# Biometric analysis of eucalyptus forests in the five initial years of development

A. L. T. Fernandes, T. de M. Florêncio & M. F. de Faria
*University of Uberaba, Brazil*

## Abstract

This research is aimed at evaluating the effects of irrigation and mineral nutrition on the growth and production of eucalyptus (*Eucalyptus grandis*) cultivated in the region of Triângulo Mineiro. The experiment was conducted at the Farm School of Universidade de Uberaba, which has 850 m of altitude, in red-yellowish Latosoil. Irrigated treatments and non-irrigated treatments with different nutritional conditions (25%, 50% and 100% of the recommended doses) were compared. It was evaluated the parameters of diameter at breast height and growth in a period of five years of conducted experiment; the final productivity of wood was also determined at the end of that period. Even though results were statistically different throughout the years, at the end of the analyzed period it was observed that irrigated treatments showed the biggest biometric values as well as the biggest rates of annual medium increment. Proximity of values may have occurred due to excessive rainfall at the local, making water more available to the non-irrigated treatments.

*Keywords: commercial wood, irrigation, fertilization.*

## 1 Introduction

According to FAO, Brazil is the second most forested country in the world with almost 477.77 millions of hectares, and the fourth country with the biggest area dedicated to plantation forestry. However, the country lacks adequate information and functional mechanisms. The usefulness of eucalyptus is evident: virtually all parts of the tree are exploited [3].

In order to improve the production of a eucalyptus forest, one of the techniques that could be applied by growers is irrigation, which aim is the controlled supply of water to the forest species in sufficient quantity and in an

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adequate period, complementing rainfall, as not only can irrigation benefit the growth of eucalyptus tree, but it can also reduce the cutting age and provide homogeneous development of the planted forest [1, 2].

All things considered, the present research aimed to evaluate different strategies of irrigation and mineral nutrition in the vegetative and productive development of eucalyptus cultivated in the conditions of Triângulo Mineiro, MG (Brazillian savannah).

## 2 Material and methods

The experiment took place in the Experimental Campus of the University of Uberaba (Farm School located at Uberaba, MG). The geographic coordinates are: Latitude 19º44′13″S, Longitude 47º57′27″W and altitude 850 m. The local climate is classified in the Köppen system as Aw hot, humid tropical and cold, dry winter. The annual rainfall is 1,474 mm and the mean annual temperature is 22,6ºC. The species evaluated was *Eucalyptus grandis* cultivated with and without irrigation. Different levels of mineral nutrition (25%, 50% and 100% of the recommended dose) were applied in a fertirrigated system for those irrigated. For the non-irrigated nutrition was applied in the standard manner. Each portion had the dimensions: 60.0 m x 53.5 m. The average of the sample area was 124.6 $m^2$. The average flow of drippers used in the experiment after field evaluations were 2. 2L $h^{-1}$. Water analysis revealed it was adequate for irrigation and soil reacquired 2 tons of dolomitic lime per hectare. Plantation occurred in October, 2003. Plant spacing was 4.0 m x 1,5 m, the formulation applied at planting 08-28-16 and of coverage 20-00-20, resulting in a total of 0.25 ton. $ha^{-1}$ and 0,2 ton. $ha^{-1}$, respectively. Data were collected in zigzag from the first measurable tree, corresponding to measurements from 2004 to 2008 with annual periodicity.

For field work, it was used meter tape in mm scale to measure tree's circumference 1.30 m above ground for later conversion to diameter. Haglof electric hypsometer was used to measure heights, for the lease of samples and measuring tape to measure the sample areas. Software Statistica 6.0 was used for statistical analysis of data. The volumetric calculation required the scaling of 14 trees, 7 in the irrigated sector and 7 in the non-irrigated. The choice of trees was based on diameter at breast height. The scaling was performed by collecting two orthogonal diameters at heights of sections 0.10, 0.70, 1.30, 2.0 and from this on, in every meter. Trees' heights were also collected. In order to calculate the solid volume of tree, Smalian's formula was applied:

$$V = \frac{(g_1 + g_2)}{2} \times c \quad (1)$$

where
$g_1$ = base diameter
$g_2$ = top diameter
c = tree's height.

In order to obtain the solid volume of each tree, an average form factor was applied (0.4412).

Graphics of the collect data were made, featuring trend lines and the $R^2$.

## 3 Results and discussion

The total volume of eucalyptus in 2008 and the Mean Annual Increment (MAI) per treatment is in Table 1. Biggest values of MAI (77.6 $m^3ha^{-1}year^{-1}$) were obtained by treatment with 100% fertilized and irrigated, with total volume for

Table 1: Total volume in 2008 ($m^3ha^{-1}$) and Mean Annual Increment, MAI ($m^3ha^{-1}year^{-1}$) of eucalyptus.

| Treatment | Statistic | Volume ($m^3ha^{-1}$) | MAI ($m^3ha^{-1}year^{-1}$) |
|---|---|---|---|
| (E-IR-A)[1] | Mean: | 376.1 | 77.6 |
| | CV % | 12.7 | |
| | CI 95% | 20,2 | |
| (E-IR-B)[2] | Mean: | 328.6 | 67.8 |
| | CV % | 22.5 | |
| | CI 95% | 35.9 | |
| (E-IR-C)[3] | Mean: | 365.8 | 75,4 |
| | CV % | 9.5 | |
| | CI 95% | 15.1 | |
| (E-NI-A)[4] | Mean: | 334.9 | 69.1 |
| | CV % | 16.4 | |
| | CI 95% | 26 | |
| (E-NI-B)[5] | Mean: | 271.8 | 56 |
| | CV % | 33.5 | |
| | CI 95% | 53.3 | |
| (E-NI-C)[6] | Mean: | 304.9 | 62.9 |
| | CV % | 20.1 | |
| | CI 95% | 32 | |

[1]E-IR-A: irrigated eucalyptus with 100% of nutrition.
[2]E-IR-B: irrigated eucalyptus with 50% of nutrition.
[3]E-IR-C: non-irrigated eucalyptus with 25% of nutrition.
[4]E-NIR-A: non-irrigated eucalyptus with 100% of nutrition.
[5]E-NIR-B: non-irrigated eucalyptus with 50% of nutrition.
[6]E-NIR-C: non-irrigated eucalyptus with 25% of nutrition.

that block of 376.1 $m^3ha^{-1}$. Lowest levels of MAI (56 $m^3ha^{-1}year^{-1}$) and total volume (271.8 $m^3ha^{-1}year^{-1}$) were observed in the treatment E-NIR-B. It is noteworthy that in Brazil a good management of production obtains a maximum of 50 $m^3ha^{-1}year^{-1}$.

Figure 1 shows eucalyptus' height with different markers referring to the annual averages and trend lines with correlation coefficients above 97%, which means data are strongly correlated. During the period studied, with lines of tendency for each treatment. In 2008 there were close height values of E-IR-A (24.16 m), E-IR-C (23.69 m) and E-NIR-A (23.25 m). Treatment E-NIR-B had the lowest levels (20.75 m)

The equations for each treatment (and each correlation coefficient) are listed below:

E-IR-A: irrigated eucalyptus with 100% of nutrition,

$$y = 13.239 \ln x + 2{,}556 \qquad R^2 = 0{,}9915 \tag{2}$$

E-IR-B: irrigated eucalyptus with 50% of nutrition

$$y = 13.805 \ln x + 1{,}5742 \qquad R^2 = 0{,}9757 \tag{3}$$

E-IR-C: non-irrigated eucalyptus with 25% of nutrition

$$y = 13.188 \ln x + 1{,}7364 \qquad R^2 = 0{,}9839 \tag{4}$$

E-NIR-A: non-irrigated eucalyptus with 100% of nutrition

$$y = 12.998 \ln x + 1{,}9664 \qquad R^2 = 0{,}9886 \tag{5}$$

E-NIR-B: non-irrigated eucalyptus with 50% of nutrition

$$y = 11.779 \ln x + 2{,}236 \qquad R^2 = 0{,}9944 \tag{6}$$

E-NIR-C: non-irrigated eucalyptus with 25% of nutrition

$$y = 11.513\, ln\, x + 2{,}0559 \qquad R^2 = 0{,}9957 \tag{7}$$

Results of Turkey's test for eucalyptus heights are in Table 2. It is observed that in 2005, 2007 and 2008 E-IR-A differed significantly from others (Table 2(A), 2(C) and 2(D)).

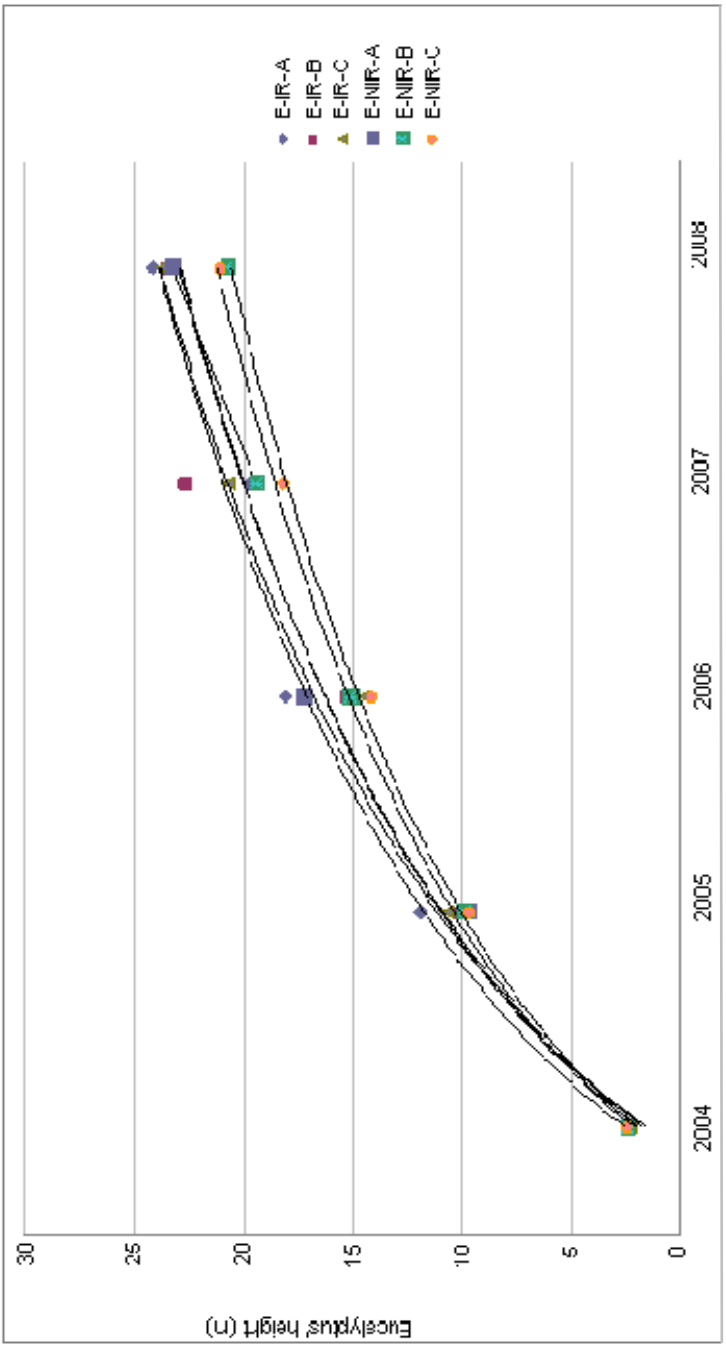


Figure 1: Eucalyptus' height (m) from 2004 to 2008.

Table 2: Results of Tukey's test for eucalyptus' height (m).

| 2005 (A) | |
|---|---|
| Treatment | Mean* |
| (E-NIR-C) [6] | 9.65625 a |
| (E-NIR-A) [4] | 9.72917 a |
| (E-NIR-B) [5] | 9.875 a |
| (E-IR-B) [2] | 10.17708 a |
| (E-IR-C) [3] | 10.66667 a |
| (E-IR-A) [1] | 11.88542 b |
| 2006 (B) | |
| Treatment | Mean |
| (E-IR-C) [3] | 14.43333 a |
| (E-NIR-C) [6] | 14.57604 a |
| (E-NIR-B) [5] | 15.06771 a |
| (E-IR-B) [2] | 15.23125 a |
| (E-NIR-A) [4] | 17.20104 b |
| (E-IR-A) [1] | 18.0375 b |
| 2007 (C ) | |
| Treatment | Mean |
| (E-NIR-B) [5] | 20.85857 a |
| (E-NIR-C) [6] | 21.0871 ab |
| (E-NIR-A) [4] | 22.75797 ab |
| (E-IR-B) [2] | 23.21538 ab |
| (E-IR-C) [3] | 23.78676 ab |
| (E-IR-A) [1] | 24.11014 b |
| 2008 (D) | |
| Treatment | Mean |
| (E-NIR-B) [5] | 20.85857 a |
| (E-NIR-C) [6] | 21.0871 ab |
| (E-NIR-A) [4] | 22.75797 ab |
| (E-IR-B) [2] | 23.21538 ab |
| (E-IR-C) [3] | 23.78676 ab |
| (E-IR-A) [1] | 24.11014 b |

[1]E-IR-A: irrigated eucalyptus with 100% of nutrition.
[2]E-IR-B: irrigated eucalyptus with 50% of nutrition.
[3]E-IR-C: non-irrigated eucalyptus with 25% of nutrition.

[4]E-NIR-A: non-irrigated eucalyptus with 100% of nutrition.
[5]E-NIR-B: non-irrigated eucalyptus with 50% of nutrition.
[6]E-NIR-C: non-irrigated eucalyptus with 25% of nutrition.
[*]Treatment means in the same group are not statistically different from each other.

## 4 Conclusion

In 2006, E-IR-A was statistically equivalent to the average of E-NIR-A. In 2007, E-NIR-B had the minimum values whereas E-IR-A featured the maximum values. The biggest value of eucalyptus' height was 24.11, corresponding to E-IR-A in 2008 (Table 2D).

Irrigated treatments showed the highest biometric rates (height). Higher values of MAI were obtained by the irrigated treatment and 100% fertilized.

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