

Economic and multivariate analysis of banana production (*Musa sp.*) Cultivated in the semi-arid region of northeast Brazil

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Abstract— *The objective of this work was to evaluate the economic viability and develop a multivariate analysis for banana crop data in the semi-arid region of Brazilian Northeastern. The study adopted a methodology widely disseminated in scientific research and income evaluations for the economic analysis. Through the economic indexes, we could evaluate the efficiency of the administrator and his workforce. Hierarchical clustering and Principal component analysis were used as multivariate analysis. The result of the economic analysis revealed that, on average, the total gross revenue from conventional management exceeded by 2.24 times the total gross income from agroecological management. However, the production costs of the conventional management exceeded by 2.15 times agroecological management. The multivariate analysis revealed that the variables are divided into three distinct groups formed between the equilibrium price and the profitability index, which do not correlate with each other or with the others, and by the subgroup formed by the return rate index, total operating profit and gross income, which are correlated with each other and not correlated with the others. We conclude that the multivariate analysis confirmed that the methodology used in the composition of all the economic indexes studied was correct.*

Keywords— *Total gross revenue, total operating cost, economic indices.*

I. INTRODUCTION

Banana is the most tasted tropical fruit and the second most harvested in the world, losing only to the orange. Nutritive, accessible to the majority of the

population and available during all year, banana is the fourth most consumed food product in the world. It accounted, in 2010, of about 4,771,944 ha of production having main producers India, China, The Philippines and Ecuador [3]. Brazil is the fifth in the world ranking of banana crop production, with a total production area of 486,991 ha, producing 6,978,310 tons and average annual productivity of 14.33 t/ha [3].

In Brazil, the banana production loses only to orange production [2]. An equivalent of 97,076,479 tons of banana was produced in 2013, grown in an area corresponding to 483,915 hectares. The States of Bahia, São Paulo, Minas Gerais, Santa Catarina, Pará, Ceará, and Pernambuco were the main responsible for the national production. Banana cultivation plays a prominent socioeconomic role in many emerging countries, being produced mostly by small farmers, contributing not only to the generation of income but to fix the workforce in rural areas. Estimates indicate that the culture is responsible for more than 500 thousand direct jobs [2].

Rio Grande do Norte is the eleventh National producer. But, the indices obtained for the States of Ceará and Rio Grande do Norte together are similar to those of São Paulo. Together, the two states are the second in planted area (52,470.00 ha) and the fifth in amount of production. They account for 623,602.00 tons of production, the sixth average yield (11,884.96 kg/ha), and the fourth in gross income, with the total sale value of R \$ 470,670,000.00 [6], [11].

The similarity of the productive aspects in the agribusiness gives the two states a level playing field about the economic indices above mentioned, besides they have

a large border in common, competing directly in the same socioeconomic and edaphoclimatic conditions, and the logistics of transportation and sales of its products in the rural environment [5].

[16] found a cost of production of banana-cultivated with coffee in Ivinhema, MS, Brazil, in the implantation phase (Year 1) of R\$ 15,758.26, in the formation phase (Year 2) of R\$ 8,127.90 and production (Year 3) of R\$ 10,146.31. The authors argue that the intercropping of banana coffee in the agroecological system is economically efficient.

For banana from the type Cavendish cultivated in Araçatuba, SP, Brazil, [4] found a total operational cost (implementation cost + cost of production) of R\$ 14,806.85, gross income of R\$ 16,660.00, total operating profit of R\$ 2,425.27, balance price of R\$ 0.41/kg, and a profitability index 0.15 and return rate of 1.17 [8].

We aim, with this work evaluate the economic viability and develop a multivariate analysis of banana crop data cultivated in the Brazilian Northeastern semi-arid region.

II. MATERIAL AND METHODS

The economic and multivariate analysis of the banana crop was carried out to obtain the degree of competitiveness between treatments in two experiments. The experiments were realized in the region named Chapada do Apodí, in the semi-arid of the Brazilian Northeast. The climate of the region is classified as hot and dry, type BSw_h' according to Köppen classification.

The first experiment was carried out at the Experimental Farm Rafael Fernandes (Mossoró Municipality/RN) (5°03'36.7"S and 37°24'6.6"W) to test the behavior of banana cultivars propagated in agroecological system. The second one was carried out at Fazenda Terra Santa (Municipality of Quixeré/CE) (5°05'07.57"S and 37°51'51.59"W) to test the behavior of banana cultivars propagated in conventional system of crop production.

For economic analysis we adopted a disseminated methodology in scientific research, as recommended by [15], observing parameters demonstrated by [13], [12] and [10]. The analysis of income, through indexes of economic result, served to verify the efficiency of the administrator and his work force.

We randomly selected the treatments between bananas from the types Pacovan and Prata-anã. For treatments with "Pacovan" cultivar, we choose seedlings with a mean weight greater than 1.0 kg, propagated by rhizomes with and without 'ceva'³, both in the agroecological and conventional system. For the cultivar "Prata-anã", we selected seedlings with an average weight higher than 1.5 kg, propagated by rhizomes with and

without 'ceva', both in the agroecological and the conventional system.

For the treatments in the agroecological system, the sampling of unities for the rhizome propagation with "ceva" was realized through the removal of the rhizome tiller from the selected cultivar for propagation in the study areas of the farm. The leaves were removed, and the seedling conditioned in a greenhouse covered by a shade cloth for a period of 15 days. One day before the final transplanting, the seedling was prepared, performing the scraping of the rhizome with a knife, eliminating the excess roots and removing the necrotic parts. The rhizomes were weighed and separated for the treatments of each cultivar. Seedling management was also used for the rhizome propagation of the experiments without "ceva".

The sampling of seedlings for rhizome propagation with "ceva" for the conventional system treatments was done by removing the rhizome tiller of the selected cultivar in the cultivated areas of the farm. The seedlings were laid to rest under shade field conditions at the soil surface. One day before its final transplanting the seedlings were prepared to eliminate the leaves and excess of roots. The rhizomes were then immersed in a solution with the active ingredient carbofuran in liquid form at 1%, dissolved in water for a period of approximately 15 minutes. The same procedure was used for the treatments for propagation by rhizome without "ceva" and the procedure of seedlings harvesting similar to that of agroecological management.

We used a randomized block design in a factorial scheme of 2 x 2 x 2, and four replicates by treatment. Therefore, we used three factors with two levels each: cultivars (Pacovan or Prata-anã), propagation methods (with or without ceva) and management methods (Conventional or agroecological). The randomization was performed for the following treatments distribution: Treatment 1 (T1), Banana plants of the cultivar Pacovan, with seedling propagated without "ceva" in the agroecological system; Treatment 2 (T2), Banana plants of the cultivar Pacovan, with seedling propagated with "ceva" in the agroecological system; Treatment 3 (T3), Banana plants of the cultivar Pacovan, with seedling propagated without "ceva" in the conventional system; Treatment 4 (T4), Banana plants of the cultivar Pacovan, with seedling propagated with "ceva" in the conventional system; Treatment 5 (T5), Banana plants of the cultivar Prata-anã, with seedling propagated without "ceva" in the agroecological system; Treatment 6 (T6), Banana plants of the cultivar Prata-anã, with seedling propagated with "ceva" in the agroecological system; Treatment 7 (T7), Banana plants of the cultivar Prata-anã, with seedling propagated without "ceva" in the conventional system; Treatment 8 (T8), Banana plants of the cultivar Prata-anã,

with seedling propagated with "ceva" in the conventional system.

The variables analyzed to evaluate the production and plant precocity in the alignment of the treatments were: TGR → total gross revenue (R\$); TOP → total operating profit (R\$); PI → profitability index (dimensionless); RRI → return rate index (dimensionless); EQP → equilibrium price (R\$ / kg).

The total gross revenue for each treatment (TGR) is calculated through the ratio between the productivity by area of each treatment (Prod.T_i) and the average price per kg of banana fruit sold (Eq. 01):

$$TGR = Prod.T_i \times R\$1.10 \quad (\text{Eq. 01})$$

The total operational profit per treatment (TOP) was obtained by the difference between the total gross income for each treatment (TGR) and the total operational cost per treatment (OPC) (Eq. 02):

$$TOP = GI - OPC \quad (\text{Eq. 02})$$

The total operational costs (TOPC) for the conventional system treatments were provided by [14] and for the agroecological system by [11] (Tables 1 and 2).

The statistic was realized using the software STATISTICA 13® [1]. We performed an ANOVA, using the F test to compare the means by treatments and the effects of the factors (GOMES, 2009). As multivariate analysis, we used a Hierarchical clustering analysis and the Pearson coefficient and Principal Component Analysis (PCA) by the correlation matrix and coordinate factors [9], [7].

We described only the possibilities that best explained the results of the analyzed variables.

Table.1: Total operational cost for the conventional model management.

Item	Description	Amount	Unit	Unit Price (R\$)	Subtotal (R\$)	%
Inputs used in plant nutrition					6,960.00	37.05%
01	- Source of organic matter: Cattle manure	10.00	ton.	120.00	1,200.00	6.39%
02	- Source of N: Urea	880.00	kg	1.60	1,408.00	7.49%
03	- Source of P ₂ O ₅ : MAP	400.00	kg	1.80	720.00	3.83%
04	- Source of K ₂ O: KCl	1,400.00	kg	1.70	2,380.00	12.67%
05	- Source of N and S: (NH ₄) ₂ SO ₄ - Ammonium sulfate	300.00	kg	1.15	345.00	1.84%
06	- Source of K ₂ O and S: K₂SO₄ - Potassium sulfate	200.00	kg	2.30	460.00	2.45%
07	- Source of Mg and S: Magnesium sulfate	100.00	kg	1.30	130.00	0.69%
08	- Source of Zn and S: ZnSO₄. 7H₂O - Zinc sulfate	30.00	kg	2.60	78.00	0.42%
09	- Source of Cu and S: CuSO₄. 5H₂O - Copper sulfate	10.00	kg	5.50	55.00	0.29%
10	- Source of Mn and S: MnSO₄. 3H₂O - Sulf. of manganese	10.00	kg	4.00	40.00	0.21%
11	- Source of B: H₃BO₃ - Boric acid	40.00	kg	3.50	140.00	0.75%
12	- Source of Cu and Mo: Comol	0.20	L	20.00	4.00	0.02%
Inputs used in phytosanitary protection of plants					473.00	2.52%
13	- Furadan in the liquid form	1.00	L	30.00	30.00	0.16%
14	- Furadan in the granulate form	1.00	kg	15.00	15.00	0.08%
15	- Inseticide Ópera	0.40	L	150.00	60.00	0.32%
16	- Talstar	0.20	kg	40.00	8.00	0.04%
17	- Herbicide Roundup	12.00	L	30.00	360.00	1.92%
Eletric energy costs					800.00	4.26%
18	- For one hectare of area in the first productive cycle				800.00	4.26%
Costs for the acquisition of the irrigation system					500.00	2.66%
19	- For one hectare of area in the first productive cycle				500.00	2.66%
Manpower costs					5,000.00	26.62%
20	- For one hectare of area in the first productive cycle				5,000.00	26.62%
Costs of mechanized activities, for the area of one hectare in the first productive cycle					1,300.00	6.92%
21	- Soil preparation				600.00	3.19%
22	- Weed mechanization control				100.00	0.53%
23	- Application of pesticides				100.00	0.53%

24	- Harvesting	500.00	2.66%
Costs for the acquisition of seedlings		2,250.00	11.98%
25	- For one hectare of area in the first productive cycle	2,250.00	11.98%
Other costs		1,503.30	8.00%
26	- Pro-labore of the producer, office supplies and other logistics costs for the area of 1 hectare in the 1st productive cycle	1,503.30	8.00%
Grand Total (R\$):		18,786.30	100.00%

Source: [14]

Table.2: Total operational cost for the agroecological model management.

Item	Description	Amount	Unit	Unit Price (R\$)	Subtotal (R\$)	%
Inputs used in plant nutrition					2,216.45	25.47%
01	- Source of organic matter: Cattle manure	1.19	ton.	120.00	142.67	1.64%
02	- Source of N: Urea	270.20	kg	1.60	432.32	4.97%
03	- Fonte de N-P ₂ O ₅ -K ₂ O: fertilizer formulation 4-14-8	303.98	kg	1.80	547.16	6.29%
04	- Source of K ₂ O: KCl	540.40	kg	1.70	918.68	10.56%
05	- Source of N and S: (NH ₄) ₂ SO ₄ - Ammonium sulfate	0.00	kg	1.15	---	---
06	- Source of K ₂ O and S: K₂SO₄ - Potassium sulfate	0.00	kg	2.30	---	---
07	- Source of Mg and S: Magnesium sulfate	135.10	kg	1.30	175.63	2.02%
08	- Source of Zn and S: ZnSO₄. 7H₂O - Zinc sulfate	0.00	kg	2.60	---	---
09	- Source of Cu and S: CuSO₄. 5H₂O - Copper sulfate	0.00	kg	5.50	---	---
10	- Source of Mn and S: MnSO₄. 3H₂O - Sulf. of manganese	0.00	kg	4.00	---	---
11	- Source of B: H₃BO₃ - Boric acid	0.00	kg	3.50	---	---
12	- Source of Cu and Mo: Comol	0.00	L	20.00	---	---
Inputs used in phytosanitary protection of plants					0.00	0.00%
13	- Furadan in the liquid form	0.00	L	30.00	---	---
14	- Furadan in the granulate form	0.00	kg	15.00	---	---
15	- Inseticide Ópera	0.00	L	130.00	---	---
16	- Talstar	0.00	kg	20.00	---	---
17	- Herbicide Roundup	0.00	L	25.00	---	---
Eletric energy costs					800.00	9.19%
18	- For the area of one hectare in two years of cultivation				800.00	9.19%
Costs for the acquisition of the irrigation system					500.00	5.74%
19	- For one hectare of area				500.00	5.74%
Manpower costs					2,095.80	24.08%
20	- For the area of one hectare in two years of cultivation				2,095.80	24.08%
Costs of mechanized activities (for 1ha in two years of cultivation)					1,100.00	12.64%
21	- Soil preparation				600.00	6.89%
22	- Weed mechanization control				0.00	0.00%
23	- Application of pesticides				0.00	0.00%
24	- Harvesting				500.00	5.74%
Costs for the acquisition of seedlings					0.00	0.00%
25	- For the area of 1 hectare in the 1st production cycle				0.00	0.00%
Other costs					791.23	9.09%
26	- Business remuneration, office supplies and other logistics costs for the area of 1 hectare in the 1st production cycle				791.23	9.09%
Grand Total (R\$):					8,703.48	100.00%

Source: Paula (2015)

III. RESULTS AND DISCUSSION

The results of ANOVA (Table 3) showed a significant effect of the method of propagation 1, at a probability level of 1%, on the total gross revenue (TGR) and total operating profit (TOP). The method of propagation 1 was composed of the forms of agroecological and conventional management. And, a significant effect of the interaction between cultivars and the propagation method 2 (C x M2P) on both variables, at

5% probability. For the profitability index (PI), significance was observed at 5% probability, for cultivars and, at 1% probability for the interaction between cultivars and propagation method 2 (C x M 2 P).

The return rate index (RRI) and equilibrium price (EQP) were not affected for any of the sources of variations studied (Table 3). Therefore, we will discuss only the mean values of the RRI and EQP variables.

Table.3: Results of the analysis of variance by the F test for the financial characteristics of the production of banana fruits (*Musa sp.*) from experiments developed in the semi-arid region of the Brazilian Northeast. 2017¹

Factor of variation	DF	TGR	TOP	RRI	PI	EQP
Cultivar (C)	1	0.364428 ^{ns}	0.364427 ^{ns}	0.514733 ^{ns}	0.045211*	0.769875 ^{ns}
Propagation method 1 (M1P)	1	0.000000**	0.002324**	0.462686 ^{ns}	0.713708 ^{ns}	0.752839 ^{ns}
Propagation method 2 (M2P)	1	0.201128 ^{ns}	0.201127 ^{ns}	0.182062 ^{ns}	0.263866 ^{ns}	0.179819 ^{ns}
C x M1P	1	0.855187 ^{ns}	0.855187 ^{ns}	0.973775 ^{ns}	0.263402 ^{ns}	0.395482 ^{ns}
C x M2P	1	0.048415*	0.048414*	0.210611 ^{ns}	0.008977**	0.274192 ^{ns}
M1P x M2P	1	0.755894 ^{ns}	0.755893 ^{ns}	0.446998 ^{ns}	0.830822 ^{ns}	0.421017 ^{ns}
C x (M1PxM2P)	1	0.098098 ^{ns}	0.098098 ^{ns}	0.397686 ^{ns}	0.618885 ^{ns}	0.407041 ^{ns}
Average		R\$ 17,072.30	R\$ 3,327.41	1.23	0.19	R\$ 0.90

¹ ns, not significant; **, significant at 1% of probability and; *, significant at 5% of probability; DF, Degree of Freedom.

² TGR, total gross revenue (R\$); TOP, total operational profit (R\$); RRI, return rate index (dimensionless); PI, profitability index (dimensionless); EQP, equilibrium price (R\$/kg).

The economic analysis of the experiments revealed that, on average, the total gross revenue (TGR) of conventional management (R\$ 23,623.06) exceeded 2.24 times the total gross income of agroecological management (R\$ 10,521.54) (Table 4). While, in the

comparison of production costs (TOPC), the conventional management (R\$ 18,786.30) surpassed 2.15 times the agroecological management (R\$ 8,703.48) (Tables 1 and 2). Both forms of cultivation had a gross income higher than the total operation cost (Tables 1, 2 and 4).

Table.4: Average values of TGR and TOP in the conventional (CVM) and agroecological management (AGM) at the experiments developed in the semi-arid region of the Brazilian Northeast

	DF	TGR	TOP
Conventional management	1	R\$ 23,623.06 ^A	R\$ 4,836.76 ^A
Agroecological management	1	R\$ 10,521.54 ^B	R\$ 1.818.06 ^B

¹ Similar letters mean a non-significant difference inside the columns, by the F test.

² TGR: total gross revenue (R\$); OP: total operational costs (R\$).

The total operating profit (TOP) was two times (almost four times) higher in the conventional management (R\$ 4,836.76) than in the agroecological management (R \$1,818.06) (Table 4). The results found here showed a higher total operational profit than the results presented by [18] for bananas of the type “banana-maçã” or “apple banana” (R \$ 1,468.07) cultivated in conventional management, in the region of São Paulo. The worst result, in the agroecological management, was 24% higher than the results found by [18], and the best

result, in the conventional management, exceeded by more than two times those obtained by [18] (R\$ 1,976.60).

The production costs obtained in our experiments, for agroecological management [11], represented about 47% ($100 \times R \$ 8,703.48 \div R \$ 18,274.21$) of the total production cost in banana cultivation developed in a consortium with coffee in agroecological management in Ivinhema/MS [16]. The costs of the Ivinhema/MS agroecological crop (R\$

18,274.21) were similar to the results found for the conventional management (R\$ 18,786.30) [14], [17].

The results of production costs together with the production efficiency achieved at relatively low production costs, reinforce the idea that the technological development in the cultivation system of the banana tree in the Brazilian semi-arid region has provided a higher income, besides the consolidation of regional development models based on the models of highly competitive productive poles in the country [5].

The ANOVA results for profitability index revealed that the Pacovan cultivar exceeded the values obtained by the Prata-anã cultivar by 8% (Table 5). This result shows that into the decomposition between operational profit and gross revenue there must be some other predominant factor that was not clearly explained in the current study, leading to a favorable high index of the Pacovan cultivar. Factors like fruit size, fruit weight and, others, for each cultivar, may be associated with productivity and affect the profitability index, but they were not investigated in the present study.

Table.5: Mean values for PI as a function of the Pacovan and Prata-anã cultivars of the experiments developed in the semi-arid region of Northeast Brazil. 2017¹

	PI ²
Pacovan cultivar	0.23 ^A
Prata-anã cultivar	0.15 ^B

¹Similar letters mean a non-significant difference inside the columns, by the F test.

²PI: Profitability index (dimensionless).

The low results of the profitability indices for Prata-anã cultivar found here (0.15) were similar to results found a study in Araçatuba, SP, while, the results found for Pacovan cultivar were 8% higher than the found for banana of the Cavendish subgroup, developed in the same local conditions [4]. The results confirm the superiority of the cultivar Pacovan for use in commercial areas of the Brazilian semi-arid (table 5).

The best results for total gross income and total operating profit were obtained when banana Pacovan was propagated by rhizome without "ceva" and banana Prata-anã by rhizome with 'ceva' (Table 6). On the other hand, for the profitability index, the best results were found for both Pacovan and Prata-anã with "ceva".

Table.6: Mean values of TGR, TOP and PI of the cultivars of banana Pacovan and Prata-anã depending on the propagation method (with and without 'ceva') on experiments developed in a semi-arid region of Northeast Brazil. 2017¹

		TGR ²	
		Propagation by rhizome without "ceva"	Propagation by rhizome with "ceva"
'Pacovan'	R\$ 17,821.12 ^{Bb}		R\$ 17,142.91 ^{Aa}
'Prata-anã'	R\$ 15,158.45 ^{Aa}		R\$ 18,166.72 ^{Bb}
		TOP	
		Propagation by rhizome without "ceva"	Propagation by rhizome with "ceva"
'Pacovan'	R\$ 4,076.23 ^{Bb}		R\$ 3,398.02 ^{Aa}
'Prata-anã'	R\$ 1,413.55 ^{Aa}		R\$ 4,421.83 ^{Bb}
		PI	
		Propagation by rhizome without "ceva"	Propagation by rhizome with "ceva"
'Pacovan'	0.17 ^{Aa}		0.22 ^{Bb}
'Prata-anã'	0.17 ^{Aa}		0.20 ^{Ab}

¹Similar letters mean a non-significant difference inside the columns (Uppercase) or rows (lowercase), by the F test.

²TGR: total gross revenue (R\$); TOP: total operational costs (R\$); PI: profitability index (dimensionless).

Comparing the results of the equilibrium prices of conventional management by [4] and agroecological management (R\$ 0.41/kg and R\$ 0.90/kg, respectively) and the total operating profit of agroecological management (R\$ 2,425.27 against R \$ 1,818.06) showed

unfavorable results for the proposal of production in semi-arid areas using the propagation method 1 (Table 4). The other indices (TGR, PI and, RRI) were equal or of superior quality to those tested in the banana subgroup Cavendish of the interior of São Paulo. These results

proved successful management for the Brazilian semi-arid showed through the better values of 70% of the economic variables studied.

The multivariate analysis (Figure 1) revealed that the tested variables are divided into three distinct groups formed between the equilibrium price (EQP), profitability index (PI) and the subgroup formed by the return rate index (RRI), total operating profit (TOP) and gross income (TGR). This division separates the EQP that was not correlated with the others, whereas the PI, OP and,

TGR are more correlated with each other than and not the others.

With the results of the hierarchical clustering (Figure 1) we could better understand why in the economic analysis the TOP and TGR variables had similar results between them (Tables 4 and 6) and the results for the PI variable were divergent from the other variables studied (Tables 5 and 6). However, a more evident discussion between the EQP and PI variables could not be made since the ANOVA for these variables showed a non-significant effect (table 3).

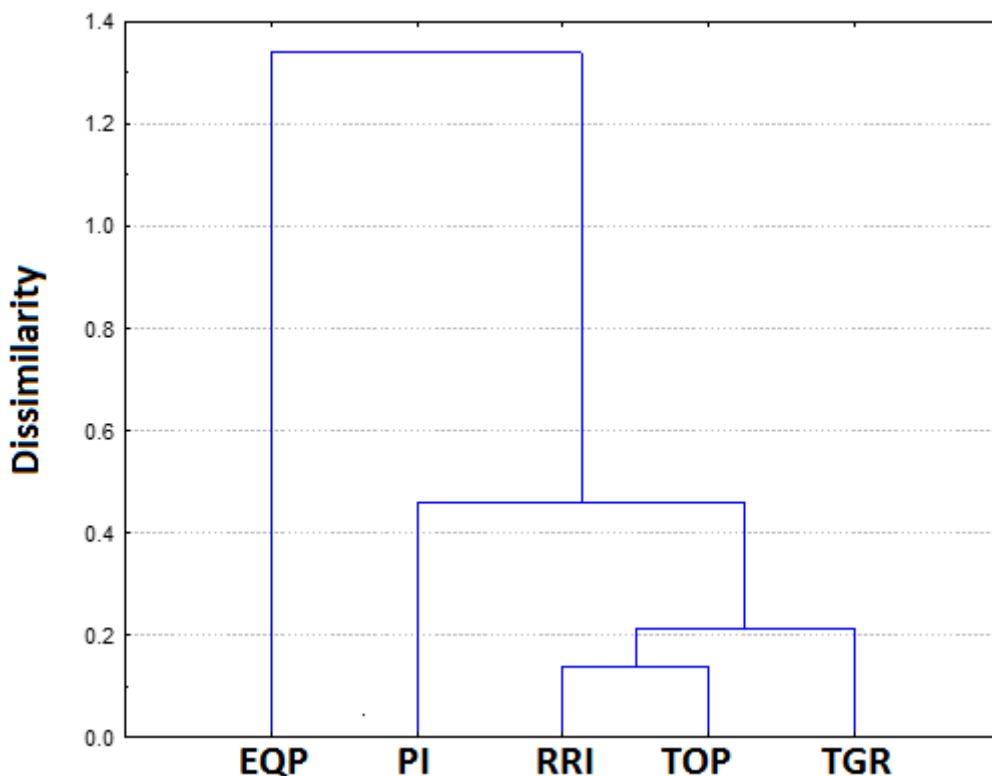


Fig.1: Dendrogram of the hierarchical clustering analysis for the equilibrium price (EQP), profitability index (PI), return rate index (RRI), total operating profit (TOP) and total gross revenue (TGR) for banana cultivation carried out in the semi-arid region of Northeast Brazil. 2017

The analysis of the correlation matrix of the principal components (Table 7) confirmed the lack of correlation (or low correlation) between the profitability index and the equilibrium price (-37.04%), and between the equilibrium price and the other variables analyzed. It shows, however, that there is a high correlation between total operating profit and total gross revenue (78.60%) and between total operating profit and the profitability index (85.68%), but a low correlation between total operational profit and the return rate index (44.39%).

It was also observed from the analysis that the equilibrium price has an inverse correlation with the

profitability index (-93.75%) and total operating profit (-77.27%), and not a lack of correlation low correlation) as the analysis of Pearson's correlation coefficient points out. This results demonstrates that the Pearson test was imprecise to explain all the characteristics among variables proposed in the present study, but we do not completely rule out this test as a way to obtain results since the results presented in the other analyzed variables had good precision, that is, they were aligned with the results of the Principal Component Analysis (Table 7 and Figure 1).

Table.7: Correlation matrix result of the Principal Components Analysis for the experiments developed in the semi-arid region of Northeast Brazil. 2017¹

Variable	TGR	TOP	RRI	PI	EQP
GI	1.000000	0.78604	0.443879	0.1879	-0.3704
OP	0.786035	1.00000	0.856831	0.5416	-0.7727
RRI	0.443879	0.85683	1.000000	0.5599	-0.9375
PI	0.187926	0.54158	0.559861	1.0000	-0.3393
EQP	-0.370389	-0.77273	-0.937508	-0.3393	1.0000

¹ All values are dimensionless.

TGR: total gross revenue (R\$); TOP: total operational profit (R\$); RRI: Return rate index; PI: profitability index (dimensionless); EQP: equilibrium price ((R\$/kg).

The adverse results observed for the relation among EQP, TOP and, RRI between the analysis of Hierarchical groupings and the Principal Components Analysis (Figure 1 and Table 7) is due to the occurrence of specificities and or demandability presented in each research proposal developed and the need for the correct choice to use one or more of the several methods available for multivariate statistical data analysis [9], 2017; [7].

After analyzing the cumulative effect of the correlation factors (Table 8), it was observed that 5 were the number of factors that explained 100% of the events of the analysis under study. And that in only 2 factors it was possible to explain 85.48% of the possibilities of the trial. For this reason, it we explain the results by only addressing the factors 1 and 2 (Table 9).

Table.8: Cumulative distribution of the correlation matrix factors from the experiments developed in the semi-arid region of Northeast Brazil. 2017¹

Variable	Eigenvalue	Percentage of total variance (%)	Cumulative Eigenvalue	Cumulative Percentage (%)
Factor 1	3.412889	68.25779	3.412889	68.2578
Factor 2	0.860911	17.21822	4.273801	85.4760
Factor 3	0.669605	13.39211	4.943406	98.8681
Factor 4	0.030244	0.60488	4.973650	99.4730
Factor 5	0.026350	0.52700	5.000000	100.0000

The analysis of the coordinate factors developed for the experiments (table 9) revealed that the variables that best explained the events studied were EQP (87.34%), TOP (-97.06%) and RRI (-94.78%). This indicates that in the whole analysis process if the equilibrium price rises, there

would be a loss of total operating profit values and the profitability index of the activity. A result that is exactly expected by the application of the methodology under study.

Table.9: Explanation of variables in the experiment developed in the semi-arid region of the Brazilian Northeast. 2017¹

Variável	Fator 1	Fator 2
TGR	-0,677747	-0,656246
TOP	-0,970626	-0,155670
RRI	-0,947818	0,149923
PI	-0,594226	0,595973
EQP	0,873400	-0,114065

¹ All values are dimensionless.

TGR: total gross income (R\$); TOP: total operational profit (R\$); RRI: Return rate index; PI: profitability index (dimensionless); EQP: equilibrium price ((R\$/kg).

All the results obtained for the multivariate analysis confirmed what theoretical studies [9]; [7] predict as fundamentals for the use of economic analysis in the interpretation of results of experimental data. Therefore, using the interpretation of both the economic analysis and the multivariate analysis we understand that the variables TOP and TGR were the ones that best explained the results obtained in the test.

In the present study, the multivariate analysis was used to indicate that the methodology (Multivariate analysis) applied to the composition of all the economic indexes was the correct one since that the results of the analysis were expected when applied the methodology adopted.

IV. CONCLUSIONS

Based on the discussion of the results from the economic and multivariate analysis developed in the trial, we concluded that:

- Both the gross revenue and the total operating profit at the conventional management showed values more than two times higher than those of the agroecological management. And, the best results were found for banana 'Pacovan' propagated by rhizome without 'ceva' and banana 'Prata-anã' propagated by rhizome with 'ceva';
- The multivariate analysis of the test confirmed that the use of the applied methodology in the composition of all economic indexes studied was correct.

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