

## NOTE

### PROVENANCE-PROGENY TRIAL FOR DOMESTICATION OF *POPULUS CILIATA* CLONES

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Greening the Himalayas is one of the priority areas of forestry in India. Great emphasis is given in establishing plantations to increase tree cover especially on degraded, community and abandoned agricultural lands. Many indigenous fast growing species are used for plantations in middle and high altitudes in Garhwal Himalaya.

*Populus ciliata* (Salicaceae) grows scattered or in small patches in blue pine, deodar, spruce or temperate hardwood forests from 1200–3000 m in Jammu and Kashmir, and from 1600–3500 m in Uttaranchal hills, Sikkim, West Bengal, Assam and Arunachal Pradesh (Khosla & Khurana 1981, Beniwal & Haridasan 1992). *Populus ciliata* grows in areas with subtemperate or temperate climate on a variety of soils ranging from sandy to clayey loam.

The use of *P. ciliata* as a substitute for packaging material, an alternative source material for match and pulp industry, and/or in agroforestry in moderately low and middle elevation localities requires screening of promising clones (Sidhu 1996). This was the prime objective of this investigation and we examined the potential of this species for rehabilitation purposes. The investigation was focussed on screening promising clones of *P. ciliata* to make available progenies of superior genotypes via clonal multiplication. This paper represents preliminary results of a two-year-old clonal progeny trial.

In April till May 2000, 10 well-grown candidate plus trees (CPTs) were selected in natural stands of *P. ciliata* throughout Garhwal hills (Table 1). Leafless, semi-hard branch cuttings of 22 cm length and 1.5 cm diameter and having at least four to five buds were prepared from all parts of the canopy of each CPT during the rainy season, i.e. 1–15 August 2000. Cuttings from all 10 CPTs in a provenance were mixed together and then brought to the Phata nursery. The nursery

is situated at 30° 17' N and 79° 14' E at 1500 m asl. The area experiences 90–140 rainy days annually with approximately 89% rainfall during rainy season, mean monthly minimum temperatures of 12.6 and 20.5 °C and maximum temperatures of 19.7 and 30.5 °C in December and May respectively.

The cuttings were planted in polybags containing soil of pH 7.1, sand and farmyard manure in 3:3:1 ratio, either on the same or the next day. Before planting, the cuttings were drenched first with aldrin insecticide (2%), then with emisan fungicide (0.1%) and finally immersed in 2% gibberilic acid (GA<sub>3</sub>, powder medium) at their basal end to enhance rooting. A total of 100 cuttings in five replications of 20 cuttings each (from composite sample) were planted in polybags for each provenance.

Planted cuttings from all provenances showed slow growth throughout the first year, i.e. until August 2001. All plants were cut back after 1.5 years and stem segments of 5–7 cm lengths and 2–3 mm diameters were collected. This gave 100 cuttings each for the 10 provenances. Prior to planting, all clones were treated in the same manner as cuttings from mother trees. Watering and weeding were conducted regularly. The clones were evaluated in terms of survival and morphological growth characteristics for one year in the nursery.

After 12 months (February 2003), the best 30 clones in terms of survival and growth were selected from each provenance and then planted for field evaluation at Phata. One-year-old ramets (average height 31.4 cm and root collar diameter 4.12 mm) were planted in the third week of February 2003 in a randomized block design (RBD) with three replications (of 10 clones each) for every population at a spacing of 4 × 4 m. A total of 500 g farmyard manure was applied to each ramet at planting. Plant height, collar diameter,

**Table 1** Geographical description of different sources (provenances) of *Populus ciliata* in Garhwal Himalaya

Provenance	Altitude (m asl)	Latitude (N)	Longitude (E)	Tree height (m)	Dbh (m)
Narayanbagar (Chamoli)	850	30° 08'	79° 25'	27.6	12.2
Narayankoti (Rudrapryag)	1450	30° 16'	79° 15'	10.2	17.5
Tapovan (Chamoli)	1950	30° 30'	79° 28'	16.6	11.0
Mussoorie (Tehri)	2004	30° 23'	78° 15'	15.4	11.7
Radee (Uttarkashi)	2100	30° 78'	78° 13'	9.6	12.9
Dhanaulti (Tehri)	2258	30° 27'	78° 06'	21.4	14.8
Ranichauri (Tehri)	2325	30° 23'	78° 20'	13.0	13.7
Hanumanchatti (Chamoli)	2500	30° 44'	79° 32'	9.0	16.9
Dharali (Uttarkashi)	2720	31° 21'	78° 47'	12.12	16.6
Gangotri (Uttarkashi)	3106	30° 59'	78° 59'	7.12	12.4

number of branches and number of leaves were recorded after three months, i.e. May 2003 and again after 12 months (February 2004). Ten sample plants (out of 30 planted) for each population were measured and the mean values were analyzed statistically using analysis of variance and Tukey's test (Bartz 1988). Variability parameters were computed as in Burton and De Vane (1953) and Johnson *et al.* (1955).

After three months under nursery conditions, Narayankoti provenance had the highest survival (92%) while the lowest (62%) was Dharali (Table 2). However, after 12 months, survival was highest in Narayankoti (80%) and lowest in Radee (58%). After three months, average maximum plant height was recorded for Dharali (17.28 cm) and minimum for Narayanbagar (10.52 cm). Collar diameter ranged from 0.77 mm (Narayanbagar) to 2.26 mm (Dharali) while number of branches per plant from 0.60 (Narayanbagar) to 1.6 (Gangotri and Dharali). After 12 months growth under open nursery conditions, plant height was highest (36.9 cm) in Gangotri, and lowest (26.59 cm) in Radee, while collar diameter ranged from 3.14 mm (Mussoorie) to 4.92 mm (Narayankoti), and number of branches per plant from 2.0 (Narayanbagar) to 4.0 (Tapovan). Immediately after this measurement, a total of 30 elite (in three replicates of 10 each) clones for each provenance were planted in the field.

After three months of field planting trial, average

plant height increased up to 48.3 cm (maximum) for Gangotri population while collar diameter varied from 3.96 mm (Mussoorie) to 5.72 mm (Dhanaulti) (Figure 1). Number of branches per plant ranged from 2.6 (Ranichauri) to 4.9 in Radee (results not shown). After one year of field planting, all the provenances had 100% survival. All growth parameters studied among the provenances showed significant ( $p = 0.05$ ) increments after 12 months under field trial. Average plant height increased to 101.4 cm (maximum) for Narayankoti population (Figure 1). Collar diameter varied from 5.67 (Radee) to 8.85 mm (Narayanbagar) and number of branches per plant ranged from 4.3 in Dhanaulti to 6.6 in Narayankoti populations (Figure 1).

Plant height showed highest genotypic (157.24), phenotypic (248.81) and environmental (127.57) variances and heritability (63.19) compared with the rest of the growth parameters studied (Table 3). On the other hand, maximum genotypic (20.59), phenotypic (37.31) and environmental (31.10) coefficients of variation were estimated for number of branches per plant. Causes of such variability are generally attributed either to genetic characters of source population/plant (Uniyal & Todaria 2003), or to impact of mother plant environment (Fenner 1991).

Correlations among growth parameters and three geographic variables studied, namely, altitude, latitude and longitude, revealed that elevation and latitude

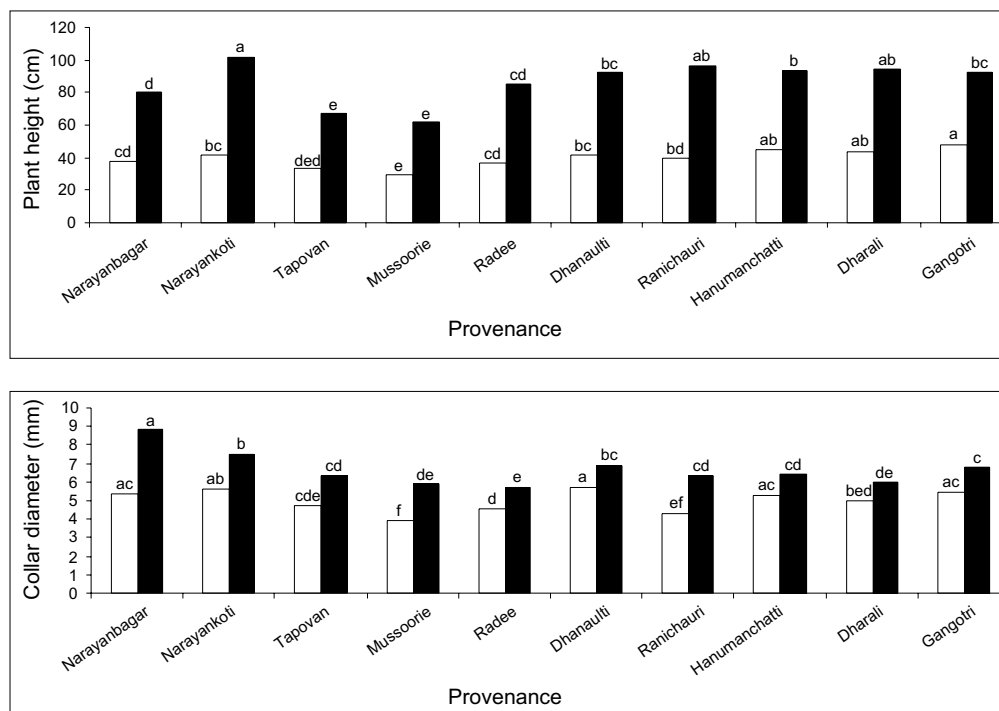
**Table 2** Growth performance of *Populus ciliata* clones of various populations under nursery conditions at Phata nursery

Provenance	3 months					12 months				
	Survival (%)	Plant height (cm)	Collar diameter (mm)	Number of branches/plant	Number of leaves/plant	Survival (%)	Plant height (cm)	Collar diameter (mm)	Number of branches/plant	Number of leaves/plant
Narayanbagar	76	10.52 ± 3.1 <sup>b</sup>	0.77 ± 0.23 <sup>c</sup>	0.60 ± 0.55 <sup>e</sup>	12.0 ± 5.43 <sup>d</sup>	60	31.48 ± 12.09 <sup>ac</sup>	4.7 ± 1.04 <sup>a</sup>	2.00 ± 1.41 <sup>d</sup>	13.6 ± 7.35 <sup>e</sup>
Narayankoti	92	14.82 ± 4.59 <sup>ab</sup>	1.14 ± 0.39 <sup>cd</sup>	0.80 ± 0.45 <sup>cd</sup>	16.6 ± 3.71 <sup>bcd</sup>	80	35.49 ± 14.51 <sup>a</sup>	4.92 ± 0.85 <sup>a</sup>	2.9 ± 0.99 <sup>bc</sup>	30.4 ± 9.58 <sup>a</sup>
Tapovan	71	17.22 ± 3.12 <sup>a</sup>	1.97 ± 0.45 <sup>ab</sup>	1.0 ± 0.71 <sup>bcd</sup>	23.2 ± 10.03 <sup>a</sup>	65	27.16 ± 3.23 <sup>c</sup>	3.92 ± 0.75 <sup>bc</sup>	4.0 ± 2.58 <sup>a</sup>	14.9 ± 4.15 <sup>de</sup>
Mussoorie	80	13.24 ± 5.10 <sup>ab</sup>	0.97 ± 0.48 <sup>d</sup>	0.80 ± 0.45 <sup>cd</sup>	13.6 ± 4.39 <sup>cd</sup>	62	26.61 ± 1.95 <sup>c</sup>	3.14 ± 1.10 <sup>d</sup>	2.4 ± 1.07 <sup>cd</sup>	13.50 ± 4.01 <sup>c</sup>
Radee	79	13.46 ± 5.88 <sup>ab</sup>	1.19 ± 0.36 <sup>cd</sup>	1.4 ± 0.55 <sup>ab</sup>	20.0 ± 7.04 <sup>ab</sup>	58	26.59 ± 8.22 <sup>c</sup>	3.47 ± 1.16 <sup>cd</sup>	3.3 ± 1.77 <sup>ab</sup>	19.2 ± 8.88 <sup>cd</sup>
Dhanaulti	78	16.26 ± 7.71 <sup>a</sup>	1.65 ± 0.90 <sup>bc</sup>	0.80 ± 0.84 <sup>cd</sup>	17.6 ± 7.44 <sup>ad</sup>	60	33.68 ± 7.96 <sup>ab</sup>	4.88 ± 0.82 <sup>a</sup>	2.8 ± 1.03 <sup>bd</sup>	26.6 ± 11.89 <sup>a</sup>
Ranichauri	86	12.78 ± 3.67 <sup>ab</sup>	1.68 ± 0.55 <sup>ac</sup>	1.2 ± 0.45 <sup>ac</sup>	12.6 ± 4.93 <sup>cd</sup>	65	27.87 ± 6.57 <sup>bc</sup>	3.33 ± 1.09 <sup>cd</sup>	2.3 ± 0.67 <sup>cd</sup>	19.9 ± 10.33 <sup>bd</sup>
Hanumanchatti	71	13.91 ± 8.69 <sup>ab</sup>	1.59 ± 1.00 <sup>bc</sup>	1.4 ± 0.55 <sup>ab</sup>	22.0 ± 10.58 <sup>ab</sup>	70	36.34 ± 11.57 <sup>a</sup>	4.26 ± 1.65 <sup>ab</sup>	2.5 ± 0.53 <sup>bd</sup>	24.8 ± 10.44 <sup>b</sup>
Dharali	62	17.28 ± 4.58 <sup>a</sup>	2.26 ± 0.59 <sup>a</sup>	1.6 ± 0.89 <sup>a</sup>	18.0 ± 5.0 <sup>bc</sup>	60	31.68 ± 12.47 <sup>ac</sup>	4.30 ± 1.42 <sup>ab</sup>	3.1 ± 0.88 <sup>bc</sup>	17.3 ± 9.3 <sup>de</sup>
Gangotri	63	15.52 ± 6.84 <sup>ab</sup>	2.1 ± 0.60 <sup>ab</sup>	1.6 ± 0.55 <sup>a</sup>	13.6 ± 3.36 <sup>cd</sup>	60	36.9 ± 10.9 <sup>a</sup>	4.29 ± 1.56 <sup>ab</sup>	3.0 ± 0.82 <sup>bc</sup>	20.1 ± 9.79 <sup>bc</sup>

± = SD. Figures followed by the same letter within a column do not differ significantly (p = 0.05)

of the parent populations had a highly ( $p = 0.01$ ) negative and significant influence on collar diameter of growing clones (Table 4). Number of branches also significantly ( $p = 0.05$ ) reduced with increasing altitude. However, number of leaves per plant increased with increasing elevation and latitude but decreased with longitude. Longitude of the parent populations had significantly ( $p = 0.01$ ) high positive correlation with collar diameter.

High and statistically significant differences observed among the sources (clones) of *P. ciliata* indicated the presence of considerable variations in growth rates. These differences can be exploited by selecting the best clones/sources for future plantations. Although these initial findings on provenance-progeny trial did not reveal clearly the superiority of any particular population, Narayankoti and Gangotri sources showed uniformly best growth



**Figure 1** Height and collar diameter per plant of *Populus ciliata* clones under field trial after three (□) and 12 (■) months at Phata nursery. Black and white bars (separately) followed by the same letter do not differ significantly ( $p = 0.05$ ).

**Table 3** Estimation of variability for different growth traits of *P. ciliata* clones under provenance-progeny trial after 12 months of field planting

Genetic variable	Plant height	Collar diameter	Branches/plant	Leaves/plant
Genotypic variance	157.24	0.77	0.89	0.89
Phenotypic variance	248.81	1.81	2.92	2.92
Environmental variance	127.57	1.04	2.03	2.03
Genotypic coefficient of variance	14.47	13.17	20.59	20.59
Phenotypic coefficient of variance	18.20	20.20	37.31	37.31
Environmental coefficient of variance	13.03	15.32	31.10	31.10
Heritability ( $H^2$ )	63.19	42.54	30.48	30.48

**Table 4** Correlation coefficient between three geographical variables and growth parameters after 12 months at Phata field trial station (n = 30)

Correlation	Plant height	Collar diameter	No. of branches/plant	No. of leaves/plant
Altitude	0.27	-0.68**	-0.37*	0.75**
Latitude	0.24	-0.57**	-0.30	0.33**
Longitude	-0.02	0.54**	0.34	-0.47**

\*Significant at  $p = 0.05$ , \*\* = significant at  $p = 0.01$

rates. Apart from these, Dhanaulti, Ranichauri, Hanumanchatti and Dharali also recorded good growth, while Narayanbagar and Mussoorie sources were the poorest populations during the entire assessment period. Earlier provenance-progeny trials of *P. ciliata* in Himachal Pradesh revealed better performance of Gahar clone in terms of plant height, collar diameter and number of branches per plant (Khosla & Khurana 1981). High variations in survival percentage, height, diameter, fresh and dry weights, leaf area and overall growth among different provenances of *P. ciliata* collected from Western Himalaya have also been reported (Chauhan 1987). Differences in growth rates among and within provenances may either be maintained or altered when subjected to variable environmental conditions.

In this study plant height and number of branches showed higher values for genetic variance and genotypic coefficient of variation respectively, indicating that these parameters were under genetic control. However, greater heritability for plant height suggested it as the most heritable character. These characters thus can be directly screened/selected for the improvement of this potential tree crop.

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