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Heritability, genetic gain and coefficient of variation analysis of willow, *Salix* species full sib f_1 progenies under nursery condition

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ABSTRACT

The control breeding/hybridization work in *Salix* clones at Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan was carried out during the year 2011 and 2012. The hybrids produced were evaluated under earthen bowls containing vermiculite media (Stage I), root trainers in sand and soil (Stage II) and then under polybags containing sand, soil and compost (Stage III). The data revealed that in progeny of crosses *Salix babylonica* x J795, PN227 x J172 and PN227 x J194 there was highest survival (100%). Plant height and basal diameter were recorded maximum in hybrids of PN227 x J172 (328.33 cm and 17.59 mm respectively) followed by hybrids of PN227 x NZ1179 (306.25 cm and 16.52 mm respectively). Hybrids of PN227 x S0-64-007 recorded maximum number of nodes (80.34), branch length (95.08 mm) and petiole length (1.17 mm). Internodal length was found highest (5.06 mm) in hybrids of PN227 x AUSTREE which was at par with hybrids of PN227 x SI-64-007, PN227 x J172, PN227 x 131/25 and PN227 x J194. Number of branches was maximum (86.48) in hybrids of PN227 x NZ1140. Branch length was found maximum in hybrids of PN227 x AUSTREE which was at par with all others except hybrids of *S babylonica* X J795 and PN227 x SI-64-007. Hybrids of PN227 x NZ1179 recorded maximum (22.08 cm^2) leaf area. On the basis of two year growth performance, hybrids namely PN227 x AUSTREE, *S babylonica* x J795, PN227 x J172, PN227 x SE-69-00, PN227 x NZ1140 and PN227 x NZ1179 were found suitable for lower and mid-hills of Himachal Pradesh.

Keywords: Full sib F_1; heritability; genetic gain; plant growth; willow

INTRODUCTION

Salix species commonly known as willows belong to family Salicaceae. The essential purpose of tree improvement is to develop a suitable clone/variety that eventually brings about economic returns and related benefits to growers. An efficient and practical means of screening the genetic resources is essentially required (Luna and Singh 2009). Knowledge of variances and heritability within and between hybrid populations is important in various breeding decisions. High genetic variances due to

hybrids are reflected in high broad sense heritability and provide an estimate of the proportion of the variation within a population that is due to genetic differences among individuals. Keeping in view the ever increasing demand of willow wood for multifarious uses particularly for sports good manufacturing entrepreneurs, household timber, constituted wood etc, selected promising hybrids developed by various research organizations throughout the world were procured and introduced at university campus. The objectives of the present study were to compare the growth parameters of selected promising hybrids in field condition as well as to estimate the genetic parameters of F_1 hybrids of *Salix* species. The main emphasis was given on traits such as diameter growth, plant height, straightness, less branches, narrow crown etc.

MATERIAL and METHODS

Location of site: The forest nursery of Dr YS Parmar University of Horticulture and Forestry, where the experiment was laid was established in the year 2011. The nursery site is located at an elevation of 1200 m amsl in the northwest of Himalaya and lies between 30°51'N latitude and 76°11'E longitude. The experimental area is hilly marked with elevations and depressions and has a gentle slope towards the southeastern aspect. The area experiences a wide range of temperature with a minimum of 1ºC in winters to a maximum of 33ºC during May and June as the hottest months. The annual rainfall reaches up to 0-342 mm with maximum downpour during the monsoon season (July-September).

Experimental design: The standard planting techniques were followed in augmented completely randomized design (ACRD) (Augmented Design I). However due to large number of hybrids and limited availability of uniform land in nursery, 10 ramets of each clone were randomly planted in single replication while two check plants (J799, SI-63-002) were used as check lots (controls) with three replications. The spacing between rows was 50 cm and between cuttings in a row was 40 cm in a sunken bed of size 250 x 150 cm under the usual nursery conditions.

Assessment of the traits: The observations were recorded when the saplings were nine months old. Survival was determined as the number of living saplings in a plot over the initial number of planted cuttings. Height of the plant was measured to the nearest centimeter while basal diameter was measured to the nearest millimeter. Volume index was calculated as per quarter girth formula (Chaturvedi and Khanna 2000). Five leaves were taken randomly from the central region of the plant for measuring leaf length, leaf breadth, petiole length and leaf area.

Genetic analysis: Genotypic, phenotypic, environmental variances and coefficients of variability, expected genetic advance at 5

per cent of selection intensity were calculated by the formulae given by Singh (2006):

$$\text{PCV (\%} \quad \frac{\overline{V_p}}{X} \times 100$$

$$\text{GCV (\%} \quad \frac{\overline{V_g}}{X} \times 100$$

$$\text{ECV (\%} \quad \frac{\overline{V_e}}{X} \times 100$$

$$\text{Genetic advance (GA} \quad \frac{V_g}{V_p} \times \overline{V_p} \times K$$

where PCV= Phenotypic coefficient of variability, GCV= Genotypic coefficient of variability, ECV= Environmental coefficient of variability, V_p= Phenotypic variance, V_g=Genotypic variance, V_c= Environmental variance, $\bar{X}$= Population mean of character, K= Selection differential at 5 per cent selection intensity. The value of K= 2.06 (Allard 1960).

Genetic gain was worked out following the method suggested by Johnson et al (1955) as under:

$$\text{Genetic gain(\%} \quad \frac{GA}{X} \times 100$$

RESULTS and DISCUSSION

The data presented in Table 1 show that all the characters varied significantly except leaf area among test clones whereas leaf breadth and leaf area showed significant differences among checks. The mean survival percentage of testing hybrids was significantly greater than check plants whereas for plant height, basal diameter and leaf area exhibited much inferior value to check plant as compared to hybrids. Survival percentage of test hybrids (89.62%) was significantly higher than check plant (51.00%). Maximum survival (100%) was recorded in the test hybrids namely *S babylonica* x J795, PN227 x J172 and PN227 x J194 while minimum survival (70%) was recorded in J799 plant. For plant height mean of test hybrids (328.33 cm) was significantly higher to mean of check plants SE-69-002 (208.5 cm). It was found maximum in hybrid PN227 x J172 which was at par with hybrids PN227 x AUSTREE (317.55 cm) and PN227 x NZ1179 (306.25 cm). Plant diameter was recorded maximum (17.59 mm) in hybrid PN-227 x J172 which was at par with hybrid PN227 x J795 (16.71 mm), PN227 x NZ1179 (16.52 mm) and PN227 x AUSTREE (16.08 mm) whereas minimum plant diameter (9.14 mm) was recorded in the plant J799.

Leaf length recorded in the hybrids PN227 x NZ1140 (15.17), PN-227 x 131/25 (15.67 cm), *S babylonica* x J795 (15.75 cm) and PN-227 x J194 (15.98 cm) was at par with the maximum value (16.08 cm) recorded in the hybrid PN227 x SI-64-007. The lowest value for this character was found in the plant J799 (10.45 cm). For leaf breadth broadest leaves were recorded in the hybrid PN227 x *S tetrasperma* (5.08 cm) and narrowest in the plant J799 (1.05 cm). Leaf area showed non-significant affect among test hybrids.

Table 1. Willow improvement performance in the year 2011-12

Hybrid/check	Survival	Plant height (cm)	Plant diameter (mm)	# nodes	Inernodal length (cm)	# branches	Branch length (cm)	Branch diameter (mm)	Petiole length (mm)	# stomata	Leaf length (cm)	Leaf width (cm)	Midrib length (cm)	Leaf area (cm^2)
S babylonica x J795	100 (89.262)	225.00	11.04	42.0	4.15	36.0	56.58	3.65	1.05	51.25	15.75	1.9	15.3	11.57
PN227 x J172	100 (89.262)	328.33	17.59	74.33	5.18	54.33	90.04	4.48	0.93	60.10	13.63	2.1	13.13	10.48
PN227 x J194	100 (89.262)	300.83	14.77	68.57	5.37	49.48	68.77	4.17	1.05	62.55	15.98	2.77	15.5	11.04
PN227 x J795	94.87 (76.911)	272.84	16.71	78.98	4.98	69.8	94.54	5.13	1.04	64.76	14.97	2.93	14.52	16.24
PN227 x 131/25	96 (78.4653)	297.71	15.63	74.59	5.06	35.68	91.3	4.38	1.08	62.22	15.67	2.87	14.69	14.3
PN227 x AUSTREE	96 (78.46)	317.55	16.08	63.84	5.59	52.38	95.42	4.1	0.55	61.18	11.34	1.42	10.81	14.82
PN227 x NZ1140	88 (69.734)	227.05	15.23	74.28	5.06	86.48	67.19	4.64	1.02	60.84	15.17	1.77	14.59	11.43
PN227 x NZ1179	91.61 (71.226)	306.25	16.52	59.15	4.22	51.79	64.49	4.6	0.74	61.49	11.89	1.64	11.35	22.08
PN227 x *S tetrasperma*	92.39 (73.98)	292.24	15.24	63.11	2.5	57.53	90.63	4.86	1.13	60.82	14.32	5.08	9.53	13.97
PN227 x SI-64-007	94 (76.066)	297.54	15.38	80.34	5.06	73.2	95.08	4.93	1.17	60.2	16.08	2.21	15.5	12.87
SE-69-002 x *S tetrasperma*	75 (60.001)	220.00	11.6	71.42	4.67	46.83	89.15	4.65	0.96	59.08	14.68	1.87	14.22	8.073
J-799	70 (51.00)	210.6	9.14	40.6	3.15	32.5	53.7	3.12	0.51	52.24	10.45	1.05	10.21	9.27
SE-69-002	71 (53.008)	208.5	10.08	41.8	3.02	34.8	54.1	2.68	0.54	51.26	11.40	1.09	10.67	9.25
Mean	91.56	248.75	15.83	68.24	4.71	55.77	80.29	4.42	0.97	58.56	14.50	2.41	13.51	4.64
SE	22.6	24.01	0.09	6.18	0.31	7.03	14.17	0.15	0.11	4.80	1.42	0.22	1.09	NS
$CD_{0.05}$	0.46	0.73	0.58	4.05	0.64	9.21	29.56	0.31	0.23	10.02	0.85	0.62	6.13	32.17
CV %	0.34	0.55	0.62	2.7	8.04	15.8	21.61	4.18	14.01	10.04	3.89	0.23	2.47	10.5

Mean of SE-69-002 x *S tetrasperma* (8.07 cm^2) was significantly inferior to mean of PN227 x NZ1140 (22.08 cm^2). The hybrid PN227 x SI-64-007 registered longest petiole length (1.17 cm) whereas shortest petiole length (0.51 cm) was in the plant J799. In consonance with the present study on morphometric data Tharakan et al (1998) found statistically significant difference between clones of *Populus* and *Salix* for height, diameter, growth, leaf area and biomass production. Tunctaner (2002) conducted similar type of work for evaluation of willow clones in Turkey and found *S excelsa* clones much better in growth performance than others and also showed better growth performance than poplar check clone while studying growth performance of 53 willow clones selected from natural population in Turkey. Significant difference in mean survival was also noticed by Tharakan et al (2001) in the clones of poplar and willow. Dutt and Jamwal (1994) also assessed the suitability of poplar clones on the basis of their growth performance. Vihera-Aarnio and Saarsalmi (1994) also noticed large variation for willow clones with respect to shoot length and collar diameter. Luna and Singh (2009) suggested on the basis of their study on *Eucalyptus* that growth basal diameter (64.86%) and petiole length (55.72%) characters are governed by the genetic make up of the trait and attribute significantly to the phenotypic performance at early stage giving ample opportunity for selection of the outstanding genotypes. Highly significant difference among poplar clones of *Populus nigra* for diameter and height were noticed by Isik and Toplu (2009) whereas Özel et al (2010) reported in *P deltoides* hybrids for volume index and survival in two year old plants. All the growth characters showed wide range of values (Table 2) indicating the extent of variation existing in the clones. Morphological traits of 30 willow *Viminalis* clones were assessed by Tharakan et al (2005). The similar data were recorded by Singh et al (2001) for survival in *P deltoides* and Shirnesan et al (2009) in *Salix alba* plants for leaf breadth and leaf area.

Genetic values

The genetic parameters furnished in Table 2 rendered that phenotypic coefficient of variation (PCV) was greater than genotypic (GCV) for all growth parameters and varied from 9.89 per cent in leaf length to 13.2 per cent. In the present findings the heritability estimates (broad sense) were used to obtain the heritable portion of variation. Maximum heritability (92.63%) was found in branch diameter followed by internodal length (82.63%), number of stomata (68.24%), leaf length (56.1%), petiole length (59.3%), branch length (45.49%) and midrib length (36.8%). The genetic gain was recorded highest (32.85%) for internodal length and lowest (15.2%) for leaf length. The results show the scope for improvement in these characters through clonal selection and control breeding. These results related to

Table 2. Phenotypic and genotypic coefficient of variation, heritability and genetic gain recorded in hybrids of *Salix* species

Plant character	VG	VE	VP	GCV	PCV	ECV	Heritability (%)	Genetic advance (%)	Genetic gain (%)
Internodal length	0.683	0.144	0.827	17.54	19.3	8.042	82.63	1.548	32.85
Leaf length	2.05	1.61	3.67	9.89	13.2	8.75	56.1	2.21	15.2
Branch diameter	0.428	0.034	0.462	14.81	15.38	4.177	92.63	1.297	29.36
Midrib length	3.0	5.15	8.15	12.8	21.1	16.8	36.8	2.16	16.0
Petiole length	0.03	0.02	0.05	16.9	22	14	59.3	0.26	26.8
# stomata	74.29	34.58	108.9	14.72	17.82	10.04	68.24	14.67	25.05
Branch length	251.3	301.1	552.4	19.74	29.27	21.61	45.49	22.03	27.43
Leaf area	0.428	0.034	0.462	14.81	15.38	4.177	92.63	1.297	29.36

VG= Genetic variance, VE= Environmental variance, VP= Phenotypic variance, GCV= Genotypic coefficient of variation, PCV= Phenotypic coefficient of variation, ECV= Environmental coefficient of variation

genetic parameters are in line as projected by Lin and Zsuffa (1993). High heritability estimates for branch diameter, internodal length, number of stomata are in support with the results obtained by Heilman and Stettler (1985) in *Populus trichocarpa* and Lambeth et al (1994) in *Eucalyptus grandis*. Heritability value of the hybrid *P deltoides* clones for diameter, height, survival and volume index was recorded 0.61, 0.62, 0.51 and 0.65 by Özel et al (2010) in two year old plants. Singh et al (2001) recorded 70.43 per cent heritability in volume followed by 54.67 per cent in diameter on the basis of clonal mean in *P deltoides*. High heritability values for height (0.67-0.71) and diameter (0.50-0.59) with higher genetic gains was obtained by Luna and Singh (2009) in *Eucalyptus* hybrids. Johnson et al (1955) reported that heritability estimates along with expected genetic gain are more useful and realistic than the heritability alone predicting the resultant effect for selecting the best genotype. The findings are in agreement to Lin and Zsuffa (1993) on *Salix eriocephala*, Singh et al (2001) on *P deltoides* and Huse et al (2008) on willow clones. Relatively high heritability and genetic gain for branch diameter and intermodal length indicated that selection can be carried out directly on the phenotypic basis for these two characters. Based on plant growth and genetic parameter, these hybrids may be used for mid-hills of Himachal Pradesh. These promising hybrids selected under present study need to be further tested under multi-location trials to test the genotype x environment interaction at different sites for analysis of suitability of hybrids for producing more productive hybrids.

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