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BIOMASS AND PHOSPHORUS CONTENT IN GIANT BAMBOO CUTTINGS INFLUENCED BY PHOSPHATE FERTILIZATION

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ABSTRACT - *Dendrocalamus asper*, known as giant bamboo or bamboo-bucket, has been used as a substitute for wood and fiber, due mainly to its wide availability, rapid growth rate, short cycle and traditional use as construction material. In general, its cultivation is carried out on phosphorus-deficient soils, using vegetative propagation, mainly from cuttings. Thus, the aim of this study was to evaluate the effect of fertilization with phosphorus doses on the biomass allocation in roots, leaves and stems and on the level and content of P in leaves and roots of bamboo cuttings. The experiment was conducted in a greenhouse, using soil with low P content (2.4 mg dm^{-3}). The treatments consisted of six doses of phosphorus (0, 20, 40, 80, 160 e 320 kg ha^{-1} of P_2O_5). The experimental design was a randomized block design, with five replications. After 90 days, the seedlings were collected and evaluated the following variables: dry mass of roots, leaves, stems and total dry mass, level and P content in leaves and roots. Phosphate fertilization promoted greater development of the cuttings and resulted in higher content of P. In general, the species *D. asper* responds positively to phosphate fertilization.
Keywords: *Dendrocalamus asper* (Schult.) Backer, seedling production, management, mineral nutrition.

BIOMASSA E CONTEÚDO DE FÓSFORO EM ESTACAS DE BAMBU GIGANTE INFLUENCIADOS PELA ADUBAÇÃO FOSFATADA

RESUMO - *Dendrocalamus asper*, conhecido como bambu-gigante ou bambu-balde, vem sendo usado como substituto para madeira e fibra, devido, sobretudo, sua ampla disponibilidade, rápida taxa de crescimento, ciclo curto e uso tradicional como material de construção. Em geral, seu cultivo é conduzido em solos carentes em fósforo, utilizando propagação vegetativa, principalmente a partir de estacas. Assim, o objetivo deste estudo foi avaliar o efeito da adubação com doses de fósforo na alocação de biomassa nas raízes, folhas e colmos e, no teor e conteúdo de P em folhas e raízes de estacas de bambu. O experimento foi conduzido em casa de vegetação, utilizando solo com baixo teor de P (2,4 mg dm^{-3}). Os tratamentos consistiram de seis doses de fósforo (0, 20, 40, 80, 160 e 320 kg ha^{-1} de P_2O_5). O delineamento experimental utilizado foi em blocos ao acaso, com cinco repetições. Após 90 dias, as mudas foram coletadas e avaliadas as seguintes variáveis: massa seca de raízes, folhas, colmos e massa seca total, teor e conteúdo de P nas folhas e raízes. A adubação fosfatada promoveu maior desenvolvimento das estacas e resultou em maior conteúdo de P. De modo geral, a espécie *D. asper* responde positivamente à adubação fosfatada.
Palavras-chave: *Dendrocalamus asper* (Schult.) Backer, produção de mudas, manejo, nutrição mineral.

INTRODUCTION

The bamboos involve various species and genera, approximately 1,500 and 87 respectively, grouped in the family Poaceae and in the subfamily Bambusoideae (LI and KOBAYASHI, 2004). With the exception of Europe, bamboo occurs naturally in tropical, subtropical and temperate regions of all countries (LIESE and KOHL, 2015; FELISBERTO et al., 2017). The cultivation area was estimated at 31.3 million hectares in 21 countries (BUCKINGHAM, 2011), especially in Asian countries such as China and India (BACHPAI et al., 2017). Brazil has one of the largest native bamboo reservoirs in the world, located in the southwest of the Amazon. Among the species, *Dendrocalamus asper*, a type of giant bamboo, stands out as to the importance of bamboo plantations in Brazil (FELISBERTO et al., 2017).

With the rapid development of the global economy, population growth and increasing scarcity of resources, the demand for wood and wood-based compounds is increasing. In view of that, the search for alternative raw materials to wood came into focus, which should have low cost, rapid growth, easy availability, with physical and mechanical properties comparable to wood,

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and should be compatible with existing processing technologies.

In this context, the bamboo has been standing out as a substitute for wood and fiber, because is abundantly available in many countries, has a very fast growth rate, short cycle, high resistance and traditional use as building material by humanity (BUCKINGHAM et al., 2014; LIESE and KOHL, 2015; FELISBERTO et al., 2017). As for the species *Dendrocalamus asper*, it has been widely used for construction in many rural areas, handicrafts, daily utensils, furniture, paper, in addition to edible sprouts production (INBAR, 2012).

However, despite the growing demand and the widespread use of bamboo, the producers still do not have adequate knowledge about the management and fertilization of this crop, being that this knowledge is essential to maintain or even increase the productivity status of nutritionally poor soils (SHANMUGHAVEL and FRANCIS, 1997). This is mainly due to the lack area research, being the literature is still very scarce when it comes to nutritional requirements and recommended fertilization for bamboo, especially in the growing conditions in Brazil (OLIVEIRA et al., 2008; LIMA NETO et al., 2010).

The bamboo propagation is mainly by vegetative propagation or asexual, due the cycle of flowering of the crop is very long of more than 100 years (SINGH et al., 2004), in addition to exhibit a low seed viability, hindering its sexual propagation (VALE et al., 2019). When compared to other plants, bamboo does not require much in terms of soil fertility (SINGH et al., 1999). However, it is believed that there may be considerable responses with favorable agronomic techniques (PEREIRA and BERALDO, 2007; BACHPAI et al., 2017). The supply of nutrients increases the growth and production of biomass in seedlings. Thus, research on bamboo fertilization is of fundamental importance for the development of this crop in Brazil, and knowing the appropriate levels for production is of great importance, especially in reducing costs.

The aim of this study was to evaluate the effect of fertilization with phosphorus doses on the biomass allocation in roots, leaves and stems and on the level and content and content of P in leaves and roots of bamboo cuttings, cultivated in greenhouse.

MATERIAL AND METHODS

The experiment was conducted in a greenhouse at the Federal University of Paraná, *Campus* Curitiba (PR). The cultivation of the cuttings of *Dendrocalamus asper* was carried out in pots with 6 kg of a Red Latossol, classified according to Brazilian Soil Classification System (EMBRAPA, 2018), which corresponding to Oxisol, in the American Soil Taxonomy System (SSS, 2014). The soil was collected at depth 0-40 cm, and presented the following characteristics: $pH_{(CaCl2)}$: 4.5; organic carbon: 13.1 g dm^{-3}; H+Al: 5.0 $cmol_c$ dm^{-3}; Ca^{2+}: 3.6 $cmol_c$ dm^{-3}; Mg^{2+}: 4.0 $cmol_c$ dm^{-3}; K^+: 0.12 $cmol_c$ dm^{-3}; P: 2.4 mg dm^{-3}; clay: 600 g kg^{-1}. It should be noted that the soil used had a low P content (NEPAR, 2017).

The treatments consisted in the application of six doses of phosphorus, corresponding to 0, 20, 40, 80, 160 and 320 kg ha^{-1} of P_2O_5 (0, 4.5, 9, 18, 35 e 70 mg dm^{-3} of P). The experimental design was a randomized block design, with five replications. The source of P used was triple superphosphate.

After collection, the soil was homogenized and allocated in the pots. The respective doses were mixed to the soil of each pot, immediately before the planting of the cuttings. For the production of the cuttings, adult stems of bamboo were used, which had, on average, 50 cm in length and 2.5 cm in diameter. Irrigation was carried out to avoid the moisture restriction to growth.

After 90 days of planting (DOP), the collect of plants was carried out, separating the roots, stems and leaves. The variables evaluated were: dry mass of roots, stems and leaves, total dry mass, P level in the root and in the leaf, P content in the root and in the leaf. For this, after collection and separation of roots, stems and leaves, the samples were washed with running water and deionized water, dried in an oven for 72 h at 60°C for determination of the dry mass (root, stem and leaf). The total dry mass was obtained by adding the dry mass of the root, stem and leaf. After, the samples of roots and leaves were weighing and ground in a mesh of 1.0 mm (20 mesh) to determine the P level, by dry digestion and solubilization in 10 mL of 3 mol L^{-1} HCl, according to Martins and Reissmann (2007) and spectrophotometer reading. The P content in the plant samples was obtained by multiplying the P level by the dry mass.

The results were submitted to analysis of variance, and in case of significant variation, submitted to the Tukey test for comparison of means, with significance level of 5%.

RESULTS AND DISCUSSION

Phosphate fertilization provided greater seedling development, resulting in higher total dry matter production (Table 1). In general, the highest dry mass of leaves stems and total was observed in the dose of 80 kg ha^{-1} of P_2O_5. On the other hand, the highest root dry mass was verified with the application of 160 kg ha^{-1} of P_2O_5, however, did not differ from the other doses (Table 1). It should be emphasized that the low P supply decreases the leaf area, mainly due to the reduction of leaf number, but also the limitation of leaf expansion (BUCHER et al., 2018).

Totey et al. (1988) studied bamboo of the *Dendrocalamus strictus* species, cultivated in pots, and verified that the phosphorus application increased plant height, rhizome length and dry matter production. The authors concluded that with the application of this nutrient a better growth of bamboo seedlings can be obtained in short time. Oliveira et al. (2008) evaluated the effect of P doses on the biomass allocation in plants of the *Bambusa vulgaris* species and verified higher production of total dry biomass, leaves and roots with the application of 10 kg ha^{-1}

of P. On the other hand, the highest dry biomass of stems resulted from the application of 40 kg ha^{-1} of P. According the authors, probably these results were due to the high content of P in the soil (Neossol Quartzarenic), which had 48 mg dm^{-3} of P.

The application of 320 kg ha^{-1} of P_2O_5 decreased the development of cuttings in relation to the intermediate doses. This result may be associated with the competition of P with other chemical elements, because the toxic effect of P on plants is unusual (HAWKESFORD et al., 2012). According to Oliveira et al. (2008), many researches have highlighted that the interaction of P with Zn can affect the absorption, translocation and concentration of these nutrients in plant tissues, resulting in inadequate relationships between these nutrients, that is, nutritional imbalance, which will result in reduced growth. In addition, they emphasized the possible competition of phosphate with sulphate. Other factor is the possible deficiency of other nutrients due to the excess of P in the soil, which may have resulted in interferences in the decrease of seedling development.

TABLE 1 - P_2O_5 doses on the dry mass of roots, leaves, stems and total of *Dendrocalamus asper* seedlings, after 90 DOP.

Doses of P_2O_5 (kg ha^{-1})	Dry mass of roots	Dry mass of leaves	Dry mass of stems	Total dry mass
	---------------------------- g per plant --------------------------------			
0	3.51 b*	8.21 b	8.70 bc	19.46 c
20	7.57 ab	10.68 ab	11.47 ab	30.22 ab
40	6.27 ab	10.67 ab	7.75 bc	22.97 c
80	6.00 ab	13.23 a	15.51 a	34.74 a
160	8.16 a	11.13 ab	9.05 bc	25.26 bc
320	6.66 ab	8.82 b	7.28 c	22.76 c
CV(%)	35.70	20.40	20.94	14.30

*Means followed by the same letter do not differ statistically from each other by the Tukey test at the 5% probability level. CV: variation coefficient.

The use of P doses resulted in significant differences in the level of this nutrient just in the leaf (Table 2). In general, the treatments with in intermediate P doses resulted in higher level of this nutrient, mainly at the dose of 80 kg ha^{-1} of P_2O_5 (Table 2). The standard of phosphorus redistribution in the plant seems to be determined by the influences of the source and drain properties rather than by the plants transport system (BIELESKI, 1973). In addition, the differences in level are also due to phosphorus being mobile in plant tissues, with movement of the root ions to other parts of the plant (BUCHER et al., 2018).

TABLE 2 - Level and content of phosphorus in roots and leaves of *Dendrocalamus asper* seedlings grown with different doses of phosphorus applied to soil.

Doses of P_2O_5 (kg ha^{-1})	P level in root	P level in leaf	P content in root	P content in leaf	P content root/leaf
	---------------- g kg^{-1} -----------------		------------- mg per $plant^1$ ----------------		
0	1.14 a*	1.94 c	10 b	9 b	1.1
20	1.26 a	3.02 ab	30ab	13 ab	2.3
40	1.22 a	2.29 c	30 ab	13 ab	2.3
80	1.27 a	3.47 a	30 ab	16 a	1.9
160	1.49 a	2.52 bc	50 a	16 a	3.1
320	1.47 a	2.27 c	20 ab	13 ab	1.5
CV(%)	15.33	14.30	42.81	25.85	

*Means followed by the same letter do not differ statistically from each other by the Tukey test at the 5% probability level. CV: variation coefficient.

Piouceau et al. (2014) studied the growth of six bamboo species under high phosphorus, and verified that the phosphorus content in leaves and stems increased with this treatment. In addition, the authors observed that the most productive bamboo species were those that stored the highest amounts of phosphorus in total above-ground biomass per hectare, with the treatment with high nutrient content. These results corroborate with the data of the present study, where the dose of 80 kg ha^{-1} of P_2O_5, which resulted in higher dry matter production, also showed the highest phosphorus level in the leaves (Table 1 and Table 2).

However, the maximum P level observed by the authors was 4.3 g kg^{-1}, being that this data, as well discussed by the authors, are four higher than those found in the existing literature. Shanmughavel and Francis (1997) reported, for a mature natural forest (without fertilization), that the P level found in the leaves was 0.8 g kg^{-1} for *Bambusa bambos* (L.) Voss. species. Therefore, phosphorus fertilization was efficient in increasing the absorption of this nutrient by bamboo plants.

The application of P doses resulted in difference in this P content both in roots and leaves. In general, the P application increased the content of this nutrient in the leaves and roots of bamboo seedlings, being that in the leaves the dose of 80 and 160 kg ha^{-1} differed from the control, whereas in the roots only the dose 160 kg ha^{-1} differed.

As the nutrient content is the product of the biomass contents (ALVES et al., 2017), it was observed that, although the leaves presented the highest levels of P in terms of values, in this component occurs the lowest content of P, compared to these values in the roots. Therefore, the P absorbed by the bamboo seedlings was deposited preferentially in the roots, in relation to the leaves (Table 2).

In this context, considering the expansion of bamboo cultivation in Brazil, the adequate phosphorus fertilization in seedlings is very important, for to result in more vigorous seedlings in the field. In addition to this study, research with fertilization in other phases of culture is necessary.

CONCLUSIONS

Fertilization with phosphorus increased the nutrient content in the leaves, not occurring in the roots of *D. asper* seedlings.

Phosphate fertilization, with doses close to 80 kg ha^{-1} de P_2O_5, provided higher growth of *D. asper* seedlings.

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