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Initial growth of African mahogany plants in response to zinc fertilization

Matheus da Silva Araújo^{1*}, Stephany Diolino Cunha², Karolayne Lemes D'Abadia², Yago Cesar Rodrigues Morais², Ednaldo Candido Rocha², Vitor Correa de Mattos Barretto³ and Gustavo Matos Coelho²

¹University of Brasília, Campus Darcy Ribeiro, C P 4357, CEP 70910-900, Brasília, DF, Brazil.

²State University of Goiás, Campus Ipameri, GO Highway 330, km 241, Beltway Zip code: 75780-000, Brazil.

³State University of Paulista, Campus de Dracena, Highway Cmte. João Ribeiro de Barros, km 651, Neighborhood of Antas, CEP 17900-000, Dracena, SP, Brazil.

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African mahogany (*Khaya senegalensis* A. Juss) has been an important option to supply the increasing demand for noble forest products for the Brazilian furniture industry. In the present study, the objective was to evaluate the initial development of mahogany plants in response to different doses of zinc. The experiment was carried out inside a greenhouse, in the experimental area of the State University of Goiás, Ipameri Campus, in 7 dm³ plastic containers, and using soil samples, identified as Dystrophic Red-Yellow Latosol (Oxisol), as substrate. The experimental design was completely randomized, with five treatments and five replications, totaling 25 experimental units. The treatments consisted of five Zn concentrations: 0, 2.5, 5, 10 and 20 mg dm⁻³, obtained by zinc sulfate fertilizer. At 150 days, the measurements of the plant height, the root crown diameter, dry matter mass of leaves, stem, root and total were evaluated. The tested increasing zinc doses did not promote increased plant growth. African mahogany presented low zinc requirement in the early stages of development for the studied edaphoclimatic condition, and no application of zinc via fertilizers was required. This fact may resulting from the natural concentration of 0.2 mg dm⁻³ of Zn in the used soil, which was enough to supply the nutritional demand of the plants in the first five months of development.

Key words: *Khaya senegalensis* A. Juss, morphology, micronutrient.

INTRODUCTION

Planted forests have great economic, social and environmental importance for the country, contributing

significantly to the tax generation, jobs, products and well-being; besides directly favoring the conservation and

*Corresponding author. E-mail. matheusflorestal@outlook.com.

preservation of natural resources (Ciriello et al., 2014). Wood from reforestation is a promising future option, and this practice is growing. Among the used species, African mahogany is a great option to supply the growing demand of noble forest products for the furniture industry (Pinheiro et al., 2011).

In Brazil, African mahogany (*Khaya senegalensis* A. Juss) stands out among exotic timber species due to its good development in areas of predominantly humid tropical climate, besides its ability for adapting to subtropical climate regions. For this reason, among noble wood species, it is the exotic tree presenting the best growth in the Cerrado, so the reforestation companies are interested in this species. In origin areas, African mahogany occurs over a wide range of climate, relief, ecological, and edaphic conditions (Danquah et al., 2011).

In order to reach the plant maximum productive potential, a correct supply of nutrients is necessary. In addition to macronutrients (nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, carbon, oxygen, and hydrogen), it is also necessary to consider micronutrients which, although required in small amounts, they are fundamental to the performance of main cellular metabolic functions (Corcioli et al., 2016). Thus, the adequate supply of these nutrients is a key point for plant growth and development, including for forest species.

Among the micronutrients required for plants, zinc along with boron are the most deficient in Brazilian soils (Malavolta, 1980). The most important contribution of zinc in the metabolic processes of plants is participating in the composition of many enzymes, such as proteases, dehydrogenases, proteinases and phosphohydrogenases. Symptoms of zinc deficiency are the most frequently observed, due to its low concentrations in the lithosphere. Its content in the soil is, on average, is lower than in the rocks, occurring in minerals, adsorbed or forming soluble and insoluble organic complexes. From the total zinc amount in the soil, only a small part is available, such availability is influenced by factors such as its content, pH, and soil organic matter content (Malavolta et al., 1997).

Although, African mahogany has stood out as a good choice in timber production, there remains the necessity of researches related to the species fertilizing. There are few studies indicating their nutritional needs, aiming at production of good quality seedlings, and consequently obtaining greater survival when submitted in the field. Some studies demonstrated nutrient deficiency symptoms and positive responses to fertilizing on African mahogany growth (Vieira et al., 2014; Perez et al., 2016; Smiderle, 2016; Vasconcelos, 2016). However, these results need to be detailed by local surveys for determining the critical levels of nutrients in the soil and the appropriate doses of fertilizers to ensure the productivity of commercial plantings of the species (Nikles et al., 2008). Therefore, the objective of the

present study was to evaluate the initial growth of African mahogany grown under greenhouse conditions, in response to different doses of zinc.

MATERIALS AND METHODS

The experiment was conducted in the greenhouse, of the experimental area of the State University of Goiás, Ipameri Campus (17°43'19"S; 48°09'35"W; 764 m height). Ipameri municipality is located in the southeastern region of the Goiás State, where the climate is classified as Aw (Tropical seasonal), and it is characterized by two well-defined seasons, one drought winter and one rainy summer. Annual precipitation is approximately 1600 mm, and the average temperature is about 23°C (Alvares et al., 2013). Inside the greenhouse, the average temperature was of 27°C.

The used substrate was an agricultural soil classified as a dystrophic Red-Yellow Latosol (Oxisol), collected in the subsurface layer (0.20 to 0.40 m). Physicochemical analysis presented the following initial values for the substrate: 300, 80.0 and 620.0 mg dm⁻³ of clay, silt and sand, pH (CaCl₂) = 5.1; H + Al = 2.2 cmol_c dm⁻³; Ca = 0.8 cmol_c dm⁻³; Mg = 0.3 cmol_c dm⁻³; P (melich) = 1.2 mg dm⁻³; K = 0.04 cmol_c dm⁻³; organic matter = 9.0 g dm⁻³; CTC = 3.36 cmol_c dm⁻³; V% = 34.57; Cu = 1.9 mg dm⁻³, Fe = 43.9 mg dm⁻³, Mn = 3.4 mg dm⁻³, Zn = 0.2 mg dm⁻³ and B = 0.19 mg dm⁻³, respectively.

The used species was *K. senegalensis* A. Juss, whose seedlings were produced from imported African seeds. Germination occurred in tubes of 53 cm³ capacity, where the seedlings remained until they reached a mean height of 15 cm and a crown root diameter of 8 mm, then they were transplanted to the vessels. During this period, they received no fertilizing.

The experimental design was completely randomized, with five treatments and five replications, totaling 25 experimental units. The treatments consisted of five Zn concentrations: 0, 2.5, 5, 10 and 20 mg dm⁻³, obtained by zinc sulfate fertilizer.

Based on the physical-chemical analysis of the used soil, all treatments received liming to raise the soil base saturation of 60% and fertilization with nitrogen (80 mg dm⁻³), phosphor (150 mg dm⁻³), potassium (80 mg dm⁻³), and micronutrients: manganese (1.5 mg dm⁻³), boron (0.5 mg dm⁻³), copper (0.5 mg dm⁻³) and molybdenum (0.1 mg dm⁻³) (Ciriello et al., 2014). The sources used for liming and fertilization were PRNT 92 dolomitic limestone, urea, triple superphosphate, potassium chloride, manganese sulfate, boric acid, copper sulfate and sodium molybdate, respectively. The doses of the established nutrients were applied individually in each vessel.

When the seedlings reached 120 days of age, in October 2014, they were transplanted to opaque black polyethylene vessels, with perforations at the bottom, and filled with 7dm³ of soil. Soil moisture was maintained throughout the experimental period in approximately 60% of the maximum water retention capacity of the soil. The volume of evapotranspired water was replenished daily by weighing the vessels.

After 150 days, the growth variables were assessed (height of the plants and root crown diameter) by measuring the height of the plants, from the root crown to the apex of the plants, using a graduated ruler, and root crown diameter, using a digital caliper and counting leaflets number. Then the plants were separated into leaves, stem and roots for the determination of the dry mass matter. The plant parts were washed with distilled water, and then they were placed into a forced air circulation oven for 72 h at 70°C until the obtention of a constant mass. After drying, they were weighed in an analytical scales, with a precision of 0.01 g, to determine the dry matter mass of leaves, stem and root, and by the sum, the total dry matter mass was calculated.

After compliance verification with the assumptions of homogeneity of variances and normality, data were submitted to

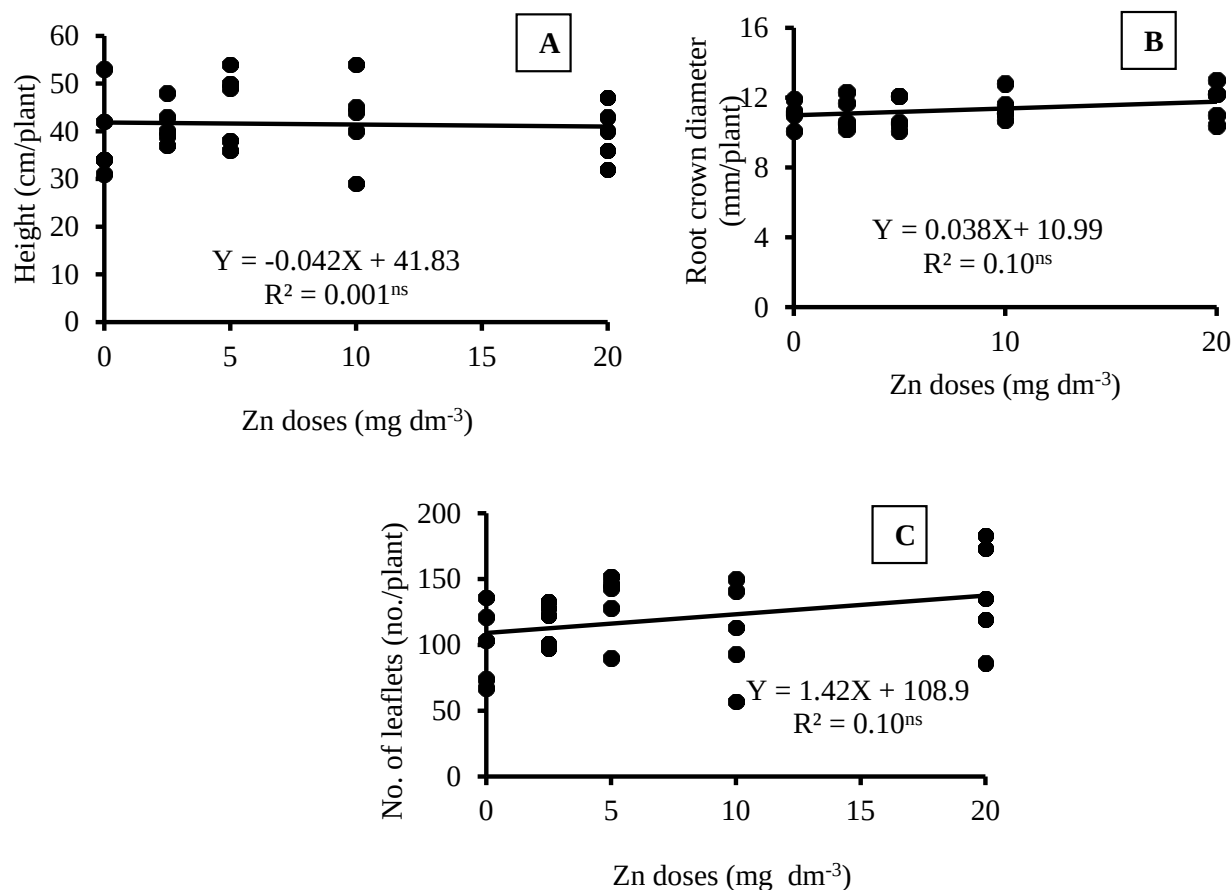


Figure 1. Results of regression analysis for plant height (A), root crown diameter (B), and the number of leaflets (C) of African mahogany plants fertilized with different doses of zinc. ^{ns}not significant ($p > 0.05$), *significant ($0.01 < p \leq 0.05$) and **significant ($p \leq 0.01$).

analysis of variance and regression, with $\alpha = 0.05$, using SISVAR 5.4 (Ferreira, 2011).

RESULTS AND DISCUSSION

Increasing doses of zinc did not increase growth in height or root crown diameter, since there was no significant regression adjustment for these variables (Figure 1A and B). The plants that did not receive supplementation with Zn presented no differences when compared with the plants supplied with the maximum Zn dose (20 mg dm⁻³). However, plants subjected to the maximum dose (20 mg dm⁻³) showed no symptoms of toxicity, and Zn excess also did not affect plant growth. It is important to stress that, although Zn is an essential micronutrient, this element can affect the normal growth and metabolism of plant species when present in toxic levels in the environment (Marschner, 1995). The levels considered toxic to the eucalyptus (*E. maculata*) crop for example, were found using a concentration of 1200 mM Zn (Soares et al., 2001).

This result may be related to the low requirement of the micronutrient by the African mahogany in its initial phase of development. A similar result was observed by Corcioli et al. (2016) in another African mahogany species (*Khaya ivorensis* A. Chev) where the omission of zinc in fertilization did not influence the plant growth in the early stages. Evaluating the growth of Australian cedar under boron and zinc supplementation, Carmo et al. (2010) concluded that Zn doses did not influence plant height and diameter during the 3-month experimental period. Additionally, Mendonça et al. (1999) demonstrated that seedlings of aroeira-do-sertão (*Myracrodruon urundeuva* Fr. All) cultivated in soil with a concentration of 0.7 mg de Zn dm⁻³ without supplementation with Zn, did not have their growth affected.

Leaflet production was not significantly affected by the application of Zn (Figure 1C). The plants submitted to the dose 0 mg dm⁻³ of Zn had an average production of 100 leaflets and a standard deviation of 29.6, while the plants submitted to the maximum dose (20 mg dm⁻³) presented a statistically similar leaflet production, corresponding to 139 leaflets and standard deviation of 39.7.

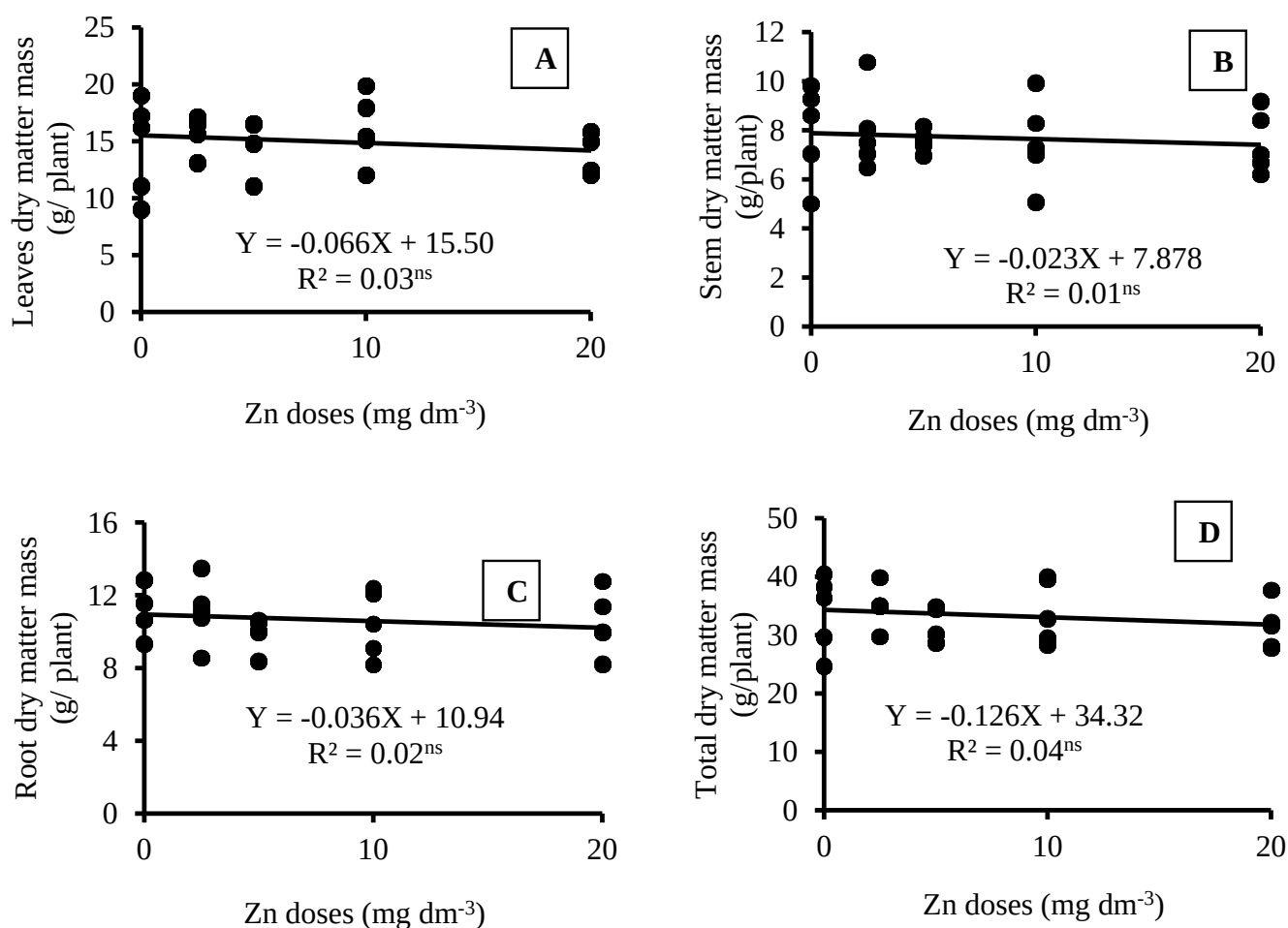


Figure 2. Results of the regression analysis for leaf dry matter mass (a), stem dry matter mass (b), root dry matter mass (c), total dry matter mass (d) of African mahogany plants fertilized with different doses of zinc. ^{ns}not significant ($p \leq 0.01$), *significant ($0.01 < p \leq 0.05$) and **significant ($p \leq 0.01$).

For the plant dry mass, none of the evaluated parts or the sum of them (leaves, stem, root and total) presented response to the different zinc doses. As with the other analyzed variables, there was no significant regression adjustment (Figure 2A, B, C and D). Evaluating the initial growth of pink cedar, Locatelli et al. (2007) observed that the Zn was the micronutrient that less limited the production of dry matter mass.

Other works concerning the production of eucalyptus seedlings have shown that there is no need for generalized application of Zn (Barros et al., 1985; Couto et al., 1985; Sgarbiet al., 1999); in some cases, even this element has brought to growth detriment of these plants when subjected to soils with high zinc content and or micronutrient high doses (Soares et al., 2001).

It is also important to emphasize that the zinc content found in the substrate 0.2 mg dm^{-3} is considered low for the initial development of the plant ($<0.7 \text{ mg dm}^{-3}$), soil zinc content may have been enough for the initial development of African mahogany plants. Although, the

zinc is considered an essential nutrient for the development of plants, it is required only in small quantities (Hooda, 2010) since the plants submitted to the dose 0 mg dm^{-3} of Zn presented the same growth rates in all analyzed variables. However, according to Raji et al. (1996), the zinc content found in the substrate 0.2 mg dm^{-3} is considered low for the initial development of the plant ($<0.7 \text{ mg dm}^{-3}$). In this case, monitoring the species development in larger experimental periods, and even when submitted in the field, would be possible to show plants eventually presenting symptoms of Zn absence.

These data corroborate the results of the present study, which did not demonstrate the need to correct the Zn contents for the initial development of the plants (up to five months), similar to that observed in the studies conducted by Camargos et al. (2002), with nutrient solution for Brazil nut, showing that the omission of zinc was not limiting to the growth of the plants.

Likewise, Silva et al. (2007), evaluated the micronutrient

effect on the growth of mahogany seedlings (*Swietenia macrophylla* King) which concluded that zinc omissions did not affect the growth characteristics of plants grown in a soil with concentration of 0.6 mg and Zn dm⁻³. This fact could be explained by assuming that the available zinc levels in the soil have been mobilized for all the organs of the plant, satisfying their needs, as in the present work.

African mahogany plants subjected to the 0 mg dm⁻³ dose of zinc did not present commonly observed deficiency symptoms such as shortening of internodes, size reduction and narrowing of new leaves, becoming lanceolate and chlorotic (Parker et al., 1992). Zinc deficiency symptoms are associated with disorders of auxin metabolism, mainly indolacetic acid (IAA), the phytohormone responsible for plant growth, a condition that was not observed in the present study. Therefore, the obtained results in the present study shows that the Zn available in the soil (0.2 mg dm⁻³) was enough for the development of the African mahogany plants in the initial phase, and no additional fertilization of this nutrient is required.

Conclusions

The African mahogany (*K. senegalensis* A. Juss) presented low zinc requirement in the development early stages, for the edaphoclimatic condition studied, and the application of zinc via fertilizers was not necessary when the used soil had contents of 0.2 mg dm⁻³ Zn. The African mahogany (*K. senegalensis* A. Juss) plants are tolerant to the application of zinc up to the 20 mg dm⁻³.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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