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Clonal evaluation of new ornamental pineapple hybrids to use as cut flowers

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ABSTRACT. Embrapa Cassava and Fruits has developed ornamental pineapple hybrids for several categories of ornamental use including cut flowers, potted plants and landscaping. The objective of this study was to carry out a clonal evaluation of two ornamental hybrids using quantitative and qualitative morphological descriptors to recommend these hybrids as new ornamental pineapple cultivars. Twenty plants of each hybrid (PL01 and PL04) were evaluated regarding the response to floral induction as well as the stability and homogeneity of the clones in two production cycles. The descriptive statistics were calculated and analyzed to determine the genetic distance based on the Gower algorithm. Four groups were formed, two using parental data and the other two containing the different hybrids that were evaluated in the two growing cycles. In the floral evaluation, the time from field planting to harvest of the stem as a cut flower was determined to be as long as 17 months in the first cycle and 13.5 months in the second cycle for both hybrids. They were characterized as a novelty in the flower market; they showed genetic stability and homogeneity and can be recommended as new cultivars of ornamental pineapple because they exhibit satisfactory quality and meet the market requirements.

Keywords: *Ananas* sp., cut flower, floral induction, new cultivars, plant breeding.

Avaliação clonal de novos híbridos de abacaxizeiros ornamentais para uso como flores de corte

RESUMO. A Embrapa Mandioca e Fruticultura desenvolveu híbridos de abacaxi ornamental para diferentes usos, dentre eles, flor de corte, plantas de vaso e paisagismo. O objetivo desse estudo foi realizar a avaliação clonal de dois híbridos ornamentais usando descritores morfológicos quantitativos e qualitativos, a fim de serem recomendados como novas cultivares de abacaxis ornamentais. Vinte plantas de cada híbrido (PL01 e PL04) foram avaliadas em dois ciclos de produção em relação à resposta à indução floral, bem como a estabilidade e homogeneidade dos clones. Foram realizadas estatísticas descritivas e uma analise para determinação da distância genética, com base no algoritmo de Gower. Foram formados quatro grupos, sendo dois com os parentais e dois com os diferentes híbridos avaliados nos dois ciclos da cultura. No que se refere a avaliação do florescimento, do plantio no campo até o ponto de corte foram aproximadamente 17 meses no primeiro ciclo e 13,5 meses no segundo ciclo para ambos os híbridos. Os híbridos se caracterizaram como uma novidade no segmento de flores mostrando-se estáveis e homogêneos e podem ser recomendados como novas cultivares de abacaxi ornamental por apresentarem qualidade satisfatória e atenderem as exigências de mercado.

Palavras-chave: *Ananas* sp., flor de corte, indução floral, novas cultivares, melhoramento de plantas.

Introduction

The flower agribusiness is a promising activity with major growth potential in both domestic and foreign markets. Cut flowers account for 40% of the flower market (Correa et al., 2007), and their high export value has led to increases in production in many countries, including Brazil. Among the species sold, tropical flowers stand out for their beauty and colors. In addition, the Brazilian climate and soil are favorable for large-scale flower production, especially of native species (Lima & Ferraz, 2008).

The market for ornamental pineapple plants as a high-value floricultural product has been growing (Brainer & Oliveira, 2007). The

pineapple has been used increasingly in recent years due to its exotic appearance, especially its pleasing colors, as well as long postharvest life (Sanewski, 2009; Souza et al., 2009; 2012; Souza, Costa, Santos-Serejo, & Souza, 2014). In addition, the small fruit at the tip of the stem forms a unique and original product. However, the stem must be uniform and at least 30 cm long, although longer stems, approximately 40 cm, are more desirable. In addition, the pineapple must have a balanced crown/syncarp (fruit) ratio, close to 1 or slightly less, which characterizes a fruit with a slightly shorter crown than the syncarp (Souza et al., 2012).

Embrapa Cassava and Fruits has an active germplasm bank with more than 600 accessions of *Ananas* and related genera. This company started genetic pre-breeding actions in 2003, aiming to identify and characterize accessions with ornamental potential to be used as parents in a controlled hybridization program (Souza et al., 2007; 2009; 2012). Some hybrids were subsequently obtained and have the potential to be selected as cut flowers and potted plants (Souza et al., 2014).

An important aspect is to know the flowering development of new hybrids because flowering control is a key step for pineapple cultivation such that natural flowering can be avoided and induction procedures can be enabled. Plant age is among the factors that most strongly influence this physiological event (Cunha, Cabral, & Souza, 1999).

In addition, the clonal evaluation of these hybrids is an important step to ensure the genetic stability and homogeneity of plants with respect to the selected traits, as well as ensuring that they are a novelty to the market. The use of quantitative and qualitative morphological descriptors under two cycles of evaluation provides the necessary information to confirm the homogeneity among plants and the genetic stability of clones. This type of approach is also applied to DUS (Distinctness, Uniformity and Stability) tests. Distinctness refers to the capability of a descriptor to demonstrate clear differences in comparison with other registered cultivars. On the other hand, uniformity refers to the intra-cultivar homogeneity, and stability refers to the temporal or spatial variation (União para a Proteção das Obtenções Vegetais [UPOV], 2002).

The two hybrids reported in this study were obtained from the crossing of two commercial varieties (*Ananas comosus* var. *erectifolius* x *Ananas comosus* var. *bracteatus*), with the aim of using these as cut flowers.

The objective of this study was to conduct a clonal evaluation of two promising ornamental hybrids using quantitative and qualitative morphological descriptors to recommend them as new ornamental pineapple cultivars, as well as to determine the best phase for floral induction of these hybrids.

Material and methods

The study was conducted at the Embrapa Cassava and Fruits experimental field in the municipality of Cruz das Almas, Bahia, located at 12°40' south latitude and 39°06' west longitude. According to the Köppen classification (Köppen, 1936), the climate is a transition between the Am and Aw zones, with an average annual rainfall of 1,143 mm, an average temperature of 24.28ºC and a relative humidity of 60.47%. The soil of the experimental area is a typical dystrophic yellow Latosol, moderate A, with loamy sandy–clayey texture, kaolinitic, hypoferric, subperennial-semideciduous rainforest transition phase, with a slope of 0-3%.

Two hybrids, i.e., PL01 and PL04, were obtained by crossing a female parental (*Ananas comosus* var. *erectifolius*) and a male parental (*Ananas comosus* var. *bracteatus*) (Figure 1). The parental hybrids were evaluated concurrently under the same growing experimental conditions. The experimental design was completely random with 20 replications per evaluated hybrid and cycle, where each replication consisted of one plant.

The experiment was repeated twice, characterizing two production cycles in different seasons to evaluate the genetic stability of the selected characteristics and to consolidate the response of the hybrids to the evaluation parameters, particularly floral induction. For each cycle, planting was performed under the same growing conditions using seedlings with the same visual appearance.

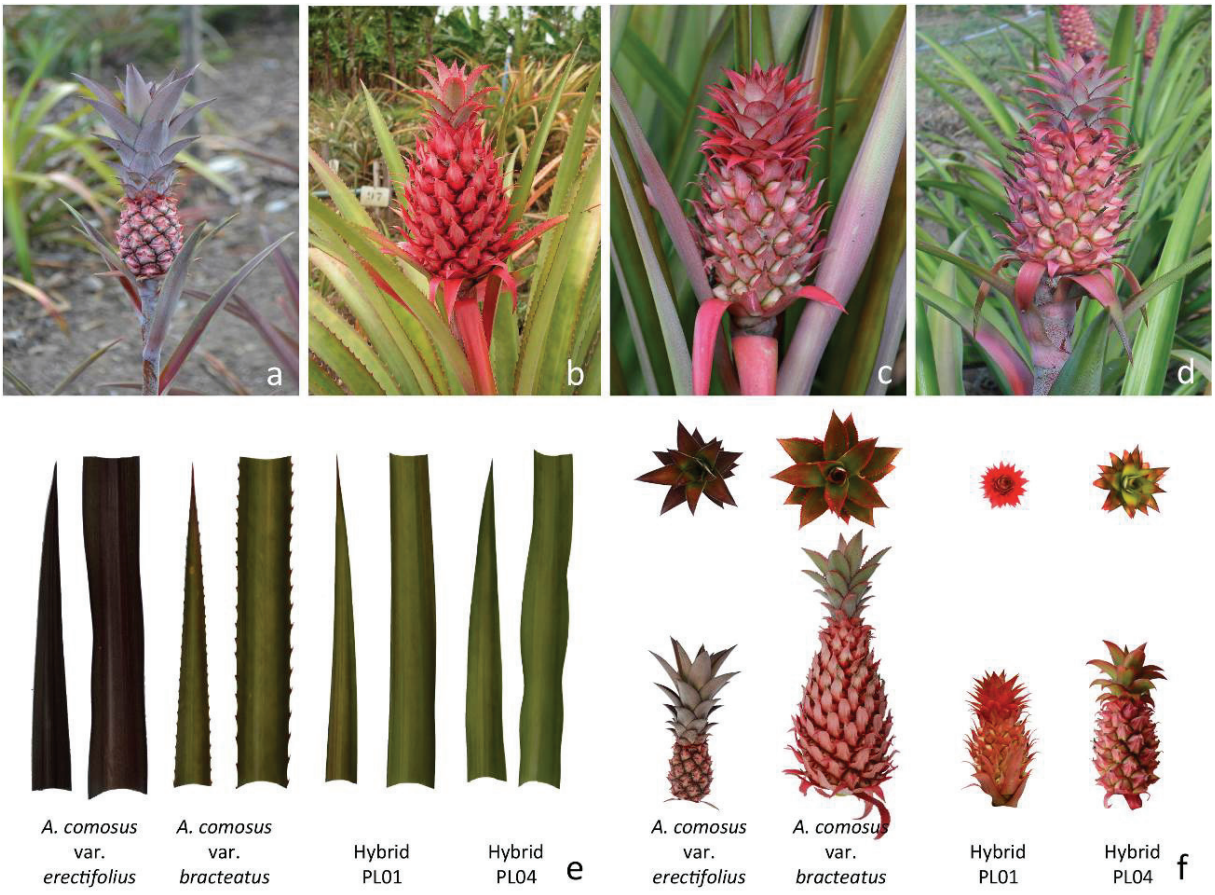

Figure 1. Parentals and hybrids of ornamental pineapple. a) Parental female (*Ananas comosus* var. *erectifolius*). b) Parental male (*A. comosus* var. *bracteatus*). c) Hybrid PL01. d) Hybrid PL04. e) Variability of leaves of parentals and hybrids. f) Variability of the crown and fruit of the parents and hybrids.

After 440 days of growth (approx. 15 months), flowering was induced using the commercial product Etrhel (ethephon 240 g L^{-1}) at a concentration of 500 ppm of the active ingredient, plus 3% urea, which was applied to the leaf rosette. The physiological stages analyzed were: induction/ emergence of floral buds; induction / first flower opening; planting/ emergence of floral buds; emergence of floral buds / last flower closing; first flower opening/ last flower closing; induction / last flower closing; and planting/ last flower closing. The last flower closing was selected because it is the current harvest point for ornamental pineapples due to enhanced syncarp colors and full fruit formation (Souza et al., 2014)

Thirty quantitative and qualitative morphological descriptors developed by the International Board for Plant Genetic Resources (International Board for Plant Genetic Resources [IBPGR], 1991) were applied and used for clonal evaluation.

Nine descriptors were applied to determine the quantitative aspects: plant height; leaf length; leaf width; peduncle length; peduncle diameter, syncarp length, syncarp diameter; crown length and crown diameter. In turn, 21 descriptors were applied to determine the qualitative features: plant habit; leaf variegation, leaf variegation distribution, main color of the sheet on the upper face, leaf anthocyanin pigmentation, spinescence, color of spines, wavy-edged blades, shape of the peduncle, external color of the shell syncarp, syncarp shape, bract apex shape of the fruitlet, overlapping bracts in relation to the fruitlet, bract color of the fruitlet, bracts at the base of the crown, bract color at the base in relation to the crown, bract color of the crown, crown length/syncarp length ratio, crown diameter/syncarp diameter ratio, number of colors of the crown and the shape of the crown apex. The color chart from the Royal Horticulture Society (RHS) (Royal Horticulture Society [RHS], 2007) was used to identify the colors adopted by the International Union for the Protection of New Varieties of Plants (UPOV, 2002) for ornamental plant protection.

The SAS statistical software system (SAS Institute, 2010) was used to calculate the descriptive statistics: average; minimum value; maximum value; standard deviation and coefficient of variation. Joint analysis of the qualitative and quantitative data was performed to determine the genetic distance, based on the Gower algorithm (Gower, 1971).

The hierarchical groupings were formed using the unweighted pair-group method with the arithmetic mean (UPGMA) based on the average Euclidean distance between clones of the hybrids and parents. The validation of the groupings was determined using the cophenetic correlation coefficient (r) (Sokal & Rohlf, 1962).

The R Development Core Team (2006) statistical software system was used to analyze the genetic distance, hierarchical groupings and cophenetic correlation (R Development Core Team). The significance of the cophenetic correlation and the correlation among matrices (cycle 1 and cycle 2) were calculated using the Student-*t* and Mantel tests (10,000 permutations). A dendrogram was generated on the basis of the distance matrix using the MEGA program 4 (Tamura, Dudley, Nei, & Kumar 2007).

Results and discussion

The responses of the hybrids to flower induction were relatively uniform, with low standard deviation values in both cycles (Table 1 and Figure 2). Hybrid PL04 proved to be slightly premature, as floral buds emerged 13 and 16 days before PL01 in the first and second cycles, respectively. According to the time from planting to the last flower closing, blossoming time was reduced in the second cycle by 102 days for hybrid PL01 and 108 days for PL04 compared with the first cycle. The second cycle was shorter because seedlings were more developed and had originated from the mother plant.

A comparison of the flower induction results from the two cycles indicated uniform behavior and allowed confirmation of the number of days between two physiological stages. This information is essential for the production system because the grower can surely plan the date of stem harvesting according to the date of flower induction. On the other hand, the last flower closing is a determinant of stem harvesting for stems that meet market quality standards.

According to Cunha et al. (1999), the induction of pineapple blossoming allows the harvest to be scheduled and lowers production costs. Uneven blossoming throughout the growing cycle creates difficulties for production planning (Almeida et al., 2003) and for meeting market demands (Souza et al., 2009). If blossoming is not induced, the harvesting of floral stems may be extended by 60 days due to uneven blossoming. The average number of days from induction to blossoming (emergence of floral buds) of 'Smooth Cayenne' pineapple is 48.3 days and can extend to 115.5 days depending on induction time (Carvalho, Neves, Bürkle, & Marur, 2005). The period from induction to harvest for one parental of the ornamental pineapple, *A. comosus* var. *erectifolius,* was 71 days (Cavalcante, Mosca, Sousa, Feitosa, & Paiva, 2010), similar to the values found in the hybrids evaluated in this study.

Table 1. Physiological stages between planting and blossoming in hybrids PL01 and PL04 (*Ananas comosus* var. *erectifolius* x *A. comosus* var. *bracteatus*).

Physiological stages	Hybrid PL01	Hybrid PL04
First cycle (number of days)		
Induction / emergence of floral buds	42.40 ± 3.08	29.35 ± 1.14
Induction / first flower opening	53.30 ± 0.47	51.65 ± 2.76
Planting/ emergence of floral buds	482.40 ± 3.08	469.38 ± 1.12
Emergence of floral buds / last flower closing	26.60 ± 3.08	40.75 ± 1.89
First flower opening / last flower closing	15.70 ± 0.47	18.45 ± 2.95
Induction / last flower closing	69.00 ± 0.00	70.10 ± 0.41
Planting / last flower closing	509.00 ± 0.00	510.10 ± 0.41
Second cycle		
Induction / emergence of floral buds	42.75 ± 2.47	26.72 ± 2.02
Induction / first flower opening	52.75 ± 0.64	50.60 ± 1.08
Planting/ emergence of floral buds	381.75 ± 2.47	361.72 ± 1.02
Emergence of floral buds / last flower closing	25.25 ± 2.47	40.40 ± 2.12
First flower opening / last flower closing	15.25 ± 0.64	16.52 ± 1.42
Induction / last flower closing	68.00 ± 0.20	67.12 ± 2.54
Planting / last flower closing	407.00 ± 0.45	402.12 ± 1.54

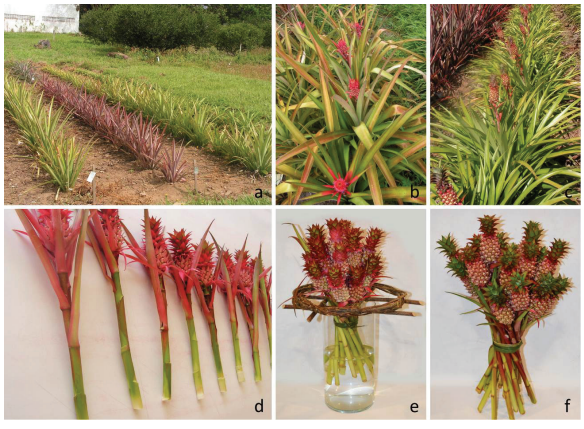

Figure 2. a) Hybrids and parentals planted under field conditions in clonal tests; b) Hybrid PL01 (*Ananas comosus* var. *erectifolius* x *A. comosus* var. *bracteatus*) at the button stage; c) Hybrid PL04 (*Ananas comosus* var. *erectifolius* x *A. comosus* var. *bracteatus*) at the harvest stage; d) Hybrid PL01 stems under evaluation; e) Hybrid PL01 stems; f) Hybrid PL04 stems.

In both cycles and for most variables, the quantitative morphological characteristics of the parentals (Table 2) and hybrids (Table 3) had low standard deviation, which indicated that the clones had high homogeneity.

Morphological differences were observed between the hybrids and parentals with respect to the size, shape, and color of different parts of the plant, as evidenced by the novelty attribute. This is characterized by the distinction of the hybrids relative to their parentals or existing varieties on the pineapple market (Figure 1 and Tables 2, 3 and 4). The parentals in this study are the only materials used in the ornamental market in Brazil (Brainer & Oliveira, 2007).

The multicategorical analysis performed on the hybrids and parentals allowed the formation of four groups in the two crop cycles (Figures 3 and 4). Here, the UPGMA clustering method based on the average Euclidean distance was used, and the average genetic dissimilarity was the cutoff point ($D\ dg = 0.21$).

Table 2. Quantitative morphological characteristics of parentals (*Ananas comosus* var. *erectifolius* and *A. comosus* var. *bracteatus*) of the PL01 and PL04 hybrids.

Descriptor	*A. comosus* var. *erectifolius*	*A. comosus* var. *bracteatus*
	First cycle	
Plant height (cm)	78.25 ± 3.12	95.33 ± 6.33
Leaf length (cm)	63.75 ± 1.65	89.00 ± 3.05
Leaf width (cm)	3.03 ± 0.32	4.13 ± 0.23
Peduncle length (cm)	41.00 ± 1.12	38.33 ± 2.01
Peduncle diameter (cm)	0.78 ± 0.04	1.87 ± 0.16
Syncarp length (cm)	5.30 ± 0.45	16.73 ± 2.18
Syncarp diameter (cm)	5.93 ± 0.21	9.73 ± 1.04
Crown length (cm)	4.15 ± 0.46	7.03 ± 0.78
Crown diameter (cm)	4.08 ± 0.27	6.33 ± 0.43
	Second cycle	
Plant height (cm)	80.13 ± 4.15	101.33 ± 7.26
Leaf length (cm)	61.44 ± 1.25	92.00 ± 2.98
Leaf width (cm)	3.11 ± 0.41	4.17 ± 0.55
Peduncle length (cm)	43.00 ± 2.44	36.13 ± 2.19
Peduncle diameter (cm)	0.81 ± 0.08	1.91 ± 0.11
Syncarp length (cm)	6.29 ± 0.63	15.95 ± 1.45
Syncarp diameter (cm)	6.02 ± 0.57	8.97 ± 1.12
Crown length (cm)	4.05 ± 0.58	6.89 ± 1.07
Crown diameter (cm)	4.15 ± 0.38	6.18 ± 0.40

Table 3. Quantitative morphological characteristics of PL01 and PL04 hybrids (*Ananas comosus* var. *erectifolius* x *A. comosus* var. *bracteatus*).

Descriptor	Average	Minimum	Maximum	Standard Deviation	CV (%)
	A. comosus var. *erectifolius* x *A. comosus* var. *bracteatus* (PL01)				
	First cycle				
Plant height (cm)	96.89	70.00	112.00	11.27	11.63
Leaf length (cm)	83.50	60.00	97.00	7.53	9.02
Leaf width (cm)	3.91	3.50	4.50	0.26	6.75
Peduncle length (cm)	35.10	32.00	38.00	1.86	5.30
Peduncle diameter (cm)	1.11	1.00	1.20	0.06	4.98
Syncarp length (cm)	4.69	4.00	5.40	0.34	7.22
Syncarp diameter (cm)	3.31	2.80	3.50	0.21	6.49
Crown length (cm)	3.76	3.30	4.40	0.30	8.11
Crown diameter (cm)	3.80	2.60	4.80	0.66	17.40
	Second cycle				
Plant height (cm)	79.50	57.00	104.00	12.84	16.16
Leaf length (cm)	78.65	58.00	100.00	11.82	15.03
Leaf width (cm)	4.43	3.70	5.20	0.38	8.64
Peduncle length (cm)	37.85	33.00	40.00	1.75	4.64
Peduncle diameter (cm)	1.05	0.90	1.10	0.06	5.78
Syncarp length (cm)	4.04	2.70	4.50	0.48	11.91
Syncarp diameter (cm)	3.25	2.90	3.70	0.26	8.08
Crown length (cm)	3.33	2.60	4.50	0.40	12.12
Crown diameter (cm)	4.17	3.50	4.80	0.28	6.70
	A. comosus var. *erectifolius* x *A. comosus* var. *bracteatus* (PL04)				
	First cycle				
Plant height (cm)	60.75	52.00	77.00	6.44	10.60
Leaf length (cm)	53.10	40.00	62.00	6.50	12.23
Leaf width (cm)	3.57	3.10	4.10	0.20	5.56
Peduncle length (cm)	40.20	36.00	45.00	2.87	7.16
Peduncle diameter (cm)	0.90	0.70	1.10	0.10	11.73
Syncarp length (cm)	3.82	3.00	5.80	0.57	14.86
Syncarp diameter (cm)	3.82	3.00	5.58	0.57	14.86
Crown length (cm)	3.39	2.50	4.50	0.51	15.01
Crown diameter (cm)	3.56	2.40	4.20	0.47	13.18
	Second cycle				
Plant height (cm)	62.65	51.00	70.00	5.09	8.13
Leaf length (cm)	59.10	47.00	65.00	4.58	7.74
Leaf width (cm)	3.58	2.70	4.50	0.39	10.82
Peduncle length (cm)	42.00	36.00	46.00	3.41	8.14
Peduncle diameter (cm)	0.91	0.70	1.00	0.08	8.66
Syncarp length (cm)	3.74	3.00	4.00	0.24	6.57
Syncarp diameter (cm)	3.74	3.00	4.00	0.24	6.57
Crown length (cm)	3.14	2.20	4.00	0.45	14.29
Crown diameter (cm)	3.79	3.20	4.50	0.38	9.98

Table 4. Qualitative morphological features of parentals (*Ananas comosus* var. *erectifolius* x *A. comosus* var. *bracteatus*) and PL01 and PL04 hybrids.

Descriptor [1]	*A. comosus* var. *erectifolius*	*A. comosus* var. *bracteatus*	Hybrid PL01	Hybrid PL04
Plant habit	Erect	Semi-erect	Erect	Semi-erect
Leaf variegation	Present	Present	Present	Absent
Leaf variegation distribution	Marginal	Marginal	Marginal	-
Main color of the sheet on the upper face	Purple-gray FAN4187A	Yellow-green FAN3146A	Yellow-green FAN3144A	Yellow-green FAN3144A
Leaf anthocyanin pigmentation	Present	Present	Present	Absent
Spinescence	Absent	Present	Absent	Absent
Color of spines	-	Different	-	-
Wavy-edged blades	Absent	Absent	Absent	Absent
Shape of the peduncle	Straight	Straight	Straight	Straight
External color of the shell syncarp	Purple-gray FAN4183B	Red FAN146B	Red FAN148D	Red FAN152D
Syncarp shape	Cylindrical	Cylindrical Conical	Cylindrical	Cylindrical
Bract apex shape of the fruitlet	Sharp	Sharp	Sharp	Sharp
Overlapping bracts in relation to the fruitlet	Partial	Total	Total	Total
Bract color of the fruitlet	Red FAN 51B	Red FAN154B	Red FAN143D	Red FAN151B
Bracts at the base of the crown	Present	Present	Present	Present
Bract color at the base in relation to the crown	Different	Different	Same	Different
Bract color of the crown	Red FAN1 184A	Red FAN152B	Red FAN151A	Red FAN1 50A
Crown length/syncarp length ratio	Low	Low	Low	Low
Crown diameter/syncarp diameter ratio	Low	Low	Low	Low
Number of crown colors	2	2	2	2
Shape of the leaf crown apex	Sharp Moderate	Acuminate	Sharp Moderate	Sharp Moderate

[1]Descriptors developed by the (International Board for Plant Genetic Resources [IBPGR], 1991).

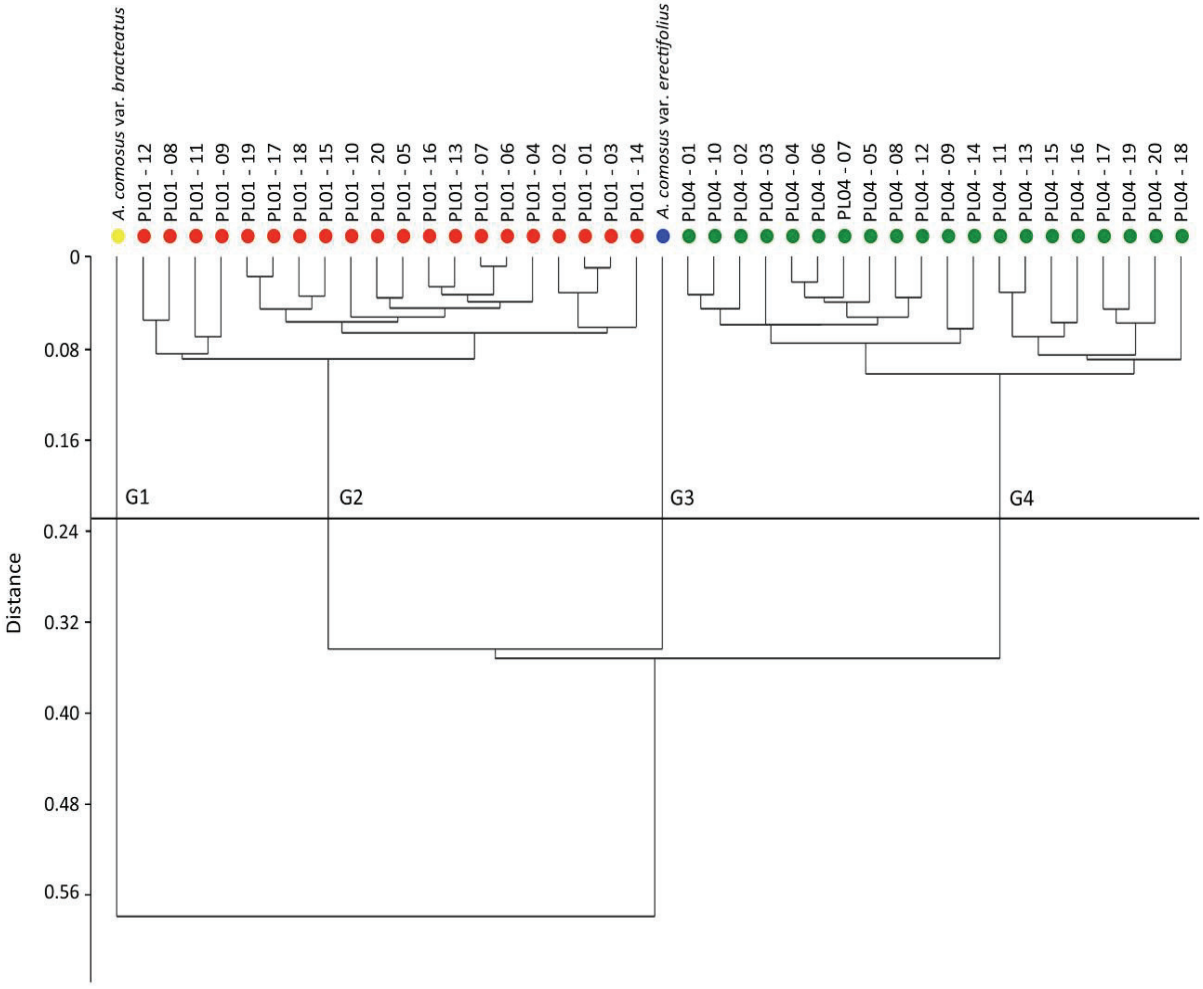

Figure 3. Genetic dissimilarity dendrogram between hybrids (PL01 and PL04) and parentals (*Ananas comosus* var. *erectifolius* and *A. comosus* var. *bracteatus*) of ornamental pineapple plants in the first cycle, based on qualitative and quantitative descriptors obtained using UPGMA based on the Gower algorithm.

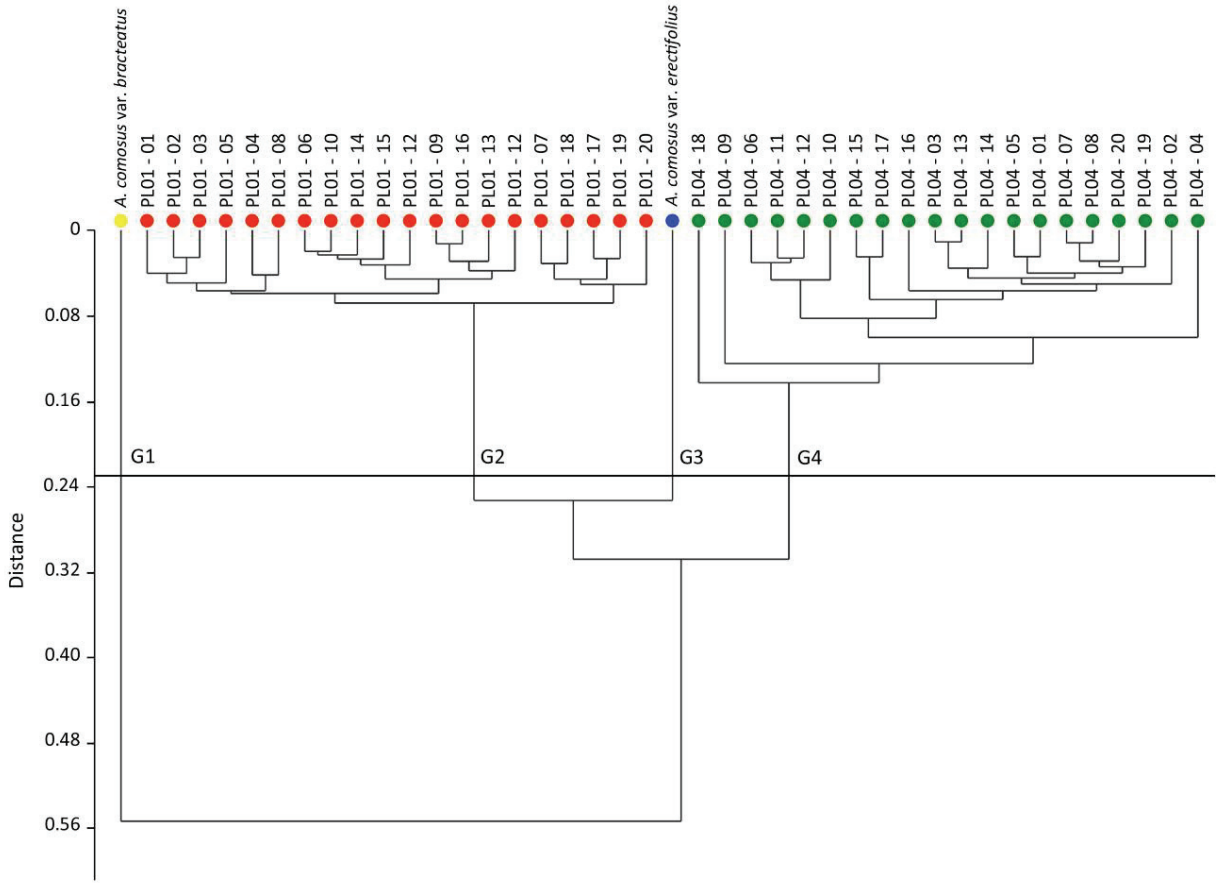

Figure 4. Genetic dissimilarity dendrogram between hybrids (PL01 and PL04) and parentals (*Ananas comosus* var. *erectifolius* and *A. comosus* var. *bracteatus*) of ornamental pineapple plants in the second cycle, based on qualitative and quantitative descriptors obtained using UPGMA based on the Gower algorithm.

The dendrogram of cophenetic correlation coefficients for the first ($r = 0.9865$, $p < 0.0001$, 10,000 permutations) and second cycle ($r = 0.9814$, $p < 0.0001$, 10,000 permutations) revealed good adjustment between the graphic representation of the distances and the original matrix (Rohlf & Fisher, 1968). The correlation between the matrices of the two cycles was highly significant at 0.659 based on the *t* test.

The G1 and G3 groups are the parentals, and groups G2 and G4 are the clones of the evaluated hybrids. The G1 group is the female parental (*A. comosus* var. *bracteatus*) (Figure 3 and 4). This genotype has large plants with an average height of 95.33 ± 6.33 cm, semi-erect growth habit, long (89.00 ± 3.05 cm) and wide (4.13 ± 0.23 cm) leaves, with differences in the anthocyanin colors between the spines and leaflet strips. The peduncles are 38.33 ± 2.01 cm in length and 1.87 ± 0.16 cm in diameter. The syncarps were cylindrical conical in shape, medium to large size (16.73 ± 2.18 cm and 9.73 ± 1.04 cm in diameter), with elongated red bracts (FAN1 54B), showing complete overlap in relation to the fruitlets (Tables 2 and 5). Using this same germplasm bank, Souza et al. (2012) analyzed 25 accessions of *A. comosus* var. *bracteatus* and noted that this botanical variety has large plants, long leaves, spines with the presence of anthocyanin and thick stalks.

The male parental (*A. comosus* var. *erectifolius*) in group G3 had different characteristics relative to *A. comosus* var. *bracteatus* (Figures 3 and 4). This genotype had a small size (78.25 ± 3.12 cm in height), erect habit and purple-gray leaves (FAN4 187A) without spines. The stalk was longer (41.00 ± 1.12 cm in length) and smaller in diameter (0.78 ± 0.04 cm). The syncarps were smaller (5.30 ± 0.45 cm in length by 5.93 ± 0.21 cm in diameter), with a cylindrical shape and a purple-gray color (FAN4 183B). The bract overlap in relation to the fruitlet was partial. The crown had an acuminate apex shape, smaller than the syncarp, with an average length of 4.15 ± 0.46 cm and a diameter of 4.08 ± 0.27 cm (Tables 2 and 4). This botanical variety has been used in floriculture as a cut flower due to the absence of spines, erect leaves, and small red

syncarps. As reported by Brainer and Oliveira (2007), this variety has been exported to Europe as a cut flower and it accounts for 75% of ornamental pineapple exports from Ceará state, Brazil.

As evidenced by the dissimilarity dendrogram, the two hybrids showed good homogeneity, demonstrated by a linkage distance close to 0.08 and a low standard deviation in the quantitative morphological traits. The evaluation between the two crop cycles substantiated the genetic stability, with a good correlation between the two matrices. No atypical clones and no variation in qualitative and quantitative morphological traits were detected.

Hybrid PL01 showed similar erect plant habits to its parental *A. comosus* var. *erectifolius*, i.e., leaves had distributed variegation at the edges and a low intensity of anthocyanins, which is similar to the parental *A. comosus* var. *bracteatus*. The stalk an had erect shape and was 35.10 ± 1.86 cm long and 1.11 ± 0.06 cm in diameter, without deformation, i.e., the crown length/syncarp length and crown diameter/syncarp diameter ratios were close to one. These characteristics are good for the sale of stems as cut flowers because they appear balanced and are aesthetically pleasing. A crown/syncarp ratio much greater than one indicates large crowns. Similarly, values smaller than one indicate smaller crowns. Ratios much greater or smaller than one are undesirable because they indicate imbalance. The crown/syncarp ratios for this hybrid were 0.80 and 0.82 for cycles 1 and 2, respectively. These values fully meet the objectives for ornamental pineapple marketing, particularly considering cut flowers and potted plants (Souza et al., 2012). The syncarp had a cylindrical apex, similar to the parental *A. comosus* var. *erectifolius*, with long red bracts (FAN1 43D) completely covering the fruitlets. The two colors of the crown exhibit a unique color pattern that is advantageous for sale as ornamental plants.

Although the PL04 hybrid size was smaller and the leaves were shorter and yellow-green in color (FAN3 144A) without anthocyanin or variegation (Table 4), this hybrid featured a semi-erect habit similar to the parental *A. comosus* var. *bracteatus*. The stalk was erect and had an average length greater than 40 cm in both cycles, qualifying this hybrid for export because peduncles with smaller sizes are rejected or undervalued by the European market. A long and not very thick peduncle in ornamental pineapples is an interesting characteristic because it has a direct influence on the weight and consequently the shipping cost, which is especially important considering the export market.

Hybrid PL04 could be adapted as a potted plant provided it is adequately managed because it exhibits a semi-erect habit and a much smaller size than the parental.

Souza et al. (2012) defined the category of ornamental potted pineapple plants that was primarily based on plant size. Preferably, these plants must be shorter than 65 cm, with a semi-erect and compact habit, and have a crown/syncarp ratio close to one; spines should be absent, and the syncarp length and diameter should be less than 5 cm and 3 cm, respectively.

Conclusion

The two hybrids exhibited genetic stability and homogeneity. In addition, they were characterized as a novelty in the flower market and can be recommended as new cultivars of ornamental pineapple because they have satisfactory quality and meet the market requirements.

In both hybrids, the time from field planting to harvest of the stem was as long as 17 months in the first cycle and 13.5 months in the second cycle.

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