EFFECTS OF CHARCOAL, PHOSPHORUS AND NITROGEN ON THE MINERAL NUTRITION OF BANANA

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Introduction

Banana cultivation is a suitable agronomic alternative for small farmers in occidental Brazilian Amazonia, either as a monoculture or as a part of agroforestry systems. In the Amazonas State (Brazil), the per capita banana consumption is approximately 60 kg/year. However, banana cultivation in this region is characterized by low productivity, associated with a low standard of technology and with phytosanitary problems, the latter especially in relation to the black sigatoka disease (*Mycosphaerella fijiensis*) that can cause harvest losses up to 100%. The banana plant demands high nutrient levels, not only to produce a large vegetal mass, but also because the high exportation for the fruits with high levels of mineral elements.

The nutritional equilibrium is important in all cycle of plants. Each nutrient is essential in metabolism and need to be available in the soil solution in quantity and adequate proportion (Borges & Silva, 2000). Upland soils in the humid tropics such as the Amazon basin are often highly weathered and therefore posses low plant-available nutrient contents (van Wambeke, 1992).

The combination of mineral fertilizers and charcoal can be a means of reducing nutrient leaching, since charcoal is a stable source of organic compounds in tropical soils.

Objective

The objective of this study was to evaluate the effect of charcoal, nitrogen and phosphorus on the nutritional status and productivity of banana.

Material and Methods

The experiment was performed from April 2002 to December 2003, in the Experimental Station of Embrapa Amazonia Ocidental, located in the geographical coordinates of 3º8' S and 59º52' W, in the county of Manaus, Amazonas State, Brazil. The banana cultivar utilized was the 'Caipira', a triploid AAA (Figure 1).

FIGURE 1 – General view of experiment (a) and bunch in the harvest point (b).

The soil was classified as dystrophic clayey Oxisol (Latossolo Amarelo following the Brazilian Classification) at Embrapa Amazonia Ocidental's field station situated in Manaus, Amazonas State, Brazil. A experimental design with a 3^3 confounded factorial scheme was used. Three levels of charcoal were tested (0, 13336 and 26672 L ha^{-1}), as well as three dosages of phosphorous (33.4, 66.8 and 113.6 kg P_2O_5 ha^{-1}), and three dosages of nitrogen (0, 90 and 180 kg N ha^{-1}) per cycle. The mineral sources used were residues of charcoal (708 g C kg^{-1}), simple super phosphate (20% P_2O_5) and urea (42% of N), respectively. Two cycles of production were evaluated. The bananas were planted in holes of 60 cm x 60 cm x 60 cm spaced 3 m x 2 m. The charcoal and the phosphorus rates were applied in holes, whereas that the nitrogen was applied on the soil surface and divided into four applications. After the first bunch harvest (after 12 months), the treatments were applied in semi circles at the soil surface in front of the daughter pseudostems.

The quantities of N, P, K, Ca, Mg, S, B, Cu, Fe, Mn and Zn in the leaves (3rd leaf of the plant) were measured, as well as agronomic variables such as: weight of the harvest, weight of the bunch, number of fruits per bunch, diameter of the fruit and diameter of the pulp.

The results were submitted to analysis of variance (F test), and regression, in accordance with the procedures described by Pimentel Gomes (1990). The software utilized was SYSTAT 8.0.

Results and discussion

The results of the first cycle show significant increase in the weight of the bunch, the number of fruits per bunch, diameter of the fruit and diameter of the pulp due to charcoal application. **In the second cycle, the weight of the bunch was not significantly changed by the applications of charcoal, phosphorous (P) and nitrogen (N). In spite of this, the larger charcoal application to the soil, caused an approximate banana yield increase of three tones per hectare.**

In the first cycle, the quantity of B (boron) in the leaves increased significantly with an increasing amount of charcoal applied to the soil, whereas, an increase in the dosage of P reduced the quantity of this element (Figures 2 and 3). The higher concentrations of C (carbon) in soil might have increased the boron solubility applied as ulexite, which might be little available to plants. According Gupta (1993), showed a significant positive linear correlation between boron absorption and carbon content of soil. With regard to phosphorus, Loué (1993) has showed negative interaction between P and B in soil.

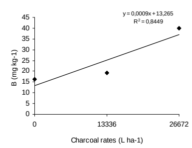

FIGURE 2 - Boron foliar uptake in function of charcoal rates (1nd cycle).

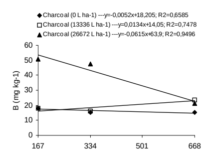

FIGURE 3 - Boron foliar uptake in function of phosphorus and charcoal rates (1nd cycle).

The results showed a significant interaction between charcoal and nitrogen, and charcoal and phosphorus in the first cycle. The treatments without charcoal showed an increase of nitrogen concentration in the leaves with increasing rates if N fertilizer (from 225 kg ha^{-1} to 450kg ha^{-1}), but the opposite occurred when charcoal was applied. (significantly at 26672 L ha^{-1}, Figure 4). The results corroborate the findings of Lehmann et al. (2003) who studied the effect of carbon on mineral nutrition of rice. He observed negative interaction between those two elements. The highest dosage of P fertilizer reduced the quantity of N in the leaves in the absence of charaol, whereas charcoal application of 26672 L ha^{-1} produced the opposite effect (Figure 5).

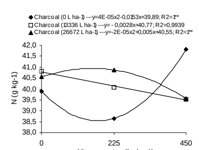

FIGURE 4 - Effect of application nitrogen and charcoal on the N concentration in leaves of banana plant (1nd cycle).

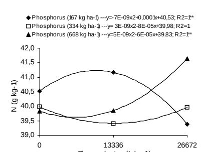

FIGURE 5 - Effect of application phosphorus and charcoal on the N concentration in leaves of banana plant (1nd cycle).

In the local edaphoclimatic conditions, the increase of P rates reduced the Mg (magnesium), Mn (mangan) and B uptake significantly. The second cycle showed a reduction of manganese uptake with increasing levels of charcoal in the soil (Figure 6), which could be a consequence of reduced solubility of Mn with increased pH level.

Increasing N applications caused a decrease of leaf Mg levels, and an increase in Fe (iron) levels (Figure 7).

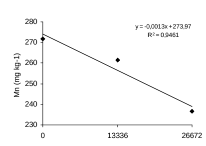

FIGURE 6 - Effect of application charcoal on the Mn concentration in leaves of banana plant (p=0,007)

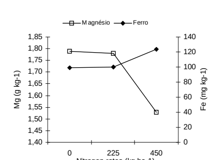

FIGURE 7 - Effect of nitrogen application on the Mg (p=0,029) and Fe (p=0,007) concentration ilave of banana plant (2nd cycle).

The amount of calcium increased with increasing dosage of simple superphosphate (P and Ca rates) at the highest dosage of charcoal, this was not the case at the other two dosages of charcoal (Figure 8). The other nutrients studied were not significantly affected by the treatments.

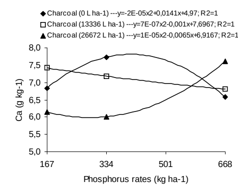

FIGURE 8 - Calcium foliar in function of phosphorus and charcoal rates (2nd cycle).

Conclusions

1. Charcoal additions significantly increased boron uptake of banana and reduce the uptake of manganese.
2. Treatments without charcoal had increased nitrogen concentration in leaves, from the N fertilization level 225 kg ha^{-1} to 450 kg ha^{-1}. The inverse occurred at the highest dosage of charcoal (26672 L ha^{-1}).
3. The P foliar content was not affected by charcoal application, nitrogen and phosphorus in soil
4. The N application enhance Fe uptake, while suppress Mg foliar uptake.

References

BORGES, A.L.; SILVA, T.O. Absorção, exportação e restituição ao solo de nutrientes pela bananeira 'Terra'. Cruz das Almas: Embrapa Mandioca e Fruticultura, n. 66, p.1-3, 2000. (Comunicado Técnico).
LEHMANN, J. SILVA, J.P.; STEINER, C.; NEHLS, T.; ZECH, W.; GLASER, B. Nutrient availability and leaching in an archaeological Anthrosol and a Ferralsol of the Central Amazon basin: fertilizer, manure and charcoal amendments. Plant and Soil, v.249, p.343-357, 2003.
GUPTA , U. Boron and its role in crop production. Boca Raton CRC Press, 1993. 237p.
LOUÉ, A. Oligoélément en agriculture. Antibes: SCPA-Nathan, 1993. 575p.
MALAVOLTA, , E.; VITTI, G.C.; OLIVEIRA, S.A. Avaliação do estado nutricional de plantas; princípios e aplicações. Piracicaba: Potafos, 1997. 319 p.
PIMENTEL GOMES, F. Curso de estatística experimental. Piracicaba: Editora Nobel, 1990. 378 p.
van WAMBEKE, A. Soils of the tropics. New York: McGraw-Hill, 1992. 343p.
VIEIRA, L.S.; SANTOS, P.C.T.C. Amazônia; seus solos e outros recursos naturais. São Paulo: Editora Agronômica Ceres, 1987. 416p.