# BALANCES OF BIOELEMENTS IN USEFUL TROPICAL PLANTS

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## ABSTRACT

The productivity of different useful tropical plants is compared with respect to their biomass production. Furthermore, analyses of nutrient contents serve to explain the interrelationship between nutrient supply and primary production. The biomass and nutrient contents from three to six month old plants from Castanha-do-Brasil (*Bertholletia exselsia* H.B.K.), Cedro vermelho (*Cedrela odorata* I.L.), Cumaru (*Dipteryx alata* L. Vogel), Cupuaçu (*Theobroma grandiflorum* (Spreng.) K. Schum.), Dendê (*Elais guianeensis* Jaqc.), Mahogany (*Swietenia macrophylla* King), Taxi branco (*Sclerobium paniculatum* Vogel) and Urucum (*Bixa orellana* L.) within the different plant fraction were determined. The elements Ca, Mg, K, Na, Fe, Al, Zn, Cu, and P were analysed with the ICP-OES (Inductively coupled argon plasma with optical-emission-spectrometry)-method. Compared to plants of temperate regions, the mineral content is distinctly higher than that for tropical plants, but most values still lie within the range of existing data. Extremly high values were found for aluminium and iron.

## INTRODUCTION

In the recent years nearly 7% of the primary forest of Amazonia has been destroyed and transformed into agricultural areas. In the case of unadapted management, especially mono-cultures, these agricultural systems can only be run for a short time and lie fallow afterwards.

The recultivation of these fallows is of major importance both ecologically and economically.

With the aim to develop recultivation methods for fallow lying areas in the densely colenized regions of Manaus, a plantation of different mixed- and monocultural systems has been established.

Under special consideration of soil biological aspects different production technologies have been applied to these agricultural systems.

This project will determine the output of biomass of the different systems with regard to a long lasting mineral supplies.

For that purpose the mineral content of various plant tissues and the mineral content of the soil components which are available for the plants will be analysed during the whole run of the plantation.

The results presented in this paper are restricted to the analysis of young recently transplanted plants.

## MATERIALS AND METHODS

First detailed biomass and nutrient determinations were carried out with the three to six months old plants of Castanha-do-Brasil, Cedro vermelho, Cumaru, Cupuaçu, Dendê, Mogno, Taxi branco, and Urucum from the nursery.

For the determination of the biomass and mineral content of different parts of the plants, three plants of Cupuaçu and Mogno and one plant of each of the other species were removed from substrate and subdivided into different fractions (fine roots, coarse roots, bark, wood, leaves, etc.).

After a drying period of three days at 103°C, the dry weight of the different plant fractions was determined.

For the mineral analysis using ICP-OES (Inductively coupled argon plasma with optical emission pectrometrie), the samples were dissolved with nitric acid under a pressure of 200 bar at a temperature of 106°C.

To guarantee the total disintegration of the samples larger samples were ground in a centrifugal mill (Company Retsch) before the acid treament.

An aliquot was taken from each sample and the 25 fold quantity (v/w) of nitric acid was added to these aliquots.

The strongly oxidizing character of the nitric acid causes the disintegration of organic matrices but does not affect silicated components.

After disintegration, the samples were diluted (1:100) with deionized water and analysed with the ICP-OES-method.

The principal of emission spectrometry with inductively coupled argon plasma is, that the supply of the sample with energy in a plasma will result in the emission of element specific light. The concentration of the element in the sample is determined by the intensity of the emitted light (Schönburg, 1987).

By means of a multiplier equipped with a polychromator, the simultaneous determination of the concentrations of Ca, Mg, K, Na, Mn, Fe, Al, Zn, Cu, Pb, Co, Sr, Ba, P, S and Si is possible. In this paper, only the contents of calcium, potassium, manganese, aluminium, iron, phosphorus, nitrogen, copper and zinc are presented.

## RESULTS AND DISCUSSION

The biomass determination of the three to six month old plants revealed that the foliar moiety of the total biomass is relatively high with values between 40% and 80%.

Comparitively, the roots on an average represent only 12% of the total biomass.

Obviously the production of the above ground biomass is favoured compared to the root system (Table 1) although these data must be vieved with caution because of the small number of samples.

The preliminary results show that the mineral content in plants of three to six month of age is partially much higher than that of plants in temperate regions (Dünisch and Bauch 1992).

The percentage of some nutritive elements on the total biomass exceeds the values of the averaged contents of all elements in plants of temperate regions, which is approximately 1%. However, with exception of iron and aluminium, the data for contents of nutritive elements is within the range of values reparted for other plants of the amazon region (Klinge 1976; Ferreira 1989; Denich 1989; Müller; Reis and Müller 1979).

The Ca-content follows the typical development of all plants. The highest values are found in the oldest leaves. Only the location within the leaf parts differs between species. In Cupuaçu for example, the highest Ca content, up to 34 000 ppm occurs in distinct modifications of the petioles and in the petioles themselves, whereas in Mahogany the maximum values are found in the leaf blades. According to Mengel and Kirbky (1987), the accumulation of calcium in the different parts of the oldest leaves is due to the low calcium concentration in the phloem sap (Wiersum 1979; Marschner and Richter 1974), in addition, mobilisation of the calcium fixed in these parts of the plant is not possible.

On the contrary, the highest potassium content occurs in the youngest leaves where they are needed to build up the cells (Marschner 1986). This is a result of the high concentration of potassium in the phloem (Mengel and Kirkby 1987).

Enhanced levels of magnesium were only found in Urucum and in the petioles and modifications of term in Cupuaçu, where the minaral content is generally higher than in other parts of this plant.

Extremely high concentrations of aluminium and iron were found. Maximum values of approxinately 17 000 ppm in Castanha-do-Brasil and Cedro vermelho for example are distinctly higher than those of the tea bush (2000 ppm to 5000 ppm) which, according to Chenery (1955), is aluminium tolerant and aluminium dependent, respectively.

The highest content of iron with values around 14 000 ppm are found in the roots of nearly all analysed plants (Cedro vermelho and Taxi branco). It can be assumed that the iron transport is blocked in these parts of the plants (Figure 2 and Figure 3).

It is possible that this is a strategy of the plants to avoid the accumulation of toxic amounts of iron in the tissue.

In all plants except in Mahogany, the phosphorus values are higher than those reported for plant

TABLE 1. Determination of the dry weight of the different plant-fractions from Castanha-do-Brasil., Cumaru, Dendé, Taxi-branco and Urucum.

| Castanha-do-Brasil | (g) | % |
|---|---|---|
| Roots | 1.757 | 11.14 |
| Bark | 1.024 | 6.49 |
| Wood | 0.967 | 6.13 |
| Leaves | 7.648 | 48.51 |
| Seed | 4.370 | 27.72 |
| Total | 15.766 | 100.00 |
| **Cumaru** | **(g)** | **%** |
| Roots | 0.465 | 14.84 |
| Bark | 0.237 | 7.56 |
| Wood | 0.34 | 10.85 |
| Leaves | 2.092 | 66.75 |
| Total | 3.134 | 100.00 |
| **Dendê** | **(g)** | **%** |
| Roots | 0.318 | 11.62 |
| Stem | 0,313 | 11.44 |
| Leaves | 1.096 | 40.04 |
| Seed | 1.01 | 36.90 |
| Total | 2.737 | 100.00 |
| **Taxi branco** | **(g)** | **%** |
| Roots | 0.093 | 4.23 |
| Stem | 0.39 | 17.72 |
| Leaves | 1.718 | 78.06 |
| Total | 2.201 | 100.00 |
| **Urucum** | **(g)** | **%** |
| Roots | 0.143 | 17.31 |
| Stem | 0.192 | 23.24 |
| Leaves | 0.491 | 59.44 |
| Total | 0.826 | 100.00 |

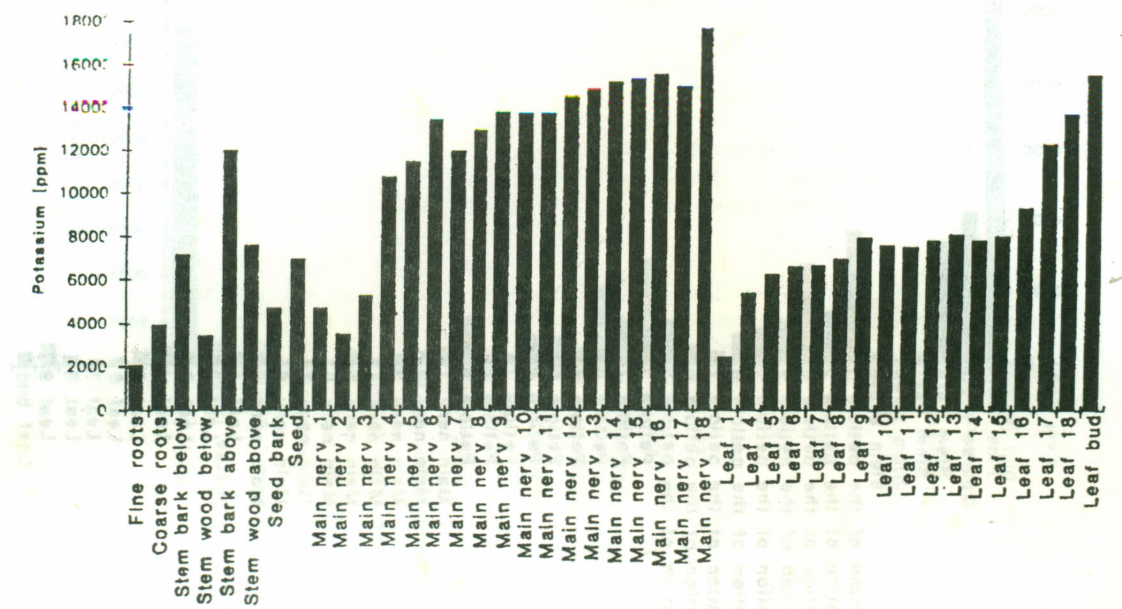
species of primary- or secondary vegetation, whereas the values of nitrogen, copper and zinc are lower compared to the data presented (Klinge 1976; Denich 1989).

Because there exists very little literature on nutritient analyses in useful tropical plants especially of the amazonian region a evaluation and analysis of the results which were found is very difficult.

The extremly high aluminium and iron content found in the plant tissues points out the importance of additional studies on the element contents of the soil. The analyses of the soil should provide

FIGURE 1. Potassium contents of the different plant fractions from Castanha-do-Brasil and Cupuaçu.

Bertholletia exselsia H.B.K. - Castanha-do-Brasil




Theobroma grandiflorum - Cupuaçu

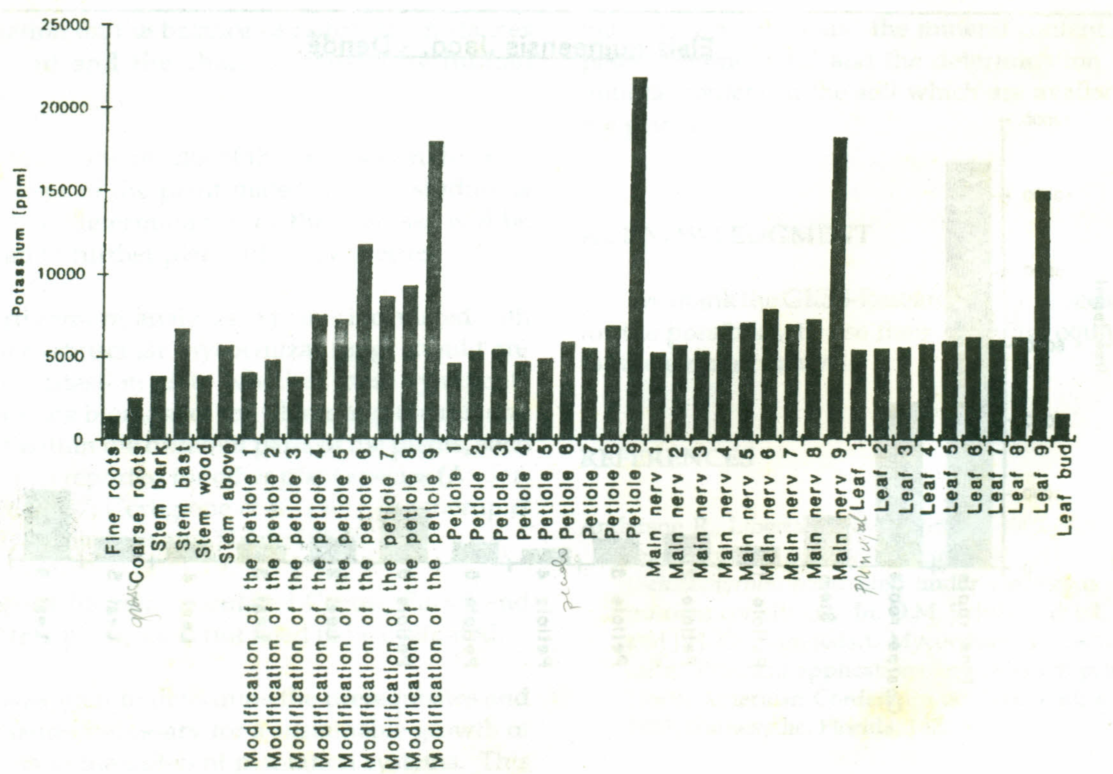
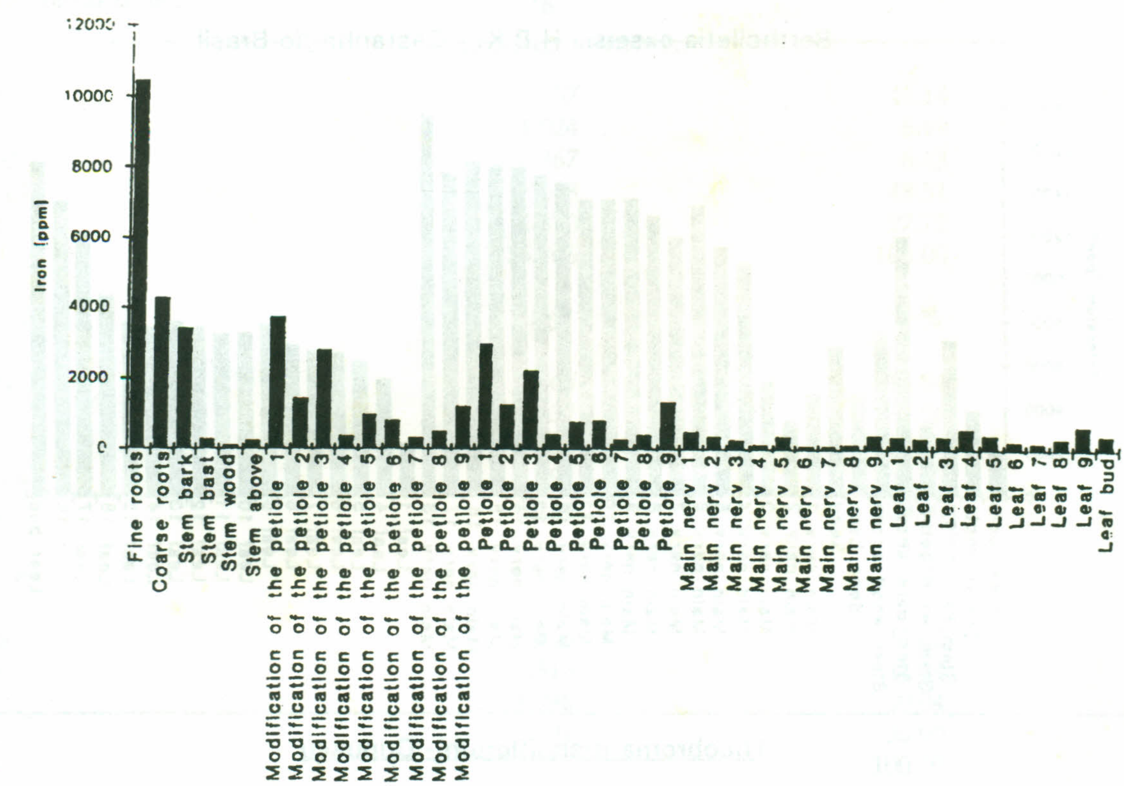


FIGURE 2. Iron content of the different plant fractions from Cupuaçu and Dendê.

Theobroma grandiflorum - Cupuaçu




Elais guineensis Jacq. - Dendê

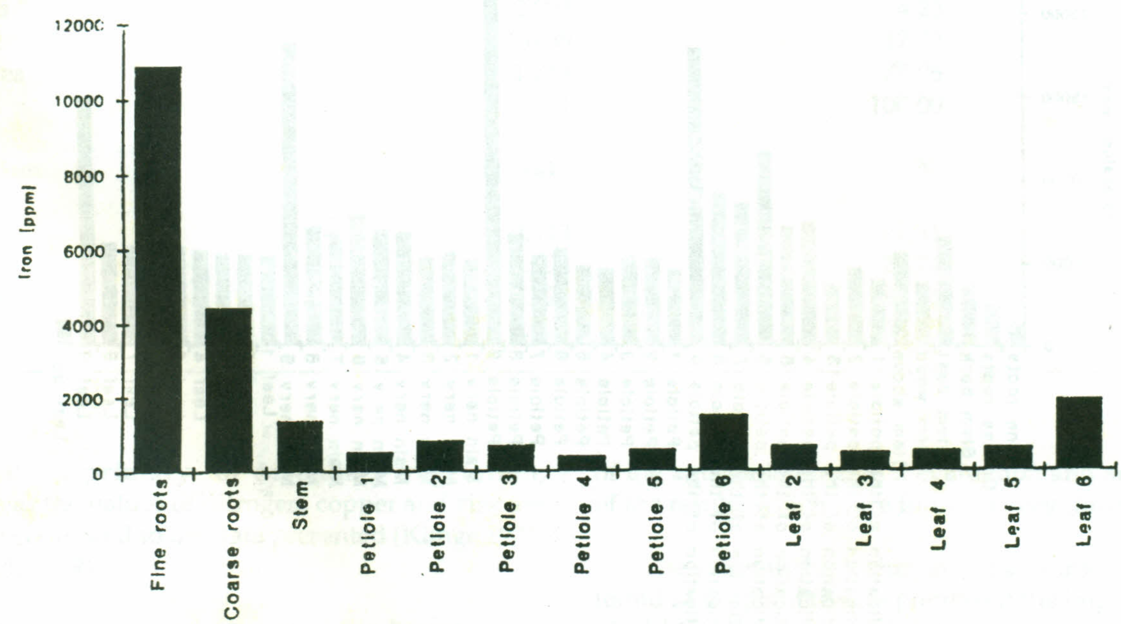
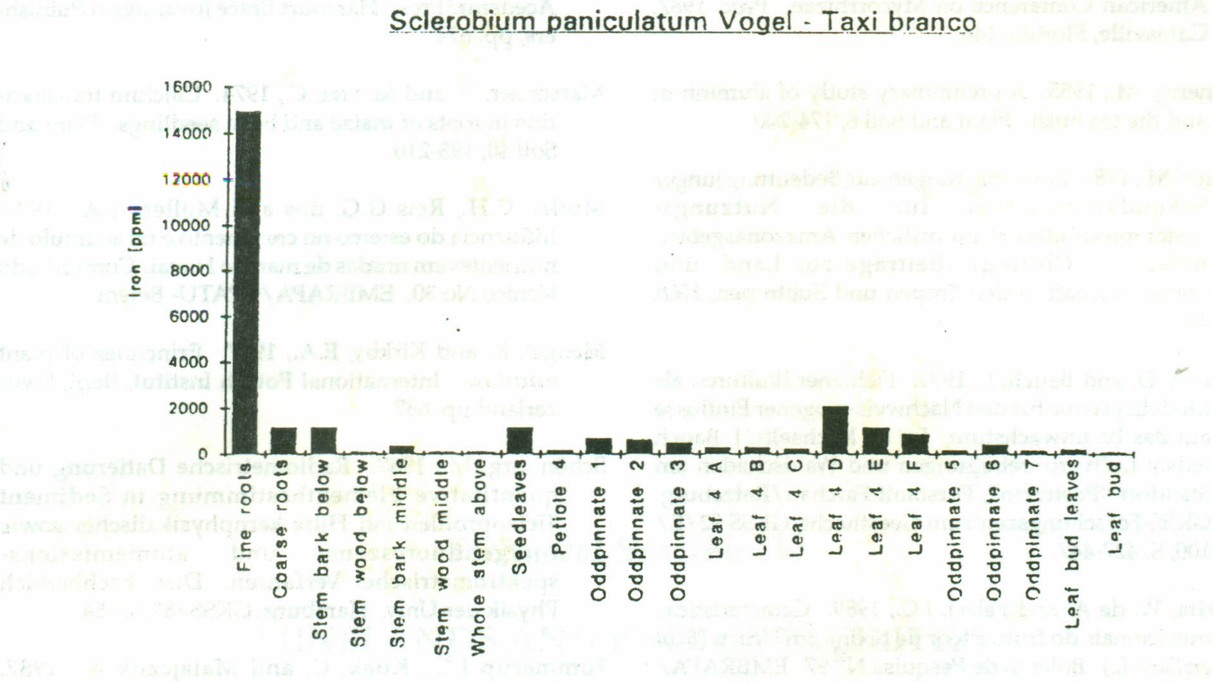


FIGURE 3. Iron content of the different plant fractions from taxi-branco.




information on the balance of nutritive substances in the soil and the changes caused by human impact.

To verify the results of the analysis on the mineral content of the plant material these studies as well as the determination of the biomass will be exceeded to further plants of every species.

Furthermore, analyses of plants inoculated with vesicular-arbuscular mycorrhizal fungi should answer the question as to whether these symbionts influence the biomass of the plants and the mineral content within the different parts of the plants, such as has been reported for other plant species (Anderson *et al.* 1987; Cerligione *et al.* 1987; Tommerup *et al.* 1987; Manjunath and Habte 1987).

Results for non inoculated Cocos-, Paricá and rubber tree plants exist but need to be evaluated.

It is aspired to determine the prerequisites and the measures necessary for a sustainable growth of the plants in the different plantation systems. This will be accomplished by means of the annual balance of biomass and the mineral content of the plants on one hand and the determination of the mineral content in the soil which are available for the plants.


## ACKNOWLEDGMENT

We thank the GKSS-Research Center Geesthacht for the possibility to use their ICP-OES equipment for the element analysis.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