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Studies on Crossability Parameters in *Salix* (willow) Through Control Crossing

Sapna Thakur*, N.B Singh, Sanjeev Thakur and R.K Gupta

Department of Tree Improvement and Genetic Resources, College of Forestry, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni- Solan- 173 230, Himachal Pradesh

**Email: sapnakullu_thakur@rediffmail.com*

ABSTRACT

The present investigation was carried out to gather information on crossability pattern and to develop suitable hybrids through controlled crossing. The per cent successful crosses ranged between 10.00 to 50.00 per cent for different crosses and were found to be maximum in PN 227 × Austree. Maximum germination percentage 59.05 per cent was found in J 799 × NZ 1140 and in which per cent successful cross ranged between 30.86 to 59.05 per cent. Similarly, survival per cent ranged between 27.67 to 56.92 per cent and was found to be maximum in J 799 × J 795. Results on crossability among diffent genotypes revealed higher crossability for intra-specific crosses as compared to inter-specific crosses.

Key words:

Germination percentage, inter-specific crosses, intra-specific crosses, per cent successful cross, survival per cent

INTRODUCTION

The willows belong to the genus *Salix* of family Salicaceae. The willows range from prostrate shrubs to large trees over 30 meters high, but most are shrubs or small trees. Willows are really rich in species diversity and distribution. There are about 330-500 species in the world, mainly distributed in North-temperate zone (Zhenfu et al. 1999). In India, there are about 33 species of willows, but majority of them are not suitable for industrial uses or has high bio-mass except *Salix tetrasperma*, which meets only certain requirements (Anonymous1972). Characteristics of good clear bole and low wood density as required by industrial entrepreneurs are also lacking in this species.

Arborescent species of willow *like Salix alba*, *S. humboltiana*, *S. excelsa*, *S. acmophyla*, *S. fragilis*, *S. nigra*, *S. matsudana*, *S. amygdaloides*, *S. jessoensis*, *S. argentensis* and *S. tetrasperma* and their inter and intra specific hybrids/clones are able to grow by vegetative propagation on a large variety of edaphic, ecological and hydrological conditions and are better adapted in monoculture as well as in agroforestry systems, where in some of the selected exotic *Salix* clones are found suitable in farmer field under agroforestry with peas, tomato, oil seeds, rice and wheat (Singh et al. 2012).

Salix is a multipurpose agroforestry tree species which serves not only purpose of producing fodder, fuel and timber but its wood is also used for pulp, veneer, reconstituted wood products, artificial limbs, sports goods *like* cricket bats, polo balls, as a substrate for shitake mushroom, *etc*. Apart from this *Salix* species also serves as a host for lac cultivation.

Hybridization between *Salix* species seems to be common. In addition to the naturally occurring hybrids in various parts of the world, a considerable number of hybrids have been artificially produced by controlled mating, often rendering their identification vary at the morphological level. Natural hybridization is supported by dioecism and is affected by diverse flowering phenologies in different *Salix* species. The possibilities of artificial intra- and interspecific hybridization among *Salix* species are of great interest to the tree breeder as it offers high reliability of combining the important traits and extending the range of useful progenies for selection of superior genotypes (Choudhary et al. 2013). The present investigations were aimed to gather information on combining abilities to develop a suitable hybrid through controlled breeding. The objective of hybridization was to capture a sufficiently inclusive and unbiased genetic representation and to generate large hybrid families. High percentage of successful crosses, high germination percentage and survival percentage are highly desirable from any hybridization programme. Higher values of these crossability parameters suggested high range of crossability among genotypes.

MATERIAL AND METHODS

Over the year's two hundred clones/ strains/ species were procured from twenty different countries covering five continents namely Europe, North America, South America, Asia and Africa and raised in the germplasm block of Naganji nursery, Department of Tree Improvement and Genetic Resources, College of Forestry, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh. These clones were repeatedly screened in the nursery followed by field testing. On the basis of their stability performance control crossing of the selected clones was carried out in 2013-2014 to develop new hybrids. The flowering plant branches of selected 4 females and 4 male clones of Salix species were used for control crossing (hybridization) using Line × Tester (i.e. 4 × 4) with 8 parents (Table 1.). Male catkins from selected species/clones were removed at anthesis time for collection of pollen to accomplish artificial pollination. All the female clones (Lines) were crossed with each of male clone (Testers) by hand pollination at stigma receptivity stage. Pollen was tested for in-vitro pollen viability before controlled crossing. Taken care that every controlled cross involves single pollen and no pollen mixture was attempted. After pollination the flowers were bagged and tagged. Seeds of controlled crosses were harvested when mature and sowed immediately as per international standard seed testing procedures. Further observations were recorded on following parameters.

Per cent successful crosses

Observations were recorded on per cent successful crosses as suggested by Jan and Pfeffer (1999).

$$\text{Per cent successful crosses (\%)} = \frac{\text{Successful crosses}}{\text{Total crosses}} \times 100$$

Germination percentage

Germination count was made within 10 days after sowing. Per cent germination was calculated as the number of seeds that germinated out of number of seeds sown and expressed in percentage.

$$\text{Germination (\%)} = \frac{\text{Germinated seeds}}{\text{Total number of seed sown}} \times 100$$

Survival per cent

Survival percentage was calculated as the number of seedlings that survived after it reached 4 leaves stage out of number of germinated seedlings and expressed in percentage.

$$\text{Survival per cent (\%)} = \frac{\text{Survived seeding}}{\text{Total number seed germinated}} \times 100$$

Table 1. List of clones used in control crossing

Sl. No.	Clone	Species	Source country/originally developed	Used as
1	J 795	*S. matsudana* × *S. alba*	UK/China	Male
2	J 799	*S. matsudana* × *S. alba*	UK/China	Female
3	*S. tetrasperma*	*S. tetrasperma*	India (Rajasthan)	Male
4	Austree	*S. alba* × *S. matsudana*	UK/Newzealand	Male
5	NZ 1140	*S. matsudana* × *S. alba*	UK	Male
6	PN 227	*S. matsudana*	Newzealand	Female
7	*S. tetrasperma*	*S.tetrasperma*	Local selection, H.P., India	Female
8	*S. babylonica*	*S. babylonica*	Local selection, H.P., India	Female

RESULTS AND DISCUSSIONS

Higher percentage of successful crosses, coupled with higher germination percentage and survival rate are highly desirable from any hybridization programme. The success of controlled intra and interspecific crosses producing viable F_1 hybrid plants and inquisition of the data appended in Table 2, indicates that high level of crossability pattern among different species.

The range of per cent successful crosses (Table 2) lied between 10.00 to 50.00 per cent for different crosses. Per cent successful cross was highest in PN-227 × Austree cross (50.00%) followed by, J-799 × NZ-1140 (45%), *Salix babylonica* × Austree (40%), PN-227 × J-795 (36.67%). The minimum percentage of successful cross was obtained for cross *Salix babylonica* × *S. tetrasperma* (10.00 %).

Maximum germination percentage (59.05%) was recorded for crosses involving J-799 × NZ-1140 followed by PN-227 × NZ-1140 (57.67%) and J-799 × *S. tetrasperma* (55.52%) was recorded and were statistically similar. Minimum (30.86%) value for germination percentage was recorded for crosses *Salix babylonica* × Austree.

Survival percentage is one of the important factors in successful establishment of a species and is the best indicator of species with respect to adaptation and growth. The range for survival percentage was between 27.67- 56.92 per cent among the crosses. Crosses *viz*., J-799 × J-795 recorded highest per cent survival (56.92%) among all other crosses followed by PN-227 × Austree (52.57%), *Salix babylonica* × Austree (51.85%) and *Salix tetrasperma* × J-795 (44.96%). Whereas, J-799 × Austree cross recorded minimum (30.17%) survival per cent.

Similarly, Choudhary (2011) in *Salix* revealed significant differences different parameters *viz*., per cent successful crosses lied between 10.00 to 50.00 per cent for different crosses, mean values of germination percentage lied between 85.00 to 62.00 per cent and higher survival percentage was recorded for intraspecific hybrid as compare to inter-specific hybrids. In the same way, Verma (2012) also revealed significant differences for all the characters in *Grewia optiva*. Characters showed that mean values varied between 00.00 to 100.00 per cent for germination percentage, 00.00 to 66.66 per cent for survival percentage was recorded for intraspecific hybrids. Likewise, Sankanur (2013) in *Terminalia chebula* revealed significant differences different parameters *viz*., per cent successful crosses lied between 0.41 to 2.14 per cent for different crosses, mean values of germination percentage lied between 47.62 to 100.00 per cent and survival percentage lied between 30 per cent to 100 per cent for different crosses.

The results of the present investigations are similar with earlier findings of Choudhary et al. (2013) on hybrid performance and species crossability relationship in willows. They were also of the opinion that, higher crossability rate for intraspecific crosses as compared to inter-specific crosses. Further, Zsuffa (1988) is also of the same opinion and supports the present findings on recorded crossability parameters that, low success of inter-specific crosses coupled with low seed set among different *Salix* species.

Table 2. Mean values of different crossability parameters of various intra- and inter- specific hybrids

Sl. No	Crosses	Per cent successful crosses (%)	Germination (%)	Survival (%)
1	PN-227 × NZ-1140	30.00 (33.21)	57.67	36.74
2	PN-227 × Austree	50.00 (45.00)	46.00	52.57
3	PN-227 × J-795	36.67 (37.27)	32.09	32.33
4	PN-227 × *S. tetrasperma*	35.00 (36.27)	41.30	34.85
5	J-799 × NZ-1140	45.00 (42.13)	59.05	27.67
6	J-799 × Austree	33.33 (36.26)	41.67	30.17
7	J-799 × J-795	23.33 (28.88)	35.00	56.92
8	J-799 × *S. tetrasperma*	33.33 (36.26)	55.52	32.01
9	*Salix babylonica* × NZ-1140	30.00 (33.21)	41.99	32.9
10	*Salix babylonica* × Austree	40.00 (39.23)	30.86	51.85
11	*Salix babylonica* × J-795	30.00 (33.21)	40.40	39.75
12	*Salix babylonica* × *S. tetrasperma*	10.00 (18.43)	44.19	29.76
13	*Salix tetrasperma* × NZ-1140	20.00 (26.57)	40.67	34.31
14	*Salix tetrasperma* × Austree	26.67 (31.09)	44.91	33.29
15	*Salix tetrasperma* × J-795	30.00 (33.21)	42.94	44.96
16	*Salix tetrasperma* × *S. tetrasperma*	23.33 (28.88)	36.11	37.46
	CD	7.87	12.32	13.53

* Values in parenthesis are arcsine transformed values

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