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Cauliflower quality and yield under tropical conditions are influenced by boron fertilization

Laurinda Mara da Penha Ribeiro[1]*, Márcio Roggia Zanuzo[1], Carlos Vinício Vieira[1], Santino Seabra Junior[2] and Flavio Fernandes Júnior[3]

[1]UFMT - Universidade Federal de Mato Grosso Instituto de Ciências Agrárias e Ambientais, Av. Alexandre Ferronato, 1200, Setor Industrial, 78557-267 Sinop/MT, Brazil.
[2]UNEMAT - Universidade do Estado de Mato Gross, Av. das Arapongas, 1384 - N, Centro, Nova Mutum/MT, Mato Grosso, Brazil.
[3]EMBRAPA Agrosilvipastoril- Rodovia dos Pioneiros MT-222, Km 2,5, Zona Rural Caixa Postal: 343 CEP: 78550-970 – Sinop/MT, Mato Grosso, Brazil.

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The aim of this study was to evaluate the influence of boron fertilization on the quality and yield of cauliflower growing under tropical conditions. The study was carried out in randomized block design in split plot design. The main plots four boron doses (0, 2, 4, 6 kg ha^{-1}) whereas subplots with 3 cauliflower genotypes (Verona CMS, Sarah and Sharon) with three replicates. Among the genotypes, the higher fresh curd weight means were observed to Sharon followed by Verona and Sarah with 1.007, 0.801 and 0.583kg plant^{-1} respectively. In relation to boron doses, genotypes of Sharon, Verona and Sarah showed responsive to boron doses with maximum fresh curd mass of 1.378, 1.216 and 0.804 kg plant^{-1} with doses of 6, 4.18 and 4.06 kg B ha^{-1}. Total yield showed variation up to 307.96% positive with boron added. In contrast, there was observed a high loss ratio in the harvest mainly due to "hollow stem" incidence. Correlations were observed between the incidence of hollow stem, cultivars and boron doses. Analyzing hollow stem disorder between genotypes, Sharon presented higher incidence than Sarah and Verona CMS with values of 88.1%; 73.10% and 66.7%, respectively. Sharon and Verona CMS presented low incidence on the doses of 2 and 4 kg B ha^{-1} (57.1 and 42.9%) respectively. For Sarah genotype boron dose was not significant whereas 85.7% of the curds were checked with hollow stem disorder. Overall, in this study we can conclude that: (i) Sharon genotype presented the higher productivity, whereas demand more boron fertilization than the other genotypes evaluated; (ii) Under tropical conditions Verona CMS is more tolerant to high temperature than Sarah and Sharon exhibiting more marketable products on postharvest by reducing hollow stem and physiological disorders.

Key words: *Brassica oleracea*, quality, mineral nutrition, tropical horticulture.

INTRODUCTION

Cauliflower (*Brassica oleraceae* var. b*otrytis* L. Family: *Brassicaceae*) is a functional vegetable by presenting high nutritional value because of its high levels of antioxidants and anticarcino-genic compounds, such as ascorbic acid (AA), carotenoids, and glucosinolates, besides of vitamins and minerals (Gu et al., 2014). This properties makes it very attractive to the consumer, generating high demand and significant economic value.

Your production is being introduced to new areas, mainly in tropical regions characterized by high temperatures, so that, breeding programs may choose lines able to tolerate temperatures higher than 30°C, which makes possible the cultivation in tropical regions (May et al., 2007). However, there is restriction of cultivation in some Brazilian regions and growing seasons, because majority of cauliflowers cultivars have long cycles, greater susceptibility to boron deficiency and poor inflorescence formation especially in areas with high thermal amplitude (Arahida, 2014).

The lack of adaptability and/or information to different environmental cauliflower cultivars cultivation reflected directly in the yield and inflorescence quality, especially in regions with high temperatures, where the genotypes are being adapted for this conditions with nights hot impair the performance of most cauliflower cultivars, leading to a reduction of leaves size and, consequently, low yield and curd standard (Kimoto, 1993). In addition to reduced productivity, high temperatures also cause physiological disorders that interfere with commercial standardization, including serious defects (leaves in the head, riceness and wine stain) that reduce marketable yield and quality (Caixeta et al., 2000).

Not only climatic disorders but also nutritional disorders are attributed to mineral fertilization. Many authors have cited boron as a crucial micronutrient, crosslink with curd quality in cauliflower (Batal et al., 1997; Dhakal et al., 2009; Mello et al., 2009; Hussain et al., 2012; Chander et al., 2014). Boron besides changing yield and quality, this nutrient has been suggested with post-harvest quality associating defects and / or anomalies caused by disability and / or excess of this micronutrient as hollow stem, brown rot and tightened curd. These physiological disorders lead to great lost on postharvest by reducing shelf-life and commercial standardization.

Others authors such as Everaarts and Putter (2003) cited that the incidence of hollow stem is related to growth shoot ratio, and not boron absent. This may occur by different conditions by assimilation and growth speed taxes of cauliflower. Campagnol et al. (2009) has noticed that may be related to the combine between environmental conditions, technical management and genotype susceptibility. Several studies were carried out to evaluating boron fertilization effects as soon as on the productivity aspects and also on the qualitative of cauliflower (Carneiro et al., 1995; Everaarts and Putter, 2003; Pizetta et al., 2005; Mello et al., 2009).

The most problem to disseminate this species under tropical conditions is the lack of technical and scientific support information about it.

Considering the lack of technological information within the mineral fertilization with boron micronutrient and adaptability of cultivars under tropical regions, this study aimed to evaluate the quality and productivity aspects of cauliflower genotypes in tropical conditions.

MATERIALS AND METHODS

The assay was carried out from 22th February to 15 June of 2015, on Sinop-MT Brazil (11º 50' 53" S; 55º 38' 57" W; 384 m). The climate classification is Aw (Tropical climate with dry winter season).

Soil characteristics was red-yellow oxisol (LVA), clayey and chemical analysis (0-20cm) showed pH in $CaCl_2$ = 4.8; MO = 21.3 g dm^{-3}; Q = 2.7 mg dm^{-3}; K = 34 mg.dm^{-3}; Ca = 1.6 mmol dm^{-3}; Mg = 0.7 mmol dm^{-3}; H + Al = 3.5 mmol dm^{-3}; SB = 2.4 mmol dm^{-3}; % V = 41.6 and B = 0.26 mgdm^{-3}.

Prior to seedling, dolomitic liming at the rate of 2.47 ton ha^{-1} (PRNT 100%) was distributed in total with harrow together with reactive phosphate natural. just to reach V% (80) following recommendations of Trani and Raij (1997).

The experimental set up was carried out in a split-plot design with three replicates. Four levels of boron: (i) 0 kg B ha^{-1}; (ii) 2 kg B ha^{-1}; (iii) 4 kg B ha^{-1}; (iv) 180 kg N ha^{-1} were assigned in the main plots and three cauliflower cv. in the subplots (Verona CMS, Sarah e Sharon).

Temperature (°C) and relative humidity (RH%) during assay were acquired by Universidade Federal de Mato Grosso.

The seedlings were grown in a greenhouse of polystyrene type 128/6 trays filled with commercial substrate. The transplant was performed at 33 days (5 to 6 leaves), arranged 0.90 × 0.80 m.

The irrigation system was used with drip type emitters spaced 0.20 m and flow rate of 7.5 L h^{-1}, applying a irrigation water level of 5.54 mm^{-1} daily.

During planting, fertilizer 4-30-16 was applied at 142 g pit^{-1} of 600 kg ha^{-1} of P_20_5, 80 kg ha^{-1} of N and 320 kg ha^{-1} of K_2O. In topdressing, 160 kg ha^{-1} N and 60 kg ha^{-1} K_2O in the form of urea and potassium chloride, parceled at 15, 30, 45 and 60 days after transplanting (DAT). Leaf fertilization with 1 g L^{-1} sodium molybdate was practised at 45 and 60 DAT.

Boric acid (17% B) was used as a source of boron fertilization in different treatments. The fertilizer was diluted in hot water (40ºC) and applied by fertigation system in the crown region at 10 DAT. Each sub-plots were composed by twelve plants and for evaluation on purpose four central plants were used and others were considered as border plants. The harvest was performed when the inflorescences were well developed and with linked flower buds as described by May et al. (2007). Cultivar Sarah (earlier) was harvested at 68 days after planting (DAP), Verona CMS at82 DAP and Sharon at 87 days DAP.

Evaluations parameters was: Curd mass - CM (kg $plant^{-1}$); total yield - TP (t ha^{-1}); Curd diameter - Cd (cm); Curd deformation - DIF (%); Average cycle - CM (days) and specific density of inflorescence - DEI (g cm^{-3}) to measure from parameter was used to calculate the ratio of the curd mass (g) and the inflorescence displacement volume (cm^3).

For qualitative analysis of commercial curd classification as soon as class and category were proceeds by HortiBrasil Program (2008). In this program, the classification is evaluated by transverse curd diameter, compactness, severe defects or physiological

*Corresponding author. E-mail: laurinda.mara@gmail.com.

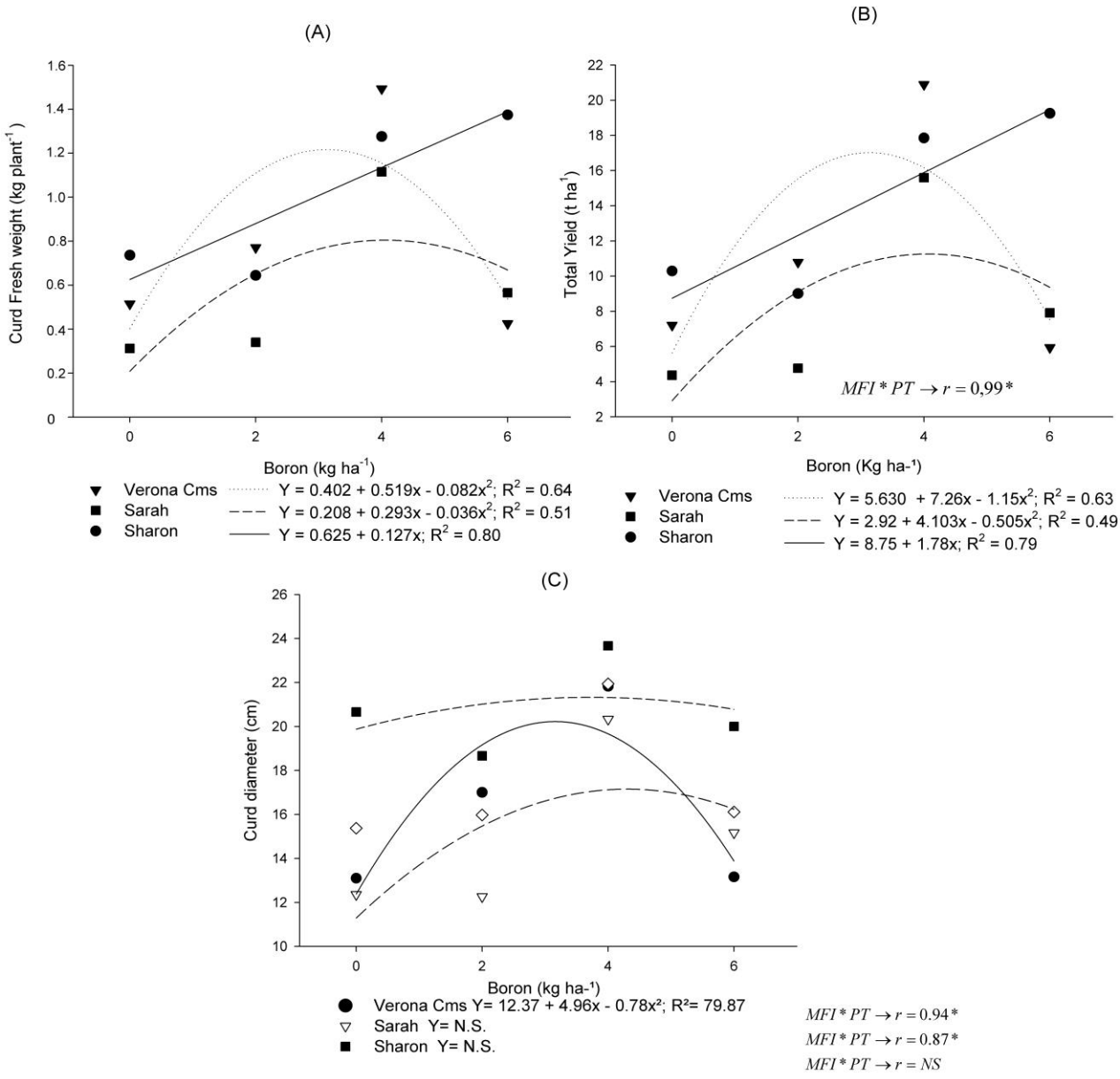

Figure 1. Fresh curd weight (CFW) (A); total yield (TY) (B) and curd diameter (CD) to Sharon, Verona CMS and Sarah cultivars under boron doses.

disorders (Caixeta et al., 2000). It was observed as an indication of deficiency or excess of boron defects as incidence of hollow stem, browning and rot. As an indication of non-adaptability to growing conditions physiological defects such as riceness, purplish stain and leafy curd appear.

The quantitative results were submitted to analysis of variance (F test, p <0.05) and the split of interactions and / or study of the isolated effect of factors was performed by regression analysis taking into account the significance of the coefficients of the models. From the regression models doses of B were estimated, to obtain the maximum points (PM) of the variables and their equivalent doses, with the help of the statistical program Sisvar® (Ferreira, 2011) and means were compared by the test Scott-Knott (p<0.05). $\chi 2$ (chi-square) test was performed to all qualitative variable. When the adjust was linear, it was considered the lower or higher dose applied as equivalent to the PM dose. Pearson correlation was performed among the variables analyzed with (p <0.05).

RESULTS AND DISCUSSION

In this study, a significant interactions between curd fresh weight (CFW) and total yield (TY) were registered (Figure 1 and Table 1), showing that boron fertilization is able to change yield parameters from each cauliflower genotype. To curd diameter (CD) there was only significant effect by dose and genotype. On other hand, specific density (DEI)

Table 1. Variance analysis resume (Fcal), average and interactions to fresh curd weight (CFW), curd diameter (CD), total yield(TY), specific curd density (ECD), deformation curd index (DCI) and development cycle (CM) in function of cultivars and boron doses (Sinop/MT, UFMT, 2016).

Treatment	CFW (kg plant^{-1})	CD (cm)	TY (t ha^{-1})	ECD (g cm^{-3})	DCI (%)	CM (Days)
Variance analysis (Fcal)						
Block	0.327^{ns}	0.101^{ns}	0.378^{ns}	0.660^{ns}	0.565^{ns}	0.863^{ns}
Dose	0. 000*	0.004*	0.000*	0.249^{ns}	0.280^{ns}	0.587^{ns}
Genotye	0.000*	0.001*	0.000*	0.037*	0.398^{ns}	0.000*
Dose × Genotype	0.000*	0.166 ^{ns}	0.000*	0.077^{ns}	0.469^{ns}	0.123^{ns}
Cauliflower genotypes						
Verona	0.801^{b}	16.27^{b}	11.20^{b}	0.95^{a}	0.93^{a}	112.83^{b}
Sarah	0.583^{c}	15.03^{c}	8.16^{c}	0.87^{b}	0.90^{a}	96.50^{a}
Sharon	1.007^{a}	20.75^{a}	14.06^{a}	0.82^{b}	0.93^{a}	115.00^{b}
Boron dose (kg ha-¹)						
0	0.521	15.37	7.29	0.89	0.94	108.55
2	0.585	15.97	8.19	0.82	0.92	109.33
4	1.294	21.94	18.11	0.93	0.96	109.66
6	0.788	16.11	11.02	0.87	0.96	106.22
CV1(%)	8.35	14.42	8.35	14.50	5.35	7.12
CV2(%)	9.35	14.39	9.35	12.18	5.59	7.58

^{ns} Not significant; * Significant at p≤0,05; Means followed by the same letter in the column do not differ by the Scott Knott test with p (≤0.05).

and development cycle there was only significant effect to genotype and to curd deformation (DI) there was not influence by factors and yours interactions.

The fresh curd weight was registered highest in Sharon genotype (1.01 kg planta^{-1}) followed by Verona CMS (0.80 kg plant^{-1}) and Sarah (0.58 kg plant^{-1}) genotypes, respectively. Total yield followed the same behavior of CFW analysis with Sharon to 14.06 ton ha^{-1} followed by Verona and Sarah genotypes with 11.20 and 8.16 ton ha^{-1}, respectively. Both variables CFW and TY showed perfect correlation with $r^2 = 0.99$ (Figure 1).

The genotypes showed different behaviours to boron doses. Verona CMS genotype showed quadratic regression analyses with CFW and TY, with maximum peak of 1.216 kg planta^{-1} and 17.02 ton ha^{-1} (Figure 1). This total yield was obtained with maximum boron dose of 3.14 kg B ha^{-1}, leading to an increment of CFW by 3.02 more times. This CFW was higher than observed by Zanuzo et al. (2013). These same authors observed to Verona 184 genotype, average of 0.91 kg planta^{-1} using 2 kg B ha^{-1}. This difference about MFI between the authors can be related to spacing transplant (0.80×0.60 m) and/or by gentoype. Verona CMS genotype is a breeding management of Verona 184.

On the Sarah genotype, optimal dose estimated was 4.06 kg B ha^{-1} with 0.804 kg plant^{-1} of CFW and 11.25 ton ha^{-1} of TY (Figure 1). This genotype showed an increment of 3.86 times in comparison to control (0 kgB) ha^{-1} with CFW of 0.204 kg plant^{-1}. Therefore, a linear regression was observed for Sharon genotype reaching maximum CFW of 1.378 kg plant^{-1} and TY of 19.44 t ha^{-1}. These datas were obtained by boron doses of 6 kg ha^{-1}.

Mello et al. (2009), while working with Sharon genotype involving N and B, showed values of 0.949 kg plant^{-1} to CFW independently to boron dose applied. In fact, this probably must be linked to boron source (Boromol (8% B and 0.8% Mo) and the dose applied (0 and 3 kg ha^{-1} from B). Analyzing all the genotypes evaluated in this study, Sharon showed more dependence and quantities of B productive potential when compared to Verona and Sarah genotypes.

Monteiro et al. (2010), evaluating cauliflower cultivars, found values of 1.06 and 1.11 kg plant^{-1} and 21.25 and 22.43 t ha^{-1} of TY to Sharon and Sarah respectively using as boron source Borax at 3 kg ha^{-1}. In fact, the higher total yield reach by these authors is justified by population density (20.000 plants ha^{-1}) against 13.988 plants ha^{-1} from this study besides soil and climatic conditions. It is acknowledged that high temperatures are able to change growth and development parameters in cauliflower genotypes (Zanuzo et al., 2013; Trevisan et al., 2003).

According to Trani and Raij (1997) values between 8 to 16 ton ha^{-1} can be consider as good for better cauliflower yield. The best results for total yield were observed in Verona CMS and Sharon with total yield of 17.02 and 19.44 ton ha-¹, with doses of 3.14 and 6 kg B ha^{-1}, respectively.

Otherwise, doses of 0 and 6 kg ha^{-1} of B to Verona CMS and Sarah, gave low yield as compared to Trani and Raij (1997), with values of 6.79 and 3.85 t ha^{-1}, respectively. These results pointed out that each

Table 2. Commercial classification and distribution of curds by diameter standardization.

Boron dose (Kg ha^{-1})	TY (t ha^{-1})	CY (t ha^{-1})	Type[1]	Class[2]								
				1	2	3	4	5	6	7	8	9
				%								
Verona CMS (Genotype)												
0	7.2	1.03	CI	-	16.7	83.3	-	-	-	-	-	-
2	10.79	0	FE	-	-	-	30	50	20	-	-	-
4	20.89	11.93	CI	-	-	-	-	-	16.7	33.3	50	-
6	5.94	1.7	CI	-	57.1	28.6	-	-	-	14.3	-	-
Sarah												
0	4.36	0.61	CI	33.3	16.7	33.3	16.7	-	-	-	-	-
2	4.76	0.68	CII	33.3	16.7	50	0	-	-	-	-	-
4	15.59	4.46	CII	-	-	-	-	50	16.7	16.7	16.7	-
6	7.91	2.26	CIII	33.3	16.7	-	16.7	33.3	-	-	-	-
Sharon												
0	10.29	2.95	CI	-	-	-	-	33.3	-	33.3	33.3	-
2	9.01	3.87	CI	-	-	-	-	-	9.7	85.2	5.1	-
4	17.85	2.55	CI		-	-	20	-	40	-	-	40
6	19.22	0	FE	-	-	-	-	9.6	33.3	57.1	-	-

[1]Type or Category according to CAIXETA (2000): FE = out of specification; CI = category 1; CII = Category 2 and Category 3 = CIII. [2]Classes according to CAIXETA, (2000), curd diameter in cm 1 = <10.0 cm; 2 = 10.0 to <13,0 cm; 3 = 13.0 to <15.0 cm; 4 = 15.0 to <17.0 cm; = 5 to 17.0 <19.0 cm; 6 = 19.0 at <21.0 cm; 7 = 21.0 to <23.0 cm; and 8≥23.0 cm; PC classification by type: FE, Out of specification; TY = total yield; CY = commercial yield.

genotype is dependent of boron calibration to maximize total yield and the range of lack and phytotoxicity for boron is very close.

Curd diameter (CD) is an important factor to be evaluated in cauliflower so this parameter is used by marketplace to quality factor. It was observed that Sharon genotype presented high CD (20.75 cm) between other genotypes (Table 1), however the value obtained was lower than Monteiro et al. (2010) and Massaroto et al. (2008) study that obtained values of 26.37 and 25.25 cm, respectively. These differences can be related to temperature as well as spacing, so that, temperature is able to changing plant development, bud development, shape and curd quality, yield and cycle time (Trevisan et al., 2003).

The data for CD analysis showed a quadratic adjust model to Verona CMS with maximum estimate value of 20.25 cm and optimal dose of 3.14 kg ha^{-1} of B (Figure 1C). Verona CMS and Sarah presented high correlation between CD and CFW (r = 0.94 and 0.87), respectively. On the other hand, Sharon genotype presented poor correlation (r=0.35) between the variables (Figura 1C). Zanuzo et al. (2013) verified high correlation (r= 0.73) for Verona between MFI and DI.at 4 kg B ha^{-1}

Other important quality attribute to be evaluated was specific curd density (ECD) in cauliflower. This parameter can be associated to compactness and can show the grade of deformation of the curd. The result nearby one means good compactness (harvest point) and above of one show that the plant has already started the flowering process in advance. This situation is characterized by non-commercial curds. For ECD analysis, Verona CMS genotype presented 0.95 g cm^{-3} when compared with Sarah and Sharon (0.87 and 0.82g cm^{-3}) respectively (Table 1). This variable is pointed out as a genotype morphological characterized and not shows correlation to boron doses (Table 5).

In relation to development cycle, it was observed that Sarah was more precocity with 96.5 days (Table 1), when compared with Verona CMS and Sharon (112.83 and 115 days) respectively. It can note that Sarah has precocity of 16.33 and 18.50 day respectively (Table 1). The development cycle was more than described by Seed Company to Verona CMS (95 to 100 days) and Sharon (100-105 days). This increase of the cycle probability occurred by temperature effects. It was observed during all the cycle maximum and minimum of 32.86 and 17.67ºC, respectively (Figure 2A). High temperature to cauliflower can stimulate more vegetative cycle than reproductive leading to change physiological, biochemical and photosynthetic parameters contributing to low yield efficiency as fast as qualitative parameters in cauliflower.

These results corroborate with Zanuzo et al. (2013) that reported a growing cycle of 106 days of Verona genotype in Sinop-MT Brazil with medium average temperature of 28°C. Therefore, Monteiro et al. (2010) reported to Sharon and Sarah cycle of 119 and 108 days, respectively when grown in temperatures of 22°C.

In case of Verona CMS the best commercial yield (CY) was observed with 4 kg B ha^{-1} with value of 11.93 ton ha^{-1} classified on the category I. Others doses were lower than this (Table 2). This result express that maximum

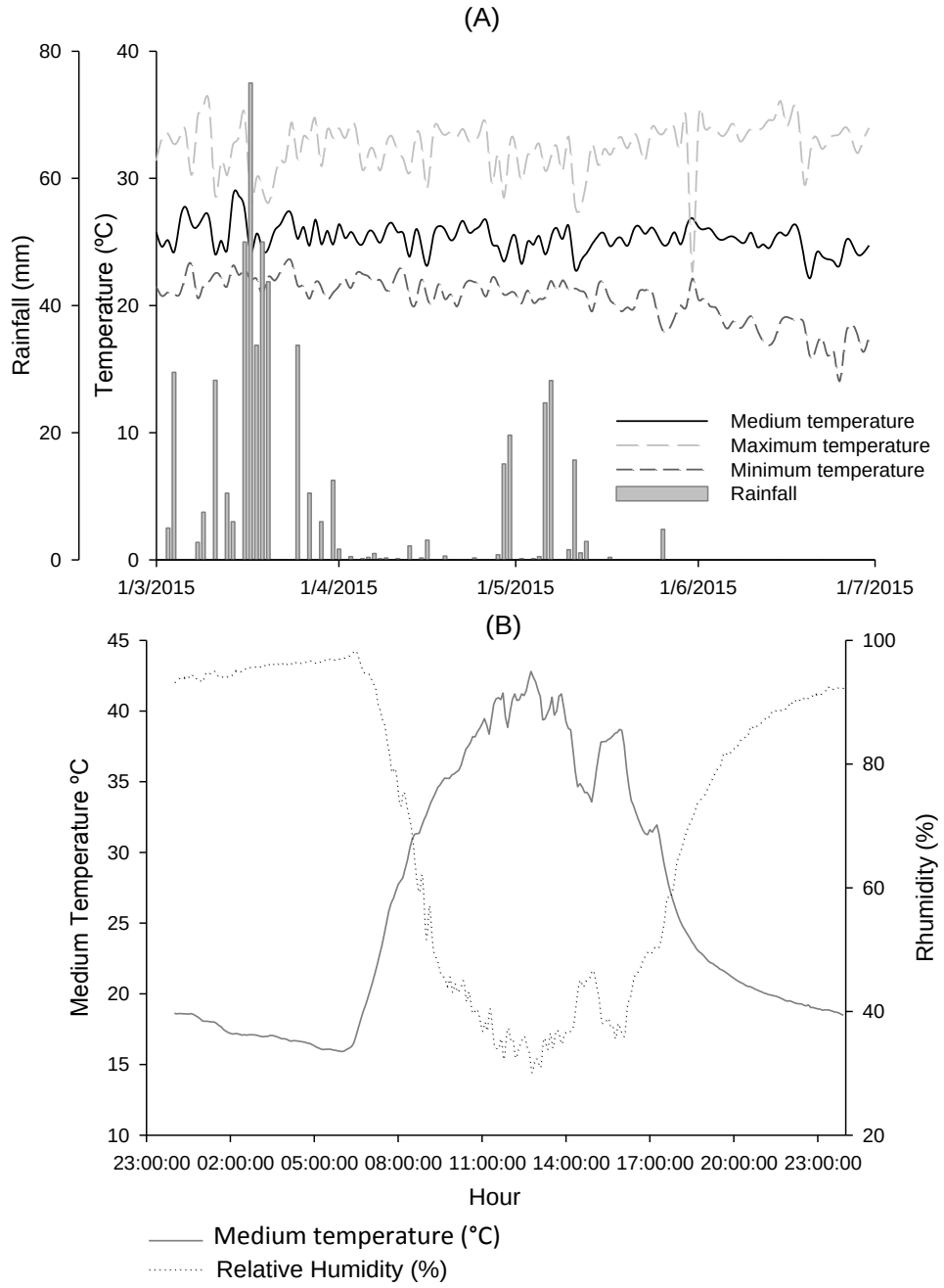

Figure 2. (A) Rainfall, maximum temperature (T max.), minimum (Tmin.) and average (T med.), day by day, and (B) medium average of temperature and relative humidity instantaneous to each 5 min checked during 05/30/2015 to 07/15/2015).

dose for qualitative parameters (CFW and TY) was 3.14 kg ha^{-1} of B.

To Sarah genotype, the major CY (4.46 t ha^{-1}) was observed on 4 kg B ha^{-1}, similar trend was obtained in case of CFW and TY. Compared Verona CMS, CY to Sarah is lower than 50%.

Sharon genotype showed high CY with 2 kg ha^{-1} of boron. The value found was 3.87 ton ha^{-1} (Table 2). Among the others genotype, MFI showed tendency for gradual enhancing boron doses. This may be due to morphological parameters as stomata numbers, leaf area, and number of leaves that contribute to increase respiration and reduce photo-assimilates to meristematic growth regions as curd. All this happens with enhancing temperature during curd development as presented in Figure 2. Mello et al. (2009) in other region of Brazil with thermal average of 21ºC verified for Sharon genotype CY of 11.33 ton ha^{-1}.

Table 3. Chi-square χ^2 test to each genotype according to hollow stem incidence (IHO),curd browning (PP); mechanical or bacterial rot (PO) and climate order defects (DC).

Defects	Sharon		Sarah		Verona CMS		χ^2
	No	Yes	No	Yes	No	Yes	
	%						
IHO	11.9	88.1	26.2	73.8	33.3	66.7	0.004*
PP	32.5	67.5	69	31	64.3	35.7	0.749^{NS}
PO	76.2	23.8	71.4	28.6	85.7	14.3	0.076^{NS}
DC	73.8	26.2	47.6	52.4	83.3	16.7	0.000*

No = absent of anomaly; Yes = presence of anomaly.

Table 4. Chi-square χ^2 test to each cultivar according to boron doses.

Genotype	Incidence	Boron Dose (kg ha-¹)				χ^2
		0	2	4	6	
		Boron dose *versus* Hollow stem %				
Sharon	No	28.6	42.9	14.3	0	0.000*
	Yes	71	57.1	85.7	100.0	
Sarah	No	14	14.3	28.6	28.6	0.540^{ns}
	Yes	85.7	85.7	71.4	71.4	
Verona CMS	No	14.3	0	57.1	28.6	0.001*
	Yes	85.7	100.0	42.9	71.4	

No = absent of anomaly; Yes = presence of anomaly. *Significant at $p<0.05$ and ^{ns} No significant a t $p<0.05$.

Analyzing hollow stem incidence (IHO) by genotypes, we can observed that Sharon presented higher incidence than Sarah and Verona CMS with values of 88.1, 73.10 and 66.7%, respectively (Table 3). In relation to climatic disorders (DC) Verona CMS showed more tolerance to high temperature with minor alterations in this parameters followed by Sharon and Sarah genotypes with values of 83.3, 73.8 and 47.6%. Disturbs of curd browning (PP) and mechanical or bacterial rot did not influenced by genotypes.

The incidence of hollow stem showed be influenced by boron doses and genotypes. It is possible to verify that Sharon and Verona CMS presented low incidence on the doses of 2 and 4 kg ha^{-1} of B (57.1 and 42.9% respectively) (Table 4). On the other hand, Sarah genotype did not show any influence due to different dose. This genotype showed highly sensitive to hollow stem incidence and temperature during the cycle. An explanation to this answer is due to high sensibility to high temperature hypothesized by sugar alcohol carrier during development that must influence distribution or partition of boron to growth apical meristems.

Sharon genotype presented high incidence 100% of IHO on dose of 6 kg ha^{-1} B. According to Everaarts and Putter (2003), the hollow stem occurrence and cavity severity are related to shoot and plant growth taxes, and not necessary to boron absent. This can occur due to the absorption of boron micronutrient do not follow the cauliflower growth taxes. In fact, we observed this and was recorded absolute growth taxes of 15.16 g g^{-1} dia^{-1} to 75 DAT applying 6 kg há-¹ of boron (Dates not presented).

Mello et al. (2009) studying Sharon genotype with boron dose of 3 kg ha^{-1} sowed directly in the pit or divided during the cycle verified that hollow stem was reduced more than 200% when compared with control without fertilization in both ways.

Kojoi et al. (2009) studying the effect of nitrogen fertilization (120, 180 and 240 kg ha^{-1} of N) and boron (2, 4 and 6 kg ha^{-1} of B) on the Shiromaru III genotype, showed that boron do not change presence or absent of hollow stem. They verified that hollow stem has linked direct with nitrogen fertilizations at high concentrations.

When climatic disturbances were analyzed wine spot, riceness and curd leafly) for Sarah genotype the research showed incidence of 52.4% (Table 3), showing that this genotype is not adapted to this region during this cultivation period. Verona and Sharon genotypes showed low values 16.2 and 26.2%) of climatic disorders as riceness, wine spot and curd leafly respectively showing better adaptation to tropical regions than Sarah genotype.

On the Sarah genotype the high defects percent and/or anomaly, become easier to know that the stress by high temperature during the observation of experimental study, with average temperature on the critical hour between 11:30 and 13:30 hours at 42.07°C (Figure 2B).

Table 5. Pearson correlation test to curd deformation (DCI); specific curd density-ECD, boron doses (B) and hollow stem incidence in IHO.

Variety		DCI	ECD	Doses	IHO
Verona CMS	DCI	1.000	0.389*	-0.106	-0.115
	ECD	0.389*	1.000	-.087	-0.424*
	B	-0.106	-0.087	1.000	-0.258
	IHO	-0.115	-0.424*	-0.258	1.000
Sarah	DCI	1.000	-0.069	0.054	0.141
	ECD	-0.069	1.000	0.146	0.075
	B	0.054	0.146	1.000	-0.156
	IHO	0.141	0.075	-0.156	1.000
Sharon	DCI	1.000	0.158	-0.175	-0.103
	ECD	0.158	1.000	-0.320	-0.388*
	B	-0.175	-0.320	1.000	0.311
	IHO	-0.103	-0.388*	0.311	1.000

*Significant at p<0.05;

According to Ferreira (1983), temperature so high and intense insolation during curd formation can speed up the growing, without reaching ideal size wanted, beside causes by other defects, as fast division and the appearance of other defects as small curds formation plus anthocyanin spots.

Analyzing the Pearson correlations between boron rates and IHO variables, DCI and ECD, we observed that the boron doses have no relationship with these variables for any of the cultivars (Table 5). However, genotype Verona and Sharon showed a moderate and weak negative correlation between the IHO respectively and gave variables, namely, the incidence of hollow stem, decreased the specific density of the inflorescence, probably caused by the incidence of severity of the hollow stem. Based on the results it is evident that boron fertilization alone is not able to elucidate the defects and/or anomalies observed during the experiment, but when added to climatic factors for the conditions of high temperatures has shown corroborative for these factors beyond expression genotypic potential of each cultivar.

Conclusions

Overall, in this study we can conclude that: (i) Sharon genotype presented the higher productivity, whereas demand more boron fertilization than the other genotypes evaluated. (ii) Under tropical conditions Verona CMS is more tolerant to high temperature than Sarah and Sharon exhibiting more marketable products on postharvest by reducing hollow stem and physiological disorders

CONFLICTS OF INTERESTS

The authors have not declared any conflict of interests.

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