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Research Article

Performance of watermelon cultivars for the “Vertente Goiana do Paranaíba” micro-region

Desempenho de cultivares de melancia para microrregião vertente goiana do Paranaíba

Victor Manoel Witis Carvalho Cunha [1(ORCID 0009-0006-8746-452X)], **Givago Coutinho** *[1(ORCID 0000-0001-8064-6028)], **Rita de Cassia Souza Dias** [2(ORCID 0000-0002-5527-3693)]

[1]University Center of Goiatuba, Goiatuba, GO, Brazil. *Corresponding author: givago_agro@hotmail.com
[2]Brazilian Agricultural Research Corporation, Petrolina, PE, Brazil.

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ABSTRACT

Watermelon (*Citrullus lanatus* Thumb.) is a crop of great socioeconomic importance, especially for family farmers, due to its low production costs and ease of management. In Brazil, the most widely planted cultivar is Crimson Sweet and similar cultivars, accounting for over 90% of the supply to the consumer market. In this sense, diversification is necessary, offering more crop options to producers that can serve different market niches. In this context, this study aimed to identify watermelon cultivars with productive potential for the "Vertente Goiana do Paranaíba" micro-region. The research was conducted at the University Center of Goiatuba, which has a predominantly semi-humid tropical climate, with average annual rainfall between 1,500 and 1,800 mm. Four cultivars were evaluated, with each cultivar considered a treatment. The work was conducted in randomized blocks with five blocks, totaling 20 experimental plots. Each experimental plot had six plants. The analysis of variance revealed significant differences in the physical characteristics of the fruits, such as longitudinal diameter, transverse diameter, and peel thickness. The Crimson Sweet cultivar stood out for its higher fresh weight and productivity, results that are largely due to the cultivar's inherent characteristics. Next, the cultivars 'BRS Kuarah' and 'Sugar Baby' were ranked highest in these criteria, respectively. The Sugar Baby weighed slightly less than the minimum required by supply centers, which is two to three kg. There was no difference in the duration of the production cycle (days) and soluble solids content (°Brix) between cultivars, demonstrating the possibility of crop diversification and the potential for exploring new cultivars in the region, especially ‘BRS Kuarah’ and ‘Sugar Baby’.

KEYWORDS: Promising cultivars. *Citrullus lanatus* Thumb. Southern Goiás. Market niches.

RESUMO

A melancia (*Citrullus lanatus* Thumb.) é uma cultura de grande relevância socioeconômica, especialmente para agricultores familiares, devido aos baixos custos de produção e à facilidade de manejo. No Brasil, a cultivar mais plantada é Crimson Sweet e cultivares semelhantes, respondendo praticamente por mais de 90% do fornecimento ao mercado consumidor. Neste sentido é necessária a diversificação, oferecendo mais opções de cultivares aos produtores que possam atender diferentes nichos de mercado. Neste contexto, este trabalho teve como objetivo identificar cultivares de melancia com potencial produtivo para a Microrregião Vertente Goiana do Paranaíba. A pesquisa foi conduzida no Centro Universitário de Goiatuba, no qual predomina o clima tropical semiúmido, com precipitação anual média entre 1.500 e 1.800 mm. Foram avaliadas quatro cultivares, sendo cada cultivar considerada um tratamento. O trabalho conduzido em blocos casualizados com cinco blocos, totalizando 20 parcelas experimentais. Cada parcela experimental contou com seis plantas. A análise de variância revelou diferenças significativas nas características físicas dos frutos, como diâmetro longitudinal, diâmetro transversal e espessura da casca. A cultivar Crimson Sweet destacou-se pela maior massa fresca e produtividade, resultados estes que se devem em grande parte as próprias características inerentes a cultivar. Em seguida foram mais bem ranqueadas as cultivares BRS Kuarah e Sugar Baby, respectivamente, nestes critérios. A Sugar Baby apresentou peso levemente inferior ao mínimo exigido pelas centrais de abastecimento, que é de dois a três kg. Não houve diferença para a duração do ciclo de produção (Dias) e teor de sólidos solúveis (°Brix) entre as cultivares, isto demonstra a possibilidade de diversificação dos cultivos e possibilidade de

exploração de novas cultivares na região, sobretudo, ‘BRS Kuarah’ e ‘Sugar Baby’.
PALAVRAS-CHAVE: Cultivares promissoras. *Citrullus lanatus* Thumb. Sul de Goiás. Nichos de mercado.

INTRODUCTION

Watermelon fruits (*Citrullus lanatus* (Thunb.) Matsum. & Nakai), depending on the cultivar or hybrid used, can weigh up to 25 kg, are oval, cylindrical, or spherical in shape, have smooth or cracked skin in various shades of green, and red or yellow flesh, with or without seeds (CAMPAGNOL et al. 2012). In 2023, approximately 1,781,971 tons of watermelon were harvested in Brazil, with the Northeast region being the main producer with approximately 677,270 tons produced (IBGE AUTOMATIC RECOVERY SYSTEM – SIDRA/IBGE 2024).

Among the various cultivars and hybrids of this species, mini watermelons have fruits weighing less than five kg, an oblong shape, and light green or dark green rinds. The fruits are considered small when compared to cultivars such as the Charleston Gray group, which can reach up to 18 kg. The preference for smaller fruits has not yet had much impact on the domestic market, but in other markets, such as Japan, the US, and Europe, this type of watermelon has won over consumers. In this context, with the increase in the expansion of the export market, there is a tendency for the share of mini watermelons in the cultivar market to increase over time (SANTOS & NASCIMENTO 2014). The cultivars in this group continue to be listed as a new alternative in the market, which has given them competitive prices (BELFORT et al. 2022).

In addition, smaller-sized oilseeds have seen increased market demand (NAKADA-FREITAS et al. 2021). Among other reasons, one that stands out is the fact that there has been a decrease in the number of people in the family environment. Mini watermelons were introduced in Brazil due to their superior quality and firmer flesh, with the aim of exporting them (FILGUEIRA 2013). These smaller fruits are considered a new option for the market (CARVALHO et al. 2022). Currently, different cultivars are found on the market. Large watermelons are produced in greater quantities and destined for the domestic market, while seedless triploid watermelons and mini watermelons are grown on a very limited scale, with production aimed at serving a niche market (AUMONDE et al. 2011).

In this sense, as the consumption of differentiated products, such as miniature vegetables and smaller watermelons, has increased in recent years, this has become a niche market of great interest to vegetable growers, as it offers greater financial returns when compared to traditional products. Plants can be grown in fields and also in agricultural greenhouses (CAMPAGNOL et al. 2016).

However, aspects such as planting crops in a suitable climate and techniques aimed at correct management are important for successful crops. In the case of mini watermelon cultivation, which is still recent, cultural practices for the best performance of each cultivar are still in their infancy (NAKADA-FREITAS et al. 2021). Identifying promising cultivars with superior productive potential is one of the first steps for cultivation in each type of climate.

In this case, comparing mini watermelon cultivars in regions with a predominantly

tropical climate is justified by the need to evaluate and recommend cultivars that are best suited to the specific climatic conditions of these areas. This enables the implementation of more technologically advanced and sustainable crops, with rational production techniques in these regions. In this context, the objective of this study was to identify watermelon cultivars with productive potential for the Vertente Goiana do Paranaíba micro-region.

MATERIALS AND METHODS

Experiment location

The work was conducted at the experimental field of the University Center of Goiatuba (Unicerrado) located in the city of Goiatuba, Goiás. The municipality of Goiatuba is located between the geographical coordinates 27°48'17“ south latitude and 50°19'30” west longitude and has an altitude of 815 meters (AMARAL et al. 2016). The prevailing atmospheric conditions in the region are tropical in nature. Rainfall is predominant during the summer and less frequent in winter. The climate classification is Aw according to Köppen and Geiger. The average annual temperature in Goiatuba is 24.1 °C. The average annual rainfall is 1,498 mm (CLIMATE-DATA 2024).

Cultivars studied

Four watermelon cultivars were evaluated, with each cultivar representing one treatment. The work was developed in partnership with the Brazilian Agricultural Research Corporation (Embrapa Semiárido), which provided seeds of the BRS Kuarah® cultivar (SOUZA & DIAS 2011) that were studied because they produce yellow fruit. In addition to this cultivar, cultivars from Feltrin® and Topsseed® that produce red fruit were also evaluated for performance. Table 1 shows the cultivars, the group to which they belong, pulp color, and the seed producer.

Table 1. Cultivars evaluated for their productive performance in the Vertente Goiana do Paranaíba micro-region. Goiatuba, GO, 2024.

Cultivars		Responsible company	Group	Color of the pulp	Weight (kg)
1	SF1057	Feltrin	Mini watermelon	Red	2 - 3
2	BRS Kuarah	Embrapa	Small	Yellow	3 - 5
3	Sugar Baby	Topseed	Mini watermelon	Red	2 - 3
4	Crimson Sweet	Feltrin	Common	Red	> 6

Experiment setup

The seedlings were planted on April 6, 2024, in black plastic bags measuring 20 cm x 15 cm (height and width, respectively), filled with Terral® commercial substrate. The seedlings were irrigated once a day, during the coolest hours, preferably in the morning, except on days when there was natural precipitation, according to the phenological stage of the crop, aiming to achieve field capacity.

Soil sampling and analysis were carried out on April 25, 2024 (Table 1), revealing that the soil had a moderate level of fertility, requiring minor corrections to improve nutrient availability, especially potassium and phosphorus. Thus, 0.8 t/ha of limestone was applied to correct acidity, raising the pH and base saturation to ideal levels. In addition, phosphate fertilization was carried out with 60 to 90 kg/ha of P_2O_5 and

potassium fertilization with 60 to 80 kg/ha of K_2O, increasing the phosphorus and potassium contents, respectively. Table 1 shows the results of the soil analysis for the experimental area.

Table 2. Results relating to chemical analysis of the soil. Goiatuba, GO, 2024.

Soil	Sand	Silt	Clay	Ca^{2+}	Mg^{2+}	Al^{3+}	H+Al	SB	CTC	V
Unit		%		---------- $cmol_c\ dm^{-3}$ ----------						%
	38	13	49	3.0	1.3	0.0	4.4	4.5	8.9	50.6
	pH		P		S		K		MO	
Unit	$CaCl_2$		---------- $mg.dc^{-3}$ ----------						$g.Kg^{-1}$	
	5.2		11.5		8.6		78.2		16.1	

Source: Provided by Curitiba Agricultural Laboratory, 2024.

The watermelon seedlings were transplanted on April 29, 2024, when they had already developed their first true leaf. The “tripa” irrigation hose was installed on April 29, 2024, and daily irrigation began. In the field, the plants were arranged in rows, with 2.0 m spacing between rows and 0.6 m spacing between plants, respectively. Each planting row corresponded to one block, totaling five planting rows. Thus, the work consisted of five rows of planting. The total area was 164 m^2.

For pest and disease control, two applications of *Beauveria bassiana* were made to combat *Diabrotica speciosa* (Germar, 1824) (Coleoptera: Chrysomelidae) (commonly known as the cucurbit beetle) and the aphid *Aphis gossypii* Glover (Hemiptera: Aphididae). The first application took place on May 3, and the second was carried out on May 14, 2024.

Experimental design

Four cultivars were studied, with each cultivar considered a treatment. The design used was randomized blocks, with five blocks, totaling 20 experimental plots. Each experimental plot consisted of six plants.

Features analyzed

The results were measured in all plants included in the study, and consequently all fruits produced in each treatment were evaluated. Thus, physical, chemical, phenological, and productivity characteristics were evaluated. The physical parameters were: Average fresh fruit weight (FW) (kg), measured using scales; Longitudinal fruit diameter (LFD) (cm), measured using a tape measure; Transverse diameter of the fruit (TDF) (cm), measured using a tape measure; Thickness of the peel at the peduncle (TPP) (cm), measured using a millimeter ruler; and Thickness of the skin at the floral scar (TSF) (cm), measured using a millimeter ruler. The chemical parameter was determined by measuring the soluble solids (SS) content (°Brix) using a GT427 Lorben refractometer on a Brix scale of 0-32% with automatic temperature compensation from 10 °C to 30 °C. For phenology, the production cycle (PC) (days) was evaluated by counting the days between the beginning of flowering and fruit harvest. Estimated productivity (EPR) ($kg.ha^{-1}$) was measured by adding up the fruit weight results for each treatment and then estimating them for $kg.ha^{-1}$.

Statistical analysis

The data were submitted to the F test and, in cases of significant differences, were compared using the Tukey test at a 5% probability level using Sisvar software

(FERREIRA 2011).

RESULTS AND DISCUSSION

There was a significant difference between treatments for variables related to the physical characteristics of the fruits, such as longitudinal diameter (cm), transverse diameter (cm), and skin thickness at the floral scar (cm), as shown in Table 2. These differences suggest that the watermelon cultivars studied have distinct agronomic potential. It is interesting to note that although seed companies disclose information about the characteristics of the most diverse varieties sold, this information is generally generic and does not necessarily reflect the behavior of genotypes under certain environmental conditions (LIMA NETO et al. 2010).

Table 2. Table analyzing variance in the characteristics analyzed, Goiatuba, GO, 2024.

		Average square			
SV	**DF**	**LFD (cm)**	**PC (days)**	**TDF (cm)**	**TSF (cm)**
Cultivars	3	621.24*	63.14ns	506.03*	0.32*
Blocks	4	79.11	108.23	68.04	0.034
Error	12	15.50	109.60	18.19	0.045
Total	19	-	-	-	-
CV (%)	-	7.72	9.99	8.64	22.90
		Average square			
SV	**DF**	**TPP (cm)**	**FW (kg)**	**SS (°Brix)**	**EPR (kg.ha^{-1})**
Cultivars	3	1.10*	12.94*	0.116ns	897.850.135.80*
Blocks	4	0.065	1.08	0.046	75,171,731.78
Error	12	0.075	0.27	0.044	18,920,135.45
Total	19	-	-	-	-
CV (%)	-	21.33	21.62	2.29	21.53

* – significant and ns – not significant at 0.05 probability by the F-test. CV: coefficient of variation. LFD = Longitudinal diameter of the fruit (cm); PC = Production cycle (days); TDF = Transverse diameter of the fruit (cm); TSF = Thickness of the skin at the floral scar (cm); TSP = Thickness of the skin at the peduncle (cm); FM = Fresh mass (kg); SS = Soluble solids (°Brix); EPR = Estimated productivity (kg.ha^{-1}).

The thickness of the skin on the stem showed significant differences between cultivars, which can be advantageous, as thicker skins provide greater resistance to transport and storage, desirable characteristics for marketing in distant regions. As BARROS et al. (2012) point out, skin thickness, associated with other quality components such as firmness and pectin, makes the fruit more resistant to transport, from harvest handling to sale to the end consumer. The results obtained based on the comparison made by Tukey's test, at a 5% probability level, are shown below (Table 3).

Table 3. Averages obtained for longitudinal diameter (cm), production cycle (days), transverse diameter (cm), skin thickness at the floral scar (cm), skin thickness at the peduncle (cm), fresh fruit weight (kg), Soluble solids (°Brix), and Average productivity (kg.ha$^{-1)}$ of watermelon cultivars in the Vertente Goiana do Paranaíba micro-region. Goiatuba, GO. 2024.

Cultivars	Characteristics			
	LFD (cm)	PC (days)	TDF (cm)	TSF (cm)
BRS Kuarah	50.15 B	104.73 A	48.55 B	0.90 AB
Sugar baby	47.31 BC	100.07 A	46.60 AB	1.08 A
SF 1057	40.06 C	108.55 A	39.08 C	0.58 B
Crimson sweet	66.45 A	106.00 A	63.13 A	1.15 A
Cultivars	**Characteristics**			
	TPP (cm)	FW (kg)	SS (°Brix)	EPR (kg.ha^{-1})
BRS Kuarah	1.10 BC	2.19 B	9.03 A	18,303.71 B
Sugar baby	1.43 AB	1.68 BC	9.20 A	14,032.77 BC
SF 1057	0.76 C	1.08 C	9.39 A	8,997.36 C
Crimson Sweet	1.86 A	4.73 A	9.13 A	39,476.42 A

Averages followed by different letters in the column differ from each other according to Tukey's test at a significance level of 0.05. LFD = Longitudinal diameter of the fruit (cm); PC = Production cycle (days); TDF = Transverse diameter of the fruit (cm); TSF = Thickness of the skin at the floral scar (cm); TSP = Thickness of the skin at the peduncle (cm); FM = Fresh mass (kg); SS = Soluble solids (°Brix); EPR = Estimated productivity (kg.ha^{-1}).

The results obtained in this study pointed to superior performance of the 'Crimson Sweet' (CS) cultivar in several aspects evaluated, as shown in Table 3. This is a particular characteristic of the cultivar, producing larger fruits compared to other cultivars available on the market. This cultivar stood out in terms of longitudinal diameter (66.45 cm), transverse diameter (63.13 cm), fresh fruit weight (4.73 kg), and average productivity (39,417 kg.ha^{-1}), confirming its productive potential based on characteristics inherent to the cultivar. The superiority of CS in these attributes can be attributed to its modified genetic development, which confers greater vegetative vigor and greater biomass accumulation. However, even with these genetic advantages, the fruits weighed 21.16% less than the minimum recommended for a cultivar (fruits larger than 6 kg), highlighting the influence of the growing environment on final performance.

The longitudinal and transverse diameters of the fruits, characteristics directly related to commercial accessibility and yield per plant, were greater in 'Crimson Sweet', evidencing greater vegetative development. In comparison, the fruits of cultivars 'BRS Kuarah' (50.15 cm and 48.55 cm, respectively), 'Sugar Baby' (47.31 cm and 46.60 cm), and 'SF 1057' (40.06 cm and 39.08 cm) are smaller in size, which may limit their commercial freedom in more demanding markets. However, it is worth noting that each cultivar can serve a different market niche.

The production cycle of the cultivars was similar, ranging from 100 to 108 days. This characteristic is relevant for crop management and harvesting planning, as it makes the harvest season homogeneous regardless of the cultivar. The natural cycle of watermelon varies from 80 to 110 days (TAVARES et al. 2018). Thus, the careful selection of cultivars with the definition of the best genotypes and cultivars that adapt to local growing conditions is decisive for the success of watermelon cultivation, the profitability of the crop, and the competitiveness of the producer (RESENDE & YURI 2019).

The thickness of the skin also revealed important differences. 'Crimson Sweet' had the highest values for both the flower scar (1.15 cm) and the peduncle (1.86 cm). In contrast, SF 1057 had the thinnest skin thicknesses (0.58 cm and 0.76 cm, respectively), which may increase its susceptibility to post-harvest losses.

In terms of fresh fruit weight, one of the main indicators of productivity and profitability, 'Crimson Sweet' once again stood out (4.73 kg), surpassing the other cultivars. However, 'Sugar Baby', with fruits weighing 1.68 kg, and SF 1057, weighing only 1.08 kg, fell below the minimum weight required by supply centers for mini watermelons, according to CEAGESP criteria. Soluble solids (°Brix), related to fruit sweetness, did not differ between cultivars, with average values between 9.03 and 9.39 °Brix, showing no significant difference. However, the fruits were harvested with a soluble solids content that, although close, below the minimum required, since according to the Classification Standards of the São Paulo Warehouse and General Storage Company – CEAGESP (2011), the fruit should not be harvested before the ideal stage of ripeness with a soluble solids content of less than 10 ° Brix.

Average productivity was highest in 'Crimson Sweet', with 39,417 kg.ha^{-1}, exceeding the productivity of the other cultivars evaluated by more than 50%. These characteristics are obviously related to the cultivar, as this watermelon is considered part of the Common group, i.e., with fruits larger than six kg, while mini watermelons fall into the varietal group of two to three kg (CEAGESP 2011). However, it is important to note that the performance of 'Sugar Baby' (14,000 kg.ha^{-}) was promising within its classification as a mini watermelon, while ‘BRS Kuarah’ had a lower average weight (2.19 kg) than that considered ideal for the cultivar according to Embrapa (four to six kg) (SOUZA & DIAS 2011).

Thus, although 'Crimson Sweet' performed best overall, these results can be attributed to its genetic potential. 'Sugar Baby' stood out as an interesting alternative for producing smaller fruits, with quality similar to 'Crimson Sweet' in terms of qualitative attributes such as °Brix and production cycle. These results reinforce the importance of considering both the cultivar and the growing conditions when recommending cultivars for the Vertente Goiana do Paranaíba Microregion, and can be studied for application throughout the Vertente Goiana do Paranaíba Microregion. Therefore, future studies related to management and cultivation methods that aim at more appropriate production protocols, with studies on irrigation methods, quantitative and qualitative fertilization methods, seedling production, plant management and handling, phenology (vegetation, flowering, and fruiting), harvesting, production seasons, etc., should be considered in order to propose efficient production strategies to producers who are engaged in or wish to engage in this crop.

CONCLUSION

The 'Crimson Sweet' (CS) cultivar showed the best overall performance, which was expected due to its larger size, standing out in diameter, fresh weight, and average yield. However, the weight of its fruits was below commercial standards. Next, the cultivars 'BRS Kuarah' and 'Sugar Baby' were ranked highest in these criteria, respectively.

The 'Sugar Baby' (SB) weighed slightly less than the minimum required by supply centers, which is two to three kg.

The 'SF 1057' cultivar performed poorly when compared to the other cultivars, especially in terms of yield and fresh weight, compromising its economic prospects.

There was no difference in the duration of the production cycle (days) and soluble solids content (°Brix) between cultivars, demonstrating the possibility of crop diversification and the potential for exploring new cultivars in the region, especially ‘BRS Kuarah’ and ‘Sugar Baby’.

NOTES

AUTHORS' CONTRIBUTIONS

Student Victor Manoel Witis Carvalho Cunha and Dr. Givago Coutinho played key roles in the development of the research work, conducting fieldwork, data collection, analysis and interpretation, and drawing conclusions about the results obtained. They were crucial in preparing the manuscript, getting involved in several important aspects of the study, such as preparation, methodology, experimental conduct, data collection, resource management, data interpretation, writing, and revision of the manuscript until its publication. Dr. Rita de Cássia Souza Dias provided part of the material from the genotypes studied and valuable assistance in the implementation and collection of data. All authors reviewed the final version of the manuscript and gave their approval for publication.

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Not applicable as this study did not involve humans or animals.

INFORMED CONSENT STATEMENT

Not applicable because this study did not involve humans.

DATA AVAILABILITY STATEMENT

Data can be made available upon request.

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CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this article.

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