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Short Communication

Studies on heterotic parameters in *Populus deltoides*

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Abstract

Exploitation of genetic variability of *Populus deltoides* Bartr. through control crossing involving Line x Tester mating design was attempted with the objective of selection of suitable clones as well as parents for hybridization in future and identification of best families and best individuals with in family for releasing first stage clones. Lines ST-72, D-121, G-48, exhibited the highest positive GCA effects for plant height, collar diameter, plant height at first branch and root length. In general G-48 also proved to be the best combiner for survival percentage, inter nodal length and leaf area. Among the testers ST-63 and ST-70 expressed highest GCA effects and excelled for a number of desirable characters. Full sib families (F_1s) of D-121 x ST-70 and G-48 x ST-63 showed desirable SCA for plant height and collar diameter and therefore F_1 hybrids of these crosses are recommended at first stage of selections. The percent contribution of line x tester interactions was higher than that of lines and testers except number of leaves per plant. 13 traits expressed higher SCA variance than GCA variance and dominant gene effect (σ^2D) were found higher than additive gene effect (σ^2A) except in root length. For recurrent selection based on GCA effects, parents G-48, ST-70, D-121 and ST-63 appeared more appropriate in crossing programme directed towards clonal improvement of Poplar in India.

Key words: *Populus deltoides*, Line x Tester, GCA, SCA, heritability, gene action

Populus deltoides (commonly known as poplar) clones were introduced in India in 1952 to increase the availability of wood for matchstick, packing cases, veneer, plywood and paper and pulp for wood based industries in the country. In India, its importance is well accepted and 70 percent plantation is based on only few clones. Clones introduced from U.K. and Europe did not perform well while the clones from southern U.S.A. and Australia (USA origin) grew well and performed better in northern plains of the country. *Populus* started being planted under irrigated conditions and grew faster than any other indigenous or exotic species. Clones G-3, G-48, D-121, S_7 C_8, S_7 C_{15} and hybrids developed from open pollinated progenies of G-48, namely Udai, WSL-22, WSL-39, L-200 presently form the backbone ie 90 per cent of the poplar planting programme which has spread in farm lands on north western part of the country. To increase the genetic base, the production of indigenous clones and introduction of more clones from suitable areas of U.S.A was carried out by Uttarakhand Forest Dept (then U.P. Forest Department), Dr. YS Parmar University of Horticulture and Forestry, Solan, FRI, Dehradun, WIMCO Pvt Ltd.,Punjab Agriculture University, Ludhiana, and GB Pant Univ Agric & Tech., Pantnagar, UK. Interspecific hybridization in Poplar is often replaced by intraspecific recurrent breeding of *P. deltoides* using provenances from lower latitudes to maintain phenological adaptation (Singh et al. 2013). Clones developed from first generation hybrids (F_1) is used most often as the control breeding strategy because it frequently results in heterosis for growth rate. Genetic variance is equal to ¼ of additive genetic variation only, or ½ of additive genetic variation and ¼ of dominance variation, when the selection units are half sibs or full sibs families respectively. An

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outstanding example of first generation heterosis in Poplar revealed an increase of 75 per cent and 177 per cent in 2- year old stem volume in *P* x *canadensis* and P x generosa, respectively (Dillen et al. 2009).

The selection of parents and procedure in L x T mating design in the present study was followed as per the breeding programme developed by Singh et al. 1999. The experimental material comprised of F_1 population of 25 crosses, developed by line x tester (5 x 5 factorial) with 10 parents. All the female clones *viz*., S_7 C_8, S_7 C_{13}, ST-72, D-121, G-48 were crossed to each of the male clones *viz*., ST-70, G-3, S_7 $C_{20,}$ S_7 C_3, ST-63 by hand pollination. The opening of the flowers are noticed in the last week of February and continued up to first week of April. Female inflorescences were bagged and tagged before anthesis. Pollen was collected from the male catkin on a sheet of paper, dried and stored in small test tube. The control pollination was done in the morning hours (6-8 AM) during March, then female flowers were bagged with proper tagging and it is repeated at least three times depending on anthesis and receptiveness of female flowers. Seed was harvested from mature capsules and sown immediately as per standard seed testing procedure of poplar. Five best individuals per full sib of F_{1s} were selected and were multiplied accordingly. The cuttings (20 cm length and 2-2.5 cm diameter) of selected individuals along with cuttings of 10 parents are raised in Randomized Complete Block Design (RBD) during February, 2001 in four replications (4 cuttings/clone/replication) along with two border rows in the periphery of experimental plot in the nursery at Forest Research Institute, ICFRE, Dehradun. All the four plants of each clone per replications of the full sib progeny were taken into consideration for recording the observations on 14 nursery traits *viz*., Survival per cent, Plant height (cm), Root length (cm), Internodal length (cm), Number of leaves/plant, Leaf area (cm^2), Number of branches/ plant, Plant height at Ist branch (cm), Branch angle (degree), Leaf defoliation period (days), Leaf emergence period (days), Shoot bark thickness (mm), Root bark thickness (mm), Collar diameter (cm). The standard procedure for statistical analysis was followed as per Dabholkar, 1992.

The lines (female parents) ST-72, D-121, G-48 exhibited the highest positive GCA effects for plant height, collar diameter, plant height at first branch and root length. In general, G-48 also proved to be the best combiners for survival percentage, internodal length and leaf area. The same line showed the non desirable (negative) GCA effect for branch angle and leaf defoliation period. However, it is desirable in the case of leaf defoliation period. This suggests that close association between GCA of the lines for juvenile volume i.e. the product of plant height and diameter as well as plant growth characteristics like root length, internodal length, leaf area (Table 1). For leaf emergence period (line ST-72 and S_7C_{13}) and root bark thickness and shoot bark thickness (line S7C8) depicted high desirable (negative) GCA effects (as good combiners).

Among the testers (male parents) ST-63 had the highest GCA effects and excelled the characters associated with plant height, root length, number of leaves/plant, leaf area, plant height at first branch and collar diameter. S_7C_{20} exhibited the highest desirable (negative) GCA effect for leaf defoliation period, leaf emergence period, root bark thickness, shoot bark thickness. Significant positive link between intra- and inter-specific GCA for both *Populus deltoides* and *P. trichocarpa* parent clones have also been are reported

Table 1. Estimation of general combining ability effects of testers (Males) in F_1 generations

Testers (males)	SP	PH	R.L	I.L	LN	L.A	NB	PHB	BA	LDP	LEP	SBT	RBT	CD
ST-70	-	18.46*	- 0.59*	0.07	- 0.47	- 6.72*	-	31.41**	0.84	0.10	0.68	-0.09*	0.02	0.27*
G-3	-	1.35	- 0.14	- 0.23	- 5.19*	- 9.63*	-	- 58.64**	- 0.92	- 1.50*	- 2.52**	- 0.01	0.01	0.07
S_7C_{20}	-	- 80.03**	- 1.00*	0.01	0.72	- 22.55**	-	- 46.61**	- 1.18	- 1.60**	- 2.67**	- 0.16**	- 0.09*	- 0.75**
S_7C_3	-	- 22.91**	1.24**	- 0.04	-5.03*	15.76 **	-	- 22.74*	0.04	0.87	2.08**	0.01	- 0.04	- 0.32**
ST-63	-	83.12**	0.49*	0.18	9.97**	23.15**	-	96.58**	1.22	2.15**	2.43**	0.07	0.09*	0.73**
SE (gi)	-	4.01	0.22	0.07	1.16	2.13	-	5.45	0.47	0.33	0.38	0.03	0.02	0.06
SE(gi-gj)	-	6.57	0.37	0.11	2.12	3.51	-	8.99	0.77	0.61	0.67	0.04	0.037	0.10
CD at 5%	-	3.93	0.92	0.52	2.11	2.86	-	4.58	1.34	1.12	1.21	0.33	0.27	0.48

*,** Significant at 5 per cent, and 1 per cent level of significance. Note : (-) Non significant in ANOVA for combining ability.

earlier (Bastien et al. 1999). Different parents expressing high desirable GCA in respect of plant height, collar diameter, volume and other traits have been reported by different workers in the genetic improvement of *Populus* nigra and *P. deltoides* (Pichot and Teissier du Cross 1988, 1989).

The F_1 hybrids S7C13 x G-3 and G-48 x ST-63 with poor and poor combiner and good and poor combiner respectively were found as promising combinations for survival percentage. For plant height, root length, number of leaves per plant, leaf area, plant height at first branch, leaf defoliation period and collar diameter, hybrids of D-121 x ST-70 with good x good combiner resulted positive SCA effects. Similarly, G-48 x ST-63 with good x good combiner exhibited higher positive SCA effect for plant height, leaf area, plant height at first branch and collar diameter, where as the same crosses with good x poor combiner and poor x poor combiner showed higher significant SCA effects for leaf defoliation period and leaf emergence period respectively. For shoot bark thickness and root bark thickness G-48 x S7C20 with poor x good and average x good combiner respectively had given highest SCA effects. In a few cross combinations *viz*., S7C13 x G-3, D-121 x S7C3 (survival percentage), S7C8 x S7C20, S7C8 x S7C3 (plant height), S7C8 x S7C20 (root length), S7C8 x S7C3, G-48 x G-3 & S7C8 x S7C20 (plant height at first branch), S7C8 x S7C3, D-121 x ST-70 & S7C8 x ST-70 (leaf defoliation period), S7C13 x ST-63, S7C8 x ST-70 & G-48 x ST-63 (leaf emergence period) S7C8 x S7C3 (collar diameter), although significant SCA effects were observed but their hybrids had both the parents as poor general combiners. These observations corroborate the findings of different researchers in poplar (Pichot and Teissier du Cross, 1988 & 1989). However, for crosses willow that involved both the parents as poor combiners lend support to these finding by Ronnberg and Gulberg 1999. The resultant performance of traits from poor x poor cross indicates that a high magnitude of non additive component was responsible for conferring the highest rank to the pertinent cross combination.

A perusal Table 2 for GCA/SCA variances revealed that SCA variances were of higher magnitude than GCA variances for all the characters except one ie root length. It shows the preponderance of non-additive gene action governing these traits. For the root length, the GCA variance was of higher magnitude than the SCA variance, indicating the predominant role of additive gene action. Out of 14 traits, 13 traits exhibited higher SCA variances than GCA variances and (σ^2D) values were also found higher accordingly except for root length in which GCA variance is higher than SCA variance and additive variance (σ^2A) is also higher than dominant variance (σ^2D). The results of the present study are in accordance with earlier researchers on Poplar (Pichot and Teissier du Cross 1988, 1989; Bastein et al. 1999) and on Willows (Ronnberg and Gullberg, 1999). The percent contribution of line x tester interactions were, in general

Table 2. Estimation of genetic components of variance and proportional percent contribution of lines, testers and their interaction

Components	SP	PH	RL	IL	LN	LA	NB	PHB	BA	LDP	LEP	SBT	RBT	CD
σ^2GCA (Lines)	-1.80	2515.18	5.84	0.31	325.23	638.83	-0.01	13708.14	-1.26	-3.44	0.49	0.01	0.00	0.42
σ^2GCA (Testers)	-4.69	2718.88	0.16	-0.06	-14.02	119.17	-0.05	1646.91	0.-233	-2.29	4.12	0.00	0.00	0.21
σ^2GCA (Ave.)	-3.24	2617.03	3.00	0.12	155.60	378.99	0.029	7677.52	1.79	-2.86	2.30	0.005	0.00	0.31
σ^2SCA	28.22	3991.18	2.70	0.37	249.12	1152.78	0.20	12056.99	15.30	23.28	8.39	0.06	0.04	0.53
σ^2A	-12.99	10468.14	12.01	0.50	622.43	1515.99	-0.12	30710.11	-7.19	-11.47	9.21	0.02	0.00	1.26
σ^2D	112.86	15964.70	10.79	1.48	996.49	4611.14	0.82	48270.94	61.21	93.13	33.57	0.23	0.14	2.11
Contributions of lines	37.84	11.04	14.36	11.52	72.66	14.93	16.38	7.40	7.31	15.81	6.18	18.51	38.58	4.52
Contribution of testers	30.75	4.22	2.91	18.82	4.88	0.88	13.30	4.41	3.14	34.03	19.72	14.66	20.52	4.54
Interactions	79.62	32.43	25.66	44.35	33.42	43.57	79.04	32.69	80.67	83.07	47.64	58.81	67.19	34.17

SP=Survival percentage, PH=Plant height, RL=Root length, IL=Internodal length, LN=Number of leaves, LA=Leafarea, NB=Number of branches, PHB=Plant height at Ist branch, BA=Branch angle, LDP=Leaf defoliation period, LEP=Leaf emergence period, SBT=Shoot bark thickness, RBT=Root bark thickness and CD=Collar diameter higher than the contribution of lines or testers except number of leaves per plant where contribution of line is higher than interaction contribution. Keeping in view the GCA and SCA effects and variances as well as additive (σ^2A) and dominant (σ^2D) components of variances, it would be worthwhile to affect genetic improvement in Poplar (*P. deltoides*) by exploitation of hybrid vigour or recurrent selection followed by clonal propagation which arrests both additive and non additive variances for almost all the traits which had high dominant (σ^2D) components of variances to that of additive (σ^2A) components of variances except root length. However, the survival was found to be predominantly controlled by dominant gene action. The gene action studies have revealed that since the non-additive genetic component had pre dominant role for all the characters except root length, suggest the need of exploitation of hybrid vigour or repeated crossing of parents (recurrent selection) which captures both additive and non-additive genetic variances.

References

Bastien C., Schneider C., Laine A., Lefevre F., Rozenberg P. and Villar M. 1999. Breeding poplars for wood density : Intra and inter specific variability in a 9 x 9 factorial mating design involving *Populus trichocarpa* & *P. deltoides*. Proc. Intern. Poplar Sym II. Orleans, France. p. 15.

Debholkar A. R. 1992 Elements of Biometrical Genetics. Concept Publishing Co., New Delhi. PP. 187-214.

Dillen S. Y., Storme V., Marron N., Bastien C., Neyrinck S., Steenackers M., Ceulemans R. and Boerjn W. 2009. Genomic region involved in productivity of two interspecific poplar families in Europe. I. Stem height, circumference and volume. Tree Genet. Genomes, **5**: 147-164.

Pichot C. and Teissier du Cros E. 1988. Estimation of genetic parameters in the European black poplar (*P. nigra* L.). Consequence on the breeding strategy. Ann. Sci. For., **45**(3): 223-238.

Pichot C. and Teissier du Cros E. 1. Estimation of genetic parameters in eastern cotonwood (*Populus deltoids* Bartr.) Consequences for the breeding strategy., Ann. Sci. For., **46**(4): 307-324.

Ronnberg-Wastljung A. C. and Gullberg U. 1999. Genetics of breeding characters with possible effects on biomass production in *Salix viminalis*. Theor. Appl. Genet., **98**: 531-540.

Singh N. B., Kumar D., Rawat G. S. and Srivastava S. K. 1999. Improvement of *Populus deltoides* in India. II. Future Strategy. Indian Forester, **125**(4): 341-354.

Singh N. B., Kumar Dinesh, Gupta R. K., Kumar Pradeep and Singh K. 2013. Improvement of *Populus deltoides* Bartr. in India. Provenance variation and intraspecific breeding. Indian Forester, **139**(3): 222-227.