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THE PRODUCTION PERFORMANCE OF FODDER SORGHUM ACCORDING TO IRRIGATION SHEETS AND LAND COVER

PAULO GLEISSON RODRIGUES DE SOUSA[1]; THALES VINÍCIUS DE ARAÚJO VIANA[2]; CLAYTON MOURA DE CARVALHO[3]; KILMER COELHO CAMPOS[4]; FRANCISCO LIMEIRA DA SILVA[5] E BENITO MOREIRA DE AZEVEDO [2].

[1] *Doutorando em Engenharia Agrícola pela Universidade Federal do Ceará - UFC, (Departamento de Eng. Agrícola, 804, Pici, CEP 60.455-760 Fortaleza, Ceará Brasil. e-mail: paulo.ufc.agro@gmail.com.*
[2] *Docente de Engenharia Agrícola pela Universidade Federal do Ceará - UFC, Departamento de Eng. Agrícola, 804, Pici, CEP 60.455-760 Fortaleza, Ceará Brasil. e-mail: thales@ufc.br*
[3] *Docente de Engenharia Agrícola pelo Instituto Federal de Educação, Ciência e Tecnologia Baiano - IF Baiano, Campus Serrinha, BA, (Estrada Vicinal de Aparecida, s/n, Aparecida, Serrinha, Bahia, Brasil. e-mail: clayton.carvalho@ifbaiano.edu.br.*
[4] *Docente de Economia Agrícola, pela Universidade Federal do Ceará - UFC, (Departamento de Economia Agrícola, 826, Pici, CEP 60.440-970 Fortaleza, Ceará Brasil. e-mail: kilmer@ufc.br.*
[5] *Docente de Engenharia Agrícola, Instituto Federal de Educação, Ciência e Tecnologia do Ceará - IFCE, (Fazenda Floresta, Rua Carlos Antônio Sales, s/n – Floresta, CEP: 62660-000, Umirim – CE, Brasil. e-mail: fco_limeira@yahoo.com.br.*

1 ABSTRACT

The present work evaluated the productivity and efficiency of the use of the water in the culture of sorghum forager (BRS Black Tip) under different blades of irrigation (50; 75; 100; 125 and 150% of the evapotranspiration of the culture, ETc) associates the different levels of covering deceased (mulch) (0.00; 2.50; 3.75; 5.00 and 6.25 cm). The experimental delineation was made use in subdivided parcels, 5 x 5 with 5 repetitions, having totaled 125 experimental units. It was analyzed: productivity of cool mass, productivity of dry substance, productivity of seed, weight of 100 seed, weight of the seed for panicle, efficiency of use of water in the production of cool mass in (kg m^{-3} and R$ m^{-3}). For the results it was possible to conclude that, the factors of production in irrigation blades and in bagana coverage had been promising for the productivity of the culture of sorgo; The significant effect for efficiency in the use of the water in the 0 variable of productivity of cool biomass and dry substance in kg m^{-3} and R$ m^{-3}, indicates this being a promising culture for the region, associated with the adopted techniques of culture in the present work.

Keywords: Forage production, irrigation management, water efficiency.

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2 RESUMO

O objetivo do presente trabalho foi avaliar a produtividade e eficiência do uso da água na cultura do sorgo forrageiro (BRS Ponta Negra) sob diferentes lâminas de irrigação (50; 75; 100; 125 e 150% da evapotranspiração da cultura, ET_C) associadas a diferentes níveis de cobertura morta (0,00; 2,50; 3,75; 5,00 e 6,25 cm). O delineamento experimental foi disposto em parcelas subdivididas, 5 x 5 com 5 repetições, totalizando 125 unidades experimentais. Foi analisado: produtividade de massa fresca, produtividade de matéria seca, produtividade de semente, peso de 100 semente, peso da semente por panícula, eficiência de uso da água na produção de massa fresca em (kg m^{-3} e R$ m^{-3}). Pelos resultados foi possível concluir que, os fatores de produção em lâmina de irrigação e da cobertura com bagana foram promissores para a produtividade da cultura do sorgo; O efeito significativo para eficiência no uso da água nas variáveis de produtividade de biomassa fresca e matéria seca em kg m^{-3} e R$ m^{-3}, indicam essa ser uma cultura promissora para a região, associado às técnicas de cultivo adotadas no presente trabalho.

Palavras-chave: Produção de forragem, manejo da irrigação; eficiência de água.

3 INTRODUCTION

Sorghum (*Sorghum bicolor* L) is a plant of tropical origin, a C_4 type that stands out for its ease of cultivation, high biomass production for silage, resistance to diseases, great tolerance to water deficit, good development of the root system, the possibility of regrowth cultivation when submitted to the proper handling, considering it as one of the more versatile and efficient forage species in food production. (XIN; AIKEN; BURKE, 2009; BORBA et al., 2012; BEHLING NETO et al., 2017).

However, it's necessary to optimize water use, because irrigation planning requires special care in order to harmonize the water balance with the demand, so that the plant water requirement is the main means to that purpose, considering the water necessity of the plant to be variable in its level of development throughout the cycle, considering its relevant knowledge in the sizing and in the management of irrigation projects, to quantify the water to be replaced to the soil in order to comply with the crop demand (FREIRE et al., 2011; SANTOS JÚNIOR; FRIZZONE; PAZ, 2014).

In this context, the evaluation of different irrigation sheets has been used to determine the water necessities of a crop in specific conditions of cultivation, obeying the limits imposed by its genetics potential, being it essential to optimize the productivity and to increase efficiency in the use of water, beca use its development is affected in a very meaningful way by the water availability, both by its absence and by the excess of it (SIMÕES et al., 2016; FERNANDES et al., 2014).

Management strategies to optimize the use of water have been conducted with the mulching/soil coverage technique, which promotes a higher water retention, keeping the ground humid for a longer time and so, it will be possible to increase the intervals among irrigation season, besides these advantages, acting also as an insulating agent, preventing excessive oscillation of the soil temperature and contributing to a lesser water evaporation stored with a better content exploitation of water by the plants. To be feasible the mulching/soil coverage technique, it is necessary the use of available material in the cultivation area (BIZARI et al., 2009; FARIAS et al., 2015).

Therefore, this paper aimed to assess the production and efficiency factors in the use of water in the sorghum crop (BRS Ponta Negra type) on different irrigation sheets associated with the different levels of mulching/soil coverage with carnauba straw frames.

4 MATERIAL AND METHODS

The experiment was conducted at Floresta Farm, at Federal Institute of Education, Science and Technology of Ceará (IFCE) - Umirim Campus, located at the Umirim municipality, CE (3° 41' 7.96" S; 39° 20' 25.52" O); the altitude of 76 m, in the period from September 2016 to January 2017. According to Kopper Climate Classification, the local climate is BSw'h', which corresponds to the semi-arid climate, with irregular rainfall and high temperatures. The annual average amount of rainfall is 807.1 mm (from 1978 to 2016).

The reference evapotranspiration (ETo) was calculated through the Penman-Monteih/FAO method (SMITH et al., 1991), using the Cropwat software. The entry data to calculate the reference evapotranspiration (ETo) were obtained from a historical rain series in the municipality of Pentecoste in the 1970–1998 period (CABRAL, 2000), in the following sequence: January; February, March, April, May, June, July, August, September, October, November, December – 6.15; 5.33; 4.14; 4.14; 4.28; 4.61; 5.21; 6.85; 7.83; 7.97; 7.77; 7.27 mm, respectively.

The crop coefficient (Kc) in several phenological stages were obtained by Allen et al. (1998), (Stage I; Stage II; Stage III; Stage IV; 0.40; 0.68; 1.14; 1.10).

Thus, the Kr factor, suggested by Keller and Karmelli (1994) was applied to the regular calculus in the water consumption by equation 01:

$$Kr = \frac{\%AC}{0.85} \qquad (01)$$

Where Kr = wetting reduction factor, recommended adopting the smaller value ($Kr \leq 1$); %AC - a percentage of area covered by the top of the trees (shade area of the plant canopy), considering this projection was made by the treetop (shade) at noon.

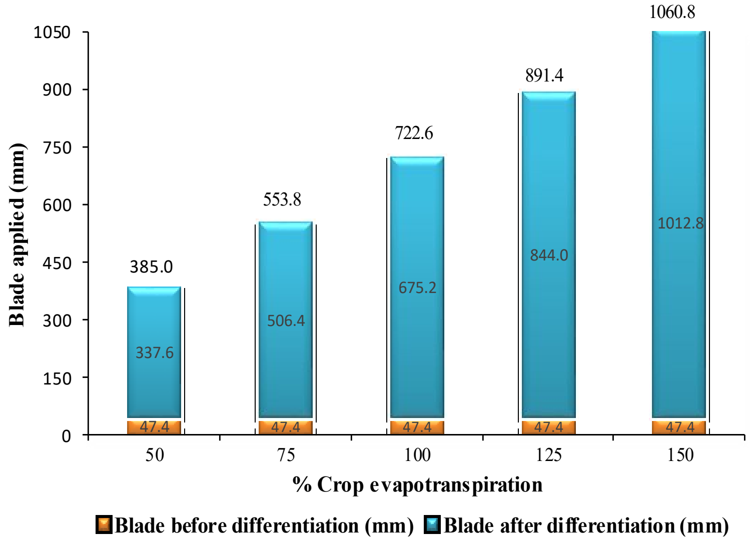
The irrigation sheets were equivalent to 50%, 75%, 100%, 125% e 150% da (ET_c), which resulted in throughout the cycle (102 days), where it was calculated by the following equation 02:

$$ETc = kc * ETo \qquad (02)$$

Where: ETc is the crop evapotranspiration, in mm day^{-1}; Kc is the crop coefficient, dimensionless, tabulated; ETo is the reference evapotranspiration, in mm day^{-1}.

Thus, the picture 1 represents the irrigation shifts demanded according to ETc and the applications according to the treatments.

Picture 1. Sheets applied in the early levels and with differentiation and in total in the cycle per treatment.



Fonte: Sousa (2017)

As for the secondary factor, levels of coverages, it was evaluated according to the answer of the height of the mulching (bagana) applied (height 0.0; 2.5; 3.75; 5.00 e 6.25 cm, named C_1, C_2, C_3, C_4 e C_5 respectively), being that this generated the volumes 0.00; 250.00; 375.00; 500.00 and 625.00 m^3 ha^{-1} respectively in relation to each applied level.

The total area of the experiment cultivated with sorghum was 1000 m^2 (40 x 25 m); the experimental design adopted was in the subdivided parts scheme; the treatments were composed of the combination of five irrigation sheets (parts) and five levels of mulching (subplots) totalling 25 treatments in repetitions.

The experimental plots (blocks) measured 200 m^2 (25 m x 8 m), composed of 5 subplots (subparts) of 40 m^2 (5 m x 8 m), with ten rows of plants spaced 0.8 m between the lines and an average density of 12 plants per meter.

It was used only five of the ten rows considered useful to obtain the data, and the others were considered as borders. In the row of useful plants were also considered the plants with edges as borders, that is, of the five meters of each subplot only the two central meters of each row were used for analysis, that is, 1.5 m from the beginning and end were considered borders.

The physical and chemical attributes of the soil in the (0 - 0.2 m) layer were determined at the Soil and Water Lab at the Soil Sciences Department (Laboratório de Solo e Água do Departamento de Ciências do Solo), part of the Agricultural Sciences Center of the Federal University of Ceará, considering the chemical attributes in the layer (0 - 0.2 m), P mg kg^{-1} = 1.00; K $cmol_c$ kg^{-1} = 0.36; In $cmol_c$ kg^{-1} = 0.09; Ca $cmol_c$ kg^{-1} = 1.80; Mg $cmol_c$ kg^{-1} = 1.20; Al = $cmol_c$ kg^{-1} = 0.20; M.O. g kg^{-1} = 16.96; C/N = 11.00; pH = 5.60; CE dS m^{-1} = 0.09; PST = 1.00. Additionally, the physical attributes: Sand % = 53.80; Silt % = 22.40; Clay % = 23.80.

The irrigation system used was a drip irrigation system with spacers spaced 0.3 m, operating at a flow rate of 1.6 L h^{-1}, with a pressure of 1 kgf cm^{-2}. The system consisted of a main line of PVC pipes (diameter 50 mm), with lateral lines consisting of polyethylene hoses (16 mm diameter).

The water requirement of the crop was calculated considering the different months and stages, according to equation 03 below:

$$Ti = 60 * \frac{fi*ETo*Kc*Ap*Kr}{N*qe} \quad (03)$$

Considering: Ti irrigation time, in minutes; fi: adjustment factor in accordance with slide treatments, 0.50; 0.75; 1.00, 1.25 and 1.50 dimensionless; ETo: daily reference evapotranspiration, mm; Kc: crop coefficient, dimensionless; Ap: floor area per plant, m^2; Kr: coefficient of reduction, in percentage, dimensionless; N: number of emitters per plant, dimensionless; qe: emitter flow, L h^{-1}.

Before the establishment of the sorghum crop in the field, it was verified the need for liming for soil pH correction, taking, as a reference, the operations instructions manual of fertilization and liming recommendation for the State of Pernambuco (2008). Cover fertilization was conducted via fertigation with the following fertilizers: urea; mono-ammonium phosphate (MAP) and white potassium chloride.

It was evaluated, in this paper, the variables of natural material productivity (NMP), dry matter yield (DMY), grain yield (P grain) and water use efficiency in the natural material productivity (kg m^{-3} e R$ m^{-3}) from the sorghum crop.

The dry matter yield (DMY) of the aerial part was obtained by accumulation in the different organs of the plant (stem, leaf and panicle), and the average was obtained using three random samples per subplot (subparts), where each sample was composed of one plant. The samples were previously identified and taken to a forced circulation air oven (greenhouse), under a stable temperature of 70 °C, for 48 h. After that period, the samples were removed and their total weight of three plants in a digital scale of 0.05 g precision, and then, it was checked and then the average values expressed in grams per plant (g p^{-1}) were measured. Additionally, with the proportion of dry matter by natural matter, the average productivity in tons per hectare was estimated by the estimated average of plants per hectare.

The grain yield was obtained by the average obtained using the grains harvested in three plants per plt in five blocks and thus estimated by the proportion of the number of plants per hectare in kg ha^{-1}.

EUA was obtained from the relation between the commercial productivity of the crop and the amount of water applied, according to Equation 04 and 05.

$$EUA_1 = \frac{Y}{I} \quad (04)$$

EUA_1: Considering the water use efficiency (kg m^{-3}); Y: Productivity of fresh mass of sorghum (kg ha^{-1}); Water volume applied via area unit ((m^3 ha^{-1}).

$$EUA_2 = \frac{R}{I} \quad (05)$$

Considering: EUA_2: Water Use Efficiency (R$ m^{-3}); R: Yield obtained from the productivity of fresh mass of sorghum (R$ ha^{-1}); volume of water applied via irrigation for area unit (m^3 ha^{-1}).

It is worth mentioning that the yield value wasobtained from the product between productivity and the value of one ton of silage, which was obtained from the average prices practiced in the period from March to December 2016.

Statistical analysis of the variables was analyzed using the Assistant 7.7 software (SILVA; AZEVEDO, 2016) and Excel. In the analysis of variance, the treatments were compared by the F test, considering a minimum level of significance of 5% probability. The comparisons between averages for the secondary treatment were performed by the Tukey test at levels of 5% and 1% of probability. For the analysis of the primary treatments because they were quantitative treatments, the regression analysis was performed.

5 RESULTS AND DISCUSSION

In order to evaluate the behavior of the hybrid BRS black type sorghum, according to the different irrigation slides and different levels of mulching, the analysis of variance was performed and the data were agglutinated in Table 1.

Table 1. Summary of ANOVA (statistical test) to (NMP), (PMS), (P grain) e (M 100 S) according to the irrigation blades and covered with carnaúba bagana. Umirim – CE. 2016.

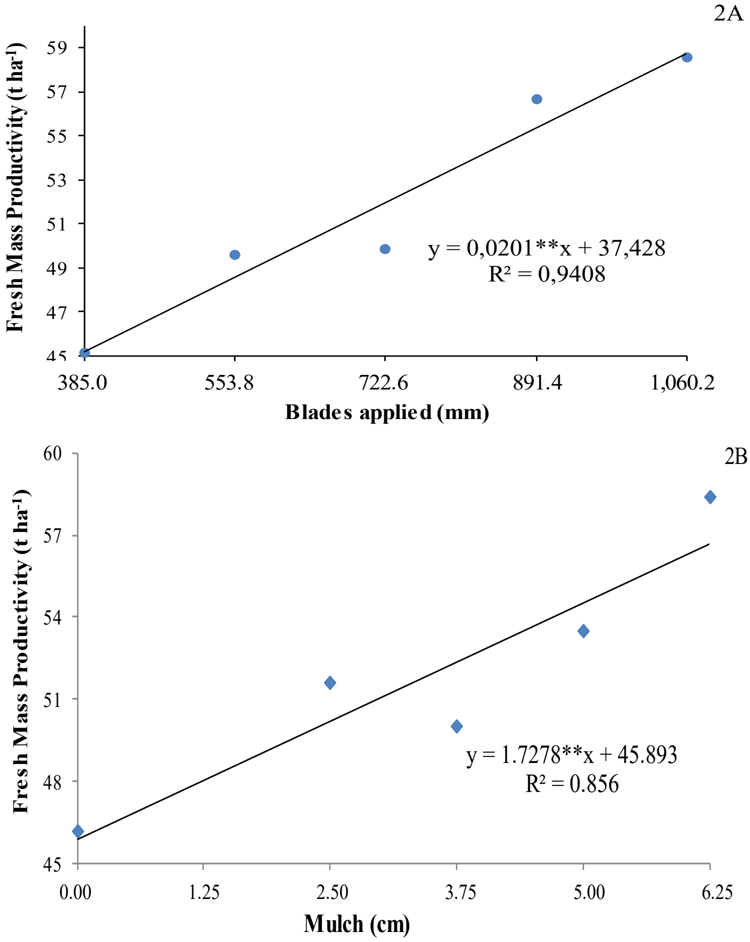
Fonte de variação	GL	Quadrado médio							
		NMP		PMS		P grain		M100 S	
L. de irrigação	4	950.51	**	299.27	**	37418498.57	**	0.23	ns
R. linear	1	756.52	**	229.40	**	-		-	
R. quadrática	1	8.04	ns	0.058	ns	-		-	
Resíduo (L)	16	80.50		48.98		1619932.14		0.10	
C. Morta (CM)	4	441.67	**	93.16	*	3049370.89	ns	0.02	ns
R. linear	1	343.95	**	66.33	*	-		-	
R. quadrática	1	5.77	ns	0.55	ns	-		-	
L x CM	16	54.89	ns	14.03	ns	3049849.87	*	0.05	ns
Resíduo (CM)	80	82.89		31.11		1511792.94		0.04	
CV (L)	(%)	17.17		30.54		26.20		21.42	
CV (CM)	(%)	17.42		24.30		25.31		13.39	

(**) Significant effect at 1% and (*) at 5% probability; (ns) not significant at the 5% probability by the F test.
Fonte: Sousa (2017)

Based on the analysis of variance presented in Table 1, it was observed that there was a significant effect at the 1% level (NMP) by the F test for irrigation and mulching, but there was no interaction between the two factors. The variable (PMS – productive of dry mass) did not occur interaction between the factors of irrigation and mulching, and there was a significant effect for leaf at 1% level and 5% for mulching. For the (P grain), interaction between the factors of irrigation blades and mulching occurred at a 5% probability level. In terms of water use efficiency, it can be seen that there was a significant effect at the 1% probability level.

The regression equation for slide and mulching that was most appropriate to the model was linear, showing an increasing trend with the increase of the respective factors. The increase in productivity with the increment of the irrigation slides was of the order of 45.13 t ha^{-1} with the smallest blade applied, being that of 385.0 mm, equivalent to 50% of ETc, to 58.55 t ha^{-1} with the highest 1060.2 mm blade, generating an increase equivalent to 22.92%, as shown in Picture 2A.

Picture 2. Fresh mass production as a function of the irrigation blades (2A) and mulch (2B).



Fonte: Sousa (2017)

The results obtained are similar to those of Santos et al. (2007) developed in São Gonçalo do Amarante - CE, showing a green mass yield of 55.26 t ha^{-1} and 55.20 t ha^{-1} for the BRS Ponta Negra type and IPA 467-4-2 varieties, respectively.

Tanaka et al. (2014) evaluated the development of sorghum plants submitted to five depths of groundwater in a greenhouse (0.17, 0.31, 0.45, 0.59, and 0.73 m), found that treatments with 0.45 m and 0.59 m, produced 137.3 g and 131.5 g, respectively, and these were the best, presenting the highest values for fresh mass.

The high sorghum forage production obtained with different irrigation slides with C_4S_1 tubular well water, high salt content and low sodium content, and electrical conductivity (EC) of 3.81 dS m^{-1}, were higher than the green mass yield data obtained by Vale and Azevedo (2013) evaluating the productivity and quality of elephant grass and sorghum irrigated with groundwater with 2.9 dS/m (EC) equal to 3.7 dS/m, obtaining 47.50 and 37.81 t ha^{-1} of sorghum green mass, respectively.

The increase in productivity reaching the different levels of mulching reached the highest value with the highest level 6.25 cm equivalent to 625 m^3 ha^{-1}, as can be seen in Picture 2B. It is observed that variation in fresh mass yield of 46.20 t ha^{-1} in treatment C_1 up to 58.38 t ha^{-1} in C_5 an increase of 21.42%.

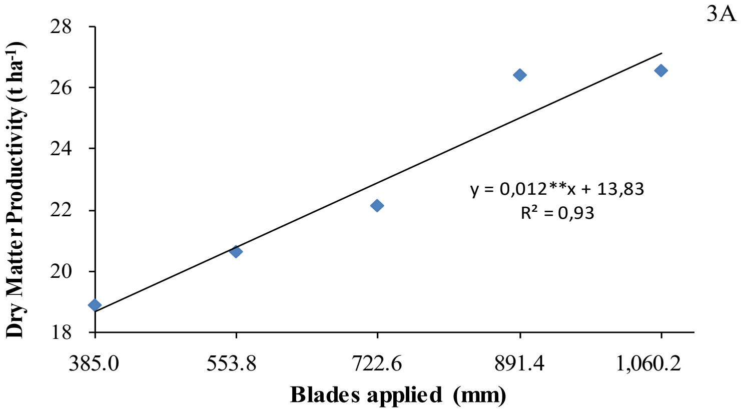
Thus, these results were contrary to those of Costa et al. (2015) evaluating the behavior of sorghum cultivation in an effluent system with and without soil cover. The researchers, mentioned, verified that there was no significant effect on the production of green mass. The researchers worked with four varieties (IPA 2502, IPA 4202, IPA 467–42, IPA SF-25) and expressed respectively values of (26.98, 24.31, 44.02, 42.52) t ha^{-1} with the use of coverage and (24.54, 20.69, 39.41, 32.17) t ha^{-1} without coverage. All the results found by the authors were lower than those found in this research at different levels of mulch with the cultivar BRS ponta negra type.

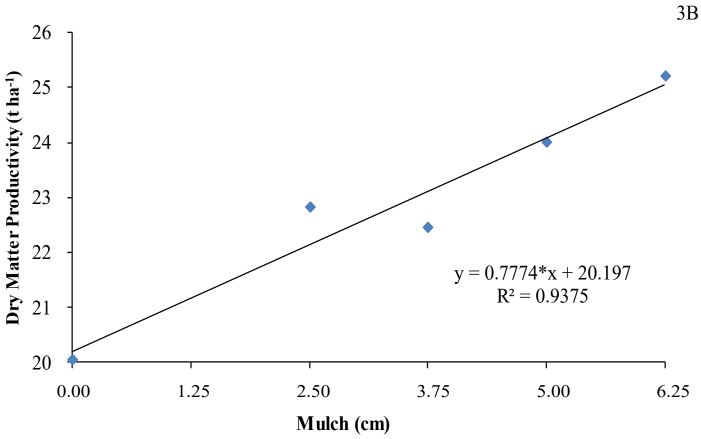
Observing the results obtained in the analysis of variance, presented in Table 1, it is observed that there was a significant effect for (PMS) at the level of 5% of probability by the test F for the irrigation blade. For mulching, there was a significant effect at the 1% probability level, and there was no significant effect as for the interaction of irrigation blades x mulch.

The effect was significant at the 1% probability level by the F test for dry matter yield as a function of soil cover level. The model that fitted the most was of the linear increasing type, as can be seen in Picture 3.

The regression equation for dry mass yield as a function of the irrigation slides that best fit was linear, presenting an increasing trend with the increment of the slides. The dry mass yield increased from 18.70 t ha^{-1}, with the lowest leaf applied, to 26.46 t ha^{-1}, with the highest leaf, generating an increase equivalent to 29.32%, as verified in Picture 3.

Picture 3. Dry matter yield of sorghum as a function of irrigation and mulch.





Fonte: Sousa (2017)

Thus, the increase in dry matter yield as a function of the levels of mulch was of the order of 12.09%, of the treatment without the cover of the ground for the first level (2.5 cm of thickness), and of 21.42%, in relation to the highest level of coverage applied (6.25 cm).

The results obtained were lower than those of Santos et al. (2007), in São Gonçalo do Amarante. These authors found dry mass yields of 39.73 t ha^{-1} and 37.10 t ha^{-1} for BR 506 and BRS Ponta Negra, respectively, under conditions of water stress during their vegetative development.

Albuquerque and Mendes (2011), evaluating the sowing time of forage sorghum in two cities of Minas Gerais State, found dry matter yields of 11.33 t ha^{-1} in Francisco Sá and 6.57 t ha^{-1} in Jaíba. These results are lower than those found with the lowest blade applied in this study.

Albuquerque, Camargo and Souza (2013), evaluating the agronomic and bromatological characteristics of the vegetative components of forage sorghum genotypes in Minas Gerais State, found that in the two sites (Leme do Prado and Nova Porteirinha) the dry matter yield oscillated at 18.96 t ha^{-1}, for SHS 500 and in 13.37 t ha^{-1} for Silotec 20. These values were also lower than those obtained in this study.

Water stress reduced dry matter yield in this study. Likewise, Costa, Pinho and Parry (2008), evaluating the dry matter yield of corn crops under different water stress levels, observed that in both vegetative and reproductive stages, water stress induced a reduction in dry matter for both crops.

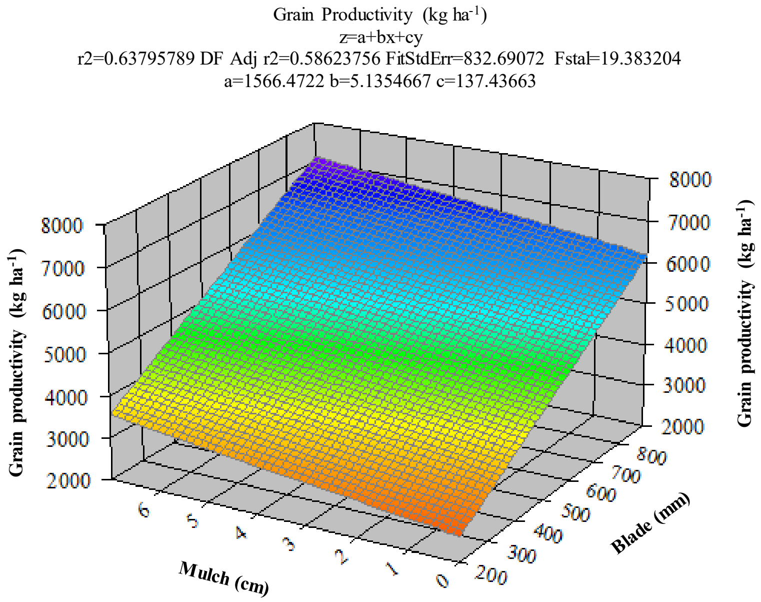
However, Costa et al. (2015), evaluating the behavior of sorghum cultivation in an effluent system with and without soil cover, found that there was no significant effect on dry mass production. The authors cultivated four varieties (IPA 2502, IPA 4202, IPA 467–42, IPA SF-25), and these varieties produced, respectively, 10.29; 10.63; 17.56; 19.97 t ha^{-1} with the use of soil coverage. Without coverage they produced 9.84; 7.85; 14.33; 12.34 t ha^{-1}. These values are lower than those obtained in this research, with the BRS Ponta Negra cultivar in Umirim, Ceará State.

Viana et al. (2012), working with irrigation blades and soil cover in the sunflower crop, under semi-arid conditions, concluded that mulch did not present significant results nor did the interaction between slides and coverings for all variables analyzed. However, the authors consider that it was possible to perceive that the use of the rice husk provided greater moisture retention in the soil. Ratifying the importance of this type of management, associating irrigation and mulching effectively and objectively.

Corroborating with these authors, Pereira, Moreira and Klar (2002) state that the use of mulch (dead soil cover) is considered as the most important factor in explaining the tendency of soils under no-tillage to present higher water content when compared to conventional plantation systems. The authors determined that when the soil surface had a coverage of at least 50% of plant material, it became fully possible to obtain water savings and, consequently, to reduce costs with irrigation.

There was an interaction for the variable (P grain) where the linear model according to the variables was significantly ($P<0.05$) with a determination coefficient of 0.63. In this way, it is possible to notice a linear increase with the increase of the irrigation blade with a variation of (3.263,16 to 5.756,88 kg ha^{-1}) in L_1 and L_5 respectively, with an increase of 43.32%, as it can be verified in Picture 5. It is also possible to observe that the increase generated because of the bagana levels varied from (3.885,82 to 5.339,28 kg ha^{-1}) for C_1 and C_5, respectively, of the order of 27.22%.

Picture 4. Grain yield due to irrigation and mulch.



Fonte: Sousa (2017)

These results corroborate with Cysne and Pitombeira (2012) evaluating the adaptability and stability of sorghum genotypes in different environments in the state of Ceará, and thus determined that the average grain yield of the sorghum cultivars evaluated was 4,421.60 kg ha^{-1}. The results obtained in this study are higher than the most recent national average published by CONAB 2,937.00 kg ha^{-1}.

Also resembling the results obtained by Crusciol et al. (2011) Nutrition and productivity of grain sorghum hybrids of contrasting cycles intercropped with marandu-grass, and thus identified yield results of grains above 5,300.00 kg ha^{-1}.

The variable (P 100 S) did not present a significant result (P <0.05) as a function of the analyzed parameters, presenting an average weight among treatments of 2.38 g. Similar results were obtained by Crusciol et al. (2011), where the authors verified that the mass of one thousand grains of hybrid P8118 (29.0 and 28.9 g in monoculture and intercropping respectively) and the hybrid P8419 (25.4 and 25.6 g in monoculture and intercropping, respectively).

To evaluate the efficiency of water use in the production of the BRS Ponta Negra hybrid sorghum, according to the different levels of irrigation and different levels of mulching (death soil cover), the analysis of variance was applied and data were agglutinated in Table 2.

Table 2. Summary of ANOVA for (EUA kg m^{-3}) and (EUA R \$ m^{-3}) as a function of the irrigation blades and cover with carnauba bagana. Umirim - Ceara State. 2016.

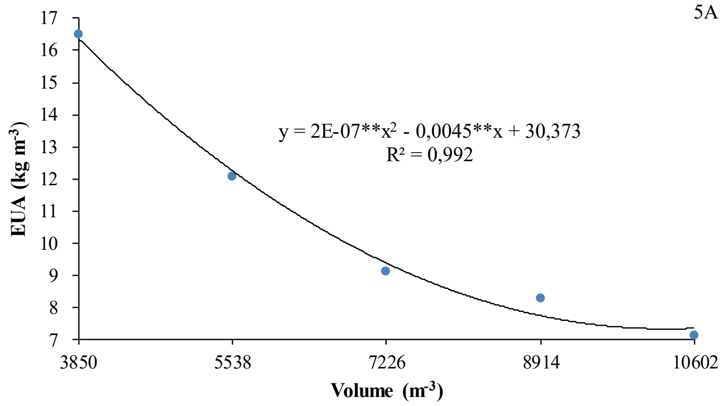
Source of Variation	GL	Quadrado médio Middle Square	
		EUA kg m^{-3}	EUA R\$ m^{-3}
L. de irrigação	4	52.76 **	5.53 **
R. linear	1	253.48 **	26.17 **
R. quadrática	1	26.93 **	2.69 **
Resíduo (L)	16	9.67	1.01
CV (L)	(%)	29.35	29.62

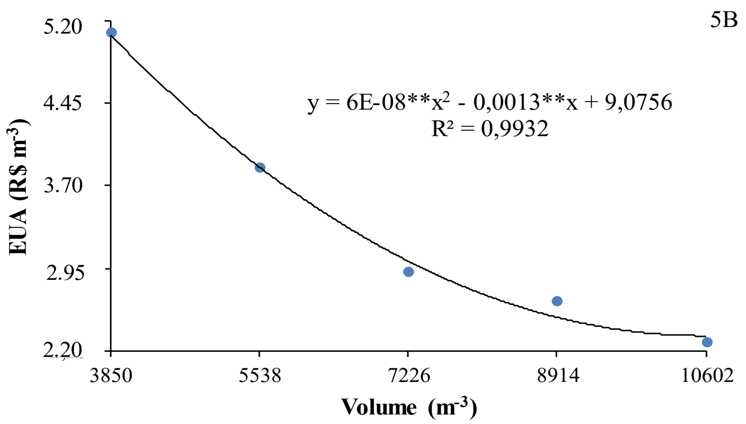
(**) significant effect at 1% and (*) at 5% probability; (^{ns}) not significant at the 5% probability level by the f test.
Fonte: Sousa (2017)

The maximum productivity of the water was observed with the 271.73 mm blade, that of 16.49 kg of fresh mass per cubic meter of applied water. It is also observed that the lower water productivity is observed in the largest irrigation blade 821.15 mm, which is 7.13 kg m^{-3}.

The increase in the water volume applied decreased water productivity, corresponding to a reduction of 56.76% from the lowest to the highest blade applied, evidencing the importance of improvement and mastery in the management techniques, since the loss of efficiency in the use of water may generate uneconomic results. The regression equation that best fits the models was quadratic polynomial type, as can be seen in Picture 5.

Picture 5. Efficiency of water use in (kg m^{-3}) and (R\$ m^{-3}) according to the blades applied





Fonte: Sousa (2017)

From the results observed in this paper, it can be observed that the deficit irrigation, according to ETc, can be used to improve the water use efficiency in the production of fresh mass in the sorghum crop. The difference between the efficiency of water use on the highest and lowest blade applied was 9.36 kg of fresh mass of sorghum per m^{-3} of applied water, corresponding to a 56.76% increase in efficiency.

Moreira et al. (2013), evaluating the physiological characterization of sweet sorghum in different irrigation intensities, reported that there was no effect (P> 0.05) for intrinsic water use efficiency (EIUA), at the water availability (80%, 60%, and 40% of field capacity). The authors state that the average for this parameter was 73.88 ± 27.75.

Martin et al. (2012) compared the water yield for the corn silage production at three levels of ETc (50%, 75%, and 100%), reported that the treatment with 50% ETc replacement obtained the highest value, being that of 14.9 kg m^{-3} for the production of green mass (NMP). This value was deferred from the treatment with 100% of ETc replacement, being that of 13.9 kg m^{-3} for NMP, where these values differ statistically at the 5% probability level.

The maximum water productivity for this variable was observed with the 271.73 mm blade, which was 5.09 R$ m^{-3}. It is also observed that the lower efficiency of water use is observed in the greater irrigation blade 821.15 mm, being that of 2.28 R $ m^{-3}.

From the results observed in this paper, it was observed that irrigation deficits with reduced irrigated blade can be used to improve water use efficiency in the production of fresh mass in the sorghum crop. irrigation with the reduction of the applied blade, it was observed that the fresh mass yield of the sorghum crop was reduced, and the reduction of 150% to 50% in the replacement of ETc resulted in the increase of 2.81 R$ per m^{-3} of applied water, corresponding to 56.76% of increase, thus evidencing the importance of improving and mastering the management techniques.

Evaluating the productive performance and economic return of the sorghum crop submitted to deficit irrigation (ZWIRTES et al., 2015) claim that the economic return on the cost of water application increased linearly with the reduction in ETc replacement from 100 to 25%. The authors also claim that the 25% reduction in ETc increases R$ 0.56 (20%) in the economic return on the cost with the application of water.

6 CONCLUSION

The factors of production as a function of water and bagana were promising for the yield of the sorghum crop, indicating these as relevant factors to be considered for the appropriate management of the production;

The significant effect and the values obtained for water use efficiency in the variables of fresh biomass and dry matter in kg m^{-3} and R$ m^{-3} indicate that this is a promising crop for the region studied, associated with the cultivation techniques adopted in the present study;

The adoption of deficit irrigation reduces the production of sorghum fresh matter, however, it increases water productivity. This technique can be an alternative in conditions where water is a limiting factor, and it can be used to the point where the economic viability similar to the full irrigation option is maintained.

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