

Agronomic performance of banana genotypes under agroecological management in the semi-arid region of Paraíba, Brazil

Introduction: Northeastern Brazil is a The banana producing zone where tree is a relevant culture for Brazilian Northeast, however the selection of banana tree genotypes has significantly increased crop more and more potentials for certain area and cultivation form provides increment in the productivity.

Aims: The study aimed to evaluate the agronomic performance of different banana-tree genotypes under agroecological management in the Upper Sertão region of Paraíbanortheastern Brazil.

Place and Duration of Study: The experiment was conducted in the orchard of the Federal Institute of Education, Science and Technology of Paraíba, Sousa campus.

Methodology: The experiment was conducted in the orchard of the Federal Institute of Education, Science and Technology of Paraíba following a With randomized complete experimental block design with nine where the treatments (consisted of nine banana tree genotypes)in four replications. T1: Pacovan Ken; T2: Prata Anã; T3: PHIA-18, T4: Prata Graúda; T5: Grande Naine; T6: Maçã comum; T7: Princese; T8: Tropical and T9: Terra. The Bbanana tree seedlings used as in the planting material were provided by acquired in the Empresa Campo Biotecnologia., of Cruz das Almas-BA. They were produced by the micropropagation processof plantlets. Cropping wasWas used handled following agroecological practices.for all of the cultural treatments cultivation. In the end of the first cycle was checked to the growth variables and production.Growth measurements and yield data regarding the the first crop cycle were recorded.

Results and conclusions: There was significant effect for all of the agronomic characters of the banana tree genotypes.Significant differences in yields and yield traits within banana-tree genotypes were observed. Prata Graúda and Grande Naine genotypes came out on top in terms of agronomic performance under agroecological practices.

Conclusion: There is genetic variability for the appraised agronomic characteristics in nine genotypes. The genotypes Prata Graúda and Grande Naine presented satisfactory acting when cultivated under agroecological management, in climatic conditions of the Upper Interior Paraibano.

Keywords: *Musa sp*, auto-sustainability, fitotecnia, fruticultura, interior.

1. INTRODUCTION

The banana tree (*Musa sp*) is a tropical fruitcrop ful one tropical of great economical importance with some quality traits such as source of energy, good appreciation for the flavor, of the fruit, being easy consumption, source energy, vitamins and minerals contents, including its besides the basslow cost for the consumer [1]. In Brazil, it's planted in all of the states of the country which is being the fourth fruitful largest producer of banana, and that one being the seventh exported fruit of the country [2].

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The amount of banana produced nationwideally in 2016 was equivalent to 6.764.324 tons of banana bunches with medium income of 14.401 Kg ha⁻¹, being the Northeast area of the country the largest producing with 2.285.796 tons, with prominence in Bahia, Pernambuco and Ceará [3]. being cultivation of the banana tree for the production of wide usually climbs with conventional handling.

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Because, in fruitful, the organic production in Brazil is extremely incipient, even for fruitful of great national expression, as citrus, banana, papaya, mango, grape, there are still no organic systems of commercial production consolidated [4]. However, the demand for maintainable products is growing because of the need in the consumption of these products.

The handling agroecological is one of the more maintainable agricultural systems under all of the aspects and intends to rescue the farmers' human dignity that tamed plants and animals along the history and they maintained great part of the genetic diversity used by the human species [5]. Characterized by cultural practices as rotation, consortium, organic manuring, reuse of vegetable remains, planting of repellent plants, production of **botanical bio**-pesticides, exemption of pesticides and other inorganic inputs [6]. It was known that there could be many genetic and environmental effects on the yield [7]

Studies that seek to evaluate the agronomic acting of banana tree genotypes are primordial to select those that better they behave in certain edaphoclimatic conditions and cultivation systems [8,9,10]. The most relevant characters for the evaluation and selection of superior genotypes in this fruitful one are cycle of the culture, plant height, pseudocaule perimeter, fresh mass of bunch, number of bunches and of fruits for bunch, besides the length and diameter of the fruits [11].

In Upper Paraíba interior, few banana varieties are produced, with prominence for the varieties Nanica, Prata comum and Pacovan. This way, they are necessary studies returned for the productive potential of new banana genotypes that can be incorporate and adapted to the edaphoclimatic conditions of the area. Besides, with agroecological management in banana farming are scarce [2], therefore the present work aimed to evaluate the agronomic acting of different banana tree genotypes under agroecological management in Upper Paraíba interior .

2. MATERIAL AND METHODS

2.1. Location of the Experiment

The experiment was conducted in the orchard of the Federal Institute of Education, Science and Technology of Paraíba (IFPB), in the section of horticulture in Sousa campus, located in the irrigated perimeter in São Gonçalo, 6°45' latitude S, 38°13' longitude W and altitude of 223 m, in a soil Neossolo Flúvico. In agreement with the climatic classification of Köppen, adapted Brazil [12], the climate of the area is type BSh, representing climate hot and dry semi-arido, with medium precipitation from 700 to 900 mm year⁻¹, annual medium temperature of 26,1°C and annual medium evaporation from 1000 to 1100 mm [13].

2.2. Origins of the seedlings

The banana tree seedlings used in the planting were acquired in the Empresa Campo Biotecnologia, in Cruz das Almas - BA, produced by the micropropagation process, being transferred initially for plastic sacks filled out with appropriate substrate. After period of acclimatization in covered nursery (50% shade) for 90 days, they were transplanted for holes of 50cm x 50cm x 50cm, previously fertilized with 4 kg of manure by plant, with a spacing of 3,0 m x 2,0 m.

2.3. Treatments and Experimental Design

To evaluation of the vegetative growth, the experimental design was a randomized block design, with nine treatments (genotypes), four repetitions, constituting like this thirty six portions, experimental unit constituted by three plants, totaling hundred eight plants. The treatments consisted of T1: Pacovan Ken; T2: Prata Anã; T3: PHIA-18, T4: Prata Graúda; T5: Grandet Naine; T6: Maçã comum; T7: Princesa; T8: Tropical and T9: Terra.

For evaluation of the reproductive phase, the experimental design was randomized block design, with seven treatments (genotypes), four repetitions, constituting like this twenty-eight portions, experimental unit constituted by three plants, totaling eighty four plants. Due to the differences of the production cycle (days for flowering and fructification) the genotypes T8 (tropical) and T9 (terra) they were not appraised.

2.4. Irrigation system

74 The irrigation system used in the area was of the type micro sprinkler, tends the originator a flow of
75 103 L. h⁻¹, with wetting of every experimental area. When noticing the water deficit left the ballerina of
76 the microsprinkler, maintaining the flow of the personal computer and increasing the irrigation sheet.

77 **2.5. Cultural treatments**

78
79 The cultural treatments were accomplished in agreement with the agroecological methods. Weeding
80 manual was accomplished; manuring with bovine manure, sheep, bovid and poultry in the foundation
81 and every 30 days in agreement with the needs of the culture by soil analysis. The chemical analysis
82 and of fertility was accomplished in the Laboratory of Soils and Mineral Nutrition (IFPB), using the
83 methodologies used by the [14], and the data are presented in the Table 1.

84 Table 1. Chemical analysis and of fertility of the soil before and during the cultivation of the different
85 banana tree genotypes, IFPB, Sousa, 2015.

Chemical analysis and of fertility										
Before the cultivation										
pH	P	K	Na	Ca ²⁺	Mg ²⁺	Al ³⁺	H ⁺ + Al ³⁺	SB	CTC	V
(H ₂ O)	(mg dm ⁻³)			(cmol _c dm. ₃)						(%)
7.4	730	0.40	0.37	7.0	4.1	0.0	0.0	11.87	11.87	100
During the cultivation										
6.6	762	0.33	0.12	5.6	2.5	0.0	0.7	8.6	9.3	92

86
87 Note: pH: hydrogen potential; P: phosphorus;; K: potassium; In the: sodium; Ca²⁺: calcium; Mg²⁺:
88 magnesium; Al³⁺: Aluminum; SB: sum of bases; CTC: total cation exchange capacity; V: saturation for
89 base.

90
91 Dead covering was accomplished with the cultural remains of the own banana tree and of the
92 spontaneous plants with the purpose of reducing the loss of water for the evaporation; biweekly was
93 accomplished defoliates, being cut accomplished well in the base of the close petiole to the
94 pseudocaule; the rough-hewing was accomplished monthly after the evaluation through "Lurdinha",
95 where it was driven the plant mother, daughter and granddaughter distanced amongst themselves
96 with the purpose of reducing the density of plants for hole, impeding like this, the competition for
97 nutrients and the shoring was accomplished with wood stakes. During all of the periods of transport,
98 the experiment was taken temperature measures, humidity and precipitation as presented in the
99 figure 1.

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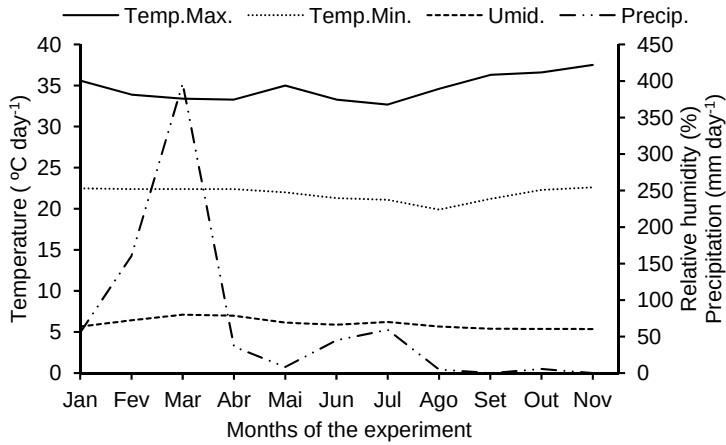


Figure 1. Values for the data of temperatures (°C), relative humidity of the air (%) and rainfall precipitation during the transport ((January to November) of the experiment), in function of the cultivation of different banana tree genotypes under agroecological management, appraised during the first production cycle, IFPB, Sousa, 2015.

2.6. Analyzed variables

The evaluations of the agronomic characteristics were accomplished monthly after the definitive planting, being determined the following parameters:

Height of the plant: using graduate measuring tape in centimeters, being measured from the base of the plant to the apical meristem, and the expressed data in centimeters for plant;

Perimeter of the pseudocaul: certain with aid of a graduate measuring tape in centimeters, accomplished to 10 cm above the base of the soil;

Number of tillers born for plant: took place the counting of the total number of born tillers born for plant;

Days of the planting to the flowering: period understood among the transplanting of the genotypes in field and the emission of the heart;

Days of the flowering the harvest: period understood between the emission of the heart and the harvest of the bunch;

Weigh of the bunch: they were heavy, being used balances and the expressed results in kilograms;

Number of bunches for bunch and number of fruits for bunches: took place the counting of the total number of the variables for bunch;

Weigh of the fruit: certain in the central fruit of the row it expresses fruits of the second bunch, being expressed results in grams for fruit;

Length of the fruit: accomplished with aid of a measuring tape, in the curvature it expresses of the central fruit of the second bunch, in centimeters;

Diameter or lateral calibration of the fruit: accomplished with digital caliper, measured in the medium part, in the sense of the length of the central fruit of the second bunch, and the results in millimeters for fruit .

2.7. Statistical analysis

The results were submitted for the variance analysis (tests F, 1 and 5%) and the averages of the data compared by the test of Tukey to 5% of probability, using the statisticians program SISVAR version 5.6 [15].

3. RESULTS AND DISCUSSION

3.1. Vegetative phase

In the Table 2 is the variance analysis for the variables height, perimeter of the pseudocaul, number of tillers for plant, days of the planting to the flowering, in function of the cultivation of different banana tree genotypes. Significant effect was observed for all the analyzed variables, demonstrating that the appraised factor influences directly in these parameters.

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Table 2. Summary of the analysis of variance of the variables height (HEIG), perimeter of the pseudocaule (PPC), number of tillers for plant (NTP), days of the planting to the flowering (DPF), in function of the cultivation of different banana tree genotypes under agroecological management, appraised during the first production cycle, IFPB, Sousa, 2015.

Variation source	GL	Medium square			
		HEIG (cm)	PPC (cm)	NTP	DPF (dias)
Block	3	4.43*	3.91*	0.32 ^{ns}	0.79 ^{ns}
Genotype	8	22.76**	35.52**	5.01**	24.48**
CV (%)		6.08	4.07	21.68	3.41
Average		402.72	67.21	3.50	393.21

** significant (P <0.01); * significant (P <0.05); ns: no significant

In relation to height of the plant (Table 3), was verified the banana tree genotypes that presented larger values were Terra and Tropical, while the genotypes PHIA-18, Prata anã and Grande Naine presented smaller load in height. Possibly for the own characteristics of those genotypes, because second [16], the cultivars them Pacovan Ken and Terra belong to high, when adult group of load banana trees crossing 4m of height, while the genotypes Prata Anã and Grande Naine belong to the low, when adult group of load banana tree the height doesn't cross 2m of height. The genotypes Maça, Princesa and Tropical they belong to the medium, when adult group of load banana trees varying from 2 to 4m.

Similar results were found for [8] evaluating the agronomic acting of banana tree genotypes in the Recôncavo of Bahia, they verified values of 2.78 and 2.52 m for the genotype Prata Anã and PHIA-18, in the first cultivation cycle. As [17] the height is an important parameter to determine the energy of the plant, the handling of the culture, because this determines the easiness or difficulty in the crop of the bunches of the banana tree. Therefore, genotypes with low stature are the favorite ones for the farmers, once practices as the not shoring need and the increase in the planting density lead to a larger economical return [18].

Table 3. Summary of the analysis of variance of the variables height (HEIG), perimeter of the pseudocaule (PPC), number of tillers for plant (NTP), days of the planting to the flowering (DPF) and days of the flowering the harvest (DFH) in function of the cultivation of different banana tree genotypes under agroecological management, appraised during the first production cycle, IFPB, Sousa, 2015.

Genotypes	Variables				
	HEIG	PPC	NTP	DPF (days)	DFH (days)
T1	453.00 AB	65.08 BC	2.92 CD	388 BC	72 E
T2	354.75 D	60.91 CD	3.91 BCD	349 D	135 B
T3	331.75 D	59.66 CD	4.08 AB	363 BC	106 C
T4	370.16 CD	64.16 BC	3.66 BCD	367 BC	126 B
T5	352.50 D	57.50 D	5.08 A	393 BC	86 D
T6	337.25 CD	70.33 B	2.25 D	417 AB	151 A
T7	417.91 BC	67.67 B	3.58 BCD	428 A	101 C
T8	448.35 B	79.83 A	2.58 CD	442 A	-
T9	508.83 A	79.75 A	3.50 BCD	-	-

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174 * Genotypes (T1: Pacovan Ken; T2: Prata Anã; T3: PHIA-18, T4: Prata Graúda; T5: Grande Naine;
175 T6: Maçã Comum; T7: Princesa; T8: Tropical and T9: Terra).

176
177 In the same way, the perimeter of the pseudocaule (PPC) was superior statistically in the Tropical and
178 Terra variety, at the time that the Grande Naine genotype was what obtained smaller equivalent PPC
179 to a reduction of 27.96% if compared to the Terra (Table 3).

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180 [19] evaluating the growth, the phenological cycle and the production of five cultivate of banana tree in
181 subtropical conditions, they found circumference of the pseudocaule of 62.6 cm to 71.8 cm,
182 respectively presented for the cultivate Prata Anã and PHIA 18, values those inferior to the found in
183 this work. This characteristic assumes importance in the genetic improvement of the banana tree,
184 once it's related to the energy of the plant, besides contemplating in the capacity of sustentation of the
185 bunch and in the susceptibility to the tipping [20].

186 The genotype Grande Naine presented larger tillering and the genotype Maçã Comum was inferior in
187 relation to other genotypes (Table 3). in agreement with [19] the number of tillers is a very important
188 parameter when the agronomic acting is evaluated of cultivate or genotypes, because it allows the
189 continuity of the family, as well as the productions of the following cycles. For small producers, the
190 knowledge on data of the presented larger tillering and the genotype potential of the cultivate makes
191 possible the production of their own seedlings, reducing the costs with the acquisition of the same
192 ones. These same authors to the they evaluate the genotype Grande Naine and PHIA-18 produced in
193 Botucatu - Paulo Paulo, they obtained observed averages of 5.5 and 2.6 tillers for plant, respectively.

194 In the Table 3 the data regarding the necessary days for the flowering of the different genotypes. It
195 was verified that the latest genotypes were Tropical and Princesa, however the most precocious
196 genotype was Prata Anã in the conditions in that the experiment was accomplished. The more
197 precocious the fastest genotype will be the farmer's financial return, therefore, the genotype Prata
198 Anã presents potentiality to be produced in the conditions in the Paraibano Semiárid.

199 [19] evaluating the growth, the phenological cycle and the production of five cultivate of banana tree in
200 subtropical conditions, they observed inferior values to the obtained in this work in what refers to the
201 period between the planting and flowering of the Prata Anã (302 days). [21], studying different
202 genotypes in the climatic conditions of Botucatu, São Paulo, they verified that the genotype Prata Anã
203 needed 327 days to begin the flowering. As [22] in the edaphoclimatic conditions of Juazeiro, Bahia,
204 the genotype Prata Anã presented first production cycle (of the planting to the first harvest) of 347.2
205 days, while for the second production cycle (between the plant-mother's crop and the one of the plant-
206 daughter) they were necessary 224.6 days.

207 In the data regarding the period understood between the flowering and the crop of the bunch, was
208 observed the most precocious genotypes were Pacovan Ken, following by Grande Naine. In
209 compensation, the latest genotypes, in other words, that need larger period of time for the formation
210 and completes maturation of the fruits, they were the genotypes Maçã Comum and the Prata Anã
211 (Table 3). precocious Genotypes are relevant for the producing of banana, especially, under the
212 economical point of view, because it results in the obtaining of successive cycles of production in
213 smaller space of time, increasing the production and the productivity [23].

214 [19], studying the growth, the phenological cycle and the production of different banana tree varieties
215 in subtropical conditions, they found superior values to the of this work for Grande Naine (117 days).
216 [24] evaluating the growth and the production of genotypes of banana trees in subtropical climate,
217 they verified that Grande Naine presented 154 days between the flowering and the crop of the bunch.
218 [25] they observed 131 days between the flowering and harvest for the banana tree Pacovan Ken in
219 the Valley Siriji River, Pernambuco, being later than this study, maybe the agroecological
220 management has influenced precocity.

221 222 3.2. Reproductive phase

223
224 For the variables weight of the bunch, numbers of bunches for bunch, number of fruits for bunch,
225 weight of the fruit, length of the fruit and diameter of the fruit, in function of the different appraised

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genotypes in the first production cycle, was verified that all the production variables presented significant effect (Table 4).

Table 4. Summary of the analysis of variance of the variables weight of the bunch (WB), numbers of bunches for bunch (NBB), number of fruits for bunch (NFB), weight of the fruit (WF), length of the fruit (LF) and diameter of the fruit (DF) in function of the cultivation of different banana tree genotypes under agroecological management, appraised during the first production cycle, IFPB, Sousa, 2015.

Medium square							
Variation source	GL	WB (kg)	NBB	NFB	WF (g)	LF (cm)	DF (mm)
Block	3	0.40 ^{ns}	0.85 ^{ns}	0.93 ^{ns}	0.36 ^{ns}	0.40 ^{ns}	0.60 ^{ns}
Genotype	6	15.51**	4.23**	3.21*	7.86**	6.91**	5.57**
CV (%)	-	15.39	11.14	17.11	24.30	9.94	9.09
Average	-	10.25	6.71	82.43	120.68	17.64	40.17

** significant (P < 0.01); * significant (P < 0.05); ns: no significant

The data of the weight of the bunch of the different appraised genotypes demonstrated better acting in the genotypes Prata Graúda, following by PHIA-18, however, the genotypes Pacovan Ken and Princesa presented the smallest values of weight of the bunch if compared to the other appraised genotypes (Table 5). [26] they also verified superiority in the genotype PHIA-18 for mass of the bunches in banana tree in Goiás state, the authors still affirm that the number of bunches and fruits influence directly in the size and weight of the bunch, that are variable related to the expression of a genotype.

In the number of fruits for bunch, was verified that the largest values were observed in the genotypes Grande Naine and Prata Anã, in compensation the smallest values were verified in the genotypes Pacovan Ken and Maçã Comum.

[27] evaluating the production of banana genotypes introduced in the area of Bonito, Mato Grosso do Sul, they obtained values of 119.30 and 69.31 fruits for bunch in the genotypes PHIA-18 and Prata-Anã, respectively. In agreement with [28] the fruits of the genotype PHIA-18 presented larger fresh mass and length, to the they evaluate quality of bananas cultivated in organic system, those authors still denote that this genotype presented excellent agronomic characteristics, being an alternative to cultivate Prata-Anã.

Table 5. Weigh of the bunch (WB), numbers of bunches for bunch (NBB), number of fruits for bunch (NFB), weigh of the fruit (WF), length of the fruit (LF) and diameter of the fruit (DF), in function of the cultivation of different banana tree genotypes under agroecological management, appraised during the first production cycle, IFPB, Sousa, 2015.

Analyzed variables						
Genotypes	WB (kg)	NBB	NFB	WF (g)	LF (cm)	DF (mm)
T1	6.75 D	5.75 B	63.75 A	88.50 B	15.00 B	40.50 AB
T2	12.25 AB	7.25 AB	87.75 A	122.75 B	18.00 AB	42.50 A
T3	9.75 BCD	6.25 AB	92.50 A	126.75 B	18.50 AB	43.50 A
T4	15.50 A	7.25 AB	81.75 A	199.00 A	20.75 A	45.75 A
T5	11.75 BC	7.50 A	95.25 A	131.75 AB	20.00 A	37.75 AB
T6	7.50 D	5.75 B	66.25 A	106.25 B	15.75 B	38.50 AB
T7	8.25 CD	7.25 AB	89.75 A	69.75 B	15.50 B	32.75 B

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255 * Genotypes (T1: Pacovan Ken; T2: Prata Anã; T3: PHIA-18, T4: Prata Graúda; T5: Grande Naine;
256 T6: Maçã Comum and T7: Princesa).

257 The genotypes that obtained larger acting as for the number of bunches for bunch (Table 5) they were
258 Grande Naine (7.50), Prata Graúda, Princesa and PHIA-18 (7.25). Corroborating with [24] where the
259 genotype Grande Naine was that obtained larger number of bunches for bunch. [29] they detach the
260 importance of that variable, as being of interest for the producer and fundamental for the genetic
261 improvement of the banana tree, once the bunch is constituted in the commercial unit.

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262 The weight of the fruit was superior in the genotype Prata Graúda with 199g, while the smallest
263 weights were observed in the genotypes Princesa 69.75g, following by Pacovan Ken with 88.50g
264 (Table 5). [30] they also verified mass of the equivalent fruit to 200g for the banana tree Prata Graúda
265 in conventional cultivation in Campo Grande - MS, in other words, the agroecological cultivation can
266 be an alternative production in the Upper Sertão Paraibano.

267 In the length of the fruit, was observed that the genotypes Prata Graúda and Grande Naine presented
268 the largest observed averages, while the smallest values were observed in the genotypes Pacovan
269 Ken, Princesa and Maçã Comum (Table 5). Result fellow creature was observed for [31] the study,
270 the development and the production of banana tree Grande Naine, they verified average of 17.8 cm.
271 [32] studying the characterization post-harvest of banana genotypes, produced in Nova Porteirinha,
272 Minas Gerais, they observed values of 21 and 22.33 cm for the genotype Prata Anã and PHIA-18,
273 respectively. [33] evaluating the physiochemical characterization of different banana genotypes
274 produced in the climatic conditions of Nossa Senhora das Dores, Sergipe, they verified that PHIA-18,
275 Prata Anã and Maçã presented length of 17.36, 13.87 and 15.74 cm, respectively.

276 In relation to the diameter of the fruits in function of the different banana tree genotypes cultivated in
277 the Upper interior of Paraíba, was verified that genotype Prata Anã fruits presented the largest
278 averages, already the smallest values were observed in the genotype Princesa (Table 5). Results
279 inferior, this work were observed for [32] characterizing the quality post-harvest and sensorial of
280 genotypes of banana trees, produced in system of conventional cultivation, which, they verified
281 diameter of 38.59 mm and 38.20 mm for the genotypes Prata Anã and PHIA-18, respectively. [31]
282 evaluating the development and the production of the banana tree Grande Naine in different handling
283 systems in the Valley of Ribeira, São Paulo, they observed diameter of 27.8 mm. [34] evaluating
284 different banana tree genotypes in the North State of Paraná, obtained diameters of fruits of 27 and
285 34 mm in the genotypes Princesa and Prata Anã. These results demonstrate the system of
286 agroecological management promotes the obtaining of fruits with larger diameters and consequently
287 larger production, being, therefore, a viable alternative for the conditions of the Upper interior
288 Paraibano.

289 290 4. CONCLUSION

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292 Genetic variability exists for the appraised agronomic characteristics in the nine genotypes.

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293 The genotypes Prata Graúda and Grande Naine presented satisfactory acting when cultivated under
294 agroecological management, in the climatic edaphic conditions of the Upper Sertão Paraibano.

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