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ECOLOGICAL OCCURANCE OF HIMALAYAN POPLAR (POPULUS CILIATA WALLICH EX ROYLE) AND ITS NURSERY EVALUATION UNDER TEMPERATE CONDITIONS OF KASHMIR

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ABSTRACT
The present study was conducted to elucidate the ecological occurrence of an endangered indigenous Himalayan poplar "*Populus ciliata*" in the temperate coniferous forests of Kashmir. In all, the species was found growing in three ecological blocks of occurrence viz. forests as climax species, evolved riparian phase with willows and colonization phase as pure stunted crop. The cuttings (25cm long and 1cm thick) collected from one year old branches were planted in nursery beds at a spacing of 1 × 1ft in the month of February. About 90% of cuttings sprouted and developed roots. The germplasm collected from these ecological blocks was screened for their growth pattern for two years under field conditions in the nursery. A significant phenotypic variation was observed and clones from all the three ecological blocks of occurrence varied in growth characteristics and biomass production potential. The seedlings raised from clones obtained from natural climax forests exhibited maximum plant height (87.2 cm), collar diameter (11.21 mm), number of branches (3.50), dry weight (114.15 gm), number of leaves (22.10) and leaf area (1021.30 cm^2). However, significant (pd" 0.05) differences were recorded almost in all parameters between site and year and also in its interactions, except in case of Root Shoot ratio. Owing to this superior growth, the half sib clones collected from the mixed climax forests with climax phase were multiplied and out planted for conservation and further evaluation.

INTRODUCTION

The Himalayan poplar (*Populus ciliata* Wallich ex Royle) a member of family Salicaceae is a deciduous endemic tree species with tall clean bole and broad rounded crown locally known as "Kashmeri fras" this member of salicates is also widely distributed across Pakistan endemic through Afghanistan, China, France, Iran, Italy, Japan, New Zealand and United States of America. In temperate and sub-temperate Himalayas regions of India viz., Kashmir and Himachal Pradesh, it is found growing along an altitudinal range of 1200-3500m a m s l. The species offers multifarious uses with its wood being chiefly multifarious uses. Used for making plywood, hardboard, packing cases, crates, support, doors, poles, trucks, barrow-trays, furniture, cross-beams and second quality match splinters. The finishing quality of its wood is nearly equal to that of teak. It is the source of fiber for various grades of papers namely, fine paper, packing paper, newsprint etc. A very robust local market is available for the timber of this species fetching a handsome price than all other poplars. It is lopped for fodder and stored to be fed to livestock during the times of scarcity. The lops and tops derived from *P. ciliata* through intermittent pruning are used as fuel wood. The tree has a high medicinal value, with its bark yielding a tonic that is used as a stimulant and blood purifier (Orwa *et al*., 2009). The paste of the bark when mixed with the ash of cow dung can be used to treat muscular swellings. The tree produces numerous strong lateral roots with little taper and as such it is extensively used in some countries to check soil erosion. Afforestation of denuded hills with this species could thus be undertaken to establish a rapid tree cover for soil and water conservation (Anon., 2011).

P. ciliata has been severely affected by commercial exploitation in Kashmir where it is currently found growing sparsely either as an individual tree or in small scatter groups with no concrete efforts to conserve this vulnerable species. The literature on ecological occurrences and growth characters of *P. ciliata* is scanty from this part of the world (Chauhan and Khurana, 1992; Chaukiyal *et al*., 1995). Furthermore; since this species hybridizes freely with other poplars, so the seeds may not come true to the type unless collected from the wild with no other poplar species growing in the vicinity (Khurana, 1989). Such plantations are found only in higher reaches of the mixed coniferous forests where seed collection is difficult owing to the inaccessibility of the area due to the presence of snow during the period of seed dispersal which lasts within three weeks. Additionally, the extremely short viability (few days) is the other constraint to propagate this species from seeds (Sheikh, 1992, Orwa *et al*., 2009). Thus, the clonal propagation by cuttings is the most preferable choice for multiplication and conservation of this species (Sidhu, 1996). With this in mind, the present study was aimed to identify the main ecological blocks of natural occurrence of *P. ciliata* in Kashmir and to screen out the best performing clones in terms of their growth pattern and biomass production potential for further multiplication and conservation.

MATERIALS AND METHODS

Study site

The ecological occurrence of Populus ciliata was evaluated by undertaking an extensive survey of three Forest Divisions of Kashmir valley; viz. Kamraj Forest Division (KFD), Tangmarg Forest Division (TFD) and Sind Forest Division (SFD) during the year 2010 and 2011. The main objective of survey was to collect the best germplasm of this over-exploited Himalayan poplar for its multiplication and nursery evaluation. The germplasm collected was propagated in the Forest Nursery at, Wadura, Sopore, Kashmir. The experimental site is located at an elevation of 1510m amsl and situated between a latitude of 34º347 and 34º354 N and longitude of 74º390 and 74º407 E. With moderate summer and severe winter, the average minimum and maximum temperature of the experimental site ranges between -5ºC to 32ºC. The area falls within the rainfed zone and receives an annual precipitation of 692-733mm. The soil of experimental site is acidic to neutral (5.8 to 7.2) in reaction and sandy loam in nature.

Twenty five (25) cm long and 1cm thick dormant cuttings of Populus ciliata were taken from one year old branches of vigorous trees found growing in all the three identified ecological blocks of occurrence of this species in Kashmir. These cuttings were planted in well prepared nursery beds at the spacing of 1 x 1 ft. during the month of February. The sprouting started in the month of April and by the mid of May about 90% cuttings vegetated and developed roots. No treatment was used for inducing rooting. However, the cuttings collected from all the sources were immersed in plain water for a period of 12 hours before placing them in the soil with only one bud exposed. The cultural practices including irrigation and weeding were carried out as and when needed. While observation on seedling growth was recorded for two consecutive years, the examination of biomass production potential was recorded after the end of second growing season (two years). All the parameters recorded were statistically analyzed following Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Ecological characterization

The survey conducted across the selected locations revealed that the natural occurrence of *P. ciliata* is restricted to three main ecological blocks of natural occurrence (Table 1). Under the first category the species occupies a matured status in the climax forests at KFD (Mawar) where it occurs in scattered patches as secondary crop in association with or growing very near to Fir, Spruce, Deodar, Kail, Yew, Maple, Elm and Ash. Under such type of occurrence, the poplar trees were very vigorous and straight boled attaining an average height of 39.5 m and dbh of 42 cm. In the second category the species occurs in evolved riparian phase at TFD (Tangmarg) where it was found growing in association with willows. Here the trees attained an average height of 26 m and dbh of 30 cm. In the third category, the species occurred in the colonization phase at SFD (Sonmarg) where it forms the hygrophilous pioneer forest as a pure stunted crop. The trees growing under such microhabitats attained an average height of 17 m and dbh of 21 cm. The results thus reveal that the phenotypic variation was greater among trees between the three ecological blocks of occurrence. These results infer that *P. ciliata* exhibits great variability in adaptation to different microhabitats with larg inconsistency in the growth pattern. Dickmann and Stuart (1983) stated that poplars could grow almost everywhere, but perform up to their full potential only under the influence of enriched microhabitats. Similar observations of variability in natural occurrences of *P. ciliata* and its growth pattern have been reported from Himachal Pradesh Khurana and Khosla (1991). Such type of dissimilarity with the observed variation among the plant genotypes depicting important community and ecosystem effects often diverts the attention of the ecologists towards the provenance selection with the observed variation among the plant genotypes depicting important community and ecosystem effects (Whitham *et al.*, 2003)**.**The Phenotypic plasticity which is higher in *Populus hybrids* can thus contribute to higher levels of phenotypic variations among the various provenances (Marron *et al.,* 2006). This plasticity can append an additional phenotypic variation through the effects of genotype × environmental interactions and thus the levels of the phenotypic variation in natural *P. ciliata* stands may be higher than that documented here. The results of the survey further revealed that under all circumstances three types of occurrences, the main ecological threats for the establishment of this indigenous tree species; in Kashmir, included disturbance by human activity through excessive lopping/ harvesting, renewal of the riparian Himalayan poplar forest along the river edges and introgression by *P. deltoides*: the female parent of the euramerican hybrid which has been introduced in areas of spontaneous regeneration.

Shoot growth Performance

The clones collected from the three identified ecological blocks exhibited great variation in all the growth parameters (Table 2 and 3). The seedlings raised from all the three sources showed slow growth during the first year, which picked up at faster rate during the second growing season. Except for branch angle during the first year of growth, the performance of *P. ciliata* clones with respect to plant height (39 and 136, 34 and 109 and 29 and 86 cm), collar diameter (4.66 and 17.76, 3.60 and 11.31 and 3.20 and 9.85 mm), Number of branches plant^{-1} (2 and 5, 2 and 4 and 2 and 3), No leaves plant^{-1} (10 and 34, 8 and 33, 8 and 28), Branch angle (52ºand 54º, 56º and 57º and 59º and 57º) and Leaf area plant^{-1} (393 and 1637, 331 and 1292 and 304 and 1017 cm^2) of KFD, TFD and SFD for 1st and 2nd growing season respectively was significantly ($p \leq 0.05$) different with respect to site and year of evaluation, Number of leaves plant^{-1} however, which exhibited non-significant correlation with both site and the year of growth.

The preceding results thus reveal that growth differences in Himalayan poplar seedlings were both source and clonal specific. The provenance tests of *P. ciliata* conducted by Chauhan and Khurana (1992) and Chaukiyal *et al.* (1995)

Table 1: Growth of *P. ciliata* trees in ecological blocks of natural occurrence

S. No.	Ecological blocks	Tree height (m)	DBH (cm)
1.	Natural climax phase	39.50	42
2.	Evolved riparian phase	26.00	30
3.	Colonization phase	17.00	21

Table 2: Growth characteristics of *P. ciliata* clones collected from various ecological blocks of occurrence

S. No.	Location	Plant height (cm)		Mean	Collar diameter (mm)		Mean	No of branches plant^{-1}		Mean
		1styear	2ndyear		1styear	2nd year		1styear	2ndyear	
1.	KFD (Mawar)	38.80	135.60	87.20	4.66	17.76	11.21	2	5	3.5
2.	TFD (Tangmarg)	34.20	108.60	71.40	3.60	11.31	7.46	2	4	3.0
3.	SFD (Sonmarg)	29.40	86.00	57.70	3.20	9.85	6.53	2	3	2.5
	Mean	34.13	110.06		3.82	12.97		2	4	
		CD(p≤0.05)	SE (m)		CD(p≤0.05)	SE (m)		CD(p≤0.05)	SE (m)	
	Site	1.03	0.33		0.14	0.045		0.70	0.22	
	Year	0.84	0.27		0.12	0.037		0.58	0.18	
	Site × Year	1.45	0.46		0.20	0.063		1.00	0.32	

Table 3: Growth characteristics of *P. ciliata* clones collected from various ecological blocks of occurrence

S. No.	Location	No of leaves Plant^{-1}		Mean	Branch angle	Mean	Leaf area plant^{-1} (cm^2)			Mean
		1styear	2ndyear		1styear	2ndyear		1styear	2ndyear	
1.	KFD (Mawar)	10	34	22	52	54	53	393	1637	1015
2.	TFD (Tangmarg)	8	33	21	56	57	57	331	1292	812
3.	SFD (Sonmarg)	8	28	18	59	57	58	304	1017	660
	Mean	9	32		55	56		343	1315	
		CD(p≤0.05)	SE (m)		CD(p≤0.05)	SE (m)		CD(p≤0.05)	SE (m)	
	Site	2.1	0.67		0.70	0.22		0.014	0.005	
	Year	1.7	0.55		N.S	0.018		0.012	0.004	
	Site ×Year	NS	0.95		1.00	0.32		1.416	0.006	

Table 4: Biomass production and its portioning in *P. ciliata* clones collected from various ecological blocks of occurrence

S. No.		Dry weight plant^{-1} (gm)		Mean	Root : Shoot ratio		Mean
		1styear	2ndyear		1styear	2ndyear	
1.	KFD (Mawar)	47.88	180.42	114.15	0.34	0.30	0.32
2.	TFD (Tangmarg)	40.23	131.65	85.94	0.37	0.33	0.35
3.	SFD (Sonmarg)	31.91	89.96	60.93	0.38	0.36	0.37
	Mean	40.00	134.01		0.36	0.33	
		CD(p≤0.05)	SE (m)		CD(p≤0.05)	SE (m)	
	Site	1.03	0.46		N.S	0.022	
	Year	0.84	0.38		N.S	0.018	
	Site ×Year	1.45	0.65		N.S	0.032	

observed similar findings with sources from UP. Thus these results suggest that the selection of parental source is the essential aspect for the genetic improvement of poplars. Further, being important component of adaptive evolution; the recent studies have demonstrated that genetic variation within plant populations can have important ecological effects. Working with various provenances of *P. ciliata* by Khosla and Khurana (1979) and Chauhan and Khurana (1992) showed that the variation pattern in different growth characters in different provenances was controlled both by environment and genetic factors. While differences in growth rate in male and female trees were not found to be significant, the current annual growth (CAI) in various ecological conditions varied significantly (Khurana and Khosla, 1982).

The better performance of clones collected from natural climax communities (at Mawar) in the present study corroborates with the findings of Megan *et al*. (2008) which reveal that genetic variation in morphological traits of some Aspen (*P. tremuloides*) genotypes collected from wet and dry sites in Southern Utah, USA, exhibited heritable differences in 4 of the 10 phenotypic traits (total height, leaf number, water use and stem structure). Similar trend in comprehensive genetic analysis of growth and leaf traits has been found by Xibing *et al*. (2010) in case of 28 hybrid clones of *P. deltoides* × *P. ussuriensis* compared with *P. beijingensis* as control. This study has further suggested; that at the age of 4 years, large variations and significant differences ($p < 0.01$) existed in height (757 ± 28 cm), diameter in basal area (10.8 ± 0.6 cm) and diameter at breast-height (8.3 ± 0.6 cm) among the 28 tested clones. For branch characteristics, the analysis showed that F values varied from 15.02 to 27.75 indicating extremely significant differences ($p < 0.01$) in these traits. The study further revealed that the striking dissimilarity variations in various leaf traits including length, width, area and specific leaf weight among these clones also exhibited significant differences ($p < 0.01$).

Biomass production

The data on biomass accumulation (Table 4) indicates that two year old seedlings raised from cuttings collected from ecologically climax communities (Mawar - KFD) attained 27 and 50% higher biomass as compared to those raised from the germplasm collected from other two locations (TFD, 40.23 and 131.65 and SFD, 31.91 and 89.96 g plant^{-1}for 1st and 2nd growing season respectively). The statistical analysis of the data revealed positive and significant ($p \leq 0.05$) interaction for biomass production between various sources and the year of growth. These results indicate that germplasm collected from climax communities was superior in terms of clonal relative

performance for total seedling height, basal diameter and high biomass production which is critical for strengthening the viable prospects of plantation of these seedlings on denuded/ degraded areas. The biomass production recorded in present study are almost similar to those recorded by Chauhan and Khurana (1992) and Khosla and Khurana (1979) but lower to those reported by DesRochers and Thomas (2003) for this species. On the other hand the studies conducted by Hall *et al*. (2010) revealed that harvests of one-year-old aspen stands yielded about 3.4 oven dry MG/ ha which in our case may vary between 0.78 - 1.56 MG/ ha with a density of 8,700 stems/ ha under intensively managed system. Megan et. al., (2008) and Xibing *et al*. (2010) have found that at the end of the first growing season the variation in above ground biomass accumulation differed significantly ($P < 0.001$) between 39.4g to 123 g per tree among the various poplar clones.

Contrary to biomass production, the root shoot ratio was higher (0.38 and 0.36 for 1st and 2nd growing season) for seedlings raised from cuttings obtained from SFD as compared to those raised from cuttings collected at newly colonized and riparian sites (TFD 0.37 and 0.33 and KFD 0.34 and 0.30 for 1st and 2nd growing season respectively). The interaction between various sites and the year of growth was; however, non-significant (p d" 0.05) for shoot and root ratio. These results indicate that while shoot growth and biomass production potential was more in seedlings raised from clones collected from ecologically mature zone (Kamraj and Tangmarg Forest Divisions), the germplasm collected from stunted crop at Sindh Forest Division allocated more carbon to root system and thus produced planting material with reduced shoot growth. From these results it can also be inferred that Himalayan poplar exhibits wide variation in its ability to adapt to a varied ecological conditions to compete for its survival and growth. Many researchers (Megan *et al.,* 2008 and Xibing *et al.,* 2010) have also found that this species surviving in variety of habitats with different growth adaptations and varied biomass production potential

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