

GENETIC TESTING OF EXOTIC AND INDIGENOUS CLONES OF *POPULUS DELTOIDES* UNDER SEMI-ARID CONDITIONS OF PUNJAB, INDIA

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ABSTRACT

A clonal trial comprising 12 poplar clones was planted at Regional Research Station, Bathinda in semi-arid region of Punjab following randomized block design with three replications and plot size of ten trees. The data collected on diameter at breast height, tree height and volume per tree at 2, 3, 5 and 7-year age were analyzed and genetic parameters were worked out. Significant differences among clones were noticed for all growth traits at all ages. Clones S₇C₈, 113324, L-188/84, L-313/85, L-51/84, L-71/84, 154/84, 110702 and 64-243-1 were promising clones at 7-year age with volume per tree ranging from 0.242 to 0.320 m³. The phenotypic and genotypic coefficients of variation were relatively higher for volume (11.15-31.78 %) and the minimum for tree height (4.71-13.65 %). The broad sense heritability ranged from 29.68 to 73.11 per cent with relatively higher values for diameter (36.07-73.11%) and height (44.73-54.81 %). The genetic advance was lowest for height (6.49 – 14.10 % of mean) and relatively higher for wood volume (12.51 – 38.96 %). The study indicated that exotic clones S₇C₈ and 113324 were the potential clones for commercial cultivation.

Key words: poplar, heritability, genetic advance, clonal variation

INTRODUCTION

Intensive forestry practices is the need of the hour to meet the increasing demands of wood based products, fibre, fodder and minor-forest products, as the over-exploited natural forests of developing countries are having poor productivity. Presently, the tree cover of India is about 23 per cent of total geographic area (dense forest area is 12 %) having a low productivity (0.7 m³/ha/yr) in comparison to that (3.1 m³/ha/yr) of world (Singh *et al.*, 2010). Considering the alarming situation, massive afforestation programmes on government lands, common places and farmlands have been advocated to bring one third of total geographic area under vegetative cover. Short rotation tree species mainly exotics have caught recent attention of tree growers to diversify their cropping pattern. *Populus deltoides* Bartr. is one of such successful exotic species of India and has become an integral part of landscape in most parts of north-western India. The soft, attractive, and easy to work wood is suitable for plywood, paper, furniture, packing cases, etc. Its better economic returns and suitable features like straight stem, thin crown, deciduous nature, etc. has made it widely adopted in this region. The productivity of well-managed poplar plantations under Punjab conditions had been estimated to be 46.9 m³/ha/yr (Verma,1993). However, poplar plantations in these states are having narrow genetic base consisting of only a few superior clones (G-3, G-48). Such situation of raising narrow genetic base material has resulted in creation of insect-pest problems. There is urgent need to bring genetically diverse and promising clones for commercial plantations.

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Punjab Agricultural University, Ludhiana started poplar improvement programme in late eighties of the last century and has introduced more than 200 poplar clones. Introduced clones from many organizations/ institutions of the country were evaluated at the nursery stage for three years (Sidhu 1989, 1994, 1996). The promising ones were evaluated in a series of clonal trials conducted in various agro-climatic regions of the state. The objective of the present study was to find out genetic variation among the 12 clones evaluated under semi-arid region of the state, and to identify the site-specific clones.

MATERIALS AND METHODS

The study was conducted at PAU Regional Research Station, Bathinda of Punjab. The site falls in Semi-arid region of the state (latitude 30°17' N, longitude 74°57' E, altitude 211 m) with sub-tropical arid climate. The canal is the only irrigation source and quality of underground water is poor. The soil was loamy sand to sandy loam with pH of 8.6. Twelve clones used for the study were selected on basis of initial screening for three years at the nursery stage (Sidhu, 1989). The detail of these clones is given in Table 1. The ETP's (entire transplants, one year old plants) of these clones were raised at nursery area of department of Forestry & Natural Resources, PAU, Ludhiana following recommended practices. The one-year old bare rooted plants were transplanted at the study site following randomized block design with three replications and plot size of ten trees. The ETP's were planted at 5 x 4 m spacing with planting depth of one meter. The recommended cultural practices were given throughout the study period (Sidhu et al, 1990). The data on plant height and diameter at breast height (DBH) were recorded in January of each year. Volume per plant was worked out following the regression equation developed by Dhanda and Verma (2001) for this region. The data recorded at 2, 3, 5 and 7 year age was analyzed using the CPCS1 computer package developed by Punjab Agricultural University, Ludhiana. The genetic parameters were worked out following Johnson *et al.* (1955) as per following formulae.

Phenotypic coefficient variation (P.C.V.)	=	$(\sigma_p/\bar{a}) \times 100$
Genotypic coefficients variation (G.C.V.)	=	$(\sigma_g/\bar{a}) \times 100$
Heritability in broad sense (H^2)	=	$(\sigma_g^2/\sigma_p^2) \times 100$
Genetic advance (GA) (% of mean)	=	$k.H^2.\sigma_p/\bar{a} \times 100$

Where, σ_p and σ_g are phenotypic and genotypic standard deviation of variance, respectively, \bar{a} is the general mean of the population, σ_g^2 and σ_p^2 are genotypic and phenotypic variance, respectively and k is selection differential (which is 2.06 at 5% selection intensity).

Table 1. Details of clones used for the study

S No.	Clone Name	Source/origin
1	G-3	Australia
2	1467	USA
3	L-188/84	Forest Research Center, Lal Kuan, Uttrakhand
4	L-71/84	Forest Research Center, Lal Kuan, Uttrakhand
5	L-313/85	Forest Research Center, Lal Kuan, Uttrakhand
6	200/84	Forest Research Center, Lal Kuan, Uttrakhand
7	S ₇ C ₈	USA
8	L-51/84	Forest Research Center Lal Kuan, Uttrakhand
9	64-243-1	USA
10	113324	USA
11	154/84	USA
12	110702	USA

RESULTS AND DISCUSSION

The analysis of variance of data revealed that differences due to clones were highly significant ($P < 0.01$) for all the traits at all ages except for DBH and volume at age 2 where it was significant at $P < 0.05$. The differences due to replications were also highly significant (except at age 3) which implies that blocking was precise (Table-2). The mean diameter at breast height and tree height is given in Table-3. The differences among clones were observed to be significant for all the traits at all ages. DBH ranged from 4.30 to 6.86 cm, 5.37 to 9.05 cm, 10.99 to 17.47 cm and 14.33 to 21.42 cm at age of 2, 3, 5 and 7 yr, respectively. Clone '113324' registered top ranking at age 2, 5 and 7 yr and was closely followed by clone 'L-188/84'. At age 7, clone '113324' recorded maximum DBH which was however at par with clones 'S₇C₈', 'L-188/84', 'L-313/85', 'L-71/84', 'L-51/84', '154/84', '110702' and '64-243-1'. Clone 'G-3' registered the lowest rank at age 2, 5 and 7 yr with respect to diameter. The top ranking for tree height was not stable and changed at each subsequent reading; however, all these clones were statistically at par with each other. Like diameter, Clone '113324' attained the highest value and was similar to all clones except those of '200/84', '64-243-1', 'G-3' and '1467'. The volume per tree at age 7 varied from 0.122 to 0.320 m³ with significant differences among the clones (Figure 1). Again, nine clones i.e. 'S₇C₈', '113324', 'L-188/84', 'L-313/85', 'L-51/84', 'L-71/84', '154/84', '110702' and '64-243-1' were promising and at par with each other. The significant differences among the clones for the diameter, height and volume may be attributed to their distinct genetic constitution. The earlier studies conducted in the Punjab at nursery stage (Sidhu 1989, 1994, 1996) and field conditions (Sidhu and Dhillon, 2007, Dhillon, 2004, Singh et al 2008, Dhillon et al, 2010 a,b) also found apparent variation for the growth traits. Similar genetic variation for height and diameter under field conditions had been reported by Nelson and Tauer (1987), Jha *et al.* (1991, 1993), Puri *et al.* (2001), Toky *et al.* (1996), Singh *et al.* (2001).

Table 2. Mean sum of squares and F ratios based on ANOVA of various traits recorded at four ages

Source	df	DBH 2		DBH 3		DBH 5 yr		DBH 7 yr	
		MSS	F Ratio	MSS	F Ratio	MSS	F Ratio	MSS	F Ratio
Replication	2	6.049	8.28**	3.252	3.40	31.08	23.98**	53.02	22.86**
Clones	11	1.967	2.69*	3.880	4.06**	11.87	9.16**	15.36	6.63**
Error	22	0.7305		0.956		1.296		2.319	

Source	df	Height 2		Height 3		Height 5 yr		Height 7 yr	
		MSS	F Ratio	MSS	F Ratio	MSS	F Ratio	MSS	F Ratio
Replication	2	1.016	11.19**	3.242	5.61*	27.75	26.86**	31.43	32.19**
Clones	11	0.311	3.43**	2.320	4.02**	4.80	4.64**	4.24	4.34**
Error	22	0.0908		0.578		1.033		0.976	

Source	df	Volume 2		Volume 3		Volume 5 yr		Volume 7 yr	
		MSS	F Ratio	MSS	F Ratio	MSS	F Ratio	MSS	F Ratio
Replication	2	0.42 ⁻⁰⁴	8.11**	0.934 ⁻⁰⁴	3.04	0.193 ⁻⁰¹	25.97**	0.716 ⁻⁰¹	25.99**
Clones	11	0.12 ⁻⁰⁴	2.27*	0.996 ⁻⁰⁴	3.24**	0.419 ⁻⁰²	5.63**	0.117 ⁻⁰¹	4.23**
Error	22	0.52 ⁻⁰⁵		0.307 ⁻⁰⁴		0.745 ⁻⁰³		0.276 ⁻⁰²	

* and ** denotes significance at $P < 0.05$ and $P < 0.01$, respectively.

Table 3. Diameter and height growth of poplar clones at various ages

Clone	Diameter at Breast Height (cm)				Total Tree Height (m)			
	2 yr	3 yr	5 y	7 yr	2 yr	3 yr	5 yr	7 yr
G-3	4.30 ^e	6.28 ^{cd}	10.99 ^d	14.33 ^c	5.20 ^d	6.69 ^{cd}	13.22 ^d	17.34 ^{de}
1467	4.47 ^{de}	5.37 ^d	12.43 ^d	15.56 ^c	5.22 ^{cd}	6.25 ^d	14.67 ^{cd}	17.11 ^e
L-188/84	5.89 ^{abcd}	8.84 ^a	17.20 ^a	21.14 ^a	6.06 ^a	8.89 ^a	16.83 ^{ab}	19.37 ^{abc}
L-71/84	5.67 ^{abcde}	7.52 ^{abc}	16.29 ^{abc}	20.36 ^{ab}	5.72 ^{abc}	8.17 ^a	16.52 ^{ab}	19.12 ^{abc}
L-313/85	5.99 ^{abc}	9.05 ^a	16.57 ^{ab}	20.74 ^{ab}	5.94 ^{ab}	8.59 ^a	16.90 ^{ab}	19.96 ^{abc}
200/84	4.65 ^{cde}	6.88 ^{bcd}	14.73 ^{bc}	18.30 ^b	5.45 ^{bcd}	6.78 ^{bcd}	16.27 ^{abc}	18.96 ^{bcd}
S ₇ C ₈	6.42 ^{ab}	8.27 ^{ab}	16.60 ^{ab}	21.26 ^a	6.03 ^a	8.87 ^a	17.14 ^{ab}	20.22 ^{ab}
L-51/84	6.05 ^{abc}	8.55 ^a	16.87 ^a	20.31 ^{ab}	5.97 ^a	8.32 ^a	17.56 ^a	20.57 ^{ab}
64-243-1	5.04 ^{bode}	6.88 ^{bcd}	14.50 ^c	19.52 ^{ab}	5.58 ^{abcd}	7.81 ^{abc}	15.80 ^{bc}	18.53 ^{cde}
113324	6.86 ^a	8.69 ^a	17.47 ^a	21.42 ^a	5.97 ^a	8.49 ^a	17.09 ^{ab}	20.69 ^a
154/84	6.13 ^{ab}	8.14 ^{ab}	16.22 ^{abc}	20.05 ^{ab}	5.89 ^{ab}	8.05 ^{ab}	17.43 ^{ab}	20.37 ^{ab}
110702	5.83 ^{abcd}	7.49 ^{abc}	15.77 ^{abc}	19.76 ^{ab}	6.09 ^a	7.71 ^{abc}	15.74 ^{bc}	19.77 ^{abc}
Mean±	5.61±	7.66±	15.47±	19.40±	5.76±	7.89±	16.23±	19.33±
S.E.	0.20	0.24	0.42	0.51	0.08	0.19	0.32	0.32

The genetic parameters revealed medium to high variability among the poplar clones (Table-4). The phenotypic coefficient of variation (PCV), genotypic coefficients of variation (GCV) and genetic advance (% of mean) were relatively higher for volume and lower for height. The broad sense heritability in general was medium and was relatively higher for DBH (36.1-73.1 %) and height (44.7-54.8 %). The trend of all genetic

parameters with respect to age was inconsistent. In general the values were the highest at age 3 or 5. Similarly, many earlier studies have reported moderate to high genetic parameters for growth traits of poplar (Singh *et al.* 2001, Dhillon 2004, Singh *et al.* 2008). On the other hand, Wilcox and Farmer (1967) found low heritability (0.21 to 0.31) for growth traits of *P. deltoides*. Nelson and Tauer (1987) while studying variation in *P. deltoides* at 2-year age also found the low heritability values for height and diameter (0.19 and 0.35).

Table 4. Genetic parameters of growth traits of poplar clones.

Genetic Parameter	Age (yrs)	DBH (cm)	Height (m)	Volume per tree (m ³)
PCV (%)	2	19.06	7.04	20.47
	3	18.13	13.65	31.78
	5	14.19	9.30	31.16
	7	13.31	7.43	29.86
GCV (%)	2	11.45	4.71	11.15
	3	12.88	9.67	20.78
	5	12.13	6.89	24.27
	7	10.75	5.40	21.50
Broad sense heritability (%)	2	36.07	44.73	29.68
	3	50.50	50.15	42.76
	5	73.11	54.83	60.69
	7	65.22	52.71	51.84
Genetic advance (% of mean)	2	14.17	6.49	12.51
	3	18.86	14.10	27.99
	5	21.37	10.50	38.96
	7	17.89	8.07	31.88

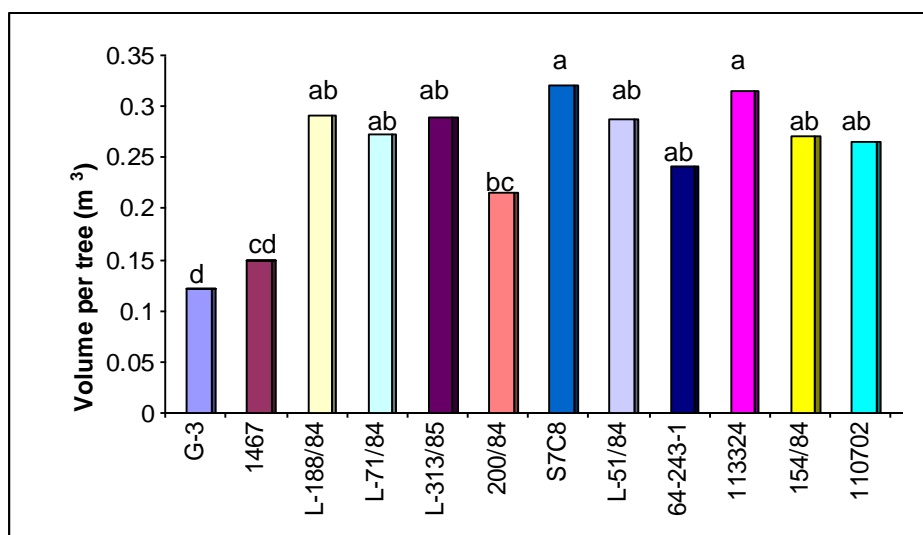


Fig. 1. Volume per tree (m³) of Poplar clones at age 7 year. Clones having same alphabets are having statistically similar values at <0.05.

CONCLUSION

The present study involving 12 poplar clones has found significant clonal variation for all the growth traits. Three clones i.e. 'S₇C₈', '113324', 'L-188/84' were found to be promising ones with respect to volume and may be used for commercial cultivation. There is urgent need to make further introductions of new exotic clones and to initiate systematic poplar improvement programme at National Level.

REFERENCES

- Dhanda, R.S. and R. K. Verma, 2001. Timber volume and weight tables of farm-grown poplar (*Populus deltoides* Bartr. Ex Marsh.) in Punjab (India). *Indian For.* 127 (1): 115-130.
- Dhillon, G.P.S., 2004. Studies on genotype x environment interaction of poplar (*Populus deltoides*) in Punjab. Ph.D. Dissertation. Forest Research Institute Deemed University, Dehradun, India. pp. 189.
- Dhillon, G.P.S., A. Singh, P. Singh and D.S. Sidhu, 2010 a. Field evaluation of *Populus deltoides* Bartr. Ex Marsh. at two sites in Indo-gangetic plains of India. *Silvae Genetica* : 59 (1): 1-7.
- Dhillon, G.P.S., Avtar Singh and D.S. Sidhu, 2010 b. Variation, inheritance and correlation of growth characteristics of *Populus deltoides* Bartr. at various ages in the central-plain region of Punjab, India. *For. Stud. China* 12 (3): 126-130.
- Jha, K.K., C. Gupta and R.S. Verma, 1991. Field testing of few promising clones of poplar in terai. *Ind. J. For.* 14 (2): 83-89.
- Jha, K.K., C. Gupta, Verma, R.S. and C.B. Chhimwal, 1993. Performance of exotic poplar clones in terai. *Indian For.* 119 (2): 97-111.
- Johnson, H.W., H.F. Robinson and R.E. Comstock, 1955. Estimates of genetic and environmental variability in soybean. *Agron. J.* 47: 314-318.
- Nelson, C.D. and C.G. Tauer, 1987. Genetic variation in juvenile characters of *Populus deltoides* Bartr. from the Southern Great Plains. *Silvae Genetica* 36 (5-6): 216-221.
- Puri, S., S.L. Swami and A.K. Jaiswal, 2001. The potential of *Populus deltoides* in the sub-humid tropics of central India: survival, growth and productivity. *Indian For.* 127 (2) : 173-86.
- Sidhu, D.S., 1989. Nursery testing for genetic diversification of poplar plantations. *Ind. J. For.* 12 (4): 265-269.
- Sidhu, D.S., 1994. Evaluation of exotic and indigenous *Populus deltoides* Marsh. clones for genetic diversification of agroforestry plantations. *J. Trop. For.* 10 (4): 263-270.

- Sidhu, D.S., 1996. Genetic evaluation of *Populus deltoides* (Marsh) clones in nursery under Punjab conditions. *Ind. J. For.* 19 (1): 21-25.
- Sidhu, D.S. and G.P.S. Dhillon, 2007. Field performance of ten clones and two sizes of planting stock of *Populus deltoides* in Indo-gangetic plains of India. *New Forest* 34 (2): 115-122.
- Sidhu, D.S., A.S. Hans and R.S. Dhanda, 1990. Poplar Cultivation, Punjab Agricultural University Publication. p.38.
- Singh, A., G.P.S. Dhillon and D.S. Sidhu, 2008. Field testing of *Populus deltoides* Bartr. clones under semi-arid conditions of Punjab. *Ann. For.* 16 (2): 192-196.
- Singh, A., Toky, O.P. and G.P.S. Dhillon, 2010. Growth performance of *Eucalyptus tereticornis* and *E. camaldulensis* progenies under various levels of soil salinity. *Indian For.* 136 (2): 1610-1615.
- Singh, N.B., D. Kumar, G.S. Rawat, R.K. Gupta, K. Singh and S.S. Negi, 2001. Clonal evaluation on poplar (*Populus deltoides* Bartr.) in eastern Uttar Pradesh II. Estimates of genetic parameters in field testing. *Indian For.* 127 (2): 163-172.
- Toky, O.P., R.P. Bisht, N. Kumar and R.R. Singh, 1996. Growth variability of *Populus deltoides* (Marsh.) clones in arid climate of North-Western India. *Ind. J. For.* 19 (1): 69-73.
- Verma, R.K., 1993. Studies on growth and performance of *Populus deltoides* Bartr. in Punjab. M. Sc. Forestry Thesis. Punjab Agric. Univ., Ludhiana. 154 pp.
- Wilcox, J.R. and R.E. Jr. Farmer, 1967. Variation and inheritance of juvenile characters of eastern cottonwood. *Silvae Genetica* 16: 162-165.