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Crop Production

Agronomic behavior of banana cultivars in the geographic microregion of Assis, São Paulo, Brazil

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Abstract – The characterization of banana cultivars is an important stage, which allows the identification of materials adapted to a particular region. The aim of this study was to evaluate the agronomic performance in the edaphoclimatic conditions of the geographic microregion of Assis, State of São Paulo, during the first three production cycles. The experiment was installed at São José Farm, Palmital, SP, where ten banana cultivars (Grande Naine, IAC 2001, FHIA 02, Bucaneiro, FHIA 17, Calypso, Ambrosia, Thap Maeo, BRS Princesa and Caipira) were evaluated during the three production cycles. The experimental design was in randomized blocks, with four replicates, each plot with 8.75 m^2 and 5 plants per plot. The evaluated variables were plant height, pseudostem perimeter, number of leaves at flowering and harvesting, bunch mass, number of hands per bunch, fruit and pulp yield. Results were submitted to analysis of variance, means comparison tests and multivariate clustering or tree clustering analysis. 'Grande Naine' and 'IAC 2001' cultivars, as well as those of the Cavendish subgroup, are the most suitable for cultivation in the geographic microregion of Assis, SP, considering production performance in the evaluated production cycles.

Index terms: *Musa* sp.; agronomic performance; regionalization; cluster analysis.

Perfil agronômico de cultivares de bananeiras na microrregião geográfica de Assis, São Paulo, Brasil

Resumo – A caracterização de cultivares de bananeiras constitui etapa importante, que permite identificar materiais adaptados para determinada região. O objetivo foi avaliar o desempenho agronômico nas condições edafoclimáticas da microrregião geográfica de Assis-SP, durante os três primeiros ciclos de produção. O experimento foi instalado na Fazenda São José, Palmital-SP, sendo avaliadas 10 cultivares (Grande Naine, IAC 2001, FHIA 02, Bucaneiro, FHIA 17, Calypso, Ambrosia, Thap Maeo, BRS Princesa e Caipira), durante três ciclos produtivos. O delineamento experimental foi em blocos casualizados, com quatro repetições e parcelas de 8,75 m^2, compostas por 5 plantas. As variáveis avaliadas foram: altura, perímetro do pseudocaule, número de folhas no florescimento e colheita, massa do cacho, número de pencas por cacho, produtividade de frutos e polpa. Os resultados foram submetidos à análise de variância, aos testes de comparação de médias e à análise multivariada de agrupamentos ou "tree clustering". As cultivares Grande Naine e IAC 2001, do subgrupo Cavendish, são as mais indicadas para o cultivo na microrregião geográfica de Assis-SP, considerando o desempenho produtivo nos ciclos avaliados.

Termos para indexação: *Musa* sp; desempenho agronômico; regionalização; análise de agrupamento.

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Introduction

Banana is the world's most consumed fresh fruit, which has, in addition to excellent nutritional characteristics, low production cost and high productive potential, making it present in the daily diet of millions of people, making banana farming essential for world food safety (GERUM; SANTANA; ROCHA, 2020; IICA, 2021). The global banana production in 2019 was approximately 116 million tons (FAOSTAT, 2021), with Brazil being the fourth producer, with 6.75 million tons, with the state of São Paulo standing out, with estimated production of 1.06 million tons per year (TURCO et al., 2021).

Phytosanitary problems, inadequate management and reduced number of cultivars with high productive potential and adapted to the environmental cultivation conditions contribute to the low productivity of Brazilian banana crops, which is currently 15 Mg ha^{-1} (LIMA et al., 2018; AGRIANUAL, 2021). Among these problems, water deficit and extreme temperatures stand out (UWIMANA et al., 2021), in addition to pests and diseases, in particular fungi causing Yellow Sigatoka (*Mycosphaerella musicola*, Leach), Black Sigatoka (*Mycosphaerella fijiensis* Morelet) and Fusarium wilt (*Fusarium oxysporum* f. sp. *cubense*); and nematodes such as *Radopholus similis* and the weevil borer (*Cosmopolites sordidus*) (SILVA et al., 2016a; ALAKONYA et al., 2018).

The main banana cultivars commercially grown in Brazil are Prata, Maçã, Cavendish and Terra. In each of these subgroups, there are cultivars that compose the market, such as "Grande Naine" and "Willians" (MARTINS et al., 2011), from the Cavendish subgroup; "Prata-Anã", "BRS Platina" (AMORIM et al., 2012) and "Prata Catarina" (LICHTEMBERG et al., 2011), from the Prata subgroup, in addition to "Maçã" and "BRS Princesa" (SOUZA et a., 2021), from the Maçã subgroup. According to Silva et al. (2016b), the main banana cultivars commercially grown in Brazil belong to the Prata type, mainly "Prata-Anã".

The choice of the cultivar to be used depends mainly on the destination of the fruit to be produced, whether for fresh consumption or for industry (SILVA et al., 2019). However, the characterization of the agronomic performance in a specific environment is essential for the regionalization of cultivars and also for the identification of genetic materials tolerant to the main pests and diseases, early cycle, with small size and better vegetative development, in order to improve the banana cultivation activity in several Brazilian regions (BORGES et al., 2011; ROQUE et al., 2014; LIMA et al., 2018).

In the mid-20th century, race 1 of *Fusarium oxysporum* f.sp *cubense* caused greate losses to Brazilian and world banana production; commercial crops of cultivars from the Gros Michel and Maçã subgroups, the latter with high susceptibility to the fungus, were replaced by resistant cultivars such as Nanica and Nanicão, from the Cavendish subgroup. During this period, the Vale do Ribeira region, considered a major banana producer, began to share this responsibility with the Planalto Paulista region, state of São Paulo, where banana cultivation advanced in recent years, and allowed banana growers to continue to produce bananas of cultivars from Gros Michel and Maçã subgroups (MARTINS et al., 2015; MARTINS; SUGUINO, 2016; BRASIL, 2018). In the last Levantamento Censitário das Unidades de Produção Agropecuária do Estado de São Paulo (LUPA Project), carried out by the Secretaria de Agricultura e Abastecimento (SAA), through the Coordenadoria de Assistência Técnica Integral (CATI) and the Instituto de Economia Agrícola (IEA), campaigns of 2016/17, this region had 923 ha cultivated with banana, with 321.7 ha in the municipality of Palmital (SÃO PAULO, 2019), showing the importance of the region chosen for the conduction of this study.

The aim of this work was to evaluate the agronomic profile of banana cultivars under the edaphoclimatic conditions of the geographic microregion of Assis, state of São Paulo, in order to propose new options for the region.

Material and methods

The experiment was carried out at São José Farm, Água do Pau d'Alho, Palmital - SP (22º 49'N; 50º 16'S and 400 m a.s.l.), in a dystroferric red latosol. The soil has very clayey texture (75% clay, 19% silt, 6% sand). The climate is Cfa, (Köppen), that is, moderately humid, without dry season, with precipitation in the driest month greater than 30 mm. It was observed that in the first and second cycles, the average monthly rainfall was 143.4 mm and 125.4 mm, respectively, meeting the crop demand. However, in the third cycle, the average monthly rainfall was 56.2 mm, showing water deficit that affected plants, especially in the months of October, November and December 2017, at the end of the production cycle. On the other hand, average monthly temperatures were within standards in the three production cycles, with values of 21.9 ºC, 22.9 ºC and 21.5 ºC, respectively. (Figure 1).

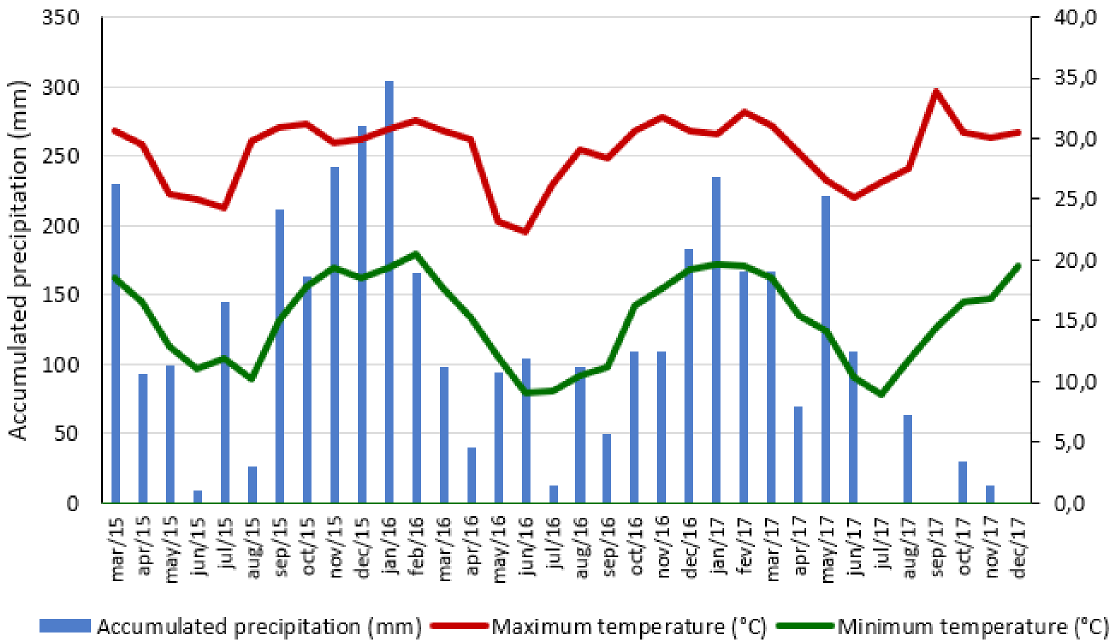

Figure 1. Accumulated precipitation (mm) and average maximum and minimum temperatures between March 2015 and December 2017. Palmital, SP. (Source: CIIAGRO, 2021).

Ten banana cultivars (Table 1) were evaluated during the three initial production cycles. Planting was carried out with previously acclimatized micropropagated seedlings, and fertilization consisted of the application of thermophosphate and organic matter; nutritional management was carried out according to soil analysis results and crop recommendations. Phytosanitary control was carried out during all production cycles, aiming at the rational management of the main diseases and pests. Plants were managed with tiller thinning, keeping the family scheme (mother – daughter – granddaughter). The experimental design was in randomized blocks, with four replicates. Each plot of 8.75 m^2 was composed of 5 plants, spaced 2.5 m in the row and 3.5 m between rows. The following characters were evaluated: a) plant height (H – m): obtained with the aid of tape measure, when the bunch is emitted, whose value refers to the distance between the ground level and the point of stalk exit; b) pseudostem perimeter (PP – m): measurement obtained with the aid of tape measure, at the time of the bunch emission at 30 cm from ground level; c) number of leaves at flowering (NLF): obtained by counting the number of functional live leaves (with 50% or more of green leaf blade) present on the mother plant at the time of flowering; d) number of leaves at harvest (NLH): obtained by counting the number of functional live leaves present on the mother plant at the time of bunch harvest; e) bunch mass (BM – kg): value referring to the mass of the newly harvested bunch, obtained with the aid of a platform scale with capacity of 50kg and precision of 10g; f) number of hands per bunch (NHB): obtained by counting the number of hands per bunch at the time of harvest; g) productivity (FY – Mg ha^{-1}): value obtained by multiplying the value of the bunch mass (BM) by the number of plants per hectare (1,140 plants ha^{-1}); h) pulp yield (PY – Mg ha^{-1}): yield result (FY) after removing the fruit peel values.

Data were submitted to analysis of variance (ANOVA), and averages were submitted to the Scott Knott cluster test, aiming to compare cultivars within the same cycle and the Tukey test of averages, to compare production cycles. The characteristics were compared through joint analysis and between the three evaluation cycles, when the ratios between the residual mean squares of individual analyses of variance of each cycle did not exceed 7:1, as proposed by Banzatto and Kronka (2006).

The multivariate clustering analysis technique (HAIR et al., 2009) was applied to data from the 10 cultivars under study, and the clustering statistical variable was formed by the set of variables explored in this work, so that the complete-linkage clustering algorithm was chosen using the Euclidean distance measure. To represent clusters, dendrogram (hierarchical tree) displayed in the profile diagram model was used, in which cultivars were listed along the horizontal axis while scaled along the vertical axis. This analysis was performed using the STATISTICA 13.5.0.17 application (TIBCO SOFTWARE INC., 2018).

Table 1. Description of banana cultivars evaluated in Palmital, SP, from 2015 to 2017.

Cultivar	Group	Subgroup	Description
Grande Naine	AAA	Cavendish	Small size, susceptible to Yellow and Black Sigatokas and resistant to Fusarium wilt
IAC 2001	AAA	Cavendish	Somaclonal variation of Nanicão cultivar, tolerance to Yellow Sigatoka
FHIA 02	AAAB	Cavendish	Williams x SH33-93 hybrid resistance to Yellow and Black Sigatoka and Fusarium wilt
FHIA 17	AAAA	Gros Michel	Gros Michel hybrid, medium size, resistance to Black Sigatoka and Fusarium wilt
Bucaneiro	AAAA	Gros Michel	Gros Michel hybrid, medium size, resistance to Black Sigatoka and Fusarium wilt
Calypso	AAAA	Gros Michel	Gros Michel hybrid, medium size, resistance to Black Sigatoka and Fusarium wilt
Ambrosia	AAAA	Gros Michel	Gros Michel hybrid, medium size, resistance to Black Sigatoka and Fusarium wilt
Thap Maeo	AAB	Maçã	Mysore variant, productive, small fruits, resistance to Yellow and Black Sigatoka and Fusarium wilt
BRS Princesa	AAAB	Maçã	Resulting from the crossing of the Yangambi nº 2 cultivar (AAB) with the M53 diploid (AA), resistance to Yellow and Black Sigatokas and Fusarium wilt
Caipira	AAA	Maçã	Known as 'Yangambi km 5', from West Africa, small fruits, resistance to Yellow and Black Sigatoka and Fusarium wilt

Source: LIMA et al. (2005); GARRUTI et al. (2012); WEBER et al. (2017); NOMURA et al. (2017); LIMA et al. (2018)

According to Nakamura et al. (2013), cluster analysis brings together multivariate statistical procedures that organize a set of individuals, for whom detailed information is known, into relatively homogeneous groups. This technique was used to explore similarities between banana cultivars under study, defining them in groups, considering simultaneously, in the first case, all variables observed for each individual and, in the second, all individuals in which the same measurements were performed.

Result and discussion

All characteristics evaluated showed significant differences between cultivars and crop cycles. Figure 1 shows that the average temperatures fluctuated within the appropriate limits for crop development throughout the evaluated period. The ratio between the mean square and the residual mean square of the analysis of variance was less than 7:1, being thus possible to compare the three cycles with each other.

Regarding the vegetative development characteristics (Tables 2 and 3), differences were individual by cultivars and not by the different banana cultivar subgroups (Cavendish, Maçã and Gros Michel).

In the three cycles, FHIA 17 and BRS Princesa cultivars had the highest average height (3.70 and 3.71 m, respectively), with no statistical difference between the three cycles. On the other hand, Grande Naine and IAC 2001 cultivars showed lower average height (2.73 and 2.78 m, respectively), with significant growth after the first cycle (Table 2).

Table 2. Height (H) and pseudostem perimeter (PP) (m) of different banana cultivars (*Musa* sp.) during three crop cycles. Palmital, SP.

Cultivars	H (m)				PP (m)			
	1st cycle	2nd cycle	3rd cycle	Mean	1st cycle	2nd cycle	3rd cycle	Mean
Grande Naine	2.55Db	2.80Da	2.86Ca	2.74	0.65Dc	0.76Bb	0.81Ca	0.74
IAC 2001	2.65Db	2.85Da	2.84Ca	2.78	0.69Cc	0.79Bb	0.88Ba	0.79
FHIA 02	2.66Dc	3.99Aa	3.44Bb	3.36	0.64Db	0.72Ca	0.76Da	0.71
FHIA 17	3.09Ab	4.05Aa	3.96Aa	3.70	0.83Ab	0.85Ab	0.94Aa	0.87
Bucaneiro	2.79Cb	4.06Aa	3.99Aa	3.61	0.73Cc	0.84Ab	0.92Aa	0.83
Calypso	2.97Bb	3.45Ca	3.43Ba	3.28	0.79Ba	0.78Ba	0.79Ca	0.79
Ambrosia	2.95Bb	4.08Aa	4.04Aa	3.67	0.70Cc	0.83Ab	0.89Ba	0.81
Thap Maeo	2.74Cc	3.53Bb	3.91Aa	3.39	0.54Eb	0.71Ca	0.75Da	0.67
BRS Princesa	3.07Ac	4.11Aa	3.96Ab	3.71	0.76Ba	0.77Ba	0.76Da	0.76
Caipira	2.59Db	3.41Ca	3.36Ba	3.12	0.49Eb	0.51Dab	0.56Ea	0.52
F	34.33**	273.21**	164.15**		36.05**	59.30**	56.79**	
CV (%)	2.73	1.88	2.27		5.81	3.77	4.12	

[1] Means followed by equal capital letters in the column do not differ from each other at 5% probability by the Scott-Knott test. [2] Means followed by equal lowercase letters on the row do not differ from each other at 5% probability by the Tukey's test.

Cultivars from the Cavendish subgroup usually have medium to low height as a genetic characteristic (NAPOLEÃO et al., 2021). However, small differences can be observed in different producing regions, as those observed by Weber et al. (2017) in the Northeastern region of Brazil, where increase in the height of Grande Naine cultivar plants was observed until the third production cycle, reaching 3.10 m at the end of the cycle, while, in Palmital, SP, the same cultivar reached 2.86 m also in the third cycle. Despite these values, no statistical difference in these variables was observed between the last two cycles, a trend also observed in most other cultivars.

Thap Maeo cultivar was the only one that showed growth in height until the third cycle, and FHIA 02 and BRS Princesa cultivars showed decrease in height in the third cycle in relation to the second. The water deficit recorded during the third production cycle in 2017 (Figure 1) may partially explain this behavior. Plant height tends to vary according to the edaphoclimatic conditions of the region, being an important plant characteristic to define the planting spacing to be adopted for each cultivar, which directly influences plant density and consequently, productivity (SILVA et al., 2016b).

FHIA 17 and Caipira cultivars had the highest and lowest mean pseudostem perimeter, respectively, with 0.87 and 0.52 m, respectively (Table 2). In the case of the Caipira cultivar, this average value was similar to that found in the northern region of Minas Gerais by Gonçalves et al. (2008). In this study, there was medium gain in stem perimeter, with the advance in the production cycles, except for Calypso and BRS Princesa cultivars, whose values remained constant throughout the experiment. Pseudostem perimeter is a very important feature in the characterization of cultivars, since it is related to plant vigor and ability to support the bunch weight (SILVA et al., 1999).

BRS Princesa cultivar showed the highest absolute number of leaves at flowering, ranging from 13.4 to 14.6, in the three production cycles; however, these values did not show significant differences from those obtained with Calypso, Ambrosia, Grande Naine and IAC 2001 cultivars, depending on the cycle evaluated. Grande Naine and Bucaneiro cultivars had the lowest mean number of leaves at flowering with 10.7 and 10.6 leaves, respectively (Table 3). When compared to values obtained by Weber et al. (2017), these last two cultivars had identical value for this parameter for the Bucaneiro cultivar in an experiment carried out in the Northeastern region of Brazil; however, FHIA 02 cultivar showed lower values, which again, shows the effect of regional climatic conditions on the development of cultivars.

Table 3. Number of leaves at flowering (NLF) and at harvest (NLH) of different banana cultivars (*Musa* sp.) during three cultivation cycles. Palmital, SP.

Cultivars	NLF				NLH			
	1st cycle	2nd cycle	3rd cycle	Mean	1st cycle	2nd cycle	3rd cycle	Mean
Grande Naine	8.8Cb	11.2Ba	12.0Aa	10.7	7.8Ba	8.2Ba	7.4Ba	7.8
IAC 2001	10.6Bb	11.6Cab	12.8Aa	11.7	9.6Aa	9.6Aa	9.8Aa	9.7
FHIA 02	10.2Ca	11.8Ca	11.6Ba	11.2	7.8Bb	10.0Aa	9.8Aa	9.2
FHIA 17	11.8Ba	12.2Ba	12.0Ba	12.0	9.8Aa	10.4Aa	10.2Aa	10.1
Bucaneiro	10.2Ca	10.6Ca	11.0Ba	10.6	8.2Ba	8.6Ba	8.8Aa	8.5
Calypso	13.4Aa	12.8Ba	13.4Aa	13.2	10.4Aa	9.4Aa	9.4Aa	9.7
Ambrosia	11.0Bb	12.6Bab	12.8Aa	12.1	6.6Cb	8.0Ba	7.0Bab	7.2
Thap Maeo	11.2Ba	11.4Ca	11.6Ba	11.4	6.6Ca	6.4Ca	6.2Ba	6.4
BRS Princesa	13.6Aa	13.4Aa	14.6Aa	13.9	10.6Aa	10.2Aa	9.4Aa	10.1
Caipira	11.4Bab	13.0Aa	10.8Bb	11.7	6.8Ca	5.8Ca	6.8Ba	6.5
F	8.93**	5.19**	4.24**		13.89**	20.81**	11.84**	
CV (%)	9.73	7.24	10.25		11.15	8.96	11.31	

[1]Means followed by equal capital letters in the column do not differ from each other at 5% probability by the Scott-Knott test. [2]Means followed by equal lowercase letters on the row do not differ from each other at 5% probability by Tukey's test.

FHIA 02, FHIA 17, Bucaneiro, Calypso, Thap Maeo and BRS Princesa cultivars showed no differences in the number of leaves at flowering, regardless of cycle evaluated. Grande Naine, IAC 2001 and Ambrosia cultivars showed tendency to increase the number of leaves at flowering from the 2nd cycle onwards. Caipira cultivar had higher average number of leaves at flowering in the 2nd cycle (13.0 leaves) than in the 3rd cycle (10.8 leaves), presenting a different behavior when compared to the others, demonstrating a probable greater susceptibility of this cultivar to water deficit occurred in the last cycle, which negatively affected its vegetative development in terms of leaf emission (Table 3 and Figure 1).

IAC 2001, FHIA 17, Calypso and BRS Princesa cultivars had the highest mean number of leaves at harvest (9.7; 10.1; 9.7 and 10.1 leaves, respectively) and Caipira and Thap Maeo cultivars had the highest mean number of leaves at harvest (6.5 and 6.4 leaves, respectively). According to studies carried out by Lessa et al. (2012) and Silva et al. (2016b), plants that retain greater number of leaves at harvest tend to have heavier bunches. This relationship was observed only in cultivars from the Gros Michel subgroup; with regard to cultivars from the Cavendish and Maçã subgroups, it was not possible to identify the correlation between number of leaves at harvest and bunch mass (Tables 3 and 5). It is important to emphasize that phytosanitary management was effectively carried out during all production cycles, so that diseases and pests were kept under control.

FHIA 02 and Ambrosia cultivars tended to increase the number of leaves at harvest from the 2nd cycle onwards, while the other cultivars did not show differences in the number of leaves at harvest, regardless of cycle evaluated (Table 3).

The average number of leaves at flowering was greater than the average number of leaves at harvest for all cultivars in all cycles. This occurs because, after bunch emission, the plant no longer emits new leaves, prioritizing fruiting. Environmental factors, diseases and pests can destroy the remaining leaves until fruiting, influencing fruit set.

According to Lessa et al. (2012), the number of leaves at harvest is essential for determining productivity; however, in the first cycle, banana production is greatly influenced by climatic conditions.

In relation to yield characteristics (Tables 4 and 5), Grande Naine and IAC 2001 (Cavendish group) cultivars presented means with higher fruit yield (29.62 and 29.06 Mg ha^{-1}), pulp yield (23.26 and 22.06 Mg ha^{-1}) and bunch mass (28.18 and 27.81 kg), in the three cycles evaluated. Silva et al. (2019) studied five banana genotypes in the region of Ceres, GO, and observed that the yield of the Grande Naine cultivar was 28.42 Mg ha^{-1} in the first cycle and 28.28 Mg ha^{-1} in the second cycle, which, when compared to results obtained here, respectively, were lower and higher than values found for this cultivar in Palmital, SP.

Regarding the yield values of the IAC 2001 cultivar, it was observed that the results obtained in Tangará da Serra, MT, in a study carried out by Lima et al. (2018), were lower when compared to those obtained for this cultivar in the microregion of Assis, SP (southeastern region). These results effectively exemplify that these differences in yield indicate great influence of the local climatic characteristics in each cultivar. According to Figure 1, the year 2017 presented total rainfall (1,073.9 mm) below the average for the region (1,278.3 mm), with marked water deficit for the crop mainly in the months of

September and December, which corresponds to the fruit filling period, negatively affecting the yield values of the third cycle. On the other hand, temperatures were within the appropriate limits during the three crop cycles.

Cultivars from the Maçã subgroup (Caipira, BRS Princesa and Thap Maeo) were the least productive in this study. In the studies by Lima et al. (2018), yield values even lower than those of this work were obtained for BRS Princesa cultivar, with 6.90 and 6.74 Mg ha^{-1}, in the first and second cycle, respectively, so that the average values (Table 4) demonstrate excellent adaptation of this material when cultivated in Palmital, SP. The results obtained in this study show that the BRS Princesa cultivar is an option for the production of Maçã subgroup in this region, mainly because it is a genetic material resistant to *Fusarium oxysporum* f. sp. *cubense*.

Table 4. Fruit (PY) and pulp (PY) yields (Mg ha^{-1}) of different banana (*Musa* sp.) cultivars during three cultivation cycles. Palmital, SP.

Cultivars	FY (Mg ha^{-1})				FY (Mg ha^{-1})			
	1st cycle	2nd cycle	3rd cycle	Mean	1st cycle	2nd cycle	3rd cycle	Mean
Grande Naine	24.71Ab	31.44Aa	32.72Aa	29.62	19.91Ab	24.91Aa	24.95Aa	23.26
IAC 2001	25.28Ab	30.06Aa	31.85Aa	29.06	19.05Ab	22.90Aa	24.22Aa	22.06
FHIA 02	20.99Bb	23.05Ba	22.81Ba	22.28	15.15Cb	17.05Ba	16.77Bab	16.32
FHIA 17	21.96Bb	30.09Aa	31.35Aa	27.80	17.13Bb	23.73Aa	24.49Aa	21.78
Bucaneiro	19.52Cb	24.01Ba	23.25Ba	22.26	14.94Cb	17.87Ba	17.50Ba	16.77
Calypso	19.36Cb	22.60Ba	22.25Ba	21.40	14.67Cb	16.81Ba	16.57Ba	16.02
Ambrosia	17.39Db	19.42Ca	20.33Ca	19.05	13.11Db	14.56Cab	15.12Ca	14.26
Thap Maeo	11.34Eb	12.69Dab	14.26Da	12.76	8.23Eb	9.08Db	10.71Da	9.34
BRS Princesa	10.60Eb	14.01Da	14.88Da	12.98	7.77Eb	10.53Da	11.23Da	9.84
Caipira	9.18Eb	12.25Da	12.14Ea	11.19	7.35Eb	9.40Da	9.59Da	8.78
F	169.01**	104.02**	138.10**		66.58**	89.45**	142.52**	
CV (%)	8.54	7.27	6.34		9.15	8.33	6.35	

[1]Means followed by equal capital letters in the column do not differ from each other at 5% probability by the Scott-Knott test. [2]Means followed by equal lowercase letters on the row do not differ from each other at 5% probability by Tukey's test.

In addition, the productive potential characteristic of each type of cultivar must be considered, since cultivars from the Maçã subgroup usually have lower yields than cultivars from the Cavendish, Prata and Gros Michel subgroups, due to the fact that their bunches are comparatively smaller (CAMOLESI et al., 2012; GARRUTI et al., 2012).

Regarding pulp yield (Table 4), it was observed that the results followed the same trend of fruit yield. When analyzing pulp yield (relationship between fruit yield and pulp yield), it was observed that Grande Naine, FHIA 17 and Caipira cultivars were those that presented the highest values in the three evaluated cycles, despite the water deficit observed in the third cycle (Figure 1).

Pulp yield is an important parameter for identifying potential cultivars for use in agroindustry, since the higher the pulp yield (directly related to the peel/pulp ratio), the better the use of fruits in the industry. The maturation stage directly influences this parameter, since with the ripening process, the peel dehydrates more than the pulp, increasing yield (DAMATTO JUNIOR. et al. 2005).

With regard to bunch mass, the highest values recorded were for Grande Naine and IAC 2001 cultivars (Cavendish subgroup) (Table 5) in the three evaluated cycles; however, they did not differ from FHIA 17 cultivar (Gros Michel subgroup), in the last two cycles. Cultivars from the Maçã subgroup (Thap Maeo, Caipira and BRS Princesa) produced bunches with the lowest masses in the three cycles, as expected. FHIA 02 cultivar, from the Cavendish subgroup, showed productive behavior similar to cultivars from the Gros Michel subgroup.

Table 5. Bunch mass (BM - kg) and number of hands per bunch (NHB) of different banana cultivars (*Musa* sp.) during three cultivation cycles. Palmital, SP.

Cultivars	BM (kg)				NHB			
	1st cycle	2nd cycle	3rd cycle	Mean	1st cycle	2nd cycle	3rd cycle	Mean
Grande Naine	23.46Ab	29.91Aa	31.16Aa	28.18	7.6Db	9.0Ca	9.2Ca	8.6
IAC 2001	24.16Ac	28.65Ab	30.62Aa	27.81	7.4Dc	8.4Cb	9.6Ca	8.5
FHIA 02	20.08Bb	22.00Ba	21.99Ba	21.36	8.2Ca	8.8Ca	8.4Da	8.5
FHIA 17	20.63Bb	28.84Aa	29.74Aa	26.40	9.8Aa	10.4Aa	9.6Ca	9.9
Bucaneiro	18.68Cb	22.52Ba	22.20Ba	21.13	9.0Ba	9.6Ba	9.4Ca	9.3
Calypso	18.42Cb	21.66Ba	21.04Ba	20.37	8.4Cb	9.4Ca	8.4Db	8.7
Ambrosia	17.03Cb	18.91Ca	19.81Ca	15.25	7.8Cb	8.8Ca	9.2Ca	8.6
Thap Maeo	10.99Db	12.51Dab	13.93Da	12.48	10.2Ab	10.8Ab	12.2Aa	11.1
BRS Princesa	10.38Db	13.71Da	14.65Da	12.91	8.0Cb	10.0Ba	10.6Ba	9.5
Caipira	9.09Db	11.97Da	12.24Ea	11.10	7.0Db	8.6Ca	8.2Da	7.9
F	77.66**	117.42**	148.61**		15.27**	9.38**	18.95**	
CV (%)	7.92	6.64	5.88		7.12	6.29	6.46	

[1]Means followed by equal capital letters in the column do not differ from each other at 5% probability by the Scott-Knott test. [2]Means followed by equal lowercase letters on the row do not differ from each other at 5% probability by Tukey's test.

Variable number of hands per bunch (Table 5) showed individual differences between cultivars and not between different cultivar subgroups (Cavendish, Maçã and Gros Michel). Thap Maeo cultivar in all cycles (10.20, 10.80 and 12.20 hands bunch^{-1}) and FHIA 17 cultivar in the 1st and 2nd cycles (9.8 and 10.40 hands bunch^{-1}) showed, respectively, the first and second highest values for this variable when compared with the other cultivars. Observing data for Grande Naine and IAC 2001 cultivars, it was possible to verify that this value increases with the advance in the harvest cycles and the same trend can be observed in cultivars from the Maçã subgroup, which is not observed for all cultivars from the Gros Michel subgroup, since only the Ambrosia cultivar showed this behavior.

In commercial terms, the number of hands per bunch is of great importance as it is a marketing unit in some regions (GONÇALVES et al., 2008; SANTOS;CARNEIRO, 2012). However, this work clearly shows that this relationship has a strong genetic characteristic, not being indicated for comparisons between the different banana cultivars.

The hierarchical tree points to the existence of 2 to 10 different clusters (Figure 2), since each observation (cultivar) forms a single group so that the number of clusters is equal to the number of observations. At half of the total linkage distance (90), 3 genetic clusters were observed.

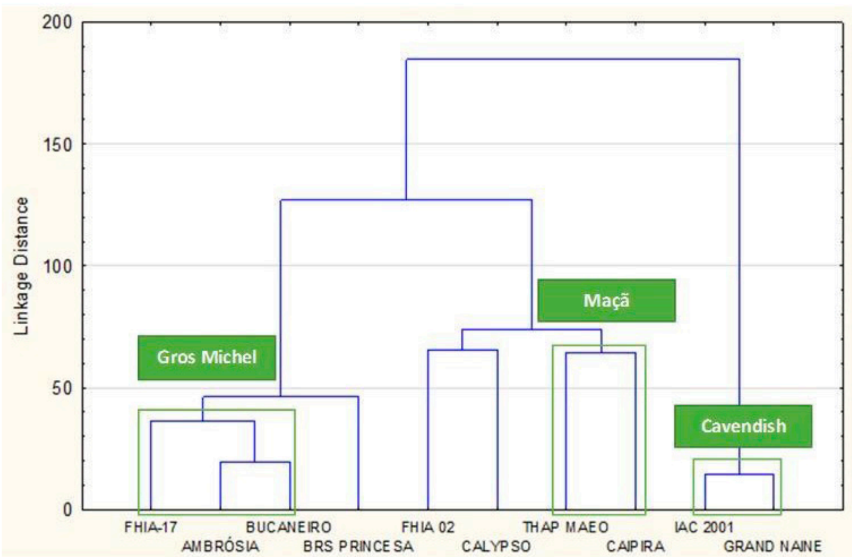

Figure 2. Hierarchical clustering tree for 10 cultivars, complete linkage method with Euclidean distance. Palmital, SP.

IAC 2001 and Grande Naine cultivars (Cavendish subgroup) differ from the others by composing a single cluster from the linkage distance 15, which remained isolated up to distance 200 (maximum). Among the other cultivars, clustering of cultivars from Gros Michel and Maçã subgroups was observed, with greater emphasis on Ambrosia and Bucaneiro cultivars, in addition to Thap Maeo and Caipira (Figure 2).

BRS Princesa cultivar and the other cultivars from the Gros Michel subgroup behaved in a similar way, with linkage distance of less than 50. The behavior of the FHIA 02 cultivar in relation to the others from the Cavendish subgroup, its similarity to the Calypso cultivar and its presence in the group formed by cultivars from the Maçã subgroup (linkage distance 80) stand out.

The vegetative and productive development found in FHIA 02 cultivar below the other cultivars from the Cavendish subgroup denotes the negative interaction of the genotype with the soil and climate characteristics of the microregion. The low average minimum temperatures recorded during the winter, associated with periods of water deficit characteristic of the regional climate, had negative impact on this cultivar (Figure 1).

Finally, the results obtained in the tree clustering analysis reinforced and complemented those found through the univariate technique of Scott-Knott, especially with regard to the productive superiority of cultivars from the Cavendish subgroup and the low production rates of the FHIA 02 cultivar.

Conclusions

Grande Naine and IAC 2001 cultivars, belonging to the Cavendish subgroup, are the most suitable for cultivation in the geographic microregion of Assis, São Paulo, considering the production performance in the three evaluated production cycles.

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