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Effect of fertilization on the fiber production of curauá (*Ananas lucidus* Miller) in the eastern Amazon Region of Brazil

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Abstract

Curauá is a versatile crop, originating from the lower Amazon basin. It was already used by indigenous people in pre-Columbian times. Curauá leaves contain fibers of high quality. Their resistence against mechanical forces is higher than that of most other natural fibers, e.g. sisal (*Agave sisalana* P.). Presently, curauá fibers are considered as a biodegradable substitute for fiberglass in manufacturing of fiber-reinforced plastics. Among the fiber-producing species from the Brazilian Amazon basin, curauá has a very high potential for being used by the automotive and textile industries. Information on improving curauá fibre production, however, is very scarce. Therefore, field research was carried out between 1998 and 2001 to study the growth and yield perfomance of curauá in various cropping systems. Field trials with fertilizer application were established close to Santarém in the Brazilian federal state of Pará. The application of high doses of mineral fertilizer in combination with a higher planting density resulted in a yield increase of up to 900% when compared to yields of local farmers under traditional crop management and even up to 306% when compared to the control tratment. In addition, production costs per kg of fiber decreased to almost 60%, when remuneration of farm family labor was included. In conclusion, the tested agronomic measures showed high potential for improving the fiber yield of curauá and supplying small-scale farmers with a reliable cash crop.

Introduction

Curauá (*Ananas lucidus* M.) is a monocotyledonous, perennial Bromeliaceae which originates from the lower Amazon basin. Today, it is mainly cultivated in the Lago Grande de Curuaí region, located in the municipality of Santarém, Pará, Brazil (Medina, 1959; Ledo, 1967). Currently, two varieties are cultivated, one with green leaves locally named curauá branco and one with greenish-violet leaves named curauá roxo. Curauá is often described as a low demanding plant with no specific needs regarding fertilization and crop management and high potential for income generation even in traditional low external input production systems (Ledo, 1967; Mitschein, 1994). This concept, however, is totally erroneous, considering an estimated demand of 200 t per year by the automotive industry when using curauá fibers as a substitute for fiberglass. The current curauá fiber production does not match the industrial demand by far. Fiber yields of local small-scale farmers are very low, amounting to 370 kg per ha and year on an average basis (Hammer, 2000). These low production levels and the lack of knowledge with regard to improvement of curauá cropping demand for research on nutritional, climatic and soil requirements, as well as measures for improving crop management. Recent research indicated a good fertilizer response of curauá (Behrens, 1999). The present study aims at finding the best input/output relation for curauá under fertilizer application and at reducing fiber production costs under small-scale farming conditions.

Materials and Methods

Site description

The experiments were established at two fields close to Santarém in the eastern Amazon region of Brazil at the confluent of Tapajos and Amazon rivers. The field trials were conducted between October 1998 and December 2000.

The climate at the test site is humid according to the Köppen system and characterized by a distinct dry season between August and October (Diniz, 1986). The long-term precipitation mean for Santarém is 2,096 mm (Salgado et. al, 1987). Rainfall and temperature were monitored during the research period. The annual precipitation of the test site showed values above the long-term means for this region. During the experimental period a strong influence by both the El Niño (1997-1998) and the La Niña (1999-2000) phenomenon was noticed. The latter usually leads to higher precipitation and the former to lower precipitation levels than usual. The annual precipitation measured during the research period was 4,444 mm for 1999 and 3,421 mm for 2000. The mean annual temperature was 26.3°C for 1999 and 31°C for 2000, ranging from 19.2 for the coolest month to 39.4°C the hottest month during the research period.

The soil was a highly weathered acric ferralsol, very poor in exchangeable cations, low pH (4.3) and CEC values, and high levels of exchangeable aluminum, with 22-26% clay, 6% silt, 24% fine sand and 45-51% sand.

Trial description

In October 1998, two separate trials on recently cleared fields were established in a completely randomized Latin square design with four replicates and eight and five fertilizer treatments for curauá branco and curauá roxo, respectively (Schuster et al., 1992). Due to the lack of planting material, the number of treatments and the plot size had to be reduced in the curauá roxo trial. Fertilizer was applied at 3, 5 and 10 MAP[1] for each treatment. Nitrogen was given as urea, potassium as KCl, phosphate as super phosphate and calcium as dolomitic limestone by using the following levels: 0-0-0-0 (control), 150-50-150-0, 300-100-300-0, 450-150-450-0, 0-0-0-500, 150-50-150-500, 300-100-300-500, 450-150-450-500 of N, P, K, Ca in kg ha^{-1} for curauá branco and 0-0-0-0 (control), 300-100-300-0, 450-150-450-0, 300-100-300-500, 450-150-450-500 of N, P, K and Ca in kg ha^{-1} for curauá roxo.

Both trials were planted with uniform planting material between mid and the end of October 1998 at a spacing of 1.5 m x 1.0 m, representing 30 plants per plot in the curauá branco trial and 20 plants per plot in the curauá roxo trial.

Curauá leaves were harvested at 12, 18 and 24 MAP for determination of fiber production. During the first two harvests only older leaves were removed, whereas the entire plant was removed from the field at 24 MAP, harvesting all leaves developed by

[1] Months after planting

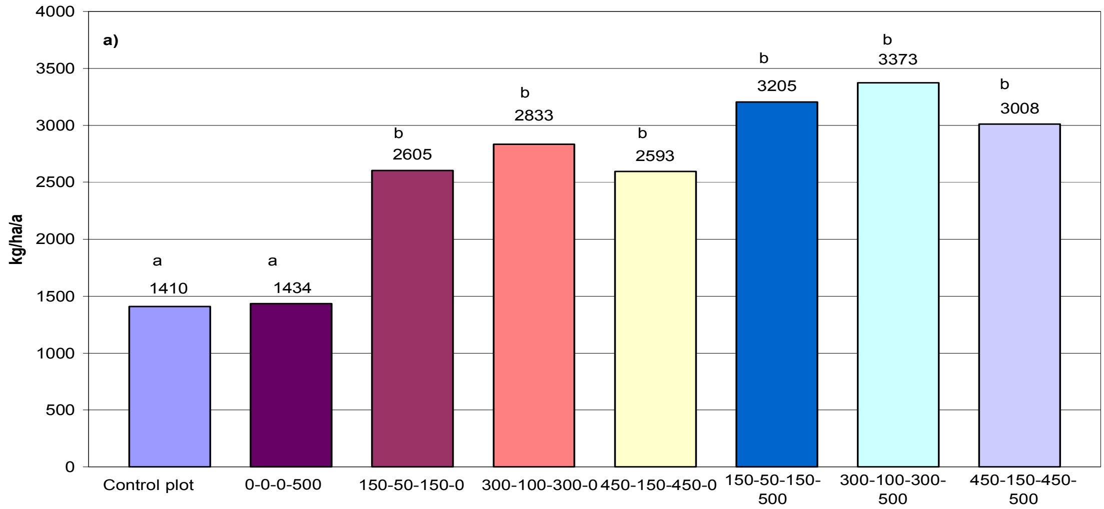
the main plant and the slips. After harvest, fibers were removed from leaves by using a decorticator and then air-dried. Fiber yields are presented on a yearly basis.

Economic data on production of Curauá including costs for planting material, labor, working materials, oil and diesel, and transport derived from interviews held with local farmers. The production costs per kg of dry fiber were calculated by dividing production costs in R$ ha^{-1} and the dry fiber yield in kg ha^{-1}

Statistical analysis of yield data was done with Sigmastat version 2.3 for Windows, using a one-way ANOVA for treatment comparisons followed by a Student-Newman-Coils post-hoc test with $p < 0.05$.

Results

Curauá showed a significant increase of dry fiber yields after being fertilized with high doses of mineral fertilizers (Figure 1). For curauá roxo, total yield on a yearly basis increased from 830 kg ha^{-1} in the control to 2,543 kg ha^{-1} when 300-100-300-500 kg of N-P-K-Ca ha^{-1} were applied, representing a yield increase of 306%. The same result was observed for curauá branco. However, the fiber yield increase was less pronounced



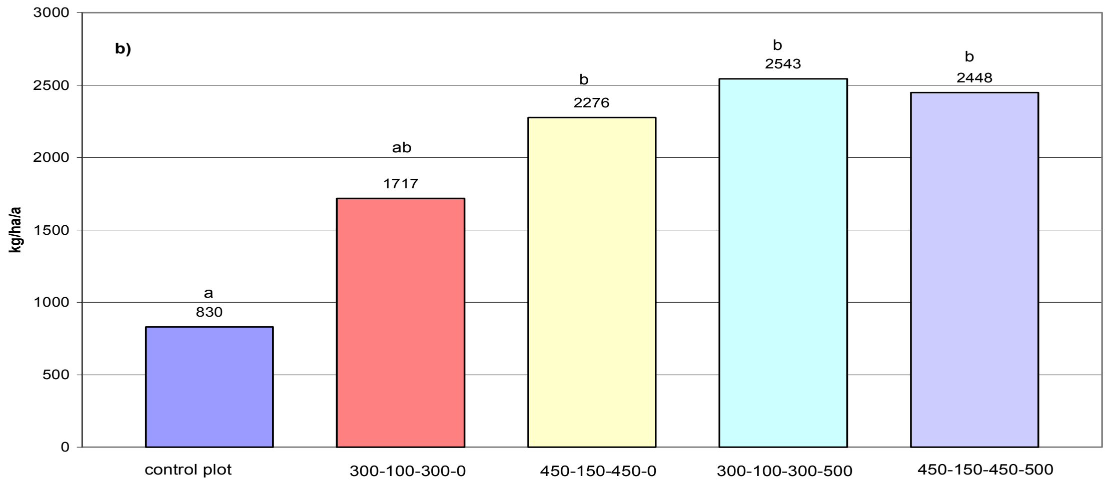


Figure 1. Dry fiber yields (kg ha^{-1} a^{-1}) of (a) Curauá branco and (b) Curauá roxo as affected by fertilizer application (N-P-K-Ca in kg ha^{-1}). Bars with differing lower case letters indicate significant differences of the means within variety at $p<0.05$.

and amounted to 239% (1,410 kg ha^{-1} in the control *vs.* 3,373 kg ha^{-1} a^{-1} in the 300-100-300-500 kg ha^{-1} N-P-K-Ca treatment). In addition, curauá branco showed a higher total fiber production compared to curauá roxo. Application of lime (1,563 kg ha^{-1}) two weeks after planting indicated an increase of fiber yield only in combination with fertilizer application (Fig. 1a). Liming alone, however, showed no effect on fiber production.

Furthermore, differences between the various fertilizer treatments within one variety were not significant. Significant differences were only obtained between the control and fertilizer treatments, particularly at higher levels.

With regard to fiber production costs, mineral fertilizer reduced the cost per kg of fiber produced when compared to local production systems (Fig. 2). In this study, the best input/output relation was found at a mineral fertilizer application of 300-100-300-500 of N-P-K-Ca in kg ha^{-1} for both varieties. This treatment resulted in a cost cutting from R$ 3.84 (US$[2]1.54) to R$ 1.76 (US$ 0.71) and R$ 1.64 (US$ 0.66) per kg of fiber for curauá roxo and curauá branco, respectively, when farmers' family remuneration was included. In addition, production costs were substantially reduced after planting Curauá more densely than it is

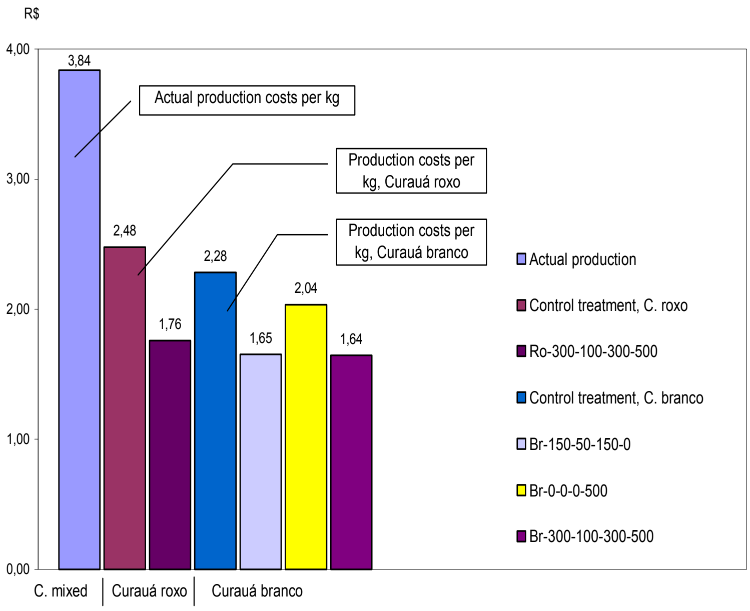


Figure 2. Production costs per kg Curauá dry fiber. Comparison of actual production costs (left) with mineral fertilized Curauá roxo (middle) and branco (right) experiment. (1 RS$= US$ 0.40; 04.08.01). Calculation based on farmers labor remuneration of one monthly minimum salary (R$ 180 /m).

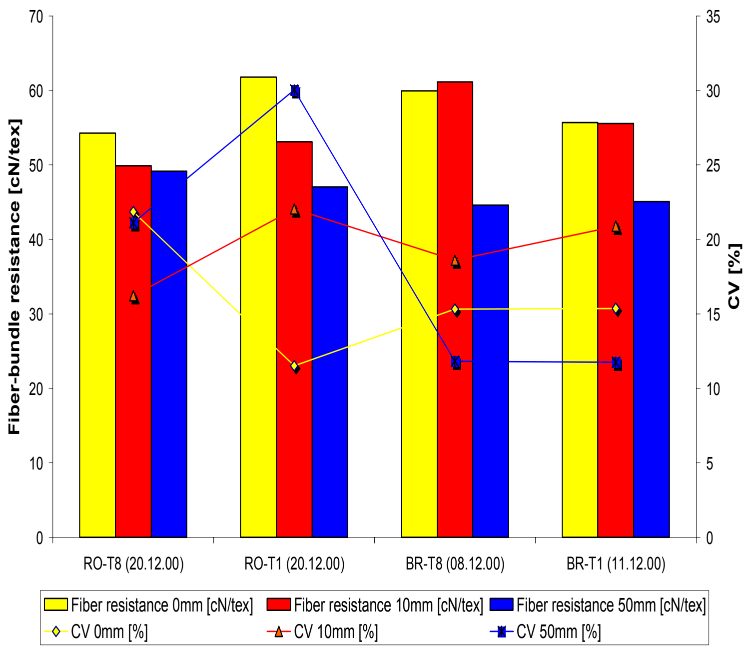


Figure 3. Curauá fiber quality as affected by fertilization (control *vs.* highest fertilizer treatment). Differences were not significant at $p<0.05$.

[2] 1 US$ = R$ 2,491, 4.8.2001

currently practiced in traditional small-scale farming systems.
Preliminary results regarding fiber quality showed no significant difference between control plots and the highest fertilizer treatment for both varieties (Fig. 3).

Discussion

Curauá is mainly cropped in the region of Lago Grande de Curuaí in Pará, where it is an important cash crop of small-scale farmers. The local EMATER[3] office and the government of the Federal State of Pará promote its production as a contribution to a sustainable development of land use in the eastern Amazon of Brazil. Presently, these farmers cultivate cassava (*Manihot esculenta* Crantz) and cowpea (*Vigna spp.*) among others for their subsistence, often intercropped with Curauá. The current production methods of curauá are very archaic and production levels under traditional farming conditions are low. The poor use of external inputs and the restricted availability of farm family labor limit the fiber production per unit of land (Ledo, 1967; Hammer, 2000). Curauá fibers are still locally used for production of ropes, fishing-nets, hammocks and handicrafts (Medina, 1959). Recently, it received attention as an industrial crop because of its very resistant fiber, as its quality is better than that of sisal (*Agave sisalana* P.) and due to its potential for substituting fiberglass or sisal fiber in fiber composite materials in the automotive industry (Gayer, 1995; Behrens, 1999). However, the actual fiber production is by far not matching the industrial demand. Applying mineral fertilizer and improving crop management are considered as feasible measures for increasing curauá fiber production per unit of land together with reducing the costs of production. The results obtained in this experiment showed both an increased curauá fiber production and a cost reduction per kg of curauá fiber. However, these results are in contradiction to the wide-spread opinion that curauá is a low demanding crop (Ledo, 1967; Mitschein, 1994; Borborema, 1994). But, this study confirms statements of Camargo (1943) and Medina (1959) who observed that curauá has higher soil and nutritional requirements than other *Ananas* species and that it may disappear if these requirements are neglected.
Presently, the fiber production of traditional systems amounts to 370 kg per ha and year. For matching the estimated industrial demand of 200 t per year, this could only be achieved by extending the production area, consequently leading to an increased deforestation of the tropical rain forests. Improving the crop management of curauá may reduce the pressure on the natural resources as fiber production can substantially be increased by fertilizer application (curauá branco: 239%; curauá roxo: 306%). In addition, raising the planting densities may also result in a lower area demand at a higher fiber production.
Preliminary results on the impact of fertilization on the fiber quality of curauá showed no adverse effects. At the same time the production costs per kg dry fiber decreased by 43% when using fertilizers due to the strong increase of fiber production. A comparison of dry fiber yields obtained under traditional and improved crop management (planting densities of 4308 *vs.* 6666 plants ha^{-1}; traditional slash and burn agriculture *vs.* fertilizer application) showed a dry fiber yield increase of up to 911% per ha due to the improved crop management. This means that current curauá cropping area of about 150 ha would already cover the present industrial demand (Central de Comercialização, personal communication). Finally, an improvement of the traditional fiber extraction method,

[3] EMATER = Empresa técnica de assistencia e extenção Rural, Brazilian State small scale farming technical consultant institution.

which dates back to the late sixties (Ledo, 1967), may further reduce the production costs of raw curauá fiber .

Conclusions

The current fiber production in the main production area of curauá is lower than the industrial demand. Therefore, improvement of the curauá crop management is required, if rainforest deforestation and degradation shall be avoided. High levels of fertilizer application to either one of the curauá varieties significantly increased the fiber production compared to both the control treatment and the local production systems. But, there were no significant differences between the fertilizer treatments within the same variety. Significant differences were only found between control and fertilized plots for both varieties. It is therefore concluded that increasing the planting density and applying fertilizer are well suited to reduce the area demand required for the fiber demand of the industries. The discussed results, especially the production cost aspect, may increase the interest of farmers and local technical advisors to promote the cultivation of Curauá to supply the industries with the desired amount of fiber.

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