Scientific Article

Morphophenological characterization of ornamental ginger and selection for landscape use [1]

CARLOS EDUARDO FERREIRA DE CASTRO[2], ANA CECILIA RIBEIRO DE CASTRO[3]*, CHARLESTON GONÇALVES[2], VIVIAN LOGES[4]

ABSTRACT

Many species of *Zingiber* have great ornamental potential, due to durability and exotic appearance of the inflorescences. Despite its large phenotypic variability, they are scarcely exploited or not yet exploited regarding the ornamental potential. To conserve potential ornamental genotypes, and subsidize breeding program, the Agronomic Institute (IAC) maintain a Germoplasm Collection of Ornamental Zingiberales with promising accessions, including *Zingiber.* The aim was the morphophenological characterization of ten *Zingiber* accessions and the indication for landscape purposes. A large variation was observed to the evaluated characters: Clump height (CH); Inflorescence visualization (IV); Clump area (CA); Clump density (CD); Leaf stem Firmness (LSF); Number of leaf stems per clump (NLSC); Number of leaves per stem (NLS); Leaf color (LCol); Evergreen tendency (ET); Flower stem growth (FSG); Flower stem length (FSLe); Flower stem diameter (FSD); Flower stem per clump (FSC); Color sensorial perception (CSP); Flower stem weight (FSW); Inflorescence length (IL); Inflorescence diameter (ID); Bracts aspects (BAs); and Flowering season (FSe). The accessions very suitable and with the best performance to use for landscape purpose were *Z. spectabile*, IAC Anchieta (*Z. spectabile*), *Z. newmanii*.

Keywords: Tropical flowers, landscaping, ornamental zingiberales, characterization

RESUMO

Caracterização morfofenológica de gengibre ornamental e seleção para uso paisagístico

Muitas espécies de *Zingiber* tem grande potencial ornamental, devido a durabilidade e aparência exótica de suas inflorescências. Apesar da larga variabilidade fenotípica, essas plantas são escassamente ou não exploradas apesar de todo apelo ornamental. Para conservar genótipos ornamentais e subsidiar o programa de melhoramento, o Instituto Agronômico (IAC) mantem uma coleção de germoplasma de Zingiberales ornamentais com genótipos promissores, incluindo os do gênero *Zingiber.* O objetivo foi a caracterização morfofenológica de dez acessos de *Zingiber* e a indicação de uso ornamental. Uma grande variação foi observada nas características avaliadas: Altura da Touceira (CH); Visualização da Inflorescência (IV); Área da touceira (CA); Densidade da Touceira (CD); Firmeza da haste foliar (LSF); Numero de hastes foliares por touceira (NLSC); Numero de folhas por haste (NLS); Cor da folha (LCol); Tendência de permanecer sempre verde (ET); Crescimento da haste floral (FSG); Comprimento da haste floral (FSLe); Diâmetro da haste floral (FSD); Haste florais por touceira (FSC); Percepção sensorial de cor (CSP); peso da haste floral (FSW); Comprimento da flor (IL); Diâmetro da flor (ID); Aspecto das brácteas (BAs); e época da floração (FSe). Os acessos mais adequados e com melhor desempenho para uso em paisagismo foram: *Z. spectabile*, IAC Anchieta (*Z. spectabile*), *Z. newmanii*.

Palavras chave: Flores Tropicais, paisagismo, zingiberales ornamentais, caracterização

1. INTRODUCTION

Zingiber is one of the most important genera of the ginger family (Zingiberaceae) but the real number of species is not known. Kishor and Leong-Skornicková (2013) described more than 250 species. Recently, Govaerts et al. (2015), after discarding synonyms, confirmed only 177 valid species. These plants are herbaceous and aromatic living originally in humid regions of the tropical to warm-temperate Asia. Thailand is the country with the richest representation of the genus *Zingiber,* center of diversity with 56 species, followed by China, with 42 species, of which 36 are endemic (TRIBOUN et al., 2014).

The inflorescence usually arises from the base of the leaf stem, on a underground stem (SABU, 2003). Bracts often bright red, orange, or yellow, closely imbricate or with the apices free, forming small bags filled up with mucilage, comprising a single cincinnus. These exotic appearance of the inflorescences, flowering characterized by many flower stems breaking-the ground, the architecture and the typical ginger aroma are positive aspects to be explore in landscape.

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(2) Instituto Agronômico (IAC), Centro de Horticultura, Campinas-SP, Brazil.

(3) Embrapa Agroindústria Tropical (CNPAT), Fortaleza-CE, Brazil. *Corresponding author: cecilia.castro@embrapa.br

(4) Universidade Federal Rural de Pernambuco (UFPE), Recife-PE, Brazil.

Some species are appreciated as ornamental plants due to durability and the exoticism, as an example, *Zingiber spectabile* (COELHO et al., 2017). Despite its large phenotypic variability, few forms of *Zingiber* genera are exploited commercially regarding the ornamental potential. Based on the genera amplitude, probably exists many others potential species, geographically restricted and poorly known.

The Germoplasm Collection of Ornamental Zingiberales of the Agronomic Institute (IAC), has promising genotypes, including *Zingiber*. The objective of this work was the morphophenological characterization of ten Zingiber accessions and the indication for landscape purposes.

2. MATERIAL AND METHODS

Evaluations were performed at Germoplasm Collection of Ornamental Zingiberales of the Agronomic Institute (IAC). Three Clumps aged 3 years, distributed randomly and maintained in the field at full sun condition of the following accessions were evaluated during a year: *Z. spectabile*; IAC Anchieta (*Z. spectabile*); IAC Angatu (*Z. spectabile*); *Z. zerumbet*; IAC Almada (*Z. spectabile x zerumbet*); IAC Suanno (*Z. spectabile x zerumbet*); *Z. macradenium*; *Z. newmanii*; *Z. ottensii*; and *Z. pachysiphon*.

To perform the characterization, based on traits of clump, stems, leaves, inflorescences and flowering, were applied the following descriptors: Clump height (CH) - low (< 2.00 m), medium (≥ 2.00 and < 2.90), high (≥ 2.90 m); Inflorescence visualization (IV) - evident or hidden; Clump area (CA): clump base diameter (m) and clump canopy diameter (m); Clump density (CD) – agglomerate, intermediate and sparse; Leaf stem firmness (LSF) - firm or overturn tendency; Number of leaf stems per clump (NLSC): low (< 20); intermediary (≥ 20 and < 40); high (≥ 40); Number of leaves per stem (NLS); Leaf color (LCol); Evergreen tendency (ET): yes or no; Flower stem growth (FSG): erect or decumbent; Flower stem length (FSLe) - distance between the base to apex (cm); Flower stem diameter (FSD) (cm); Flower stem per clump (FSC) - low (< 15); medium (≥ 15 and < 30); high (≥ 30 and < 45); and very high (≥ 45); Color sensorial perception (CSP); Flower stem weight (FSW) (g); Inflorescence length (IL) (cm); Inflorescence diameter (ID) (cm); Bracts aspects (BAs): (appressed or free bracts and color); and Flowering season (FSe) – months of inflorescence occurrence.

A point scoring system was used to determine the accessions most suitable as ornamental plants base on: Inflorescence visualization (IV) (3 points - evident; 2 points - hidden); Clump density (CD) - (3 points - agglomerated; 2 points - intermediated; 1 point - sparse); Leaf stem firmness (LSF) - 3 points - firm; 0 points - overturn tendency; Evergreen tendency (ET) - 3 points - yes; 0 points - no; Flower stem per clump (FSC) - 3 points - very high and high; 2 points - medium; 1 point - low; Color sensorial perception (CSP) - 4 points to very intense color and contrast; 3 points to intense color and contrast; 2 points to intermediated color and contrast; 1 point to pale color with or without contrast; Flowering season (FS) - 3 points to more than 4 months; 2 points 4 to 3 months; 1 point - less than 3 months. Base on the total point score, the species were considered poorly suitable (less than 13 points), suitable (13 to 19 points) and very suitable (more than 19 points) to ornamental plants use.

3. RESULTS AND DISCUSSION

It was observed morphophenological variation between accessions with respect to general characteristics of clump, stems, leaves, inflorescences and flowering (Tables 1 to 5).

About plant height, accessions ranged from 1.80 to 3.30 m and were classified as low (*Z. zerumbet*), medium (IAC Anchieta, IAC Angatu, IAC Almada, IAC Suanno, *Z. newmanii*, *Z. ottensii* and *Z. pachysiphon*) and high (*Z. spectabile* and *Z. macradenium*). All accessions showed evident inflorescence visualization in the clump, except *Z. zerumbet* whose inflorescence were hidden below the foliage (Table 1).

Table 1. Clump characteristics of the Zingiber Accessions.

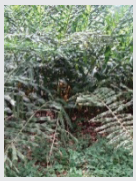
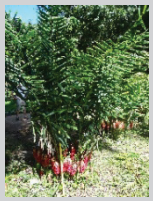
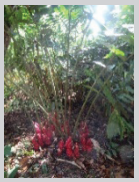
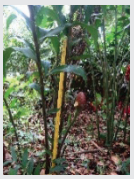
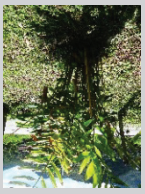
Accession	Clump height (CH)	Inflorescence visualization (IV)	Clump area: base and canopy (CA)	Clump density (CD)	Photo
Z. spectabile	3.30 m (high)	evident	1.20 and 4.10 m	intermediate	
IAC Anchieta	2.50 m (medium)	evident	0.83 and 3.10 m	agglomerate	

Table 1. cont.

IAC Angatu	2.70 m (medium)	evident	1.70 and 5.10 m	sparce	
Z. zerumbet	1.80 m (low)	hidden	1.15 and 3.50 m	agglomerate	
IAC Almada	2.50 m (medium)	evident	0.75 and 3.10 m	intermediate	
IAC Suanno	2.75 m (medium)	evident	1.20 and 3.60 m	agglomerate	
Z. macradenium	3.00 m (high)	evident	0.73 and 2.90 m	intermediate	
Z. newmanii	2.60 m (medium)	evident	1.11 and 3.50 m	intermediate	
Z. ottensii	2.50 m (medium)	evident	1.50 and 2.60 m	sparce	
Z. pachysiphon	2.20 m (medium)	evident	0.73 and 2.30 m	sparce	

Regarding the clumps area, there was a variation between 0.73 to 1.70 m at the base and the canopy ranging 2.30 to 5.10 m. It was observed that plants of the accession with large base also had high canopy (e.g. IAC Angatu), and plants with small base had low canopy (e.g. *Z. pachysiphon*), but neither were the highest nor lowest plant height. Plants with most clustered growth (up to 3.50 m canopy projection) are interesting choices for gardens with limited area, since requires smaller spacing. Base on clump density, accessions with agglomerated and intermediated characteristic could be indicated to hidden walls or fences better than accessions with sparse clumps (Table 1).

Only the accessions *Z. zerumbet* and *Z. ottensii* had stems with overturn tendency. Other accessions keeps the stems firm and erect at the clump. The overturn tendency

is not directly related to the highest clumps. The number of stems per clump ranged from 16 to 58. The number of leaves was also quite variable, between 20 to 52 leaves per stem, but do not have a direct relation to the number of stems per clump. The leaves color vary from green to dark green. *Z. zerumbet* was the only accession that foliar stems remains dry on the plant. The others accessions were evergreen during the year (Table 2).

Table 2. Leaf stem characteristics of the Zingiber accessions.

Accessions	Leaf stem firmness (LSF)	Number of leaf stems per clump (NLSC)	Number of leaves per stem (NLS)	Leaf color (LCol)	Evergreen tendency (ET)
Z. spectabile	firm	19 (low)	28	dark green	yes
IAC Anchieta	firm	50 (high)	47	green	yes
IAC Angatu	firm	33 (intermediary)	45	dark green	yes
Z. zerumbet	overturn tendency	52 (high)	31	dark green	no
IAC Almada	firm	26 (intermediary)	35	green	yes
IAC Suanno	firm	58 (high)	52	green	yes
Z. macradenium	firm	18 (low)	50	dark green	yes
Z. newmanii	firm	16 (low)	55	dark green	yes
Z. ottensii	overturn tendency	17 (low)	20	green	yes
Z. pachysiphon	firm	29 (intermediary)	28	green	yes

About the characterization of inflorescences was noted that all the flower stems were erect except by *Z. newmanii* and *Z. pachysiphon* which growth were decumbent. In all the accessions were observed that the length of the flower stems were quite variable in the same clump. The diameter of the flower stems ranged from 2.20 (*Z. zerumbet*) to 4.30 cm (*Z. pachysiphon*) (Table 3).

Table 3. Flower stem characteristics of the Zingiber accessions.

Accession	Flower stem growth (FSG)	Flower stem length (FSLe)	Flower stem diameter (FSD)	Flower stem/ clump (FSC)	Color sensorial perception (CSP)
Z. spectabile	erect	0.40-1.20cm	3.0 cm	23 (medium)	intense color and contrast
IAC Anchieta	erect	0.40-0.80 cm	3.0 cm	60(very high)	intense color and contrast
IAC Angatu	erect	0.49-0.63 cm	3.0 cm	28(medium)	very intense color and contrast
Z. zerumbet	erect	0.30-0.70 cm	2.2 cm	38(high)	intermediated color and contrast
IAC Almada	erect	0.30-0.60 cm	2.8 cm	20(medium)	intermediated color and contrast
IAC Suanno	erect	0.41-0.90 cm	3.0 cm	61(very high)	intense color and contrast
Z. macradenium	erect	0.40-0.70 cm	3.2 cm	8(low)	very intense color and contrast
Z. newmanii	decumbente	0.15-0.30 cm	3.8 cm	25(medium)	very intense color and contrast
Z. ottensii	erect	0.50-0.70 cm	2.6 cm	4(low)	Pale color without contrast
Z. pachysiphon	decumbent	0.10-0.30 cm	4.3 cm	8(low)	intermediated color and contrast

About the inflorescence number, the accession IAC Suanno and IAC Anchieta were the most productive, with 60 and 61 stems per clump. *Z. zerumbet*, with 38 flower stem per clump, was classified as high production. Accessions classified as medium produced among 15 to 30 stems (*Z. spectabile*, IAC Angatu, IAC Almada, *Z. newmanii*) and some accessions produced up to 10 inflorescences per plant (*Z. macradenium*, *Z. ottensii* and *Z. pachysiphon*).

Regarding the inflorescence characteristics, it was observed that the flower stem weight varied greatly

depending on the accession. It was observed that inflorescence weight is not only influenced by length and width, morphological aspects as having free bracts also seem to influence. The correlation between inflorescence length/width and flower stem weight could be noticed in accessions with free bracts as *Z. spectabile* and *Z. macradenium*.

The color of the bracts is also very varied, depending on accession, ranging from green, yellow, orange to darker red on the lips. Most of the accessions have a gradual change color with the inflorescences aging, from the basis for the apex, adding exoticity (Table 4). Thus, the sensorial perception could range for very intense color and contrast to pale color without contrast (Table 3).

Table 4. Inflorescence characteristics of the Zingiber accessions.

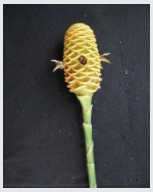
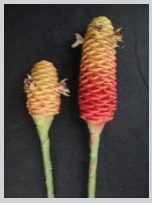
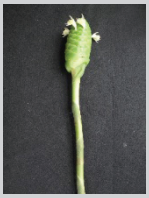
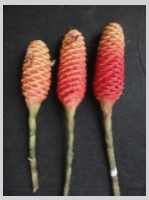
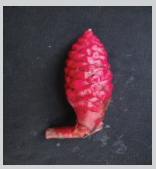
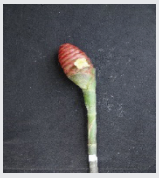
Accession	Flower stem weight (FSW)	Inflorescence length (IL)	Inflorescence diameter (ID)	Bracts aspects (BA)	Photo
Z. spectabile	340 g	20.0 cm	9.0 cm	Free. Orange-yellowish	
IAC Anchieta	200 g	14.0 cm	6.5 cm	Free. Yellow to orange	
IAC Angatu	280 g	14.0 cm	8.0 cm	Free. Yellow to yellow greenish, bracts borders (base) turning orange	
Z. zerumbet	220 g	13.0 cm	5.5 cm	Appressed. Green turning red when mature	
IAC Almada	140 g	15.0 cm	8.0 cm	Appressed. Yellow to orange	
IAC Suanno	210 g	19.0 cm	7.0 cm	Free. Yellow to orange in Apex, pale pink at the inflorescence base, borders red	
Z. macradenium	430 g	21.0 cm	13.0 cm	Free. Pale green internally, bracts borders red to brown	

Table 4. cont.

Z. newmanii	200 g	16.0 cm	6.0 cm	Appressed. Red	
Z. ottensii	250 g	10.0 cm	6.0 cm	Free. Red brown (base) to greenish toward apex when flowering and turning bright red	
Z. pachysiphon	140 g	15.0 cm	6.5 cm	Appressed Red to purple when matures bracts borders are dark necrotic.	

The flowering season months observed was very early (August to September) as observed in IAC Suanno and *Z. macradenium*, mid (October to November) as observed *Z. spectabile*, IAC Anchieta, IAC Angatu, *Z. zerumbet* and *Z. newmanii* or late (December to January) as observed IAC Almada, *Z. ottensii* . *Z. pachysiphon* was the only accession that produce flowers from May to August.

4. CONCLUSIONS

The accessions morphophenologic characteristics were influenced by genetic variation and these traits are useful to indicate the type of use.

From the variability observed was possible to select potential accessions for landscaping.

The morphophenologic characterization and genotypic and phenotypic differences conserved in the collection is of great significance to agriculture, to provide important data for the commercial cultivation of potential species and to generate important information for breeding programs.

The accessions very suitable for use to landscape purpose were *Z. spectabile*, IAC Anchieta (*Z. spectabile*) and *Z. newmanii* and present easy inflorescence visualization, leaf stem firmness and evergreen tendency, high number of flower stem per clump, very intense color and contrast sensorial perception.

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AUTHORS CONTRIBUTIONS

C.E.F.C. 0000-0002-1407-0611: Planting; Field analysis and data collection; Descriptors and selection criteria elaboration; Manuscript critical review. **A.C.R.C.** 0000-0001-6441-9888**:** Field analysis and data collection; Descriptors and selection criteria elaboration; Manuscript critical review and manuscript final version review. **C.G.** 0000-0001-5414-0306: Planting; Field analysis and data collection; Descriptors and selection criteria elaboration; Manuscript critical review. **V.L.** 0000-0001-9948-9501: Field analysis and data collection; Descriptors and selection criteria elaboration; manuscript critical review.

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