Economic indexes of banana production (*Musa* Sp.) in the brazilian semiarid region

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***Abstract*—** *Applying several economic indexes commonly used in national scientific research, we assessed the productive efficiency of banana crops in commercial areas of the Brazilian semi-arid region. The analysis of income, through economic indexes, provided an overview of the effectiveness of administration and workforce. The result of the multivariate analysis revealed (i) three independent groups composed by the total net profit, and (ii) a subgroup joined by the opportunity cost, the interest rate for the period from planting to harvest, and the leveling point. The best options for net return on banana propagation in the Brazilian semiarid region were (i) the use of conventional management, (ii) the cultivation of Pacovan cultivar propagated by rhizome without "ceva" and, (iii) use of the Dwarf Prata cultivar propagated by rhizome with "ceva". The economic resources applied to the banana production provided the best output among those evaluated since it exceeded four folds the obtained with the capital remuneration in the financial application.*

***Keywords*—**: **Leveling point; opportunity cost; total net income.**

I. INTRODUCTION

The banana stands out as the most consumed and the second most harvested tropical fruit in the world. Accessible to the majority of the population and available year-round, the total area planted in the world in 2014 was estimated in 5,393,811 ha, yielding a total of 114,430,151 t. India, China, and the Philippines comprised the primary producers. Brazil ranked fourth in the world ranking and second in the classification of the Americas, surpassing even Countries like Ecuador and Guatemala in the production with the culture. In 2014, Brazil planted a total area of 478,765 ha, producing of 6,953,747 t, with average annual productivity of 14.52 t/ha [5].

In Brazil, the volume of production of banana loses only to orange [3]. The leading producers are the states of Bahia, São Paulo, Minas Gerais, Santa Catarina, Pará, Ceará, and Pernambuco. The main feature of this production is that it relies mostly on small farmers. Thus, the banana tree plays an important socio-economic role in many emerging countries, contributing not only to income generation but also to keep labor in rural areas. The banana culture answers by more than 500 thousand direct jobs [3].

The state of Rio Grande do Norte comprises the eleventh leading Brazilian production of banana. However, joining the indexes of Ceará and Rio Grande do Norte, we obtain values similar to São Paulo. Thus, the semiarid of Brazil rise in the rank of several categories, such as: to the second place of area harvested (10.98% of the total); fifth place in quantity produced (9.00%); second in the increase of production relative to previous harvest (19.92%); fourth in gross income (value of R$ 470,670,000.00); and sixth in profit per unit area (R$ 8,970.27/ha/year) [8], [12]).

The Ceará and Rio Grande do Norte share a vast frontier. They have the same conditions of socio-economy, climate, soil, logistics of transport, and sales of its products in rural areas [7]. The similarity of the productive aspects of the agribusiness allows assessing the two states with the same approaches of the economic indexes mentioned above.

Richett [18] analyzed the economic performance of the banana-coffee intercropping in agroecological management in Ivinhema, Mato Grosso do Sul. They found that the cost of production in the first year (implantation phase) was R$ 15,758.26, in the second year was R$ 8,127.90, and in the third year was R$ 10,146.31. The net income was R$ -15,758.26, R$ 11,515.46, and R$ 12,843.19, consecutively. These results show the economic efficiency of intercropping banana and coffee.

Studied the economic viability of *in vitro* micropropagation of seedlings against the conventional production systems of "Maçã" banana cultivar in the Jales region, northwest of São Paulo [20]. The two production systems were profitable, but crops with micropropagated seedlings yielded the highest net revenue (R$ 1,976.60), which was 34% higher than the conventional method (R$ 1,468.07), while profitability indexes in both systems were very good, 31% and 33%, respectively.

Studied the Cavendish banana plants under the density of 1,666 plants/ha in Araçatuba, São Paulo. The total operating cost (implementation cost + cost of production) was R$ 14,806.85; the gross receipts was R$ 16,660.00; total operating income of R$ 2,425.27; the total net income of R$ 1,735.51; and opportunity cost of R$ 689.76 [6].

II. MATERIAL AND METHODS

The economic analysis of the banana crop was carried out to assess the degree of competitiveness between treatments in two experiments located in the microregion of Chapada do Apodí, in the northeastern region of Brazil.

The first experiment, sited at the Experimental Farm Rafael Fernandes (5º03'36.7"S-37º24'6.6"W; Mossoró/RN), tested the behavior of banana cultivars propagated in the agroecological system. The second experiment, sited at the Terra Santo Farm (5°05'07.57"S-37°51'51.59"W; Quixeré/CE), tested the behavior of banana cultivars propagated through the conventional system of crop production. Both regions have hot and dry weather, comprising BSwh' climate according to the Köppen classification.

We applied the economic analysis described by [17], observing parameters demonstrated by [14], [11]. The study of income, through the indexes of the economic result, assessed the effectiveness of the administrator and his workforce.

We choose the sample through randomization of treatments between the cultivar kinds. The sampling comprised a Randomized Block Design in a factorial scheme 2x2x2, with four blocks and the repetitions composed of the mean values obtained by each treatment in each block. All treatments were randomized within each block.

The randomization resulted in the following treatments. (T1 and T2) Banana of the Pacovan cultivar, with seedling propagated with and without "ceva" in the agroecological system. (T3 and T4) Banana of the Dwarf Prata cultivar, with seedling propagated with and without "ceva" in the agroecological system. (T5 and T6) Pacovan banana, with seedling propagated with and without "ceva" in the conventional system.(T7 and T8) Dwarf Prata banana, propagated with and without "ceva" in the conventional system.

In the agroecological system, the collection of the experimental units for propagation with "ceva"¹ was done with the removal of the sprout with the rhizome of the cultivar of each treatment, in the areas of exploitation of the banana tree in the experimental farm of the UFERSA. Subsequently, we removed the leaves and maintained the units in a greenhouse covered with shade cloth and ground beaten for 15 days. One day before the final transplanting, we prepared the seedling with a simple scraping the rhizome with a knife for the elimination of excedent roots and removal of necrosed parts. Finally, we weighed the rhizomes to separate the treatments used and the "refuse" of each cultivar. In the treatment of rhizomes without "ceva", the seedlings were also prepared, but they were harvested one day before planting, at which time all the leaves were removed, leaving only the seedling with the rhizome.

In the conventional system, we collected the experimental units for rhizome propagation with "ceva" performing the removal of the sprout with the rhizome of the cultivar of each treatment in the Terra Santa farm. The period of rest occurred under shading on field conditions and the soil surface. One day before the final transplanting, the seedlings were prepared through the elimination of leaves and excedent roots. All rhizomes were immersed for approximately 15 minutes in a solution with liquid carbofuran at 1%. This procedure was also applied to the treatments of propagation by rhizome without "ceva". In both cases, the collection of the sprout with rhizome was to the agroecological process [10].

We analyzed the following indexes: LP → leveling point (kg/ha); IR → interest rate of the period from planting to harvest (%); OC → opportunity cost (R$); and TNI → total net income (R$). To obtain the indexes mentioned above, we measured the variables: total operating revenue (TOR); total operating cost (TOC); and total operational profit (TOP).

The total operational cost (TOC) of the conventional system was obtained in commercial areas of banana production in the region, according to [15]. The total operational cost of the agroecological system was achieved in areas of banana production in the region, according to [12]. The total operating cost in the conventional exploration activity (TOCc) was R$ 18,786.30 and in the agroecological system (TOCa) was RS 8,703.48.

We included the following items as standard costs for both kinds of propagation: (i) inputs for plant nutrition (bovine manure, urea, fertilizer formulation 4-14-8, and potassium chloride); (ii) electric power consumption; (iii) irrigation system; (iv) labor force; (v) mechanized activities (tillage, brush cutting, and harvesting); and (vi) costs for the acquisition of seedlings. The miscellaneous items cost (business compensation, office supplies, and prices in the logistics of each area studied) were considered as the sum of 10% all items of each kind of propagation.

The costs assigned only to the conventional propagation were: (i) the labor and mechanized activity adopted in the application of agrochemicals; (ii) the inputs for phytosanitary control of plants with the use of agrochemicals (Furadan liquid and granulate, Opera insecticide, Talstar, and Roundup herbicide); and (iii) inputs for plant nutrition with the use of ammonium sulphate, potassium sulphate, magnesium sulphate, zinc sulphate, copper sulphate, manganese sulphate, boric acid, and Comol fertilizer.

The total gross revenue (TGR) for a given treatment (ti) was obtained by the ratio between the productivity per area obtained by each treatment (prodt.ti) and the average price[2] of banana per kg sold (Eq. 01). That is,

([2] The average selling price of 1 kg of banana produced at the farm Terra Santa, municipality of Quixeré-CE, on 11-18-2015 = R$ 1.10)

$$TGR = Prodt.ti \times R\$1{,}10 \qquad \text{(Eq. 01)}$$

We obtained the total operating profit (TOP) per treatment using the difference between the total gross revenue for each treatment (TGR) and the total operating cost per treatment (TOCt) (Eq. 02). That is,

$$TOPti = TGR - TOCti \qquad \text{(Eq. 02)}$$

We estimated the opportunity cost per treatment (OC) by the simulation of the bonus that the cost of stable capital would provide if applied in another activity (interest - in the case of financial application - or profitability of the alternative activity). For other items of stable capital (buildings, machines, equipment, etc.) the opportunity cost was obtained as the annual interest that reflects the alternative use.

As the chosen interest rate for this calculation should be equal to the rate of return of the best alternative application, we used the Selic rate. This index is considered the basic interest rate of the economy, which value reflects the average profitability of productive activities of the national economy.

During the period from Mar/2012 to Mar/2013 (the period of the research in the agroecological system) and Sep/2013 to Sep/2014 (period of the conventional system), the projection of interest was respectively 0.63% and 0.82% per month, and 7.54% and 9.86% per annum [16]. Thus, we considered the opportunity cost separated for the agroecological system (OCa) and conventional system (OCc).

As the outlay of resources is in installment during the productive cycle, the interest accounted for half of the total value of the cost for the two situations in studies (OCa and OCc) multiplied by the annual interest rate for the first cycle divided by twelve months and by the interval between planting and harvesting of the first cycle divided by the sum of the days of the months that comprised the period.

The total interest rate of the period by treatment, the interval between planting and harvesting of each treatment was taken into account and added to the "ceva" period, in cases where the treatments underwent "ceva". In this way, the opportunity cost of capital (OC) was calculated as shown in Eqs. 03 and 04.

$$OCa = \frac{OCti}{2} \times \frac{\substack{\text{annual crop interest rate} \\ \text{for agroecological model}}}{12} \times \frac{\substack{\text{interval from planting to harvest} \\ + \text{period of "ceva" or not}}}{\substack{\text{sum of the days of each month} \\ \text{of the interval}}} \qquad \text{(Eq. 03)}$$

$$OCc = \frac{OCti}{2} \times \frac{\substack{\text{annual crop interest rate} \\ \text{for conventional model}}}{12} \times \frac{\substack{\text{interval from planting to harvest} \\ + \text{period of "ceva" or not}}}{\substack{\text{sum of the days of each month} \\ \text{of the interval}}} \qquad \text{(Eq. 04)}$$

At the end of the analysis inferences, the total net income of each treatment (TNI) was calculated by subtracting the total operating profit per treatment (TOPti) and the opportunity cost per treatment (OCti). Instantaneously, such calculation differentiates, quantitatively and qualitatively, which treatments exceeded the bonus that the cost of stable capital provides if it were applied in another financial activity. The formula is shown in Eq. 05.

$$TNI = TOPti - OCti \qquad \text{(Eq. 05)}$$

([2] The average selling price of 1 kg of banana produced at the farm Terra Santa, municipality of Quixeré-CE, on 11-18-2015 = R$ 1.10)

Finally, the data were tested to the ANOVA assumptions by the residue test and submitted to analysis of variance through the F test and the hierarchical grouping analysis using the single linkage method of the Euclidean distances of the multivariate statistic [13], [9]. In the univariate statistic, the means were compared by treatments and by unfolding of factors that had significance [13]. We show only the possibilities that best

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explain the results of the analyzed. The statistical test was carried out in the software STATISTICA 13® [1].

III. RESULTS AND DISCUSSION

Our data met all assumptions for parametric analysis. Therefore, we applied standard tests without transformation of data.

The hierarchical grouping split three independent groups: (TNI) the total net income; (OC and IR) the opportunity cost with the interest rate for the period from planting to harvest; and (LP) the leveling point. The variable LP has the highest degree of independence from the other ones (low correlation), TNI has intermediate autonomy from LP and the subgroup (OC and IR), while the variables OC and IR showed the highest degree of dependence (high correlation) (Figure 1).

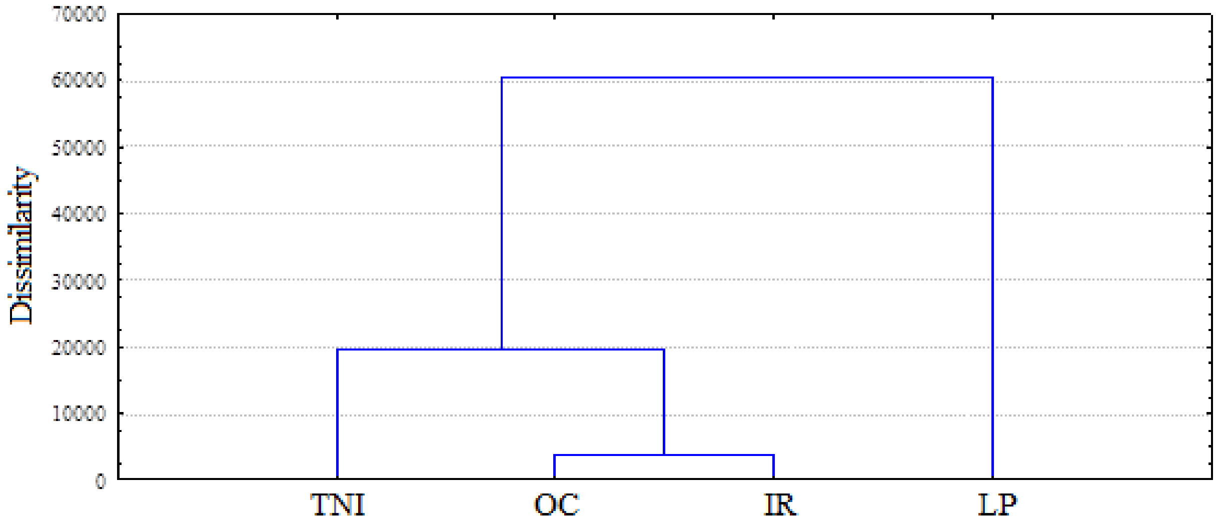

Fig.1: Dendrogram of the distance matrix for the LP, IR, OC, and TNI variables evaluated by the single linkage method of Euclidean distances carried out in the study of the banana tree economy in the semi-arid region of northeastern Brazil. 2015.

At 1% of probability, we obtained the following results. The method of propagation 1 (MP1) affected the leveling point (LP) significantly. The cultivar (C), MP1, the interaction between cultivar and method of propagation 2 (C x MP2), and the interaction among cultivar, method 1, and method 2 (C x MP1 x MP2) affected the of the interest rate (IR). The cultivar, MP1, interaction C x MP1, and the interaction C x M1P x MP2 influenced the opportunity cost (OC) (Table 1).

The total net income (TNI) was affected only by MP1 and the interaction C x MP2 at 5% of probability. Similarly, the IR was influenced by the interaction C x MP1 only at 5% of probability (Table 1).

Table.1: Results of the analysis of variance by the F test for the financial characteristics of the banana fruit production (Musa sp.) of experiments carried out in the semi-arid region of northeastern Brazil. 2017[1].

Source of variation	df[2]	LP (kg/ha)	IR (%)	OC (R$)	TNI (R$)
Cultivar (C)	1	1.000^{ns}	0.007**	0.002**	0.372^{ns}
Method of propagation 1 (MP1)	1	0.000**	0.000**	0.000**	0.012*
Method of propagation 2 (MP2)	1	1.000^{ns}	0.131^{ns}	0.157^{ns}	0.199^{ns}
C x MP1	1	1.000^{ns}	0.019*	0.003**	0.865^{ns}
C x MP2	1	1.000^{ns}	0.001**	0.197^{ns}	0.049*
MP1 x MP2	1	1.000^{ns}	0.905^{ns}	0.545^{ns}	0.758^{ns}
C x (MP1xMP2)	1	1.000^{ns}	0.000**	0.000**	0.095^{ns}
Average		12,495.36	8,553	620.74	2,706.66

[1]ns = non-significant; * P < 0.05; ** P < 0.01; [2]df = degree of freedom; LP = leveling point; IR = interest rate of the period from planting to harvest; OC = opportunity cost; TNI = total net income.

These results suggest that the application of the economic resources in the agricultural production of banana crops comprises the best investment among the ones evaluated. The average net income (R$ 2,706.66) generated resources four-fold higher than what he would obtain with the remuneration of capital in the financial application (R$ 620.74). Also, the banana production provides social benefits, since this activity avoids the rural exodus giving opportunities to keep the population in the field, with employment, income, and a better chance in food production [7], [2].

The method of propagation 1 yielded the most representative leveling points, clearly stating the superiority of agroecological management (7,912.26 kg/ha) against the conventional system (17,078.45 kg/ha). Only 46% of the production in the conventional experiment was required to pay all the costs of the agroecological one. Conventional agriculture produced the highest leveling point (17,078.45 kg/ha). Intermediate leveling points were obtained for the other variables (12,495.36 kg/ha), where agroecological management accounted for 63% of their average values (table 2).

Table.2: Mean values for LP, IR, OC, and TNI according to the factors studied in the experiment developed in the semi-arid region of northeastern Brazil. 2017¹.

	df	LP² (kg/ha)	IR (%)	OC (R$)	TNI (R$)
Pacovan cultivar	1	12,495.36^{B}	8.62%^{B}	R$ 626.87^{B}	R$ 3,110.25^{B}
Dwarf Prata cultivar	1	12,495.36^{B}	8.49%^{C}	R$ 614.61^{C}	R$ 2,303.08^{B}
Agroecological system	1	7,912.26^{C}	7.25%^{D}	R$ 315.32^{D}	R$ 1,502.74^{C}
Convencional system	1	17,078.45^{A}	9.86%^{A}	R$ 926.17^{A}	R$ 3,910.59^{A}
Propagation without "ceva"	1	12,495.36^{B}	8.59%^{C}	R$ 623.36^{B}	R$ 2,121.53^{B}
Propagation with"ceva"	1	12,495.36^{B}	8.52%^{C}	R$ 618.13^{BC}	R$ 3,291.79^{B}

¹In each column, averages with the same letter do not differ from each other by the F test; ²df = degree of freedom; LP = leveling point; IR = interest rate of the period from planting to harvest; OC = opportunity cost; TNI = total net income.

On average, the interest rate obtained in the financial market (banking application) with the financial resource applied in the costing of the plants of the cultivar Pacovan (8.62%) outperformed the interest obtained with the Dwarf Prata cultivar (8.49%) by 0.13%. Such difference brought Pacovan a slight disadvantage compared to Dwarf Prata because the interest rate was affected by its delay in harvest, which delayed the production of revenues, thus raising the cost of capital invested. Both propagation types (with and without "ceva") showed statistically similar means, and these are considered regular compared to the extreme values of interest rates obtained in the test (table 2).

The interest of the cultivar variation source was higher than the recommended in other studies, where values range around 6% per year (the real rate paid by the savings account) with practically no risk [19], [15]. However, the total net income of the Pacovan cultivar (R$ 3,110.25) and Dwarf Prata cultivar (R$ 2,302.76) were similar to the values in other studies, which were R$ 3,216.00 ha^{-1} [4] and R$ 2,809.89 ha^{-1} (Santana et al., 2004) [19], [15], [4], respectively.

The interest rate of agroecological management (7.25%) was 2,61% lower than the conventional system (9.86%). However, this surplus of 2.61% was purely coincidental due to the two experiments were carried out in different periods (the agroecological occurred in the 2012/2013 fiscal year, while the conventional in the 2013/2014 fiscal year). In this case, the inter-period rate surplus was caused solely by the Brazilian economic policy. Therefore, the discussions of the mean values obtained for propagation method 1 and its double and triple interactions (C x MP1, MP1 x MP2, and C x MP1 x MP2) are unnecessary for analysis of the results (table 2).

As the result of cluster analysis showed a correlation between the opportunity cost (OC) and the interest rate (IR), we also discarded the discussion of the mean values obtained for propagation method 1 and its double and triple interactions (C x MP1 and C x MP1 x MP2) (Table 2).

In this case, the opportunity costs of the cultivars were R$ 614.37 and R$ 626.87 for Dwarf Prata and Pacovan, respectively (Table 2), which indicate a disadvantage of R$ 12.50 of Pacovan relative to Dwarf Prata cultivar. Thus, the Pacovan cultivar has a more significant expectation of success in the use of the resources of costing in the financial application. However, recent research, developed under the same conditions, obtained an opportunity cost of R$ 689.76 [6]. This value exceeded R$ 69.14 the mean value of OC in our experiment, which reinforces that the choice of the application of the costing resource in the banana plantation for Brazilian semi-arid conditions was the best option among those evaluated.

The total net income (TNI) under the method of propagation 1, the agroecological management provided the lowest value (R$ 1,502.74), while the highest value was obtained in the conventional system (R$ 3,910.53). The average values in conventional management were 2.6 folds higher than the average value of the agroecological management. The remaining sources of variation were statistically similar (Table 2).

Even with the interest rate surplus between the two periods of experiments (2.61%), there was no advantage to obtain the net income in the agroecological system, supporting the independence between the TNI and the other variables analyzed (table 2).

We obtained similar or better than [20] for all variables, except the agroecological management (R$ 1,502.74). This author propagated Dwarf banana in the conventional system, with the best results ranging R$ 1,976.60. The total net income of all treatments evaluated, only 16.67% of the results were unsatisfactory (value of agroecological management).

Unfolding of cultivars within each kind of propagation, the highest interest rate of the Pacovan cultivar occurred when we propagated them by rhizome without "ceva" (8.74%). This effect, however, was utterly overcome since it provided one of the best total net incomes (R$ 3,444.37) (table 3).

Table.3: Mean values for the unfolding of cultivars within the banana propagation by rhizome with and without "ceva" for the variables IR and TNI of the experiment carried out in the semi-arid region of northeastern Brazil. 2017[1].

Cultivar	df[2]	IR		TNI	
		Without “ceva”	With “ceva”	Without “ceva”	With “ceva”
Pacovan	1	8.74%^{Aa}	8.50%^{Ab}	R$ 3,444.37^{Aa}	R$ 2,776.13^{Bb}
Dwarf Prata	1	8.44%^{Ba}	8.53%^{Aa}	R$ 798.70^{Bb}	R$ 3,807.46^{Aa}

[1]In each column, and to each group of two consecutive columns, averages with the same letter do not differ from each other by the F test; [2]df = degree of freedom; IR = interest rate of the period from planting to harvest; TNI = total net income.

Inversely, the unfolding of the Dwarf Prata cultivar on the propagation by rhizome without "ceva" showed the lowest interest rate (8.44%), confirming that this cultivar had the best results. However, their propagation with "ceva" (8.53%) was statistically similar to the propagation of Pacovan with "ceva" (8.50%). Thus, that the total net income of Dwarf Prata propagated without "ceva" provided the worst result (R$ 798,70), with the profit of R$ 2,776.13. Conversely, the yield of the Dwarf Prata propagated with "ceva" (R$ 3,807.46) was statistically similar to the best profit option (propagation of the Pacovan without "ceva") and superior to the other options (table 3).

Thus, the best options of net income (TNI) of banana propagation in northeastern Brazilian was the conventional management, with the use of Pacovan cultivar propagated without "ceva" or the Dwarf Prata with "ceva" [10]. The second option was the use of the Pacovan cultivar propagated by rhizome with "ceva", while the less recommended option was the use of Dwarf Prata rhizome without "ceva" (Tables 2 and 3).

IV. CONCLUSIONS

Based on the indexes obtained from the economic analysis, we can conclude that:

- The application of financial resources in banana production was the best investment among the evaluated ones since it exceeded by more than four times what would be obtained with the remuneration of the capital in the financial application;
- The best options of net economic income for banana propagation in the Brazilian semi-arid region were the conventional management with the use of Pacovan cultivar propagated by rhizome without "ceva" or Dwarf Prata cultivar propagated by rhizome with "ceva";
- The worst option of net economic income was the use of the Dwarf Prata cultivar propagated by rhizome without "ceva".

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