

## **Cupuassu plant management and the market situation of Itacoatiara, Manacapuru and Presidente Figueiredo counties, Amazonas State, Brazil**

**Manejo do cupuaçu e situação do mercado nos municípios de Itacoatiara, Manacapuru e Presidente Figueiredo, Estado do Amazonas, Brasil**

**Gestión de cupuaçu y situación de mercado en los municipios de Itacoatiara, Manacapuru y Presidente Figueiredo, Estado de Amazonas, Brasil**

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### **Abstract**

*Theobroma grandiflorum* (Willd. ex Spreng. Schum.) is one of the most cultivated fruit species in the Amazon. This work analyzed three aspects of cultivation and fruit processing in the Amazonas State counties of Itacoatiara, Manacapuru and Presidente Figueiredo: the farms producing cupuassu, the utilization, and marketing forms of its byproducts. In these counties there is no uniformity in cupuassu plantations for plants density, fruit and seed yields. They were formed without proper guidance from State agencies agricultural assistance, resulting in very poor cultivation system, with high plants densities found in almost all rural properties. These high densities increase plants competition for nutrients and light, favor the pests and diseases proliferation and hinder harvesting. If farmers use technologies and proper techniques of cultivation and maintenance, cupuassu pulp productivities could increase from 442-649 (counties averages) to 2,000-3,000 kg.ha<sup>-1</sup>. Seed production jump from 0 (when not sold) or 178-261 (counties averages) to 1,000-1,257kg.ha<sup>-1</sup>.

**Keywords:** Rural productivity; Pests and diseases managements; Crop management; Agricultural practices.

### **Resumo**

*Theobroma grandiflorum* (Willd. Ex Spreng. Schum.) é uma das espécies frutíferas mais cultivadas na Amazônia. Este trabalho analisou três aspectos do cultivo e do processamento de frutos nos municípios amazônicos de Itacoatiara, Manacapuru e Presidente Figueiredo: as fazendas produtoras de cupuaçu, a utilização e as formas de comercialização de seus subprodutos. Nestes municípios não há uniformidade nas plantações de cupuaçu para densidade de plantas, produção de frutos e sementes. Elas foram formadas sem a devida orientação dos órgãos estaduais de assistência agrícola, resultando em um sistema de cultivo muito precário, com altas densidades de plantas encontradas em quase todas as propriedades rurais. Essas altas densidades aumentam a competição das plantas por nutrientes e luz, favorecem a proliferação de pragas e doenças e dificultam a colheita. Se os agricultores usarem tecnologias e técnicas adequadas de cultivo e manutenção, a produtividade da polpa de cupuaçu pode aumentar de 442-649 (médias do município) para 2.000-3.000 kg.ha<sup>-1</sup>. A produção de sementes salta de 0 (quando não vendida) ou 178-261 (médias dos municípios) para 1.000-1.257kg.ha<sup>-1</sup>.

**Palavras-chave:** Produtividade rural; Manejo de pragas e doenças; Manejo de culturas; Práticas agrícolas.

### **Resumen**

*Theobroma grandiflorum* (Willd. Ex Spreng. Schum.) es una de las especies frutales más cultivadas en el Amazonas. Este trabajo analizó tres aspectos del cultivo y procesamiento de frutas en los distritos de Itacoatiara, Manacapuru y Presidente Figueiredo del estado Amazonas: las fincas productoras de cupuassu, la utilización y formas de comercialización de sus subproductos. En estos condados no hay uniformidad en las plantaciones de cupuassu en

cuanto a densidad de plantas, rendimiento de frutos y semillas. Se formaron sin la debida orientación de las agencias estatales de asistencia agrícola, lo que resultó en un sistema de cultivo muy deficiente, con altas densidades de plantas que se encuentran en casi todas las propiedades rurales. Estas altas densidades aumentan la competencia de las plantas por los nutrientes y la luz, favorecen la proliferación de plagas y enfermedades y dificultan la cosecha. Si los agricultores utilizan tecnologías y técnicas adecuadas de cultivo y mantenimiento, la productividad de la pulpa de cupuassu podría aumentar de 442-649 (promedios de los distritos) a 2,000-3,000 kg.ha<sup>-1</sup>. La producción de semillas aumentó de 0 (cuando no se vende) o 178-261 (promedios de los distritos) a 1,000-1,257 kg.ha<sup>-1</sup>.

**Palabras clave:** Productividad rural; Manejo de plagas y enfermedades; Manejo de cultivos; Prácticas agrícolas.

## 1. Introduction

The cupuassu is one of the most cultivated fruit species in the Amazon. This is due to the high commercial fruit and seed values (Vriesmann et al., 2009; 2010; Pugliese et al., 2013), whose pulp is already marketed widely in the region as well as in Brazil and other countries (Alves et al., 2014; Socha & Pinheiro, 2016). The fruit also generate large amount of solid waste which can have economic values, such polyphenol and flavonoids (Costa et al., 2019). The continuous expansion of cupuassu pulp trade has generated a growing demand for these products, ensuring to the producer, the sale of agricultural production of this species.

Across the North region of Brazil, the area of greatest concentration of cupuassu plantations, there are records of the incidence of diseases and pests with direct interference in fruit yield and consequently, pulp and seeds production (Silva Jr. et al., 2011). Despite other factors that limit the fruits productivity, such as genetic, seasonality, nutritional, farmers who grow cupuassu recognize the need to maintain strict control of diseases and pests to avoid significant production losses. Nevertheless, in the State of Amazonas is common to find cupuassu plantations that do not follow the guidelines planting techniques and, soil and pests and diseases management, factors that affect plant productivity over time.

The lack of adoption of techniques to control diseases and pests and the expansion of commercial plantations of cupuassu in the Amazon are factors contributing to the increased incidence of diseases that causes a significant reduction in fruit production. The utilization of cupuassu seeds could minimize such negative impact and increases the value of this species in the region. The seeds of cupuassu represent a significant fraction of the fruit and have high nutritional value (Genovese & Lannes, 2009).

Amazonian climate and soil conditions are adequate for cupuassu plantations and are fundamental to its successful cultivation. According to Alves et al. (2013), the cupuassu is found in the entire Amazon basin, but originally occurred in the native forests at the south of Amazonas river, west of Tapajó river, including part of Pará and Maranhão States. Cupuassu grow well at relatively high temperatures, with an annual average of 21 °C to 28 °C, with annual relative humidity above 75 % and annual rainfall ranging from 1,900 mm to 3,100mm (Diniz et al., 1984; Venturieri, 2011). The time between fruit set and physiological maturity is about 120 days, with the cupuassu fruit reaching physiological maturity when it shows changes in pulp color, and about 5.7±0.8°Brix, which are a good index of maturity along, with days after fruit set (Hernandez & Hernandez, 2012).

The seed processing results in butter and pie. The first one is widely used by the cosmetics industry and the second one, with smaller scale, is used by the food industry in the manufacture of chocolates bars and chocolate powder, as well as for feeding fish and animals. Nonetheless, lots of cupuassu seeds become waste, being discarded during the fruit processing, especially when this is done in the rural property.

Despite having a niche market, seeds of cupuassu are poorly marketed and most of producers in the Amazon do not know their destination, and use of economic value, a factor that results in their discarding on the farm, without commercial use, failing to generate profits for the producer and invalidating the strengthening of this market niche.

The present study assessed by the first time, the situation of cupuassu in three counties of Amazonas State, Brazil, to make allowances for public policies for a better use of the Amazonian biodiversity.

## 2. Methodology

### Study Area

The area covered by this survey was restricted to Amazonas, the largest Brazilian State, with geographical area corresponding to 1,570,745.68 km<sup>2</sup>, distributed in 62 counties, with a population estimated of 4,080,611 (IBGE, 2018a).

The research that substantiated this work was carried out in the counties of Itacoatiara, Presidente Figueiredo and Manacapuru, on 60 rural farms with cupuassu cultivation.

### Physical and geographical aspects of the counties

The County of Itacoatiara has land area of 8,892 km<sup>2</sup> and is situated in the 8th Sub-State Region, the Region of the Middle Amazon. Access to the city is by road and river, with access to the Manaus by the AM 010 road, 175 km away from Manaus (straight) by upland or 201 km by waterway. The climate is tropical, rainy and humid, with average temperature of 27 °C (INMET, 2010). Its population is of 86,840 inhabitants, with an Education Index of 95.1 % and IDHM of 0.644 (IBGE 2018b).

The county of Presidente Figueiredo has land area of 25,459 km<sup>2</sup> and is situated in the 8th Sub-State Region, the Region of the Middle Amazon. The main access way is the county road, connected to Manaus by the BR 174 road, 107 Km away (straight) from the capital. The climate is tropical, hot and humid, with temperatures averaging 32°C (INMET, 2010). Its population is estimated on 35,352 inhabitants, with an Education Index of 91.1 % and IDHM of 0.647 (IBGE, 2018c).

The county of Manacapuru has land area of 7,337 km<sup>2</sup>, and is situated in the 7th Sub-State Region, the Region of Rio Negro. The access of the city is by road and river, connected to Manaus by AM 070, 68 Km away from Manaus (straight) by land and 88 km through the waterway. The climate is tropical rainy and humid, with average temperature of 26 °C (INMET, 2010). The municipality has an estimated population of 96,236 inhabitants, with an Education Index of 92.3 % and IDHM of 0.614 (IBGE, 2018d).

This work can be classified as exploratory, which is characterized by providing a better understanding of the topic under study. It is indicated for the initial stages of research when there is no deeper knowledge of the problem search. The objective was to characterize the potential use of cupuassu on an industrial scale, through the identification of aspects that influence the process of utilization of cupuassu byproducts. The study analyzed three aspects in the cultivation and byproducts processing of cupuassu: the cupuassu farms production, the utilization of byproducts, and the forms of marketing.

A survey was carried out on rural properties using the methodology described in Salking (1991) and Pereira et al. (2018), to check the level of organization, the area planted with this plant species, number of trees per ha, the pulp and seed production per tree and per property. This study enabled the diagnosis of production to understand how the cupuassu producers see the market potential for this species. The study also identified processes of cupuassu plant formation and maintenance, the presence or absence of pests and/or diseases, and also, the existence or absence of such control, as well as the level of farmers knowledge to prevent their proliferation.

The cupuassu products marketing was observed to identify the categories of buyers involved, if cooperatives, companies or intermediaries; forms of marketing, whether wholesale or retail, the place of delivery, if in the farm or in the commercial venture and the average sales price of by-products marketed.

This work also verified whether the cupuassu was processed or not in the rural properties to identify instances in which it is being performed and the type of processing done, such as if the shell, pulp, seeds are removed. If they are removed in the rural properties, how this processing is performed, whether manual or mechanized, and also what kind of packaging and storage forms they use, whether in freezers or refrigerated chambers.

Another aspect analyzed was the form of commercialization of agricultural production: in raw fruits or cupuassu pulp to understand what kind of byproducts was marketed and what the destination of the seeds, the basic raw material for the butter production. By observing this process, it was possible to realize the quality of obtaining seeds which subsequently undergo a process of fermentation and drying to produce the butter.

During the research, it was realized that the producers do not usually keep general data about the cultures in their property. In the case of cupuassu, they could not inform the amount of fruits, seeds and shell produced per season, knowing only the amount of pulp (kg) marketed, as well as the area planted, plant spacing and sometimes, the number of cupuassu plants in their properties.

Thus, it was possible to obtain the data presented in Table 1, about the cupuassu pulp production and seeds obtained in the 2009-2010 season harvest. These data allowed to know the quantity of pulp and seeds produced per cupuassu tree, using, respectively, the following calculations:

$$PPT = \frac{PP}{TPF} \quad SPT = \frac{SP}{TPF}$$

Where PPT, SPT, and TPF, PP, SP, are, respectively, pulp yields per tree, seed production per tree, tree producing fruits, pulp production and seed production.

## Field Research

The field trials were carried out on farms and agricultural cooperatives in the three counties, as well as in cupuassu pulp enterprises processing and seed processing industries.

In Itacoatiara, the data collection was performed at the Community of Sagrado Coração de Jesus, located in Novo Engenho region and in the region of Novo Remanso. In Presidente Figueiredo, data collection encompassed the communities along the highway 240 AM. In Manacapuru, data were collected in the Community of Santa Luzia, repartimento of Tuiú/Aquidabam.

The data were obtained using two structured questionnaires; the first one intended to agricultural cooperatives and/or associations, and the second one, to those responsible for the farms.

Final product industries and companies of cupuassu seed processing gave information that the supply of cupuassu with quality was insufficient to meet a growing market.

The industries of cosmetics are the main consumers of cupuassu butter, used in the formulation of hydrating facial and body massage creams, anti-aging formulation, bath oils, conditioners and hair masks, balms emulsions and powders shave, pre and post sun formulations protection, sunscreens, lipsticks, deodorants sticks, etc. The goal was to identify in the cupuassu agribusiness, which is the production potential of this species and how many amounts of seeds are being produced and used within its processing chain.

The research involved 60 farmers, 20 in each county, which corresponds to 3.05% of the cupuassu producers, and 9.46% of the area cultivated with this crop in the three counties (Table 1). Information data were also obtained in organs of agriculture technical support, such as the Institute of Agricultural Development and Sustainable Forestry of the State of Amazonas - IDAM and Sustainable Development, Secretariat of the State of Amazonas – SDS. The choice of sites for this study was made based on the fact that the counties of Itacoatiara, Presidente Figueiredo and Manacapuru are considered the

major producers of cupuassu, as indicated by the Institute Development of Agriculture and Forestry's Sustainable Amazonas State - IDAM (2010) (Table 1).

**Table 1.** Estimated acreage of cupuassu producers and counties from Amazonas State.

County	Farmers (n.)	Farmers (%)	Planted area (ha)	Planted area (%)	Fruits production (1000)	Fruits production (%)
Itacoatiara	1,230	23.27	1,910	31.91	3,820	32.39
Presidente Figueiredo	300	5.68	1,000	16.71	2,000	16.96
Manacapuru	435	8.23	482	8.05	963	8.17
Total	1,965	37.18	3,392	56.67	6,783	57.51
Amazonas State	5,285	100.00	5,986	100.00	11,794	100.00
This study	60	1.14	320	5.35	417	3.54

Source: IDAM (2010), year 2008. Adapted.

Together, the three counties have 37.18 per cent of total Amazonas cupuassu farmers, with 56.67 per cent of the planted area in the state and 57.51 per cent of fruit production. These counties are among those with larger areas planted with cupuassu in the state and a more refined study may indicate the reasons why Presidente Figueiredo and Manacapuru have fruit production far below that seen in Itacoatiara. The choice of areas was also motivated because the three counties are located in areas close to the state capital, which is the largest consumer center for agricultural products from Amazonas, and also because all them have access road to Manaus, which theoretically would facilitate the flow production conditions giving better utilization and marketing of by-products of this culture.

### 3. Results and Discussion

#### Diagnosis of cupuassu in the three counties of the State of Amazonas

The diagnosis in the counties of Itacoatiara, Presidente Figueiredo and Manacapuru indicated that there was a wide variation among farms and counties evaluated for acreage with the culture of cupuassu, as well as plant density and pulp and seeds productivity (Table 2). This table shows the maximum, minimum and the averages values for each agronomic characteristic analyzed to facilitate the high variations observed among the rural properties.

The minimum area cultivated in the 60 rural properties of the three counties studied was 0.5 ha in a property of Presidente Figueiredo and a maximum of 25 ha observed in Itacoatiara, which can characterize them as smallholder farmers. When analyzing the averages of cultivated areas in the three counties, we found that it was 7.8 ha in Itacoatiara, 5.5 ha in Presidente Figueiredo and only 2.7 ha in Manacapuru.

The number of cupuassu trees per ha also showed a large disparity among the counties, being identified in President Figueiredo, properties with a minimum of 100 plants per ha while in Itacoatiara, properties were detected up to 625 trees per ha, a plant density more than the double of recommended, which is 235 plants per ha (Venturieri et al., 1985; Souza et al., 1999). The high plant densities observed in the rural properties of Itacoatiara (400-625 plants/ha) (Table 2), well above those recommended by Venturieri et al. (1985) and Souza et al. (1999), indicate monocultures in these properties. In Presidente Figueiredo and Manacapuru, it was observed rural properties with high and with low plant densities, some of them with fewer plants than the recommended by the authors cited above. In most of searched properties in Manacapuru, for example, predominated SAFs in which the cupuassu divided spaces with other species.

**Table 2.** Real status (2009/2010 agricultural season) and desirable cupuassu tree density, and pulp and seeds farms productions in the three counties of Amazonas State.

		AWC (ha)	NCT ha <sup>-1</sup>	PP (kg)	SP (kg)	PPT (kg)	SPT (kg)	PP (kg.ha <sup>-1</sup> )	SP (kg.ha <sup>-1</sup> )
Itacoatiara	Maximum	25.0	625	13,620	5,480	3.27	1.32	2,043	822
	Minimum	1.0	400	341	137	0.05	0.02	29	12
	Averages	7.8	540	3,637	1,463	1.20	0.50	466	188
P. Figueiredo	Maximum	20.0	600	8,036	3,230	5.00	2.01	1,200	482
	Minimum	0.5	100	120	48	0.50	0.20	30	12
	Averages	5.5	324	2,462	989	2.00	0.80	442	178
Manacapuru	Maximum	4.0	480	4,000	1,608	11.00	4.00	2,000	804
	Minimum	1.0	200	200	80	0.49	0.20	110	44
	Averages	2.7	291	1,735	697	2.81	1.20	649	261
Desirable situation A <sup>(1)</sup>	Maximum	1.0	234	2,600	1,200	11.11	5.12	2,600	1,200
	Minimum	1.0	234	1,800	800	7.69	3.41	1,800	800
	Averages	1.0	234	2,200	1,000	9.40	4.30	2,200	1,000
Desirable situation B <sup>(2)</sup>	Maximum	1.0	235	3,666	1,645	15.60	7.00	3,666	1,645
	Minimum	1.0	235	2,420	869	10.30	3.70	2,420	869
	Averages	1.0	235	3,043	1,257	12.95	5.35	3,043	1,257

AWC = acreage with cupuassu; NCT = number of cupuassu trees, PP = pulp production; SP= seed production; PPT = pulp production per tree; SPT = seed production per tree; (1) Venturieri et al. (1985), (2) Souza et al. (1999). Maximum and minimum considering the 20 farms from each county.

Source: Authors.

According to Souza et al. (1999), the high density of plants does not favor the cultivation and can cause significant decreases of yield per tree and per ha, which was confirmed in this study (Table 2). The property with less pulp production was found in Presidente Figueiredo (120 kg of pulp in 0.5 ha) and the highest was 13,620 kg in 25 ha, in Itacoatiara. Similarly, seed production ranged among properties with a minimum of 48 Kg in President Figueiredo and a maximum of 5,480 Kg in Itacoatiara.

The pulp production per tree ranged from 0.05 kg in Itacoatiara and 11 kg in Manacapuru and seed yield per tree ranged of 0.02 kg in Itacoatiara and 4 kg in Manacapuru. The production of pulp per ha had a minimum of 29 kg and a maximum of 2,043 kg in Itacoatiara, resulting in a minimal production of seeds per ha of 12 kg and a maximum of 822 kg.

When comparing the averages of the counties, the farmers of Manacapuru had the lowest average acreage with cupuassu, of 2.68 ha per property, while in Itacoatiara, it was 7.8 ha. However, farmers of Manacapuru had the highest pulp production, with 649 kg per ha, while Itacoatiara, with the highest average acreage, produced 466 kg/ha, and Presidente Figueiredo, 442 kg/ha. Even in Manacapuru, where occurred the largest pulp production per ha, is still far away bellow the ideal indicated for pulp production by Venturieri et al. (1985) and Souza et al. (1999), respectively, 2,200 and 3,043 kg / ha.

The lower productivity found in the three counties studied was 29 kg of pulp per ha in a farm of Itacoatiara, and the highest of 2043 kg per ha in another farm also in this county, and consequently, 12 and 822 kg of seeds per ha in the respective rural properties. These quantities, in that order, are far below from the optimal productivities suggested by Venturieri et al. (1985) and Souza et al. (1999).

The highest average yield of pulp per ha presented by Manacapuru may be justified by the plant density, corresponding to 291 trees per acre, approaching the plants density recommended by Venturieri et al. (1985) and Souza et al. (1999), of 235 plants /ha in opposition to the high density registered in Itacoatiara, in the order of 540 plants/ ha. This can be

confirmed in the analysis of Presidente Figueiredo, where, despite each property cultivate an average of 5.5 ha with cupuassu, 30% less than Itacoatiara, showed productivity per ha of 442 kg pulp, only 4% less than in this municipality.

Calzavara et al. (1984) analyzed the productivity of fruits per plant and found an average production without fertilization, of 12 to 20 fruits per plant, after five years of growth, with each fruit weighing about 1 kg. With 234 plants.ha<sup>-1</sup> (7 m x 7 m triangular spacing), this means 2.8 to 4.7 t/ha/year (1.0-1.8 t of pulp, 0.45 to 0.80 t of seeds). Venturieri et al. (1985) suggested that the handling and adequate soil fertilization can increase productivity to a level of 20-30 fruits/plant (4.7-7.0t of fruits/ha/year, 1.8-2.6 t of pulp, 0.8-1.2 t of seeds) after five years, rising to 60-70 fruits (14.0-15.4 t of fruits/ha/year, 5.3-5.6 t of pulp, 2.4-2.6 t of seeds) after seven years. Souza et al. (1999) also analyzed the performance of cupuassu culture and found that the average production ranged from 26 to 37 fruits per plant. The pulp yield ranged from 10.3 to 15.6 kg/plant and fresh almond 3.7 to 7.0 kg /plant.

If producers had conducted soil management and pests and diseases control as recommended by Venturieri et al. (1985), their pulp yields could increase to an average of 2,200 kg/ha. If they had adopted the recommendations of Souza et al. (1999), their average productivity would be 3,043 kg/ha. The seeds production, following Venturieri et al. (1985), would be 1,000 kg/ha or, according to Souza et al. (1999), 1,257 kg/ha.

**Figure 1.** Cupuassu with Magnesium deficiency (A); with fruit borer (B); with herb of bird (C); with witches' broom (D).



Source: Authors.

Other factors, such as cultural practices, flowers pollination and the incidence of pests and diseases can be linked to these results, as discussed further in this work. Nutrients deficiencies are very common, mainly with Mg (Figure 1A), since farmers do not apply fertilizers in their plantations, and regional Oxisols and Ultisols are low fertile soils (Cochrane et al., 1985, Magalhães et al., 2019, Sousa et al., 2020). Figure 1 also shows a fruit colonized with fruit borer (Figure 1B), as well as plants with herb of bird (Figure 1C) and with witches' broom (Figure 1D). They are the main problems found on cupuassu cultivation in the Amazonas State, and perhaps in all the Amazon Region.

### Diagnosis of pest and disease incidences

All checked cupuassu plantations have suffered or suffer attack of pests and / or diseases and they affected the average yield of fruits, pulp and seeds of in these counties. The most frequent diseases that affect the culture of cupuassu are the witches' broom (*Moniliophthora perniciosa* (Stahel) Aime & Phillips-Mora), dieback disease (*Lasiodiplodia theobromae* (Pa) Griff & Maubl.), red rot (*Ganoderma philipii* (Bres. & P. Henn) Bras.), Phomopsis spot (*Phomopsis* sp) (Souza et al., 1999; Silva Jr et al., 2011).

The biggest problem faced by producers of cupuassu in these counties is the occurrence of witches' broom, present in 100 % of the properties analyzed (Table 2). The occurrence of this disease in all properties can be one of the factors responsible for the low productivity (Table 2), where none of the 60 rural properties of the three counties achieved fruits yield per ha as those observed by Venturieri et al. (1985) and Souza et al. (1999).

The cupuassu fruit borer, *Conotrachelus humeropictus* Field (Coleoptera: Curculionidae), was found in 65 % of properties in Itacoatiara and Manacapuru and 10 % of the properties of Presidente Figueiredo. Adding to this, also was detected herb of bird (*Struthanthus flexicaulis* (Mart. ex Schult. f.) Mart) in 25 % of the properties in Itacoatiara and Manacapuru and 10 % in Presidente Figueiredo (Figure 2).

It was observed that 65 % of cupuassu plantations in Itacoatiara and Manacapuru were infected with witches' broom and fruit borer, while in Presidente Figueiredo, the disease and borer incidences were 10 %. The analysis also showed the presence of witches' broom and herb of bird in 25 % of the rural properties in Itacoatiara and Manacapuru and 10 % in Presidente Figueiredo (Figure 2).

The presence of both fruit borer and herb of bird were found in 25 % of cupuassu plantations in Itacoatiara and Manacapuru, but in Presidente Figueiredo none of the farms presented they together. The same result was found when the presence of the three pests and disease were analyzed together.

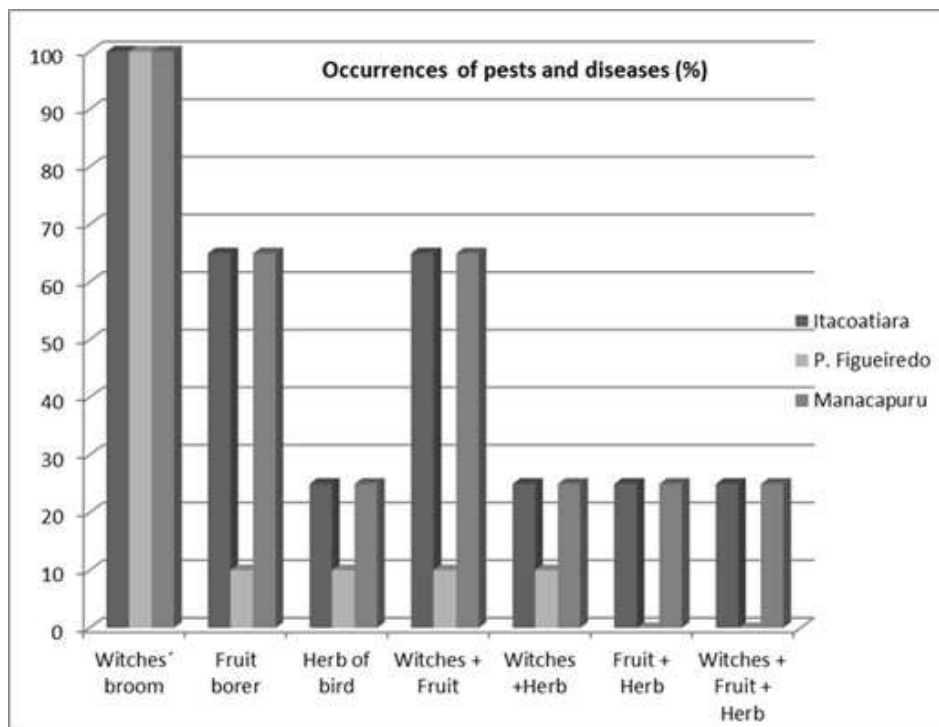
Disease and pests can compromise much of the fruit production, causing serious economic harm to producers and discouraging the maintenance of cupuassu plantations and to control witches' broom and fruit borer. This lack of control aggravates their occurrence and spread in plantations.

The witches' broom is the main cupuassu disease and causes enormous economic damage to production. Occurs in seedlings and in adult plants, attacking the growing meristematic tissues, flowers and fruits of cupuassu (Venturieri et al., 1993). In the State of Pará, Alves et al. (2009) verified that the emission of vegetative brooms is especially important between July and September. The evolution of the disease showed that phytosanitary prunings should be carried out in the months of May / June, and again in September / October. Souza et al. (1999; 2007) indicate that the climate of the Amazon, which alternate sunny and rainy days, favor the reproduction of basidiocarps, which is the critical time of spread of disease between plants cupuassu when fungi are transported by wind.

The most effective control of witches' broom requires periodic inspections of the plantations for the withdrawal of brooms and dry greens and fruits affected by the disease. This waste must be burned or buried outside the area of planting (Venturieri et al., 1993, Venturieri, 2011) (Figure 1C). None of the 60 farmers studied makes this sanitary control on their cupuassu plantations. They justified that it is not economically feasible this practice now that the plants are already heavily committed.



**Figure 2.** Cupuassu pests and diseases in the farms of Itacoatiara, Presidente Figueiredo and Manacapuru, Amazonas State.



Source: Authors.

Fruit borer is the most frequent pest in cupuassu growing areas of the Amazon and causes serious economic damage to plantations in the cases of intense attack. Garcia et al. (1985) explain that for pest control is not recommended the use of pesticides, since this process has been tested for curculionideous in cocoa and showed no positive effect. It should also be noted the high cost, making the process uneconomic and with high environmental impact. The indiscriminate use of pesticides can lead to problems with pollinators, stressing the fact that no isolated technique to control this pest is available.

The indiscriminate use of pesticides can lead to problems with pollinators, stressing the fact that no isolated technique to control this pest is available. Pollination deficiency is a limiting factor that affect cupuassu fruit production, as pointed out by Venturieri (2011). This author verified that about 67% of the flowers produced by cupuassu remain unpollinated.

The situation found by our results are in accordance with Altieri et al. (2011), whose studies about the inefficiency of land use in the region are mostly a result from errors in the management and production processes derived from the absence or low use of the knowledge available for agriculture.

### Commercialization of cupuassu by farmers in the counties studied

The commercialization of cupuassu is attributable to the sale of raw fruits to three large groups of buyers: cooperatives, companies, and intermediaries (Table 3). It is also possible to see in this table, how farmers commercialize, delivery their products and the prices they sell fresh fruits, pulps, and seeds.

In Presidente Figueiredo and Manacapuru, most of the marketing is done for intermediates, while the local cooperative of Itacoatiara (ASCOPE) is responsible for purchasing 50 % of the fruits; the remainder 40% are bought by intermediaries and 10 % by pulp processing companies. These companies are also responsible for 20 % of purchases in Presidente Figueiredo. In Manacapuru, all production is sold to intermediaries, since the communities studied were far away from the capital. Moreover, there was no cooperative and/or companies acting in processing the pulp and/or seeds nearby, a factor that negatively affects the cupuassu cultivation.

**Table 3.** Sales of cupuassu in the three counties of Amazonas state regarding the 2009-2010 harvest.

Counties	Category of buyers			Commercialization		Delivery location		Sale price (average)		
	Cooperatives	Business	Intermediates	Wholesale	Retail sale	Farms	Buyer Property	Fresh fruit	Pulp	Pulp and seeds
	----- % -----					----- US\$/kg -----				
Itacoatiara	50	10	40	100	00	100	00	--	--	0.72
Presidente Figueiredo	15	20	75	80	20	50	50	--	2.26	1.76
Manacapuru	00	00	100	70	30	25	75	--	1.91	--

Source: Authors.

When analyzing the form of marketing, predominated the held wholesale, occurring in 100 % in Itacoatiara, 80 % in Presidente Figueiredo and 70 % in Manacapuru.

In Itacoatiara, the entire production is sold on farms, with the buyer being responsible for the disposal of the product, not resulting in losses for the rural producer. In Presidente Figueiredo, selling in the rural property drops to 50 per cent, and in Manacapuru, only 25 per cent of the fruits are marketed by this way. In the latter case, it should be noted that there is considerable transport costs in the commercialization process, given the distance between this community and the consuming centers.

In Itacoatiara, the product is marketed in the form of pulp with seeds at an average price of R\$ 1.22 (US\$0.72) per kg. In Presidente Figueiredo we identified two forms of marketing: only the pulp, at an average price of R\$ 3.85 (US\$2.26) per kg, and the pulp with seeds at R\$ 3.00 (US\$1.76) per kg. In these cases, it was possible to gain when marketing the pulp and seeds together, since from seeds are extracted the butter, used in cosmetics and foods. In Manacapuru, only the pulp is sold at an average price of R\$ 3.25 (US\$ 1.91) per kg. The seeds are discarded in the farms.

### Beneficiation and utilization of cupuassu seeds

In Itacoatiara, 50 % of the farmers delivered the whole fruit for the local cooperative and the others realized little improvement in fruit, consisting of removing the shell and/or seeds to sell the pulp (Table 4). Of these, 35 % separated the pulp from the seeds, performing this service on the farm, by hand, while 50 % had their fruit pulps removed mechanically in the cooperative. This means that 15 % of producers withdrew their shell and traded pulp and passed along the seeds without removing them. Another characteristic also observed in this city was that 50 % of the pulp and seeds storages were in freezers and the other half in refrigerated chambers.

In Presidente Figueiredo, 85 % of producers removed the shells and separate the pulp and seeds, and of these, 60 % use the process by hand and 40 % mechanically, also performed in cooperatives. In this city, 80 % of the storage is done in freezers and only 20 % in freezers chambers. In Manacapuru, all the producers remove the shells and separate the pulp from the seeds by hand, just for selling the pulp. The seeds and shells are discarded on the farm, while the pulp is stored in freezers until the time of marketing.

**Table 4.** Processing cupuassu in the farms of the Amazonas State.

Fruits Processing		Itacoatiara	Presidente Figueiredo	Manacapuru
		----- % -----		
Type of processing	Bark withdrawal	50	85	100
	Pulp of withdrawal	0	85	100
	Seeds withdrawal	0	85*	100*
Pulp removal processing	Handling	35	60	100
	Mechanical	50	40	0
Storage conditions pulp and seeds	Freezer	50	80	100
	Freezing chambers	50	20	0

\* Seeds not used for marketing and discarded in the farm.

Source: Authors.

The fruit beneficiation process by hand compromise the quality of the pulp (low hygiene), since the process uses metal scissors, most often not sterilized. This process also compromises the farmers production costs, since this type of pulping demand considerable allocation of manpower, reducing the sale profits, who, at the end of the season, concludes that the cultivation of cupuassu not pay and, in some cases, even offers losses.

The pulp is packaged for storage in freezers until the buyer comes at the farm, consuming energy and increasing production costs. Furthermore, this procedure can compromise the maintenance of product quality, particularly due to the loss of organoleptic properties of the fruit, since the pulp frozen in domestic freezers may release a large amount of juice when thawed, caused by disruption of the cells by crystals ices formed at 0°C (Clay et al. 2000).

#### 4. Conclusions

In the Itacoatiara, Manacapuru and Presidente Figueiredo counties, there is no uniformity in cupuassu plantations for plants density, fruit, and seed yields.

The cupuassu plantations were formed and managed without proper biotechnological guidance from State agencies and/or municipal agricultural assistance, resulting in very poor cultivation in their forms of composition, with high plants densities found in almost all rural properties that cultivate cupuassu.

The high density increases plants competition for nutrients and light, and favors the proliferation of pests and diseases and hinder harvesting.

All these factors significantly compromise the plant and area productivity and discourage the producers for the continuity of this culture.

If rural producers make use of technologies and proper techniques of cultivation, as well as maintenance of plantings, cupuassu pulp productivities could increase between 226 and 231 %; seed production jump from 0 (when not sold) to 241 and 281 %, improving rural economy and land use.

In order to increase their productivity, it is necessary that farmers have technical assistance capable of guiding them on the best densities of cupuassu trees in the upland soils of the Amazon, as well as how to manage the fertility of these soils and also, how to control pests and diseases.

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