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EVALUATION OF GROWTH PERFORMANCE OF FIVE PROVENANCES OF *POPULUS CILIATA* WALL. EX ROYLE UNDER HIGH HILL CONDITIONS OF HIMACHAL HIMALAYAS, INDIA

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ABSTRACT

A study was conducted at Jagatsukh, Kullu district of Himachal Pradesh India to investigate the field growth performance of male and female genotypes of *Populus ciliata* provenances *viz*., Khanola, Pahnala, Nashala, Solangnala and Gaganshil. The trial was established in a Randomized Block Design with three replications to find out suitable provenance for integration in agroforestry systems and afforestation programs in high hill temperate region of Himachal Himalayas. The growth traits demonstrated stability over different provenances except for crown width in different provenances. Maximum GBH (56.01 cm) was observed for Khanola provenance, however highest total height (19.04 m) and clean bole height (6.34 m) were recorded for Gaganshil provenance. Solangnala provenance demonstrated largest crown width (5.60 m) and survival percentage (75.00 %). Females performed better for GBH (54.70 cm), total height (17.83 m), crown width (4.40 m) and males performed better in terms of clean bole height (6.10 m) and survival percentage (63.33 %).
Keywords **:** *Populus ciliata,*, growth performance, provenance, Himachal Himalayas.

Introduction

Populus ciliata Wall. ex Roylealso known as Himalayan poplar, is a native tree species of India, Pakistan and Afghanistan. In India, it is naturally found in Himachal Pradesh, Jammu and Kashmir, Uttarakhand, Sikkim and Arunachal Pradesh (Khosla and Khurana, 1979). *P. ciliata* is utilized for packaging, poles, barrow-trays, furniture and cross-beams. Traditionally, its bark is used as blood purifier, against rheumatism, fatigue and inflammation. It is a large deciduous tree with tall clean straight trunk and wide rounded crown. The bark of the young trees is smooth greenish-grey and the bark of the old trees is dark brown with vertical cracks. Leaves are broadly ovate with serrulate-crenate and hairy margins. Poplar is a dioicous tree species, hence male and female flowers occur in separate trees. Morphological and physiological charactersvary between males and females (Eckhart and Chapin, 1997). Seeds are minute covered with silky hair and have short duration of viability, hence Poplar is commonly propagated through stem cuttings. The optimum rotation of the species varies from 20 to 22 years depending on the plantation site and objective of the plantation (Abedi *et al*., 2018).

Forest trees are genetically close to their wild state in the natural range. Considerable variation exists between different populations within a species and also between individual trees within populations, hence there are opportunities to improve the economic value of a poplar species by identifying the best wild seed sources and selecting individuals within these seed sources to develop varieties through breeding programmes (Ranpise *et al*., 2014). Genetic improvement of a poplarcan be achieved through provenance studies followed by tree breeding programmes (Wani *et al*., 2019). Researchers found significant variation among different provenances of *P. ciliate* for growth traits *viz*., total height (m), DBH (cm), and leaf area (cm^2) (Khosla *et al.*, 1979 and Sharma and Khurana, 2011).

Poplar is a fast-growing tree species that has been extensively under plantations to fulfilraw material requirement of wood-based industries and has also been planted in agroforestry systems. Majority of the tree improvement programs in India focuses on exotic poplar species like *Populus deltoids* (Thakur *et al*., 2019; Dobhal *et al*., 2018; Sharma *et al*., 2014; Verma *et al*., 2013), however less attention was given to indigenous poplar tree species such as *P.ciliata*. Therefore, in present investigation we assessed the growth performance of *P. ciliata* under field conditions in Himachal Himalayas.

Materials and Methods

Study area

Cuttings from both female and male plants of *P. ciliata* were collected from five provenances from a wide altitudinal range (1500-2900 m asl) *viz*., Khanola, Pahnala, Nashala, Solangnala and Gaganshil in Kulludistrict of Himachal Pradesh as demonstrated in **Table 1** and **Figure 1**. The

provenances were from all the four aspects as shown in Table 1.

Table 1: Study area details.

Provenances	Latitude (ºN)	Longitude (ºE)	Altitude (a.m.s.l.)	Slope (º)	Aspect
Khanola	31.539273	77.624612	2874.00	22.52	South
Pahnala	31.920138	77.107403	1571.00	27.05	East
Noshala	32.063335	77.160556	1907.00	25.15	North
Solangnala	32.291847	77.172149	2543.00	33.27	South
Gaganshil	31.818543	77.241321	1759.00	38.23	West

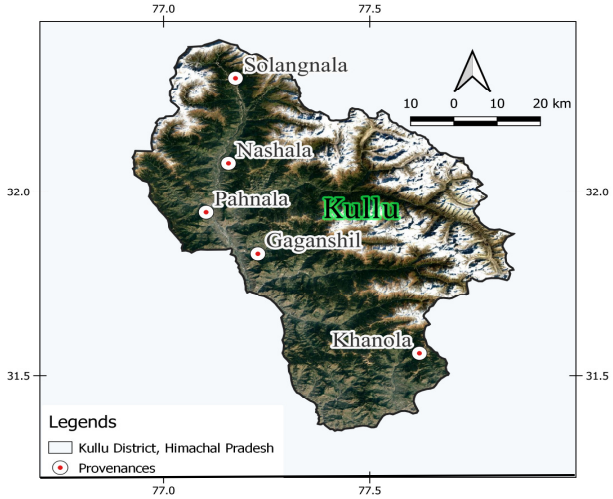

Fig. 1 : Study area map

Field trial was established at Forest Research Station, Jagatsukh, Kullu, Himachal Pradesh, which is situated at 32.200271ºN and 77.200045ºE and elevation 1865 meters a.m.s.l. The trial was established using Randomized Block Design factorial and all treatments were replicated thrice. Treatments includes two factors *viz*., provenances and genders with five and two levels respectively. The data recorded was analysed using standard statistical procedure as described by Panse and Sukhatme (1967).

Growth Traits

The growth characters were recorded for twenty-two years old Himalayan poplar (*Populus ciliata).* Girth at breast height was recorded in centimetres using measuring tape. Clinometer was used to record total height (m) and clean bole height (m) of trees. The crown width (m) was measured in two directions viz., North-South and East-West by using a plumb bob, perpendicular staff and measuring tape. The average crown width was calculated by taking the mean of crown width in both directions. Survival percentage (%) was calculated using the following formula as per Jan and Pfeffer (1999).

$$\text{Survival percentage (\%)} = \frac{\text{Survived plants}}{\text{Total no. of stem cuttings}} \times 100$$

Results and Discussion

Growth traits viz., GBH, total height, clean bole height is presented in **Table 2** and crown width and survival percentage are presented in **Table 3**. All growth traits showed stability among different provenances except for crown width (m), which showed statistically significant variation among different provenances.

Table 2: GBH (cm), total height (m) and clean bole height (m) of selected provenances at twenty-two years old age.

Provenance	GBH (cm)			Total height (m)			Clean bole height (m)		
	Female	Male	Mean	Female	Male	Mean	Female	Male	Mean
Khanola	59.52	52.49	**56.01**	18.78	14.86	**16.82**	5.45	5.63	**5.54**
Pahnala	53.33	55.16	**54.25**	16.24	17.84	**17.04**	5.93	6.05	**5.99**
Nashala	47.01	48.27	**47.64**	17.17	17.44	**17.31**	4.35	6.18	**5.27**
Solangnala	58.33	51.66	**55.00**	18.75	16.86	**17.81**	6.40	5.55	**5.98**
Gaganshil	55.33	49.44	**52.39**	18.20	19.88	**19.04**	5.58	7.11	**6.34**
Mean	**54.70**	**51.41**	-	**17.83**	**17.38**	-	**5.54**	**6.10**	-
$CD_{0.05}$ (Provenance)			NS		NS			NS	
$CD_{0.05}$ (Gender)			NS		NS			NS	
$CD_{0.05}$ (Provenance × Gender)			NS		NS			NS	

Mean values of crown width varied significantly among provenances from 3.30 to 5.60 (Table 3). Among different provenances, Solangnala showed the maximum crown width (5.60 m) which was statistically at par with Noshala (4.95 m). Gaganshil demonstrated lowest crown width (3.30 m) which was statistically similar to Khanola (3.93 m) and Pahnala (3.99 m). Between genders, females showed more crown width (4.40 m) as compared to males (4.31 m) (Table 3).

Table 3: Crown width (m) and survival percentage (%) of selected provenances at twenty-two years old age.

Provenance	Crown width (m)			Survival percentage (%)		
	Female	Male	Mean	Female	Male	Mean
Khanola	3.85	4.00	**3.93**	83.33	50	**66.67**
Pahnala	3.75	4.23	**3.99**	33.33	72.22	**52.78**
Nashala	5.07	4.83	**4.95**	27.77	59.26	**43.52**
Solangnala	5.95	5.25	**5.60**	77.78	72.22	**75.00**
Gaganshil	3.39	3.22	**3.30**	37.04	62.96	**50.00**
Mean	**4.40**	**4.31**	-	**51.85**	**63.33**	-
$CD_{0.05}$ (Provenance)		0.91			NS	
$CD_{0.05}$ (Gender)		NS			NS	
$CD_{0.05}$ (Provenance×Gender)		NS			NS	

Table 4 shows descriptive statistics of growth traits of *P. ciliata* at 22 years old age. Girth at breast height (cm) among different genotypes ranged from 35.16 to 73.30 cm with a mean and standard error of 53.06 cm and 1.23 cm, respectively (Table 4). Maximum GBH (56.01 cm) was observed for Khanola provenance and minimum GBH (47.64 cm) for Noshala. Mean performance of females was better for GBH (54.70 cm) as compared to males (51.41 cm) (Table 2). Uniyal and Todaria (2006) observed comparable GBH of mature *P. ciliata* stand varying from 34.54 to 54.95cm. The GBH of matured *P.ciliata* genotypes ranged from 84.78 to 131.88 cm in the study conducted by Masoodi *et al*. (2014). Khosla *et al*. (1979) found better growth rate in females for DBH (45.05 cm). Chauhan *et al*. (2012) reported non-significant variation in GBH of *Populus deltoides.* Among different genotypes, total tree height fluctuated from 11.45 to 22.90 m with an average height and standard error of 17.60 m and 0.71 m (Table 4). Maximum total height (19.04 m) was recorded for Gaganshil provenance and minimum (16.82 m) for Khanola provenance. Females had more total height (17.83 m) than the male genotypes (17.38 m) (Table 2). Uniyaland Todaria (2006) observed a broader range for total height of mature *Populus ciliate* stand varying from 7.12 to 27.6 m, on the other side Masoodi *et al*. (2014) found it to vary between 17.0 to 39.5 m. Khosla *et al*. (1979) found better growth rate in females for total height (26.07 m). Singh *et al*. (2019) found no variation among tree height of different genotypes of *P. deltoides.* Clean bole height (m) among different genotypes varied from 3.30 to 8.63 m with anaverage clean bole height and standard error of 5.82 and 0.61 m, respectively (Table 4). Largest clean bole height (6.34 m) was recorded for Gaganshil provenance and smallest (5.27 m) for Noshala. Male genotypes (6.10 m) performed better as compared to the female genotypes (5.54 m) for the clean bole height (Table 3). Comparable result was obtained by Chaudhry*et al*. (2003) for *P. deltoides* in which a mean of 6.50 m clean bole height was observed. Among different genotypes, crown width fluctuated from 2.30 to 7.40 m with an average crown width and standard error of 4.35 m and 0.56 m (Table 4). Chauhan *et al.*(2012) reported *P. deltoides* crown width ranging from 6.15 to 7.91 m. However, Chaudhry *et al*. (2003) observed lesser mean crown width (3.70 m) for *P.deltoides* under pure plantation. Survival percentage (%) among different genotypes varied from 11.11 to 100.00% with an average survival percentage and standard error of 57.59 % and 3.73%, respectively (Table 4). Solangnala provenance demonstrated largest survival percentage (75.00 %) and minimum survival percentage was observed for Noshala (43.53 %). Males had greater survival percentage (63.33 %) as compared to the female genotypes (51.85 %) (Table 4). Uniyal and Todaria (2006) reported 58.00 to 80.00 % survival in *P.ciliata*trial after 12 months of establishment. Mushtaq *et al*. (2017) reported 76.53 % survival of *P.deltoides* clones in degraded sites.

Table 4: Descriptive statistics of growth traits of poplar at twenty-two years old age.

Descriptive parameters	GBH (cm)	Total height (m)	Clean bole height (m)	Crown width (m)	Survival (%)
Mean	53.06	17.60	5.82	4.35	57.59
Median	53.83	17.67	5.58	4.27	61.12
Minimum	35.16	11.45	3.30	2.30	11.11
Maximum	73.30	22.90	8.63	7.40	100.00
Standard Error	1.23	0.71	0.61	0.56	3.73
Standard Deviation	8.92	2.75	1.46	1.13	26.36
Sample Variance	79.55	7.54	2.13	1.28	695.01
Kurtosis	-0.02	-0.22	-0.36	0.60	-0.84
Skewness	0.11	0.05	0.55	0.62	-0.17

Conclusion

The present investigation was carried out at KulluDistrict of Himachal Pradesh to study the field growth performance of *P.ciliata* provenances *viz*., Khanola, Pahnala, Nashala, Solangnala and Gaganshil, for five growth characters *viz*., GBH (cm), totalheight (m), clean bole height (m), crown width (m) and survival percentage (%). The growth traits demonstrated stability except for crown width among the different provenances. Highest total height and clean bole height were recorded for Gaganshil provenance. Solangnala provenance demonstrated largest crown width and survival percentage. Female genotypes performed better for GBH, total height and crown width, however male genotypes performed better in terms of clean bole height and survival percentage.

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