POPULUS TREE IMPROVEMENT IN NORTHERN INDIA

S. B. Land, Jr.[1] and N. B. Singh[2]

Abstract:--The status of tree improvement for *Populus* species in the hills and alluvial plains of northern India (above 28° N latitude) was assessed during two visits by the senior author in 1996. *Populus deltoides* Bartr. ex Marsh. var. deltoides from the USA is economically the most important Poplar species, but additional superior-performing clones need to be developed. Selection and studies of genetic variation in the indigenous poplars have started slowly and need to be accelerated, but hybridization work with *Populus ciliata* Wall. ex Royle appears promising for the hills. An All-India Coordinated Project on Poplar Improvement (AICPPI) has now been organized by the Indian Council of Forestry, Research & Education to coordinate and direct poplar improvement in the country, and Dr. N. B. Singh has been appointed director of the project. Priorities will be breeding *Populus deltoides* for agroforestry in the alluvial plains of northern India, developing indigenous poplars and hybrids for the hilly region of northern India, and introducing and testing subtropical and tropical poplars for agroforestry in central India.

Keywords: *Populus deltoides* Bartr. ex Marsh. var. deltoides, *Populus ciliata* Wall. ex Royle, India.

INTRODUCTION

The objective of this paper is to report the current status of *Populus* tree improvement research, development, and use in northern India. Information was obtained by the senior author from interviews, field trips, and reference materials during two visits to India in 1996. The visits were part of a consultancy activity between Winrock International Institute for Agricultural Development and the Indian Council of Forestry, Research and Education (ICFRE). Dr. N. B. Singh was the Indian counterpart from ICFRE for the consultancy.

USE OF POPLARS IN INDIA

Poplars are primarily used in agroforestry systems on the Indo-gangetic plains north of 28 degrees N latitude (Figure 1) and, to a lesser extent, in forestry plantations on the hills of north

---

Forest and Wildlife Research Center, Department of Forestry, Mississippi State University, Mississippi State, MS 39762-9681.
[2] Silviculture Division, Forest Research Institute, Dehradun 248 006, India. Approved for publication as Journal Article No. FA077-0597 of the Forest and Wildlife Research Center, Mississippi State University.

India. There is potential for their use in the valleys of the northwestern Himalayas, in the plains and hills of northeast India, and (possibly) for portions of east-central India north of 22 degrees N latitude (states of Madhya Pradesh [=M.P.], Bihar, Orissa, and West Bengal). The crop mixtures used in the agroforestry systems are described later in this paper.

Populus deltoides Bartr. ex Marsh. var. deltoides (typical eastern cottonwood from the USA) is an exotic and is currently the species of choice for agroforestry in the Indo-gangetic plains of the states of Uttar Pradesh (U.P.), Haryana, and Punjab. It is also the candidate species for use in east-central India, and may eventually be an important component of poplar culture in northeast India. Indigenous Indian species of *Populus* do not tolerate the heat of the plains (the possible exception is *Populus euphratica* Oliv., but this species grows slowly and has a bushy form). Little is known about *Populus gamblei* Dode in northeast India, but Dr. H. B. Naithani at the Forest Research Institute (FRI) in Dehradun, U.P., does not think that it can tolerate the high temperatures either. Hybrids of *P. deltoides* with the indigenous *Populus ciliata* Wall. ex Royle

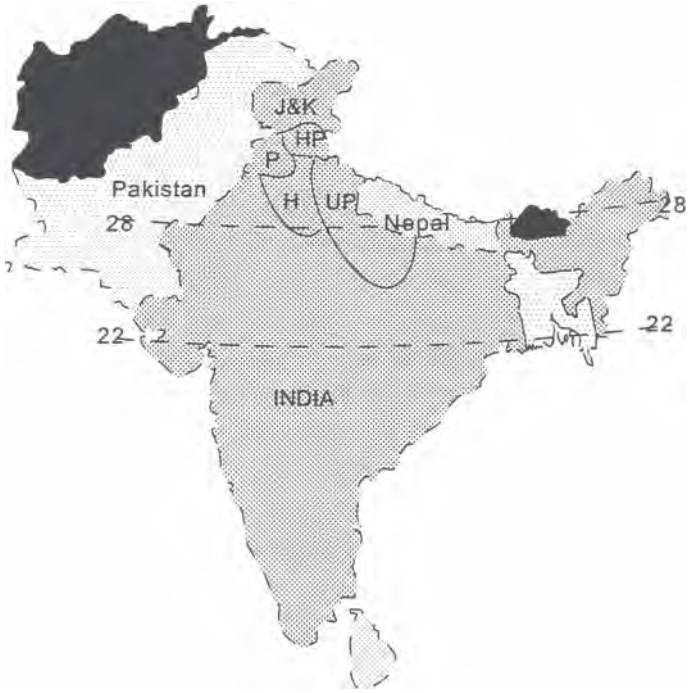

Figure 1. Locations of several states in northern India where Poplars are currently being planted. State abbreviations are J&K for Jammu and Kasmir, HP for Himachal Pradesh, P for Punjab, H for Haryana, and UP for Uttar Pradesh. Latitude 28 degrees North has traditionally been the southern limit for use of Poplars in India, but use of subtropical Poplar species may allow extension of this limit to 22 degrees North latitude.

exhibit heterotic growth in the nursery of the U.P. Forestry Department at Lalkuan, U.P., but fail (dieback) in agroforestry plantings on the U.P. plains by age three (personal communication with scientists at WIMCO Seedlings Ltd. near Lalkuan). A very robust market has developed for poplars grown in agroforestry systems on the Indo-gangetic plains. The primary products are

plywood, veneer, and matches, but secondary products include charcoal, fuelwood, leaf litter (composted), and (occasionally) fodder. Farmers are making money from these trees, and many now consider wood as their primary farm crop (personal communications with K. K. Sharma of ICFRE and Dr. J. P. Chandra at WIMCO).

The indigenous poplars, hybrids of P. *deltoides* with indigenous poplars, and other exotic poplar species and their hybrids with indigenous poplars are proving most suitable for reforestation/ afforestation in the hills of northern India. Dr. D. K. Khurana at the Y. S. Parmar University of Horticulture and Forestry in Solan, Himachal Pradesh (H.P.), recommends *P. deltoides* clones in the valleys below 900m elevation, the hybrid of *P. ciliata* x *P. maximowiczii* Henry on hills between 900m and 1500m elevation, and *P. ciliata* on hill sites between 1500m and 2800m (personal communication). He also reports that tests are being conducted further north in the state of Jammu and Kashmir (J&K) at Shere Kashmir University of Agricultural Sciences and Technology on the exotic species *Populus nigra* L. and *P. deltoides,* the indigenous species *Populus alba* L. and *Populus sauveolens (?),* and the hybrid of *P. deltoides* x *P. ciliata* (from his work). D. V. Negi with ICFRE at the Himachal Forest Research Institute (HFRI) in Shimla, H.P., reports that *P. alba* and *P. euphratica* only occur in limited, cold areas (high elevations) and might have potential for forest plantations above the *P. ciliata* plantings or for irrigated plantings in the cold desert region of H.P. and J&K. The U.P. Forestry Department is producing and testing some hybrids of *P. deltoides* x *P. ciliata* and *P. deltoides* with *Populus yunnanensis* Dode for use in the hills. Planting with poplars in the hills will be done almost entirely by State Forestry Departments on government lands without benefits of irrigation. Production will not be as rapid as for poplars in the agroforestry systems. Primary objectives shift from wood production to establishing a rapid tree cover for water and soil conservation. However, there is a local market for packing cases to serve the horticultural industry in H.P., so that poplar plantations on state lands might better serve this market than the imported eucalyptus cases from the plains. As the plantations mature, the plywood industry could expand into the hills to utilize the silvicultural cuttings from these plantations.

TREE IMPROVEMENT -- INTRODUCTION OF EXOTICS

At *least 440 clones of various* poplar species and hybrids were introduced and tested in northern India from 1958 to 1983 (Tiwari 1993). There were also some *P. deltoides* clones sent to India in the mid 1980's by Dr. Sam Foster (then in Louisiana and now with the U.S. Forest Service in Asheville, North Carolina), who made controlled crosses among some selected clones from Stoneville, Mississippi. These clones were tested by WIMCO Seedlings Ltd., but they did not perform well at early ages and were discarded. An additional large collection of approximately 200 *P. deltoides* clones from throughout the eastern United States was sent by Dr. E. A. Hansen of the U. S. Forest Service at St. Paul, MN, (now retired) to Dr. A. N. Chaturvedi of the U.P. Department of Forestry in January 1986.

Results indicate that *P. deltoides* from Texas and southern Mississippi River sources are best for the plains of northern India. These origins represent the southern 25% of the native range of *P. deltoides,* but clones have not been tested from origins east of the Mississippi River in the southern part of the range. *P. maximowiczii* and *P. yunnanensis* are other promising exotic

species (in the form of hybrids with *P. deltoides* or *P. ciliata)* for use in the mid-elevation range of the hills.

In 1990, Dr. D. K. Khurana at the Y. S. Parmar University of Horticulture and Forestry in Solan collected open-pollinated seeds from 103 *P. deltoides* trees along the Colorado and Brazos Rivers in Texas and along the southern part of the Mississippi River from Baton Rouge, Louisiana, to Davenport, Tennessee (Farmer and Khurana 1990, and personal communication with Dr. Khurana). He raised 50,000 seedlings at Solan and screened them down to 50 clones after three years of nursery measurements. Screenings were based on growth, stem form, and resistance to *Melampsora* spp. of leaf rust and to stem-borer insects. These 50 clones have been distributed to five state agricultural universities (in Punjab, Haryana, J&K, Orissa, and M.P.), two institutes (Tropical Forest Research Institute [TFRI] at Jabalpur, M.P., and Tata Energy Research Institute in New Delhi), and one private company (WIMCO Seedlings Ltd. in Rudrapur, U.P.). The oldest field trial (at Solan) was three years old in 1996.

TREE IMPROVEMENT--PROVENANCE INFORMATION ON INDIGENOUS POPLARS

There are six indigenous poplar species identified by Tiwari (1993) in India: *P. ciliata, P. alba, P. euphratica, P. gamblei, P. jaquemontiana* var. *glauca (?),* and *P. laurifolia* Ledeb. Dr. D. K. Khurana at Solan also identifies a seventh species: *Populus sauveolens* (personal communication). These species occur in the hills of northern India, usually as scattered individual trees or as a few widely separated stands. The only provenance studies conducted to date have been for *P. ciliata, P. alba,* and *P. euphratica,* and almost all of the reported work has focused on *P. ciliata* in H.P.

Drs. P.K. Khosla and D.K. Khurana (both at the Y.S. Parmar University of Horticulture and Forestry in Solan) have initiated numerous studies on variation in *Populus ciliata.* They identified four ecological blocks ["types"] of natural occurrences of *P. ciliata:* (1) High-level association with fir-spruce, (2) Low-level association with blue pine *(Pinus wallichiana* A.B. Jacks) and deodar cedar *(Cedrus deodara* Roxb. Loud.), (3) Ravine/seasonal-water-source association with *Alnus, Ulmus,* and *Salix,* and (4) River flood basin/water channel sites on sandy soils (Khurana and Khosla 1982 and 1991). Phenotypic variation is greater among trees within stands than between stands within a type, but large differences are found between types. Provenance tests of *P. ciliata* that have been reported in the literature (Chauhan and Khurana 1992; Chaukiyal *et al.* 1995) involve cuttings from one clone (ortet) per source and from only nursery observations at one nursery near Solan. There is some evidence from these tests that better growth occurs from U.P. sources, but fewer limbs and better resistance to stem borers are found from J&K sources.

Recently, Dr. Khurana at Solan has established a larger provenance test of *P. ciliata* to rectify the problems of too few trees in the earlier tests (personal communication). He collected cuttings from 85 provenances (trees) throughout J&K, H.P., and U.P., and these are now 5 to 7 years old in field trials at three sites in H.P. He has also collected open-pollinated seeds from these same 85 trees, but the seedling clones have not yet been planted in field provenance tests.

D.V. Negi at HFRI in Shimla has recently completed a survey of *P. ciliata* in H.P. and *P. alba* and *P. euphratica* in H.P. and J&K (personal communication). In 1996, he collected and planted cuttings in Shillaru Nursery, H.P., from 124 trees (one male and one female tree in each of 62 stands) for *P. ciliata,* 32 trees (16 stands) for *P. alba,* and six trees (three stands) for *P. euphratica.* None of the *P. euphratica* cuttings survived. He plans to return to the trees (ortets) of *P. alba* and *P. euphratica* to collect open-pollinated seeds. This is part of a rangewide survey proposed to FAO[3] and coordinated by P. Khanna (FRI). Collaborators from FAO are Dr. J. B. Ball, Senior Forest Officer Plantations, and Dr. Oudara Souvawnavong (from Laos), who are located with the Forest Resource Development Service of FAO in Rome. Dr. H. B. Naithani (Botany Division, FRI) has been assigned responsibility for surveying *P. ciliata* in U.P. as part of this project. He has surveyed approximately one-half of the area in U.P. and has taken measurements on 200 trees. He will complete the survey in 1997, but has no plans to collect cuttings or seeds until so instructed by Mr. Khanna. The responsibility for a survey of *P. ciliata* and *P. gamblei* in northeast India has been assigned to Dr. Jasbir Singh and Mr. Sharma at the Institute of Rain and Moist Deciduous Forest Research (IRMDFR) in Jorhat, Assam. No accomplishments have been reported from that institute.

TREE IMPROVEMENT -- BREEDING (INCLUDING SPECIES HYBRIDIZATION)

Breeding involves crossing among selected trees to produce progenies with new combinations of genes for testing and selection. The resulting selections will be the clones of the next generation of improvement. Breeding requires flowering trees of the selected clones that will be used as parents. This is a major problem for exotics like *P. deltoides,* since almost no provisions have been made to establish and maintain breeding orchards of mature individuals of the introduced clones.

All controlled crosses involving *P. deltoides* before 1997 have been opportunistic, depending on what was flowering. Seven *P. deltoides* clones flowered during this time (G-48, D-121, and S7C8 were females, and G-3, S7C1, S7C15, and S7C20 were males). Except for D-121, all of these were from Brazos County, Texas. One male flowering clone of *P. yunnanensis* and one male of P. *`robusta'* (Euramerican hybrid) were also used. "Breeding" in U.P. has been by the U.P. Forestry Department's Lalkuan Research Centre, Silviculture Division, Sal Region, by nearby WIMCO Seedlings Ltd. in Rudrapur, and at FRI in the Genetics and Tree Propagation Division. Initially, most of the new clones came from open pollinations between G-48 and G-3 (the first two clones to flower). These seedling progeny clones provided the "L-series" clones of the U.P. Forestry Department and most of the "WSL-series" clones of WIMCO. Subsequently, the U.P. Forestry Department nursery manager at Lalkuan made the following crosses (female x male): G-48 x G-3, D-121 x S7C1, G-48 x *P. ciliata,* D-121 x *P. ciliata,* G-48 x *P. yunnanensis,* and G-48 x *P. `robusta'*. WIMCO selected three seedling clones from their own controlled crosses of G-48 x G-3, and they made some backcrosses (such as G-48 x *P. `robusta)* to stabilize desired hybrid combinations of P. *deltoides* with *P. nigra.* Controlled crosses by the

---

Noh, E.R., K.K.Sharma, and M.L.Kapoor. 1995. A report submitted to FAO on Improvement Programme of Indigenous Poplars with Particular Reference to India. FRI, Genetics & Tree Propagation Division, Dehradun.

Genetics and Tree Propagation Division at FRI were made in the spring of 1996 and required transport of flowering branches from Lalkuan. The crosses G-48 x G-3 and G-48 x *P. ciliata* were successfully accomplished. The *P. ciliata* male flowers came from the hills of nearby Mussoorie.

The greatest amount of controlled crosses among Populus species in India has taken place at the Y. S. Parmar University of Horticulture and Forestry in Solan, H.P. Flowers (male and female) of P. *ciliata* could only be successfully ripened on cuttings in the greenhouse if the cuttings were cleft-grafted to potted rootstock seedlings in January before bud break (Khurana 1989, Khurana and Thakur 1995). Water cultures and 'twig in pot' methods did not work. Cuttings of *P. gamblei* bearing male flowers could not be forced to ripen and shed pollen at Solan under any method, so no crosses with this species were made. Dr. Khurana successfully produced the hybrids *P. ciliata* x *P. maximowiczii* (pollen obtained from Japan), *P. ciliata* x *P. yunnanensis*, and *P. deltoides* (female) x *P. ciliata* (male) (but not the reciprocal) (personal communication). The *P. ciliata* x *P. maximowiczii* hybrid was heterotic for growth, but had the branch knot problem of *P. maximowiczii.* Dr. Khurana selected 20 clones from field tests of this hybrid for minimum branch knots.The *P. ciliata* x *P. yunnanensis* and *P. deltoides* x *P. ciliata* hybrids did not show heterosis for growth in his tests. Backcrosses of the Euramerican hybrid clone '1-455' (female), which exhibits fast growth but is highly susceptible to *Melampsora* spp. of leaf rust, with *P. deltoides* (male) by Dr. Khurana produced two selections that exhibited extremely fast growth (4 to 5 meters per year in height) on recently-exposed, well-drained forest sites (not agroforestry) in H.P.

A total of 358 clones (primarily *P. deltoides,* including some intraspecific crosses of G-48 by G-3) have been preserved in a germplasm bank at FRI in Dehradun, U.P. There are also 277 clones of *P. deltoides* in a germplasm bank at the HFRI Shilly Research Nursery in Solan, H.P. Most of these are duplications of the clones at FRI, so that protection against a catastrophic loss of clones (from fire, etc.) is provided. The U.P. Forest Department's Lalkuan Research Centre is also maintaining a collection of clones from previous introductions and from inter- and intraspecific crosses. Many of these are duplications of clones at FRI. There are 150 clones in the Department's nursery at Lalkuan (100 *P. deltoides* clones), another 60 clones in a replicated test planted in February 1985 at `Ganga Pur Patia East' near Lalkuan, and 233 clones in the Department's populetum planted in February 1989 at Tanda, U.P. (Plot #47). Forty-four of the clones in the Tanda planting came from Dr. Hansen's 1986 shipment of 200 clones to India and were selected based on nursery performance at the Lalkuan nursery. The Ganga Pur and Tanda tests were just beginning to flower in 1996 and will provide the only breeding orchard available in India (108 clones) for the initiation of an advanced-generation mating design with *P. deltoides*.

NURSERY AND GREENHOUSE TECHNIQUES

All *Populus* propagules being commercially planted in agroforestry or in reforestation/ afforestation are E.T.P.s (Entire Transplants). These are one-year-old rooted cuttings. The tree improvement program must therefore use E.T.P.s for clonal field trials.

Nursery management techniques include soaking the cuttings and nursery beds in water before planting and then planting the 18-25cm length cuttings at a spacing of 80cm x 60cm. Debudding to remove young limbs on the E.T.P.s is done from June to November. The nursery beds are flood irrigated 1-2 times per week during March - June, until the rainy season begins. Backpack sprayers are used to apply insecticides for control of leaf beetle, thrips, and wood-borer insects. The target E.T.P. for production nurseries is a plant whose ground-line diameter is 1/100th of the height (in cm) (personal communication with Dr. J. P. Chandra). When harvesting the one-year-old E.T.P.s in December - February, the tap root is cut at a 25cm depth and all side roots more than 10cm long are trimmed (Chaturvedi 1982, Sidha *et al.* 1990). The plants are packed, transported, sold, and planted with a naked root.

Research nurseries have the additional task of developing uniformity among E.T.P.s of the same clone. Re-propagating E.T.P.s annually from the previous year's E.T.P.s for 4-5 years in the nursery may be required to remove "C-effects" (age, position-in-tree, or vigor effects on cuttings taken from the crowns of different-aged ortets on different sites). The clones will not be taken to the field trials until within-clone variation is less than 10-15% (personal communication with Dr. Khurana at Solan). Furthermore, the multiplication of seedling-derived clones will take at least three years in the nursery to produce enough E.T.P.s for field trials at 2-3 sites.

When seeds are produced from controlled crosses during breeding, they must be germinated and grown before they can be vegetatively multiplied as E.T.P.s. *P. ciliata* seeds are very fragile and will lose viability in 7-10 days if not germinated quickly (personal communication with Mr. D. V. Negi). All *Populus* species seedlings are vulnerable to sun scald (heat) damage and diseases (damping off) during germination. Procedures for germinating and growing seedlings at WIMCO Seedlings Ltd. provide a working model for success. Fungicide-treated seeds are planted in rows on moist, heat-sterilized sand in flat clay pots and placed in a double-walled polygreenhouse with fans. The polygreenhouse is covered with 50% shade cloth. Approximately 15 days after the seeds have germinated, the germinants are 'pricked' and transplanted to individual cells in container racks. The soil in the containers is a barnyard mixture of manure that has been sterilized, so no additional fertilization is required. Containerized transplants are placed in a mist chamber in the greenhouse for one week (mist for 1-2 seconds at 5-minute intervals), then moved into a shadehouse for one week and subsequently outside under the shade of trees for 15 days. Finally, the acclimated seedlings are placed in the open sunlight where they remain until they are 30cm tall. At this size the roots can retain soil in a 'plug' when removed from the container. The 'plug' seedlings are then planted in the research nursery (personal communication with Dr. S. Chauhan of WIMCO).

AGROFORESTRY

The entire agroforestry industry with *Populus* is founded on a very limited genetic base. Approximately 90% of poplars being planted for agroforestry in U.P., Haryana, and Punjab come from the *P. deltoides* clones G-48, G-3, and S7C15 (personal communication with Dr. J. P. Chandra of WIMCO Seedlings Ltd.). The next two clones in popularity are 'Udai' from WIMCO and L-34 from the U.P. Forestry Department. Both of these clones come from open pollinations between G-48 and G-3. Other clones that are not quite as desirable, but which are being held in

reserve in case of a serious disease or insect outbreak, are S7C8, S7C4, L-43, ST-240, ST-70, and ST-67. All of these clones (except the three ST clones) came from gene pools in Brazos County, Texas. The three ST clones came from the southern Mississippi River alluvial plain just north of Vicksburg, Mississippi USA.

Typical agroforestry methods are to plant 4m-5m tall E.T.P.s in (1) "bund" (shelterbelt) plantings on the small levees around flood-irrigated agricultural fields, (2) "block" plantings at 5m x 5m, 5m x 4m, or 6m x 4m spacings within agricultural fields (underplanted with the crops), or (3) "row" plantings that contain alternating rows of Poplars and horticultural tree species underplanted with agricultural crops. Typical spacing between "rows" is 6m, so the *P. deltoides* rows are 12m apart. Rotation lengths for poplars are 5-8 years (5 years for plywood, 8 years preferred for veneer and matches). Typical crop combinations with "bund" plantings are sugarcane or rice, but rice is not recommended because of the requirement for summer flooding. Crop combinations with "block" plantings involve sugarcane for the first two years and then winter wheat or a combination of winter wheat alternating with summer-grown tumeric or pearl millet during the third through eighth years of the *P. deltoides* rotation. A new alternative to tumeric or pearl millet is celery. Dr. N. B. Singh has also observed rice being cultivated in some block plantings during the fourth through eighth years. Apparently, *P. deltoides* can tolerate flooding at the older ages. "Row" planting mixtures in agro-horti-forestry systems are based on a rotation length of up to 50 years for the final horticultural orchard. These systems may involve poplar-peach, poplar-litchi, or poplar-mango combinations with sugarcane, tumeric, and winter wheat as under crops. Up to two 5- to 8-year rotations of *Populus* may be grown before the fruit trees (particularly mango) spread in crown diameter to become a full orchard. In all of these systems the poplar trees are pruned of lower limbs (recommended lower 1/3 of stem height after the second year). The leaves are collected and composted at the end of the growing season for placement back on the fields, and the stumps are dug up and removed for fuelwood/charcoal at the end of the rotation. The above information was obtained from field visits and personal communications with Dr. R. P. Singh (HFRI), Mr. K. K. Sharma (ICFRE), and Dr. J. P. Chandra (WIMCO Seedlings Ltd.).

SUMMARY COMMENTS AND RECENT DEVELOPMENTS

There has been much plant material, expertise, and work involved in *Populus* tree improvement for India. However, there has also been little coordination of effort or continuity of guidance, since long-term assignments to projects have not been common. Although the widespread testing of many introduced clones, release of a few selected clones, and development of a new income source for farmers is worthy of praise, much more should have been accomplished in 40 years. Dr. Khurana in Solan has been very astute in seeing and working on the tasks that were most needed: (1) breeding of superior clones of *P. deltoides* and a few other exotic poplar species that were already present and proven in northern India (i.e. "land races"), (2) provenance testing of indigenous poplars for performance and for amounts and patterns of geographic genetic variation, (3) introduction of a larger gene pool (through seed collections) from the portion of the natural range of *P. deltoides* that has proven to be most productive in northern India, and (4) widespread testing of new clones from breeding, provenance testing, and new introductions across all of northern and east-central India.

The Indian government has recently recognized the need for central coordination of forestry research and development activities and has assigned this task to the Indian Council of Forestry, Research and Education (ICFRE). Desirable steps have already been taken. In mid 1996 the Director General of ICFRE appointed Dr. N. B. Singh to be Chief Technical Advisor (Coordinator) and Mr. Dinesh Kumar to be Associate Technical Advisor for an All-India Coordinated Project on Poplar Improvement (AICPPI). These two scientists are located at FRI in Dehradun, which is where ICFRE administration is headquartered. Priorities will be:

(1) advanced-generation breeding of land-race' clones of *P. deltoides* and introductions of new collections of *P. deltoides* from the southeastern USA for agroforestry in the alluvial plains of northern India (above 28 degrees N latitude), (2) developing indigenous poplars *(P. ciliata and P. gamblei)* and their hybrids with *P. yunnanensis* and *P. maximowiczii* for the hills of northern India, and (3) initiating introduction trials of subtropical and tropical poplars *(P. ilicifolia* Rouleau from the Tana River of tropical Kenya and *P. mexicana* subsp. *mexicana, P. mexicana* subsp. *dimorpha, P. fremontii* subsp. *mesetae,* and *P. guzmantlensis* from subtropical Mexico) (Pryor 1992) for agroforestry between 22 and 28 degrees N latitude in central India.

Several activities have already been accomplished at FRI during December 1996 through March 1997. A National Poplar Germplasm Bank with 350 clones has been established, 45 promising clones of *P. deltoides* have been planted in a breeding orchard, control crosses of *P. deltoides* have been made among six female clones and 15 males, and cuttings of 20 *P. deltoides* clones have been supplied to 15 cooperating research institutions for multilocational trials.

Perhaps with the new AICPPI the long-term commitment of resources needed for a *Populus* tree improvement program can be sustained. Such an approach is necessary to efficiently achieve the main goal of continually providing better planting material and products for the nation.

LITERATURE CITED

Chaturvedi, A.N. 1982. Poplar farming in U.P. (India). U.P. Forest Bull. No. 45 (Revised 1982). 44 p.

Chauhan, P.S., and D.K.Khurana. 1992. Growth performance of different provenances of Himalayan poplar. In: Proceedings, 19th Session of the International Poplar Commission, Volume I. pp. 687-693.

Chaukiyal, S.P., D.C.Mahtolia, and Ombir Singh. 1995. Comparative performance of some provenances of *Populus ciliata* planted under nursery conditions. Adv. For. Res. in India XIII:35-44.

Farmer, R.E.Jr., and D.K.Khurana. 1990. Seed collection and storage of *Populus deltoides.* IDRC-TIFNET Newsletter 2:6-8.

Khurana, D.K. 1989. Crossability patterns in *Populus ciliata* Wall. ex Royle. In: Recent Developments in Poplar Selection and Propagation Techniques. Proceedings. Meeting of IUFRO Working Party S2.02.10 held at Hann. Munden, Fed. Republic of Germany, Oct. 2-6, 1989. Institute of Forest Tree Breeding of the Hessian Forest Res. Station and Res. Institute of Fast Growing Tree Species, D-3510 Hann. Munden, Germany.

Khurana, D.K., and P.K.Khosla. 1982. Studies in *Populus ciliata* Wall. ex Royle. III. Phenotypic variation in relation to ecological blocks. J. Tree Sci. 1(1&2):35-45.

Khurana, D.K., and P.K.Khosla. 1991. *Populus ciliata* -- Its Genecology and Culture. Tech. Bull. No. FBTI4, Dr. Y.S.Parmar University of Horticulture and Forestry (Solari, H.P.) and International Development Research Center (Canada). 33 p.

Khurana, D.K., and Sanjeev Thakur. 1995. *Populus ciliata* x *maximowiczii:* Preliminary report on a potential hybrid for mid west Himalayan zone. Indian Forester 121(9):802-806.

Pryor, L.D. 1992. The selection of poplars for planting in tropical and subtropical countries, pp. 651-683. In: Proceedings, 19th Sesion de la C.I.A., Volumen I. International Poplar Commission, Forest Resources Development Branch, FAO, Via delle Terme di Caracalla, Rome, Italy.

Sidhu, D.S., A.S.Hans, and R.S.Dhanda. 1990. Poplar cultivation. Published by Communication Centre, Punjab Agricultural University, Ludhiana-141004. 38 p.

Tiwari, D.N. 1993. Poplar. Surya Publications, Rohini Printers and Publishers, Dehradun, India. 321 p.