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Scientific Article
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Development of native and introduced tree species under two water regimes in Acaraú, Ceará[1]

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ABSTRACT - The aim of this study was to evaluate development in the following tree species: *Acacia mangium* Willd, *Anadenanthera colubrina* var. *cebil* (Griseb.) Altschu, *Casuarina equisetifolia* L. ex J. R. Forst. & G. Forst, *Handroanthus impetiginosus* (Mart. Ex DC.) Mattos, and *Colubrina glandulosa* subsp. *reitzii* (M.C.Johnst.) Borhidi under two water regimes in the Irrigated Perimeter of Baixo Acaraú, in the state of Ceará. The experiment was conducted over seven years, with the factors represented by water regimes, species and periods in an arrangement of split-split plots in a completely randomised design repeated over time with four replications of two plants each. The response variables were total height, diameter at breast height, volume, absolute growth rate in height and diameter, and current and average annual increase in volume. After seven years, the species *Acacia mangium*, *Casuarina equisetifolia*, *Handroanthus impetiginosus*, *Anadenanthera colubrina* and *Colubrina glandulosa* presented the following respective mean volumes: 0.62, 0.47, 0.45, 0.31 and 0.29 m^3 irrespective of the water regime. Despite a reduction in the growth rates of the species during each period, they remained positive, and growth did not stop. The mean values for volume confirm that the species showed similar growth for the water regimes under study. An irrigated regime of up to one year is therefore suggested for cultivating these species in the Irrigated Perimeter of Baixo Acaraú, Ceará.

Keywords: Dendrometry. Water stress. Planted forest.

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INTRODUCTION

Brazil covers an area of 851.48 million hectares. Of these, 58% are covered by natural and planted forest, which represent the second largest forested area on the planet, behind only Russia (FAO, 2015). There are an estimated 485.8 million hectares of native forest (FAO, 2015) and 9.5 million hectares of planted forest (IBGE, 2021).

The forestry sector in Brazil shows great potential for growth in area and productivity. This is because, in addition to representing a strong incentive for a low-carbon economy, forests are fundamental to the generation of various products such as paper and cellulose, charcoal for various uses, timber, solid wood products and processed wood, in addition to cleaner fuels originating from biomass and cellulosic ethanol (Mendes *et al*., 2016). Furthermore, the activity is considered important, since soils are generally poorer and badly suited to agriculture, with a vertical structure or industrial hubs that guarantee to absorb production.

The demand for forest products is growing to satisfy the main consumer segments of forest raw materials, such as construction, furniture, packaging, steel, pulp and paper (IBGE, 2010). However, the forestry base to meet this diversified demand has not grown at the same rate.

Previously concentrated in the south and southeast of Brazil, forestry activities in recent decades have expanded into new regions, such as the states of Mato Grosso do Sul, Mato Grosso and Tocantins. More recently, growth has begun in the north and northeast of the country (Fernandes *et al*., 2015). The climate characteristics of the state of Ceará, with low precipitation and irregular rainfall, can be limiting to economic productivity, and even to the survival of various species that may be introduced into the region, increasing the risks to the success of forestry activities.

Studies that seek to select species that are tolerant to regions with water restrictions are the key point to the success of forestry activities, since plant growth and development are affected by water stress caused by both excessive evaporative demand and by the limited supply of water in the soil, restricting photosynthetic activity (Yu *et al*., 2009).

The specific growth behaviour of forest species in each region, together with the environmental factors, makes it possible to view jointly the distinct characteristics of forest plantations, allowing these to be related to the productive capacity of each species as an aid to decision-making for intervention in these areas. (Hess *et al*., 2009).

Growth in the diameter, volume and height of forest species can aid in forest management, above all by providing information on their productive potential, and by making it possible to quantify the time needed for the trees to reach the desired dimensions for commercial production and, consequently, to evaluate the economic investment made in growing these species (Hess *et al*., 2009).

In this context, the aim of the present study was to evaluate the development of different native and introduced tree species under two water regimes, in order to understand the parameters of the forests and their potential for reforestation in the Irrigated Perimeter of Baixo Acaraú, Ceará.

MATERIAL AND METHODS

Characterisation of the experimental area

The experiment was evaluated over seven years in an experimental area of Embrapa Tropical Agroindustry, located on a plot of the Irrigated Perimeter of Baixo Acaraú, Ceará, in a region bordering the district of Marco, Ceará, at 3°06’02” S and 40°04’05” W and an altitude of 56 m. According to the Köppen classification, the climate in the region is type Aw’. There is a marked difference between the rainy season (January to May) and the dry season (June to December). The average annual rainfall varies around 900 mm, with an average annual temperature of 28.1ºC, average annual relative humidity of 70%, average annual evaporation of 1600 mm, insolation of 2,650 hr yr^{-1} and average wind speed of 3.0 m s^{-1} (DNOCS, 2016). Rainfall values during the study period were obtained from a weather station at the Fundação Cearense de Meteorologia e Recursos Hídricos (FUNCEME), in the district of Acaraú, approximately 15 km from the experimental area.

The soil in the experimental area was classified as a quartzarenic Neosol (EMBRAPA, 2013) with the following characteristics in the 0 to 50 cm layer: textural class - sand, soil moisture at 0.03 MPA - 4.38%, moisture at 1.5 MPA - 2.95%, pH - 6.1, EC - 0.19 dS m^{-1}, organic matter - 9.0 kg^{-1}, P - 19.9 mg dm^{-3}, and 14.65, 6.45, 1.05, 3.35 and 5.4 $mmol_c$ dm^{-3} Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, and $H^{+}+Al^{3+}$, respectively.

Setting up the experimental area

The seeds of the native and introduced species used to produce the seedlings were obtained from the coastal and sertão regions of Ceará. Seedlings of the species *Acacia mangium* Willd, *Anadenanthera colubrina* var. *cebil* (Griseb.) Altschu, *Handroanthus impetiginosus* (Mart. ex DC.) Mattos, and *Colubrina glandulosa* subsp. *reitzii* (M.C.Johnst.) Borhidi were produced in the nursery at the experimental area of Embrapa Tropical Agroindustry in Pacajus, Ceará, by direct sowing in tubes of 288 cm^3 containing a mixture of carbonised rice husk + crushed carnauba straw + hydromorphic soil at a ratio of 3:2:2 v/v. Irrigation during the period was carried out manually to maintain the apparent humidity of the substrate. No fertiliser was applied during production of the seedlings. Only seedlings of *Casuarina equisetifolia* L. ex J. R. Forst. & G. Forst were obtained from a commercial nursery in the district of Aquiraz, Ceará. Before planting, the seedlings were hardened for a period of 30 days, with only those that were homogeneous in size, vigorous in appearance and free from disease and pests being planted in the field.

The species were planted in experimental subplots measuring 6 x 28 m, comprising three rows of 15 individuals per row, with the first and third row considered borders together with the first and last plants in the central row. A spacing of 3 m was used between rows and 2 m between trees, giving a total of 0.27 ha.

During the first 12 months, the entire area was irrigated daily by micro-sprinkler with an irrigation depth of 2.7 mm day^{-1}. Following this period, the area was divided into two sub-areas (plots), with irrigation continuing in only one sub-area, but with the frequency changed to two days and the irrigation depth to 5 mm day^{-1}. This regime was maintained for 36 months, when irrigation was discontinued.

Experimental design

The experiment was conducted in an arrangement of split-split plots, in a completely randomised design with four replications, with the plots corresponding to the two water regimes (irrigated for one year and irrigated for three years), the split plots corresponding to the five species, and the split-split plots to seven annual assessment periods. The data were collected annually over seven years. During the fourth year after planting, selective thinning was carried out in the split plots corresponding to each species, continuing evaluation of the remaining individuals.

The observed data met the assumptions of the analysis of variance regarding the additivity of effects, the independence and normality of the errors, and homoscedasticity. The data were submitted to analysis of variance to check the isolated effects and the interaction between factors. The data relating to the evaluation periods and their significant interactions were broken down by regression analysis, with the model chosen based on the adjusted R^2, while the data relating to species and water regime and their significant interactions had their mean values compared by Tukey's test ($p < 0.05$).

Radical transformation was applied to the data relating to volumetric growth in order to meet the principle of homogeneity of variance as stipulated by Pimentel Gomes (2012). The statistical analysis was carried out in the SISVAR software, developed by Ferreira (2008).

Variables under analysis

Total height (m) was monitored by annual measurements over a period of seven years, taking the height of the entire plant from the collar to the apex. The diameter at breast height (DBH, cm) was also measured annually as the circumference 1.30 m from the collar. The absolute growth rate in height (AGRH, m^{-1} yr^{-1}) and diameter (AGRD, cm^{-1} yr^{-1}) were determined as a function of time using Equation 1.

Table 1 - Monthly rainfall (mm) at the weather station of the Fundação Cearense de Meteorologia e Recursos Hídricos (FUNCEME) in Acaraú, Ceará, from October 2010 to October 2017

Month	Year							
	2010	2011	2012	2013	2014	2015	2016	2017
JAN	-	355.2	6	18.4	35.6	6.8	263.8	96.6
FEB	-	154.7	111.6	116.3	127	85.8	170.6	195.4
MAR	-	252.3	150.1	77.5	38.8	307	181.6	286.8
APR	-	405.6	202.6	211.6	192.8	414.4	354	221
MAY	-	226.6	81.2	103.4	119.8	65	19.8	188.8
JUN	-	123.2	7	47.4	53.4	85	6.8	35
JUL	-	38	0	18.9	4	43.8	18.2	5
AUG	-	0	0	3	0	0	0	0
SEP	-	0	0	0	0	0	0	0
OCT	0	43	0	0	0	0	4.2	0
NOV	0	0	0	1.8	3	0	0	-
DEC	7.2	0	0	0	0	9.4	24	-

$$AGR = (V2 - V1)/(T2 - T1) \quad (1)$$

where: AGR = absolute growth rate; V = variable; T = length of each period.

From the data for total height and diameter, the volume (m^3) was calculated using Equation 2.

$$V = \left[\frac{(\pi \times DBH^2)}{40000 \times H \times f} \right] \quad (2)$$

where: V = volume (m^3); DBH = diameter at breast height, 1.3 m from the tree collar (cm); H = total height of the tree (m); $\bar{f}$ = form factor: 0.47 for *Acacia mangium* (Veiga *et al*., 2000), 0.50 for *Casuarina equisetifolia* (Georgin *et al*., 2015) and 0.63 for the native species (Souza and Jesus, 1991).

From the data for volume, the current annual increase (CAI, m^3) and mean annual increase (MAI, m^3) in volume as a function of time were determined using Equations 3 and 4.

$$CAI = V2 - V1 \quad (3)$$

$$MAI = \frac{V}{T} \quad (4)$$

where: CAI = current annual increase (m^3); MAI = mean annual increase (m^3); V = volume (m^3); T = length of each period.

RESULTS AND DISCUSSION

Figure 1 shows the values for height in the five species under the two water regimes as a function of time. It can be seen that in the treatment with irrigation for one year, the species *Casuarina equisetifolia* and *Colubrina glandulosa* achieved lower values for height in the years following irrigation as a result of the initial water stress. At the end of seven years, this difference was 9.19% and 15.30% greater in the treatment with irrigation for three years in *Casuarina equisetifolia* and *Colubrina glandulosa*, respectively. In *Acacia mangium* and *Handroanthus impetiginosus*, the height of the plants was similar regardless of the water regime: in this case the first year of irrigation was sufficient for the species to become established under the one-year irrigated regime, even after the reduction in the water supply. In *Anadenanthera colubrina*, the regimes differed in the seventh year, where the total height was 14.69% greater under the one-year irrigated regime.

The main effects of water stress on plant growth are associated with reduced turgor and limited metabolism, especially in the synthesis of proteins and amino acids. The reduced synthesis in protein metabolism results in the interruption of cell division, reducing the speed of mitosis and slowing the growth process, particularly in length (Larcher, 2006).

For the regression equations fitted for the total height of each species as a function of the evaluation period under each water regime (Figure 1), the fitted models were quadratic for *Acacia mangium*, with an estimated maximum age of seven years and height of 18.52 m under the three-year irrigated regime and a maximum age of six years and height of 18.03 m under the one-year irrigated regime. These results are superior to those found in the literature, where Veiga *et al*. (2000) observed an average height of 14.9 m in *Acacia mangium* after seven years in the region of Botucatu, São Paulo. For *Casuarina equisetifolia*, *Colubrina glandulosa* and *Anadenanthera colubrina*, the height increased linearly with age. After seven years, these species presented respective heights of 20.40, 13.66 and 10.69 m under the three-year irrigated regime and 18.68, 11.85 and 12.53 m under the one-year irrigated regime. These results are superior to those presented by Ndiaye *et al*. (1993), who recorded an average height of 7.5 m for *Casuarina equisetifolia* after 10 years in Senegal. Carvalho (2005) found, an average height of 10.10 m for *Colubrina glandulosa* after seven years in Cianorte, Paraná, and Toledo Filho (1988) found an average height of 6.90 m for *Anadenanthera colubrina* after eight years in Casa Branca, São Paulo. In *Handroanthus impetiginosus*, the total height also increased linearly with age, with an average of 12.73 m regardless of the water regime after seven years. This result is higher than that seen by Carvalho (2003), who recorded an average height of 5.79 m for *Handroanthus impetiginosus* after of eight years, in Santa Helena, Paraná.

Figure 2 shows the values for diameter at breast height (DBH) of the five species under the two water regimes as a function of time. It can be seen that the DBH in *Acacia mangium*, *Anadenanthera colubrina*, *Casuarina equisetifolia* and *Colubrina glandulosa* presented similar values regardless of the water regime. In this case, the first year of irrigation was sufficient for the species to become established. In *Handroanthus impetiginosus* under the one-year irrigated regime, the DBH values were lower from the sixth year onwards only, so that this difference was 12.94% greater under the three-year irrigated treatment by the end of seven years.

In relation to the regression equations fitted for species diameter as a function of the evaluation period under each water regime (Figure 2), the fitted models were quadratic for *Acacia mangium*, with an estimated maximum age of seven years and DBH of 24 cm under the three-year irrigated regime and DBH of 22.58 cm under the one-year irrigated regime. These results are superior to those found in the literature, where Veiga *et al*. (2000) observed an average DBH of 8.50 cm in *Acacia mangium* after seven years in the region of Botucatu, São Paulo. For *Casuarina equisetifolia*, *Anadenanthera colubrina* and *Colubrina glandulosa* the diameters increased linearly with age. After seven years, these species presented a respective average DBH of 16.87, 12.25 and 11.33 cm regardless of the water regime. These results are again superior to those found in the literature, where Ndiaye *et al*. (1993) recorded an average DBH of 12.5 cm in *Casuarina equisetifolia* after 10 years in Senegal. Toledo Filho (1988) found an average DBH of 10.3 cm in *Anadenanthera colubrina* after eight years in Casa Branca, São Paulo, and Carvalho (2005) found an average DBH of 10.7 cm in *Handroanthus impetiginosus* after seven years, in Cianorte, Paraná. For *Handroanthus impetiginosus*, the adjustment was quadratic, with the estimated maximum age as seven years and DBH of 18.26 cm under the three-year irrigated regime, and a maximum of six years and DBH of 16.14 cm under the one-year irrigated regime. These results are higher than those seen by Carvalho (2003), who recorded an average DBH of 10.1 cm for *Handroanthus impetiginosus* after eight years, in Santa Helena, Paraná.

Figure 3 shows the volume data for the five species under the two water regimes as a function of time. It can be seen that in each species the volume remained similar regardless of the water regime, as seen above with DBH (Figure 2). The irrigation adopted during the first year was therefore sufficient for the species to become established under the one-year irrigated regime.

Figure 1 - Total height of five tree species grown for seven years under two irrigated regimes

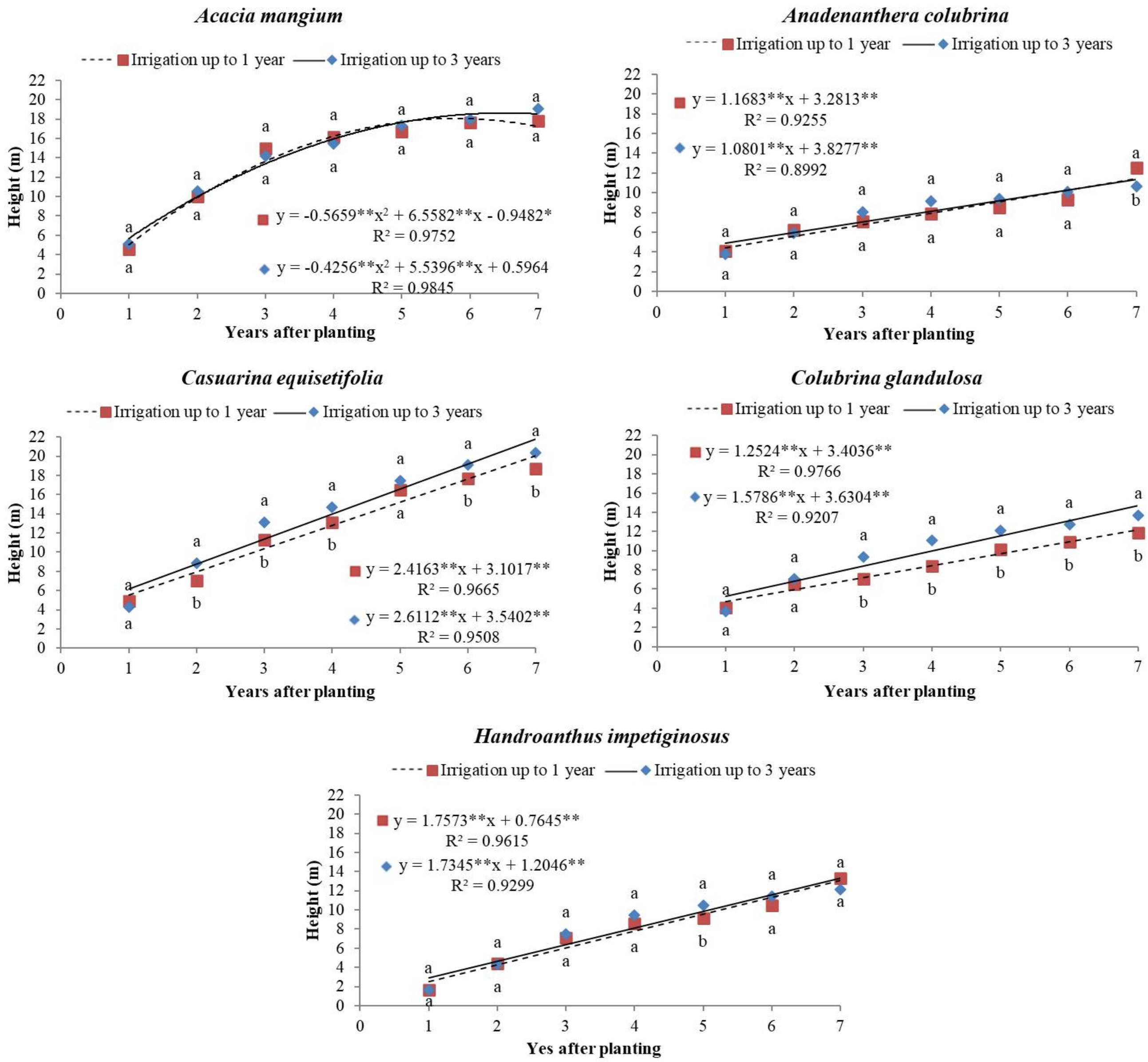


Figure 2 - Diameter at breast height (DBH) in five tree species grown for seven years under two irrigated regimes

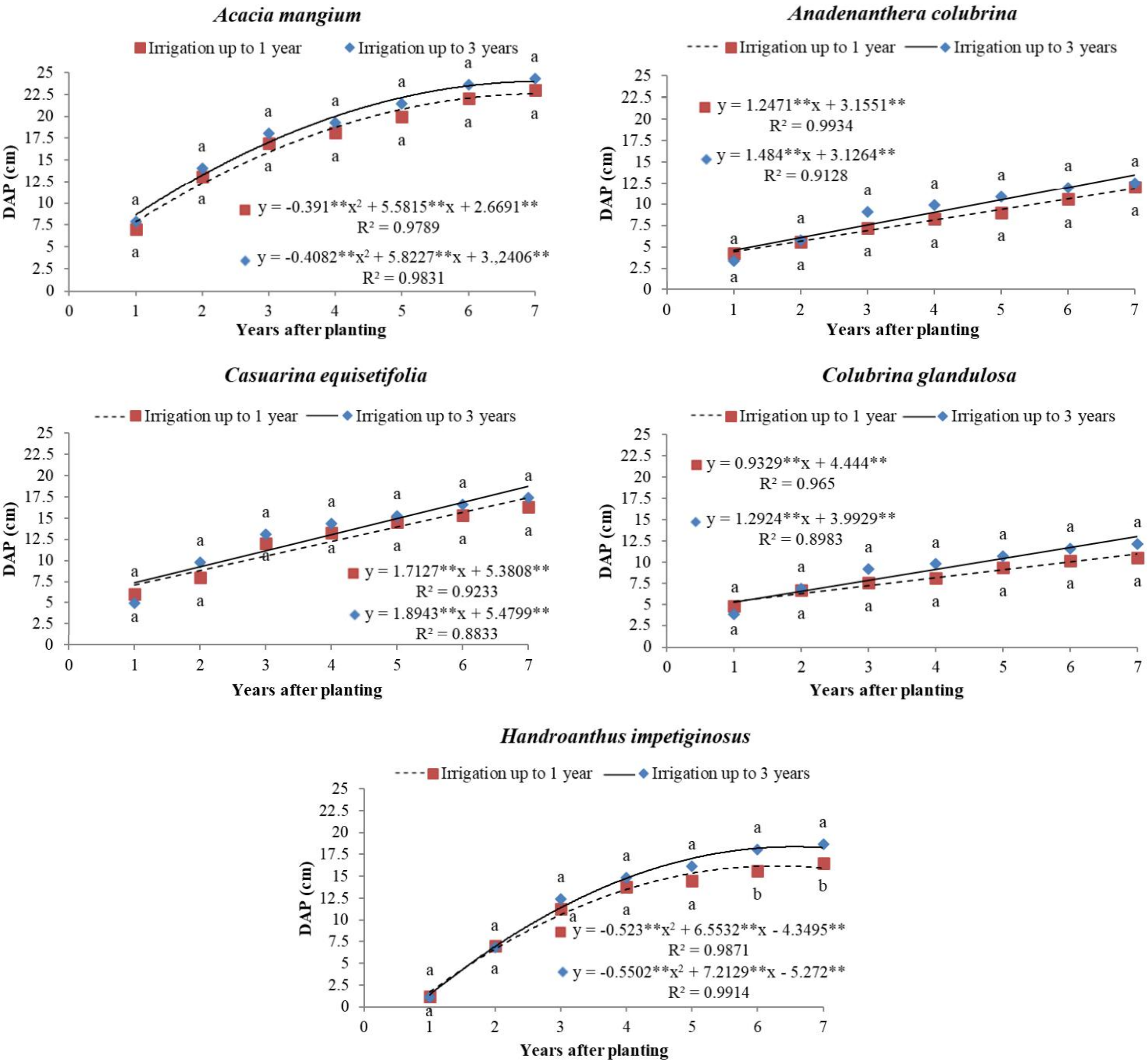
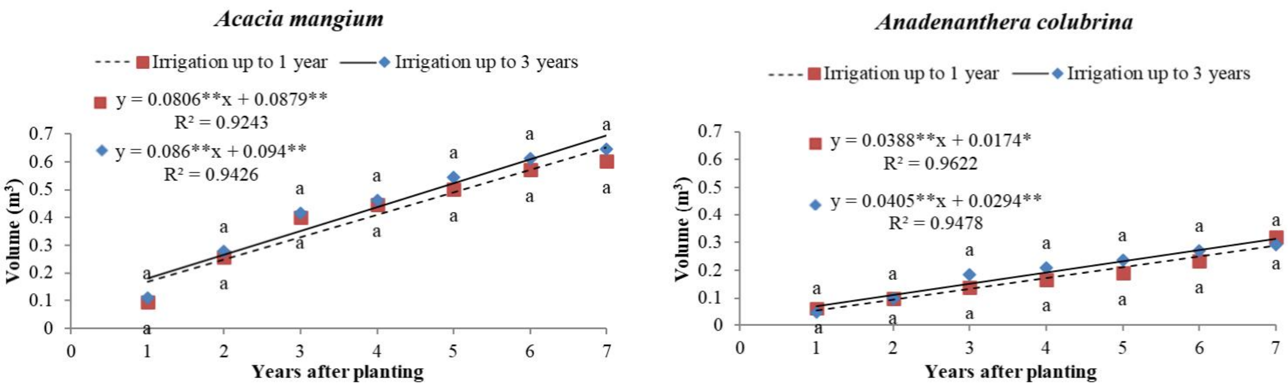


Figure 3 - Wood volume in five tree species grown for seven years under two irrigated regimes. Note: Square root data transformation



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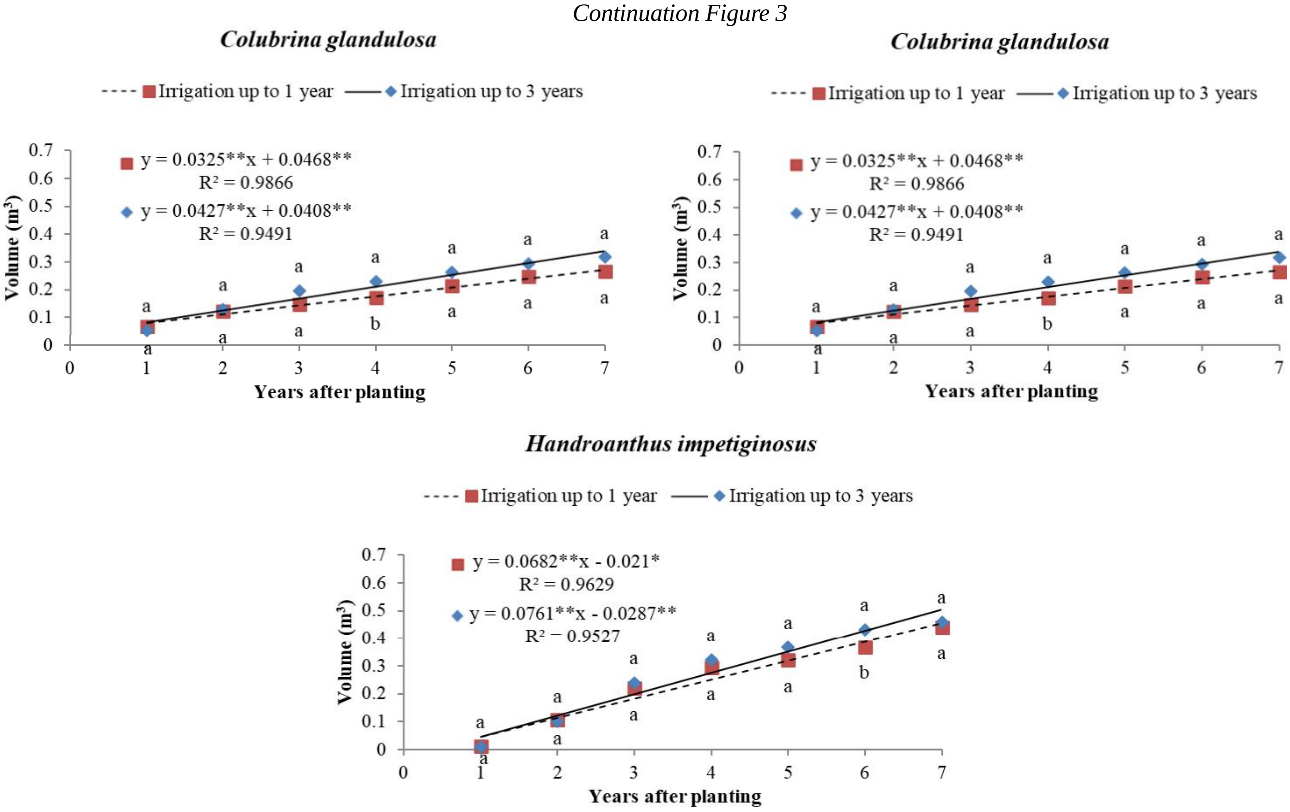


The regression equations were fitted for the volume of each species as a function of the evaluation period under each water regime (Figure 3). The volume of each species increased linearly with age. After seven years, *Acacia mangium*, *Casuarina equisetifolia*, *Handroanthus impetiginosus*, *Anadenanthera colubrina* and *Colubrina glandulosa* presented an average respective volume of 0.62, 0.47, 0.45, 0.31 and 0.29 m^3 (square root transformation) independent of the water regime. The results are far higher than those found in the literature, where the average volume was 0.04 m^3 for *Acacia mangium* after seven years in the region of Botucatu, São Paulo (Veiga *et al*., 2000), 0.03 m^3 for *Casuarina equisetifolia* after 10 years, in Senegal (Ndiaye *et al*., 1993), 0.02 m^3 for *Handroanthus impetiginosus* after eight years in Santa Helena, Paraná (Carvalho, 2003), 0.04 m^3 for *Anadenanthera colubrina* after seven years in Cianorte, Paraná (Toledo Filho, 1988) and 0.05 m^3 for *Colubrina glandulosa* after seven years in Cianorte, Paraná (Carvalho, 2005).

When taking into account the water regimes used with these species, there was a slight variation in the growth variables (Figures 1, 2 and 3), especially in the wood volume, where there was no significant difference between the regimes adopted over the seven years evaluation of each species (Figure 3). This may have been due to the recharge of groundwater from excessive water levels in other cultivated areas. Andrade *et al.* (2016), studying the fluctuation of the water table in the Irrigated Perimeter of Baixo Acaraú, found an increase in the water table in wells due to excessive irrigation in the region.

Of the species under study, *Acacia mangium* had the best average value for DBH and wood volume (Figure 2 and 3), directly attributed to its being a pioneer species, its fast growth and competitiveness. These characteristics were also observed by Souza *et al.* (2010).

For most of the species, there were no trajectories for sigmoidal growth variables, i.e. showing a tendency to reduce growth with increasing age (FIGURE 1, 2 and 3), suggesting that the species have not yet neared the end of their growth cycle.

There is a sharp reduction in absolute growth rate in height (AGRH) in each of the species until the fifth year after planting, with the exception of *Casuarina equisetifolia* under the one-year irrigated regime, which shows similar behaviour from the third year only. However, from the fifth year onwards the fall in growth rate slows down in all species under the three-year irrigated regime, with a resumption in growth in *Anadenanthera colubrina* and *Handroanthus impetiginosus* under the one-year regime (Figure 4). This recovery of the AGR seen in

Anadenanthera colubrina (Figure 4) may be the cause of the difference in height of this species between the regimes in the seventh year, where the total height was 14.69% greater under the one-year irrigated regime (Figure 1).

For the regression equations fitted for the AGRH of each species as a function of the evaluation period under each water regime (Figure 4), the rates of all of the species showed quadratic behaviour, with the exception of *Casuarina equisetifolia* and *Handroanthus impetiginosus* which showed cubic behaviour under the one-year irrigated regime. The AGRH of the species during the seventh year ranged from 0.21 (*Acacia mangium*) to 3.22 $m^{-1}\ yr^{-1}$ (*Anadenanthera colubrina*) under the one-year regime and from 0.62 (*Anadenanthera colubrina*) to 1.34 $m^{-1}\ yr^{-1}$ (*Casuarina equisetifolia*) under the three-year irrigated regime.

There is a sharp reduction in the absolute growth rate in DBH (AGRD) (Figure 5) in *Anadenanthera colubrina*, *Casuarina equisetifolia*, *Handroanthus impetiginosus* and *Colubrina glandulosa* up to the fifth year after planting. However, from the fifth year onwards, this fall in the AGR slows down in these species. In *Acacia mangium*, this slowdown is early, from the fourth year onwards.

Figure 4 - Absolute growth rate in height (AGRH) in five tree species grown for seven years under two irrigated regimes

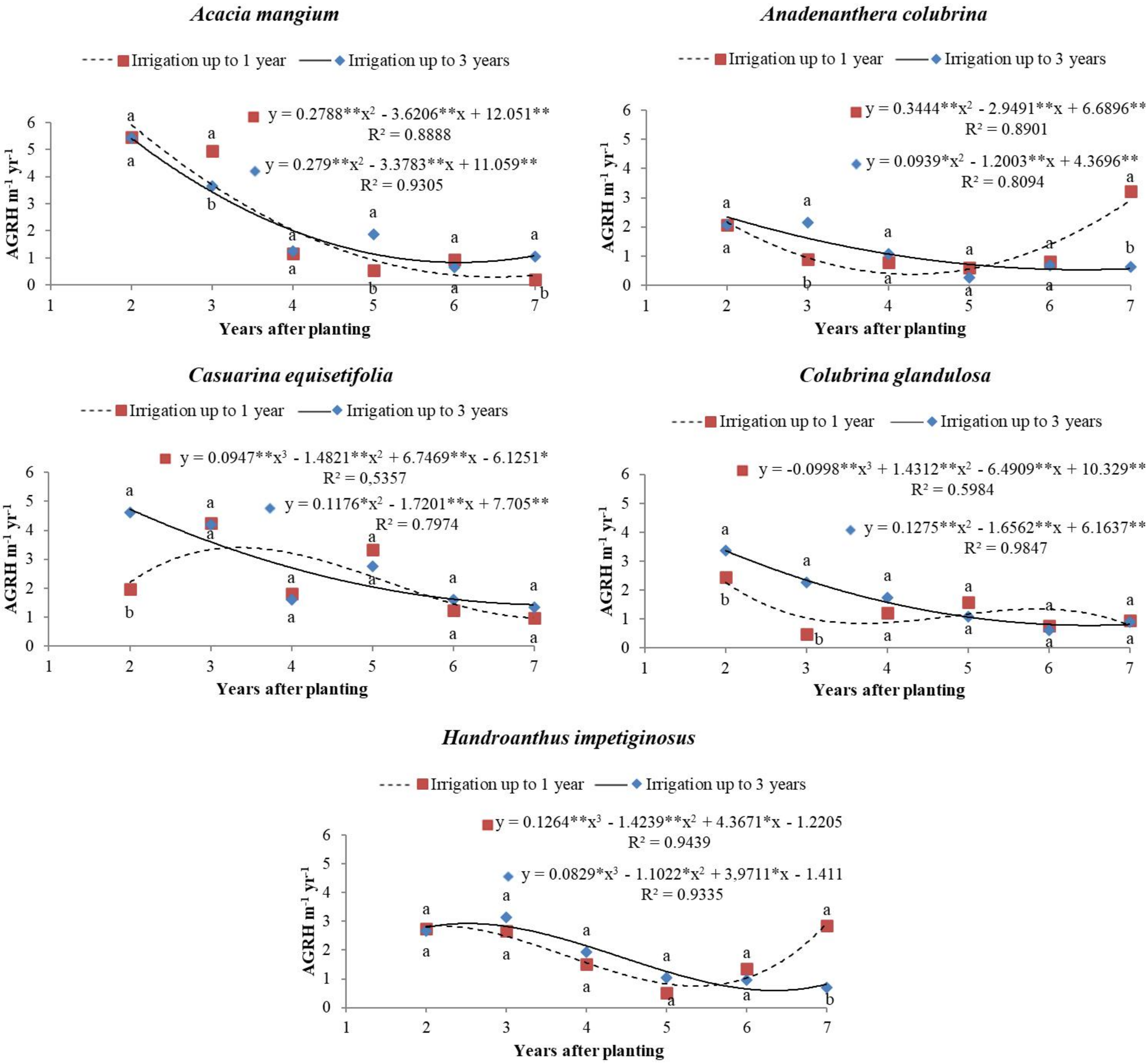
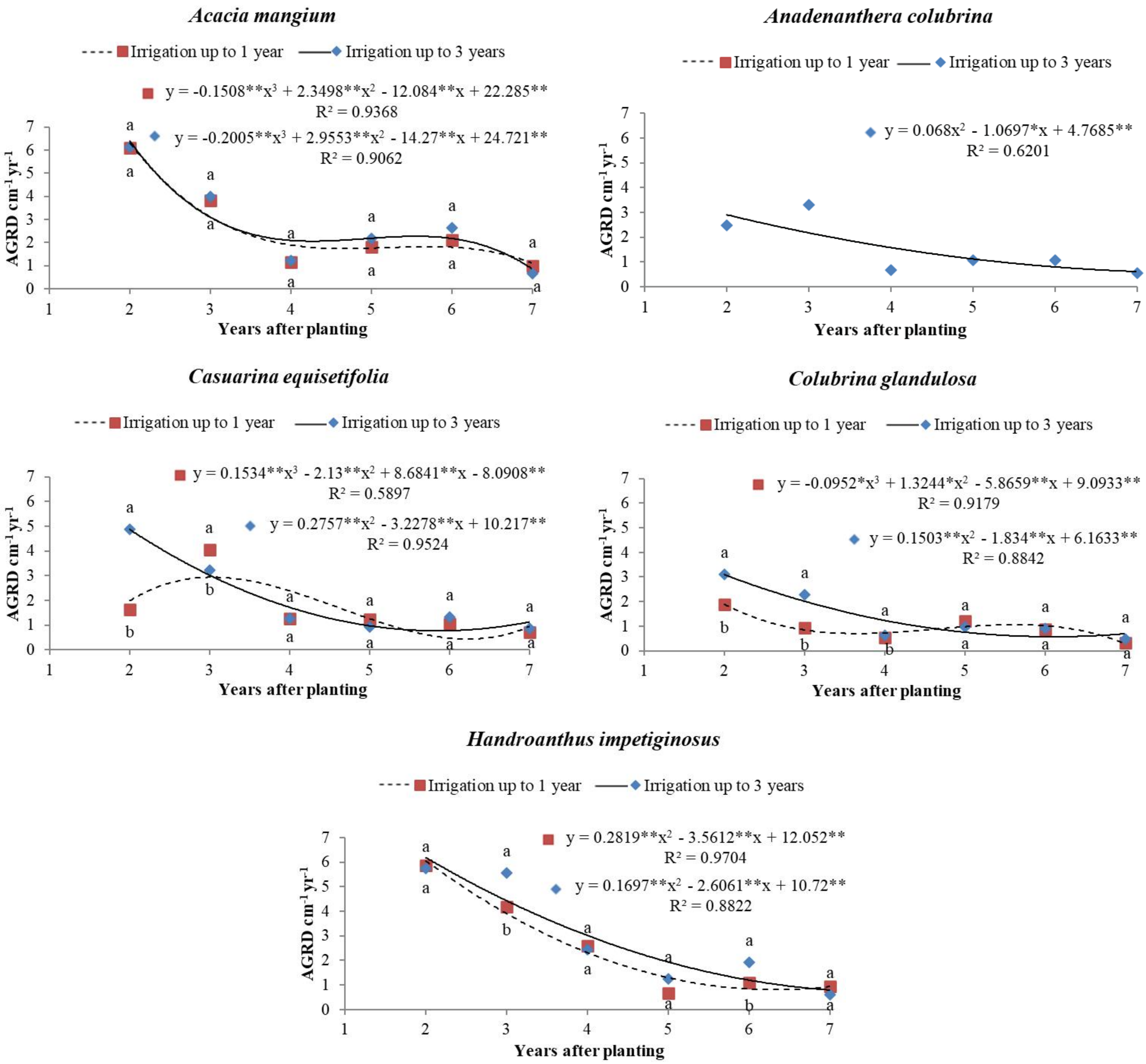


Figure 5 - Absolute growth rate in DBH (AGRD) in five tree species grown for seven years under two irrigated regimes



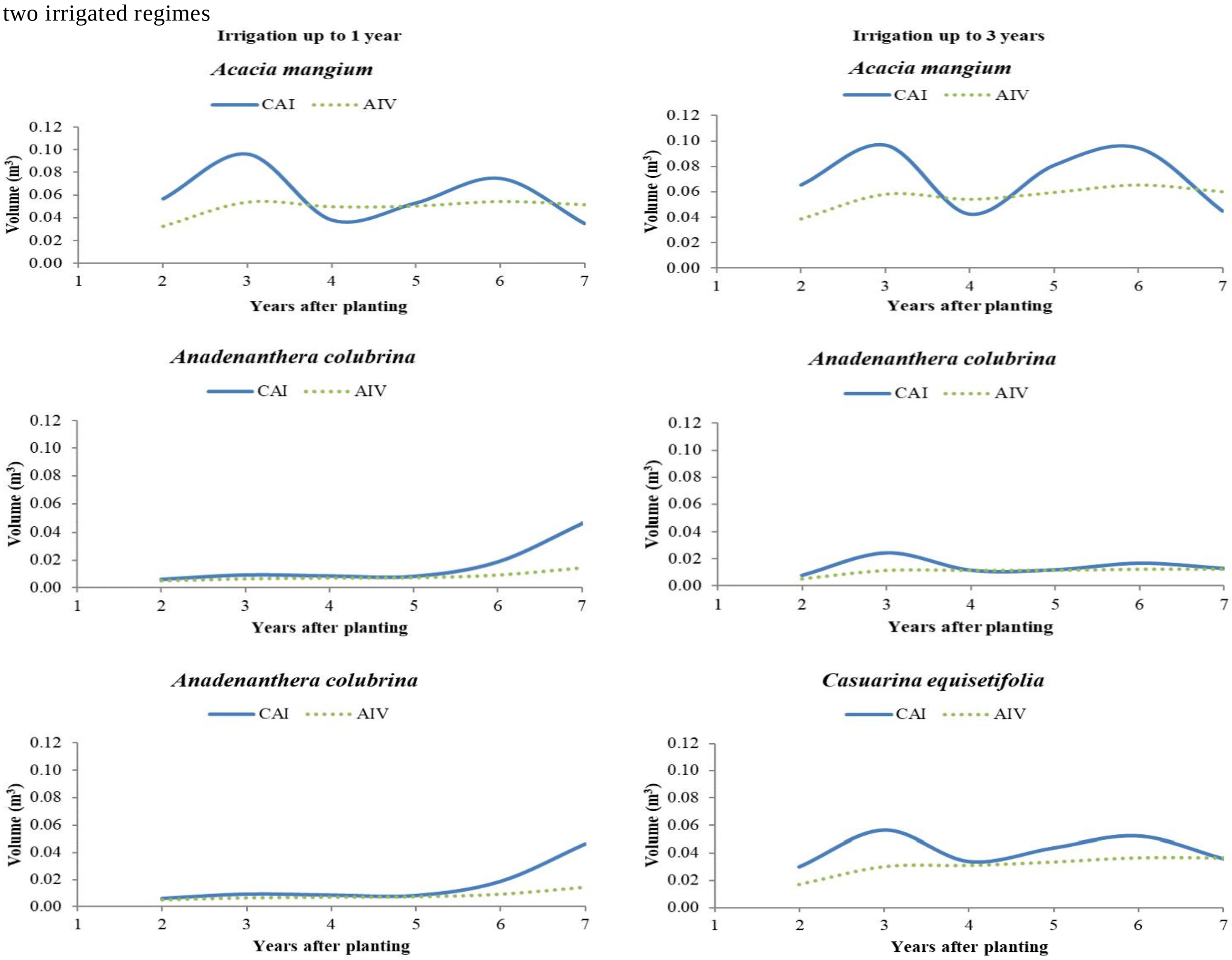
For the regression equations fitted for the AGRD of each species as a function of the evaluation period under each water regime (Figure 5), the fitted models were cubic (*Acacia mangium*, *Casuarina equisetifolia* and *Colubrina glandulosa*) and quadratic (*Handroanthus impetiginosus*) under the one-year irrigated regime, and cubic (acácia mangium), quadratic (*Casuarina equisetifolia*, *Handroanthus impetiginosus* and *Colubrina glandulosa*) and linear (*Anadenanthera colubrina*) under the three-year irrigated regime. The AGRD of the species during the seventh year ranged from 0.32 (*Colubrina glandulosa*) to 0.98 cm^{-1} yr^{1} (acácia mangium) under the one-year irrigated regime and 0.49 (*Colubrina glandulosa*) to 0.86 cm^{-1} yr^{-1} (*Casuarina equisetifolia*) under the three-year irrigated regime.

The reduction in absolute growth rate in total height and DBH of each species over the initial years is possibly associated with greater density at the start of planting, which ended up generating competition between the plants, so that after the selective thinning carried out in the fourth year, there is a slowdown, and in some cases a resumption of growth during subsequent years. This suggests that space for the growth of each tree had expanded, affording greater plant growth and development (Figure 4 and 5). Ferreira *et al*., (2014) observed that spacing is one of the variables to affect the growth of a tree population. Leles *et al.* (1998) and Oliveira Neto *et al*. (2003) report the effect of density and the ability to generate a high level of competition between plants in a stand of eucalyptus at different plant spacings. Furthermore, according to Leles *et al*. (1998), in denser plantations, the effects of water deficiency on the plants can be heightened, reducing the productivity of the forest due to intense competition between species for water, nutrients, light and space. In addition, other studies monitoring growth reveal that individuals of the same tree species can present relatively long periods with low growth rates and, sometimes, a total interruption in growth for several months or years. This interruption may continue for a period that can vary between species and years, but above all depends on the vigour of the tree (Détienne, 1989).

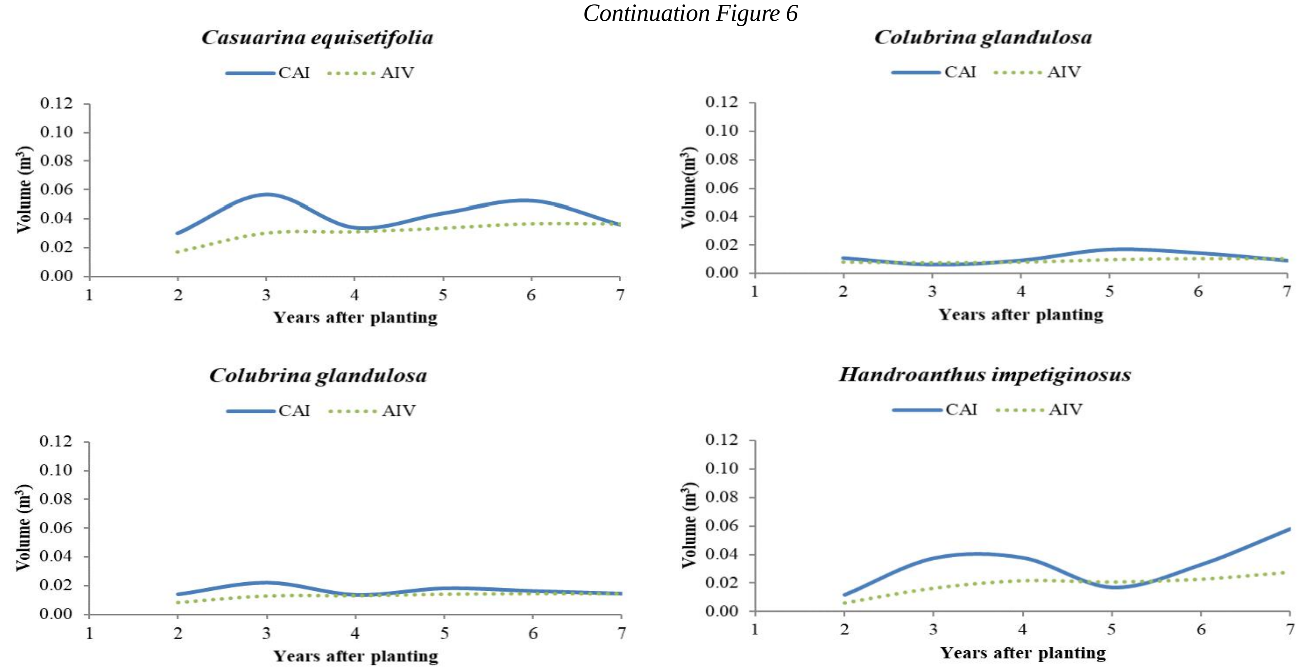
Despite a reduction in absolute growth rate in total height and DBH of each species over the years (Figures 4 and 5), the rates remained positive, and growth in height and diameter did not stop, as can be seen in Figures 1 and 2. It should be noted that in addition to environmental factors, the high variation in the growth rates of the trees over time is also related to genetic factors.

Figure 6 shows the data on current annual increase (CAI) and average increase in volume (AIV) in the five species under study, grown for seven years under two irrigated regimes. In *Acacia mangium* and *Casuarina equisetifolia* under both regimes, and *Anadenanthera colubrina* under the three-year irrigated regime, a fall in the CAI can be seen after the third year, recovering after the fourth year, and showing a further fall from the sixth year onwards. In this case, the CAI was lower than the AIV during the fourth and seventh years for *Acacia mangium* and *Anadenanthera colubrina* and only in the seventh year for *Casuarina equisetifolia*. In *Handroanthus impetiginosus* irrigated for three years, there is also a fall in the CAI after the third year, with recovery only after the fifth year, again showing a fall after the sixth year; however, the CAI was only inferior to the AIV during the seventh year. Unusually for *Anadenanthera colubrina* and *Handroanthus impetiginosus* irrigated for one year, the CAI recovers after the fifth year, showing an apparent distance from the AIV, while in *Colubrina glandulosa*, the CAI recovered after the fourth year, the AIV being fairly close.

Figure 6 - Current annual increase (CAI) and average increase in volume (AIV) in five tree species grown for seven years under two irrigated regimes



Continuation Figure 6



The fall in CAI seen after the third year, and the recovery after the fourth or fifth year (Figure 8) suggest the same effect from densification on the absolute and relative growth rate in total height and diameter (figures 4 and 5). The higher density at the start of planting ended up generating competition between the trees; after carrying out selective thinning in the fourth year, the space for each tree increased, affording greater growth and development. However, the fall in CAI seen after the sixth year may be evidence of competition between the individuals, and also due to the average rainfall being lower than expected for the region (Table 1). The beneficial effect of thinning on tree growth was observed in other studies (Jardim and Soares, 2010). However, as found in this study, those authors report that the beneficial effects of timber harvesting tend to disappear over time. Sousa *et al*. (2015), in a study carried out at Fazenda Rio Capim Farm in the Forest Management Area in Paragominas, Pará, found that these effects lasted for only three years following exploitation of the forest. The CAI exceptionally distancing itself from the AIV in *Anadenanthera colubrina* and *Handroanthus impetiginosus* irrigated for one year is associated with the fact that selective thinning, albeit less common, afforded higher growth rates in total height (Figure 4 and 5), with a direct influence on the increase in estimated volume.

CONCLUSION

1. The growth rates remained positive throughout the seven years of the plantation;
2. After seven years, the highest growth averages were recorded for *Acacia mangium*, followed by *Casuarina equisetifolia*, *Handroanthus impetiginosus*, *Anadenanthera colubrina* and *Colubrina glandulosa*;
3. The CAI and MAI for volume demonstrated the need to carry out another selective thinning at seven years for all cases, with the exception of *Anadenanthera colubrina* and *Handroanthus impetiginosus* under the one-year irrigated regime;
4. The average values for volume confirm that the species under study can be planted under any of the water regimes; as such, a one-year irrigated regime is suggested for the cultivation of these species in the Irrigated Perimeter of Baixo Acaraú, Ceará.

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