

# PRODUCTION OF *Eucalyptus urophylla* x *Eucalyptus grandis* SEEDLINGS WITH DIFFERENT FERTILIZERS

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Received for publication: 12/10/2018 – Accepted for publication: 15/04/2019

## Resumo

*Produção de mudas de Eucalyptus urophylla x Eucalyptus grandis com diferentes adubações.* A adubação mineral é uma prática importante, que contribui para a produção de mudas com qualidade satisfatória. Este trabalho teve como objetivo avaliar o efeito da aplicação de cloreto de potássio (KCl) e monofosfato de amônio (MAP) no crescimento e nutrição de mudas de *Eucalyptus urophylla* x *Eucalyptus grandis*. O experimento foi conduzido a pleno sol, com semeadura direta em tubetes contendo substrato composto (casca de *Pinus*, fibra de coco, esterco bovino e vermiculita). O delineamento experimental foi de blocos casualizados, esquema fatorial 5 x 2, sendo cinco doses de KCl (0,0; 0,025; 0,050; 0,100 e 0,200 g muda<sup>-1</sup>) e duas doses de MAP (0,0 e 0,10 g muda<sup>-1</sup>), com quatro repetições. Aos 120 dias verifica-se efeito da interação entre as doses de KCl e MAP para as variáveis: diâmetro do coleto; massa seca de parte aérea (MSPA) e total (MST); índice de qualidade de Dickson; conteúdo de N, P e K na parte aérea; conteúdo de K nas raízes; eficiência de absorção (EAB) de N e P. Para as variáveis: altura (H); área foliar; massa seca de raízes (MSR); razões H/DC e MSPA/MSR; e conteúdo de N e P nas raízes, observa-se efeito apenas da aplicação de MAP, enquanto para EAB\_K o efeito foi somente do KCl. Assim, há variação no efeito das doses de KCl em função da variável morfológica e nutricional avaliada. Em geral, o melhor crescimento e nutrição das mudas ocorre com a dose aplicada de 0,100 g de KCl + 0,10 g de MAP muda<sup>-1</sup>.

*Palavras-chave:* Cloreto de potássio, eucalipto, monofosfato de amônio, qualidade de mudas.

## Abstract

Mineral fertilization is an important practice that contributes to the production of seedlings with satisfactory quality. This study aimed to evaluate the effect of the application of potassium chloride (KCl) and monoammonium phosphate (MAP) on growth and nutrition of *Eucalyptus urophylla* x *Eucalyptus grandis* seedlings. The experiment was conducted in full sun, with direct sowing in tubes containing composite substrate (*Pinus* bark, coconut fiber, bovine manure and vermiculite). The experimental design was a randomized block design in a 5 x 2 factorial scheme, with five doses of KCl (0.0, 0.025, 0.050, 0.100, and 0.200 g seedling<sup>-1</sup>) and two doses of MAP (0 and 0.10g seedling<sup>-1</sup>), with four replicates. At 120 days, the effect of the interaction between the KCl and MAP doses was verified for the variables: diameter at root collar, dry mass of the aerial part (DMAP) and total (TDM), Dickson Quality Index, N content, P K in the aerial part, K content in the roots, absorption efficiency (AE) of N and P. For the variables: height (H); leaf area; root dry mass (RDM); H/DCR and DMPA/RDM ratios; and N and P content in the roots, only effect of the application of MAP is observed, whereas for AE\_K the effect was only of KCl. Thus, there is variation in the effect of KCl doses as a function of morphological and nutritional variables evaluated. In general, the best seedling growth and nutrition occurs with the applied dose of 0.100 g KCl + 0.10 g MAP seedling<sup>-1</sup>.

*Keywords:* Potassium chloride, eucalyptus, monoammonium phosphate, seedling quality.

## INTRODUCTION

The formation of forest stands with quick-growing species, such as those of the genus *Eucalyptus*, is strategic to increase the supply of wood and other forest products, reducing the pressure on native forests. In Brazil, due to the increased demand for wood and its derivatives, forest plantations will be necessary in more than eight million hectares, located largely in the South and Southeast regions, where it is already observed, almost exclusively, plantations of species of the *Eucalyptus* and *Pinus* genera (IBÁ, 2017). Thus, it is necessary to produce seedlings of good quality, that is, seedlings that have high rates of survival and initial growth in the field, in order to guarantee success in the implantation of such stands. In addition, it is necessary to investigate ways to reduce the high costs involved in the seedling production process.

In this regard, research carried out with the hybrid *Eucalyptus urophylla* ST Blake x *E. grandis* W. Hill ex Maiden, which aimed to evaluate and/or recommend: the physiological responses of genotypes to water availability and potassium fertilization (MENDES *et al.*, 2013); doses of mineral nutrients that provide adequate rates of survival and initial growth of seedlings in the field (ROCHA *et al.*, 2013); the use of various effluents as

a source of nutrients for seedlings (ROCHA *et al.*, 2014), in addition to substrates based on organic compounds from the industrial manufacture of cellulose (TOLEDO *et al.*, 2015).

The frequent use of organic components to improve the physical, chemical and biological attributes of the substrates, in general, has formulations that cover insufficient amounts of nutrients for plant growth (DELARMELINA *et al.*, 2014). With this, mineral fertilization is an important practice that contributes to the production of seedlings under satisfactory conditions (D'AVILA *et al.*, 2011), which involves everything from the choice of fertilizer types, to doses and application times in the substrate. There are several types of mineral fertilizers, among which potassium chloride (KCl) (source of potassium) and monoammonium phosphate (MAP) (source of nitrogen and phosphorus) for the substrate can be highlighted. However, it is necessary to know precisely what quantity of these elements should be applied to guarantee the quality of the forest seedlings, avoiding unnecessary expenses with mineral fertilization.

Evaluating the effect of potassium fertilization doses (potassium chloride - KCl) in the cultivation of *Eucalyptus grandis* seedlings, Evedove and Simonetti (2009) observed that, in dosages above 6.0 g L<sup>-1</sup> of K, the seedlings, in addition to not presenting better results, they reduced in height, their neck diameter and the amount of dry matter of the aerial part. Similarly, Rocha *et al.* (2013) observed that, in order to obtain quality *E. urophylla* x *E. grandis* seedlings produced from cuttings, doses of P (monoammonium phosphate) must be used in the range of 3.6 to 3.8 mg plant<sup>-1</sup>, considering that doses higher than 4 mg plant<sup>-1</sup> hinder the development (height, neck diameter and total dry mass) of the seedlings.

The hypothesis of the work is that the application of potassium chloride (KCl) and/or monoammonium phosphate (MAP), promotes improvement in the morphological and nutritional quality of *E. urophylla* x *E. grandis* hybrid seedlings. The objective of the work was to evaluate the effect of doses of potassium chloride (KCl) and monoammonium phosphate (MAP), on the initial growth and nutrition characteristics of *E. urophylla* x *E. grandis* seedlings.

## MATERIAL AND METHODS

The experiment to produce seedlings of *Eucalyptus urophylla* x *E. grandis* took place in full sun, from April to August 2013, at the Fernando Luiz Oliveira Capellão forest nursery, belonging to the Silviculture Department (Forestry Institute) at Federal Rural University of Rio de Janeiro. The seeds, acquired at the Forest Research and Studies Institute (IPEF), were sown directly in 55 cm<sup>3</sup> tubes, containing substrate composed of 40% commercial substrate based on *Pinus* bark, 30% coconut fiber, 20% bovine manure and 10% medium-sized vermiculite, on a volumetric basis. The base fertilization consisted of a mixture of 5 kg of NPK 06-30-06 and 1 kg of simple superphosphate per m<sup>3</sup> of substrate, which was then homogenized. The tubes were inserted in a support formed by floor trays with a capacity for 187 seedlings.

The experimental design adopted was randomized blocks (RBD) with a 5 x 2 factorial scheme, with four doses of potassium chloride (KCl) (0.025; 0.050; 0.100 and 0.200 g seedlings<sup>-1</sup>) and the control (0.0 g seedlings<sup>-1</sup>), in the absence (0.0g seedlings<sup>-1</sup>) or presence (0.10g seedlings<sup>-1</sup>) of monoammonium phosphate (MAP), with four repetitions for each treatment, totaling 40 tubes.

The doses of fertilizers (KCl and MAP), which were dissolved in water, were applied fortnightly, from 60 days after sowing, until 120 days, using graduated syringes with 5 ml of aqueous solution per seedling. At 120 days after sowing, the diameter at root collar (DRC (mm)) and height (H (cm)) were determined with the aid of a digital caliper and a graduated ruler, respectively. Then, the aerial part and the root system were individualized, washed in tap water and packed in paper bags. The leaves were removed to determine the leaf area (LA (cm<sup>2</sup>)) using the LI-COR model LI-3100C equipment. Subsequently, these materials were dried in an oven (70°C for 72h) with forced air circulation for the later determination of the dry mass of the aerial part (DMAP (g)), root dry mass (RDM (g)) and total dry mass (TDM (g)), on a digital scale to two decimal places.

From these (morphological) variables, the H/DRC, DMAP/RDM ratios and Dickson's Quality Index (DQI) were

calculated, where:

$$DQI = \left[ \frac{TDM}{\frac{H}{DRC}} \right] + \left( \frac{DMAP}{RDM} \right)$$

After this procedure, the material was milled in a Willey-type mill to proceed with sulfuric digestion and determine the N content by the modified Kjeldahl method, P by colorimetry and K by flame photometry (TEDESCO *et al.*, 1995). From the product between the dry mass value and nutrient content, the content of N, P and K was obtained in the aerial part (N\_PA, P\_PA and K\_PA, respectively) and in the roots (N\_R, P\_R and K\_R, respectively). Then, the absorption efficiency (AE) for each nutrient was estimated, using the equation by Swiader *et al.* (1994), in which:

$$AE = \frac{\text{Nutrient content at the aerial part} + \text{Nutrient content at the roots}}{RDM}$$

Then, all data obtained were submitted to normality analysis, by the Shapiro-Wilk test, and homogeneity of variances, by the Bartlett test, with the aid of the R software. Given the premises, the analysis of variance (KCl

and MAP) and regression (KCl) was performed to obtain the equation that best identifies the response variable. In these univariate statistical analyzes, which were performed using version 5.6 of the Sisvar software, the significance level  $\leq 5\%$  was considered. The statistical analysis of hierarchical grouping (Ward's distance method) was performed with the help of version 2.17c of the PAST software. The performance of the referred multivariate analysis aimed to assist in the interpretation of the large set of data obtained and to identify possible similarities between treatments.

## RESULTS

There was an effect of the interaction between the doses of potassium chloride (KCl) and monoammonium phosphate (MAP) for most of the morphological (DRC, DMAP, TDM, DQI) and nutritional variables (N\_PA, P\_PA, K\_PA, K\_R, AE\_N, AE\_P) of *Eucalyptus urophylla* x *E. grandis* seedlings (Figures 1 and 2). For variables H, LA, RDM, H/DRC ratio, DMAP/RDM ratio and content of N\_R and P\_R, there was an effect only from the application of MAP (Figures 1 and 2), while for AE\_K the effect was only of application of KCl (Figure 2I).

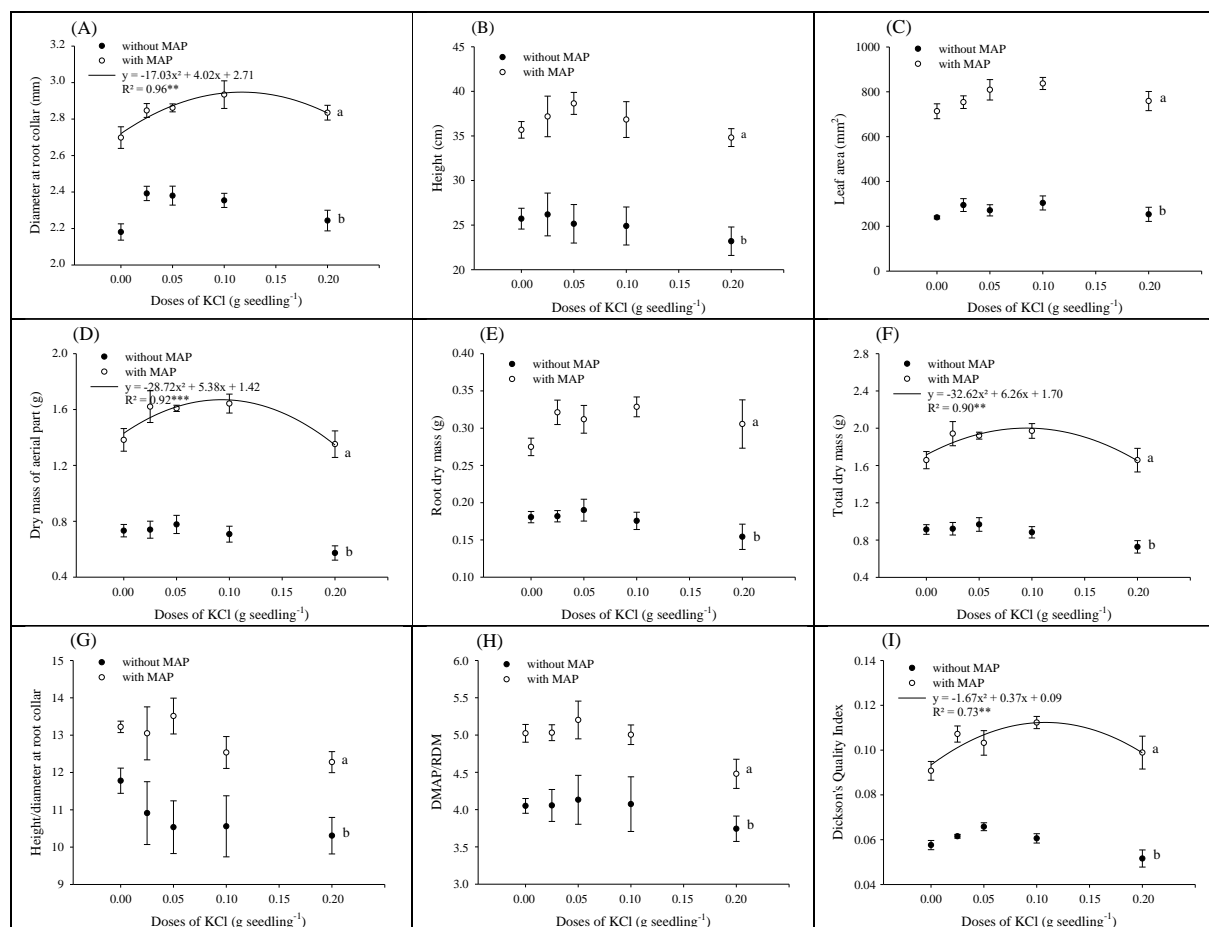


Figure 1. Morphological variables and quality indexes of *Eucalyptus urophylla* x *E. grandis* seedlings under different doses of potassium chloride (KCl), with and without fertilization with monoammonium phosphate (MAP), under greenhouse conditions at 120 days after the installation of the experiment. Lowercase letters indicate significant difference between the absence and presence of MAP. (\*)  $P \leq 0.05$ ; (\*\*)  $P \leq 0.01$ ; (\*\*\*)  $\leq 0.001$ . Dry mass of the aerial part; RDM: Root dry mass.

Figura 1. Variáveis morfológicas e índices de qualidade das mudas de *Eucalyptus urophylla* x *Eucalyptus grandis* sob a adubação com diferentes doses de cloreto de potássio (KCl), com e sem adubação com monofosfato de amônio (MAP), em casa de vegetação aos 120 dias após a instalação do experimento. As letras minúsculas indicam diferença significativa entre a ausência e presença de MAP. (\*)  $P \leq 0,05$ ; (\*\*)  $P \leq 0,01$ ; (\*\*\*)  $\leq 0,001$ . MSPA: Massa seca de parte aérea; MSR: Massa seca de raiz.

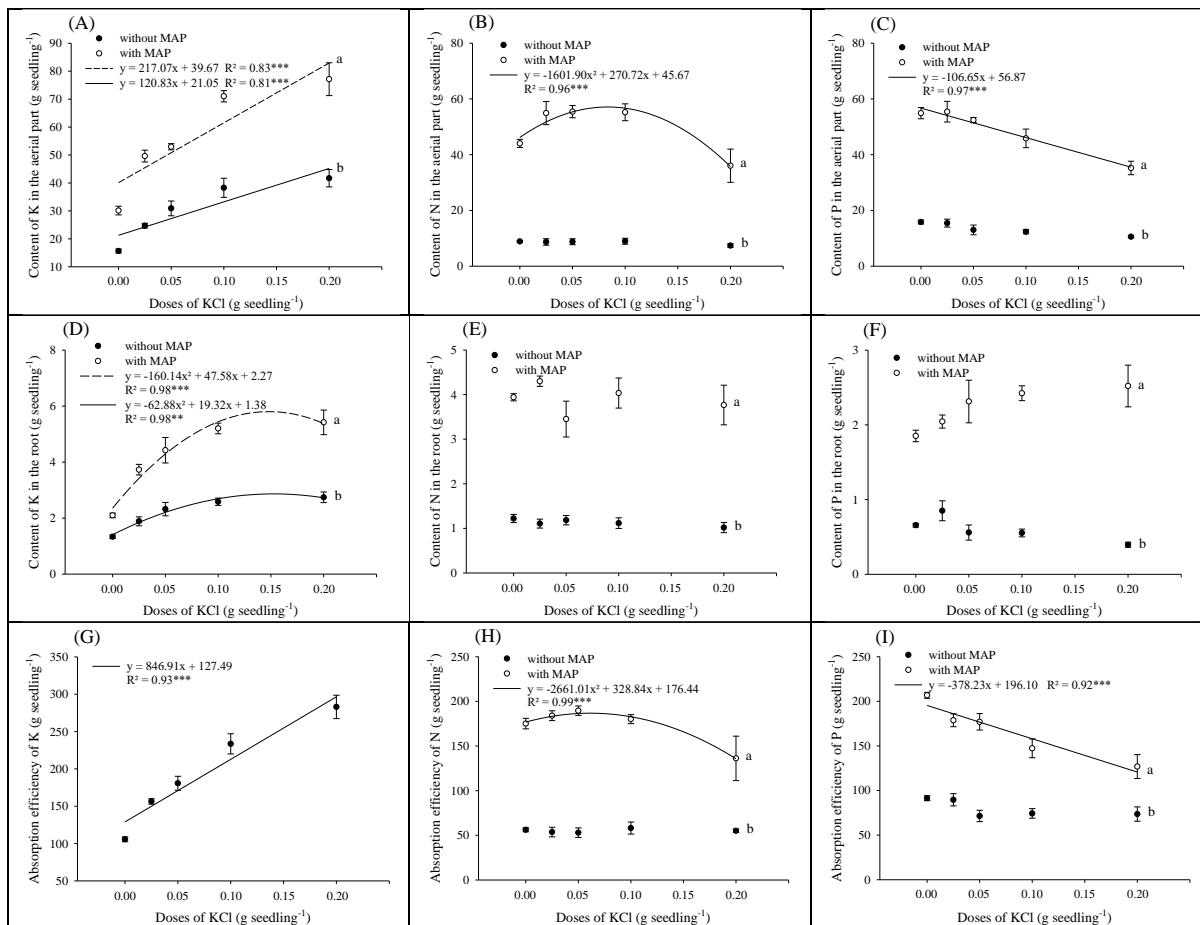


Figure 2. Nutritional variables of the *Eucalyptus urophylla* x *Eucalyptus grandis* seedlings for nutritional variables under different doses of potassium chloride (KCl), with and without fertilization with monoammonium phosphate (MAP), under greenhouse conditions at 120 days after the installation of the experiment. Lowercase letters indicate significant difference between the absence and presence of MAP. (\*)  $P \leq 0.05$ ; (\*\*)  $P \leq 0.01$ ; (\*\*\*)  $P \leq 0.001$ .

Figura 2. Variáveis nutricionais das mudas de *Eucalyptus urophylla* x *Eucalyptus grandis* para as variáveis nutricionais sob a adubação com diferentes doses de cloreto de potássio (KCl), com e sem adubação com monofosfato de amônio (MAP), em casa de vegetação aos 120 dias após a instalação do experimento. As letras minúsculas indicam diferença significativa entre a ausência e presença de MAP. (\*)  $P \leq 0,05$ ; (\*\*)  $P \leq 0,01$ ; (\*\*\*)  $P \leq 0,001$ .

The regression analysis for the variables DRC, DMAP, TDM, DQI, N\_PA, K\_R, AE\_N shows that the response of the seedlings of *Eucalyptus urophylla* x *E. grandis* to KCl doses presents a better fit to the quadratic model in the presence of MAP (Figures 1 and 2). The doses of maximum technical efficiency (DMET) estimated were 0.118, 0.094, 0.096, 0.108, 0.084, 0.148 and 0.062 g of KCl, respectively. In the absence of MAP, there was no significant adjustment for these variables (Figures 1 and 2). On the other hand, for the variables P\_PA, K\_PA, AE\_P and AE\_K, in the presence and/or absence of MAP, the best adjusted model was the linear model, being negative for P\_PA and AE\_P and positive for K\_PA and AE\_K (Figure 2).

It is verified by the univariate analysis that, in general, the presence of MAP is responsible for the increase in all evaluated variables, when compared to its absence (Figures 1 and 2). Multivariate analysis of hierarchical grouping indicates high dissimilarity between treatments with and without MAP fertilization, with individualization of treatments in two large groups. The first group (located above in the figure), represented by all treatments without the addition of MAP, has a large distance (value close to 900) from the second (located below in the figure), which was formed by the combination of treatments with the addition of MAP (Figure 3).

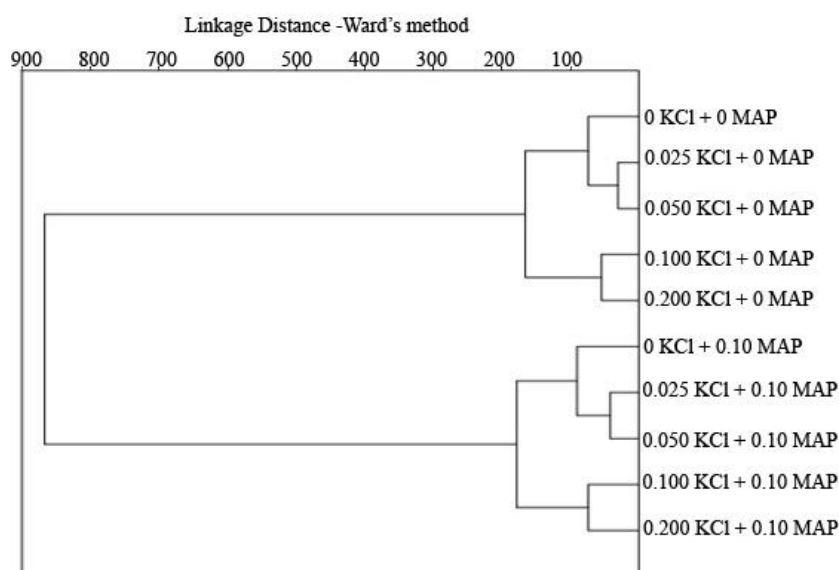


Figure 3. Dendrogram of similarity for *Eucalyptus urophylla* x *E. grandis* seedlings with different doses of potassium chloride (KCl), in the presence or absence of monoammonium phosphate (MAP), under greenhouse conditions at 120 days after the installation of the experiment\*.

Figura 3. Dendrograma de similaridade para mudas de *Eucalyptus urophylla* x *E. grandis*, sob adubação com diferentes doses de cloreto de potássio (KCl), com e sem a adubação com monofosfato de amônio (MAP), em casa de vegetação, aos 120 dias após a instalação do experimento.

## DISCUSSION

The variety of responses of *E. urophylla* x *E. grandis* seedlings to the 10 treatments tested is, probably, a reflection of the large number of growth and nutrition variables considered (18, in total). This result can also be indicative of the reflection of the significant interaction between fertilizers for some variables, while for others it is verified that there is an isolated effect of the doses of both fertilizers. The response to fertilization with doses of KCl and/or MAP observed for the morphological and nutritional variables of the seedlings of *E. urophylla* x *E. grandis* reflects the level of demand of the species in relation to the fertility of the substrate, with less development of the aerial part and roots under inadequate nutrition.

The quadratic adjustment, observed in the regression analysis, for the variables DRC, DMAP, TDM, DQI, N\_PA, K\_R, AE\_N, indicates that fertilization with KCl provides a positive effect up to a certain dose. The increasing increments for these variables, in the presence of MAP, up to the dose of 0.100 g of KCl seedling<sup>-1</sup>, and the decrease under the dose of 0.200 g of KCl seedling<sup>-1</sup>, is explained by the fact that high doses of potassium can result in toxicity to seedlings. This justification is used by Neves *et al.* (2007) to explain the lower growth in H, DRC, DMAP and RDM of *Spondias tuberosa* Arr. Cam. Seedlings produced with potassium doses above 187mg dm<sup>-1</sup>.

The diameter of the root collar is one of the most important variables in the evaluation of the seedling potential for survival and growth after planting, since, for the same species, plants with higher DRC present greater survival due to the greater capacity for formation and growth of new roots (DEL CAMPO *et al.* 2010). The DMET of KCl, in MAP treatments, estimated at 0.118 g of KCl seedling<sup>-1</sup> and DRC = 2.95mm, provides increments of around 10% in the DRC of the seedlings, in relation to the control (0.0 g of KCl seedling<sup>-1</sup>). This increase is even greater (35%) when compared to the absolute control (0.0 KCl + 0.0 MAP seedling<sup>-1</sup>) showing the importance of the interaction between these two factors. D'Ávila *et al.* (2011) observed a quadratic effect of KCl doses in the DRC of seedlings of three hybrid clones of *Eucalyptus* (*E. grandis* x *E. urophylla*), in the rusting phase. These authors verified increases of 55% in the DRC in the dose of 259 mg L<sup>-1</sup> of KCl, in relation to the control.

Although a better dose of KCl is observed in the presence of MAP, it is important to note that, at 120 days after sowing, the non-application of KCl (0.0 g of KCl seedling<sup>-1</sup>) allows the seedlings to reach DRC (2.70 mm) above the recommended minimum value (DRC 2.5mm) (Sturion *et al.*, 2000) for removing eucalyptus seedlings from the greenhouse. This performance was not observed in the absence of MAP (minimum 2.18 mm in the treatment 0.00 g KCl and maximum 2.39 mm in the treatment 0.025 g KCl). Thus, it appears that only the application of MAP (0.10 g) already allows the production of seedlings within the minimum standard of quality

necessary for planting in the field. In addition, it can be inferred that, with the application of MAP, the time that the seedling remains in the nursery is shorter, since, at 120 days, in the estimated DMET, these are with DRC values around 20% more higher than the recommended minimum. Gomes *et al.* (2003), evaluating the growth of *E. grandis* seedlings in different tube sizes (50, 110, 200 and 280 cm<sup>3</sup>) and N-P-K fertilization, recommend that the removal of seedlings from the nursery be in less than 120 days after sowing, even in larger tubes, as the restriction to height and root growth is affected by the containers. According to these authors, the seedlings undergo a process of "hardening", increasing the diameter at root collar and gaining more weight of dry matter, presenting a height much higher than the ideal for successful planting.

While there is no effect of KCl on height, fertilization with MAP allows increments of around 45% in relation to its absence, resulting in seedlings with height (on average 36.63 cm) well above the interval (between 15 and 25 cm) recommended by Sturion *et al.* (2000) for the dispatch of seedlings of forest species to the field. According to Gomes *et al.* (2003), there are controversies about the ideal size of seedlings to be sent to the field, and consider that the seedlings could be ready to be planted with heights ranging from 20 to 35cm and a minimum diameter of 2.0 mm. Xavier *et al.* (2009) recommend height ranging between 20 and 40 cm and a minimum diameter of 2.0 mm, which fits all seedlings (with or without MAP) within the quality standards.

The stimulus to growth in height, provided by the addition of MAP, reflected in the increase of the H/DRC ratio, being observed that the effect of fertilization with P and N is, in greater proportion, in the height than in the DRC of the seedlings of *E. urophylla* x *E. grandis*. While in the presence of MAP, the increase in growth in DRC is up to 25% in relation to the absence of this fertilizer, the increase in height is around 50%. Assessing the effect of different nitrogen doses on the initial development of seedlings of *Calophyllum brasiliense* Camb. (Guanandi), Belapart *et al.* (2013) observed that nitrogen fertilization promoted an increase in plant height, but there was an absence of this effect on the diameter, which provided an increase in the H/DRC ratio. The H/DRC ratio reflects the balance in growth between the aerial part and the root system of the seedlings. High H/DRC values indicate the plant's susceptibility to tipping, if the increase in the diameter of the stem is disproportionate to the growth of the plant in height (DA ROS *et al.*, 2017). Carneiro (1995) considers that, in general, for forest species, the ideal value for this variable would be between 5.4 and 8.1. However, this range of variation cannot be applied to eucalyptus seedlings, since the present study, in addition to the studies by Batista *et al.* (2014), Rocha *et al.* (2014) and Toledo *et al.* (2015) result in values of the H/DRC ratio above the maximum limit of this interval.

MAP fertilization provides 184% increments in the leaf area of the seedlings in relation to their absence. This effect is interesting, as it directly affects the photosynthetic capacity of plants, which is probably related to the increments observed in the other biometric data evaluated in this work (BELAPART *et al.*, 2013). Zambrosi *et al.* (2012) argue that, under conditions of P deficiency, the lower growth of plants is attributed to the decrease in leaf area available for interception of photosynthetically active radiation, which causes a decrease in the amount of carbohydrates produced and available to meet the growth demand. Berghetti *et al.* (2019) observed a greater increase in the leaf area of *Cordia trichotoma* seedlings with the increase in the dose of P. These authors infer that plants cultivated with higher levels of P may show higher growth rates in the field, since the photosynthetic process is influenced the dimensions of the photoassimilator system.

For the DMAP and TDM of the seedlings, there was an interaction between the factors (KCl x MAP), verifying, in the presence of MAP, the influence of KCl doses with quadratic behavior. The estimated DMET (0.094 g of KCl seedling<sup>-1</sup> for DMAP and 0.096 g of KCl seedling<sup>-1</sup> for TDM) promote increments of 21% in relation to the control (0.0 g of KCl seedling<sup>-1</sup>). Berghetti *et al.* (2019) associate the increases observed in the DMAP and TDM of *Cordia trichotoma* seedlings, fertilized with P and K, to the fact that P has a great influence on the photosynthetic rate, especially in the activity of the Calvin cycle and in the regeneration of the rubisco enzyme. In addition, they point out that the increase in the supply of P and K has been correlated with greater efficiency in the use of water (MENDES *et al.*, 2013), contributing to the accumulation of biomass in plants. It is also important to note that MAP is a source of N, which also stimulates vegetative growth. Belapart *et al.* (2013) observed a positive effect of nitrogen fertilization on the vegetative growth of guanandi seedlings, emphasizing the importance of this nutrient for the increase in the dry mass of the leaves.

The DMAP/RDM ratio (on average: 4.01 without MAP and 4.95 with MAP), observed in the present study, presents values above (> 3.0) that considered (close to two) by Brissette (1984) as being better relationship between these variables. Relationships greater than 3.0 were also observed by Batista *et al.* (2014), evaluating the effect of swine wastewater (SW) on the development and quality of *E. urophylla* seedlings. These authors attribute this fact to the supply of N to seedlings via SW or via mineral fertilizer, contributing to a better development of the aerial part in relation to the root. It can be seen, in the present study, that, while the application of MAP increases DMAP by up to 135% in relation to the non-application of this fertilizer, the increase in RDM occurs around 75%. This fact can be associated with both the increase in the addition of N and the addition of P, because, due to the fact that P has a synergistic relationship with N, it can cause greater absorption of N by the plant. What, according to Belapart *et al.* (2013), stimulates vegetative growth, since both N and P are involved in the process

of photosynthesis (BERGHETTI *et al.*, 2019). This pattern was highlighted by Rocha *et al.* (2013), to justify the greater growth of the aerial part of eucalyptus seedlings when they evaluated their production and development according to different doses of phosphorus.

The Dickson Quality Index (DQI) has been considered in several studies (BATISTA *et al.*, 2014; ELOY *et al.*, 2013) as a good indicator of the seedling quality standard, since it considers robustness and the balance of biomass distribution. Higher DQI in DMET, estimated at 0.108 g KCl + 0.10 g MAP seedling<sup>-1</sup>, indicates that this fertilization is providing *E. urophylla* x *E. grandis* seedlings with better quality standards, at 120 days.

The responses to fertilization with KCl are different for the accumulation of each nutrient (K, P and N) in the aerial part and roots, as well as for the efficiency of absorption of these nutrients by the seedlings, in the presence and/or absence of MAP (Figure 2). The increase in the accumulation of N\_PA and AE\_N, in the initial doses of KCl, decreasing with higher doses, may be associated with the fact that, in higher doses of KCl, the growth of seedlings is compromised, as verified in the evaluations carried out of diameter and dry mass of the aerial part. On the other hand, the increasing application of KCl doses reduces the accumulation of P\_PA and AE\_P, showing no relationship with the morphological variables. The linear increase in the K content, in the aerial part and in the K absorption efficiency, both in the absence and in the presence of MAP, suggests that higher concentrations of K in the substrate favor a more efficient functioning of the roots in the absorption process of this nutrient. However, this behavior does not reflect the increase in K content in the roots, since in this compartment there is an initial increase in K accumulation, and after a certain dose, the response to fertilization starts to decrease. Thus, the increase in AE\_K with the highest doses of KCl is probably related to the positive effect of K supply on the accumulation of this nutrient by the aerial part. This is due to the fact that the demand of the aerial part acts as the main regulating factor in the absorbed amounts of nutrients (ZAMBROSI *et al.*, 2012). When evaluating the effect of KCl doses, in seedlings of three hybrid eucalyptus clones (*E. urophylla* x *E. grandis*), D'Ávila *et al.* (2011) observed increases in the concentrations of K in the leaves, with higher doses.

The high dissimilarity between treatments with and without MAP fertilization (Figure 2) emphasizes the importance of applying MAP (source of P and N) to produce seedlings of *E. urophylla* x *E. grandis*, which have morphological and nutritional quality higher than those without MAP fertilization. In addition, favoring growth and nutrition of seedlings with the supply of N and P occurs even when potassium is not supplied to the seedlings. Evaluating the seedling production of a hybrid clone of *Eucalyptus urophylla* x *E. grandis* under different doses of phosphorus, Rocha *et al.* (2013) observed that, in relation to the control (0.0 mg of P seedling<sup>-1</sup>), all doses applied provided gains in the morphological and nutritional quality (N, P, Mg) of the seedlings, at 90 days after staking. Other works - D'ÁVILA *et al.* (2011) and ROCHA *et al.* (2015) - also demonstrated improvements in the morphological and nutritional quality of seedlings of different clones and species of eucalyptus, in different experimental conditions (types of vegetative propagules, containers, substrates, doses and sources of fertilizers), from the use of fertilizers based on N, P and/or K.

## CONCLUSION

- There is variation in the effect of KCl doses as a function of the morphological and nutrition variable of the seedlings of *Eucalyptus urophylla* x *Eucalyptus grandis* evaluated.
- The doses of maximum technical efficiency of KCl, in the presence of MAP, of the morphological variables (neck diameter, dry mass of the aerial part, total dry mass, Dickson's Quality Index) and nutritional (content of N in aerial part, content of K in the root and absorption efficiency of N) from seedlings of *Eucalyptus urophylla* x *Eucalyptus grandis*, are between 0.062 and 0.148 mg of KCl seedling<sup>-1</sup>. The best growth and nutrition of all seedlings of this hybrid occurs with the applied dose of 0.100 g of KCl + 0.10 g of MAP seedling<sup>-1</sup>.
- Fertilization of the substrate with 0.10 g of MAP seedling<sup>-1</sup> results in seedlings with growth characteristics (height; diameter at root collar; leaf area; dry mass of the aerial part, roots, and total; H/DRC and DMAP/RDM ratio; and Dickson's Quality Index) and nutrition (N, P and K content in aerial parts and roots; and N and P absorption efficiency) superior to seedlings without fertilizer application.

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