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THE USE OF PHYTOMASS IN THE RECOVERY OF DEGRADED SOIL - VILA BURITI / MANAUS (AM)

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Abstract

The objective of this study was to evaluate the recovery of a degraded area using phytomass together with Theobroma Grandiflorun Schum (cupuassu). A fur her aim was to monitor the growth of individual plants of the species in question, measure the nutrients added to the soil; compare the physical soil properties between the plots with and without phytomass, and estimate the increase of the matter in the soil's surface horizons from the decomposition of the added phytomass. The soil degradation level was evaluated through impact penetrometer tests and a Guelph Permeameter. Soil samples were collected to analyze particle size, and bulk and real density. Allometric measurements of the seedlings were performed every four months, concurrently with the renewal of the phytomass on one of the plots. These measurements aimed to monitor the vertical growth and development of the crown. The findings show that the seedlings in the plot with the addition of phytomass developed better, however, in the final stages it was observed that of the 30 initial individuals only two in the control plot and one in the phytomass plot survived.

Keywords: Keyword: Degraded Area, Phytomass, Nutrients, Erosion.

Resumo / Resumen

A UTILIZAÇÃO DE FITOMASSA NA RECUPERAÇÃO DE SOLO DEGRADADO – VILA BURITI / MANAUS (AM)

Este trabalho teve como objetivo avaliar a recuperação de uma área degradada a partir do uso de fitomassa associada ao uso da Theobroma Grandiflorun Schum (cupuaçu). Soma-se a esse objetivo o monitoramento do crescimento dos indivíduos da espécie estudada; mensuração do acréscimo de nutrientes ao solo; comparação das propriedades físicas do solo entre as parcelas (parcelas com e sem fitomassa); e estimativa do acréscimo de matéria nos horizontes superficiais do solo a partir da decomposição da fitomassa adicionada. Para avaliação do experimento foram analisados o nível de degradação do solo através de testes com o penetrômentro de impacto e com o permeametro de Guelph. Amostras de solo foram coletadas para analise granulométrica, densidade aparente e real. Foram realizadas medições alometricas das mudas quadrimestralmente, juntamente da reposição da fitomassa em uma das parcelas. Essas medições objetivaram acompanhar o crescimento vertical e desenvolvimento da copa. Como resultados, percebeu-se que as mudas da parcela com adição de fitomassa apresentaram melhor desenvolvimento, porém, nos estágios finais notou-se que dos 30 indivíduos iniciais sobreviveram somente 2 na parcela controle e 1 na com fitomassa.

Palavras-chave: Palavras-chaves: Área Degradada, Fitomassa, Nutrientes, Cupuaçu, Erosão.

LA UTILIZACIÓN DE FITOMASSA EN LA RECUPERACIÓN DE SUELO DEGRADADO - VILA BURITI / MANAUS (AM)

Este trabajo tuvo como objetivo evaluar la recuperación de un área degradada a partir del uso de fitomassa asociada al uso de la Theobroma Grandiflorun Schum (cupuaçu). Se suma a ese objetivo el monitoreo del crecimiento de los individuos de la especie estudiada; La medición del aumento de nutrientes al suelo; Comparación de las propiedades físicas del suelo entre las parcelas (parcelas con y sin fitomassa); Y estimación del aumento de materia en los horizontes superficiales del suelo a partir de la descomposición de la fitomassa agregada. Para la evaluación del experimento se analizó el nivel de degradación del suelo a través de pruebas con el penetramiento de impacto y con el permeametro de Guelph. Muestras de suelo fueron recolectadas para análisis granulométrico, densidad aparente y real. Se realizaron mediciones alométricas de las mudas cuatrimestralmente, junto con la reposición de la fitomassa en una de las parcelas. Estas mediciones tuvieron como objetivo acompañar el crecimiento vertical y el desarrollo de la copa. Como resultados, se percibió que las mudas de la parcela con adición de fitomassa presentaron mejor desarrollo, pero en las etapas finales se notó que de los 30 individuos iniciales sobrevivieron solamente 2 en la parcela control y 1 en la con fitomassa.

Palabras-clave: Área Degradada, Fitomassa, Nutrientes, Cupuaçu, Erosión.

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INTRODUCTION

Together with the pollution of watercourses and the air, soil degradation is currently a growing concern for many reasons, including the reduction of arable land. Harmful actions that lead to the impoverishment of the soil may be related to deforestation and the burning of green areas, the expansion of the livestock population, and monocultures that fail to take measures to prevent soil depletion, among others (LEPSCH, 2002).

Thus, degraded areas are the direct result of human actions in the environment, when they do not employ criteria or actions aimed at the rational use of space, whether it be urban or rural. Degraded soils are easily identified by the total, or almost total, absence of vegetation and the likelihood that intense erosive processes may develop, causing linear erosive features such as furrows, ravines, and gullies.

For Gonçalves et al. (2003), the soil is the primordial substrate of natural ecosystems. Its preservation or recovery is essential for the ecological balance or restoration of the environment. For these authors, degraded soil has suffered a partial or complete loss of its ability to sustain the growth of plants and other organisms. Therefore, the term recovery refers to a set of actions aimed at reversing this situation (DIAS and MELLO, 1998; AQUINO, 2010).

One way to recover degraded areas is the direct planting of species adapted to these environments. This research selected an unconventional species to recover degraded areas, Theobroma Grandflorun Shum (Cupuassu). The justification for this choice was the need to recover a specific area using a species that had an agricultural/productive function, rather than simply introducing a species without any commercial value.

The choice of this particular species was influenced by the results obtained by Monteiro (1999), who pointed out the high efficiency of this species in protecting the soil against the effects of rain erosion, taking into consideration aspects such as: the fast and lasting formation of leaf litter, the uneven crown and trunk that prevent the formation of trunk flows, and the height of the crown and the shape of the leaves, which hinder water droplets larger than the original raindrops.

This study aimed to evaluate the recovery of a degraded area in Manaus, using phytomass from Theobroma Grandiflorun Schum (cupuassu) as a soil improver. Once the species had been introduced, each individual plant (n = 30) was monitored and the addition of nutrients to the soil (chemical properties) as a result of litter formation and the introduction of phytomass (shredded biomass from the surrounding area) was measured. The physical properties of the soil between the plots were compared (plots with phytomass and control plot/without phytomass) and an estimate was made of the increase of matter in the superficial soil horizons from the decomposition of the phytomass added to the plot and the decomposition of the seedlings' leaves.

STUDY AREA

The study area where the experiment was located was near the village of Marinha, in the Vila Buriti neighborhood, in the South Zone of Manaus. This site was also close to the CEASA Port (State Supply Center S / A), in the area belonging to the Adjunct Superintendence of Operations - SAO / SUFRAMA (Superintendence of the Manaus Free Trade Zone) (FIGURE 01). The predominant soil in this area is the dystrophic Yellow Latosol, which has been significantly altered and no longer has O and A horizons (resulting from the effects of earthworks); the B horizon is partially altered (AQUINO, 2012). The formation of rust crusts and several erosive features, such as pedestals, were among the results observed due to this earthmoving process and the consequent compaction.

There are two large gullies in the area that dominate the local landscape, both are classified as Connected according to Oliveira's (1989) model. One is classified as Rectangular in shape and the other as Bifurcated (VIEIRA, 2008).

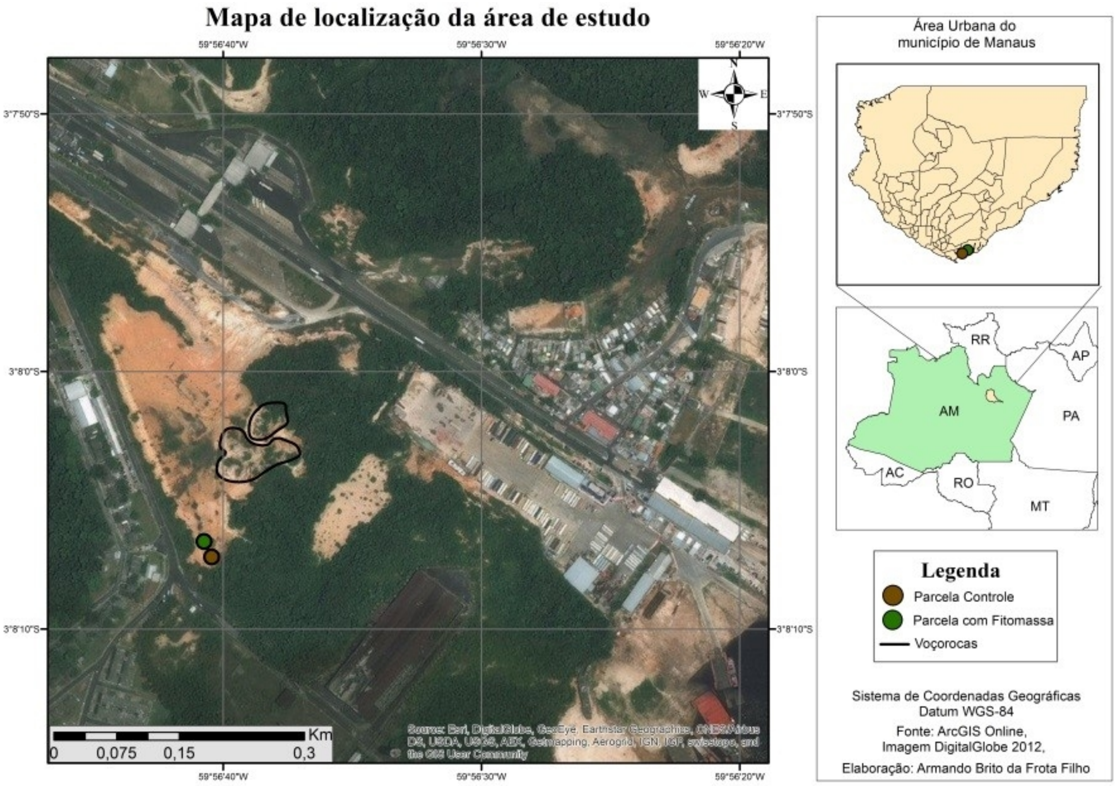


Figure 01 - Location map of the study area. Source: Image Google Earth Pro, 2011. Org .: by the Author, 2015.

In geological-geomorphological terms, the city of Manaus is in the Morphostructural Unit of the Dissected Plateau of the Trombetas River / Rio Negro, a system of small and medium flat-topped hills, which belongs to a vast section of tertiary sediment tableland, varying between 50 and 100 meters (SILVA, 2005). It has closed, narrow and embedded valleys and narrow, elongated interfluvial zones (NW-SE and NE-SW), forming an intricate and dense drainage network (AB'SABER, 1953).

With respect to pedological features of the city area, on the whole, Yellow Latosols occur in the upper and middle slopes of the plateaus. From the middle slope to near the valley bottoms there are Yellow Argisols and at the foot of the slope and in the valley floor are the sand-rich soils, such as Spodosols (LUCAS, 1989; VIEIRA, 2008).

The predominant vegetation consists of the species that compose the Dense Ombrophylous Forest, which is sustained by a climate characterized by a short dry season, fitting Köppen's classification as Climate A (Tropical Rainy Climate) or, more specifically, Amw. This climate type means Manaus had an accumulated total average (annual) rainfall of 2,193.8 mm in the period from 1917 to 2006 (VIEIRA, 2008). As a result the city has a high soil erosion rate, in the order of 14,129 mm ha-1 h-1 year-1 (SILVA et al., 2009). The temperature is 26.7°C, with a maximum average of 31.5°C and a minimum average of 23.2°C (AGUIAR, 1995).

MATERIALS AND METHODS

Setting up the experiment

Two plots were selected to plant 15 individual Theobroma Grandiflorum Shum seedlings per plot. The first was the control plot, where the individual plants were placed directly in the degraded soil without receiving any kind of improvement (fertilizers, phytomass, etc.). The second plot received an addition of phytomass (shredded biomass from the surrounding area / 50kg for monitoring) as a form of soil enrichment.

The individual Theobroma Grandiflorum Shum seedlings were planted at the beginning of 2010 (January 12th) and each plot occupied an area of 10 m² (with a spacing of 1m x 1m between the plants) (FIGURE 02).

Figure 02 - The Plot with Phytomass and the Control Plot. Source: by the Author (12/11/2010).

Monitoring the growth of individual Theobroma Grandiflorum Shum plants

Physiographic evaluations were carried out for each plant on both plots. The crown size and height were ascertained with a measuring tape and a digital caliper was used to measure the stem thickness. These verifications took place at four-month intervals (February / 2010; June / 2010; October / 2010 and February / 2011).

Adding phytomass

Fifty kilograms of phytomass were added to the plot every four months during the period that the individual plants were being measured. This material was taken from the vegetation in the surrounding area and then cut into pieces with a maximum of 10 cm in length (FIGURE 3). As 50 kg of phytomass was added to the plot at the time of each monitoring, by the end of the experiment 200 kg of organic matter had been added.

Figure 3 - Weighing bag with 50kg of shredded biomass from the surrounding area (phytomass). By the Author, 2010.

The measurement of the addition of Organic Matter and Soil Nutrients (Chemical Properties)

Kopecky rings were used to collect three soil samples at the depths of 0 to 10 cm and 0 to 20 cm, to verify macronutrients and micronutrients by chemical soil analysis following the methodology of EMBRAPA (1997) and Silva (1999) to determine the levels of P, K, Ca and Mg. These collections were performed in both plots at two times: at the beginning and end of the experiment. Even in the control plot that did not receive phytomass, it was expected that the mere presence of cupuassu seedlings could contribute to the increase of organic matter in the soil and the improvement through the aggregated macro and micronutrients from the leaf decomposition.

The same samples collected for nutrient verification were used to estimate the total weight of the organic matter per sample. This was achieved by burning in a muffle furnace, where a sample of a known weight (20 g) was placed in the oven at a temperature between 600 and 800°C for approximately two hours. After this period the sample was weighed again and the result was subtracted from the initial sample weight; the difference was considered to be the organic matter.

The physical characterization of the soil in the two plots

The physical properties (texture, infiltration capacity, penetration, real density, bulk density, and porosity) of the soil with added phytomass and the control plot were compared. Soil samples to a depth of 10 cm were collected with a Kopecky cylinder to perform the Apparent Density and Porosity analyzes.

A Guelph Permeameter was used for the infiltration test (FIGURE 4), this involves placing the metal cylinder of the permeameter at a depth between 3 and 5 cm, and then pouring water around and inside the cylinder (for hydrostatic balance). As the water inside the cylinder infiltrates the soil, the water in the permeameter is released, refilling the cylinder. This allows the amount of water released and the number of minutes to be measured.

Figure 04 - The Guelph Permeameter. Source: By the Author, 2010

The penetration test was performed with an Impact Penetrometer (FIGURE 5), which is a metal rod that receives impacts of a mass of known value. It counts how many impacts are required for the rod to penetrate the ground for every 5 cm (Ross et al., 2011).

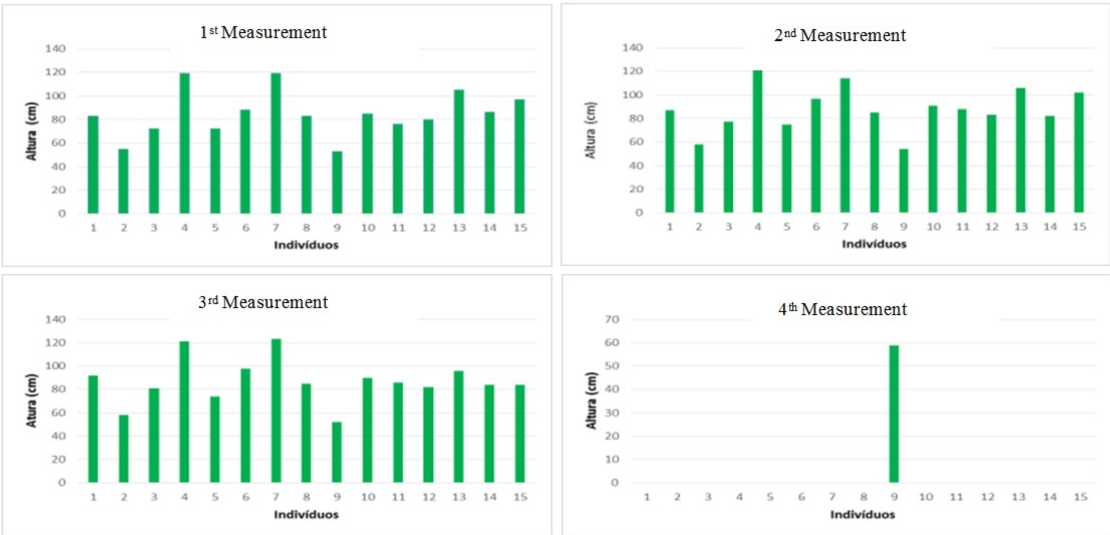
Figure 05 - Impact Penetrometer. Source: By the Author, 2010

The granulometry was verified by collecting soil samples at 0-10 cm and 10-20 cm, using the methodology recommended by EMBRAPA (1997) and Silva (1999). These samples were processed at the Laboratory of Analysis and Treatment of Sediments and Soils - LATOSSOLO.

RESULTS AND DISCUSSION

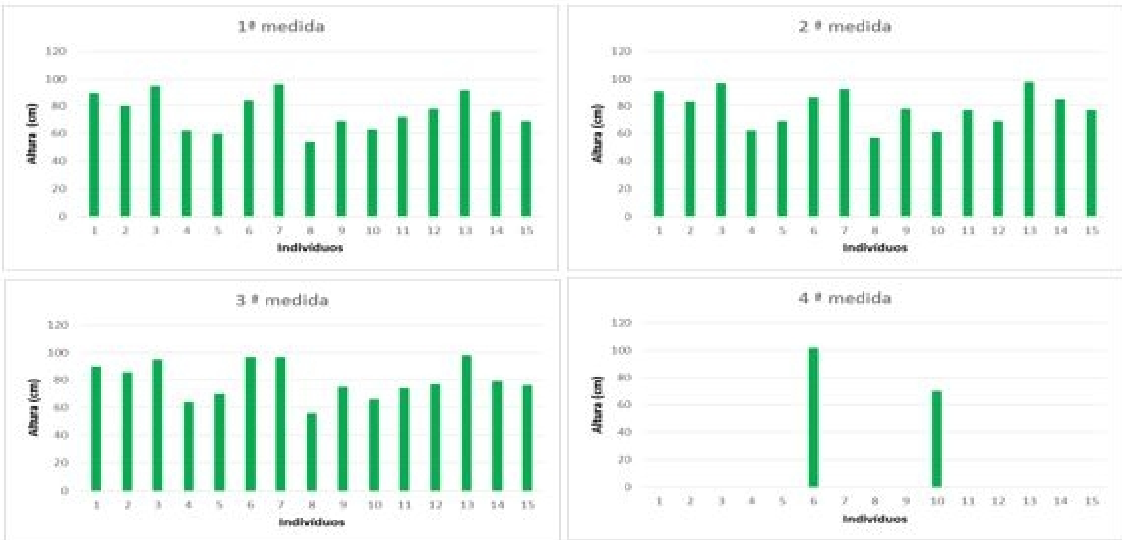
Monitoring the growth of the individual Theobroma Grandiflorum Shum plants

Four measurements were performed over the 12 month period, for the three initial measurements it was observed that the individual plants had grown (Graphs 01 and 02). During this interval, the specimens that grew the most were seedlings 01 and 03 in Plot 01 (with phytomass), which grew 9 cm in 9 months. However, they did not survive until the last measurement. Seedling 06 in the control plot grew 18 cm in the study period (12 months).



Graph 01 - Growth chart of individual seedlings in the plot with added phytomass

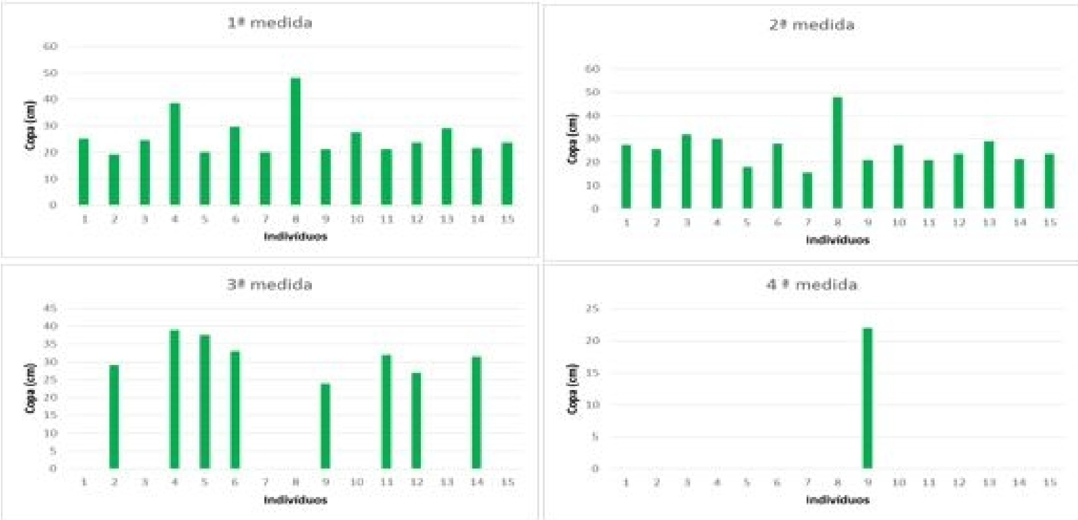
1st Measurement: 12/02/2010; 2nd Measurement: 06/11/2010; 3rd Measurement: 10/08/2010; 4th Measurement: 10/02/2011. Org. (By the Author 2015). Org. "Autor", 2015



Graph 02 - Growth chart of individual seedlings in the control plot

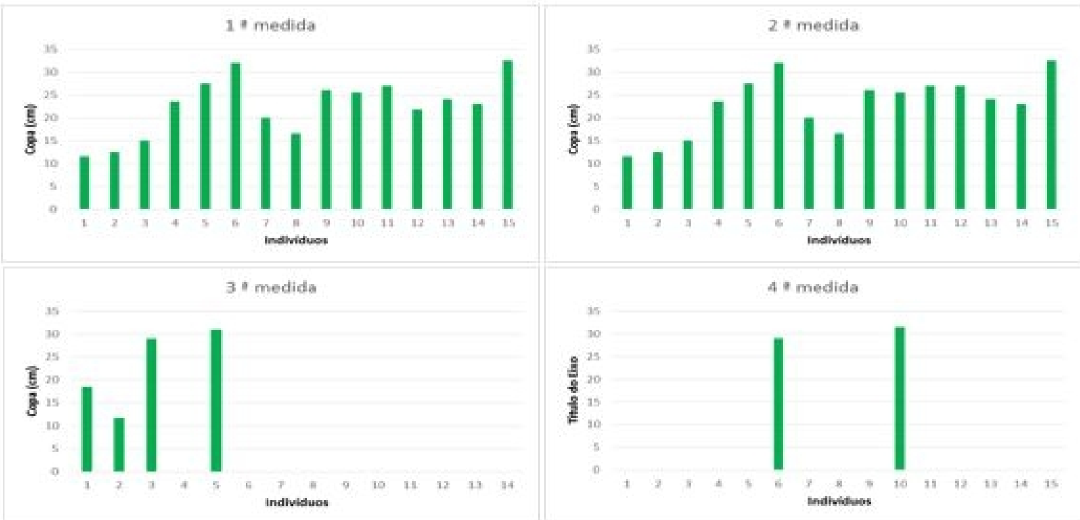
1st Measurement: 12/02/2010; 2nd Measurement: 06/11/2010; 3rd Measurement: 10/08/2010; 4th Measurement: 10/02/2011. Org. (By the Author 2015)

An individual was considered dead as soon as there was leaf loss (crown area) and if it showed no signs of reinvigoration between measurements. In relation to the crown area, the specimens started to lose their leaves from the second measurement (GRAPH 03 and 04), of these, only seedling 10 from the Control Plot had a reduction in its crown area followed by its revitalization.



Graph 03 - The canopy area of the individuals in the plot with phytomass

1st Measurement: 12/02/2010; 2nd Measurement: 06/11/2010; 3rd Measurement: 10/08/2010; 4th Measurement: 10/02/2011 Org. (By the Author 2015)



Graph 04 - The canopy area of the individuals of the control plot

1st Measurement: 12/02/2010; 2nd Measurement: 06/11/2010; 3rd Measurement: 10/08/2010; 4th Measurement: 10/02/2011. Org. (By the Author 2015)

The data on stem circumference did not show large variations between measurements. Of the 30 individual plants (15 in each plot), only three survived to the end of the study, two in the control plot and one in the Phytomass plot.

MEASUREMENT OF THE ADDITION OF NUTRIENTS TO THE SOIL (CHEMICAL PROPERTIES) AS A RESULT OF PLANTING THEOBROMA GRANDIFLORUM SHUM AND THE ESTIMATION OF THE ADDITION OF ORGANIC MATTER TO THE SURFACE SOIL HORIZONS.

According to Lepsch (2002), the imbalance of the soil (either more or less) and existing nutrients in the soil (macro and micronutrients) can compromise the quality of plant development. Thus, in order to rebalance and restore the soil, these nutrients need to be recovered. This research examined the use of phytomass harvested from the forest near the study area in aiding this recovery.

Ten kilograms of this material was collected on October 14, 2010, of which 5 kg was placed into an oven to check the moisture content. It was found that there was about 2.75 kg of moisture in every 5 kg; 55% of the total weight of the sample. In general, it can be said that 55% of all the phytomass used during plot monitoring corresponded to 110 kg of humidity, the remaining 90 kg was organic matter.

The other 5 kg were used for the chemical analysis giving the estimated values for macronutrients such as calcium, magnesium, nitrogen, potassium, phosphorus, and iron, as well as the zinc and manganese micronutrients (TABLE 01).

Sample Identification	**Ca**	**Mg**	**N**	**P**	**K**	**Fe**	**Zn**	**Mn**
	g/kg					**mg/kg**		
Vegetable material	16,07	3.14	14.02	1.66	6.67	71	31.0	186.5

Table 01 - The identification of the macro and micronutrients found in the phytomass*

* values equivalent to 5 kg. Org.: “Autor”, 2011.

By adding the data above to the soil nutrient data prior to the experiment, it can be evidenced that the phytomass contains nutrients that provide a soil supplement that supports plant development. Table 2 shows the nutrients, the pH, and the quantity of the Organic Matter found in the soil in the control plot and the plot with added phytomass, in two periods, before and after the project was started.

IDENTIFICATION		**pH**	**Al**	**Ca**	**Mg**	**K**	**P**	**Fe**	**Zn**	**Mn**	**C**	**M.O**	**N**
Plot	**Period**	H_2O	$cmol_c\ kg^{-1}$				mg Kg^{-1}				g kg^{-1}		
Control	Before	6,03	0,00	1,50	0,21	0,01	0,26	9,70	1,30	2,30	3,73	6,43	0,43
Control	After	5,50	0,00	1,15	0,12	0,00	0,17	8,00	0,50	0,32	2,22	3,83	0,08
With Phytomass	Before	5,44	0,00	0,92	0,09	0,00	0,17	6,30	0,90	0,50	2,83	4,88	0,38
With Phytomass	After	5,70	0,00	1,60	0,31	0,10	0,26	7,90	1,10	2,11	4,87	8,40	0,04

Table 02 - Description of the nutrients found in the plots in the study area.

*In red - reduction of values, in blue - increased values. Org. “Autor”. 2015

The data show that there was a growth of nutrients (macro and micro) as well as pH and organic matter in the plot with Phytomass, whereas in the Control Plot a reduction was measured for all the parameters in the same period. This is because in addition to cycling nutrients, the phytomass protects against the processes of leaching and sheet erosion, playing the role of leaf litter or the O Horizon in natural environments. This is corroborated by the reduction of nutrients in the Control Plot, which had no protection against these processes.

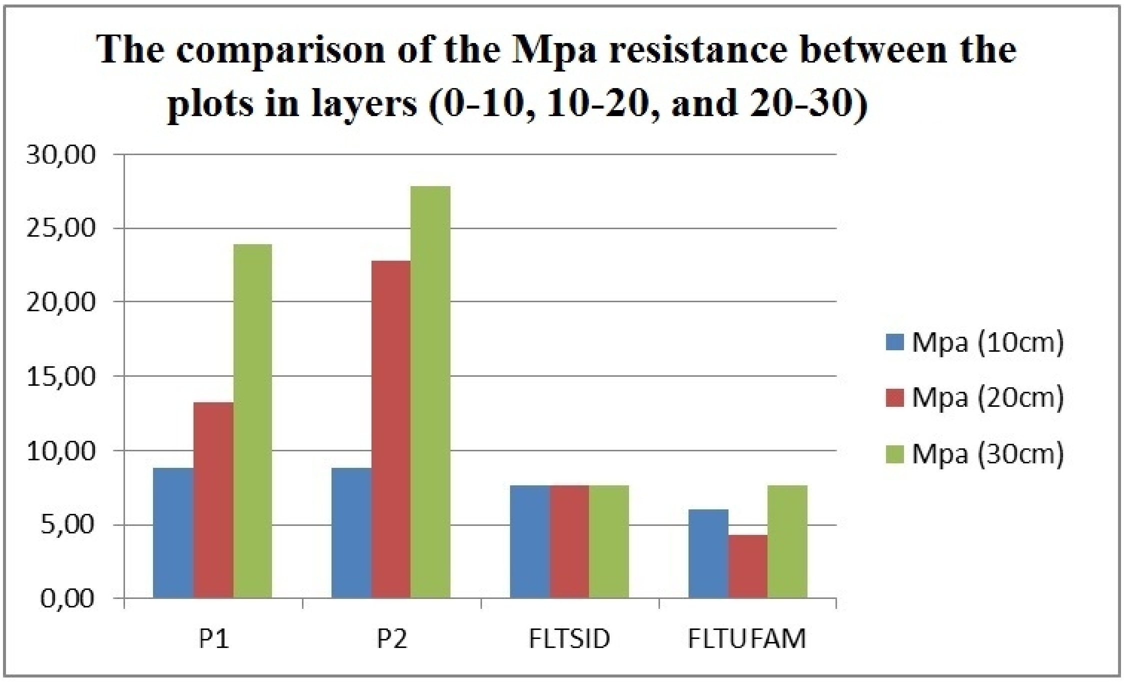
A comparison of the physical soil properties between the plot with added phytomass and the control plot

One of the physical characteristics observed in the field was penetration resistance. Broadly speaking, the resistance to penetration was lower in the phytomass plot than in the control plot, even though it had similar textural characteristics (TABLE 03).

	Total sand		Clay		Silt		Texture
	g/kg	%	g/kg	%	g/kg	%	
Plot 01 - Control	166.6	16.66	745	74.5	88.4	8.84	Very Clayey
Plot 02 - Phytomass	143.5	14.35	770	77	86.5	8.65	Very Clayey

Table 03 - Textural characteristics of the soil of the control and phytomass plots. Org: “Autor”, 2012.

Although at first, the two plots have similar values, as the profile deepens the resistance rate in the phytomass plot is lower when compared to the control plot (GRAPH 05 and TABLE 04). However, it is still significantly higher than the area with vegetation, even if this is secondary, as in the case of the surrounding vegetation (Siderama Forest - FLTSID) and the Forest of the Federal University of Amazonas (FLTUFAM).



Graphic 05 - Bar graph with the number of impacts performed in the experiment.

Mpa: Pascal Measure; P1: Plot with phytomass; P2: Control plot; FLTSID: Secondary forest adjacent to

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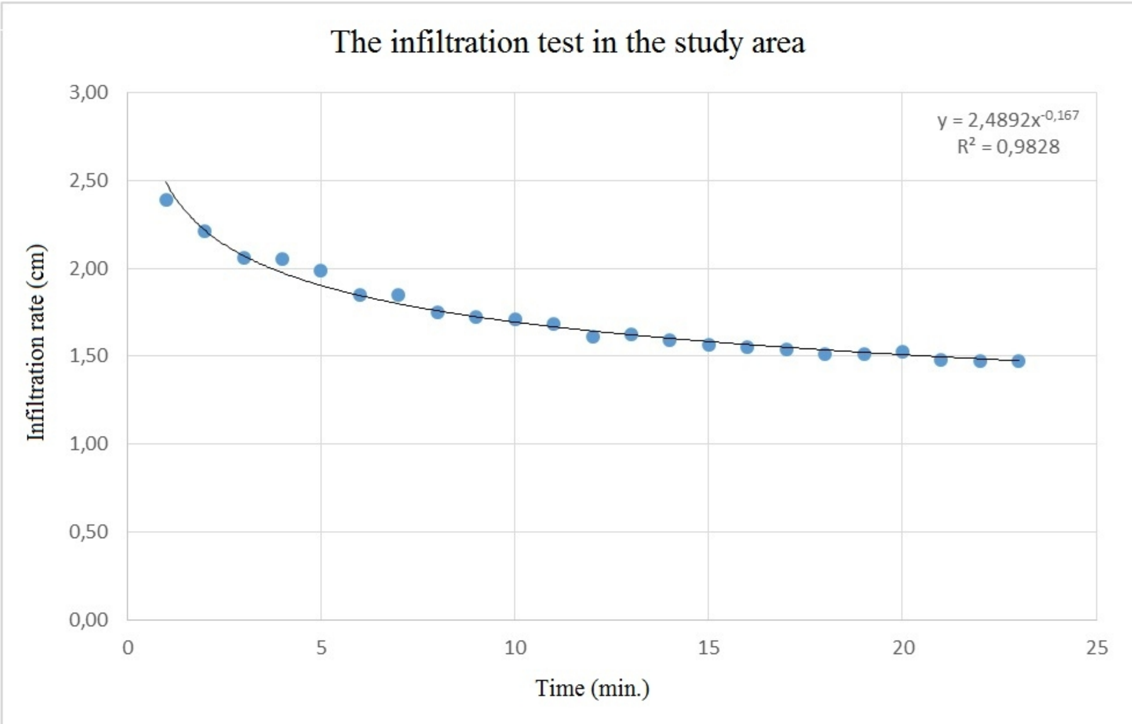
the study area; FLTUFAM: UFAM secondary forest. Org: By the Author, 2011.

Plot with Phytomass			Control Plot		
Depth (cm)	Impact	Mpa	Depth (cm)	Impact	Mpa
10	5	11.03	10	4	9.35
20	9	17.75	20	17	31.19
30	11	21.11	30	16	29.51

Table 04 - Number of impacts performed in the experiment. Org: “Autor”, 2011

Two infiltration tests were carried out for comparison purposes, one in the study area and the other in the UFAM Forest. As has been mentioned above, the study area has a high level of compaction. Graph 6 shows that the infiltration rate is low, not exceeding 2.39 cm/min, with an average infiltration of 1.73 mm/min; the test took about 44 minutes to complete.



Graphic 06: The infiltration test in the study area. Org. “Autor”, 2015

The low infiltration rate is due to the fact that the test was performed on the B horizon, well known for being more compact, less aerated and with less biological activity.

In contrast, Graph 07 shows that the initial infiltration reaches about 6 cm in the first minute, with an average infiltration of 4.09 cm/minute and the stability of the infiltration rate was reached in 24 minutes. Therefore, it is concluded that the test carried out in forest with the presence of leaf litter, reveals a more aerated and less compacted soil, which consequently has a greater infiltration capacity.

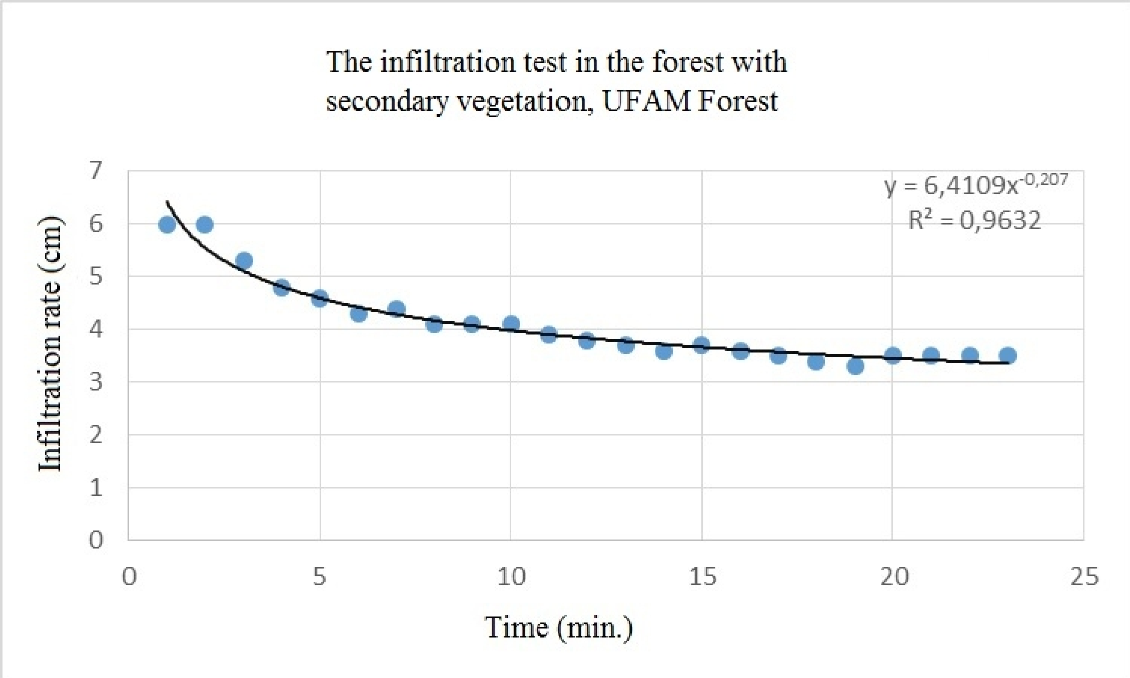


Gráfico 07 - The infiltration test in the forest with secondary vegetation, UFAM Forest. Org. (By the Author)

When the physical characteristics of the soil were examined, the data in Table 05 indicates that the Total Porosity has higher values in the plot with added phytomass, because this feature increases with the presence of organic matter and moisture in the soil, unlike the control plot. Besides not receiving this extra material, the control plot does not benefit from the protection offered by the decomposing phytomass, so it loses moisture, organic matter, and nutrients.

	D.A.	No.D.R.	Pt		D.A.	No. D.R.	Pt
Plot 01 Control	0.19	109.35	99.82	Plot 02 Phytomass	0.20	113	99.82
	0.19	113.09	99.82		0.19	106,65	99.81
	0.19	113.09	99.83		0.19	109.35	99.82
	0.22	109.35	99.79		0.20	109.35	99.81
	0.22	110.27	99.79		0.20	109.35	99.81
Average	0.20	111.03	99.81	Average	0.19	109.56	99.81

Table 05 - DA - Apparent Density; DR - Real Density; Pt - Total Porosity Org .: By the Author, 2015

Overall, from the point of view of both physical and chemical properties, the soil was richer. This demonstrates the importance of introducing phytomass as a supplementary element in fertilization and soil improvement. As Chieza (2010) points out, phytomass improves soil properties, whether physical properties or macro and micronutrient values (chemical properties), while helping to conserve moisture and improve soil aeration, which occurs due to the increased number of ants and other insects that collaborate with this process.

CONCLUSION

Considering that of the 30 samples planted, only three survived the experiment (12 months), that is, 90% of the research plants did not resist, it is clear that in conditions with extremely degraded soil Theobroma Grandflorum Shum is not an ideal species for the recovery these areas. However, the use of phytomass proved to be an important aid in improving both physical and chemical soil properties.

Among the factors that contribute to these results are the phenological characteristics of the Theobroma Grandflorum Schun (Cupuassu), which indicate that it adapts better to high humidity and shade (SOUZA et al, 1999). It is significant that the physiography of the research area has undergone earthworks, with a more resistant soil that does not encourage the natural emergence of vegetation.

As far as the individual plants are concerned, another fact that may have corroborated their poor development is the possible stress suffered due to the transportation between the seedling preparation site and the cultivation site.

Thus, the ability of the phytomass to recover some soil characteristics, such as macro and micronutrients and porosity is remarkable. Despite its incompatibility with the species selected, phytomass fulfills the role of an Organic Horizon, in terms of the protection and cycling of nutrients.

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