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Research Article

Leaf Trait Related to Growth in 61 *Catalpa bungei* Clones

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Abstract: In order to clarify the relationship of leaf characteristics and growth of *Catalpa bungei* and provide a theoretical basis for clone selection in *Catalpa bungei*, the growth and leaf morphology characteristics of 61 *Catalpa bungei* clones were studied. The results showed that significant variances were found in leaf length, width, width/length, leaf stalk length, specific leaf mass, Diameter at Breast Height (DBH) and height among 61 clones. Leaf length, width and leaf stalk length were positively correlated with each other. Leaf length and leaf stalk length were positively related to DBH and height and leaf width was positively related to height. This suggests that leaf morphological indices, such as leaf length, leaf stalk length and leaf width, can predict the tree growth for *Catalpa bungei* clones, which would be helpful for clonal selection in future.

Keywords: *Catalpa bungei* clones, growth, leaf traits, variation coefficients

INTRODUCTION

Catalpa bungei, belonging to the family *bignoniaceae*, genus *catalpa* is usually known as "the king of trees", with valuable timber and famous ornamental tree species endemic to China (Pan *et al*., 1991; Tang *et al*., 2007). *Catalpa bungei* is widely distributed in China due to its strong adaptability such as high survive rate and fast growth rate. The high-quality plummy timber harvested from *Catalpa bungei* can meet the large domestic needs for advanced timber (i.e., superfine wood) (Qiao *et al*., 2003).

Leaf, one of the most critical assimilation organs of the plant, influences the productivity of the plant. Leaf traits play a significant role in genetic improvement and strategy-making (Fernanda *et al*., 2002). Understanding variation of leaf traits for different clones may provide the basis for breeding and selection. The previous studies are mainly focused on the environmental driven factors, photosynthesis or fluorescence characteristics of *Catalpa bungei* clones (Wang *et al*., 2007; Wang *et al*., 2008; Wu *et al*., 2008; Zhao *et al*, 2012; Feng *et al*., 2012), while growth and physiology characteristics of *Catalpa bungei* is poorly understood, especially the uncertainties among clones. Therefore, the overall objective of this research is to 1) figure out the relationship of leaf characteristics and growth of *Catalpa bungei*, 2) provide a theoretical basis for clone choice in *Catalpa bungei*.

MATERIALS AND METHODS

The study site was located in Liangxi Village, Liangduo Town, Dongtai City, Jiangsu Province, P. R. China (120°21'04"N, 32°46'40"E). It was agricultural land before afforestation with flat terrain and medium fertility. Annual mean precipitation is 1044 mm and means temperature is 15.6°C. Frost-free period is about 237d. A dibble planting design (40 cm×50 cm) was applied to plantation. A completely randomized block design was used. Compound fertilizer (0.2 kg/m^2; N: P_2O_5: K_2O = 15: 15: 15) was applied before afforestation and stumping treatments were done after afforestation. Four replicates of each clone were randomly assigned to each block and one replicate composed of four individual plants (bareroot seedlings). The strain spacing was 3 m×3 m.

Methods: Measurements of total Height (H) and Diameter at Breast Height (DBH) were taken for each

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tree. Two individuals were randomly selected for each reduplication of each block, that was eight individuals of each clone, were chosen and the 3rd, 6th, 9th, 12th, 15th leaves on the longest main branch of the individual plant were systematically sampled for leaf traits measurement. And leaf Length (L), Width (W), width/length (W/L), Leaf Stalk Length (LSL) and specific leaf mass (SLW) were measured and calculated.

Analysis methods: One-way ANOVA was used to test the differences in leaf traits among clones. A linear regression model, regression equation Y = AX+B, was developed to clarify the relationships among the leaf traits. All data analysis were conducted with SPSS software version 18.0 (SPSS Inc., Chicago, Illinois, USA).

RESULTS AND DISCUSSION

Leaf length, width, W/L, leaf stalk length and SLW exhibited some variations for 61 clones, ranging from 14.66-25.05 cm for leaf length, 9.50-21.43 cm for leaf width, 0.58-1.06 for W/L, 12.00-22.63 cm for leaf stalk length and 83.92-158.22 g cm-2 for SLW, respectively. The average values were 19.81 cm for length, 16.21 cm for width, 0.82 for W/L, 16.92 cm for stalk length and 121.68 g cm-2 for SLW. Overall, the variability of leaf length, W/L and SLW [coefficient of variation (CV) = 13%] were smaller than that of stalk length (CV = 15%) or leaf width (CV = 16%). Meanwhile, significant differences ($p<0.01$) were found for each leaf trait index among 61 clones (Table 1).

Leaf length, width and leaf stalk length were positively correlated with each other among 61 clones (Table 2 and Fig. 1). The independent effects of leaf length and width on SLW were detected (Table 2 and Fig. 2).

DBH ranged around 1.38-3.35 cm, with the mean of 2.29 cm. Height ranged from 1.45-3.25 m, with an average of 2.32m. The variations of growth indices, with the CV of 0.19 and 0.18 for DBH and height, were larger than leaf trait indices. Similarly, significant differences were found for growth indices among 61 clones.

Leaf length and leaf stalk length were positively related to DBH and height and only leaf width was positively related to height (Table 2).

Leaf phenotypic variation in plant traits is an interesting topic in plant ecology (Smith *et al*., 2011). Polymorphism is accounted for leaf variation in many tree species, e.g., oaks (Aydin and MEhmet, 2003), birches (Jentys, 1937, 1955), sweetgum (Duncan 1959), aspens (Barnes, 1969), populus (Weber *et al*., 1985; Ceulemans *et al*., 1987). Leaf, as the main organ of the plant for photo-Length and length of leaf stalk:

$Y = 0.5674 x + 5.7002$, $R^2 = 0.3364$, $F = 29.9078$ $p<0.0001$

Width and length of leaf stalk: $Y = 0.5458x+7.8837$, $R^2 = 0.3929$, $F = 38.1888$ $p<0.0001$

Length and SLW: $Y=2.4623x+73.2668$, $R^2 = 0.1622$, $F = 11.4186$ $P = 0.0013$

Width and SLW: $Y=1.8673x+90.9824$, $R^2 = 0.1177$, $F = 7.8728$ $P = 0.0068$

Synthesis, respiration and transpiration, is an energy converter of the primary producers in the ecosystem (Zhang and Luo 2004). In this study, significant differences were detected for each leaf trait index among 61 *Catalpa bungei* clones. Moreover, the variability in leaf length, W/L and SLW were smaller than that in stalk length or leaf width, indicating that leaf length, W/L and SLW are more stable. Leaf stalk length, leaf length and width were positively correlated among 61 clones. SLW was independently influenced

Table 1: The variation and ANOVA for leaf traits and growth index for 61 clones

	Length cm	Stalk length cm	Width cm	W/L	SLW g cm^{-2}	DBH cm	Height m
Max	25.05	22.63	21.43	1.06	158.22	3.35	3.25
Min	14.66	12.00	9.50	0.58	83.92	1.38	1.45
Ave	19.81	16.92	16.21	0.82	121.68	2.29	2.32
Std	2.52	2.46	2.65	0.10	16.26	0.43	0.41
CV	13	15	16	13	13	19	18
F	4.46	3.29	6.80	8.27	5.85	5.36	4.89
p	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 2: Correlation values for leaf trait and growth index for 61 *Catalpa bungei* clones

	Length of stalk	Width	L/W	SLW	Diameter	Height
Length	0.592**	0.654**	-0.166	0.351**	0.438**	0.508**
	0.000	0.000	0.201	0.006	0.000	0.000
Length of stalk		0.615**	0.020	0.262*	0.439**	0.451**
		0.000	0.118	0.041	0.000	0.000
Width			0.632**	0.313*	0.242	0.304*
			0.000	0.014	0.060	0.017
L/W				0.046	-0.119	-0.095
				0.725	0.360	0.465
SLW					0.115	0.119
					0.378	0.362
Diameter						0.860**
						0.000

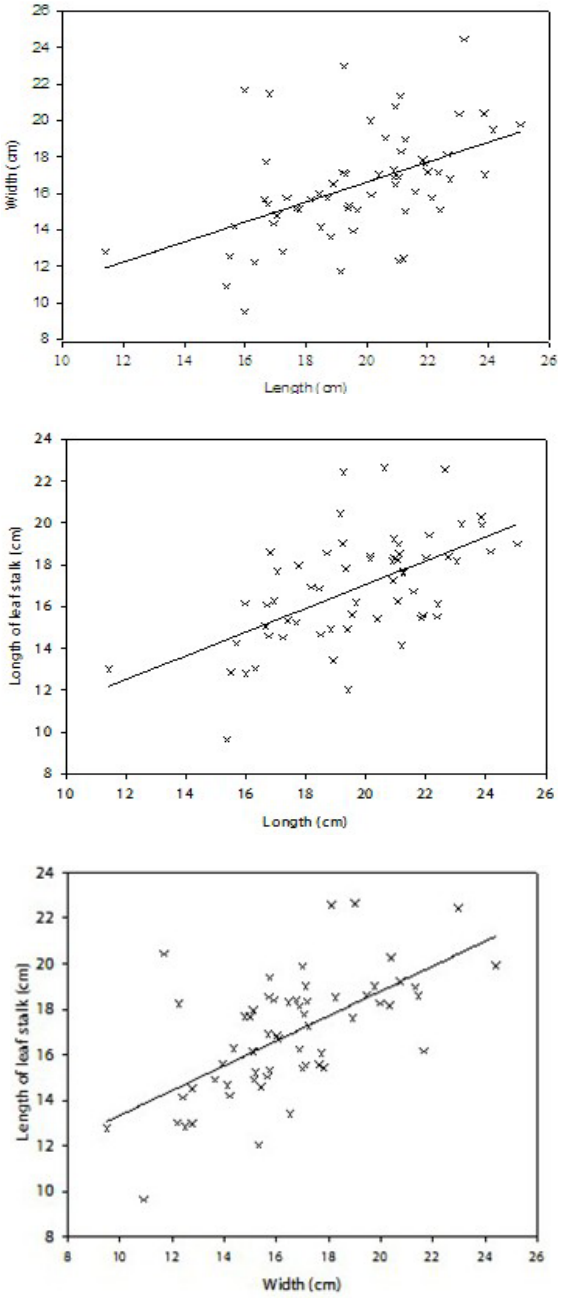

Fig. 1: Linear regression models of leaf traits

by leaf length and width because of the change of single leaf area.

Differences in phenotypic expression are regulated by the interaction of genotype and environment (Barnes, 1969). Variations across the clones in respectto the relationship of leaf width, leaf length to height and DBH are probably responsible to the development of the respective ramets of clones. The crown class of the ramet, length of the leaf-bearing short shoot and the relative position of the leaf on a twig may also be important factors that affect the leaf traits. In this study, a large clonal diversity was

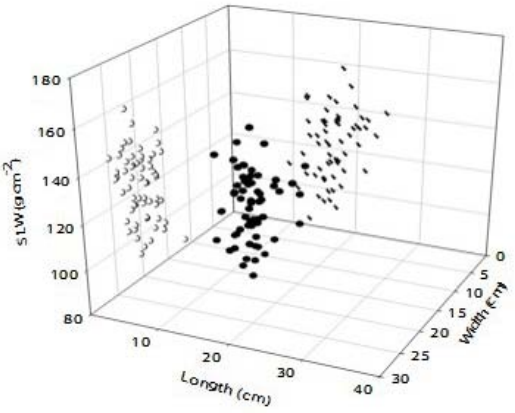

Fig. 2: Relationships among leaf length, width and SLW

observed for growth indices and leaf traits of *Catalpa bungei* clones, which was in agreement with earlier studies (Romain *et al*., 2005; Nicolas and Reinhart, 2006). Substantial clonal diversity in the traits allows selection efforts to focus on clones with desirable traits. The growth and development of leaf is correlated with the tree growth conditions (Westoby, 1998; Vendramini *et al*., 2002). Appropriate physiological traits are known to be good indicators of productivity, which can achieve improved genetically yield (Stettler and Ceulemans 1993; Bunn *et al*., 2004). Leaf stalk is related to biomass production indirectly through the improvement of light interception: longer leaf stalk has been shown to improve light interception because they decrease leaf aggregation and can support larger leaf laminas (Niinemets and Fleck 2002; Niinemets *et al*., 2004). Specific Leaf Weight (SLW) refers to the weight of the unit leaf area, a parameter measuring leaf photosynthesis performance, which reflects the ability of plants to adapt to the habitat and use of resources. Plants with high potential SLW are better able to adapt to the resources-scanty and arid environment, while plants with low value of SLW have strong ability of maintaining nutrition (Oren *et al*., 1986). As leaf length and width have independent effects on SLW from the former results, the adaptive capacity of *Catalpa bungei* could be visually determined by leaf phenotypic traits. To sum up, leaf length, leaf width, leaf stalk length and SLW could be good indicators of *Catalpa bungei* growth for different clones. More precisely, the ANOVA analysis showed that the leaf traits that contribute most strongly to growth indices were leaf length and leaf stalk length.

CONCLUSION

This study confirmed that leaf traits and growth indices display a large clonal variability among 61 *Catalpa bungei* clones. It demonstrated that the new individual generated by asexual propagation was able to maintain the improved inherent characteristics while significant variations were existed among clones. Furthermore, the previously formulated results support

the idea that leaf traits, such as leaf length, leaf width and leaf stalk length, can be indicators of seed breeding and selection and used for making silvicultural decisions.

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