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Evaluation of Growth *Cedrela odorata* L. in a Secondary Vegetation Area

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Abstract: The aim of this investigation was to evaluate the survival and rates of growth of trees in a four years old *Cedrela odorata* plantation in Southern Mexico. In Mexican tropical forest the rate of deforestation in this area exceeds 2 %. In the state of Campeche plantations amount 156 ha (125,480 trees) has been established from 2005 to 2007. In the Cristalina, Carmen, Campeche a plantation of *Cedrela odorata* amount 0.75 ha was established in this period. In 2009 the survival and growth of tress of 2, 3 and 4 years old were evaluated. From each parcel of 50×50 m^2 30 trees were selected randomly to measure height, diameter and survival by year of plantation. The data were analyzed as random blocks with three replications. The survival rate was 43.7% for two years old and 47% for those of three years old and above. The growth average is from 3.24 to 7.27 m $year^{-1}$ and the diameter increase from 3.58 to 13.13 cm $year^{-1}$. From this data it is concluded that *Cedrela odorata* is adequate for reforestation.

Key words: Reforestation, rate of survival, vegetation growth, tropical plantations

INTRODUCTION

The deforestation of tropical forest is one most important problems that the world faces today (Affendy *et al*., 2009; Reyer *et al*., 2009; Ceccon and Miramontes, 2008). The principal causes of deforestation are the human activities like mining, livestock expansion and agriculture (Nkongolo and Pallssmeyer, 2010; Podeh *et al*., 2009; Ying-Qiu *et al*., 2001; Confalonieri, 2000). This last one is considered like a major cause of the fragmentation of tropical forest in Latin America and is the most principal menace for biological diversity (Sierra, 2000; Dale *et al*., 2001; Mendoza and Dirzo, 1999).

Mexico does not escape to this tendency; the rates of annual deforestation in this country exceed the 2% (Durand and Lazos, 2004). However, the government is looking the communities that use the wood from forest for subsistence implementing new projects of silviculture that can reduce the impact in rates of deforestation at national level (Dornelas and Rodriguez, 2006; Alix-Garcia *et al*., 2005) these projects include propose however this process requires relatively long time sees such as carbon capture and commercial use of wood (Rämö *et al*., 2009). The main idea of the projects is the fact that the degradation of forest through can be reversed by secondary succession of vegetation (Leigh *et al*., 2004; Guevara *et al*., 2004) however, this process requires relatively long time (Pedraza and Williams-Linera, 2003).

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The establishment of plantations is considered like a tool for the restoration of degreed areas with their positives effects on the structure, microclimate, soil and vegetation; several studies has shown that by repopulation and plantations species that previously disappear in rainforest areas can appear eventually (Martinez *et al*., 2009). In Mexico 50,000 ha year^{-1} were reforested between 1985 and 1990 with restauration proposes and for the 1998-1999 the reforestation was incremented between 203,000 and 225,000 ha year^{-1}. However, the survivals rates of seedlings are were low between 34-54% (Pedraza and Williams-Linera, 2003).

The deforestation rates in the country are continuously incremented. In the period between 2000 and 2005 was estimated a deforestation area of 314,000 ha year^{-1}. In 2007 and 2008 250 and 280 millions of trees were planted, covering an area of 250,000 and 280,000 ha year^{-1}. This numbers area lower than the deforestation area in the country (Affendy *et al*., 2009).

Cedrela odorata is a specie that has winning a lot of importance for reforestation by its easy propagation and fast grown, it can be grown in subtropical forest to tropical-wet or seasonally dry, it is found in latitude from 26°N in Mexico Pacific coast, Central America and Caribbean Also grows in latitudes of 28°S in the South America mountains foot in altitudes of 1200 m width: This tree can be found forming colonies or as aisled trees, which gave them an added value to the high quality of wood (Gonzalez-Rivas *et al*., 2009) compared with pure plantations, the survival and grow in agroforestry are betters (Gyimah and Nakao, 2007; Navarro *et al*., 2004).

In Carmen, Campeche, Mexico since 2003 government implemented a reforestation program using *Cedrela odorata.* In 2006 an area of 156 ha were reforested with 124,800 plants. The survival rates reported a national level (Martinez *et al*., 2009). That match with the registries dates to national level in Mexico. There it is not information about the growth of *Cedrela odorata* in Campeche either in natural forest or in commercial plantations. The objective of this study was to evaluate growth parameters height and diameter in *Cedrela odorata* plantations in trees of 2, 3 and 4 years old.

MATERIALS AND METHODS

This investigation was realized in plantations of forest enrichment of *Cedrela odorata* of two, three and four years old sown in 2007, 2006 and 2005, respectively. The Cristalina, Carmen, Campeche, Mexico, inside Laguna de Terminos Flora and Fauna Protected area. The height is 10 m a.s.l, the climate is warm-humid and a range of medium temperature from 25°C to 33°C and relative humidity of 83%, the precipitation is superior to 1600 mm, in summer and winter with a dry station of 4 to 6 months. The plantation was established in three squares one for each year, in squares of 50 by 50 m, the percentage of survival of trees with two years old were evaluated for each of the three years of plantation in 2009. By square 10 trees were selected for the measurement of height and 10 for the measurement of diameter and the amount 90 trees in total, 30 for each year of plantation. The trees were georeferenced with a GPS and marked with enamel paint, identifying each tree with a sequential number. The diameter was measured at 1.3 m from the base of the tree with a digital king foot. The height and diameter were used to evaluate the growth of the tree. The experimental design was blocks to random with 3 repetitions and a variance analysis was performed to the data.

RESULTS

The statistical analysis shows that significant differences exist for the height growth variables (Table 1). The statistical analysis shows that significative differences exist for diameter of the trees (Table 2). In Table 3, it is observed that diameter of the trees varies from

Table 1: ANOVA for the growth in height of trees of *Cedrela odorata* in different ages

Source	df	SS	MS	F-value	p-value
2 years					
Effect	2	2.863	1.431	0.48	0.673
Error	2	5.905	2.952		
Total	4	8.768	4.383		
3 years					
Effect	1	0.881	0.881	0.399	0.641
Error	1	2.205	2.205		
Total	2	3.086	3.086		
4 years					
Effect	2	7.882	3.941	31.53	0.124
Error	1	0.125	0.125		
Total	3	8.007	4.066		

Table 2: ANOVA for the growth in diameter of trees of *Cedrela odorata* in different ages

Source	df	SS	MS	F-value	p-value
2 years					
Effect	3	14.604	4.868	1.43	0.321
Error	6	20.316	3.386		
Total	9	34.920	8.254		
3 years					
Effect	5	5.449	1.089	3.92	0.105
Error	4	1.111	0.277		
Total	9	6.560	1.366		
4 years					
Effect	3	17.281	5.760	2.00	0.214
Error	6	17.234	2.872		
Total	9	34.515	8.632		

Table 3: Mean growth in height and diameter in *Cedrela odorata* of 2, 3 and 4 years old

		Growth in height (m year^{-1})			Growth in diameter (cm year^{-1})		
Ages (years)	Survival (%)	Range	Mean	SD	Range	Mean	SD
2	43.7	3.0-6.8	3.24a	1.11	3.58-6.21	4.83	0.72
3	47.0	4.3-8.1	4.99ab	1.51	4.38-8.62	6.09	0.91
4	47.0	5.8-12.1	7.27b	1.28	5.79-13.13	9.04	1.68

3.58-6.21 cm for 2 years old, 4.38 to 8.62 cm for 3 years old and 5.79-13.13 cm in trees of 4 years old. The increment in average for diameter was 4.83, 6.09 and 9.04 cm year^{-1}. A minimal and maximum growth in height of 3 and 6.8 m for 2 years old, 4.3 and 8.1 m for 3 and 4 years old trees with a minimum of 5.8 to 10.8 m, but there are three plants with a height of 12.1 m. The height increment in average for the trees of 2 to 3 years old was 3.05 m and for the trees of 3 to 4 years old was 3.58 m. The survival range, for the trees with 2 years old it was of 43.7% with a maximum of 47%. However, some of these trees showed tearing on branches and break on the stem by wind effect that.

DISCUSSION

The results show that the rates of survival in the plantations are lower that those found by others authors for *Cedrela odorata* in Mexico for reforestation of diverse species 57% (Moreno-Casasola *et al*., 2009).

Due to the low rate of survival in the 2 initial years after plantation are critical for the establishment of the plantations, a careful management of space, nutrients, competence with other plants and the attack from defoliating insect and to the bark must be applied to increase the rate of survival (Ewel and Mazzarino, 2008; Wilson *et al*., 2007). A capacitation and economic and technical support for management. Despite of the problems plantations in the

tropic represents an alternative for restoration of degraded lands forest owners (Zhang and Owiredu, 2007) and this practices is considered a substantial improvement of sustainable management of plantations in the tropics (Blay *et al*., 2008).

The results found about the growth of *Cedrela odorata* shows that it can be adapted to adverse growth conditions such as that found in the experimental place the lack of water for long periods and other unfavorable conditions of the site that put the trees on stress as mentioned by Dünisch *et al*. (2003) and Affendy *et al*. (2009).

The average growth in height of *Cedrela odorata* trees for 2 years (3.24 m) and 3 years old (4.99) in this study were similar to that reported for Mexico and in the world (75-2.5 m for 2 years old trees) (Navarro *et al*., 2004; Ward *et al*., 2008; Wightman *et al*., 2008). Meanwhile, this growth numbers in diameter 4.83-6.09 cm with an average increment of 1.26 cm year^{-1} for 2 and 3 year old in this study are minors to the registries for Garcia *et al*. (2008), whose reported values of 3.33 cm and for 2 and 3 years old trees was 5.17 cm with an increment average of diameter of 1.84 cm year^{-1} values that are higher to that reported in this research. For ages of 3 and 4 years old the results showed a tendency to increase and are similar to those reported to the fore mentioned authors. The results for the 3 to 4 years old trees are similar to that reported by Menalled *et al*. (1998), Piotto *et al*. (2004) and Erskine *et al*. (2005) in different climatic conditions.

The results found about the growth of *Cedrela odorata* shows that it can be adapted to adverse growth conditions such as that found in the experimental place the lack of water for long periods and other unfavorable conditions of the site that put the trees on stress as mentioned by Dünisch *et al*. (2003) and Affendy *et al*. (2009).

CONCLUSIONS

In the state of Campeche the establishment of plantations is an incipient activity despite the fact that plantations of *Cedrela odorata* as is a commercial specie for production of wood world wide. This study shows that the rates of growth are similar that those founds worldwide. However, it is necessary to improve the management of the plantations to increase the survival rates and the capacitation of the forest owners for a better management of the plantations. Studies of commercial plantations is necessary to evaluate the economic return of this activity.

However, the species is adopt and grows for that is necessary envelopment an appropriate and attractive management plan for the small producers in view of agroforestry sustainable management of tropical forest.

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