

Growth Traits of *Toona Ciliata* under Different Fertilization Levels in Guangdong Province*

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Abstract

Toona ciliate, which belongs to *Toona* of *Meliaceae*, is a rare and native timber species in China. However, little progress has been made in the cultivation of *Toona ciliate*. The height and diameter at breast height of *Toona ciliata* were assessed for fertilization cultivation techniques aged 1 year. Analysis of variance showed that there were significant differences on height among different treatments and replicates and the difference on diameter at breast height among different replicate was also significantly. Treatment with 200 g urea (N > 46.5%) + 60 g superphosphate (P₂O₅ > 12.0%) + 100 g potassium chloride (K₂O > 60.0%) could improve the height and diameter at breast height of *Toona ciliate*. In summary, more fertilizer could not always improve the growth traits and the site location could affect the growth significantly, therefore more test trials should be carried out before diffusion.

Keywords: Precious Species; Nitrogen Fertilizer; *Toona Ciliata*; Growth Traits

1 INTRODUCTION

According to the seventh forest assessment, China's forest covers 195 million hectares, about 20.36 percent of the land area. China has become a leading country in the production, consumption, import and export of forest products in general, and the total output value of forestry sector in China, which reached US\$180 billion in 2007, has developed rapidly along with the overall growth of the national economy (Ma *et al.* 2009; FAO 2009; Wu *et al.* 2015). However, the dependence on import of timber has reached 50%.

Toona ciliate, which belongs to *Toona* of *Meliaceae*, is a rare and native timber species in China while it also has been listed in Red Book of China Plant and became the national second class endanger species because of the human activity, biological characteristics and environment and so on (Xie 2010; Liang *et al.* 2011; Wu *et al.* 2015). *Toona ciliate* distributed from 24°21' N to 30°31' N and 100°16' E to 119°40' E, mainly including Guangdong, Guangxi, Fujian, Sichuan, Jiangxi, Guizhou and Yunnan provinces (Wu *et al.* 2014; Wu *et al.* 2015).

Silviculture traditionally focused on various aspects of tree planting, such as tree selection, site selection, site preparation, regeneration methods and fertilization and so on, and the role of silviculture at that time was to manage forests scientifically for continuous production of goods and services while meeting biological and economic requirements (Endo 2003; Goncalves *et al.* 2004; Mead 2005). Fertilization is an essential practice in plantation forestry and is implemented to increase growth, shorten rotation times and maximize profits. For one thing, the application of fertilizer could increase leaf nitrogen and phosphorus concentrations and photosynthetic rates. For another, the soils available for plantations in south China are generally lateritic and lateritic red earths which are acidic in reaction, highly leached, generally heavy in texture and deeply weathered (Lin *et al.* 1999; Xu and Dell 2002), with nitrogen, phosphorus, potassium, and copper deficiencies being relatively widespread.

In general, there are relatively few reports on fertilization of *Toona ciliate*. The published paper for *Toona ciliate*

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only concentrated on protection strategies (Liang, 2011), propagation (Wu 2011) and cultivation techniques (Cheng and Cui 2010). Therefore, fertilization research of *Toona ciliata* should be carried out.

The objectives of this study were to: (1) compare growth traits of different fertilization level, (2) analyze the variance among treatments and replicates, (3) explore the implications and techniques for *Toona ciliata* improvement. This information will be used to develop appropriate cultivation strategies for *Toona ciliata* protection and utilization in China.

2 MATERIAL AND METHODS

2.1 Trial Description

The trial was established at Shuangshui town of Xinhui City (22°33'N, 113°02'E, 45m asl), and is affected by the south subtropical monsoon with annual mean temperature of 19.9 to 22.3°C and annual mean rainfall of 1750 to 1800mm. There is not frost period and average annual mean accumulated temperature is 7653°C.

2.2 Methods Description

The fertilizer of urea (N > 46.5%), superphosphate (P₂O₅ > 12.0%) and potassium chloride (K₂O > 60.0%) were used for N, P and K. The details of level are presented in Table 1.

TABLE 1 THE DETAILS OF LEVEL OF FERTILIZER

Level	N (g)	P (g)	K (g)
1	200	30	50
2	400	60	100
3	600	90	200

All *Toona ciliata* were planted in May 2013 and were tested in November 2014. The field design was randomized block with 2×3m spacing while four rows were designed as one treats. Planting pits (50cm×50cm×40cm) were prepared for individual tree. The height of families (H) was measured by ruler, and the diameter at breast height (DBH) was measured by calipers. The details of treatment are presented in Table 2.

TABLE 2 THE DETAILS OF TREATMENT OF FERTILIZER

Treatment	N (g)	P (g)	K (g)
1	200	30	50
2	200	60	100
3	200	90	200
4	400	30	100
5	400	60	200
6	400	90	50
7	600	30	200
8	600	60	50
9	600	90	100
10(CK)	0	0	0

2.3 Statistical Analysis

The significance of fixed effects was assessed using F-tests. Meanwhile, the analysis of variance was performed using the PROC ANOVA.

$$y_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij} \quad (1)$$

where y_{ij} is the performance of the ramet of i^{th} treatment within the j^{th} replicate, and μ is the general mean, α_i is the random effect of the i^{th} treatment, β_j is the random effect of the j^{th} replicate, ε_{ij} is the random error.

3 RESULTS AND DISCUSSION

The productivity of the most forest plantations is less than their physiological potential as defined by the prevailing climate, because the supply or capture of light, water and nutrients is less than optimal (Goncalves *et al.* 2004).

Therefore, dramatically increasing growth of *Toona ciliate* can be improved by application of fertilizer as basal fertilizer after plantation establishment. The analysis of variance of studied traits among treatments and replicates is presented in Table 3. The results showed that there were highly significant differences on height among treatment and replicate with 4.70 to 12.32 of F value, indicating the treatment and replicate could affect the growth. Meanwhile, the difference among replicate on DBH was also significant. However, there were not significant differences on DBH among treatments, indicating the near growth speed on DBH.

TABLE 3 ANALYSIS OF VARIANCE OF THE STUDIED TRAITS WITH DIFFERENT TREATMENT AND REPLICATES

Trait	Type	DF	F Value	Pr>F
H	Treatment	9	4.70	<0.0001
	Replicate	4	12.32	<0.0001
DBH	Treatment	9	1.49	0.1525
	Replicate	4	6.27	0.0023

3.1 Differences among Treatments in Growth

The growth traits among different treatments are presented in Figure 1. The results indicated that height and DBH had different responses to the same treatment. For height, *Toona ciliate* had faster growth under treatment 2 and 3, ranging from 1.7 to 2.0 m whereas treatment 1 had the least effect for height, implying 200 g urea ($N > 46.5\%$) + 60 g superphosphate ($P_2O_5 > 12.0\%$) + 100 g potassium chloride ($K_2O > 60.0\%$) and 200 g urea ($N > 46.5\%$) + 90 g superphosphate ($P_2O_5 > 12.0\%$) + 200 g potassium chloride ($K_2O > 60.0\%$) could improve the growth of *Toona ciliate*. It is interesting to find that the treatment 10 (ck) even had better effect for growth than treatment 1.

For DBH, *Toona ciliate* had faster growth under treatment 2 and 8, ranging from 2.7 to 3.0 m whereas treatment 9 had the least effect for height, implying 200 g urea ($N > 46.5\%$) + 60 g superphosphate ($P_2O_5 > 12.0\%$) + 100 g potassium chloride ($K_2O > 60.0\%$) and 600 g urea ($N > 46.5\%$) + 60 g superphosphate ($P_2O_5 > 12.0\%$) + 50 g potassium chloride ($K_2O > 60.0\%$) could improve the growth of *Toona ciliate*. The treatment 10 (ck) even had better effect for growth than treatment 9. It is interesting to find that the treatment 2 had the best effect for growth both height and DBH even though with least urea ($N > 46.5\%$), middle superphosphate ($P_2O_5 > 12.0\%$) and middle potassium chloride ($K_2O > 60.0\%$), probably due to the interaction between different element. In addition, treatment 2 and 9 generally had the least effect for growth both height and DBH.

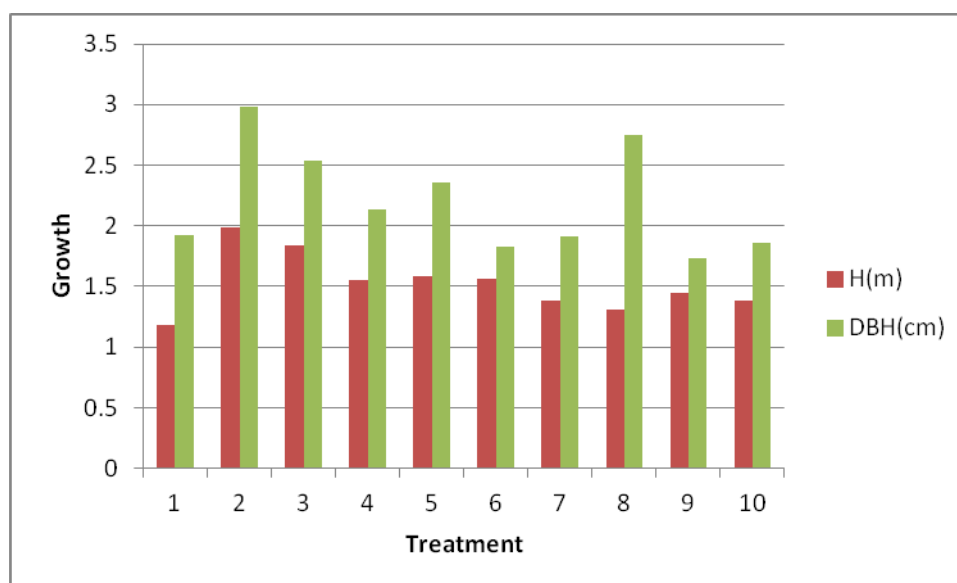


FIGURE 1 GROWTH TRAITS AMONG DIFFERENT TREATMENT

3.2 Differences among Replicates in Growth

The growth traits among different replicates are presented in Figure 2. As described by analysis variance, the growth

traits among different replicates were all significant, implying the site location could affect obviously the growth traits. Generally speaking, the third replicate had the highest growth both on height and DBH while the first replicate had the least growth on studied traits. And the first and second replicates had less growth than third, fourth and fifth replicates, probably due to the worse land capability.

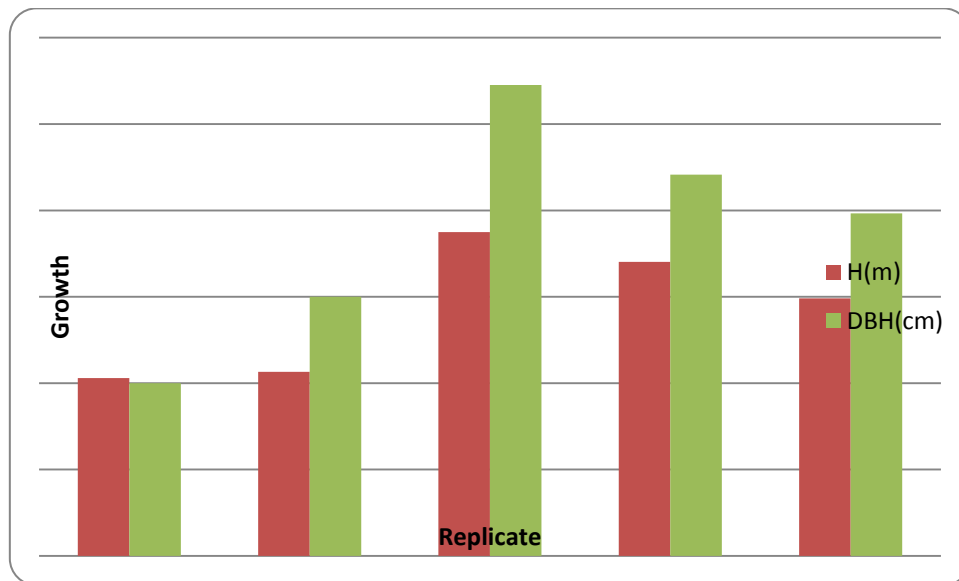


FIGURE 2 GROWTH TRAITS AMONG DIFFERENT REPLICATE

3.3 Major Conclusions and Implications for Breeding Programs

In the present study, the variance and difference among treatments and replicates were examined. Joint analysis in the present study showed three implications for tree improvement in *Toona ciliata* in China. Primarily, more fertilizer could not always improve the growth traits. Secondly, the site location could affect the growth significantly and more test trials should be carried out before diffusion. Furthermore, treatment 2, 200 g urea ($N > 46.5\%$) + 60 g superphosphate ($P_2O_5 > 12.0\%$) + 100 g potassium chloride ($K_2O > 60.0\%$), had the best effect for growth traits.

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