Introduction

Populus and its ‘sister’ lineage, the genus Salix (willows), have been considered the only two genera in the Salicaceae family, although some taxonomists have included other genera, mostly from eastern Asia (Eckenwalder, 1996). More recently, however, the Flacourtiaceae family, the closest relative of Salicaceae, was re-classified, and a number of genera formerly included in Flacourtiaceae are now assigned to Salicaceae sensu lato, with in the Malpighiales order of the ‘Eurosid I’ clade (Chase et al., 2002; APG, 2003).

Populus is the classical name of the poplar, others consider that this plant was used in ancient times to decorate public places in Rome where it is called ‘arbore populi’ ‘people’s tree’; i.e., Populus alba (Naithani et al., 2001). These plants are usually dioecious, rarely monoecious, viz., Populus lasiocarpa Oliv., native of western China (FAO, 1979). Exceptionally bisexual in Populus Jacquemontiana var. glauca, a species endemic to eastern Himalaya (Grierson and Long, 1983; Haines, 1906). Genus Populus Linn. includes 44 species in five sections. These are white poplars (Leuce), black poplars (Aigeiros), balsam poplars (Tecamahaca), Leucoides and Turanga. These are widely distributed in the temperate and subtropical regions of the Northern Hemisphere. In the plateaus of near-east and in the borderlands of Mediterranean Sea, since antiquity, people have been planting poplars near their homes, around their fields or along ditches and roads; these trees not only furnished fuel and timber for domestic use as well as forage to cattle but also provided shade, shelter and greenery in countries that would be otherwise.

Realizing the importance of poplars, a National Poplar Commission was created in France in 1942 and, subsequently, an International Poplar Commission was set up under the aegis of the FAO during 1947. India became a member of this Commission in 1965 and constituted a National Poplar Commission with the objective of cultivation of poplars to meet the requirements of timber, fuel wood, etc. However, before the establishment of National Poplar Commission the cultivation of poplar was traditional in Kashmir for a very long time and in recent years extended to Punjab, Haryana, Himachal Pradesh, Uttar Pradesh and on a very small scale, in West Bengal. Poplars, because of their fast rate of growth, high financial return and multiple utility, have become a very important species for cultivation both in the forest and farms. Poplar wood is widely used in plywood.
and match splints. Market has been developed for poplar in Punjab, Haryana and Uttar Pradesh.

With regard to the occurrence of poplar in India, Bor (1958) mentioned eight species, viz., *P. alba* Linn., *P. euphratica* Oliv., *P. microcarpa* Hook. f. and Th., *P. nigra* Linn., *P. laurifolia* Led. (*P. balsamifera* Linn.), *P. ciliata* Wall. ex Royle, *P. gamblei* Dode and *P. jacquemontiana* var. *glauca* Haines. There is controversy about the indigenous poplars in India. Many authors, viz., Tewari (1993), Singh and Kumar (1998) considered *P. laurifolia*, *P. euphratica* and *P. alba* as indigenous. In fact, many of them are exotic, viz., Sind poplar, bahan, bhan, padar (*P. euphractica*) has a remarkable geographical distribution. It occurs in Ladakh, plains of the Punjab and Sindh (Pakistan), Tibet; westwards it is indigenous on riverine areas in Afghanistan, Turkey, Iran, Iraq and Palestine, which exhibits a wide range of leaf polymorphism. *P. alba* and its cultivars known from southern Europe, western Siberia and Central Asia, were introduced and naturalized in Kashmir and Ladakh, known by the local name ‘Safeda’ and ‘Mal’. Black poplar (*P. nigra*) and its cultivars are native of temperate Europe, introduced in Kashmir, Himachal Pradesh and in some parts of Garhwal Himalaya. Balsam poplar (*P. laurifolia* Ledeb.) (*P. balsamifera* Linn.) a species of Central Asia, was planted in Leh (Ladakh), Lahaul and Spiti (Himachal Pradesh) and Tawang district of Arunachal Pradesh, where it is generally planted by the Buddhists near monasteries. Eastern cottonwood (*P. deltoides*) from North America is very commonly planted by the farmers in agroforestry plantations in Punjab, Haryana, Uttarakhand and Uttar Pradesh. A part of these *P. x euramericana* and *P. x berolinensis* were introduced in India in 1950. Clones of *P. canescens*, *P. maximowiczii*, *P. trichocarpa*, *P. smonii*, *P. szechuanica*, *P. yunnanensis*, etc. were introduced in the subsequent years. *P. deltoides* performed better than all other exotic poplars in the plains of North India, and relegated most other exotic poplars to the status of anonymity in India. In the hills, *P. yunnanensis* and *P. x euramericana* ‘Robusta’ proved better than other species (Seth, 1969). These exotic poplars do not regenerate readily due to the absence of seeds caused by the lopping.

**Classification**

Louis-Albert Dode (1875-1945), a noted French dendrologist worked on *Populus* and *Salix*. He had a private plantation having approximately 1,500 poplars and willows. In addition to studying his own living collections he made extensive use of his own herbarium collections.

Dode’s classification of poplar is interesting, he was the first to recognize sub-genera (as well as sections) in the genus. He raised section *Turanga* of Bunge (including only *P. euphractica* and *P. pruinosa*) to subgenus. Wesmael (1868) previously classified these species with the aspens in section *Leuce*. Browicz (1966) used subgenus *Balmiflua* (Griff.) Browicz, for the turanga poplars as a whole, and recognized a Kenyan species, viz., *Populus ilicifolia* in a section *Tsava* (Jarn.) Browicz (Table 1).

### Table 1. Classification of Populus

<table>
<thead>
<tr>
<th>Section (synonym)</th>
<th>Species</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahaso Eckenwalder</td>
<td><em>Populus</em> Mexicanus Wesmael</td>
<td>Mexico</td>
</tr>
<tr>
<td>Turanga Bunge</td>
<td><em>P. euphratica</em> Oliver</td>
<td>NE Africa, Asia</td>
</tr>
<tr>
<td></td>
<td><em>P. ilicifolia</em> (Engler) Rouleau</td>
<td>E Africa</td>
</tr>
<tr>
<td>Leuceoides Spach</td>
<td><em>P. jacquemontiana</em> var. <em>glauca</em></td>
<td>China ?</td>
</tr>
<tr>
<td></td>
<td>Haines <em>sl</em></td>
<td>USA</td>
</tr>
<tr>
<td></td>
<td><em>P. heterophylla</em> L.</td>
<td>China</td>
</tr>
<tr>
<td></td>
<td><em>P. laiocarpa</em> Olivier</td>
<td>USA</td>
</tr>
<tr>
<td>Aigeiros Duby</td>
<td><em>P. deltoides</em> Marshall <em>sl</em></td>
<td>N America</td>
</tr>
<tr>
<td></td>
<td><em>P. fremontii</em> S. Watson</td>
<td>USA</td>
</tr>
<tr>
<td><em>P. nigra</em> L.</td>
<td></td>
<td>EUR Asia, N America</td>
</tr>
<tr>
<td>Tacamahacca Spach</td>
<td><em>P. angostifolia</em> James</td>
<td>N America</td>
</tr>
<tr>
<td></td>
<td><em>P. balsamifera</em> L.</td>
<td>N America</td>
</tr>
<tr>
<td></td>
<td><em>P. ciliata</em> Royle</td>
<td>Himalaya</td>
</tr>
<tr>
<td></td>
<td><em>P. laurifolia</em> ledebour</td>
<td>EUR Asia</td>
</tr>
<tr>
<td></td>
<td><em>P. simoni</em> Carriere</td>
<td>E Asia</td>
</tr>
<tr>
<td></td>
<td><em>P. sueveolens</em> Fischer <em>sl</em></td>
<td>NE China, Japan</td>
</tr>
<tr>
<td></td>
<td><em>P. szechuanica</em> Schneider</td>
<td>EUR Asia</td>
</tr>
<tr>
<td></td>
<td><em>P. trichocarpa</em> Torrey and Gray</td>
<td>N America</td>
</tr>
<tr>
<td></td>
<td><em>P. yunnanensis</em> Dode</td>
<td>EUR Asia</td>
</tr>
<tr>
<td><em>Populus</em> (Leuce Duby)</td>
<td><em>P. adenopoda</em> Maximowicz</td>
<td>China</td>
</tr>
<tr>
<td></td>
<td><em>P. alba</em> L.</td>
<td>EUR Africa, Central Asia</td>
</tr>
<tr>
<td></td>
<td><em>P. gamblei</em> Haines?</td>
<td>EUR Asia?</td>
</tr>
<tr>
<td></td>
<td><em>P. grandidentata</em> Michaux</td>
<td>N America</td>
</tr>
<tr>
<td></td>
<td><em>P. guzmanantlensis</em> Vazquez and Caevas</td>
<td>Mexico</td>
</tr>
<tr>
<td></td>
<td><em>P. monticola</em> Brandgee</td>
<td>Mexico</td>
</tr>
<tr>
<td></td>
<td><em>P. sieboldi</em> Miqael</td>
<td>Japan</td>
</tr>
<tr>
<td></td>
<td><em>P. simarors Ziedowski</em></td>
<td>Mexico</td>
</tr>
<tr>
<td></td>
<td><em>P. tremula</em> L.</td>
<td>EUR America, NE Asia</td>
</tr>
<tr>
<td></td>
<td><em>P. tremuloides</em> Michaux</td>
<td>N America</td>
</tr>
</tbody>
</table>


**Key to the Sub Genus**

1. Leaves entire, coriaceous, glaucous, never tomentose below, both surfaces identical; foliar glands not far projecting; buds small, bowl-shaped, often showing only scale; perianth caducous; stigma 3, large carmine; stamens ± 12; capsule elongated-----------------

Subgenus Turanga

Leaves sometimes lobed, light green above, sometimes tomentose below; foliar glands projecting, bowl-shaped; bud average, with several obvious scales; perianth persistent; stigma, 2 pale-
pink to carmine; stamens 5-20; capsule elongated——
----------------------------------------Subgenus Leuce

Catkins always rather compact
Leaves green above, lighter of sometimes pubescent below, teeth very deep, never lobed; petiole ± compressed with quadrangular or rectangular section; buds rather large, viscid with many very obvious scales; perianth persistent; stigma 2-4, greenish, warted; stamens 8-8; capsule elliptic-globular------------------------Subgenus Eupopulus

Key to the Group
1   Leaves ± glaucous below; foliar glands ridge-shaped; Petioles ± compressed laterally, those of the turion leaves clearly so and all proportions remaining equal to extent of those of brachyplast leaves;-------------------Eupopulus
+    Leaves white tomentose beneath-------P. alba (P. caspica)
+    Leaves without translucent border-------------------P. laurifolia (P. pamirica)
+    Leaves deltoid at base; glands present at the base of blade-------------------P. deltoides

1. Leaves not lobed; buds sticky---------------------------------3
2. Leaves glabrous, polymorphous, entire in young plants and suckers ---------------------------------P. euphractica
+    Leaves white tomentose beneath---P. alba (P. caspica)
3. Leaves with clearly defined translucent border---------4
+    Leaves without translucent border---------------------P. laurifolia (P. pamirica)
+    Leaves rhomboidal, cuneate at base; glands at the base of the blade absent---------------------P. nigra
+    Leaves deltoid at base; glands present at the base of blade--------------------------------------P. deltoides

Indigenous Species
There are four indigenous species of Populus namely P. ciliata, P. gamblei, P. Jacquemontii var. glauca and P. Rotundifolia found in the Himalaya. These species are important for cultivation in Himalayan zone and deserve attention for improvement. These need recognition, systematic survey, collection and evaluation of desirable geographical races and development of suitable clones.

Key of Indigenous Species
1. Leaves ovate, acuminate------------------------------------------2
+   Leaves broadly ovate or orbicular, shortly acute or apiculate---------------------------------P. Rotundifolia
2. Plants dioecious; leaf margin crenate or dentate-serrate;-
+    Flowers bisexual; leaf margin sharply serrate--------------P. Jacquemontii var. glauca
+    Leaves truncate at base; capsule 2-valved-----------------P. gamblei
3. Leaves cordate at base; capsule 3-valved----------------------P. ciliata

Populus ciliata Wall. ex Royle
Vern.: Himalayan poplar, safeda, piplas, pahari pipal, cheluan, chalni, banpipal, bagnu, syan, pak butra
This is the most widespread species of native poplars. Distributed from Kashmir to Arunachal Pradesh at an altitude between 1,000-3,000m. It is most widely distributed species in India and grows well on alluvial deposits along the water channels, road cuttings, land slides, occasionally forming small gregarious patches on banks of the large water courses. During a qualitative survey during 1995 to 1997 in Uttarakhand in western Himalayas, it was found growing in ban-oak (Quercus leucotrichophora), pangar (Aesculus indica), toon (Toona serrata), deodar (Cedrus deodara), kail (Pinus wallichiana), fir (Abies pindrow), spruce (Picea
It has been observed that known from north Myanmar and Yunnan Province of China. Forest Division, where a tree of maximum 4.5 m girth (Tons Forest Division) and in Gangotri Range, Uttarkashi best trees were located at Govind Pashu Vihar in Taluka Range and marked with numbers for the selection. In the survey was taken up. In Uttarakhand about 500 trees were observed and Kumaun hills for selection of provenance and plus trees of Indigenous Poplar in India’ was undertaken in Garhwal indigenous species of poplar a project entitled ‘Conservation provided to indigenous species. Thus to encourage the northern India. However, not much emphasis has been exotic species of poplar have been planted in many parts of places, it is affected by parasite Loranthes which causes damage.

Keeping in view their fast growing nature various exotic species of poplar have been planted in many parts of northern India. However, not much emphasis has been provided to indigenous species. Thus to encourage the indigenous species of poplar a project entitled ‘Conservation of Indigenous Poplar in India’ was undertaken in Garhwal and Kumaun hills for selection of provenance and plus trees was taken up. In Uttarakhand about 500 trees were observed and marked with numbers for the selection. In the survey best trees were located at Govind Pashu Vihar in Taluka Range (Tons Forest Division) and in Gangotri Range, Uttarkashi Forest Division, where a tree of maximum 4.5 m girth (Fig. 1) was observed. Earlier probably record girth was measured 4.62 m from Kullu Forest Division, Himachal Pradesh (Singh, 1982) and 3.5-4 m from Hazara (Troup, 1921). Joshi (1981) stated that in Uttar Pradesh, the total area of P. ciliata (in mixture with other coniferous and broad leaved species) would be around 40,000 ha, but this species generally constitutes a small component (less than 5 per cent) of the whole crop. Its pure patches are also located at Hanuman Chatti, Badrinath Forest Division below Bhayundar, on way to the Valley of Flowers and Dharali area of Uttarkashi. These pure patches for conservation point of view should be declared as ‘National Poplar Reserve’.

According to Rajawat et al. (1987) suitability of P. ciliata has also been found to give good veneers on peeling. Plywood prepared from the veneers using U-F and P.F. glues has been found to be suitable for making general purpose plywood, marine plywood for concrete shuttering work, preservative treated plywood and fire retardant plywood. The species could thus be included in the relevant Indian Standards specifications for their manufacture. It is also suitable for hardboards (Shukla et al., 1985). It is suitable for making packing cases and crates (Shukla, 1981). It also supports doors. Its wood is of excellent quality for the manufacture of matches (FAO, 1979). It is also used in manufacture of artificial limbs. These includes knee skin assemblies and knee mechanism of all types, hip disarticulation joint, wooden foot and wooden block. The laminated wooden blocks manufactured cover block thigh, block foot, block knee, block ankle, etc. (Misra, 1981). In Kashmir, it is used for building purposes and also as fuel. The bark is used as tonic, stimulant and blood purifier. The leaves are used as a fodder for goats (Khan and Kachroo, 1981). Guha and Mathur (1959) staed that P. ciliata is suitable for writing and printing paper. It is useful for afforesting unstable hill slopes.

Haines (1906) and Parker (1918) mentioned that the male trees are rare in P. ciliata. However, Khurana and Khosla (1978) analysed natural stands of P. ciliata and also plantations for sex ratio around Manali, Harlu, lower Kulu and Parvati ranges in Himachal Pradesh. Based on survey of 3,531 trees, it was observed that male trees dominate and have 67.71 per cent frequently as compared to 38.9 per cent female. This gives an approximately 3:2 male to female ratio. Singh (1982) stated that pooling the data of 586 trees examined in various localities of Himachal Pradesh gave the ratio of male and female trees as 2:1. However, during survey in 1995-1998 in Garhwal Himalaya, Uttarakhand, it was found that the population of female trees was maximum (Fig. 2) and that male trees were very less. Joshi (1981) also stated that in the Uttar Pradesh region most of trees were female, male trees were scarce. Gupta (1969) while mentioning its occurrence in Jaunsar and Tehri Garhwal, Uttarakhand also stated that the male trees were very scarce. This indicates that the ratio of male and female trees varies with the locality.

P. ciliata can easily be propagated by cuttings. Troup (1921) stated that its regeneration through seeds is negligible. However, the commonest form of its natural reproduction is by root-suckers. The seeds of P. ciliata are light, about 14,000 to 15,000 seeds weigh one gram (Singh, 1981; Beniwal and Singh, 1989). In laboratory condition, 75-95 per cent germination of seed was noted by Singh and Gupta (1981). Mathur et al. (1982) mentioned that under laboratory condition its germination is
86.25 per cent, while on land slip under natural condition, only 0.30 per cent was noticed. Under natural conditions, however, seed germination is considerably poor. Some seedlings, manage to grow in crevices of rocks or newly exposed ground such as landslips and road cuttings and on alluvial boulder deposits along streams. The seedlings establishment is uncommon because of the following reasons (Singh, 1982):

- Most of the seeds are caught on the grass, weed and moss covering the soil fail to come in contact with mineral soil.
- Unfavourable moisture conditions at the time of seed dispersal. Sufficiently moist soil is needed at the time of germination and for a fairly long time after germination.
- Susceptibility of seedlings to fungal attacks particularly damping off.
- Washing away of seeds and tiny seedlings by run-off water on slopes and their deposition in depressions where they get covered by soil and fail to germinate.

Nautiyal et al. (1995) reported its profuse natural regeneration in Tons Forest Division, Uttarakhand. They also stated that the area of around 40 m radius was full of the seedlings. The site was sunny and slopey.

A study of the performance of forest clones of poplars and the farm forestry condition trial was laid down at Kalimpong (Himachal Pradesh) in 1976 with six species namely *P. ciliata*, *P. casale*, *P. yunnanensis*, *P. trichocarpa*, *P. oxford* and *P. deltoides* planted at 60 x 30 cm spacing. It was found that maximum survival was recorded in *P. ciliata* followed by *P. deltoides* while height and diameter was maximum in *P. yunnanensis* followed by *P. ciliata* (Khurana and Khosla, 1978). During the period of 1986 to 1990, seeds were produced in Gaja Nursery, Uttarakhand. The best clones were tried in the field in January 2008.

**Populus gamblei** Dode

Vern.: Pipalpate,pilpile

It is the southern-most poplar in the Northern Hemisphere and is distributed in Yazuli and Yachuli area of Lower Subansiri District of Arunachal Pradesh. In Darjeeling hills, West Bengal, it is naturally found in Damson forests, where it is sometimes observed colonizing the slip areas. Also occurs along the roads from Kalimpong to Teesta. In the recent past, it has been naturally found common 4 km before Sechu (Sechii) on Kohima-Dimapur Road, Nagaland. About 40 small to medium sized tree were located in the area. A large tree about 15 m high having a girth of 3.2 m (Fig. 3) is also measured. Beside Sechu some tree of this species are also located Niepfei area near Kohima. In Nagaland, it is used in shifting cultivated fields for temporary hut construction (Naithani et al., 2005). In a very recent (May 2012) quantitative survey conducted by one of the author in Yazuli, Lower Subansiri District, Arunachal Pradesh, *P. gamblei* was found associated with common trees which Schima wallichii, Dalbergia sericea, Erythrina indica, Callicarpa arborea, Rhus chinensis, Celtis australis, Engelhardtia spicata, Sterospermum chilinoides. Ground cover was with Artemisia nilagirica, Euopterium adenophorum, Pteridium revolutum, Oxalis corniculata, Lepidagathis incurva, Sida rhombifolia, Bidens pilosa, etc. During March-April each year, natural regeneration of *P. gamblei* is found in profusion under the areas affected by land slips, the young seedlings appear to colonize the slip affected areas.

*P. gamblei* provides an annual output from 16.3 m per ha to 35.9 m per ha depending on age (Lahri, 1979). The wood of *P. gamblei* has been found to the suitable for ply, match and packing case industries. Eighteen trees of *P. gamblei* planted in the year 1975 are growing in the Tashiding I compartment beat in Kalimpong Division, North Bengal. The seeds of *P. gamblei* are very minute, weighing about 1,500 an ounce and attached to fluffy floss, often difficult to collect because of short time gap between flowering, fruiting and quick dispersal (Ghose, 1969; Lahri, 1979) Muhle-Larsen (1970) reported 12 species of *Populus* showing change in sex in standing population. Sharma et al. (1999) reported reversion of sex in *P. gamblei* from male to female in a 20-yr old tree cuttings which were brought from Arunachal Pradesh and planted in the Plant Physiology Discipline of Forest Research Institute, Dehradun. The reversion of sex mentioned by Sharma et al. (1999) is incorrect. This tree, when first flowered was examined and noted that it was female and not male (Fig. 4).

Branch cuttings of most of the poplar species root easily without any pretreatment of synthetic growth regulators but cuttings of *P. gamblei* do not root easily (Guhathakurta, 1973). Ghose and Bhatnagar (1977) stated that rooting response of short time gap between flowering, fruiting and quick dispersal (Ghose, 1969; Lahri, 1979) Muhle-Larsen (1970) have considerably increased rooting. Twenty-four hours dip treatment in aqueous solution of 200 ppm concentration of indole acetic acid has given best results in which 70 per cent rooting has been achieved. In view of its good rate of growth it offers potential of developing hybrid clones (Guhathakurta, 1973).
Fig. 1. *Populus ciliata* in Uttarkashi Forest Division, Uttarakhand tree with a girth of 4.5 m.

Fig. 2. *Populus ciliata* female.

Fig. 3. *Populus gamblei* tree, 15 m high with a girth of 3.2 m in Nagaland.

Fig. 4. *Populus gamblei* female inflorescence.

Fig. 5. *Populus Jacquemontiana* var. glauca inflorescence. (Courtesy: Stainton, 2005).
at an altitude between 2,500-2,900 m. It is generally found in forests clearing; quite common around villages. A beautiful colour photograph of this rare species was given by Stainton (2005). It is also regarded by some experts as a form of \textit{P. ciliata} (FAO, 1979). At present, it is not correct because \textit{P. ciliata} is dioecious.

\textit{Populus jacquemontiana} var. \textit{glauca} was tested against the cadmium stress which is highly toxic heavy metal, which causes strong oxidative stress, thereby, interaction PSII and the photosynthetic electron transport by Solti \textit{et al.} (2011) and found that an acute acclimatization phase were identified as a consequence of the delay in activation of anti-oxidative defense mechanism, the protective role of which is important in the acclimatization to moderate cadmium stress.

\textit{Populus rotundifolia} Griff. (\textit{P. microcarpa} Hk. f. and Th.; \textit{P. bonatii} Leve.)

\textit{Vern.}: Kashing, kashi

A shrub or tree, 2-10 m. This species is endemic to Thimpu, Punakha and Bumthang District of Bhutan Himalaya, distributed in \textit{Pinus wallichiana} (blue pine) forest at an altitude between 2,300-3,050 m (Grierson and Long, 1983). This little known species has been included here because phyto-geographically Bhutan is a part of eastern Himalaya. Therefore, in future it can be found in adjacent states like Sikkim and Arunachal Pradesh as the vegetation of these states is similar to Bhutan.

In the plains, introduced clones of \textit{P. deltoides} have given good performance. However, instead of depending solely upon introduced clones of \textit{P. deltoides} for the hills, work should be initiated in indigenous species to generate new clones or hybrids. Suggested lines of work are:

- Patches of wild poplar should be declared and maintained as ‘National Poplar Reserves’.
- Germplasm banks of plus trees of indigenous poplars should be raised at plantation sites in hills to study genotype and site interaction.
- A poplar breeding programme incorporating indigenous and exotic poplars should be taken up on priorities to generate superior clonal material for planting under agroforestry in hill areas and plains.

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