Eucalyptus grandis trees growth: Effects of nutrition and water availability and interactions with the environment in a prolonged drought period

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INTRODUCTION

In Brazil, most Eucalyptus plantations are located in regions subject to long periods of water deficit (Gonçalves et al., 2004). IPCC forecasts predict longer periods of drought with changes in the frequency and intensity of rains and increase in temperature (IPCC, 2013), in fact, on 2014 there was the strongest drought period since 1930 along the southeast of Brazil (Dearden, 2015). Potassium fertilization has a big effect on wood production and may increase the efficiency of water use under water stress (Almeida, 2010; Battie-Laclau et al., 2016). Sodium has gained importance as a potential substitute for potassium, (Almeida et al., 2010). In this context, the evaluation of the effects of fertilization with potassium and sodium in interaction with water availability on the growth of Eucalyptus grandis trees, in extreme drought period, is necessary to better understanding the future consequences of climate change on the productivity of eucalyptus plantations.

Our objectives were:
- Evaluate the effect of fertilization with K and Na on the secondary growth of Eucalyptus grandis trees, on higher and lower water availability.
- Evaluate the relation of the secondary growth with the meteorological variability and soil moisture, for each treatment.

METHODS AND MATERIALS

In a split-plot design installed in June 2010, in Itatinga, São Paulo State-Brazil; six treatments (two water regimes x three fertilization supplies) were installed in three repetitions (Figure 1). The water regimes-1th factor was: 37% rainfall exclusion on the plot (-W) and without rainfall exclusion (+W) (Figure 2), and three fertilization supplies-2th factor were: potassium (+K), sodium (+Na) and control (-K). As in commercial plantation, the design received basic fertilization but without K.

We calculate the basal area increase from the measure of stem circumference increase at breast height each two weeks, by dendrometer bands, between October 2013 to October 2015. Also weekly soil moisture, daily rainfall and daily temperature was register.

Analyses of variance with split model were used to test the factor effects, on the other hand linear correlation analyses were used to test the relation between meteorological seasonality and growth for each treatment.

RESULTS

Fertilization with K showed a higher growth rate; with Na, trees had an intermediate growth rate between K and control treatments. The artificial exclusion of 37% of throughfall had a negative effect on the increment growth of K fertilized trees but it had no significant effect in the control and Na treatments 65 months after plantation (Figure 3).

The biweekly increase of basal area varied significantly between treatments and it was dependents of climate conditions. The differences were higher in favorable climatic conditions; in rainy periods, the area basal increases were higher in contrast with K or Na supplies, but generally higher in +W that –W water regime, except in the year 2015 where the differences were smaller between these treatments. However, in dry periods, the area basal increases were higher in controls trees that trees with K or Na supplies. In fact, cumulative basal area increase along six months, in rainy and dry seasons of 2013, 2014 and 2015, showed that in abnormal dry period 2014 with strong water deficit (extreme drought, Figure 4), there is no significant positive effect on growth of E. grandis trees (Figure 5).

Trees with K supplies were more responsive to rainfall, minimum temperature, VPD and soil moisture. Trees without K or Na supplies showed very lower influence of these meteorological variables (Figure 6).

CONCLUSIONS

The application of K of E. grandis trees, increased greatly the sensitivity to seasonal variations of rainfall, minimum temperature and vapor pressure deficit. While Na supply in replacement of K showed less sensitivity of basal area growth to meteorological variations, and even, an increase in water deficit does not had severe impact on tree growth, contrary to the effect on trees fertilized with K. The addition of K in basic fertilization is very important to obtain high growth rates, although in future scenarios of increasing the frequency of prolonged extreme droughts. Other strategies will have to be taken into account to maintain a high productivity of E. grandis plantations and decrease the risk of death. In addition to economic interest, the partial replacement of K by Na could be of greater interest compared to a total replacement of K by Na; although more research is needed to understand their responses to periods of extreme droughts.