ISSN 2359-6562 (ONLINE) 2359-6562 (CD-ROM)

CARACTERIZAÇÃO DE SISTEMAS AGROFLORESTAIS DO PROGRAMA "REFLORESTAR" LOCALIZADOS NO NORTE DO ESPÍRITO SANTO

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RESUMO: Sistemas agroflorestais (SAFs) são meios de produção agrícola sustentáveis, uma vez que resultam em uma maior diversificação do uso da terra, gerando, consequentemente, mais de um produto para venda, contribuindo com o aumento e manutenção da renda dos agricultores. Esse tem sido o principal modelo adotado por participantes do Programa "Reflorestar", idealizado pelo governo do estado do Espírito Santo como política pública para a união da conservação dos recursos hídricos e preservação ambiental com oportunidades de geração de renda. A configuração dos SAFs é variavel, sendo influenciada por fatores climáticos, culturais e socieconômicos aos quais os produtores estão inseridos. Nesse contexto, esta pesquiva teve o objetivo de apresentar uma caracterização dos sistemas agroflorestais adotados por produtores do norte do Espirito Santo participantes do Programa Reflorestar. Foram selecionadas três propriedades classificadas na modalidade agricultura familiar, localizadas em municípios distintos (Ponto Belo, Montanha e Pinheiros). Com as informações obtidas por meio de uma empresa de consultoria do referido Programa, observou-se que as culturas agrícolas escolhidas para plantio em consórcio com especies florestais nativas foram: banana prata, coco e café conilon, por essas lavouras apresentarem altos rendimentos e melhores possibilidades de venda devido à existência de associação de produtores (caso do café conilon).

Palavras-chaves: SAF, desenvolvimento rural sustentável, consórcio de culturas, banana, café conilon.

CHARACTERIZATION OF AGROFORESTRY SYSTEMS OF THE "REFLORESTAR" PROGRAM LOCATED IN THE NORTHERN OF ESPÍRITO SANTO

ABSTRACT: Agroforestry systems (AFS) are means of sustainable agricultural production since they result in greater diversification of soil use, generating, consequently, more than one product for sale, contributing to the increase and maintenance of farmers' income. This has been the main model adopted by participants of the "Reflorestar" Program, idealized by the state government of Espírito Santo as a public policy to integrate water resources conservation and environmental preservation with income generation opportunities. The configuration of the AFS is variable, being influenced by climatic, cultural, and socioeconomic factors in which the producers are inserted. In this context, this research aimed to present a characterization of the agroforestry systems adopted by farmers from northern of Espírito Santo, participants of the Reflorestar Program. Three rural properties classified as family farms, located in distinct municipalities (Ponto Belo, Montanha, and Pinheiros), were selected. With the information obtained through a consulting company of the mentioned Program, it was observed that the crops chosen for planting in intercrop with native forest species were silver banana, coconut, and conilon coffee because this crops present high yields and better possibilities for sales due to the existence of producers' association (case of conilon coffee).

Keywords: AFS, sustainable rural development, intercropping, banana, conilon coffee.

Recebido em 26/01/2023 e aprovado para publicação em 22/05/2023
DOI: http://dx.doi.org/10.17224/EnergAgric.2023v38n2p45-55

1 INTRODUCTION

Recognition and awareness of the importance of the environmental, economic and social values of forests have led to strong trends toward changes in land use, with the use of more sustainable production systems, in which, in addition to socioeconomic aspects, environmental aspects such as the biological productivity of the soil.

Seeking improvements in land use in Espírito Santo, the state government created the "Reflorestar" program in June 2012. This program is based on the old "Florestas para Vida" project and aims to use funds from different sources to assist small and medium-sized rural producers in reconstituting vegetation cover in portions of their agricultural properties, using agroforestry systems (SAFs), managed forests, recovering degraded areas with the planting of native species or agricultural crops, and isolating areas with the purpose of promoting natural regeneration, among other actions (Sossai, 2021).

According to information from the Government of the State of Espírito Santo (2023), every rural owner in the state has the right to join the Reforestation Program. Producers enrolled in the program receive financial benefits, either through Payment for Environmental Services (PSA) and/or assistance with the purchase of inputs. In turn, the environmental benefits generated by these people by allocating part of their rural property to preserving the environment or adopting more sustainable agricultural practices and optimizing land use will be enjoyed not only by them but also by the entire local community. The modalities covered by the program include silvopastoral systems, SAFs, standing forests, managed forests, recovery with the planting of native species and natural regeneration.

SAFs have stood out as the choice of producers. According to Tubenchlak *et al.* (2022), data from the Reflorestar program indicate that in 2019, 60% of the 1,600 hectares of forest restoration in Espírito Santo occurred through agroforestry. According to the analysis of forestry engineer Marcos Sossai, manager of the Reflorestar program, presented by Couzemenco (2021):

> There is a change in behavior on the part of rural producers. He is realizing that he can plant forests and have them as an asset not only environmentally but also economically. This ensures that, in a medium period of time, it is possible to change the culture. Today, it is still common to think that you either have the forest, which does not provide any return, or the pasture. The producer understands that he can make economic gains from the forest.

When choosing to implement an agroforestry system (SAF), producers participating in Reflorestar receive R$8,598.72 [1]per hectare for the purchase of inputs (Government of the State of Espírito Santo, 2023). By 2019, more than 2,400 hectares of SAFs had been implemented with this program (Tubenchlak *et al.*, 2022).

SAFs promote the improvement and conservation of edaphic factors (related to the soil) through several processes, interfering with the quantity and availability of nutrients in the saturated root zone of agricultural crops and reducing the loss of these nutrients through leaching. Areas with SAFs also present a large amount of organic matter in the soil, reduced erosion processes, increased fertility and a reduced need for the application of agricultural pesticides. Furthermore, the conservation and improvement of edaphic factors due to the increase in vegetation cover helps to recover the flow in springs and improve water quality (Comas, 2017).

Agricultural practices through SAFs generate better diversification of land use, labor and production, which consequently contributes to an increase in farmers' income (Arco-Verde; Amaro, 2021; Wandelli *et al.*, 2001). Martinelli (2020) highlights that the SAFs adopted in Brazil have different configurations, varying from region to region. The author points out the need to develop mapping and characterization research on SAFs to obtain a profile of Brazilian SAFs. In this

[1] The value reported was calculated based on the State Treasury Reference Value (VRTE) for the current year, which is updated annually.

context, this research aimed to characterize the agroforestry systems adopted by producers in northern Espirito Santo participating in the Reflorestar Program.

2 MATERIALS AND METHODS

Information about SAFs was collected from a consultancy company that provides technical assistance services with the Reflorestar Program. Thus, a qualitative approach was adopted to characterize the SAFs, consisting of data collection through documentary research and indirect nonparticipant observation. This company presented information on three SAF areas, all of which are located in northern Espírito Santo and are classified as family farms.

Technical assistance is one of the support mechanisms offered by the Reflorestar Program to rural producers and is carried out by independent professionals, such as the consultancy company providing the data. These professionals must undergo accreditation with the Development Bank of the State of Espírito Santo (BANDES). Collecting the necessary documentation, preparing the technical project for the SAFs and providing technical guidance regarding planting and conducting the project are actions carried out by professionals accredited with the Reflorestar Program. Support mechanisms present in the program also include legal security with the environmental licensing body for the sustainable extraction of timber and nontimber forest species (juçara, puninha, among others) and the structuring of business centers to enable the flow of production at a fair price (Tubenchlak *et al.*, 2022).

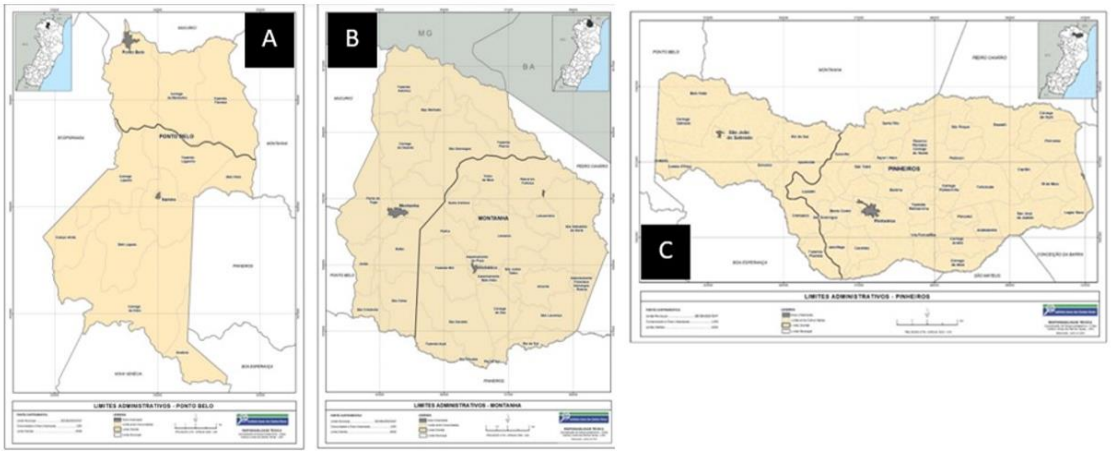
The three SAF areas studied were named consortium 1, consortium 2 and consortium 3. Table 1 presents the UTM (Universal Transverse Mercator) coordinates of the selected areas and the municipalities where they are located, while Figure 1 presents the locations of the municipalities in the state of Espírito Santo. The SAF areas were delimited in the *Google Earth Pro program.* Using the "Historical Images" tool in *Google Earth Pro*, 2 (two) satellite images of the areas were selected to show the differences before and after the implementation of the agroforestry system.

Table 1. Location of SAFs participating in the Reforest program objects of this research

Agroforestry System	UTM coordinates (24K Zone)	County
Consortium 1	337939.21 m E; 7995688.30 m S	Point Belo
Consortium 2	358374.08 m E; 7996294.98 m S	Mountain
Consortium 3	378863.61 m E; 7968024.92 m S	Pine trees

Source: Consulting company (2021)

Figure 1. Maps of the municipalities of Ponto Belo (A), Montanha (B) and Pinheiros (C) and their locations in the state of Espírito Santo



Source: Capixaba Research Institute, Technical Assistance and Rural Extension (2021)

RESULTS AND DISCUSSION

When adding the areas of the three SAFs studied (Table 2), we found 4.2 ha, which represents 0.17% of the 2,400 hectares implemented with SAFs in Espírito Santo through the Reflorestar Program until 2019.

Table 2. Data from SAFs participating in the Reforest program objects of this research

Agroforestry System	Consortium components	Area	Date of joining the Reflorestar Program	County
Consortium 1	Prata Banana, Coconut, Conilon Coffee and native forest species[2]	1.0 ha	02/01/2019	Point Belo
Consortium 2	Rubber Tree, Prata Banana, Conilon Coffee and native forest species	2.4 ha	02/01/2015	Mountain
Consortium 3	Prata Banana, Coconut, Conilon Coffee and native forest species	0.8 ha	02/01/2016	Pine trees
Average		1.4 ha		

Source: Consulting company (2021)

It appears that consortium 2, located in the municipality of Montanha, has the largest area (2.4 ha) and has participated in the Reflorestar Program for the longest time (since 2015). It was also observed that the rural properties studied were small, with an average size of 1.4 ha. Although the SAFs are located in different municipalities in the north of the state of Espírito Santo, they have similar arrangements, including consortia 1 and 3, with areas close to or equal to 1 ha, which have the same arrangement; this arrangement is composed of a combination of cultivated agricultural species, silver banana, coconut and conilon coffee, with native forest species. In consortium 2, which has an area of more than 2 ha, coconut was not used. The SAF arrangement consisted of combining the rubber forest species with native forest species and the agricultural crops banana and coffee (Table 2).

[2]Jequitibá-rosa (*Carinian a legalis)*, Vinhático (*Plathymenia reticulata)*, Braúna (*Melanoxylon brauna)* , Louro-pardo (*Cordia trichotoma)*, Aroeira or Pimenta-rosa (*Schinus terebinthifolia)*, Pau-cigarra (*Senna multijuga)* , I ngá (*Inga edulis)* , Pau-jacaré (*Piptadenia gonoacantha)* , among others.

The similarity observed in the configuration of the SAFs is because ten arrangements are usually implemented in the Reflorestar Program that combine agricultural crops (cupuaçu, cocoa, coffee, etc.) with perennial woody species (palm trees, shrubs, trees, etc.). The following species were used for different extracts: high extract (EA), a species that can reach a height of more than 15 meters; medium extract (EM), a species that can reach 5 to 15 meters in height; and low extract (EB), a species with a height of up to 5 meters (Tubenchlak *et al.*, 2022).

According to the State Secretariat for the Environment and Water Resources (2017), five of these ten arrangements consist of the following combinations: 1) Rubber tree (*Hevea brasiliensis*) species of EA + banana (*Musa spp*.). and palm [3], both EM + coffee conilon (*Coffea canephora*), native EB + species [4]; 2) Rubber tree, EA + banana, EM + cupuaçu (*Theobroma grandiflorum*), species of EM + palm, EM + native; 3) Fruit trees [5], EA + banana, EM + Arabica coffee (*Coffea arabica*), EB + native species; 4) Rubber tree, EA + banana, EM + cupuaçu, EM + palmaceae, EM + conilon coffee, EB + native; and 5) Banana, EM + palm, EM + Arabica coffee, EB + native.

It is noted that in the SAFs of consortia 1 and 3 (Table 2), a combination of native species was used with agricultural crops that have the following extracts: silver banana and coconut (medium extract) and conilon coffee (low extract) in agreement with arrangement 5, cited as one of the combinations usually adopted in the SAFs of the Reflorestar Program. The SAF of consortium 3 presented a configuration close to arrangement 1, consisting of a combination of native species with the rubber tree (a high extract species), the banana tree (a medium extract species) and the conilon coffee (a low extract species).

The state of Espírito Santo (ES) is characterized by the production of coffee, bananas, coconuts and rubber trees. Coffee is an important crop for the state economy, as ES is the second largest producer and exporter of grain in Brazil (Tubenchlak *et al.*, 2022). Banana and coconut cultivation are of great socioeconomic importance, as they are predominantly carried out by family farming. Banana farming generates more than 30 thousand jobs in its production chain, with the Prata subgroup representing 80% of the cultivated area (INCAPER, 2023a). While coconut farming is used in the agricultural diversification of coffee cultivation, being a counterpoint to monoculture, it is an important source of income generation for the producer due to the commercialization of "in natura" coconut fruits to meet the consumption of green coconut water. during the year. This market is greatly boosted by tourism (INCAPER, 2023b). Finally, rubber tree cultivation is highly profitable for producers in the state, as it is sold at R$80 per hectare/month and is highly resistant to drought and disease, with meeting its water demand being more crucial only in the first six months. after planting (G1 ESPÍRITO SANTO, 2015).

According to Schembergue *et al.* (2017), the choice of crops that will make up an SAF is influenced by socioeconomic factors, agronomic characteristics and climatic variations. The existence of producer associations is a socioeconomic issue. The Cooperativa Agrária de Cafeicultores de São Gabriel (Cooabriel), which has more than 7 thousand members, is located in northern Espírito Santo, the largest conilon coffee cooperative in Brazil. Founded in 1963, Cooabriel currently provides its members with storage units, a clonal garden, an analysis laboratory, an experimental farm, agricultural stores, technical consultancy, sustainability certification and financing options for fertilizers, fertilizers, equipment, pesticides, clonal seedlings and crop costing. All of these benefits contribute to improving the quality of coffee produced, expanding production and

[3]The çaí (*Euterpe oleracea)* , peach palm (*Bactris gasipaes)* or royal palm (*Archontophoenix alexandrae)*

[4]Jequitibá-rosa (*Carinian a legalis)*, Vinhático (*Plathymenia reticulata)*, Braúna (*Melanoxylon brauna)* , Louro-pardo (*Cordia trichotoma)*, Aroeira or Pimenta-rosa (*Schinus terebinthifolia)*, Pau-cigarra (*Senna multijuga)* , I ngá (*Inga edulis)* , Pau-jacaré (*Piptadenia gonoacantha)* , among others.

[5]Pineapple, acerola, abiu, blackberry, avocado, cajá-manga, biribá, cashew, guava, citrus, mango, lychee, cherry and passion fruit.

sales areas and opening new markets (COOABRIEL, 2023). Therefore, it can be inferred that the existence of this cooperative influenced the choice of conilon coffee as one of the agricultural crops to be implemented in the SAFs studied (Table 2).

Table 3 presents the guidelines that were passed on to producers regarding the planting of consortia 1 and 3, while Table 4 presents the guidelines regarding the planting of consortium 2.

Table 3. Recommendations for planting crops included in consortia 1 and 3

Cultivation	Recommendations
Café Conilon	Coffee should be planted with a spacing of 2 m between plants and a spacing of 3 m between rows. For every two lines of coffee plants, one line containing coconut alternated with native species and another containing banana will be planted.
Coconut and native forest species	Alternately plant a coconut seedling and a native species seedling with a spacing of 4 m between plants and 3 m between rows. Coconut planting should be alternated with native species after two rows of coffee.
Silver banana	The banana must be planted with a spacing between plants of 2 m and 3 m between rows. Its planting begins after the planting line containing coconut alternated with native species.

Source: Consulting company (2021)

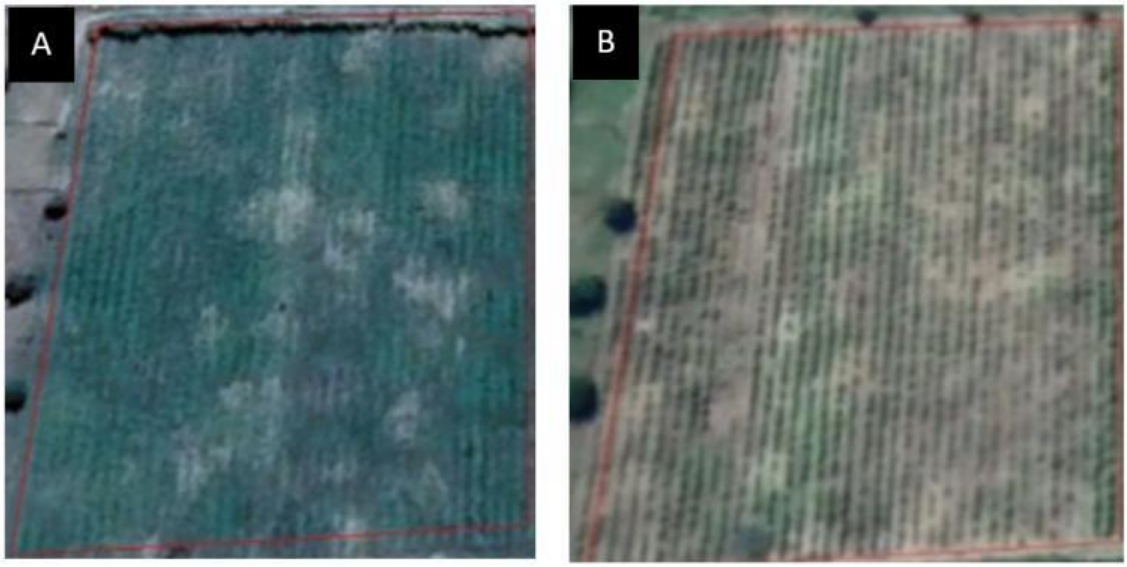
Table 4. Recommendations for planting crops included in consortium 2

Cultivation	Recommendations
Conilon coffee and silver banana	Coffee should be planted with a spacing of 2 m between plants and a spacing of 3 m between rows. In the same line, coffee planting should be alternated with banana planting, for every two coffee plants a banana tree will be planted.
Rubber tree and native forest species	The rubber tree will be planted alternately with native species, using a spacing of 4.77 m between plants and 3 m between rows. Plant a rubber tree seedling and a native species seedling alternately. Alternate planting lines, planting one line containing conilon coffee and banana and the next containing rubber trees and native species.

Source: Consulting company (2021)

Figures 2, 3 and 4 present satellite images for consortia 1, 2 and 3, respectively. Thus, it is possible to perceive the changes that occurred on rural properties after the implementation of SAFs (crop planting). In consortia 1 and 2 (Figures 2 and 3), the change in spacing between both plants and between lines was noticeable. In consortium 3 (Figure 4), there was no vegetation before the implementation of the SAF, with this property being used for cattle pasture.

Figure 2. Satellite images of the Agroforestry System (SAF) Consortium 1, delimited by the red line, located in the municipality of Ponto Belo, north of Espirito Santo, captured on **A)** 13/06/2018 (before the implementation of the SAF) and **B)** 07/03/2019 (after the implementation of the SAF), showing the changes that occurred on the rural property

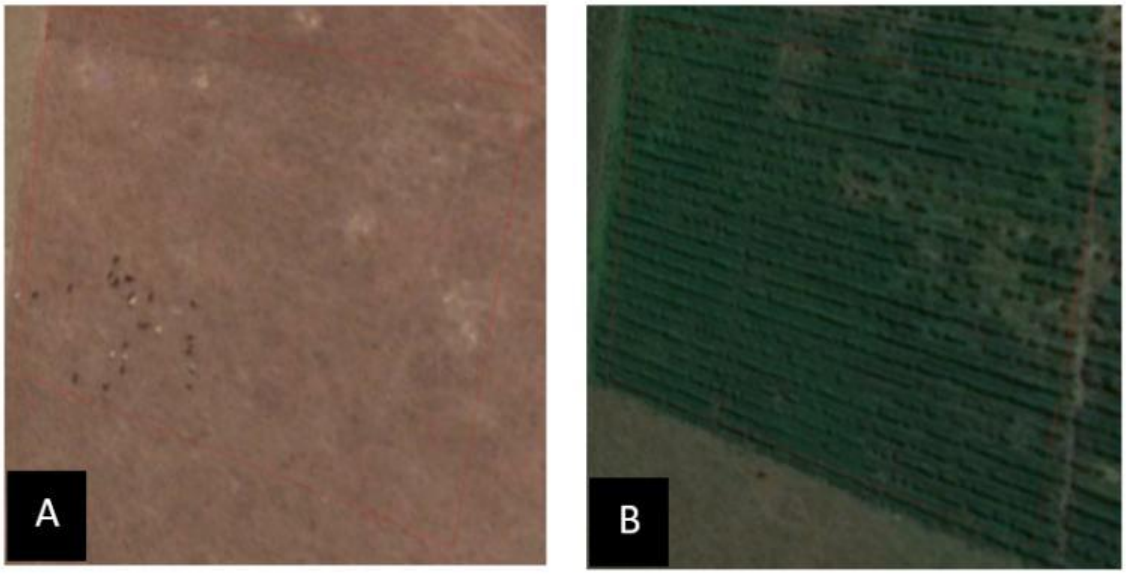


Source: Google (2021)

Figure 3. Satellite images of the Agroforestry System (SAF) Consortium 2, delimited by the red line, located in the municipality of Montanha, north of Espirito Santo, captured on **A)** 17/06/2010 (before the implementation of the SAF) and **B)** 09/11/2019 (after the implementation of the SAF), demonstrating the changes that occurred on the rural property

Source: Google (2021)

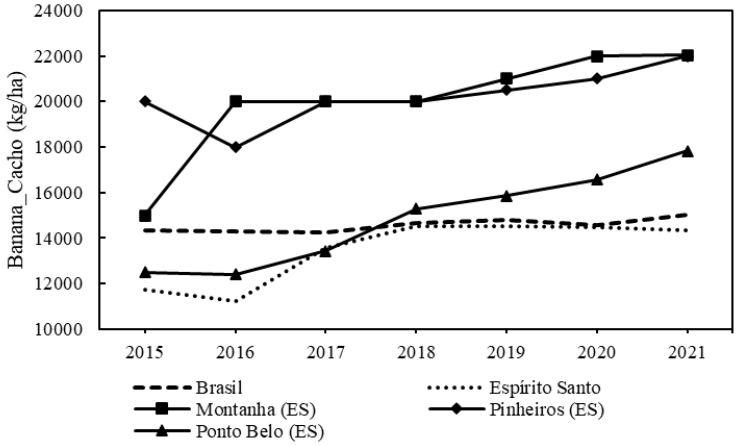
Figure 4. Satellite images of the Agroforestry System (SAF) Consortium 3, delimited by the red line, located in the municipality of Pinheiros, north of Espirito Santo, captured on **A)** 25/08/2013 (before the implementation of the SAF) and **B)** 19/05/2018 (after the implementation of the SAF), demonstrating the changes that occurred on the rural property



Source: Google (2021)

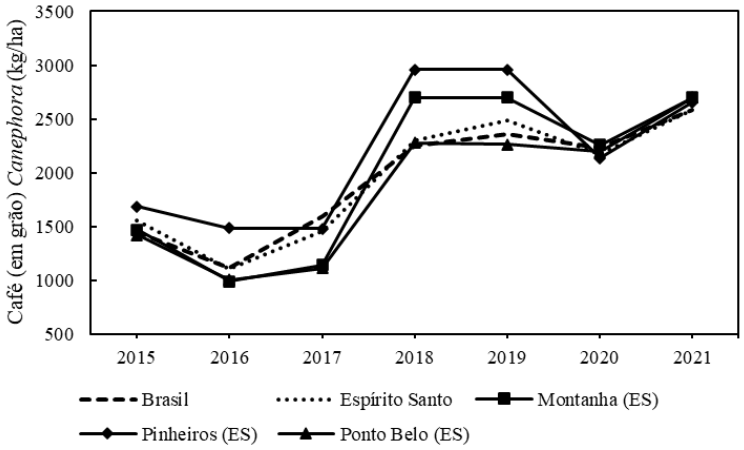
Another relevant point related to the choice of crops that make up the arrangement of an SAF is the yield of the selected agricultural crops, which can be understood as the result of good cultural treatment combined with a suitable climate for the development of the crop. In this regard, the municipalities in which the studied SAFs are located have yields close to or above the national and state average for the following crops: banana, conilon coffee and coco-da-baía according to Municipal Agricultural Production (PAM) data made available by IBGE through its Automatic Recovery System (SIDRA). This statement can be proven by observing Figures 5, 6 and 7, which present the average yields, in kg/ha, of the agricultural crops banana, *Canephora coffee* (conilon) and coconut, respectively, for the period from 2015 (the year of installation of the oldest SAF, consortium 2, Table 2) to 2021. Table 5 shows the average yield of crop production recorded for this period in the municipalities of Montanha, Pinheiros and Ponto Belo in comparison with the national and state averages.

Figure 5. Average banana yield (bunch) in kg/ha recorded from 2015 to 2021 in the municipalities of Montanha, Pinheiros and Ponto Belo in the state of Espírito Santo and Brazil



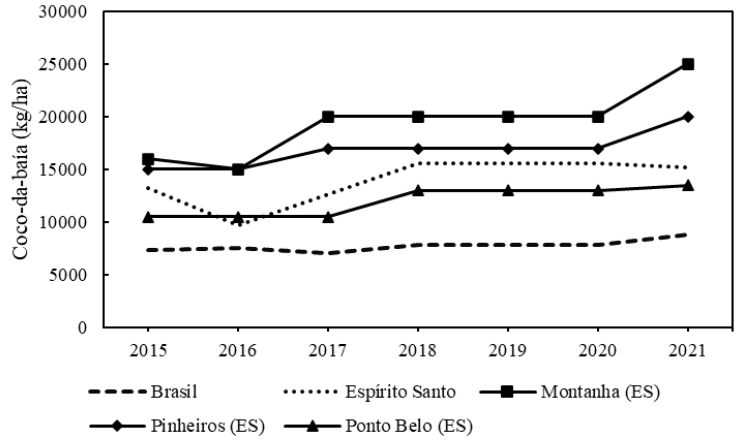
Source: IBGE (2021)

Figure 6. Average yield of *Canephora coffee* (conilon) in kg/ha (grains) recorded from 2015 to 2021 in the municipalities of Montanha, Pinheiros and Ponto Belo in the state of Espírito Santo and Brazil



Source: IBGE (2021)

Figure 7. Average yield of coconut in kg/ha recorded from 2015 to 2021 in the municipalities of Montanha, Pinheiros and Ponto Belo in the state of Espírito Santo and Brazil



Source: IBGE (2021)

Table 5. The average yields of banana, conilon coffee and coco-da-baía crops recorded in 2015-2019 in the municipalities of Montanha, Pinheiros and Ponto Belo compared to the national and state averages

	Banana (bunch) (kg/ha)	**Conilon coffee (bean) (kg/ha)**	**bay coconut (kg/ha)**
Mountain	20,006.8	1,994.0	19,428.6
Pine trees	20,214.3	2,194.0	16,857.1
Point Belo	14,839.4	1,853.0	12,000.0
National	14,566.9	1,941.1	7,760.1
State	13,478.1	1,951.3	13,923.0

Source: IBGE (2021)

Considering the average for the period from 2015 to 2021, it appears that bananas, conilon coffee and coco-da-baía have high yields in all municipalities. The municipality of Montanha, the location of SAF consortium 2, presented an average of 20,006.8 kg/ha for bananas, 1,994.0 kg/ha for conilon coffee and 19,428.6 kg/ha for coco-da-baía. The municipality of Pinheiros, the location of SAF consortium 3, presented averages of 20,214.3

kg/ha for banana, 2,194.0 kg/ha for conilon coffee and 1,6,857.1 kg/ha for coconut. -bay. The municipality of Ponto Belo, which is the location of SAF consortium 1, presented an average of 14,839.4 kg/ha for bananas, 1,853.0 kg/ha for conilon coffee and 12,000.0 kg/ha for coconut. . Notably, with the exception of the municipality of Ponto Belo for conilon coffee and coco-da-baía crops, the yields of the municipalities were greater than the national and state averages.

4 CONCLUSIONS

The arrangement of agroforestry systems adopted in agricultural areas located in municipalities in northern Espírito Santo, whose producers are participants in the Reflorestar Program, prioritized the combination of species from different strata (high, medium and low), adopting the planting of agricultural crops silver banana, coconut and conilon coffee in combination with native forest species, as these crops present high yields and better sales possibilities due to the existence of a producer association (in the case of conilon coffee).

5 ACKNOWLEDGMENTS

The authors would like to thank the National Council for Scientific and Technological Development (CNPq) for granting a scholarship.

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