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Economy

Economic analysis of fertilization management in 'Prata-Anã' Gorutuba banana plants

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Abstract - Brazilian banana farming is one of the most important agricultural activities in the national scenario and can be highly productive and economically profitable for producers who invest in technology. The objective of this work was to compare the economic viability of two different fertilization managements in the cultivation system of 1st -cycle 'Prata Anã' Gorutuba bananas. The conventional fertilization treatment (CM), adopted by the producer (control), was compared with the alternative treatment: conventional management + 3 soil conditioners + 1 biostimulant (CM + 3SC + 1B). The four products selected for the alternative treatment were oyster shell limestone, Celtonite, *Lithothamnium calcareum* and Acadian. The application of the four products in the CM + 3SC + 1B treatment provided satisfactory results on crop performance, mainly due to the increase of 4.032 tons ha^{-1}. The CM+3CS+1B alternative management was more economically viable than CM, as the total operational cost (1st + 2nd year) of the alternative management was 6.71% higher compared to the conventional management; however, the alternative treatment productivity was 28.08% higher. The cost to produce one ton of bananas was R$ 2.456,91 in the conventional treatment and R$ 2.047,07 in the alternative treatment, which represents a 16.68% reduction in the average cost, indicating the economic feasibility of this treatment.
Index terms: Organomineral fertilization. 'Prata Anã' banana. Profitability.

Análise econômica de manejos de adubação de bananeira 'Prata-Anã' Gorutuba

Resumo - A bananicultura brasileira é uma das atividades agrícolas mais praticadas no cenário nacional, podendo ser altamente produtiva e economicamente rentável ao produtor que investe em tecnologia. Objetivou-se com este trabalho comparar a viabilidade econômica de dois manejos distintos de adubação no sistema de cultivo de bananeira 'Prata-Anã' clone Gorutuba de 1º ciclo. O tratamento convencional de adubação (MC), adotado pelo produtor (testemunha), foi comparado com o tratamento alternativo: manejo convencional + três condicionadores de solo + um bioestimulante (MC+3CS+1B). Os quatro produtos selecionados para o tratamento alternativo foram: calcário de conchas, Celtonita, *Lithothamnium calcareum* e Acadian. A aplicação dos quatro produtos no tratamento MC+3CS+1B proporcionou resultados satisfatórios no desempenho da cultura, principalmente pelo aumento de 4,032 toneladas/ha^{-1}. O manejo alternativo MC+3CS+1B foi mais viável economicamente que o MC, pois o custo operacional total (1º + 2º ano) do manejo alternativo foi 6,71% maior que no manejo convencional; entretanto, a produtividade do tratamento alternativo foi 28,08% maior. O custo para produzir uma tonelada de banana foi R$ 2.456,91 no tratamento convencional e R$ 2.047,07 no tratamento alterativo, o que representa a redução de 16,68% do custo médio, indicando a viabilidade econômica deste tratamento.
Termos para indexação: Adubação organomineral; Banana 'Prata-Anã`; Lucratividade.

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Introduction

Banana is one of the most produced fruits (Figure 1) and one of the most consumed foods in the world (FAOSTAT, 2021). In Brazil, banana farming is seen as an important crop in food production, being considered the most consumed fruit in the country and the second most produced, only behind oranges (SANTANA JUNIOR et al., 2020). According to IBGE data for the 2019/2020 harvest, 6.86 million tons of bananas were produced, with negative variation of 3.5% compared to the 2018/2019 harvest; with 488.5 thousand planted hectares and 15.1 tons ha^{-1} of national average productivity (IBGE, 2020).

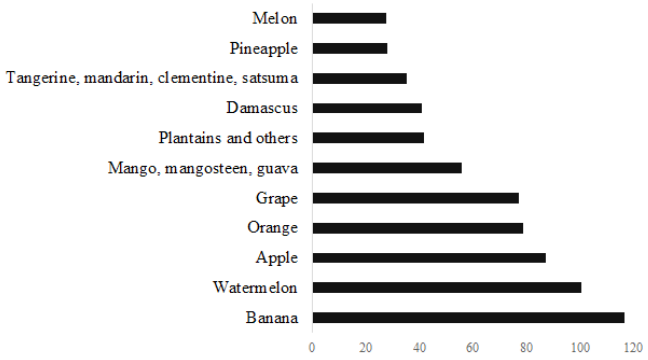

Figure 1. World banana production in 2019 (in millions of metric tons). Source: FAOSTAT, 2021.

One of the most important Brazilian banana production regions is located in the state of Minas Gerais, especially in the northern region, covering banana-growing municipalities located 100 km from the capital to neighboring regions such as the banana production region of Bahia in the southwestern state and in the São Francisco River Valley (SALOMÃO et al., 2016). The northern region of the state of Minas Gerais stands out for producing basically the 'Prata-Anã' cultivar (QUEIROZ et al., 2019), especially its clone, known as 'Prata Anã' Gorutuba (FERNANDES et al., 2019; NOMURA et al., 2019).

The 'Prata Anã' Gorutuba tree has stood out as the most produced and marketed in Minas Gerais, which explains the peculiar preference of Brazilians for the 'Prata' subgroup – responsible for 80% of the banana marketed in the country (NOBRE et al., 2018; SANTOS et al., 2017).

Despite the large production volume, Brazilian banana farming has some problems that reduce the average annual productivity and the post-harvest quality of fruits (SALOMÃO et al., 2016). The use of low-fertility soils, without specialized technical assistance and the lack of maintenance of adequate levels of nutrients during the plant cycle are factors that prevent the evolution of the national scenario of this crop.

According to Salomão et al. (2016), due to the importance of this agricultural activity for the Brazilian trade balance, with generation of jobs and source of income for small and large producers, fertilization studies with the objective of productivity gains have been carried out with banana trees of the 'Prata' subgroup (AAB), the most accepted by consumers in the national market (NOBRE et al., 2018; NOMURA et al., 2019; SANTANA JÚNIOR et al., 2020; SANTOS et al., 2017).

Currently, the use of soil conditioners as supplements for planting fertilization, as well as the use of biostimulants, especially those composed of seaweed-based extracts, has been adopted in agricultural experiments in some regions of the country and the world (BROWN; SAA, 2015; CARVALHO; CRUZ; MARTINS, 2013; DU JARDIN, 2015; MELO et al., 2016, 2017; YAKHIN et al., 2017). Although there are studies with biostimulants and soil conditioners in different crops, little is known about the effect of these products on the growth and development of banana trees, even less about their combined performance (MELO et al., 2016; MELO et al., 2017; SANTOS et al., 2017), with need for greater research contributions in this area of knowledge.

The positive effects provided by new products on crop growth and productivity in regions characterized by water stress and low natural fertility must be economically evaluated in order to spread, or not, the use of these technologies by producers (EMBRAPA, 2018; RODRIGUES et al., 2018; PIRES, KRAUZE, 2020). The profitability of an agricultural enterprise is related to the market, product sales price, total production costs and productivity. Proper fertilization management can provide improvements in the vegetative and reproductive development of plants, increasing production per area and, consequently, the business profitability, provided that this increase in productivity exceeds the costs of inputs (NOMURA et al., 2019; RODRIGUES et al., 2018).

New managements demand higher costs that, due to lack of control, can reduce the profitability of the production system. According to Pacheco et al. (2016), for banana cultivation to be viable, some production costs are necessary, including implantation of the area, soil maintenance, fertilization and costs of harvesting, transport and post-harvest, all of which are considered and analyzed necessarily before starting production. Therefore, knowledge about costs is essential, since they help in decision making (CARDOSO, 2020; DO COUTO et al., 2020).

Based on the above, the objective of this work was to compare the economic viability of two different fertilization managements for 1st-cycle 'Prata Anã' Gorutuba banana (*Musa* sp.) in terms of productivity and economic viability.

Material and methods

The experiment was carried out in an irrigated commercial banana orchard with 80 ha located in the municipality of Paraopeba, central region of the state of Minas Gerais (19º16'01.1" S, 44º26'02.6" W and 761 m a.s.l.). The climate in the region is Aw, according to the Koppen classification, tropical with dry season and average annual rainfall of 1244 mm and a critical period of water deficit extending from May to September. The average annual temperature in the region is 21.8 °C, with variation of + 5.2 °C throughout the year.

The experimental area is located on a central region of approximately 22.3 ha, with soil classified as Red Latosol (EMBRAPA, 2013), previously cultivated with corn and/or beans. This area remained in the fallow period for two years and the soil had the following chemical characteristics before the banana plantation was established in December 2017 (Table 1):

Table 1. Analysis of the initial fertility of soil collected in the Cerrado area in the central region of Minas Gerais - Brazil in the 0-20 cm layer, located in the experimental area and in the commercial ´Prata Anã` Gorutuba banana implantation (*Musa* sp.).

pH		P resin	K	S	Ca	Mg	Al	H+ Al
(water)	($CaCl_2$)		mg/dm³			cmolc/dm³		
6.00	5.30	22.00	128.7	7.90	4.20	0.70	0.0	2.80
V	m		Ratios		Total CEC	SB	OM	OC
%		Ca/K	Mg/K	Ca/Mg	cmolc/dm³		g/dm³	
65.13	0.00	12.72	2.12	6.00	8.03	5.23	22.00	13.00

Total CEC: total cation exchange capacity; OM: organic matter; OC: organic carbon; V: base saturation; m: aluminum saturation.

It is noteworthy that macronutrients were present at the following levels: P (low); K (high); S (low); Ca (adequate) and Mg (low). Base saturation (V%) presented values below the ideal (V% = 70) for the banana crop. Therefore, soil correction with limestone was performed to increase this index and to increase Mg in the participation of soil bases.

The experiment was implemented in the experimental area on May 19, 2018 and conducted until the end of the 1st crop cycle, which coincided with the date of the last harvest on March 8, 2019, of the three that were carried out. Seedlings were planted in furrows (0.40 x 0.40 x 0.40 m), with double row spacing of 2.7 m between rows and 3.3 m between double rows and 2.0 m between plants, totaling planting density of 1666 plants/ha. Planting fertilization consisted of: 200 g of simple superphosphate (SS), 200 g of Yoorin and 1 kg of chicken manure per seedling or meter of planting furrow.

Irrigation was performed using central pivot for six months, with a two-day irrigation shift, and later replaced by micro-sprinkler, for 1 hour and 30 minutes in a two-day irrigation shift until the end of the 1st cycle.

The experimental design used was the CRD (Completely randomized design), with two treatments and 10 replicates, totaling 20 experimental plots. Each experimental plot consisted of three 'Prata Anã' Gorutuba banana plants (*Musa* sp.), totaling N = 60 plants or sample units.

In this case, the experimental area did not need to be divided into blocks due to the homogeneous soil and climate conditions in the two planting rows selected for experimentation. The initial allocation of both treatments was randomly performed using the R software (R CORE TEAM, 2018).

Conventional treatment was defined by the conventional fertilization management adopted at the Agromila farm, the same standard for irrigated banana farming carried out in northern Minas Gerais, which is coded by CM. Alternative treatment consisted of four products that represented fertilization supplements for banana trees, previously selected in a screening test, as the most efficient for application in banana-growing regions of the state of Minas Gerais. The alternative management consisted of CM + 4 products, in this case, it was coded as CM+3CS+1B, that is, the sum of the conventional treatment with the application of three soil conditioners and a biostimulant.

The three soil conditioners selected for the alternative treatment (CM+3CS+1B) were: oyster shell limestone (49% CaO, 0.05% MgO), from CYSY® - 180 g/pit/year; Celtonite (NPK-enriched zeolite), from ZEOCEL Portugal Ltda. - 200 g/pit/year and ALGUE® (32% Ca), *Lithothamnium calcareum* (Powder), from CERES TECNOLOGIA LTDA - 180 g/pit/year. In due order, they were coded as follows: CC; CT and LT. These doses were converted into 1/3 of the commercial value for conditioners, as each plant received a CC:CT:LT blend (w:w:w).

The algae extract-based biostimulant used was Acadian® (5.3% K_2O), from Acadian Seaplants Limited – ASL, coded as ACA and applied separately in commercial dose.

Mineral fertilizations with soil conditioning products were divided into three applications: from May to July 2018, considering the annual Ca dose required by the banana crop, subgroup 'Prata' (AAB) in g/pit, and the respective Ca content provided by each product. Supplementation fertilizations (conditioners) were performed by casting, carrying out a crowning of products around the seedling.

Fertilizations with biostimulants were divided into three stages: vegetative growth with application in July 2018; pre-flowering with application in September 2018 and fruiting (formation of the first bunches), with application in November 2018. The Acadian product was applied at dose of 0.5% or 500 mL/ha for the three applications.

Foliar fertilization with the biostimulant was not performed directly on leaves due to the high wax concentration on the adaxial surface of this species, a fact that led to the adoption of an application pattern with jet directed at the soil, spraying the closest to the mother plant's rhizome, in the vegetative cycle. The last biostimulant applications, in the pre-flowering and fructification stages, were carried out with jet directed at the inflorescence and bunch, respectively. For this type of fertilization/operation, a 5-L backpack sprayer was used.

Production costs followed descriptions given by Vilela et al. (2016) and Do Couto et al. (2020), specified based on the Effective Operation Cost (EOC), consisting of services and inputs applied to the production of 'Prata' Gorutuba bananas and by the Total Operation Cost (TOC); resulting from the sum of the EOC and other costs (10%), represented by any financial charges not foreseen in the crop implementation (technical assistance, fixed capital interest, depreciation of goods and machinery and family labor).

The economic analysis of costs considered the 1st (implantation) and 2nd year (conduction) of cultivation evaluated during the field experiment, that is, TOCs of only the first harvest (2nd year) of 'Prata' Gorutuba banana tree in the central region of Minas Gerais were accounted for.

The economic viability analysis was carried out by means of a simulation for one hectare of production and by comparing results between the two managements adopted (conventional and alternative), obtained during the first cycle of the 'Prata' Gorutuba banana trees. To identify the feasibility of supplementary fertilization in this cultivar, the production variable PROD, in t, was considered as the product of the weight of the useful plant stemless bunch and the planting density, which is equal to 1666 plants.

Statistical analyses were performed to compare the productivity of the two fertilization managements using the R software (R CORE TEAM, 2018). The variable was submitted to analysis of variance (ANOVA), according to its assumptions.

After ANOVA, the sources of significant variation were submitted to the 't test' estimation in order to obtain the direction of the causal effect of this source of variation on a given response variable, that is, increase (sign +) or decrease (sign -) of this variable.

Results and discussion

Productivity had significant effect at 5% for the treatment factor (p-value: 0.0356) by the 'F test'. CM+3CS+1B treatment (18.393 t ha^{-1}) increased productivity by 4.032 t ha^{-1} (p-value: 0.036) compared to the control treatment (14.361 t ha^{-1}), with standard error of 1.775 t ha^{-1}.

Oliveira (2017) evaluated two soil conditioners (oyster shell limestone and *Lithothamnium calcareum*) and three biostimulants (Alga *Ascophyllum*; Algae *Laminaria digitata* and *Hypnea musciformis*; Algae *Laminaria digitata*, *Hypnea musciformis* and *Sargassum vulgare*) and found that the two conditioners and the three algae combinations were efficient to increase the production of *Physalis peruviana*. Conditioners and biostimulants contain various growth regulators, such as cytokinins, auxins, gibberellins, as well as macronutrients such as Ca, K, P, and micronutrients such as Fe, Cu, Zn, B, Mn, Co, Mo (KHAN et al., 2009), which allow wide possibilities of use of these products.

Production variables, although directly expressing the profitability of cultivars, cannot be considered in isolation when choosing a new management, because other factors are related, mainly the quality and acceptability of fruits and the economic viability of the management.

Table 2 shows the cost per hectare of implementation and production of the 'Prata Anã' Gorutuba banana plantation under two fertilization managements in the central region of Minas Gerais. The effective operational cost (EOC) for the implementation of 1 hectare of orchard in the CM+3CS+1B management (R$18.095,86) was higher compared to CM (R$17.061,23), showing a difference of R$1.034,63 per hectare. In the second year after implementation, the difference was R$ 1.118,18.

Table 2. Cost per hectare of implementation and production of 'Prata Anã' Gorutuba banana plantation (*Musa* sp.) under different fertilization managements in the central region of Minas Gerais, Brazil.

Specification	Unit	Price/ unit	Year 1		Price/ unit	Year 2	
			Quant.	Value		Quant.	Value
1. INPUTS							
Seedlings (+10%)	Unit	2,10	1833	3.848,46	-	0	0,00
Chicken manure	kg	0,25	1666	416,50	-	0	0,00
Dolomitic Limestone *	Mg	197,00	1.4	275,80	-	0	0,00
Urea*	kg	-	0	0,00	1,88	870	1.635,60
Simple superphosphate *	kg	3,18	333.2	1.059,58	-	0	0,00
Potassium chloride *	kg	4,48	750	3.360,00	4,20	1250	5.250,00
Yoorin Master	kg	1,80	333.2	599,76	-	0	0,00
Mineral oil OPPA	L	3,90	58	227,76	16,90	58	980,02
Tilt (25%)	L	160,00	1.6	256,00	169,00	1.6	270,40
Beauveria bassiana	L	120,00	3	360,00	139,90	3	419,70
Pesticide (fipronil)	L	63,50	2	127,00	89,90	2	179,80
Subtotal**				**10.530,86**			**8.735,52**
Percentage share				**58,19**			**54,15**
2. SOIL PREPARATION AND PLANTING							
Soil analysis	Unit	45,00	1	45,00	-	0	0,00
Soil sampling	Man/day	65,32	1	65,32	-	0	0,00
Plowing	Hour/tractor	124,91	3	374,73	-	0	0,00
Liming	Hour/tractor	84,79	1	84,79	-	0	0,00
Harrowing (02)	Hour/tractor	124,91	2	249,82	-	0	0,00
Furrowing	Hour/tractor	124,91	1	124,91	-	0	0,00
Demarcation of pits	Man/day	65,32	2	130,64	-	0	0,00
Opening of pits	Man/day	65,32	5	326,60	-	0	0,00
Planting fertilization	Man/day	65,32	1	65,32	-	0	0,00
Planting and replanting	Man/day	65,32	7	457,24	-	0	0,00
Subtotal**				**1.924,37**			**0,00**
Percentage share				**10,63**			**0,00**
3. CULTURAL AND PHYTOSANITARY TREATMENTS							
Leaf analyses	Unit	-	0	0,00	48,00	6	288,00
Weeding (manual)	Man/day	65,32	16	1.045,12	75,00	2	150,00
Top dressing	Man/day	65,32	11	718,52	75,00	11	825,00
Cultural treatments	Man/day	65,32	6	391,92	75,00	3	225,00
Sprays	Man/day	65,32	5	326,60	75,00	5	375,00
Phytosanitary treatment	Man/day	65,32	5	326,60	75,00	5	375,00
Manual harvest	Man/day	65,32	0	0,00	75,00	15	1.125,00
Internal transport	Man/day	65,32	2	130,64	75,00	2	150,00
External transport	L	-	0	0,00	4,55	66.66	303,30
Packer	Box	-	0	0,00	0,54	900	486,00
Packing	Unit	-	0	0,00	1,38	900	1.242,00
Subtotal**				**2.939,40**			**5.544,30**
Percentage share				**16,24**			**34,37**
4. IRRIGATION***							
Irrigator	Man/day	65,32	5	326,60	75,00	5	375,00

Irrigation	Implementation	1000,00	1	1.000,00	-	0	0,00
Irrigation	Maintenance	100,00	1	100,00	105,00	1	105,00
Energy	Kwh	0,16	1500	240,00	0,17	1500	255,00
Subtotal**				**1.666,60**			**735,00**
Percentage share				**9,21**			**4,56**
5. ALTERNATIVE TREATMENT (CM+3CS+1B)							
Oyster shell limestone (CC)	kg	0,86	99.96	85,97	0,89	99.96	88,96
Celtonite/FERTCEL (CT)	kg	2,30	111.07	255,46	2,39	111.07	265,45
Lithothamnium calcareum (LT)	kg	1,50	99.96	149,94	1,56	99.96	155,93
Acadian® (5,3% K2O)	L	100,90	1.5	151,35	105,23	1.5	157,84
Top dressing	Man/day	65,32	3	195,96	75,00	3	225,00
Spraying (leaf axilla)	Man/day	65,32	3	195,96	75,00	3	225,00
Subtotal**				**1.034,64**			**1.118,18**
Percentage share				**5,72**			**6,93**
EFFECTIVE OPERATION COST - CM				17.061,23			15.014,82
EFFECTIVE OPERATION COST - CM+3CS+1B				18.095,86			16.133,00
TOTAL PERCENTAGE				100,00			100,00
FINANCIAL CHARGES (10%) - CM				1.706,12			1.501,48
FINANCIAL CHARGES (10%) - CM+3CS+1B				1.809,59			1.613,30
TOTAL OPERATION COST - CM				18.767,35			16.516,30
TOTAL OPERATION COST - CM+3CS+1B				19.905,45			17.746,30

Stand of 1666 plants per hectare in double row spacing (3.30 m x 2.70 m x 2.00 m).
** Refers to the maximum recommendation, which can be reduced according to soil analysis results.
*** R$ ha^{-1}.
**** Irrigation values were estimated for ten hectares and diluted to one hectare.

The distribution of effective operational costs (EOC) in the first year of cultivation of 'Prata' Gorutuba banana for the central region of Minas Gerais, with the inclusion of the alternative treatment, was shown as the following percentages in the implementation stage: 58.19% of inputs, 10.63% of soil preparation and planting, 16.24% of culture and phytosanitary treatments, 9.21% of irrigation and 5.72% of alternative treatment (CM+3CS+1B), being the lowest cost of the 1st year (Table 3).

Table 3. Distribution of effective operational costs (EOC), in %, for the production of 'Prata Anã' Gorutuba bananas (*Musa* sp.), in the first two years of cultivation (implantation + 1st harvest), with the addition of alternative fertilization management (CM+3CS+1B), in the central region of Minas Gerais, Brazil.

	EOC (%)*					
Period	**Inputs**	**Soil preparation and planting**	**Culture treatments**	**Irrigation**	**Alternative treatment (CM+3CS+1B)**	**Total**
1st YEAR	58,19	10,63	16,24	9,21	5,72	**100,00**
2nd YEAR	54,15	0,00	34,37	4,56	6,93	**100,00**
Mean	56,17	5,31	25,30	6,88	6,32	

* EOC: costs calculated for 1 hectare with stand of 1666 plants.

In a study carried out by Pacheco et al. (2016) during the implementation of a banana plantation in Aquidauana, Mato Grosso do Sul, costs on inputs represented 46.23% of the EOC due to the need to purchase seedlings, plastic bags and greater use of fertilizers. Rodrigues et al. (2018) evaluated the economic and financial profitability for the implementation of a 'Prata Anã' banana plantation in Ipameri, Goiás, and found that inputs represented the highest costs in the year of crop implementation, representing 74.06% of the total operation cost (TOC) for the activity.

In the present work, it was observed that expenses with inputs reduced about 6.94%, from the first to the second year due to their higher cost during planting fertilization. In addition, it was observed that the cost of culture and phytosanitary treatments doubled (211.63%) and there was a reduction in irrigation cost by 50.48%. Culture treatments increased in % due to the expectation of production from the 1st year to the 2nd year; on the other hand, irrigation costs decreased, since the highest cost occurred in the system implementation in the 1st year of cultivation (Table 3). The same behavior was described by Pacheco et al. (2016), Rodrigues et al. (2018) and Do Couto et al. (2020). Costs with seedlings, area preparation, inputs and labor for implantation and management of the banana plantation, excluding costs related to irrigation and application of the alternative treatment, accounted for most of the effective operational cost, about 85.1% in the first year and 88.5% in the second year. In an economic viability study with 'Prata' banana trees under two irrigation managements, in Goiânia, Goiás, Do Couto et al. (2020) found values close to those found in this study, with 88.7% of the EOC for the aforementioned costs and 11.3% for irrigation.

The total operational cost (TOC) in the first year (implementation) was R$19.905,45 for the CM+3CS+1B treatment, representing an increase of 5.71% when compared to the common management, whose TOC was R$18.767,35 (Table 2).

The high participation of manual operations in the TOC from the production phase (second year) is due to the crop needs in its production process, having high demand for labor, mainly for the harvest of fruits and culture treatments. According to Furlaneto et al. (2011), manual operations accounted for about 20% of the TOC after the formation of the banana plantation in the region of Paranapanema, São Paulo.

The adoption of the alternative treatment in this production system was quite feasible, as it represented, in percentage terms, average annual cost of 6.32%, which is very close to the average annual cost of irrigation (6.88%), as shown in Table 3.

Higher TOC was verified for both treatments in the implantation year due to the operational costs of soil preparation and planting, as well as due to the higher costs of inputs in planting fertilization, seedlings and chemicals (Table 3).

The economic feasibility of the CM+3CS+1B alternative treatment can be seen in Table 4, where the total operation cost (1st + 2nd year), productivity (t ha^{-1}) and average cost of producing one ton of 'Prata Anã' Gorutuba bananas are presented. It was found that the total operational cost (1st + 2nd year) of the alternative management was 6.71% higher compared to the conventional management; however, the productivity of the alternative treatment was 28.08% higher. The cost to produce one ton of banana was R$ 2.456,91 in the conventional treatment and R$ 2.047,07 in the alternative treatment, which represents a 16.68% reduction in the average cost, indicating the economic viability of this treatment.

Table 4. Total operation cost (1st + 2nd year), productivity (t ha^{-1}) and average cost of producing one hectare of Prata Anã` Gorutuba banana (*Musa* sp.) in the central region of Minas Gerais, Brazil, with two fertilization managements.

Treatments	Total operation cost (1st + 2nd year) (R$)	Productivity (t ha^{-1})	Average production cost (R$ ha^{-1})
Conventional management (CM)	35.283,65	14,361	2.456,91
CM+3CS+1B	37.651,75	18,393	2.047,07
Ratio	6,71%	28,08%	-16,68%

In this way, the extra application of the four products mentioned above to conventional management, regardless of banana marketing value, provides greater profits or smaller losses compared to conventional management, as it reduces the average total operation cost.

Further studies should be carried out in the same region with this alternative treatment during subsequent cycles of the 'Prata' Gorutuba variety.

Conclusion

The alternative management (CM+3CS+1B) was more economically viable than CM because the total operation cost (1st + 2nd year) of the alternative management was 6.71% higher compared to the conventional management; however, the productivity of the alternative treatment was 28.08% higher.

The cost to produce one ton of banana was R$ 2.456,91 in the conventional treatment and R$ 2.047,07 in the alternative treatment, which represents a 16.68% reduction in the average cost, indicating the economic viability of this treatment.

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