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# Applying boron to coconut palm plants: effects on the soil, on the plant nutritional status and on productivity boron to coconut palm trees

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**Abstract**

Boron, one of the micronutrients frequently found in low levels in tropical soils affects nutrition and productivity of coconut palm trees essentially cultivated in tropical climates. The objective of this research study was to evaluate the effect of boron on the nutritional status of the plant and its productivity when artificially applied to the culture soil. The experiment was carried out in a four year old, artificially irrigated, dwarf coconut palm orchard in Brazil, between January, 2005 and October, 2006. The soil was a red yellow Latosol (B: 0.18 mg $dm^{-3}$). The treatments consisted in the application of five boron dosages: zero, 1, 2, 4, and 6 kg $ha^{-1}$. In the field, the treatments were arranged according to a completely randomized block design, with four replications. Boron (borax) dosages were applied in equal halves directly into the soil in the months of January and February of 2005. Boron concentration in the soil and plant and plant productivity were evaluated. The higher palm tree production was associated to levels of 0.6mg $dm^{-3}$ of B in the soil and 23.5mg $kg^{-1}$ in leaves. Ninety five percent of palm trees maximum production was obtained with the use of a boron dosage of 2,1kg $ha^{-1}$.

**Keywords:** *Cocos nucifera* L, mineral nutrition, micronutrients.

## 1. Introduction

Cultivation of coconut palm (*Cocos nucifera* L.) trees has grown steadily in recent years not only in Latin America but in several parts of the world. The species is mainly cultivated in lowland coastal areas usually characterized by low fertility soils, the main cause of low productivity. Notwithstanding its recognized economic importance, mineral nutrition of coconut palm plants has received little attention from investigators in the area. The poor available information refers essentially to the giant variety (cultivars of coconut that bear fruit at a later stage than the "dwarf" varieties) or to the hybrid genotype (Santos *et al.*, 2004). The most important observations indicate that mineral nutrient deficiencies, mainly of micronutrients, cause reductions in the number of feminine flowers per spathe and the fruits, which eventually succeed easily drop off the plant, a condition generally referred to as "abortion of immature fruits" (Holanda *et al*, 2007; Siqueira *et al*., 1997). Nutritional equilibrium is essential for high and sustainable productivity of the coconut palm tree (Srinivasa Reddy *et al*., 2002).

Low levels of boron found in tropical soils is, according to Mattiello *et al.* (2009), attributable to factors such as naturally occurring low fertility levels, removal of nutrients by several successive crops, and the increased use of fertilizers and acidity correctives, which contribute to decrease the solubility of several soil minerals (Keren and Bingham, 1985). Silva *et al*. (1995) and Communar and Keren (2006) also point out the importance of factors such as sandy soils, low in organic matter and exposed to heavy rains, which drain much of the boron to deeper layers. In heavy, clayish soils, boron may also be unavailable to plants due to strong adsorption to soil particles (Chaudary and Shukla, 2004). Chronic B deficiencies, caused by soil drying and/or high soil pH affect multiple leaves and ultimately, productivity.

Boron deficiency, in general, reduces root growth (Lima Filho and Malavolta, 1997; Viegas *et al*., 2004) and in the coconut palm tree, production of total roots is reduced by 30% and of thin roots by 48%( Pinho *et al*. 2008a), Sobral (1998), Broschat (2005), and Santos *et al.* (2003) observed that boron deficiency also damages the plant aerial part ,which produces less expanded young leaves with signs of blighted, necrotic, and corky areas. The primary symptoms of B deficiency in coconut trees are leaflet tip truncation, leaf crumpling or distortion, and failure of the spear leaf to open normally.

Santos *et al.* (2004), in an evaluation of the nutritional status of a coconut palm orchard, reported that boron was one of the most yield limiting factors. According to their findings, the most important elements for coconut production in decreasing importance were K > Ca > B. Sobral (1998), Rognon (1984), and Manciot *et al.* (1980) observed that a critical boron level in plant leaves was 10 mg $kg^{-1}$.

General recommendations for the application of boron to coconut plants are that young plants should receive 30 g of borax applied to the 4th leaf axilla. For producing plants, it is recommended that the micronutrient should be applied directly into the soil – in a dosage of 2 kg $ha^{-1}$ of B as borax (Sobral, 1997) when analysis indicates levels lower than 0.2 mg $dm^{-3}$ (hot water) (Teixeira *et al*. 2005). The application of boron directly into the soil is more efficient than foliar techniques due to the low mobility it shows in plant tissues. Boron applied to the soil has a more persistent effect than when it is deposited in leaf axillae (Pinho *et al*., 2008b; Broschat, 2011).

Recommendations about boron dosages to be applied to coconut plants are scarcely found in the literature (Teixeira and Silva, 2003; Santos *et al.*, 2003). The objective of this research study was to evaluate the effects of boron applied to the soil by measuring concentrations of the nutrient in plant leaves and the production of fruit.

## 2. Material and Methods

This research project was carried out at the "Nossa Senhora Aparecida" farm, in Uberlandia, state of Minas Gerais, Brazil, between January of 2005 and October of 2006, in a producing orchard of coconut trees of the dwarf-green variety (cultivar Anão Verde do Brasil de Jequiti). The trees growing in a red-yellow Latosol (162 g $kg^{-1}$ of clay) were artificially irrigated. The climate of the region, according to Koppen's classification, is described as Aw Megathermic, characterized by the occurrence of rains during summers (from October through March) and by a dry period during the winter (from May through September)( Rosa *et al.* 1991).

Soil data, as shown by chemical analyses, were the following: 1- pH($CaCl_2$): 5.2. 2- Organic matter: 19 g $dm^{-3}$. 3- P (by ionic resin exchange): 49 g $dm^{-3}$. 4- K: 1.0 mmol $dm^{-3}$. 5- Ca: 32 mmolc $dm^{-3}$. 6- Mg: 13 $mmol_c$ $dm^{-3}$. 7- H + Al: 22 $mmol_c$ $dm^{-3}$. 8.-CTC (Cation Exchange Capacity): 68.9 $mmol_c$ $dm^{-3}$ . 9- V (Bases Saturation): 68%. 10. B: 0.18 mg $dm^{-3}$. This B value is low according to Raij *et al*. (1997), indicating that the soil in the experimental cultures should respond to boron fertilization.

The coconut palm orchard was annually fertilized with a mixture of 1.5 kg of N, 0.4 kg of $P_2O_5$, and 1.8 kg of $K_2O$ per plant, following recommendation by Sobral (1998). The mixture was applied over a 40 cm wide band at a distance of 30 cm from the plant trunk. Phosphorus was applied in a single dosage (January of 2005) whereas N and K applications were split in four – in January, February, March, and April of 2005.

Boron treatments described in this report consisted of five dosages: 0, 1, 2, 4, and 6 kg of B (as borax) per hectare applied in two equal parts each in a volume of 600 L $ha^{-1}$ and corresponding to concentrations of borax of 0, 0.72, 1.45, 2.9, and 4.35% ,respectively. The treatments were arranged in the experimental area according to a completely randomized block design, with four repetitions. In each of the two applications 3.4L of the boron solution dose were sprayed (3,4L of solution per plant, in a circular area of 1,25$m^2$ of soil around each plant) one in January and the other in February of 2005, in order to reduce fertilizer losses from leaching.

In March of 2006, soil samples were taken from 12 points of the fertilized areas and then mixed so as to obtain a composite sample, which was used to represent boron concentration in the soil. The analytical procedure was that described by Raij *et al*. (2001).

Analysis of leaf samples harvested in April of 2006 was as described by Rognon (1984). The samples consisted of leaflets of leaf nine from four year old plants. Boron concentration was determined by the procedure described by Bataglia *et al.* (1983).

Fruit, were collected approximately 7 months after spathe opening, at intervals of approximately 30 days during the periods of January to April and August to October of 2006. Productivity was expressed by the average number of fruits harvested per plant, per year.

According to the experimental design each unit was formed by three rows of five plants. The distance between plants in the row and between rows was 7.5 m. Experimental data was from samples collected in three central plants of the central row of each experimental unit.

Experimental data were submitted to the analysis of variance and polynomial regressions adjusted to 5 % significance.

## 3. Results and Discussion

Boron contents in fertilized soils increased linearly with the applied dosages (Figure 1). The high coefficient of determination ($R^2$ = 0.95**) relating dosages of fertilizer and boron content in the soil indicates that hot water is an efficient boron extractor. Dosages of boron fertilizer used in the experiment described in this report resulted in a soil nutrient gradient with values considered medium (0.21 to 0.60 mg $dm^{-3}$) when the fertilizer dosage was of 2 kg $ha^{-1}$ The highest fertilizer dosage resulted in a soil boron concentration of 0.9 mg $dm^{-3}$, a high content according to Raij *et al*. (1997)

Boron fertilizer dosages also resulted in a linear growth of nutrient concentration in plant leaf tissues (Figure 2). The results could be related to the increased concentrations in the corresponding soil samples. Comparing the average boron content in leaves of the control treatment (9 mg $kg^{-1}$) to that produced by the highest boron fertilizer dosage (51 mg $kg^{-1}$) it is seen

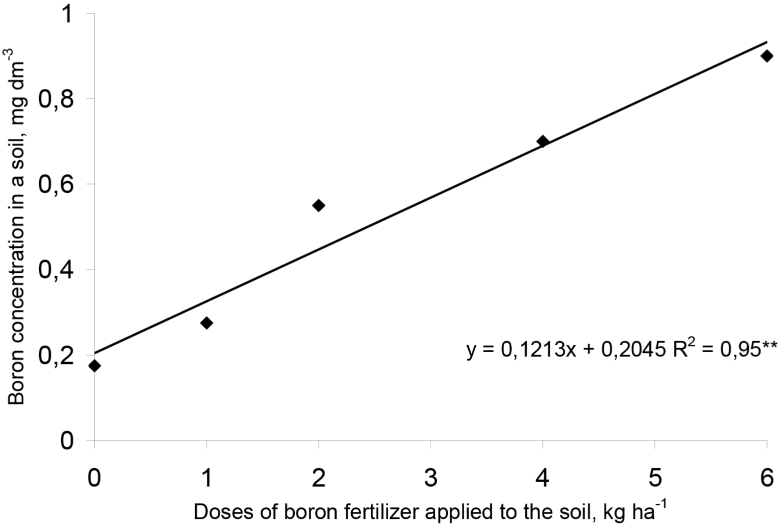


**Figure 1.** Boron concentration in soils of coconut palm trees cultures after application of different dosages of boron fertilizer. ** Results significant at 1% level according to the F test.

that the treatment resulted in over a fivefold increase Only fertilizer dosages of 0, 1, and 2 kg $ha^{-1}$ resulted in leaf boron concentration levels lower than the considered critical level ( 10 mg $kg^{-1}$) as indicated by Sobral (1998), Rogon (1984), and Manciot *et al*. (1980). Teixeira *et al.* (2003), in a study of two year old coconut palm trees of seven genotypes growing in Bebedouro, State of São Paulo, Brazil, found foliar B levels higher than 10 mg $kg^{-1}$ (43.9 to 47.9 mg $kg^{-1}$ of B in leaf 9).

The number of fruits per plant showed a quadratic increment with increasing boron fertilizer dosages (Figure 3).

Data in Figure 3 show that the highest fruit production resulted when the boron concentration in soil was 0.6mgd$m^{-3}$ and 23.5 mg $kg^{-1}$ in leaves. If one considers 95% of this maximum production the value would be 2,1 kg.$ha^{-1}$ , quite close to the dosage of 2 kg $ha^{-1}$ recommended by Teixeira *et al*. (2005) for soils with boron levels lower than 0,2 mg $dm^{-3}$ when the extractor is hot water.

Literature data confirm the beneficial effects of boron to coconut palm tree cultures. Santos *et al.* (2003) reported the positive effects of the micronutrient applied to the leaf axillae. Similar beneficial effects were also reported by Pinho *et al*. (2008).

It is suggested that the beneficial effects of boron are due to its role in cell wall formation and in pollen tube growth (Prado, 2008). Results shown in Figure 3 indicate that dosages higher than the one corresponding (3.2 kg $ha^{-1}$) to maximum fruit yield causes a reductions in production of up to 35% when the highest dosage (6 kg $ha^{-1)}$ is used and a foliar boron level reaches 50 g $kg^{-1}$. Prado (2008) points out that the interval between the boron foliar levels at maximum fruit yield and the intoxication levels is rather short. Thus, applications of boron fertilizer to coconut palm trees should be very carefully planned to avoid plant intoxication and even death.

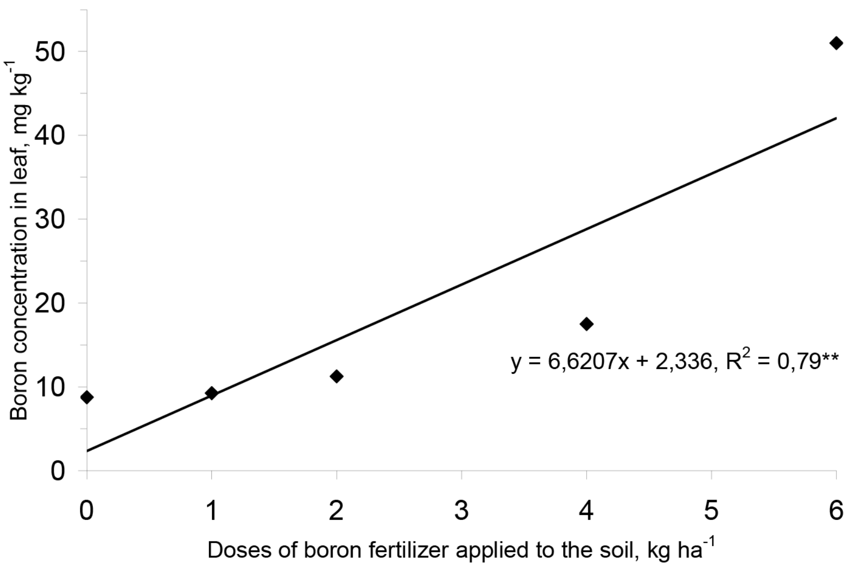


**Figure 2**. Boron concentration in leaf tissue of coconut palm trees determined after application of different boron fertilizer dosages to the soil. ** Results significant at 1%level according to the F test.

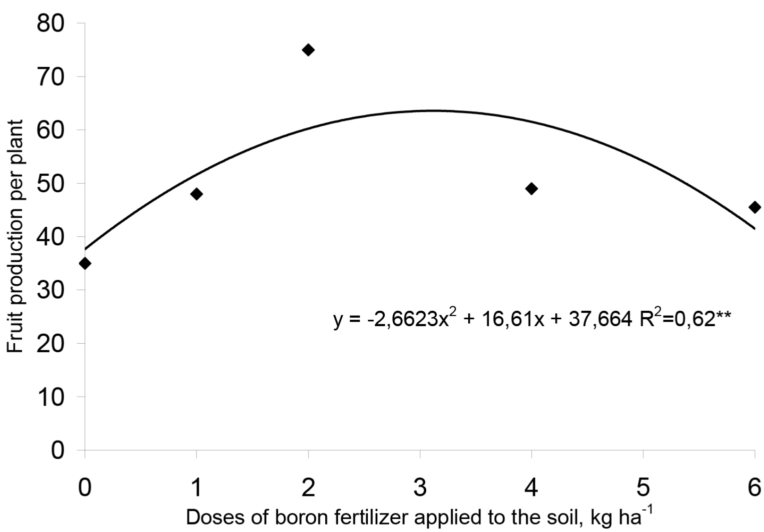


**Figure 3.** Fruit production of coconut palm trees resulting from the application of different dosages of boron fertilizer to the culture soil. ** Results significant at 1% level according to the F test

## 4. Conclusion

The application of boron fertilizer to a coconut palm orchard increased boron soil and leaf levels and affected fruit production.

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