (Figure 3D) the greatest variation (37.85%) was observed at 110 DAS within the different irrigation managements, with the lowest value observed under L8 = 31.7 mg.

Variables such as NSP[1,2], TSW[1,2], ESI[1,2], EC[2], RL[1,2] and E[1,2] did not meet the assumptions of normality and homogeneity of variances, applying the non-parametric Kruskal-Wallis test, with multiple pairwise comparisons by Dunn's test (5%). NSP[1], CR[1,2] and E[1] did not show a significant effect ($p > 0.05$) in terms of any of the factors (Table 5).

As for the NSP, it was verified that there was a significant effect regarding the application of different intervals between irrigations in the 2nd experiment. In which water replacement every 8 days reduced seed production by up to 50.4%.

The TSW suffered a significant effect as a function of the interval between irrigations in both experiments, and in the 1st one a higher mean was observed in L0 (21.21 g). Behavior different from that observed in the 2nd experiment, in which increasing the interval between irrigations reduced the values obtained by up to 46.3% (TSW L8 = 9.81 g). As for the harvest time factor, despite the lower means at 110 DAS, there were no significant differences ($p > 0.05$) for TSW.

Grain filling is dependent on the photoassimilates produced by the leaves. Under conditions of severe water deficit, premature senescence and leaf abscission may begin, consequently reducing the availability of photoassimilates for seed filling (QUAIN *et al*., 2014; XIE; SU, 2012). Carvalho and Nakagawa (2012) consider seed weight as an important aspect for assessing vigor, as seeds with larger sizes and density generally have healthy and well-formed embryos and give rise to plants with greater vigor.

Lessa *et al.* (2017) when producing seeds of sweet sorghum of the BRS 511 variety, in the semi-arid region of Ceará, under natural drying, obtained a higher TSW (21.8 g) than the results observed in this work, performing the harvest at 109 DAS. Still, according to the authors, drying seeds increases the cost of production, being generally necessary only in regions of high moisture. However, what can justify this higher weight obtained by the authors is the high water content (14%) compared to that observed in this work (WC < 9%).

Still in Table 5, it is noted for the ESI, a significant effect due to the increase in the interval between irrigations, and in the 1st experiment a higher value was observed in the seeds produced in L8, a value 3.1% higher than the lowest mean. In the 2nd experiment, there was a contrasting effect to that observed in the 1st experiment, with a lower mean in L8. As for E, it was observed that in the 2nd experiment that the harvest at 110 days showed a high value (91.7%), which corresponds to 30.5% higher than that obtained at 102 DAS.

For EC in the 1st experiment, a significant effect was observed ($F_{2;9} = 5.837$; $p \leq 0.05$) only in seeds soaked for one hour as a function of the interval between irrigation.

Table 5 - Number of seeds per panicle (NSP), thousand seed weight (TSW), emergence speed index (ESI), root length (RL) and emergence (E) of sweet sorghum seeds produced under different intervals between irrigations and harvest periods

Factor	Treat	NSP[1]	NSP[2]	TSW[1]	TSW[2]	ESI[1]	ESI[2]	RL[1]	RL[2]	E[1]	E[2]
		Seeds panicle^{-1}		---------- g ---------		-		-------- cm --------		--------- % ---------	
(I)	0	1005.6 a	1000.2 a	21.2 a	18.3 a	16.7 b	4.9a	15.7a	11.4 a	97.0 a	81.5 a
	4	988.7 a	855.7 a	19.9 ab	16.5 b	17.2 ab	5.4a	17.1 a	11.5 a	99.0 a	84.1 a
	8	853.3 a	496.2 b	19.3b	9.8 c	17.3 a	4.5b	15.9 a	9.9 a	99.0 a	67.5 a
p-value		0.327	< 0.01	0.022	0.001	0.029	0.013	0.128	0.138	0.172	0.151
(C)	102	986.5 a	864.8 a	20.7 a	15.5a	17.1 a	4.7a	16.1 a	11.5 a	98.0 a	63.7 b
	110	945.5 a	703.3 a	19.6 a	14.2a	17.1 a	5.2a	16.3 a	10.5 a	98.6 a	91.7 a
p-value		0.643	0.453	0.116	0.543	0.839	0.133	0.137	0.204	0.586	< 0.01
CV (%)		29.93	31.37	9.88	12.38	2.46	13.54	7.51	37.15	2.37	22.92

[1,2]First and second experiment, respectively. Treat – Treatment; I – Interval between irrigations; C – Harvest time; CV – Coefficient of variation; Means followed by the same letter in the column do not differ respectively by Dunn's non-parametric test (5%)

In the other periods, no significant difference ($p > 0.05$) was observed in the interval between irrigations and harvesting time, nor in the interaction between the factors, in any of the soak periods.

The interval between irrigations showed a significant difference ($p \leq 0.01$) in all soak periods in the seeds produced in the 2nd experiment (Table 6), with greater solute leaching under L8 (maximum value of 89.28 µS cm^{-1} g^{-1}- 24 hours). This value represents a difference of 52.82 µS cm^{-1} g^{-1}(equivalent to 144.87%) compared to the smallest obtained in L0. Machado *et al.* (2020) when evaluating the quality of corn seeds produced under conditions of water deficit, showed a higher EC value (54.47 µS cm^{-1} g^{-1}), suggesting greater release of leachates and therefore, low viability.

Seeds produced under daily irrigation (L0) showed lower values (9.8 – 1 h and 36.5 – 24 h) than those obtained by Nunes, Pinheiro and Dutra (2019), who, when evaluating the electrical conductivity of different lots of seeds of Sweet sorghum (Cultivar BRS 506) obtained EC values of 39.84 µS cm^{-1} $g^{-1}$with seeds kept under soaking process for a period of 24 hours.

High EC values in seeds suggest degradation of cell membranes and the beginning of the deterioration process (MARCOS FILHO, 2015; MARQUES; DUTRA, 2018). More deteriorated seeds present a lower speed of restoration of the integrity of cell membranes during the soaking process, releasing a greater amount of leachate into the water (MARCOS FILHO, 2015). Because it is easy to perform and quick, the electrical conductivity test has desirable characteristics for routine use in the seed analysis laboratory, allowing the effective separation of lots with different quality (CASTILHO *et al.*, 2019; NUNES; PINHEIRO; DUTRA, 2019).

Table 6 - Electrical conductivity (µS cm^{-1} g^{-1}) of seeds of the sweet sorghum variety BRS 511 as a function of the interval between irrigations and harvesting time, under different soak periods

1st Experiment										
Factor	Treat	------------------------- Soak period (hours) -------------------------								
		1	2	3	4	6	8	10	12	24
Irrigations (I)	0	12.6 b	22.6 a	27.1 a	30.1 a	36.4 a	40.3 a	44.3 a	48.2 a	60.6 a
	4	20.4 a	25.4 a	29.7 a	32.9 a	39.2 a	42.2 a	45.1 a	47.9 a	59.9 a
	8	15.1 b	20.5 a	24.8 a	27.1 a	32.6 a	35.3 a	38.6 a	41.9 a	51.1 a
p-value		< 0.05	1.125	0.934	1.027	1.315	1.639	1.266	1.028	2.602
Harvest (C)	102	16.4 a	24.4 a	28.7 a	31.2 a	37.5 a	40.6 a	43.8 a	47.1 a	58.9 a
	110	15.6 a	21.4 a	25.7 a	28.9 a	34.7 a	38.1 a	41.5 a	44.1 a	53.4 a
p-value		0.080	1.038	1.018	0.555	0.607	0.652	0.451	0.309	2.128
CV^{I} (%)		28.59	29.04	26.78	26.88	22.66	20.12	20.87	21.78	14.91
CVC (%)		42.61	31.71	26.51	25.29	24.19	19.56	20.09	20.76	16.58
2nd Experiment										
Factor	Treat	--- Soak period (hours) ---								
		1	2	3	4	6	8	10	12	24
Irrigations	0	9.8 b	14.4 b	16.6 b	19.2 b	22.1 b	25.7 b	28.9 b	32.1 b	36.5 c
	4	15.3 b	17.9 b	22.6 b	25.5 b	30.1 b	33.1 b	36.5 b	39.9 b	51.3 b
	8	31.3 a	41.3 a	45.8 a	50.6 a	57.5 a	64.1 a	68.8 a	73.5 b	89.3 a
p-value		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Harvest	102	19.9 a	25.1 a	29.3 a	33.9 a	39.6 a	43.9 a	46.6 a	49.3 a	61.5 a
	110	17.7 a	23.9 a	27.3 a	29.6 a	33.5 a	38.1 a	42.9 a	47.7 a	56.5 a
p-value		0.386	0.355	0.225	0.184	0.184	0.184	0.418	0.773	0.488
CV (%)		32.2	20.26	20.03	18.46	18.35	15.08	15.75	17.47	19.30

Treat – Treatment; CV – Coefficient of variation; Means followed by the same letter in the column do not differ between the Scott-Knott test (5%) in the 1st experiment and Dunn's non-parametric test (5%) in the 2nd experiment

CONCLUSIONS

1. The replacement of irrigation water every eight days during the reproductive stage reduces the production and quality of sweet sorghum seeds (cultivar BRS 511);
2. Under an interval between irrigations of eight days, carrying out the harvest at 110 DAS reduces the germination potential of seeds and seedling vigor of sweet sorghum;
3. External factors, such as soil type and environmental temperature, provoke different responses in seed production in sweet sorghum plants.

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