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Initial development of seedlings of macauba palm (*Acrocomia aculeata*)

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ABSTRACT

The macauba palm (*Acrocomia aculeata*), also know as the grugru palm, macaw palm and coyol palm, has great potential for the production of oil for biodiesel. The aim of this study was to evaluate the development of macauba palm seedlings in two types of soil, with and without the use of a soil conditioner. The study was conducted under screening mesh in 20 l pots containing two kinds of topsoil (0–20 cm): Eutroferric Red Latosol (clayey) and Dystroferric Red Latosol (sandy). The following treatments were tested for each soil type: T0 = control, TC3 = 3 kg m^{-3} Terracottem®, TC6 = 6 kg m^{-3} Terracottem®, CF = chemical fertilizer (urea, simple superphosphate and potassium chloride) and TC6 + CF = 6 kg m^{-3} Terracottem® + chemical fertilizer. The chemical and biological attributes of the soil, nutrient levels in the leaves and phytotechnical indices were evaluated. For the majority of contrasts carried out there were no significant differences. However, increases in soil and plant nutrient levels were observed depending on whether the conditioner or chemical fertilizer were applied on their own or combined. There were no significant differences in any of the phytotechnical parameters evaluated in the two soils tested. Sandy soils tend to result in lower plant development.

1. Introduction

The macauba palm (*Acrocomia aculeata)* is found growing in various biomes and soil types. It is more abundant in clayey and eutroferric soils, but can occur in sandy, low-fertility soils (Motta et al., 2002), which means that large populations are found on grassland that is often degraded and of low fertility (Negrelle et al., 2002).

The fruit of the macauba palm has been recommended as a good alternative for the production of biofuels. However, to confirm that this is so, phenological, morphological and agronomic studies need to be conducted. The initial management of fertilization of the macauba palm to be applied in the field, especially after the initial period of three months in its growth, is essential to provide support for the development of plants. The growth and development of the palm in different soil types with the use of fertilizers and conditioners also needs to be investigated.

In regard to soils and fertilizers, studies have shown that the macauba palm prefers fertile, well-drained soils (Motta et al., 2002). In a trial set up in Cerrado (savanna) areas in the Brazilian State of Maranhão, Leite et al. (2010) it was observed that the macauba palm does not affect the chemical and biological attributes of the soil, maintains good nutrient levels and, when intercropped on grassland, increases soil fertility and stocks of organic matter.

Both natural and artificial soil conditioners are increasingly being used in agricultural production, especially in the production of seedlings, since they are able to improve plant development and soil attributes. This means that adding conditioner at the beginning of macauba palm development could lead to benefits, although no experimental studies have been conducted to test the effects on macauba palm. Some studies on conditioners have indicated that plant growth is boosted (Danneels and Van Cotthem, 1994; Rodriguez and Garcia, 1997) and some soil attributes improved (Trout et al., 1995; Ben-Hur and Keren, 1997). These benefits include improved nutrient transport and absorption, increased fruit productivity and, in particular, improved oil content and quality, as well as better root development.

According to Motoike et al. (2013) and Pimentel (2012), initial macauba palm nutrition is essential to speed up growth, since the macauba palm grows slowly if it has to rely solely on the nutrients available in the soil. After three months, macauba palm seedlings

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grown in the greenhouse are ready to be transplanted, and the authors cited above applied different rates of fertilizer or fertilizer combinations to obtain satisfactory results. The use of fertilizers in the first six months of growth is the basis for rapid development.

The aim of this study was to evaluate the development of macauba palm seedlings in two soils (Eutroferric Red Latosol (clayey) and Dystroferric Red Latosol (sandy)) for a period of six months and soil attributes with and without the use of a soil conditioner.

2. Material and methods

The experiment was conducted over a six-month period (from July to December 2012) after the three-month old seedlings were transplanted into 20-liter pots under screening mesh to block 50% of the light. The site was the Experimental Farm at the State University of Londrina (23° 20′ 23.45″ S and 51° 12′ 32.28″ W), in state of Paraná (PR)-Brazil, elevation 532 m, with a humid subtropical mesothermal climate according to Köppen (Cfa), and an average temperature of 21 °C. The seedlings were irrigated constantly to keep the moisture content at 70% of field capacity. Pre-germinated seeds from state of Minas Gerais were acquired and grown in the greenhouse until they were three months old.

The pots were filled using a 4 mm sieve with topsoil (0–20 cm) taken from two locations: Londrina-PR (Eutroferric Red Latosol (clayey)—ERL) and Jaguapitã-PR (Dystroferric Red Latosol (sandy) – DRL). Two types of soils were used to check the their effects on the macauba palm in terms of the differences in clay and nutrient content. The two soils were previously analyzed and the results were as follows: ERL-pH in $CaCl_2$ = 4.85; P = 1.35 mg kg^{-1}; OM = 18.5 g kg^{-1}; K = 0.37 $cmol_c$ kg^{-1}; Ca = 6.46 $cmol_c$ kg^{-1}; Mg = 1.57 $cmol_c$ kg^{-1}; H + Al = 4.96 $cmol_c$ kg^{-1}; Al = 0.08 $cmol_c$ kg^{-1}; Cu = 20.8 $cmol_c$ kg^{-1}; Fe = 13.2 $cmol_c$ kg^{-1}; Zn = 0.32 $cmol_c$ kg^{-1}; Mn = 23.8 $cmol_c$ kg^{-1}; SB = 8.4 $cmol_c$ kg^{-1}; V = 62.8%; clay = 654 gkg^{-1}. DRL-pH in $CaCl_2$ = 4.53; P = 1.13 mg kg^{-1}; OM = 4.07 g kg^{-1}; K = 0.01 $cmol_c$ kg^{-1}; Ca = 1.72 $cmol_c$ kg^{-1}; Mg = 0.48 $cmol_c$ kg^{-1}; H + Al = 2.95 $cmol_c$ kg^{-1}; Al = 0.03 $cmol_c$ kg^{-1}; Cu = 4.2 $cmol_c$ kg^{-1}; Fe = 13.8 $cmol_c$ kg^{-1}; Zn = 0.27 $cmol_c$ kg^{-1}; Mn = 6.6 $cmol_c$ kg^{-1}; SB = 2.21 $cmol_c$ kg^{-1}; V = 42.6%; clay = 111.5 g kg^{-1}.

The experimental design consisted of randomized blocks of 5 treatments and four replications. The treatments tested were as follows: T0: control; TC3: Terracottem soil conditioner 3.0 kg m^{-3}; TC6: Terracottem 6.0 kg m^{-3}; CF: chemical fertilizer consisting of ammonium sulfate –1.0 kg m^{-3}, simple superphosphate –8.0 kg m^{-3} and potassium chloride –0.3 kg m^{-3}; TC6 + CF: Terracottem 6.0 kg m^{-3} + ammonium sulfate –1.0 kg m^{-3}, simple superphosphate –8.0 kg m^{-3} and potassium chloride –0.3 kg m^{-3}. The same treatments were tested on both soils. One seedling of macauba palm with three pairs of leaves (2 month's old) was planted in each pot. The data was collected in December, at the end of the 6-month experimental period.

During this period, fertilizer was applied to the plants monthly in the form of 1.0 g urea, 0.5 g potassium chloride and 0.5 g magnesium sulfate per plant.

Chemical analyses were carried out according to the methodology described by Pavan et al. (1992) to determine the following: pH in $CaCl_2$ 0.01 M; exchangeable acidity in KCl 1 M by titration with NaOH 0.01 N; potential acidity estimated by SMP; Ca and Mg extracted by KCl 1 N and EDTA titration; P and K using Melhich-1 extraction and spectrophotometry at 630 nm (P) and in a flame photometer (K); carbon by oxidation with $Cr_2O_7^{2-}$ titrated with $FeSO_4$ and organic matter determined by the carbon value multiplied by 1.72; and micronutrients, Cu, Fe, Zn and Mn by Melhich-1 extraction and atomic absorption spectrophotometry.

Physical soil analyses were carried out in accordance with Claessen (1997). Particle size was determined using the pipette method with slow stirring and addition of 1 N sodium hydroxide dispersant, and a given reference weight.

Microbial biomass carbon (C) was determined using the fumigation-extraction method (Vance et al., 1987). After incubation, the organic carbon in the two samples was extracted and quantified by oxidation with $K_2Cr_2O_7$ (Anderson and Ingram, 1993).

Terracottem® soil conditioner was analyzed following the methodology described by Vieira and Silva (2009). The calculations were carried out as follows: N using the Raney nickel methos and P_2O_5 using the molybdovanadophosphoric acid colorimetric method in a spectrophotometer set to a wavelength of 400 nm; K_2O by flame photometry with solubilization in water; Ca, Mg, Cu, Fe, Zn and Mn by atomic absorption spectrometry, digesting the material with HCl. The results (%) were as follows: N: 5.95; P_2O_5: 1.51; K_2O: 2.00; Ca: 3.08; Mg: 5.47; Cu: 0.018; Fe: 5.95; Zn: 0.007; Mn: 0.283.

Plant height (between the base and the leaf junction), base diameter and number of leaves were evaluated every thirty days. At the end of the experiment, the leaf area index (LI—3100 Area Meter) (LAI) and dry and fresh weight of the shoot (SDM) and roots (RDM) were also evaluated.

Before set-up and at the end of the experiment, leaflets in the median part from both sides of the plants were collected for leaf analysis. N, P, K, Ca, Mg, Cu, Fe, Zn, and Mn were analyzed using the method described in Myazawa et al. (2009).

The data obtained were subjected to analysis of variance using the Tukey test at 5% probability. In addition, we compared some non-orthogonal contrasts using the Scheffé test at 5% and 10%. Statistical analyses were run on Sisvar® software (Ferreira, 2008).

3. Results and discussion

3.1. Soil evaluation

The use of Terracottem® soil conditioner and chemical fertilizer increased the levels of macro and micronutrients, organic matter and microbial biomass carbon in both soils tested.

Table 1 gives the mean values for soil nutrient levels, the values of non-orthogonal contrasts for macronutrients and organic matter for the clayey Eutroferric Red Latosol (ERL) and sandy Dystroferric Red Latosol (DRL). The results for the ERL soil indicate that the use of chemical fertilizer alone or combined with Terracottem® increased nutrient levels in the soil, except for Mg^{2+} which dropped for all treatments by comparison with the control. For the DRL soil, levels of Ca^{2+}, Mg^{2+}, P and K^+, as well as organic matter increased by comparison with the control. The contrasts were not significant for most combinations in the Scheffé test at 5% and 10% probability; levels of P and K^+ were significantly higher with the application of 6 kg m^{-3} Terracottem® and chemical fertilizer.

In a Dystrophic Red-Yellow Latosol in the Brazilian State of Maranhão under intercropped macauba palm and grassland, Leite et al. (2010) reported lower values than those obtained in our study for calcium, magnesium, phosphorus and potassium. In terms of organic matter and microbial biomass carbon, the values were similar.

Chemical fertilizer raised Ca^{+2} levels in both soils (Table 1). For the ERL soil, the T0 x CF contrast was significant at 5% probability; at 10% probability the T0 x TC6 + CF and TC6 x TC6 + CF contrasts were also significant. However, for the DRL soil, the significant contrasts at 5% were T0 x CF; TC6 x TC6 + CF, and at 10%, T0 x TC3; T0 x TC6 and T0 x TC6 + CF. In terms of Mg^{+2} in the ERL soil, the control exhibited the highest level, and levels for treatment with chemical