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Nursery Growth Performance of Hybrid Seedlings of Willow (Salix species)

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ABSTRACT

Clones of willow (Salix species) were selected for control breeding/hybridization during the year 2011. The hybrids produced were raised and evaluated in earthen bowl (Stage I), root trainer (Stage II), polybags (Stage III) and finally shifted to the nursery (Stage IV) in the winter season and growth and leaf characters were evaluated in the year 2012. The nursery data revealed that growth (plant height and basal diameter) was recorded highest (347.48 cm, 18.98 mm, respectively) in family PN 227 x SI-64-007 followed by family PN 227 x NZ 1179 (328.35 cm, 18.40 mm, respectively). Number of branches was recorded maximum in family PN 227 x NZ 1140, while branch length, branch diameter, leaf length, petiole length were almost at par among all of the families. Correlation coefficient was found maximum for leaf length with midrib length (0.960) followed by plant height with basal diameter (0.851). A significant and positive correlation of basal diameter with number of nodes, branch diameter and branch number was recorded. On the basis of principal component analysis four components were extracted contributing 86.88 per cent of total variation. The first component explained 41.87 per cent variability included number of nodes (0.855), branch number (0.780), branch diameter (0.691), midrib length (0.670), basal diameter (0.653), branch length (0.588) and plant height (0.566). The maximum priority should be given to number of nodes along with other characters in first component for the selection in further breeding programme.

Key words:

Salix, Family, hybrids, willow, correlation

INTRODUCTION

The genus *Salix (Salicaceae)* is one of the most important taxonomic entities of the world because of the great number of species and variety (Chaudhary et al 2011) having 330-500 species worldwide (Argus 1997). Around 31 species of willows are reported from India (Sharma et al 2011). Salix being a lifeline for cold desert areas of Himachal and Jammu and Kashmir is used to make agricultural implements, ropes, boxes, baskets etc. The bark and leaves are main source of winter fodder to cattle, sheep and goats (Rawat et al 2006). Willow wood is best suited for sport items i.e. cricket bats (Bhat 2004) polo bats etc. and artificial limbs. Willows in the Trans-Himalayan region are used for making charcoal

and Kangri (fire pot) from twigs, chips etc. to overcome severe winter conditions, as cattle feed from foliage during lean seasons and wickerwork for the manufacture of baskets, flower vases, trays, chairs and other novelty items. Several different forms in terms of habit, utilization properties and value addition for *Salix* in the Himalayan region are the result of natural hybridization (Biswas and Hussain 2008). Sinha and Sharma (2002) have emphasized the suitability and growth pattern of Salix species in Himalayan foot hills. The possibilities of artificial intra and inter specific hybridization among *Salix* species are of great interest to the breeder as it offers high reliability of combining the important traits and extending the range of useful progenies for selection of superior genotypes. Willows offers lots of advantages viz., wide natural range, immense genetic diversity, unique opportunities for manipulation through hybridization and selective breeding, an ease of vegetative propagation for genetic improvement (Chaudhary et al. 2013). In addition to the naturally occurring hybrids in various parts of the world, a considerable number of inter- and intra-specific hybrids have been artificially produced by controlled mating (Zsuffa et al. 1984; Kajba et al. 1998 and 1999; Larsson 2000 and Kopp et al. 2001). Many hybrids of *Salix* species (Willow) have been developed through control-pollination in India (Singh et al. 2012a, Chaudhary et al. 2013).

Over the years two hundred clones/ strains/ species were procured from twenty different countries covering five continents namely Europe, North America, South America, Asia and Africa. These clones were subjected to repeat screened in nursery (Singh et al. 2012a & b; Sharma et al. 2014) and field (Sharma et al. 2011; Singh et al. 2014). Phenological study of *Salix* species has been completed in Indian conditions (Chaudhary et al. 2011). The hybrids were prepared by involving superior clones (Table 1) as a parent. The control breeding/hybridization work was done during the year 2011 involving superior parents (Chaudhary et al. 2013) as well as seeds were collected from superior female clones. The seeds of hybrids was raised in earthen bowl and seedlings were firstly shifted to hecotrays and then to nursery which was evaluated for growth and leaf characters.

Table 1: Clones involved in hybridization programme

Sr No.	Clone	Species	Source country/ originally developed	Used as
1	J795	*S. matsudana x S. alba*	UK/China	Male
2	J-799	*S. matsudana x S. alba*	UK/China	Female
3	J172	*S. babylonica x S.alba x S. matsudana*	UK/China	Male
4	J194	*S. matsudana x S.arbutifolia x S. matsudana*	UK/China	Male
5	131/25	*S. babylonica x S. alba*	UK/Aregentina	Male
6	AUSTREE	*S.alba x* S. *matsudana*	UK/New zeland	Male
7	NZ1179	*S. matsudana x S. alba*	UK/Newz eland	Male
8	NZ1140	*S. matsudana x S. alba*	UK	Male
9	SI-64-007	*S. alba*	Italy	Male
10	PN227	*S. matsudana*	Newz eland	Female
11	SE-69-002	*S. matsudana*	Italy	Female
12	*S. tetrasperma*	*S. tetrasperma*	Local selection	Male & Female
13	*S.babylonica*	*S.babylonica*	Local selection	Female

MATERIALS AND METHODS

Location of site and experimental design

The hybrid seedlings developed by controlled pollination along with seeds collected from open pollinated female clones in the year 2011. The seeds were raised in earthen bowl (Stage I), shifted to root trainer (Stage II), polybags (Stage III) and finally shifted to the Naganji nursery (Stage IV) of the Department of Tree Improvement and Genetic Resources, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan (HP) for evaluation. The hybrids/progeny of each cross/family were planted in three replications in Completely Randomized Design in spacing of 30 cm x 30 cm in a sunken bed of size 250 cm x 150 cm under the usual nursery conditions. The nursery site is located at an elevation of 1200 m above mean sea level in the north-west of Himalaya and lies between 30°51'N latitude and 76°11'E longitude. The area experiences a wide range of temperature with a minimum of 1°C in winters to a maximum of 33°C during May and June as the hottest months. The annual rainfall ranges between 0-800 mm with maximum downpour during the monsoon season (July - September). The growth and leaf characters were evaluated in the year 2012. The number of progenies was variable in each replication (Table 2). All the seedlings in each replication were included for stem characters (plant height, basal diameter, number of nodes). Three branches each from top, mid and lower portion were randomly included for branch characters. Three mature three leaves from selected branches were randomly taken for leaf characters. The plant height from ground level to top and internodal length between two nodes were recorded in the last week of November. Basal diameter 15 cm above from ground level and branch diameter at 5 cm away from main stem was recorded with the help of digital calliper. Number of nodes and branches were counted. Leaf length, width, petiole length and midrib length were measured with measuring scale, while leaf area was measured with digital leaf area meter in the last week of August Data were statistically analyses with the statistical package for social sciences (SPSS), version 16.0.

Table 2 : Number of progenies in each replication of families

Sr No.	Family	Number of Progenies in each replication
Full Sib	Families	
1	PN227 x 131/25	25
2	PN227 x AUSTREE	50
3	PN227 x J172	18
4	PN227 x J194	15
5	PN227 x J795	25
6	PN227 x NZ1140	20
7	PN227 x NZ1179	20
8	Pn227 x *S.tetrasperma*	24
9	Pn227 x SI -64 -007	40
10	*S.babylonica* x J795	12
11	SE-69-002 x *S.tetrasperma*	12

Half Sib Families		
12	J799	45
13	PN227	40
14	S. *tetrasperma*	43
15	SE - 69 - 002	32

RESULTS AND DISCUSSION

Growth performance

Stem character studied in the year 2012 revealed (Table 3) that hybrids of family PN 227 x NZ 1179 (328.35 cm and 18.40 mm, respectively) recorded at par plant height and basal diameter with maximum recorded in family PN 227 x SI-64-007 (347.48 cm, 18.98 mm, respectively) followed by hybrids of family PN 227 x *S. tetrasperma* (313.56 cm and 18.18 mm, respectively) for basal diameter. Maximum internodal length was recorded in family PN 227 x Austree (5.61 cm) followed by PN 227 x J 194 (5.30 cm) and PN 227 x J 172 (5.18 cm). Number of nodes were recorded maximum in family PN 227 x SI-64- 007 (80.83) followed by family PN 227 (79.77), PN 227 x J795 (78.80), and J 799 (76.89).

In the present study seedling of hybrids obtained by crossing superior parents were evaluated. In the same line, seedling growth of hybrids of *Populus* species were evaluated by Dhir and Mohn (1976), Vaario et al. (2011) and Singh et al. (2013b). The characters studied significantly varied between the families except leaf width and leaf area. The significant difference is obtained between populations of eastern cottonwood developed by crossing two sources for plant height, stem diameter, number of internodes, petiole length (Dhir and Mohn 1976). Significant height and mean number of leaves was reported by Vaario et al. (2011) in families of *P. tremula* obtained by controlled crossing between four male and three female trees at two different soil types. Family screening trials of willow hybrids were carried by Smart et al. (2007). Intraspecific breeding in *Populus deltoides* was carried out by Singh et al. (2013) and growth traits of cottonwood hybrids at nursery stage were studied (Ozel et al. 2010).

Number of branches were recorded maximum in family PN 227 x NZ 1140 (85.14) followed by families PN 227 x SI-64-007 (73.08) and PN 227 x J 795 (70.40). Branch length and diameter of the families studied were at par with families SE-69-002 (98.05 cm) and J799 & PN 227 x J795 (5.15 cm), respectively except in families PN 227 x J 194 (66.84 cm), *S. tetrasperma* (63.80 cm), S. babylonica x J795 (30.85 cm) and PN 227 x NZ 1179 (62.33 cm) for branch length and PN 227 x Austree (4.05 cm) for branch diameter. Leaf length and petiole length were showed at par among most of the families with maximum leaf length recorded in family PN 227 x SI-64-007 (16.08 cm) and petiole length in PN 227 (1.18 cm). Maximum midrib length was recorded is the family PN 227 x SI-64-007 (15.51 cm) followed by PN 227 x J 194 (15.50 cm), PN 227 (15.46 cm) and S. babylonica x J795 (15.3 cm). Leaf width and leaf area varied non-significantly. Leaf width of 2.92 cm was recorded highest in open pollinated family J799 followed by PN 227 x J 795, PN 227 x 131/25 and PN 227 x J194. Leaf area was recorded more in families *Salix tetrasperma,* PN 227 x Austree and PN 227 x 131/25.

Weber et al. (1984) found large range of variation in 15 leaf, branch and phenological characters in *Populus trichocarpa* and its hybrids due to regional climatic gradient, riparian environment and the life history characteristics of the species. Significant difference among leaf characters in nursery growth of willow was obtained by Singh et al. (2012b).

Table 3 : Growth performance of hybrid seedlings of willow in nursery in the year 2012

Sr No.	Family	Height (cm)	Basal Diameter (mm)	Number of Branches	No. of Nodes	Internodal length (cm)	leaf length (cm)	Midrib length (cm)	Leaf width (cm)	Petiol length (mm)	Branch length (cm)	Branch dia (mm)	Leaf area (cm^2)
1	J799	236.37	15.24	68.55	76.89	5.01	14.97	14.54	2.92	1.05	94.72	5.15	18.65
2	PN227	318.28	15.80	66.25	79.77	5.04	16.02	15.46	2.21	1.18	92.04	5.05	17.14
3	PN227 x 131/25	308.68	16.11	35.95	74.14	5.07	15.67	14.59	2.87	1.09	90.38	4.25	19.38
4	PN227 x AUSTREE	306.74	17.30	55.85	66.30	5.62	11.35	10.82	1.42	0.55	90.05	4.05	20.24
5	PN227 x J172	311.53	17.23	54.33	74.33	5.18	13.63	13.13	2.10	0.93	87.73	4.34	13.60
6	PN227 x J194	301.24	15.26	68.62	68.03	5.30	15.98	15.50	2.79	1.05	66.84	4.10	14.41
7	PN227 x J795	313.74	17.07	70.39	78.81	4.98	14.97	14.54	2.92	1.05	94.72	5.15	21.71
8	PN227 x NZ1140	297.30	15.93	85.14	74.26	5.08	15.21	14.64	1.79	1.02	96.44	4.50	14.98
9	PN227 x NZ1179	328.35	18.40	51.26	59.08	4.23	11.76	11.16	1.65	0.75	62.33	4.39	31.90
10	PN227 x *S.tetrasperma*	313.56	18.18	57.72	63.40	2.52	14.37	12.44	1.63	1.14	89.07	4.73	18.70
11	PN227 x SI-64-007	347.48	18.98	73.08	80.83	5.07	16.08	15.51	2.22	1.17	90.96	4.91	16.80
12	*S.babylonica* x J795	214.00	11.54	36.00	42.00	4.15	15.75	15.30	1.90	1.05	30.85	2.62	16.21
13	S.*tetrasperma*	197.93	11.95	42.54	48.88	4.90	11.15	10.41	1.43	0.56	63.80	3.74	20.87
14	SE-69-002	201.26	14.50	54.51	55.27	2.07	13.98	12.01	1.60	1.12	98.05	4.42	18.23
15	SE-69-002X *S.tetrasperma*	207.07	11.62	43.50	74.25	4.70	14.65	14.15	1.90	0.78	79.61	4.35	9.94
	Mean	275.66	15.67	57.58	67.75	4.59	14.37	13.61	2.09	0.97	81.84	4.38	18.18
	CD (0.05%)	21.42	1.42	6.99	6.67	0.50	1.87	1.99	NS	0.21	24.62	0.97	NS

Correlation studies

Maximum positive and significant correlation coefficient was found for leaf length (Table 4) with midrib length (0.960) followed by plant height with basal diameter (0.851). Significant and positive correlations of basal diameter with number of nodes, branch diameter and branch number depicts that more photosynthetic area enhances the diameter growth. These correlations indicate that improvement of one character will be accompanied by the improvement in another. Khurana et al. (1992) on poplar and Singh et al. (2012b) on Salix clones also reported high correlation between plant height and collar diameter. The results from the present investigation for relationships are corroborated by similar findings reported by Randall and Cooper

(1973), Nelson and Tauer (1987) and Pandey et al. (1993) on Populus species. Correlation among leaf characters in Populus trichocarpa and its hybrids were found significant by Weber et al. (1985).

Principal Component Analysis

In the present study (Table 5) four out of ten components had eigen value greater than unity and are retained in for further analysis as per Kaiser (1958) contributing 86.88 % of total variation. The first component explains 41.87 % includes seven characters. The highest value (0.855) was exhibited in number of nodes followed by branch number (0.780), branch diameter (0.691), midrib length (0.670), basal diameter (0.653), branch length (0.588) and plant height (0.566). The second component accounted for 20.17 % of total variation, defined by leaf length (-0.712) and petiole length (-0.610). The third component exhibited 13.34 per cent of variability accounted by internodal length (0.727). Similar types of findings were reported by Tunctaner (2002), Singh et al. (2012c,) on Salix clones and Singh (2006) and Isik and Toplu (2004) on Populus species. The growth characters are attributed to distinct genetic constitution of the clones (Singh et al. 2014). The maximum priority should be given to number of nodes along with other characters in first component for the selection in further breeding programme.

Table 4. Simple Correlation Coefficient (Karl Pearson Coefficient) among different characters studied.

	Basal Diameter (mm)	Number of nodes	Internodal length (cm)	Branch number	Branch length (cm)	Branch diameter (mm)	Leaf length (cm)	Midrib length (cm)	Petiole length (mm)
Plant height(cm)	0.851**	0.425**	0.281	0.402**	0.181	0.231	0.112	0.138	0.096
Basal Diameter (mm)	1	0.479**	0.116	0.495**	0.330*	0.426**	0.138	0.120	0.201
Number of nodes		1	0.480**	0.560**	0.635**	0.666**	0.431**	0.478**	0.274
Internodal length (cm)			1	0.218	-0.005	0.056	0.087	0.291	-0.224
Branch number				1	0.480**	0.541**	0.405**	0.428**	0.329*
Branch length (cm)					1	0.645**	0.100	0.055	0.171
Branch diameter (mm)						1	0.241	0.219	0.183
Leaf length (cm)							1	0.960**	0.718**
Midrib length (cm)								1	0.602**

Table : 5 Principal components of growth and leaf traits of willow hybrids

Characters	Principal components			
	I	II	III	IV
Plant height(cm)	0.566	0.453	0.414	-0.490
Basal Diameter (mm)	0.653	0.467	0.148	-0.520
Number of nodes	0.855	0.175	0.031	0.331
Internodal length (cm)	0 .308	0.181	0.727	0.539
Branch number	0.780	0.098	-0.065	0.013
Branch length (cm)	0.588	0.355	-0.552	0.244
Branch diameter (mm)	0.691	0.280	-0.425	0.216
Leaf length (cm)	0.665	-0.712	0.075	-0.027
Midrib length (cm)	0.670	-0.662	0.244	0.106
Petiole len gth (mm)	0.538	-0.610	-0.234	-0.348
Eigen value	4.187	2.017	1.334	1.115
Percentage of variability	41.87	20.17	13.34	11.50
Cumulative percentage of variability	41.87	62.04	75.38	86.88

CONCLUSION

Hybridization is required to create variability and incorporate the desired traits of parents in the progeny. Many hybrids are produced that has been selected on family as well individual basis. Selection plays a major role in tree improvement where testing of a large number of genotypes are not possible due to the testing area and other resource constraints. In the present studies the Salix families were evaluated on the basis stem and leaf growth characters. The families will be evaluated in the field and best genotypes within and between families will be selected for further improvement.

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