PERFORMANCE BASED GENETIC VARIABILITY OF FOUR PAULOWNIA SPECIES AT PESHAWAR

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ABSTRACT

Fast growing deciduous Paulownia species have caught greater attention in afforestation and agroforestry programmes. A trial comprising four Paulownia species was conducted at the Pakistan Forest Institute, Peshawar, to asses the genetic variability based on growth parameters. These parameters such as tree height, diameter at breast height (DBH) and survival were assessed after one and two years of plantation. The results showed highly significant differences in the tested traits among the four species. *Paulownia catalpifolia* was top ranking followed by *Paulownia tomentosa*. The genotypic and phenotypic coefficients of variation were higher i.e. 23.43% and 24.36% for DBH. During the study of both years this trait also showed genetic consistency for these coefficients, broad sense heritability (0.93, 0.96) and genetic advance (2.62, 2.92). Based on these findings it is suggested that *P. catalpifolia* and *P. tomentosa* may be more appropriate in species improvement programme and for further field cultivation.

Key Words: Paulownia, genetic variability, heritability and genetic advance

INTRODUCTION

In Pakistan, forest resources are limited, it is therefore needed that maximum sustained quantity of woody raw material is produced within a reasonable period of time. With a parallel increase in food demand however, it is difficult to increase forest plantation area. A viable option is to increase forest productivity per unit area as well as reforestation programmes for wood production must be focused on the higher yield from existing forest resources. These objectives might be achieved by the introduction of suitable fast growing tree species. The Pakistan Forest Institute (PFI) has been endeavoring during the last four decades to introduce fast growing exotic tree species such as Eucalyptus, Poplar, Robinia, Ailanthus etc. Genus Paulownia being indigenous to China and having distribution between 22^{o} – 40^{o} N latitude and 100^{o} to 124^{o} E longitude (Anon., 1986) is one of such successful exotics which stepped ahead these efforts (Siddiqui and Khan, 1989). Its deciduous and fast growing characteristics have leaded its suitability for intercropping in agroforestry schemes (Khan, 1992). Paulownia timber at the age of 6-10 years is very light having low shrinkage coefficient, resistance to cracking as well as deformation. It is therefore, being used on mass scale in various forest based industries in China. On the basis of such valuable characteristics, PFI introduced promising Paulownia species in the country with a great scope of cultivation in 1980's (Siddiqui and Khan, 1989). Experiments have been conducted to study various aspects of these species.

Phoelman and Sleper (1995) reported high heritability, when genetic variation

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in a progeny was higher in relation to environmental variation and this high heritability due to greater genetic variation would result in more effective selection. They also explained that broad sense heritability estimates determine genetic advance for clonally propagated species. Chaudhary and Tewari (2006) reported that exploitation of genetic variability in the available plant material is essential for the success of any breeding programme. Heritability and genetic advance play an important role in indicating methodology of an improvement programme. Furthermore, it is desirable to screen the available genetic variation to access the variability in the species and to select best genotypes for adaptability and fast growth (Gera and Gera, 2006). Variations and their manifestation within tree species are due to heredity and environment. Growing progenies under uniform site and climatic conditions reduce the proportion of environmental variations facilitating selections for genetic variations. Selections for clonal variations are made for growth rate, adaptability and productivity and their differences make the proper selection of clonal material (Rawal and Nautiyal, 2008). Genetic diversity is the most important component of biodiversity and is foundation of ecosystem and forest sustainability (Hooda, *et al*. 2009).

The present study, therefore, was aimed at to assess coefficients of variation and broad sense heritability of various morphological traits of four Paulownia species, for species selection and for further field cultivation.

MATERIALS AND METHODS

The study was conducted at the Pakistan Forest Institute, Peshawar during March 2005 to March 2007. Four Paulownia species namely; *Paulownia tomentosa, Paulownia catalpifolia, Paulownia fortunei* and *Paulownia elongata* were selected for study on the basis of initial screening. The soil of this site is clayey loam with pH 7.5 (Sheikh, 1977). Clonal nursery of these species was raised from root cuttings. The root cuttings having 10-15 cm length were buried in sand for two weeks to initiate sprouting. These cuttings were planted in bed nursery at a spacing of 75 X 100 cm in Spring-2004. The canal water was the main irrigation source and nursery was irrigated weekly, however tube well water was also applied as required. Other nursery maintenance practices such as weeding and hoeing remained in progress round the year.

After one year the saplings were uprooted and their stumps were planted in pits of 30 cm diameter and 45cm deep by keeping planting space 3x4 m. To facilitate irrigation, pits were linked by trenches. The frequency of irrigation was maintained fortnightly during summer and on monthly basis during winter. Direct contact of irrigation water to stem was avoided by raising soil around it. Stumps of all species showed vigorous sprouting with 2-5 side shoots. All the side shoots were removed during November and December 2005 leaving the central straight and the healthiest one. Eradication of weeds was done three times and pruning was carried once in a year. The experiment was laid in randomized complete block design with five replications and plot size of eighty trees. The data on tree height, diameter at breast height (DBH) and survival were recorded after one year (2006) and two years (2007)

of planting. The data were analyzed applying 1-Way analysis of variance test using Minitab version 15.1 statistical software. The difference among the treatment was tested by applying Tukey's Honestly Significant Difference (HSD) test at p = 0.05. The genetic parameters i.e. genotypic coefficient of variation (GCV %), phenotypic coefficient of variation (PCV %), heritability (broad sense) and genetic advance were estimated following the methods as described by Poehlman and Sleper (1995).

$$GCV(\%) = \left(\frac{\sqrt{\sigma^2_g}}{\bar{X}}\right)x100$$

$$PCV(\%) = \left(\frac{\sqrt{\sigma^2_p}}{\bar{X}}\right)x100$$

$\sigma^2_e = MS_{(E)}$
$\sigma^2_g = (MS_{(spp)} - MS_{(E)})/r$
$\sigma^2_p = \sigma^2_g + \sigma^2_e$

Where

σ^2_e, σ^2_g and σ^2_p were estimates of environmental, genetic (species) and phenotypic variation respectively.

Heritability estimates were made using the components of variance computed from the analysis of variance as under:

$$h^2 = \sigma^2_g / \sigma^2_p$$

For convenience in estimation of heritability, an arbitrary scale described by Stansfield (1986) was followed.

High heritability > 0.5
Medium heritability = 0.2-0.5
Low heritability < 0.2

Genetic advance was computed at 20% selection intensity (i= 1.4) with following formula:
$GA = i\,\sigma^2_p\,h^2$
i = Selection intensity
σ^2_p = Standard error of phenotypic variance
h^2 = Coefficient of heritability (broad sense)

RESULTS AND DISCUSSION

The mean squares of four Paulownia species for tree height, DBH and survival are shown in Table 1. There were highly significant differences ($F_{3,16}$=2.18, 4.68; p<0.01) for tree height after one year and two years of planting. DBH also showed highly significant variation ($F_{3,16}$=19.23, 22.70; p<0.01) among the four

species and similar behavior i.e. $F_{3,16}$=106.01, 215.50; p<0.01 for survival of species was found during the both years of growth. The non-significant differences within the treatments indicated that blocking was precise.

Table 1. Mean squares with their significance of treatments from analysis of variance of parameters

Characters	2006		2007	
	Between treatments	Within treatments	Between treatments	Within treatments
Plant height (m)	2.182**	0.173	4.684**	0.027
DBH (cm)	19.228**	0.304	22.694**	0.169
Survival %	106.006**	4.954	215.493**	1.480

* Significant ($p \leq 0.05$), ** Highly significant ($p \leq 0.01$), Degree of freedom for between the treatments and within the treatments in 2006 and 2007 were 3 and 16, respectively.

The mean performance of three parameters i.e. tree height, DBH and survival of species is presented in Table 2. The tree height ranged from 4.84 ± 0.21 m to 6.34 ± 0.15 m during 2006 while it was 5.04 ± 0.08 m to 7.20 ± 0.09 m during 2007. During 2006 *P. catalpifolia* showed maximum height and was significantly different from *P. tomentosa* having mean height 5.26 ± 2.56m while the other two species had no significant difference from *P. tomentosa* and *P.fortunei* had minimum height (4.84 ± 0.21 m). After two years of planting although *P. catalpifolia* showed maximum height (7.20 ± 0.09 m) but had no significant difference from *P. tomentosa* having height 6.30 ± 0.07 m which explains *P. tomentosa* showed good growth behavior during 2nd year. *P. fortunei* registered the lowest rank for tree height i.e. 5.04 ± 0.08m.

The table also explains that after one year of planting DBH ranged from 6.84 ± 0.16cm to 11.16 ± 0.44cm. Maximum DBH was obtained by *P. catalpifolia* and it was significantly different from *P. tomentosa* (7.98 ± 0.12cm). *P. fortunei* showed lowest DBH and had significant difference from *P. tomentosa*. During the second year maximum DBH (12.42 ± 0.33cm) and all of the four tested species had significant difference for this trait. Minimum DBH was shown by *P. fortunei* with a value of 7.50 ± 0.11cm.

Table 2. Mean performance of various Paulownia species for tree height (m), DBH (cm) and survival %age

S. No.	Species	Tree height ± S.E		DBH ± S.E		Survival ± S.E	
		2006	2007	2006	2007	2006	2007
1.	*P. tomentosa*	5.26 ± 2.56b	6.30 ± 0.07a	7.98 ± 0.12b	9.38 ± 0.07b	88.80±0.66a	77.76±0.79b
2.	*P. catalpifolia*	6.34 ± 0.15a	7.20 ± 0.09a	11.16 ± 0.44a	12.42 ± 0.33a	90.18±1.08a	81.80±0.40a
3.	*P. elongata*	5.10 ± 0.09b	5.40 ± 0.04c	7.24 ± 0.09bc	8.48 ± 0.10c	82.42±0.37b	66.72±0.54d
4.	*P. fortunei*	4.84 ±0.21b	5.04 ± 0.08d	6.84 ± 0.16c	7.50 ± 0.11d	80.88±1.48b	72.28±0.31c
	C.V	**0.75**	**0.29**	**0.99**	**0.74**	**4.02**	**2.20**

Figures within columns with same letters are not significant at p = 0.05

Survival of species varied from 80.88 ± 1.48% to 90.18 ± 1.08% during 2006 and 66.72 ±0.54% to 81.80±0.40% after two years of growth. After one year of planting the species having highest survival (90.18±1.08%) i.e. *P. catalpifolia* was not statistically different from following *P.tomentosa* (88.80±0.66%) but had significant difference from the other two species. *P. fortunei* having survival of 80.88±1.48 % scored lowest rank. After two years of planting survival of species ranged from 81.80 ± 0.40% to 66.72 ± 0.54% for *P. catalpifolia* and *P. elongata* respectively. This explains greater mortality in *P. elongata* with respect to age. *P. catalpifolia* was followed by *P. tomentosa* (77.76 ± 0.79%), and all of the four species were significantly different from each other for this trait. The significant differences among the species for tree height, DBH and survival % may be attributed due to their distinct genetic constitution.

The earlier studies conducted in Pakistan (Haq, and Khan, 2005) also found apparent variation for growth traits. Similar genetic variation for tree height and diameter for fast growing tree species under the field conditions had been reported by Nelson and Tauer (1987), Puri *et al.* (2001), Toky *et al.* (1996) and Singh *et al.* (2001).

Table 3. Coefficients of variation, heritability and genetic advance of the traits

Characters	2006				2007			
	GCV (%)	PCV (%)	h^2	GA	GCV (%)	PCV (%)	h^2	GA
Plant height	11.78	14.09	0.70	0.74	16.13	16.36	0.97	1.33
DBH	23.43	24.36	0.93	2.62	22.48	22.90	0.96	2.92
Survival	5.24	5.85	0.80	5.64	8.77	8.92	0.97	9.00

GCV = Genotypic coefficient of variation PCV = Phenotypic coefficient of variation

h^2 = heritability GA = Genetic advance

The genotypic behavior and heritability of the three parameters studied with respect to environment is shown in Table 3. It revealed that DBH has maximum genotypic coefficient of variation (23.43%) followed by tree height (11.78%) while survival of species showed least. Due to greater genetic variability DBH also expressed high heritability i.e. 0.93 followed by survival of species (0.80). After two years of planting GCV and PCV of these parameters were same showing less influence of environment on genotypes. Survival of these species showed high heritability and greater genetic advance i.e. .097 and 9.0 respectively but lower GCV (8.77) which indicated that selection based on this parameter may be less effective. DBH having 22.48% GCV showed high heritability i.e. 0.96 resulting in more assistance in selection followed by tree height with GCV 16.13% and heritability 0.97 (Poehlman and Sleper 1995). The GCV and PCV ratio during both years of study indicates that survival of species was least influenced by environment. DBH showed more consistency for genetic parameters during both year of growth.

In general, values of parameters i.e. tree height and DBH were greater due to diverse genetic make up showing the heritable nature of these characters. Similarly many earlier studies have reported high genetic parameters i.e. heritability and genetic advance for growth traits. (Singh *et al*. 2001, Dhillon 2004, Singh *et al.* 2008) and these traits were least influenced by the environment.

CONCLUSION

Based on present results it is concluded that *P. catalpifolia* showed relatively higher achievement in observed parameter followed by *P. tomentosa* and the results also revealed their diverse genetic make up of greater heritable nature with less influence of environment. Thus it is suggested that selection of *P. catalpifolia* on the basis of greater divergence in genetic parameters like faster growth and better adaptability would be more appropriate followed by *P. tomentosa* to be used in species selection improvement programme.

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