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ARTICLE

Responses of forage watermelon genotypes submitted to different water supply

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ABSTRACT

This study aimed to evaluate yield and physiological traits of plants and bromatological and morphological responses of fruits of forage watermelon genotypes under different water supply. Seven genotypes were used (BGCIA 228; BGCIA 239; Jojoba; BGCIA 228 x BGCIA239; BGCIA 228 x Jojoba; BGCIA 239 x Jojoba and BGCIA 991) and four water supplies (470; 370; 270 and 170 mm) during the crop cycle. The experimental design was a complete randomized blocks organized in split plots and in a 7 × 4 factorial arrangement with three replications. The photosynthesis, transpiration, stomatal conductance and leaf temperature were not affected by genotypes. Applying 170 mm of WS promoted lower photosynthesis ($p = 0.0001$), stomatal conductance ($p = 0.0001$), transpiration ($p = 0.0001$) and greater leaf temperature ($p = 0.0084$). Jojoba presented greater fruit weight ($p = 0.03$), plant yield ($p = 0.02$), fruit length ($p = 0.01$) and longitudinal diameter ($p = 0.01$) in comparison to BGCIA 228. Applying 270 mm of WS decreased DM ($p < 0.0001$) and 170 mm of WS increased ADF ($p = 0.01$). Genotype BGCIA 228 presented greater total carbohydrates ($p = 0.03$) and total soluble solids contents ($p = 0.01$), lower ether extract ($p < 0.0001$) and ADF ($p = 0.006$) compared to BGCIA 239. Water supply affects physiological and bromatological responses, and the genotypes promote differences in yield, bromatogical and morphological characteristics of forage watermelon.

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Citrullus lanatus var. citroides; forage plant; water deficiency; water depths

1. Introduction

Forage watermelon (FW) (*Citrullus lanatus* var. citroides) is a Cucurbitaceae used as food for livestock in the Brazilian semi-arid. The evaluation of FW genotypes may provide important forage resources to regional production systems, promoting the identification of genetic material presenting tolerance to harsh environmental conditions (Santos et al. 2017). Water shortage has been an important obstacle to agricultural and livestock

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activities in the Brazilian semi-arid, reducing productivity (Silva et al. 2016). The adequate crop management and evaluation of genotypes are important tools to increase forage production (Fahad et al. 2017).

According to Melo et al. (2010) drought affect yield response of commercial watermelon, verifying highest fruit yield applying 130% of evapotranspiration (greater water depth), without decreases efficiency of water use (WUE). Forage watermelon could be an important forage resource for arid and semi-arid areas in the world but yield, morphophysiological traits of plants and chemical composition of fruits have been little studied. Acar et al. (2014) evaluated different water application intervals (irrigation frequency) at 5, 10, 15 days for FW and found no differences in the water by the plant.

Little is known about physiological, productive and qualitative characteristics of FW in response to water supply. However, the *Citrullus lanatus* var. citroides present genotypes tolerant to water deficit (Zhang et al. 2014). Physiological characteristics of plants can be affected by water restriction influencing crop growth and yield. Kawasaki et al. (2000) reapplied water after water deficit and verified a gradual recovery of the photosynthesis of wild watermelon. In addition, Akashi et al. (2011) observed that water deficit decreased transpiration and increased leaf temperature in wild watermelon.

Food quality is important to increases animal production and health. Forage watermelon presents crude protein contents greater than 18.73%, total digestible nutrients (TDN) higher than 60.00% and in vitro dry matter digestibility (IVDMD) above 62.01% (Silva et al. 2009; Santos et al. 2017). Moreover, that fruit size, color, and soluble solids content are important characteristics to contribute in determining the harvest point. In addition, these characteristics can be used to distinguish genotypes.

In the Brazilian semiarid, especially in the sub-medium of San Francisco River Valley presenting low and irregular rainfall the agricultural and forage crops present high risk to failure, requiring plant species adapted. Forage watermelon genotypes evaluated and indicated for Brazilian semi-arid is an important tool to promote alternative forage for the dry regions. This study aimed to evaluate yield, morphophysiological and bromatological responses of FW genotypes under different water supply.

2. Methods

2.1. Location and meteorological conditions

The test was conducted at the Embrapa Semi-Arid Experimental Station of Caatinga, in Petrolina-PE, Brazil (09º09′S, 40º22′W, 376 m altitude). According to Koppen classification, the climate is of the type BSW′ h, characterized as a hot semi-arid region presenting two distinct seasons, a rainy with irregular rainfall and a dry without precipitation. Meteorological data were obtained from Meteorological Caatinga Station, and the average values were: reference evapotranspiration (ETo) was 5.80 mm, temperature 26.76 ºC, relative humidity 55.90% and cumulative precipitation was 71 mm.

2.2. Soil characterization

The soil of the area is classified as dystrophic Red-Yellow Latosol (Embrapa, 2013). Soil samples were collected at 0–0.20 m and the mineral levels were determined as described by Nogueira and Souza (2005). Chemical and physical and chemical characteristics of the soil were pH = 5.0; P (mg dm^{-3}) = 3.28; K (cmolc dm^{-3}) = 0.22; Na (cmolc dm^{-3}) = 0.03; Mg (cmolc dm^{-3}) = 0.60; Al (cmolc dm^{-3}) = 0; H+ Al = 1.5; sum of bases (SB) = 2.5; cation exchange capacity (CEC) = 4.3, porosity (%) = 39.27; clay (g/kg) = 48.8; silt (g/kg) = 225.7; sand (g/kg) = 725.7.

2.3. Genotypes, planting and experimental design

Seven genotypes of *Citrullus lanatus* var. citroides were used: BGCIA 228, BGCIA 239, Jojoba, BGCIA 228 x BGCIA239, BGCIA 228 x Jojoba, BGCIA 239 x Jojoba and BGCIA 991. The experimental design consisted of a complete randomized block in a 7 × 4 factorial arrangement with three replicates and 12 plants per plot. Plants were spaced 3.0 × 1.0 m between rows and plants, respectively, evaluating the four central plants of each plot. Seeds of *C. lanatus* were sown in expanded polystyrene trays with 128 cells using a commercial substrate (Electric conductivity = 0.98, pH = 6.50, Calcium = 4.36, Magnesium = 3.84, Phosphorus = 1.07, Potassium = 1.15, Nitrogen = 3.65), transplanting to the field, 20 days after sowing.

2.4. Irrigation and fertilization

The water application was carried out by dripping irrigation with emitters spaced every 1 m with and nominal flow rate of 2400 L/h. The water balances were based on crop evapotranspiration (ETc), providing corresponding to 470 mm, 370 mm, 270 mm and 170 mm of water supply. Crop evapotranspiration obtained by the reference evapotranspiration (ETo) of the Class A tank and the average commercial watermelon Kc: 0, 50, 0.80, 1.05 and 0.75, for vegetative, flowering, fruiting and ripening periods, respectively (Doorenbos and Pruitt 1984).

The fertilizer application was carried out following the recommendations for commercial watermelon described in the Fertilization Manual of the State of Pernambuco, applying 3 kg/pit of goat manure, 30 kg/ha of urea, 120 kg/ha of MAP and 30 kg/ha of potassium chloride (IPA, 2008).

2.5. Foliar physiological evaluation

Foliar physiological evaluations were performed during fruiting stage using Li-6400 Portable Infrared Gas Analyzer (IRGA) at artificial light fixed at 2500 µmol m^2/s. Analyzed variables were: photosynthesis rates (A), stomatal conductance (Gs), transpiration (E) and leaf temperature (Tf) and the samplings were performed on leaves exposed to the sun, between 9:00 h and 11:00 h, choosing a not cloudy day.

2.6. Yield and morphological characteristics

The variables evaluated were: number of fruits per plant (NFP), average fruit weight (AFW, kg), weighing all fruits per plant individually in a digital balance, plant yield (PY, kg/plant) considering number and weight of fruits per plant. Morphological characteristics evaluated were: longitudinal diameter (LD), vertical diameter (VD), fruit length (FL), peel thickness (PT) and transverse diameter (TD), using a measuring tape graduated in centimeters.

2.7. Chemical composition

Total soluble solids content (°brix) was determined using a benchtop refractometer (Abbe Mark II, model 10,480- Lucca) with automatic temperature correction (AOAC, 2016). Fruit samples were pre-dried in an oven with forced air ventilation at 55°C until constant weight and milled in a Willey type mill with 1 mm diameter sieves. Variables analyzed were dry matter (DM, method 967.03), ash (method 942.05), crude protein (CP, method 981.10), ether extract (EE, method 920.29). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were performed according to Van Soest (1994) and AOAC (2016). Total carbohydrates (TC) were calculated according to Sniffen et al. (1992): TC (% DM) = 100 − (CP + EE + ashes).

2.8. Statistical analysis

The data were submitted to a normality test by the univariate procedure of Statistical Analysis System (SAS, 2011) and then it was performed the analysis of variance and Tukey test by GLM procedure (General Linear Models), considering as significant $P < 0.05$.

3. Results

Physiological responses (photosynthesis, stomatal conductance, transpiration and leaf temperature) were not affected by genotypes, but were influenced by WS. Applying 370 to 470 mm of WS proportioned greater photosynthesis, stomatal conductance and transpiration and decreased leaf temperature compared to 100 mm (Table 1). There were no interaction genotypes x WS on physiological responses.

Water supply did not influence NFP, PY and productivity (kg of GM/ha and kg of DM/ha) (Table 2), interactions between genotypes and the water supply were not observed for NFP, PY and productivity. Genotypes influenced green matter productivity (kg of GM/ha). Jojoba presented the highest productivity while BGCIA 228 presented the lowest productivity.

Morphological responses of fruits (FL, LD, VD, TD) were not affected by water supply but were influenced by genotypes (Table 3). Jojoba presented the greatest fruit lengths and lowest thick pulp. BGCIA 228 presented smaller and more rounded fruits in relation to others genotypes. The TP was influenced by water supply, applying 270 mm promoted the greatest TP in comparison to other water supply. Increasing water depth promoted reduction in TP, observing the greatest TP for 170 mm.

Table 1. Physiological responses of forage watermelon genotypes receiving different water supply.

	Genotypes								P		
WS (mm)	1	2	3	4	5	6	7	Â	G	WS	Gx WS
Photosynthesis (μmol $CO_2/m^2/s$)											
470	43.49	36.59	46.82	36.63	50.96	40.93	32.94	41.20a	0.28	0.0001	0.11
370	46.56	34.94	46.46	38.51	43.20	35.21	41.90	40.97a			
270	19.81	27.91	25.11	35.35	35.72	35.46	28.04	29.63b			
170	13.70	27.08	26.61	19.99	19.51	15.78	12.46	19.30c			
Â	30.89	31.63	36.25	32.62	37.35	31.85	28.83				
Transpiration (mmol $H_2O/m^2/s$)											
470	11.07	9.63	14.15	14.46	12.30	11.89	7.87	11.62a	0.14	0.0001	0.32
370	12.51	9.37	10.98	10.17	10.99	8.73	10.78	10.50a			
270	4.09	5.37	6.04	8.17	9.02	7.89	6.41	6.71b			
170	2.61	5.26	7.68	4.76	4.41	2.87	2.24	4.26b			
Â	7.57	7.41	9.71	9.39	9.18	7.84	6.82				
Leaf temperature (°C)											
470	32.74	34.45	33.89	33.10	32.33	32.41	33.42	33.19a	0.28	0.0084	0.05
370	32.11	34.36	32.65	34.44	32.94	33.92	34.04	33.50a			
270	35.70	32.90	33.90	33.01	33.27	33.09	35.03	33.84ab			
170	34.92	34.23	35.28	32.89	34.26	35.03	35.81	34.63b			
Â	33.86	33.99	33.93	33.36	33.20	33.61	34.57				
Stomatal conductance (mol $H_2O/m^2/s$)											
470	0.46	0.39	0.57	0.53	0.58	0.53	0.28	0.48a	0.05	0.0001	0.10
370	0.46	0.40	0.47	0.40	0.45	0.29	0.46	0.42a			
270	0.17	0.19	0.20	0.30	0.34	0.31	0.15	0.24b			
170	0.07	0.07	0.22	0.04	0.13	0.05	0.05	0.09c			
Â	0.29	0.27	0.36	0.32	0.37	0.30	0.23				

1 = BGCIA 228; 2 = BGCIA 239; 3 = Jojoba; 4 = BGCIA 228 x BGCIA 239; 5 = BGCIA 228 x Jojoba; 6 = BGCIA 239 x Jojoba; 7 = BGCIA 991. G = genotype; G x WB = genotype and water balance; P = probability; Â = Average; Average followed by the same uppercase letter in the line do not differ by Tukey test ($P > 0.05$).

Table 2. Green matter productivity, Dry matter productivity, Number of fruit per plant, Average fruit weight, Production per plant of watermelon forage genotypes receiving different water supply.

WS (mm)	Genotype 1	2	3	4	5	6	7	Â	P G	WB	Gx WS
				Green matter productivity (kg GM/ha)							
470	8.04	30.93	27.56	19.24	10.34	19.20	14.69	18.57	0.02	0.22	0.70
370	7.34	11.89	20.54	18.42	18.77	22.29	19.33	16.94			
270	6.76	29.26	34.70	37.63	16.35	16.15	47.85	26.96			
170	11.41	19.37	29.77	17.59	17.69	21.36	11.35	18.36			
Â	8.38b	22.86ab	28.15a	23.22ab	15.79ab	19.75ab	23.31ab				
				Dry matter productivity (kg DM/ha)							
470	790	1.77	2.43	900	782	1.60	1.15	1.35	0.19	0.75	0.86
370	504	852	1.47	1.47	1.55	1.79	1.40	1.29			
270	532	2.24	1.75	2.27	1.40	967	3.30	1.78			
170	914	1.43	2.24	1.32	1.38	1.85	895	1.43			
Â	685	1.57	1.97	1.49	1.28	1.55					
				Number of fruit per plant							
470	1.67	2.83	2.00	1.75	1.00	1.58	1.33	1.74	0.52	0.30	0.82
370	1.89	1.50	2.17	1.83	1.50	2.25	2.31	1.92			
270	1.33	2.67	2.25	2.50	1.50	1.50	4.50	2.32			
170	0.88	2.00	2.00	1.50	1.83	1.75	1.33	1.61			
Â	1.44	2.25	2.10	1.89	1.46	1.77					
				Average fruit weight (kg)							
470	1.54	3.24	4.14	3.34	3.10	3.61	3.84	3.25	0.03	0.45	0.84
370	1.01	2.43	2.86	3.04	3.82	3.18	2.62	2.71			
270	1.63	3.25	4.58	4.44	2.73	3.30	3.74	3.38			
170	3.56	3.20	3.92	3.39	3.16	3.98	2.21	3.35			
Â	1.93b	3.03ab	3.87a	3.55ab	3.20ab	3.52ab					
				Production per plant (kg)							
470	2.40	9.28	8.27	5.77	3.10	5.76	4.41	5.57	0.02	0.21	0.70
370	2.20	3.57	6.16	5.53	5.63	6.69	5.80	5.08			
270	2.03	8.78	10.41	11.29	4.90	4.84	14.36	8.08			
170	3.42	5.81	8.93	5.28	5.31	6.41	3.40	5.51			
Â	2.51b	6.86ab	8.44a	6.97ab	4.74ab	5.93ab					

1 = BGCIA 228; 2 = BGCIA 239; 3 = Jojoba; 4 = BGCIA 228 x BGCIA 239; 5 = BGCIA 228 x Jojoba; 6 = BGCIA 239 x Jojoba; 7 = BGCIA 991. G = Genotype; G x WB = genotype and water balance; P = probability; Â = Average; Average followed by the same uppercase letter in the line do not differ by Tukey test (P > 0.05).

Table 3. Morphological traits of fruits of watermelon forage genotypes receiving different water supply.

WS (mm)	Genotype 1	2	3	4	5	6	7	Â	P G	WS	GxWS
				Fruit length (cm)							
470	29,0	30.4	37,0	34.9	33.9	35.3	32.7	33.3	0.01	0.76	0.94
370	29,5	34.1	35,0	34.2	35.5	34.6	34.9	34.0			
270	30,5	33.3	37.9	37.2	31.5	34.1	36.9	34.5			
170	32.4	32.1	35.0	32.8	30.4	35.6	33.1	33.1			
Â	30.3b	32.5ab	36.2a	34.8ab	32.8ab	34.9ab	34.4ab				
				Longitudinal diameter (cm)							
470	58.1	62.6	73.8	69.8	66.1	71,0	66.9	66.9	0.01	0.51	0.88
370	59.7	68.6	72,0	69.4	70.8	70.1	69.8	68.6			
270	60.6	68.7	78,1	76,0	63,0	71.7	75.5	70.5			
170	30.0	66.2	73,1.	63.2	62.1	70.4	66.4	67,0			
Â	61.6b	66.5ab	74.2a	69.6ab	65.5ab	70.8ab	69.7ab				
				Vertical diameter (cm)							
470	46,0	49.3	49.8	48.1	46.9	49.5	50,0	48.5	0.03	0.77	0.60
370	44.6	51,0	50.4	48.2	52.2	50.9	51.2	49.8			
270	44.9	51.1	53.5	54.2	44.6	50.1	50.3	49.8			
170	48.7	48.5	56.4	46.3	43.9	51.0	50.2	49.3			
Â	46.0b	50.0ab	52.5a	49.2ab	46.9ab	50.4ab	50.4ab				
				Transverse diameter (cm)							
470	21.8	22.2	27,9	26.3	25.4	20.7	23.9	24.9	0.01	0.05	0.37
370	22.8	25.4	27.5	26.2	26.4	26.5	25.3	25.7			
270	22.7	25.4	29.8	28.8	23.7	27.0	27.9	26.5			
170	26.5	24.9	25.9	24.0	23,6	21.4	19.5	23.7			
Â	23.5b	24.5ab	27.8a	26.4ab	24.7ab	25.4ab	24.2ab				
				Thickness of the pulp (cm)							
470	21.1	21.4	27.1	25.4	24.5	25.8	22.9	24.0b	0.16	0.01	0.06
370	21,9	24.1	26.5	25.1	25.3	25.4	24.1	24.6b			
270	22.1	24.3	28.6	27.4	22.7	25.8	26.5	25.3a			
170	25.3	23.7	24.9	23.0	22.4	19.1	18.3	22.4b			
Â	22.6	23.4	20.7	25.2	23.7	24.0	23.0				
				Shell thickness (cm)							
470	0.20	0.20	0.21	0.21	0.20	0.20	0.22	0.20d	0.16	0.0001	0.10
370	0.22	0.23	0.22	0.23	0.23	0.22	0.24	0.22c			
270	0.22	0.24	0.23	0.25	0.23	0.24	0.26	0.23bc			
170	0.24	0.23	0.22	0.22	0.24	0.27	0.24	0.24a			
Â	0.22	0.23	0.22	0.23	0.22	0.23	0.24				

1 = BGCIA 228; 2 = BGCIA 239; 3 = Jojoba; 4 = BGCIA 228 x BGCIA 239; 5 = BGCIA 228 x Jojoba; 6 = BGCIA 239 x Jojoba; 7 = BGCIA 991. G = Genotype; G x WB = genotype and water balance; P = probability; Â = Average; Average followed by the same uppercase letter in the line do not differ by Tukey test (P > 0.05).

For the dry matter, there was difference in relation to the water supply (P = 0.01). Among the water supply applied, the 270 mm promoted the lowest DM content in the evaluated genotypes, with a mean of 6,49% of dry matter, indicating that this forage resource has a high water content, especially at harvest time (Table 4).

There was interaction between genotypes and water supply in ash (P = 0.006) content, highlighting BGCIA 228 x Jojoba receiving 401 mm of water supply. Crude protein was affected by interaction genotype x water supply (P = 0.001). Lowest CP contents were observed for BGCIA 228 and BGCIA 239 receiving 30% of water depth; Jojoba, BGCIA 228 x BGCIA 239 and BGCIA 991 in the 60% water depth and BGCIA 228 x Jojoba (16,91%) and BGCIA 239 x Jojoba applying 90% of water depth. Ether extract was influenced by genotype. The BGCIA 239 was superior to the others, presenting 9,47% EE (Table 4).

Genotypes influenced ADF, TC and SS, observing greater ADF for BGCIA 228 x BGCIA 239 and BGCIA 239 in comparison to BGCIA 228. Applying 170 mm promoted lower ADF compared to other WS levels. The BGCIA 239 presented lower TC compared to other genotypes evaluated. The genotypes BGCIA 991 and BGCIA 228 presented greater SS in relation to BGCIA 239 and the °brix ranged from 2.79 to 5.90. Genotypes, WS and interaction genotype x WS did not affect NDF (Table 4).

4. Discussion

The photosynthesis is related to stomatal conductance, plant transpiration and leaf temperature and considering an adequate hydric status the photosynthesis is increased (Tardieu 2013; Zhang et al. 2014). According to Melo et al. (2010) the adequate water content in the soil allows better nutrient availability, promoting greater leaf area of plant increasing photoassimilates and plant yield.

In this research reducing WS proportioned lower photosynthesis due to stomata closure, as indicated by decrease in stomatal conductance. In a water deficit condition, Kawasaki et al. (2000) verified for wild watermelon (*Citrullus lanatus* sp.), reduction in stomatal conductance, transpiration and photosynthetic rate and Akashi et al. (2011) evaluating wild watermelon reported a decrease in transpiration increasing leaf temperature.

Water use by the plant is a direct consequence of CO_2 absorption for photosynthesis. Most of the water absorbed by the roots is evaporated from the leaf surfaces by transpiration, while a small part remains in the plant to meet the growth demands, photosynthesis and other metabolic processes. A strategy for saving water during the critical period is a gradual closure of stomata and the maintenance of lower transpiration rates. There is evidence that stomata do not respond to changes in leaf water potential until critical water potential is reached (Hsiao 1973).

According to Zhengbin et al. (2011) the most efficient plants in water use improve their physiological functions, including osmotic adjustment, stomatal regulation, photosynthesis/transpiration ratio, photosynthetic efficiency and dry matter accumulation considering less water applied. In this research, the increasing in photosynthesis, stomatal conductance applying higher WS did not affect NFP, AFW and PY (Table 3). Higher WS proportioned greater photosynthesis and the photoassimilates possibly were targeted to aerial part. Melo et al. (2010) evaluated increased water depth to commercial watermelon and verify higher final leaf area (m^2) and leaf area growth rate (m^2/day)

Table 4. Chemical composition of forage watermelon genotypes receiving different water supply.

WS (mm)	Genotype 1	2	3	4	5	6	7	Â	P G	WS	GxWS
				Dry matter (% Fresh matter)							
470	9.82	5.95	8.81	7.57	7.56	8.15	8.11	7.99a	0.08	0.01	0.19
370	7.96	7.43	7.14	8.01	8.42	7.96	7.18	7.72a			
270	7.66	6.78	5.6	5.41	7.76	5.82	6.43	6.49b			
170	8.01	7.31	8.00	7.60	7.91	8.84	7.48	7.87a			
Â	8.35a	6.79b	7.71ab	7.31ab	7.69ab	7.69ab	7.37ab				
				Ash (% Dry matter)							
470	8.55	9.52	9.81	8.86	9.44	9.28	9.18	9.23	0.20	0.96	0.006
370	9.71	9.99	10.09	9.12	9.32	9.49	10.58	9.75			
270	11.51	9.53	10.11	9.26	9.20	8.43	8.59	9.52			
170	8.59	10.12	10.00	10.12	10.43	9.17	8.91	9.60			
Â	9.59	9.79	10.00	9.34	9.60	9.09	9.31				
				Crude protein (% Dry matter)							
470	18.93	20.31	21.58	19.84	19.26	20.78	21.07	20.25	0.13	0.50	0.001
370	20.53	22.22	21.89	19.77	16.91	19.20	20.4	20.13			
270	22.39	21.44	18.13	18.58	21.24	19.34	18.63	19.96			
170	17.70	20.01	18.76	20.48	18.58	21.11	20.85	19.64			
Â	19.89	20.99	20.09	19.67	18.99	20.11	20.24				
				Ether extract (% Dry matter)							
470	6.65	6.88	3.79	7.70	9.28	7.46	9.22	7.28	0.01	0.34	0.48
370	6.63	10.87	9.21	7.84	7.37	8.77	8.45	8.44			
270	7.60	8.92	8.93	6.33	7.00	7.93	6.36	7.58			
170	6.34	11.16	7.16	7.38	9.46	7.69	8.32	8.21			
Â	7.20b	10.95a	8.73ab	7.82b	8.63ab	8.49ab	8.09ab				
				Neutral detergent fiber (% Dry matter)							
470	32.47	34.32	32.03	36.81	36.89	37.15	39.81	35.64	0.12	0.71	0.06
370	34.96	36.35	40.92	41.51	38.98	36.79	36.15	37.95			
270	36.20	36.52	40.99	37.31	32.69	38.65	38.23	37.22			
170	35.27	40.34	31.02	36.88	40.04	37.37	33.39	36.33			
Â	34.72	36.88	36.24	38.12	37.15	37.49	36.89				

(*Continued*)

Table 4. (Continued).

WS (mm)	Genotype 1	2	3	4	5	6	7	Â	P G	WS	GxWS
	Acid detergent fiber (% Dry matter)										
470	33.68	31.50	29.05	33.83	32.15	33.88	34.75	32.69a	0.006	0.01	0.48
370	33.73	37.44	40.58	35.05	37.93	36.94	36.23	36.84a			
270	31.19	35.78	36.41	33.57	33.24	32.87	31.29	34.33a			
170	28.65	34.83	27.93	34.54	33.39	29.20	27.91	30.92b			
Â	31.81b	34.88a	33.49ab	34.24a	34.17ab	33.22ab	32.54ab				
	Total carbohydrates (% Dry matter)										
470	66.43	63.26	64.79	63.59	62.02	62.49	60.54	63.30	0.03	0.68	0.06
370	63.12	59.92	58.81	63.28	66.40	62.55	60.57	61.66			
270	58.49	60.11	62.82	65.83	62.56	64.30	66.42	62.93			
170	67.37	58.70	64.08	62.12	61.54	62.03	61.92	62.53			
Â	63.85a	60.5b	62.62ab	63.7ab	63.13ab	62.84ab	62.36ab				
	soluble solids (°brix)										
470	4.84	2.99	3.90	3.56	4.08	4.85	4.21	4.06	0.01	0.06	0.34
370	4.94	3.58	3.62	3.43	3.26	3.21	2.92	3.71			
270	4.73	4.04	3.10	3.52	4.98	3.96	4.02	4.05			
170	4.83	2.79	3.96	4.40	3.67	4.43	5.90	4.28			
Â	4.83a	3.35b	3.64ab	3.73ab	4.00ab	4.11ab	4.51a				

1 = BGCIA 228; 2 = BGCIA 239; 3 = Jojoba; 4 = BGCIA 228 x BGCIA 239; 5 = BGCIA 228 x Jojoba; 6 = BGCIA 239 x Jojoba; 7 = BGCIA 991. G = Genotype; G x WB = genotype and water balance; P = probability; Â = Average; Average followed by the same uppercase letter in the line do not differ by Tukey test (P > 0.05).

applying 204,667 mm/cycle in comparison to 143,333 mm/cycle. Akashi et al. (2011) evaluated a genotype of wild watermelon in response to water deficit and verified that stomata closure restricts leaf transpiration increasing leaf temperature. The reduction of photosynthetic efficiency by stomatal or non-stomatal factors reduces plant growth and the water can difficult the opening of stomata causing greater transpiration rate (Melo et al. 2010).

Greater water depth may promote higher availability of water and transpiration in watermelon plants contributing to cellular turgescence and lower resistance to water losses (Pereira 2012). Leaf temperature may be considered as an important indicator of water status and can be influenced by transpiration and stomata opening and closing. Stomata closure promotes lower plant transpiration, increasing leaf temperature (Taiz and Zeiger 2013; Urban et al. 2017; Yu et al. 2018).

Increasing WS promoted thinner peel. Similar results regarding the diameter of the peel were observed by Ferreira (2012) when evaluating different varieties of commercial watermelon considering WS, in which the average peel thickness in one of these varieties decreased when WS was increased.

Jojoba presented higher FL, LD, VD and TD than BCCIA 228 proportioning greater PY and AFW. Jojoba presented more elongated structure while BGCIA 228 was rounded and smaller. According to Carmo et al. (2015), rounded fruits generally do not present considerable variations between length and diameter. Increasing WS and the fruit size promoted lower TP. The same was observed by Ferreira (2012) evaluating varieties of commercial watermelon receiving different water irrigation depth, and verified in one variety decreases in the PT when it was increased water depth.

The highest DM observed in the irrigation depths of 470 and 370 mm compared to 270 mm is attributed to a physiological stage of fruits. Probably, the plants receiving higher WS started the generation of the fruits earlier and at the same time, the fruits from plants receiving greater WS were more advanced in the physiological stage, presenting greater DM. In relation to the WS of 170 mm, decreasing water supply to plants may reduce the allocation of nutrients to fruits reducing growth and high temperature and solar radiation can cause loss of water (Fischer et al. 2016), increasing DM levels. The water supply for animals via succulent plants allows water balances similar to those promoted by the water ingestion directly from the drinking fountains. In semi-arid regions, the concentration of water in food may represent an important pathway for the water supply to the animal (Thornton 2010), considering the FW as a source of water and nutrients (Santos et al. 2017). On the other hand, FW should not be the exclusive feeding for the animal, because the higher water content can affect the total DM intake. The highest DM content of BGCIA 228 compared to BGCIA 239 was possibly due to the stage of fruit development, suggesting a BGCIA 239 in a later stage presenting more ADF than BGCIA 228. Ash presents great importance to ruminants, and their lack promotes a considerable impact on animal productivity and health (Lopes-Alonso, 2012).

The lower CP for BGCIA 228 x Jojoba receiving 270 mm compared to BGCIA 228 receiving 370 mm may be promoted by higher growth rates of the plant more watered (Singh et al. 2012) and fruits advancing in maturity stage. High CP and EE can be resulted in the significant participation of seeds in the fruits (Tabiri et al. 2016). In the present study, FW genotypes presented 7.87% of EE, lower than the results found by

Silva et al. (2009) evaluating forage watermelon meal, presenting 10.39% for EE. The differences in the EE concentration may be due to the amount of seeds because the seeds are rich in this component.

Ether extract and protein are essential nutrients to determine the quality of a forage species, since these components contribute to the construction of tissues, an important factor for animals, especially in the period of food shortage. According to Van Soest (1994), CP concentrations above 7% do not influence consumption, but diets with CP concentrations below 7% cause a decline in DM intake.

The NDF found was higher than those reported by Silva et al. (2009) (38.82%) and Santos (2016) (38.2%) for FW fruits. Rodrigues and Vaz (2013) found 18.39% of ADF, a result inferior to that found in the present study. The ADF is an important component in the analysis of fiber in the diet of ruminants, may affect the digestibility. Lower ADF levels for BGCIA 228 compared to BGCIA 239 may be related to the physiological stage of the plant and the fruits as a result of lower WS. Applying 170 mm of WS promoted lower ADF in comparison to other WS evaluated.

The TC found in the present research is superior to the ones described by Silva et al. (2009) evaluating FW meal (59.01%). The BGCIA 239 presented lower TC than others genotypes what can be justified by the accumulation of other nutrients in DM as EE, since the BGCIA 239 had more EE than BGCIA 228. The lower ºbrix presented by BGCIA 239 compared to BGCIA 228 and BGCIA 991 is related to the TC content. Total soluble solids are commonly referred to as ºbrix and tend to increase with maturation. The ºbrix indicates the amount, in grams, of the solids that are dissolved in the water in a food (Chitarra and Chitarra 2005). For commercial watermelon, the value of °brix recommended in the literature as being the minimum content to obtain the acceptable flavor in watermelon is 10 ºbrix. However, the spatial distribution of the soluble solids content in the pulp is varied, being higher in the central region, with gradual reduction as it approaches the peel. These values depend on the environmental conditions, since excess water in the final stage of the cycle can result in slightly sweet fruits resulting from the higher dilution of the sugars (Gama et al. 2013).

5. Conclusions

Water supply affects physiological responses, increasing photosynthesis and stomatal conductance and decreasing leaf temperature of forage watermelon. Forage watermelon genotypes promote differences in yield and morphological characteristics.

Disclosure statement

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