Original Research Article

Study of 'Red torch' and 'Pink torch' Cultivars of Torch Ginger in Brazilian Cerrado

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ABSTRACT

Aims: To characterize the development, yield, and morphological characteristics of the 'Red torch' and 'Pink torch' cultivars of torch ginger cultivated in the Brazilian Cerrado.
Study design: The experiment was performed using two cultivars ('Red torch' and 'Pink torch') with three replications of three ginger torch clumps per plot.
Place and Duration of Study: Germplasm Active Bank of Ornamental Tropical Plants of the State University of Mato Grosso (14°08′38″S, 57°03′45″W; altitude of 488 m), Brazil, from August 2015 to July 2018.
Methodology: At monthly intervals during the first 10 months after planting, we assessed clump development, based on the measurement of the area occupied by the clump, and number of tillers emerging from the clump. The monthly yield per hectare was estimated from August 2016 to July 2018. During this period, the average number of floral stems produced per clump was determined, and the floral stems were characterized during the second year, for stem length, stem diameter, inflorescence length, inflorescence diameter, and fresh stem mass. Evaluations were based on the measurements obtained from 10 stems per clump.
Results: First-year clump expansion rates for 'Red torch' and 'Pink torch' were 4.00 and 7.90 cm^2, respectively. 'Pink torch' presented a higher monthly average of tiller emergence than 'Red torch', and consequently higher productivity. The cultivars produced floral stems of commercial standard in the second year of growth, with stem lengths and diameters greater than 60.00 cm and 10.00 mm, respectively. In this study, wefound that 'Red torch' and 'Pink torch' showed high yields and produce inflorescences with characteristics suitable for commercialization.
Conclusion: The basis of this study, we can conclude that cultivation of torch ginger in the Brazilian Cerrado would be viable.

Keywords: Zingiberaceae;Etlingera elatior Jack; adaptability; tropical flower; cut flower; floriculture.

1. INTRODUCTION

Tropical flower cultivation in Brazil is a lucrative business, with millions of reais being generated annually from the commercial production of these flowers [1]. Among the species of cultivated tropical flowers, torch ginger (*Etlingera elatior*) is particularly noted for its beauty and rusticity [2,3]. Belonging to the Zingiberaceae family and originating from Malaysia, this species has erect stems of 2 to 4 m in height and large elongated pink-tinged leaves. It bears large pyramidal inflorescences with bracts that can be red, pink, porcelain [4,5], or white.

Although torch ginger plants can develop under a range of climatic conditions, given that it is a tropical plant, full development tends to be optimal at temperatures of between 25 and

30°C and luminosity more than 1000 h of light per year [6]. Moreover, the species is water demanding, requiring an annual rainfall of between 1100 and 3300 mm and relative humidity of between 70% and 80% [4].

In Brazil, the cultivation of torch ginger is primarily concentrated in the northeast, a region with a tropical climate characterized by average temperatures above 18°C in the colder months. In regions with a subtropical climate, where annual average temperatures do not exceed 22°C, the vegetative development of torch ginger is impaired, thereby diminishing crop productivity [7,8].

With annual average temperatures of between 24.4 and 26.1°C and annual average precipitation ranging from 1260.1 to 1815.5 mm, the region of heBrazilian Cerradois considered to be eminently suitable for the cultivation of torch ginger. Nevertheless, although this region has favorable weather conditions, to the best of our knowledge, there have been no previous studies that have examined the growth, development, and productivity of torch ginger in this region. Accordingly, in this study, we sought to characterize the development and initial productivity of two torch ginger cultivars (‘Red torch’ and ‘Pink torch’), with a view toward expanding the tropical flower production chain and strengthening family agriculture in the Brazilian Cerrado.

2. MATERIAL AND METHODS

In this study, we evaluated the growth characteristics of the Torch ginger (*Etlingera elatior*) cultivars ‘Red torch’ and ‘Pink torch’ cultivated (Fig. 1) at the Germplasm Active Bank of Ornamental Tropical Plants of the State University of Mato Grosso, which is located in Tangará da Serra-MT (14°08′38″S, 57°03′45″W; altitude of 488 m), Brazil. The region of the Cerrado has a tropical climate, with a dry season from May to September and a rainy season that extends from October to April, and an average annual rainfall of 1830 mm [9,10]. The soil is classified as a Dystroferric Red Latosol with clay texture and the area has a flat to slightly undulating relief [11].

Fig. 1. The inflorescences of torch ginger (*Etlingera elatior*). 'Red torch' (a) and 'Pink torch' (b). Tangará da Serra (MT), Brazil

The experiment was performed using two cultivars ('Red torch' and 'Pink torch') with three replications of three ginger torch clumps per plot. Rhizomes obtained from commercial planting were disinfected with 0.2 g L^{-1} sodium hypochlorite solution for 20 min and thereafter placed to dry in the shade. The sterilized rhizomes were subsequently planted in pits with dimensions of 30 × 30 × 30 cm, with a spacing of 3 × 3 m. Fertilization was performed according to the recommendations for tropical flower [4]. During the evaluation period, daily precipitation (mm) and temperature (°C) theywere monitored using a Campbell Scientific automatic weather station located at State University of Mato Grosso, Tangará da Serra-MT.

We evaluated 'Red torch' and 'Pink torch' with respect to development, yield, and morphological characteristics of flowering stems. At monthly intervals during the first 10 months after planting, from August 2015 to June 2016, we assessed clump development, based on measurement of the area occupied by the clump (cm2) on the side between rows (width) and side between plants (length), obtained using the formula for a rectangle (width × length), and number of tillers emerging from the clump. The monthly yield per hectare (stems ha^{-1}) was estimated from August 2016 to July 2018. During this period, the average number of floral stems produced per clump was determined, and this value was multiplied by the plant stand in an area of 1 ha, considering the spacing of 3 × 3 m.

For morphological characterization of the floral stems, we evaluated the following characteristics during the second year (first year of production): (a) stem length (cm), measured from the ground base to the inflorescence apex; (b) stem diameter (mm), measured in the median stem region; (c) inflorescence length (cm), determined from the base to the inflorescence apex; (d) inflorescence diameter (mm), determined in the equatorial region of the inflorescence; and (e) fresh stem mass (g), obtained by weighing the marketable floral stems on an analytical balance. Evaluations were based on the measurements obtained from 10 stems per clump.

The data obtained were initially assessed with Lilliefors normality test using the Genes software [12]. As the evaluated characteristics were found to be non-normally distributed, we opted to perform a descriptive analysis of the data. Except for clump area, the characteristics are presented as bar graphs showing the means and standard errors. Data for clump area are presented as line graphs with the standard errors in each evaluated interval. The graphs were prepared using Sigmaplot 11.0.

3. RESULTS AND DISCUSSION

Precipitation and temperature data recorded during the period from August 2015 to July 2018 in the region are shown in Fig. 2. The highest rainfall in the region occurs from October to March, with monthly precipitation and temperature averages of 243.42 mm and 25.25°C, respectively.

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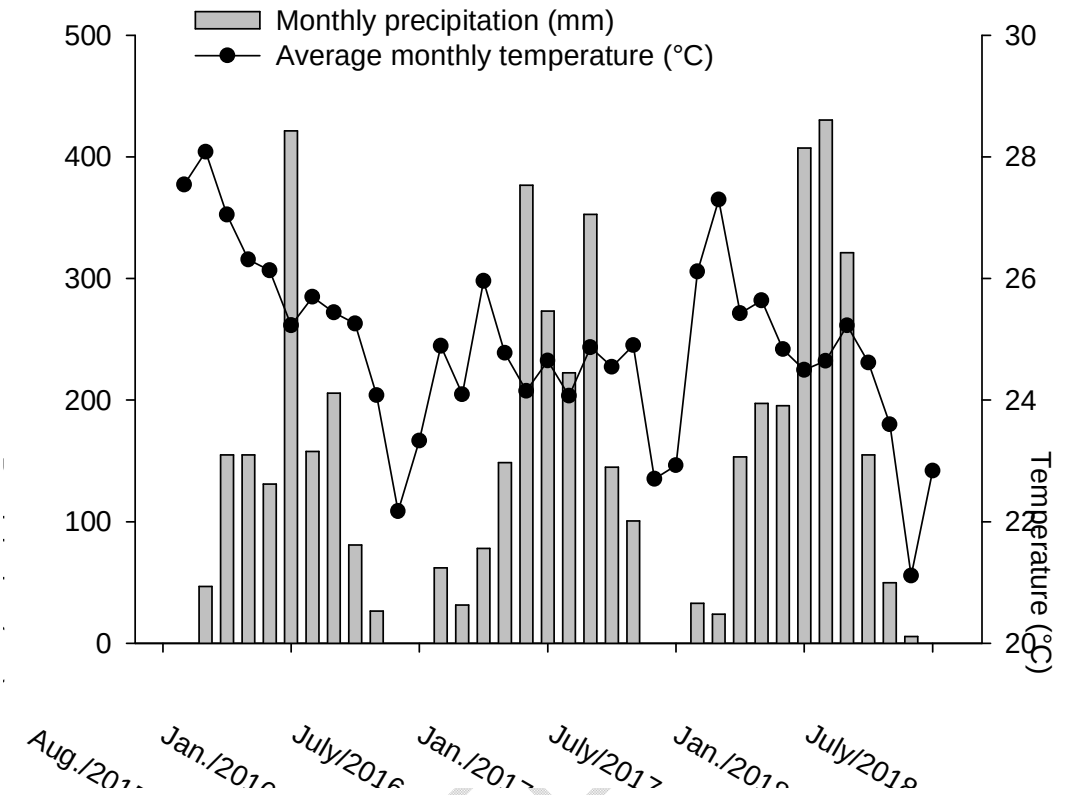

Fig. 2. Monthly precipitation and average temperatures from August 2015 to July 2018. Tangará da Serra (MT), Brazil

The 'Pink torch' showed precocity ascompared to the "Red torch". The emergence of the sprout was observed 33 days after planting in 'Pink torch', while in 'Red torch' the first sprout was observed at 39 days. We suspect that the precocity of 'Pink torch' with respect to sprout emergence may be related to certain endogenous factors such as variety, age of the parent plants, or rhizome diameter [13,14].

We observed that the early months of torch ginger development were characterized by an increase in the area occupied by clumps (Fig. 3). In the tenth month after planting, the area occupied by 'Red torch' clumps was 1194.43 cm^2, which corresponds to 1.33% of the area reserved for the development of the clump (useful area of the clump). Compared with 'Red torch', 'Pink torch' was found to have a higher clump expansion rate, with clumps covering an area of 2364.00 cm2 after 10 months, which represents 2.63% of the useful area. During the period of evaluation, we recorded average daily increases in clump growth of 4.00 and 7.90 cm^2 for 'Red torch' and 'Pink torch', respectively.

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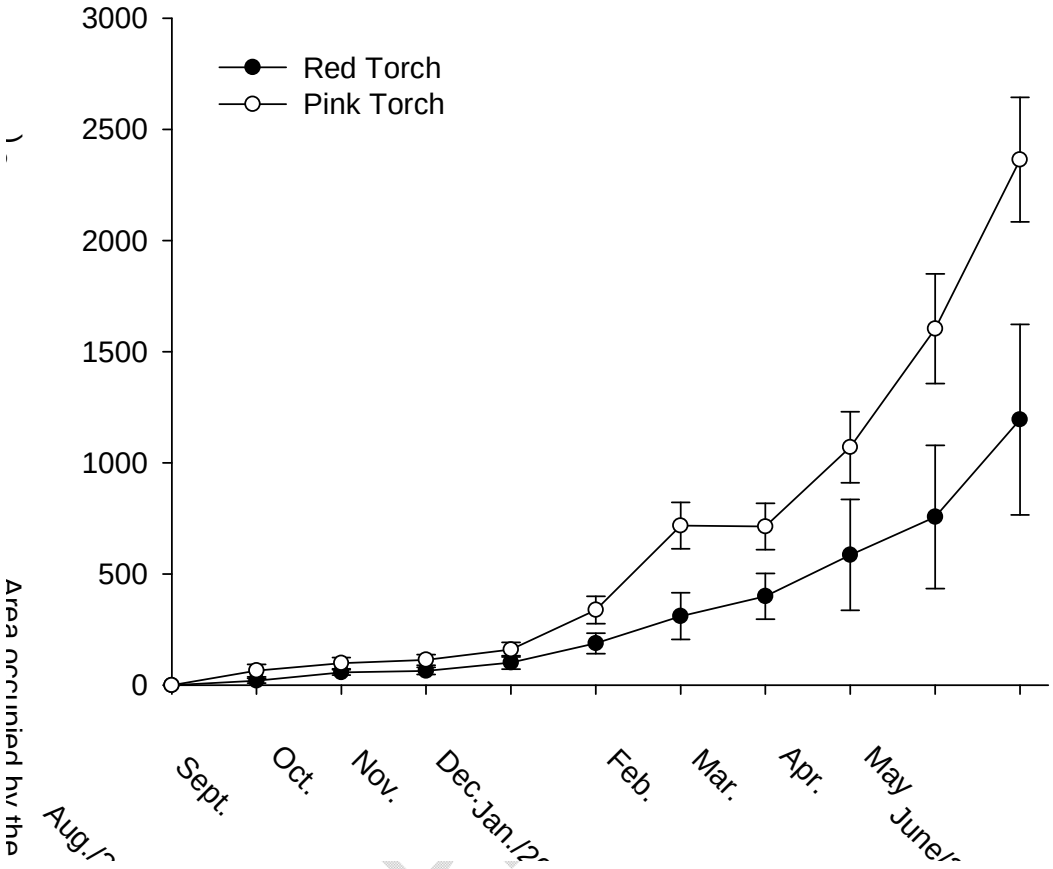

Fig. 3. Area occupied by clumps of 'Red torch' and 'Pink torch' cultivars of torch ginger. Tangará da Serra (MT), Brazil

The clump expansion rates determined for 'Red torch' and 'Pink torch' are somewhat lower than those for tropical plants reported in the literature. For example, it has been found that the daily rate of clump expansion for 'Pink torch' grown in full sunlight in Northern Paraná was close to 14.00 cm2[8], whereas in a semi-arid area of Brazil, daily growth rates of the clumps of different species of heliconia cultivated in full sunlight ranged from 2.33 cm^2 to 72.71 cm^2 [15].

We assume that these differences in clump growth are attributable to differences in environmental factors. Torch ginger is a water and humidity demanding plant, with recommendations of between 1100 to 3300 mm of annual rainfall and relative humidity in the range of 70% to 80% [4]. In the present study, rhizomes of the two cultivars were planted during the dry season in a year characterized by notably high temperatures, general absence of rain, and low relative humidity, which, even under irrigated conditions may have restricted the full development of clumps.

At 10 months after planting (June 2016), the average number of tillers produced by 'Red torch' and 'Pink torch' was 4.40 and 6.22, respectively. For both cultivars, the highest rate of

tiller emergence was recorded at 6 months after planting (February 2016), with values of 14 and 21 tillers for 'Red torch' and 'Pink torch,' respectively (Fig. 4), which we suspect may have been associated with the greater availability of water during this period. The development of torch ginger is favored in rainy periods and at temperatures above 20°C [7]. As shown in Fig. 2, the highest rainfall during the experimental period occurred between October 2015 and March 2016, with the highest amounts falling in January 2016, one month prior tothe highest tiller emergence. During this period, the average temperature was 25.25°C and the average rainfall was 243.42 mm.

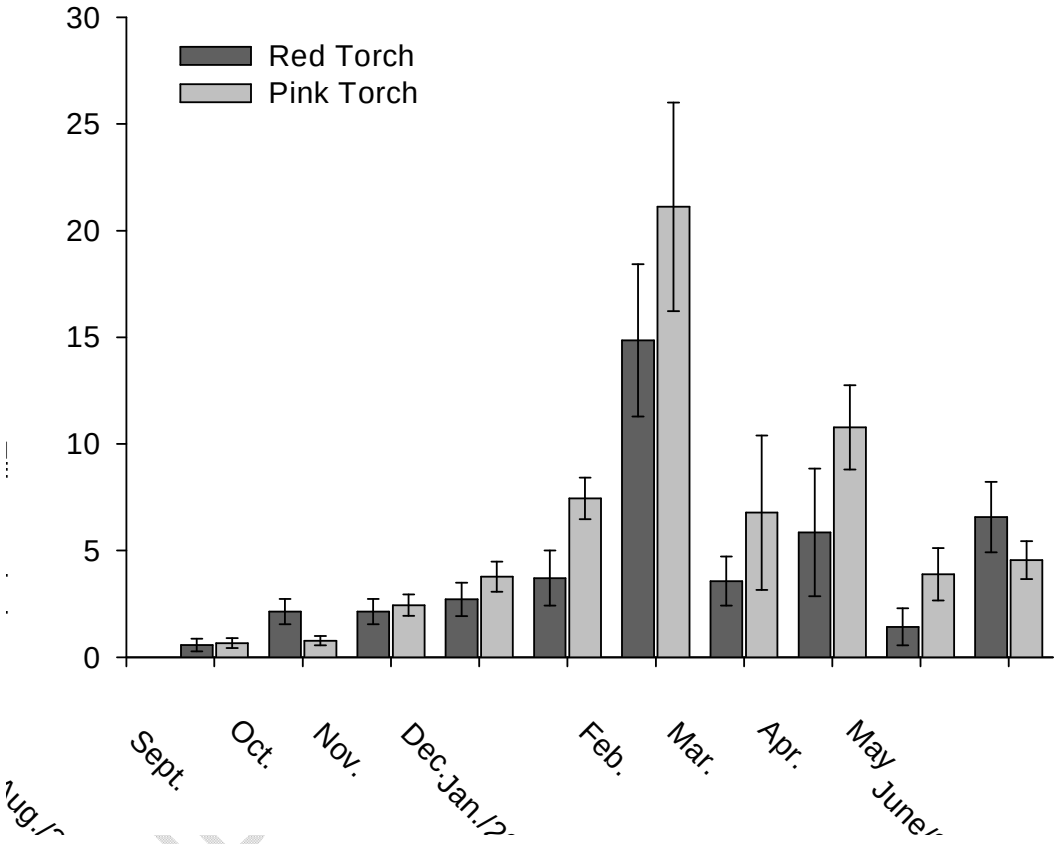

Fig. 4. Monthly emergence of tillers from clumps in the first year of cultivation of 'Red torch' and 'Pink torch' cultivars of torch ginger. Error bars indicate standard errors. Tangará da Serra (MT), Brazil

The rates of tiller production recorded in the present study are similar to those observed for 'Red torch' and 'Porcelana' cultivated under subtropical climate conditions in the southern region of Minas Gerais [7]. In this region, an average of 15 tillers per clump in the sixth month after planting, regardless of cultivar. Contrastingly, when grown under greenhouse

conditions using a hydroponic system, observed that 'Porcelana' had produced a total of 41 tillers per plant at 367 days after planting [16].

In the present study, we evaluated productivity over the period from August 2016 to July 2018 (Fig. 5). Highest yields were observed from February to May in 2017 and February to July in 2018. It can be assumed that the high productivity during these periodsis related to the influence of the rainy season, which in the study region commences between August and September and continues until May to June (Fig. 2). Torch ginger is a water-demanding plant, and this factor is directly related to production [8], with a greater availability of water favoring the emergence of sprouts [7], and thereby contributing to the higher productivity observed during these months.

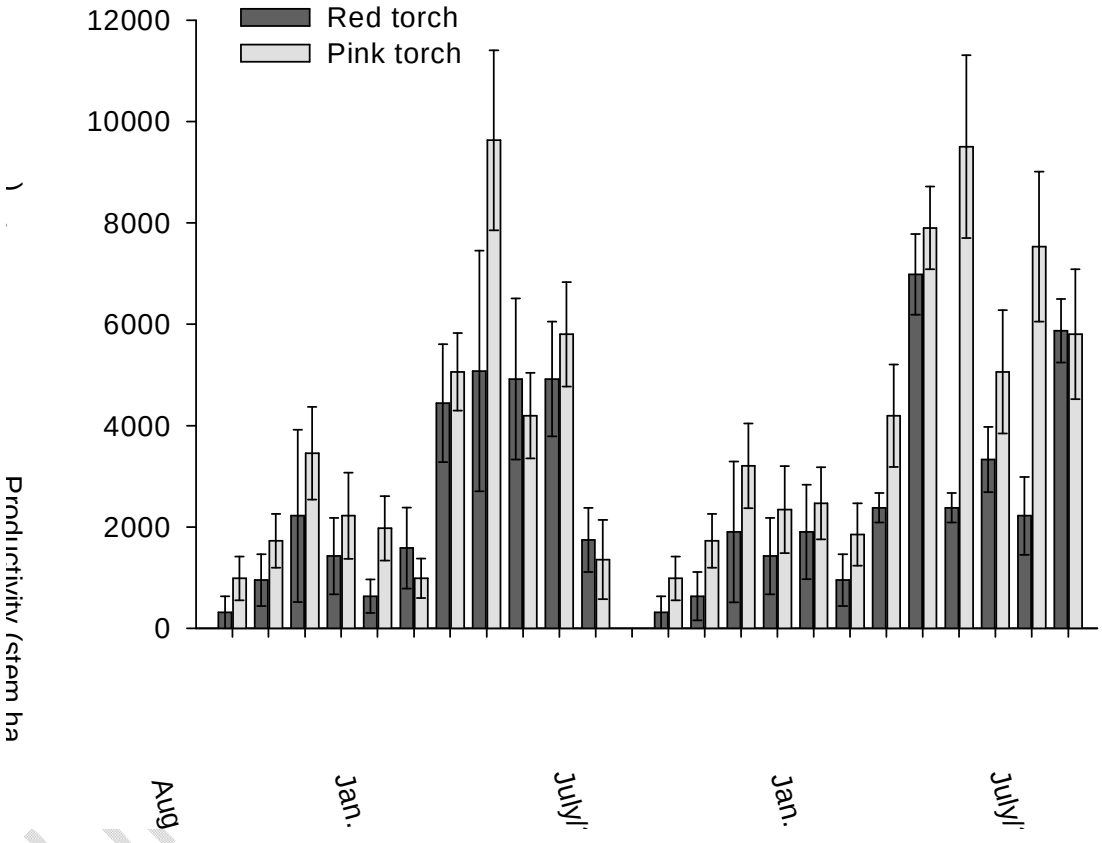

Fig. 5. Productivity during the period from August 2016 to July 2018 of 'Red torch' and 'Pink torch' cultivars of torch ginger. Error bars indicate standard errors. Tangará da Serra (MT), Brazil

The average monthly yields recorded for 'Red torch' and 'Pink torch' were 2440.48 and 3750.00 stems ha^{-1}, respectively (Fig. 5). The lower yield obtained for 'Red torch' was expected, given that this cultivar was characterized by alow clump expansion and tiller emergence, which are factors directly related to yield. Comparatively, in a subtropical climate

region, weobtained an average monthly yield of 2993.13 stems ha^{-1} over 2 years of production for 'Pink torch' [8].

Productivity in the second year of production (2017/2018) was found to be higher than the oneobserved during the first year (2016/2017), with 'Red torch' and 'Pink torch' showing 7.30% and 40.59% higher productivity, respectively, than in the first year. These results can be attributed to thefact that after 2 years of growth, the plants are fully developed, with well-formed clumps and a larger leaf area for photosynthetic activity.

Details of the morphological characteristics of 'Red torch' and 'Pink torch' are presented in Table 1. We found that for all the morphological characteristics evaluated, 'Pink torch' had higher averages than 'Red torch'. The development of torch ginger inflorescences is dependent on the availability of plant photoassimilates [8,17], and we accordingly believe that the superiority of 'Pink torch' may be related to the larger photosynthetic area for production of photoassimilate, given that the plants of this cultivar had a higher number of tillers and larger area of clump occupation.

Table 1. Mean values and the respective minimum, maximum, standard deviations (σ), and coefficients of variation (CV) values of fresh stem mass, stem length, stem diameter, inflorescence length, and inflorescence diameter of 'Red torch' and 'Pink torch' cultivars of torch ginger. Tangará da Serra (MT), Brazil

Cultivar	Characteristics	Mean[a]	Minimum	Maximum	σ	CV (%)
Red torch	Fresh stem mass (g)	171.76	59.00	280.00	58.77	34.21
	Stem length (cm)	68.73	35.00	115.00	16.53	24.05
	Stem diameter (mm)	13.15	8.85	17.23	2.20	16.71
	Inflorescence length (cm)	11.11	7.00	16.00	2.20	19.77
	Inflorescence diameter (cm)	11.20	6.00	21.00	3.34	29.83
Pink torch	Fresh stem mass (g)	192.91	70.00	389.00	66.07	34.25
	Stem length (cm)	81.39	48.00	116.00	16.18	19.87
	Stem diameter (mm)	13.52	8.74	17.86	1.91	14.13
	Inflorescence length (cm)	12.89	8.00	21.00	2.52	19.53
	Inflorescence diameter (cm)	14.40	8.00	22.00	3.44	23.91

[a]Average obtained from 70 floral stems.

We recorded average fresh mass values of 192.91 and 171.76 g for 'Pink torch' and 'Red torch', respectively, representing a 12.31% higher fresh stem mass in the former. Torch ginger genotypes are considered promising when presenting average fresh stem masses of between 166.25 and 235.07 g[18], once, high stem fresh mass values can be disadvantageous, in that they increase shipping and packaging costs. However, light stems

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tend to be less durable, as they have lower reserves of available carbohydrates to maintain post-harvest stem metabolism through cellular respiration [19].

With respect to floral stem length, we recorded mean stem lengths of 81.39 and 68.73 cm for 'Pink torch' and 'Red torch', respectively, with that of 'Pink torch' being 18.42% higher (Table 1). In terms of commercial production, floral stems should have a minimum length ranging from of 60.00 [4] cm and 80.0 cm [20]. With regards to stem diameter, we recorded similar values of 13.52 and 13.15 mm for 'Pink torch and 'Red torch', respectively, which are higher than the minimum value (10.00 mm) required for marketing [4,20].

Inflorescence lengths ranged from 7.00 to 16.00 cm for 'Red torch' and 8.00 to 21.00 cm for 'Pink torch' (Table 1), being approximately 16.0% longer in the latter. Consistently, we found the mean inflorescence width of 'Red torch' (11.20 cm) to be lower than that of 'Pink torch' (14.40 cm) (Table 1). These values are higher than those found for 'Red torch' cultivated in southeastern Brazil, under full sunlight and an average annual temperature of 19.9°C [7]. In this study, the authors point out that low temperatures affect photosynthetic activity, which can limit development and productivity. During the present study, the ambient temperatures remained within the required range for the crop, which may have favored inflorescence development.

The region of the Brazilian Cerrado is typified by climatic characteristics that are conducive to the cultivation of torch ginger, with average monthly temperatures of between 21 and 28°C and an annual precipitation exceeding 1000 mm favoring the development and yield of 'Red torch' and 'Pink torch' ginger. Except for the month of July in 2017, we observed that these cultivars produced floral stems throughout the entire cultivation period evaluated in the present study. The highest yields occurred toward the end of the rainy season, from February to June. Compared with 'Red torch', 'Pink torch' showed greater adaptability to the region, with higher yields and superior floral stem morphological characteristics.

4. CONCLUSION

The temperatures and rainfall regime presented in the Brazilian Cerrado are favorable to the growth and development of torchginger. However, during the dry season of the year, the development of clumps is affected by high temperatures and low relative humidity.

The cultivar 'Pink torch' presented greater adaptability to the region, presenting higher yields and quality of floral stems superior to 'Red torch'.

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