PROCEEDINGS OF THE WORKSHOP

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Growing of Poplar : Bottlenecks and Policy Issues

Organized by

Haryana Kisan & Agricultural Costs and Prices Commission, Panchkula, Haryana

Government of Haryana

Haryana Kisan & Agricultural Costs and Prices Commission

Government of Haryana

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Growing of Poplar: Bottlenecks and Policy Issues

Proceedings of the Workshop

Held on 8th June, 2018

Organized by

HARYANA KISAN & AGRICULTURAL COSTS AND PRICES COMMISSION

(Government of Haryana)

PANCHKULA, HARYANA

2019

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Mr. Om Parkash Dhankar, Hon'ble Minister of Agriculture and Farmers' Welfare (Govt. of Haryana) delivered the key note address. He encouraged farmers to grow poplar and other commercial trees at their farmlands. His presence and remarks has been a source of inspiration. We all are grateful to him.

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Dr. O.P. Toky
Consultant (Agroforestry & Environment) and Convener of the Workshop
Haryana Kisan & Agricultural Costs and Prices Commission
Panchkula-134 116.

Dr. Ramesh Kumar Yadava receiving the Hon'ble Sh. O.P. Dhankar, Minister of Agriculture

Mr. Devender Chawla, President Plywood Association, Yamuna Nagar welcoming the Chief Guest

PREFACE

The role of trees in environmental security has been well known for ages. Trees in Agroforestry systems not only provide direct benefits but also improve soil fertility, reduce soil erosion, filter atmospheric pollutants and most importantly they maintain carbon balance. Growing of trees along with agricultural crops has been considered as a panacea for maladies of intensive agriculture and deforestation. It is considered to be one of the key paths towards prosperity of small and marginal farmers facing the challenges of uncertain yields, deterioration of the soil and environmental resources and suffering from poverty.

Trees can act as a safety net by capturing nutrients leached from the top soil and from the environment; they can return these to the soil surface through litter. Tree litter improves water infiltration into the soil and reduces surface runoff. Effect of Agroforestry on weed suppression is also well documented. In the north-western India, poplar was introduced as an Agroforestry tree about 40 years ago. This species played a significant role in boosting the economy of the farmers and creation of livelihood. The tree is compatible with wheat, sugarcane and medicinal plants.

After the closure of plywood and veneer units in the north-eastern region on the orders of the Honorable Supreme Court in 1996, the exponential growth of such units took place in Yamuna Nagar, also called as "*Plywood Capital of India*" due to sustained supply of raw material from farm grown trees. Presently, there are more than 570 plywood and veneer units and 368 subsidiary units in the district which manufacture doors, windows, shutters, and other material. The arrival of farm-grown wood was approximately 26 lakh tons, valuing about Rs.1000crore in the Yamuna Nagar timber market during 2006-07.

Until 2013, poplar wood supply and its utilization were well synchronized. Poplar wood witnessed all times high price of over Rs. 1200/q in 2011. Progressive farmers have obtained 3-fold higher income from poplar and agricultural crop combinations than pure agriculture. Intercropping of sugarcane, wheat, medicinal plants and vegetables is more beneficial. On an average, a farmer may get total income of Rs.1, 25,000/- per acre per annum from a poplar Agroforestry system. After reducing the cost of production @ Rs. 25,000/- per acre per annum, it comes to Rs. 1, 00,000/- per acre per annum. The price of poplar timber has drastically fallen; nevertheless, the farmers hope that the price would pick up in future.

Haryana Kisan & Agricultural Costs and Prices Commission organized a one day workshop at Panchkula on 8th June, 2018 involving farmers, scientists and industrialists to discuss the problems of the farmers. The proceedings of the workshop include vital information on poplar cultivation and the points which Haryana Kisan & Agricultural Costs and Prices Commission would take up with the Govt. to solve the problems of the farmers and to make poplar Agroforestry systems as sustainable.

Dr. Ramesh Yadava
Chairman
Haryana Kisan & Agricultural Costs and Prices Commission,
Panchkula-134 116.

Hon'ble Chief Guest Sh. O.P. Dhankar addressing the participants of the workshop

Dr. O.P. Toky, Convener of Workshop explaining the objectives and interacting with the participants

CONTENTS

ABBREVIATIONS

Agro Farm Forestry Division	AFFD
All India Coordinated Research Project	AICRP
Agricultural Produce Marketing Committee	APMC
Central Arid Zone Research Institute	CAZRI
Chaudhary Charan Singh Haryana Agricultural University	CCS HAU
Central Empowered Committee	CEC
Corporate Social Responsibility	CSR
Department of Agriculture, Cooperation & Farmers Welfare	DAC & FW
Diameter at Breast Height	DBH
Decision Support System	DSS
Distinct Uniformity and Stability	DUS
Entire Transplantable Plant	ETP
Forest Research Institute	FRI
Forest Reproductive Material	FRM
Green House Gases	GHG
Haryana Agricultural and Marketing Federation	HAFED
Haryana State Forest Department	HSFD
Indian Council of Agricultural Research	ICAR
Indian Council of Forestry Research and Education	ICFRE
International Development Research Centre	IDRC
International Poplar Commission	IPC
Indian Sugar Mills Association	ISMA
Indian Tobacco Company Limited	ITC
Krishi Vigyan Kendra	KVK
Ministry of Agriculture and Farmers Welfare	MOA & FW
Minimum Support Price	MSP
Multipurpose Trees	MPTs
National Bank for Agriculture and Rural Development	NABARD
National Agroforestry Policy	NAP
Nationally Determined Contribution	NDC
National Forest Policy	NFP
National Poplar Commission	NPC
Open General License	OGL
Punjab Agricultural University	PAU
Principal Component Analysis	PCA
Principal Chief Conservator of Forests	PCCF
Research and Development	R & D
Randomized Block Design	RBD
Region of Intensive Poplar Culture	RIPC
State Agricultural Universities	SAUs
State Forest Department	SFD
Sub-Mission on Agroforestry	SMAF
Short-Rotation Coppice	SRC
Trees Outside Forests	TOF
University of Horticulture and Forestry	UHF
United State Department of Agriculture	USDA
Virus Induced Transfer'	VIT
Veneer Log Peeling Machines	VLPM
Wood Based Industries	WBIs
West India Match Company	WIMCO
WIMCO Seedlings	WS

LIST OF TABLES AND FIGURES

Nursery raising of poplar

RECOMMENDATIONS

FOR THE INDUSTRY OWNERS

- The 4 ft width peeling size of units needs to be raised to 8 ft by setting up new peeling units. This way the face veneers, which are imported nowadays, can be manufactured locally at half of the price saving foreign exchange. In case larger peeling units are allowed and face veneers are manufactured here then around one lakh cubic meter round timber (RT)of poplar and *Safeda* can be utilized, which will shorten the supply and demand gap thereby pushing the prices of raw material upwards.
- The existing waste creating units should be replaced with zero spindle peeling units adopting bigger peelers to produce face veneers in house, enhancing the capacity of presses and delinking of pressing units from licensing mechanism.
- The New Zealand pine is generally used in boards and it is available @ Rs. 400 per cubic feet. The wood of this exclusively imported species can be replaced by locally grown tree *Maha Runkh* (*Ailanthus excelsa)* so that cost can be reduced to Rs.40/cubic feet. This wood is equally effective as border blocks of boards.
- Flow of research grants from industries to research institutions is completely absent and the same needs to be initiated. This is in vogue in the agriculture sector of India since long.

FOR THE FARMERS

- On the boundaries of the fields poplar should be planted at plant to plant spacing of 3 m, and on the water channels on both sides with a plant to plant spacing of 2 m.The standard spacing of trees of poplar in block plantation is 4 m x 4 m or 5 m x 4 m. However, spacing of poplar may be 10 m × 2 m (10 m row to row and 2 m plant to plant) in north-south direction or plant at 8 m x 2.5 m spacing with 8 m wide strips in north-south direction to minimize the adverse effects of tree shading on intercrops. Farmer can also take paired row i.e. 18 m ×2 m × 2 m (18 m row to row and 2 m plant to plant in paired rows). In wider row spacing, combine harvester can harvest wheat otherwise manual harvesting reduces the income of farmers. Some farmers grow poplar at narrow spacing and try to take more number of trees/acre, which adversely affects the crop yield. A proper tree spacing as per the standard recommendations should be followed.
- Apart from the clones G-3, G-48 and S_7C_{15} farmers in Haryana can plant WIMCO-8, WIMCO-83, WIMCO-108, WIMCO-109 and WIMCO-110; while clones such as PL-1 to PL-7, L-47/88 and L-48/89 are recommended for central-plain region of Punjab and L-48/89 for semi-arid region of Punjab.
- Fertilizer management is very important for the growth of poplar. Generally, farmers apply fertilizers only for inter crops and do not include the requirements of poplar trees as a result fertility of the soil gets depleted after few rotations and then yield of both intercrops and the poplar is decreased.
- In soils with medium in available N, apply 23 g N (50 g urea) and 39 g P_2O_5(85 g DAP) in each pit at the planting time of poplar. Apply 78 g N (170 g urea) in 1 m diameter ring around the tree during 1st year, 120 g N (260 g urea) in 2 m diameter ring during 2nd year and 161,198, 239,281 g N (350, 430, 520, 610 g urea), respectively in 3 m wide strip (1.5 m on each side of tree row) during 3rd, 4th, 5th and 6th year of tree growth, respectively. Time of application is also important. Every year, apply 1/3rd urea during May after harvesting of wheat, 1/3rd urea in July and the remaining 1/3rd urea in September. There is no need of P application to poplar every year.
- The deficiency of Zn is exhibited in the nursery by interveinal yellowing of recently matured leaves. Apply 40 kg zinc suphate heptahydrate (21%) or 25 kg zinc sulphate monohydrate (33%) per acre in Zn-deficient soils at the planting time of nursery. Repeat the dose after 2 years. In the plantation apply 100, 200 and 300 g/plant zinc sulphate heptahydrate or 65, 130 and 190 g/plant zinc sulphate monohydrate in Zn-deficient soils during 1st, 3rd and 5th year of poplar growth in 1

m diameter basin, 2 m diameter basin or 3 m wide strip (1.5 m on each side of tree row), respectively around the plants after harvesting of the *Rabi* intercrop.

- Moth appears during March-April and peak activity is from July to October from overwintering pupae. The larvae eat away all the tissue of the leaves leaving the veins. Spray in nursery and plantation on appearance of larvae during July and October with Quinalphos 25 EC @ 4 ml/litre or Profenophos @ 2 ml/litre using 500 litres of water per acre, can control the pests.. Plough the field 2–3 times in December to bury pupae in soil debris.
- Poplar needs to be irrigated at frequent intervals during summer months. However, at maturity stage of intercrops farmers cannot apply irrigation, which adversely affects the growth of poplar trees. This problem can be addressed by making bunds along poplar rows and irrigation can be applied in channels. Likewise farmer can also apply fertilizer through irrigation.

FOR THE SCIENTISTS

- It is essential to develop genetically superior high yielding clones of appropriate tree species and the compatible shade-tolerant varieties of crops.
- There is an urgent need to develop fast growingpests and diseases resistant varieties.
- Development of cheaper and suitable machinery for spraying of insecticides and harvesting of trees.
- Research should be carried out with respect to the diversified uses of poplar.
- Participation of farmers in research programme on poplar cultivation is of vital importance, where progressive farmers should come forward to support field trials on their farms.
- Suitable extension material in *Hindi* and local languages should be brought out to provide guidance to farmers of Haryana, Punjab Uttarakhand, Uttar Pradesh, Himachal Pradesh and Jammu and Kashmir.
- Farmers should be educated to take summer season intercrops with poplar trees because presently only wheat is being grown in poplar fields after second year of plantation. Sugarcane is grown as intercrop only for first two years.

FOR GOVT. (SHORT TERM POLICIES)

- Transit pass charges were increased from Rs. 35/ton in 2012 to Rs 75/ton; which should be curtailed. The contractors' 5% commission charge from the factories can be reviewed.*Mandi Samiti* tax @ 2% is imposed unnecessarily on poplar wood even though physically it does not go to the *Mandi* but as it is often transported from farm to the industry directly. Removal of this tax can provide good relief to the growers. E-Way bill and GST should be introduced on poplar wood at all places to overcome unwanted hurdles from police and forest departments.
- Government should set up a regulatory authority (an autonomous price fixation committee) comprising of experts, economists, farmers and wood-based industry representatives to determine minimum basic prices for farm grown wood that are reasonably remunerative for farmers and avoid exploitation. Farmers should get at least an average price of Rs.700/quintal (Rs.1100-1200 for over-size wood and Rs. 500-600 of the under-size wood*)*.
- Medicinal plants, spices and vegetables grown in the interspaces of poplar plantations should be made easily saleable or stored or processed. The MSP above Rs. 12/kg should be fixed for turmeric crop and it should be purchased by the HAFED or any other co-operatives, etc. State Poplar Development Board/Mission should be constituted to monitor and address the day to day issues related to poplar.
- Govt. should encourage direct purchase and sale of wood between producers and consumers reducing the exploitation of farmers by the middlemen. The rules of grading and trading of timber and its finished products should be made clear cut.

- There is no regulatory mechanism to ensure supply of certified nursery stocks to the growers. Some kind of certification module is required to be introduced to stop the sale of physically or genetically inferior stocks to the growers.
- Corporate sector should be promoted for production of high quality planting stocks and promotion of plantations through innovative policies and incentives.
- Poplar trees are attacked by several species of insects and pathogens, and to get a neat and clean bole, the trees needspray.Therefore, subsidies should be provided for the machinery required for spray on treeshaving height of 30 m or more.
- Farmers are generally not aware of the trends in expansion in crop production. The situation is more complex in case of trees as they are of long gestation period. Govt. should establish a Decision Support System for poplar and other farm trees to maintain a balance of demand and supply.
- The farm grown wood should be brought within the purview of APMC Act for transparency in sale of wood.
- Declare poplar and other farm grown trees as agricultural produce and allied industry as agricultural industry.
- Banks should facilitate credit flow for agroforestry projects including those nurseries producing high quality planting stocks/genetically improved clonal saplings.
- Facilities of credit and insurance as available in case of traditional agricultural crops, needs to be extended to farm trees also.
- Government and the NABARD should make arrangement for the farmers to get the benefit from international funding agencies for plantations as carbon sink.
- As the annual import of wood and wood products in the country is about Rs. 42,000 crores, the state government should approach the Union Government for regulating this import to protect the interests of our farmers. Heavy import tax should be levied to check competition from abroad.

FOR GOVT. (LONG TERM POLICIES)

- Govt. of India and NABARD should promote investments into agroforestry sector for its promotion through innovative policies, fiscal incentives and tax benefits.
- More poplar-based industrial units need to be established in areas other than Yamuna Nagar. Govt. owned manufacturing unit for wood processing should be established at block level. This would provide alternative market to poplar growers to sell their farm wood. Simpler transit rules would enable industries in such places to easily procure poplar wood from other districts/states for the benefit of growers as well as industry.
- To strengthen the wood-based industry in Haryana, Mr. Devendra Chawla, the president of All India Plywood Manufacturers Association has suggested the establishment of a dry port at Yamuna Nagar. The face veneers and chemicals according to him are quite costly as these are transported from the Kandla port in Gujarat.
- The governments of Uttar Pradesh, Punjab, Chhattisgarh and Bihar are providing incentives in the form of cheaper land, electricity and licence fees for establishing plywood and veneer units. To maintain an edge, the Haryana Government should provide similar incentives to entrepreneurs. The Haryana Government should invite leading players to set up medium density fibre board and furniture units in the state through relaxation of conditions under its “Ease of doing business”program. These measures will protect the interests of farmers, generate employment opportunities, boost government revenue, saving of foreign exchange, and would contribute towards environment conservation and fulfilling the global commitment of CO_2 reduction.

SUMMARY

EVOLUTION OF POPLAR AGROFORESTRY

The agroforestry interventions in Haryana and other states of north-western India started with the introduction of *Safeda* (*Eucalyptustereticornis)* in early sixties and poplar*(Populus deltoides)* in late seventies. Poplar, as a substitute of *Eucalyptus* for diversification of agriculture, was introduced by the WIMCO at such a time in 1976 when the controversy against later was at its peak. However, very soon it was realized that the poplar is not a competitor of *Eucalyptus* but both are complementary to each other. Poplar agroforestry system is one of the best examples of successful diversification of agriculture.

After the closure of plywood and veneer units in the north-eastern region on the orders of the Supreme Court in 1996, the exponential growth of such units took place in Yamuna Nagar due to sustained availability of raw material. At present, there are 570 plywood and veneer units and 368 subsidiary units in the district which manufacture doors, windows, shutters, 'chowkhat' and other shuttering material. These units have employed over one lakh people who are earning about Rs.900 crores annually.

LIVELIHOOD AND ENVIRONMENT AMELIORATION

- Poplar agroforestry has facilitated the development and growth of wood-based industries in forest deficit states like Haryana, Punjab, U.P. and Uttarakhand.
- Farm grown poplars and eucalypts support nearly 80-90% of industrial roundwood. In Haryana sustainable harvest of timber from community and farm lands is about 28 lakh cubic meters (94%) per year compared to1.9 lakh cubic meters (6%) from the government forests.
- There is huge value addition through local processing and supply of useful products including plywood and paper to the society.
- Poplar agroforestry is ameliorating tree cover, nature greenery, carbon sequestration and the environmental condition in the country.
- It has helped in creation of vast employment opportunities, conservation of foreign exchange and has increased government revenues.
- Poplar farming has strongly supported the much needed diversification of agriculture in north-western India.
- It has excelled one step forward in meeting the National Forest Policy (33% tree cover) requirements.

SUPPORT OF THE FOREST DEPARTMENT FOR AGROFORESTRY

- **Plantation on farmers' field:** In the recent past, the Forest Department of Haryana raised poplar plantations free of cost on farmer fields as per suitability of the sites and also maintained them for one year.
- **Nominal rates of saplings:** The Forest Department provided the saplings of poplar at nominal rates which has been helping the farmers to carry out plantations.
- **Purchase price scheme:** Haryana Forest Development Corporation fixes and revises the purchase price of trees at every six months. This scheme is similar to that of minimum support price for tree growers and regulating the prices of timber in the market so that the tree growers can get maximum income for their produce.
- **Free felling of farm grown wood:** The farmers in Haryana are not required to take permission for felling of poplar trees or any other farm grown timber from their farms. This has created an atmosphere of freedom in the minds of farmers and encouraged them to grow poplar trees in a big way.

ELITE CLONAL GERMPLASM OF POPLAR

WIMCO did pioneer work to introduce poplar in north-western India about 42 years ago. Initially during the 1970's clones with IC series were planted in the state. Soon these clones were replaced firstly with G-3 and then with G-48 clones in 1980's, and during 1990's the 'S' series clones especially S7C8 andS7C15 found their favor among the famers. Later on, new WSL series clones were released during 2002 and as now the WIMCO-81, WIMCO-83, WIMCO-108, WIMCO-109 and WIMCO-110, are more popular than the older ones. The successful clones released by different institutes are given below (also see Table 1):

Forest Research Institute, Dehradun

The clones FRI-AM-6, FRI-AM-45, FRI-AM-51, FRI-AM-53and FRI-AM-70 outperformed the tested clone G-48.

Dr. Y. S. Parmer University of Horticulture & Forestry, Solan

UD-1000-1500, UD-3210, UD-3296, UD-5503, UD-6502, UD-10007, UD-8800 &Hybrids Solan-1, Hyb-U, UD-63N, UD-0102, UD-300-1000, UD-0700, UD-1007, UD-4400, UD-5501, UD-5512, UD-6500, UD-6501 UD-6502, UD-7007, UD-8800, IC200/86, 52/86, D-121, G-3, P1/92,and S7C16.

Punjab Agricultural University, Ludhiana

Clones PL-1, PL-2, PL-3, PL-4 and PL-5 for central region of Punjab and clones PL-3, PL-6 and PL-7 for south-western region of Punjab.

WIMCO Seedling Ltd. Rudarpur:

WSL-22, WSL-A26, WSL-27, WSL-32 and WSL-39

UP State Forest Department, Haldwani

The "L" series

Limited funds for research are a major handicap in focused research. Research support from industry is simply absent.

Table 1: Suitable clones of poplars recommended by Horticulture & Forestry University, Nauni

Species	Altitude	Recommended clones
Populus ciliata and hybrids	1500m	UFC-1000, UFC-1900, UFC-2200, UFC-010, UFC-6403, IL-3B, UCM-3287, UCM-3220, UCM-3296, UCM-2801
	1000-1500m	UCM-113
P. deltoides and hybrids	1000-1500m	UD-5503, UD-6502, UD-10007, UD-3210, UD-3296, UD-8800 and Hybrids Solan-1, Hyb-U, UD-0102, UD-0700, UD-6500, UD-4400, UD-7007
	300-1000m	UD-8800, IC, 200/86, 52/86 and P1/92 UD-5501, UD-5512, UD-6501, UD-6502, UD-1007
	<300 m	UD-63N, G-3, D-121 and S7C16

TREE DENSITY AND GEOMETRY

Small or marginal farmers prefer boundary plantations and trees should preferably be planted in north-south row direction at a distance of 3.0 m. Big and marginal farmers generally follow 5 m x 4 m spacing for block plantation that accommodates about 200 plants per acre. It is recommended to increase distance between rows to 8m and decrease distance within rows to 2.5m accommodating same number of plants per unit area but significantly increasing area for intercrops.

INTER CROPS WITH POPLAR TREES

- ***Kharif* season:** cowpea, pearl millet, *Moong*, mentha and *Arvi.*
- ***Rabi season:*** wheat, potato, barley, oats, *Berseem* and mustard.
- **Annual crops:** sugarcane, turmeric and lemon grass.

The wider strip (8m) should be used for growing intercrops and it should be in north-south row direction. The yield reduction of intercrops is lesser under wider spacing as compared to crops grown at 5 m x 4 m spacing, which may vary from 10 to 45 per cent depending on the age of trees.

PRODUCTION POTENTIAL OF POPLAR AGROFORESTRY

- Productivity up to 50m^3/ha/yr has been achieved through intensive management practices of poplar-based agroforestry systems compared to 1 m^3/ha/yr of Indian forests.
- Total weight (oven dry) of bole (main stem) and branches in trees increased from 44.73 kg/tree (16.99 t/ha) in 2-year old plantation to 187 kg/tree (74.08 t/ha) in 7-year old plantation. Bole constituted 57 per cent of the weight.
- Poplar plantations have a high potential of litter production; total litter (oven dry) ranged from 3.18 ton/ha in 2 years old plantation to 5.53 ton/ha in 7 years old. This significant quantity of litter is recycled to ameliorate the soil.
- Combining the yield of poplar and the crops, these systems are highly productive. Intercropping in poplar-based system plays an important role to make it sustainable.

LICENSING OF WOOD BASED INDUSTRIES (WBIs)

By order dated 29/30th October, 2002, Hon'ble Supreme Court of India directed the closure of all unlicensed saw mills and prohibited the opening of any new saw mill without prior permission of the Central Empowered Committee (CEC). Prior to these directions, WBIs in the state were operating without licenses and there existed no regulations in place.

In compliance of the directions mentioned as above, the Haryana Forest Regulations of Wood Based Industries Rules, 2005 were enacted and licenses to WBIs in Haryana were initially granted in the year 2007 after the approval from Central Empowered Committee (CEC) appointed by the Hon'ble Supreme Court of India. As a result 4319 saw mills, 303 veneer units, 376 plywood units and 88 others totaling 5086 units were issued licenses.

Ministry of Environment, Forest and Climate Change, Govt. of India on 23rd September, 2016 formulated and issued guidelines for regulation of WBIs. In October 2016, it was assessed that about one lakh cubic meter of wood per annum from plantations and about 7 lakh cubic meter of wood per annum by way of import from adjoining states is additionally available for which licenses to the extent of 10% of the existing number of WBIs could be granted.

Since the last licensing was done on annual availability of 20 lakh cubic meter, there was additional availability of about one lakh cubic meter of wood. Out of 5086 WBI units, which were approved for issuing licenses in the year 2007, about 201 units were not issued licenses since no machinery was found at their sites. Similarly, there are another 280 units, which could not be issued licenses due to mismatch of machinery and it has also been decided to revoke approval of such units and new licenses for equivalent units will be issued.

TIMBER MARKETING

The vibrant agroforestry-based wood industries are due to the fact that farmers and industries friendly atmosphere exists in Haryana. There is no restriction ontimber transition and the farmers do not have to take permission from forest department for felling and transportation of farm grown timbers.

The farmers and industries are happy with the *Arhatia*/timber traders (middle men) system that still prevailsin the *Mandi*s. With this system the farmers have not to wait and they get money for their produce immediately after the sale. The middle men have developed a system whereby they pay money to the farmers immediately but they may wait for money from the industries. The hidden part of the story is that some portion of the wood is declared as "*Kaat*" or wood rejected by the middle men, which is sold by them to the industries at fairly good price; farmers remain at some loss in this regard. The industrialists get this wood at little cheaper rates. The recovery of the wood is almost ninety per cent.

Jagadhari-Yamuna Nagar timber market gets only about twenty per cent of its wood supply from Haryana and the rest eighty per cent comes from adjoining states of Uttarakhand, Uttar Pradesh, Punjab and Himachal Pradesh. About 2000 wood trolleys are traded every day in Jagadhari and Yamuna Nagar towns.

About 30 to 40 ha of poplar trees are felled every day in Haryana and another 60 to 75 ha of poplar are felled every day in adjoining areas of Punjab, UP, Uttarakhand and Himachal, which reaches Yamunanagar timber market. An estimated 25,000 of trees are felled every day in and around Jagadhari-Yamunanagar. Considering 250 felling days per year: 250 x 25,000 = 62,50,000 (Sixty-two lakh and fifty thousand) poplar trees alone are felled annually.

THE REASONS FOR FALL OF WOOD PRICE

The reasons that can be attributed to downfall of prices of poplar wood are listed below:

- Worldwide recession in the economy has reduced the demand for plywood and boards, which has lead to a downfall in prices of poplar wood.
- Govt. of India has placed timber in the Open General Licence (OGL) list, which facilitates import of cheaper timbers and pulps.
- There was imbalance in demand and supply in the local market in favour of poplar wood buyers i.e. there is more supply than demand.
- Poplar is not the best choice for veneering that gave way to *Eucalyptus*, which is harder, more durable and heavier.
- Ratoon poplar wood coming from UP is sold at cheaper price in Yamuna Nagar market because it is of inferior quality; due to this reason the price of good poplar wood does not increase.

ECONOMICS OF POPLAR CULTIVATION

Poplar (*Populus deltoides)*, which is an exotic species in India occupies a small geographical area at national level, but it makes a significant contribution to socio-economy of farmers in the north-west Indian plains. Area under commercial poplar in India during 2015 was estimated at 2, 70,000 ha. Wood from poplar is the backbone of a thriving industry.

According to one estimate, about Rs. 3 crores worth of timber comes daily to Yamuna Nagar market and after value addition the wood products worth Rs.9 crores are manufactured. Peeling units and saw mills came up at the same place, scrap is sold to local paper mills for pulp formation, saw dust is supplied to brick kilns and poultry farms while bark is used as fuel; thus, every bit of wood is utilized. The maximum rates in 2014 were Rs 1400, 900, 500 and 300 for over-size, under-size, *Sokta* and *Dandi*, respectively.

In 2008-9, the income from poplar agroforestry system and mono-cropping system were compared; the net income from the poplar trees plus crops was Rs 8, 70,350/acre after 6 years while the income of sole crops was much lesser than it.

In another study, the income from poplar wood was on an average Rs. 80,000 per acre per annum and from intercrop was Rs. 45,000/- per acre per annum. Thus, total income recovered was Rs.1, 25,000/- per acre per annum. If we reduce the cost of production from these figures @ Rs. 25,000/- per acre then it comes out Rs. 1, 00,000/- per acre per annum. However, the prices have fallen slightly but are showing an upward trend at present.

Until 2013, poplar wood supply and its utilization were well synchronized. Poplar wood (over size) witnessed all times high prices of over Rs.1200/q during March 2011. There was slow and gradual decline in its prices till November, 2017.

Some progressive farmers have obtained three times higher income from poplar and agricultural crop combinations than pure agriculture. Poplar cultivation is economically more beneficial with the combination of crops like sugarcane, wheat, turmeric and vegetables.

GENERAL INTRODUCTION

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The green revolution in India had positive repercussions in terms of self-sufficiency of food production. However, it brought problems of environmental degradation in terms of reducing biodiversity, loss in soil fertility and decrease in the quality of food and water. To ameliorate the degraded lands, there is a renewed interest in the traditional systems of agriculture which ensure ecological and economic efficiencies apart from remaining sustainable. The examples of sustainability are agroforestry systems incorporating trees on farmlands. The introduction of poplars in the fertile farm lands of north-western India is one of the examples of successful agroforestry in the world.The poplar wood produced at the farmer's lands has helped to conserve the precious trees in the natural forests and on the farmlands.

Agroforestry has high potential for protecting and conserving natural resources, producing a high level of output of economic goods and improving income and raw materials for rural populations. The studies indicated that under agroforestry systems, soil organic carbon and available nutrients increased as compared to growing only trees or a sole agricultural crop. Such improvements in soil health under agroforestry systems have a direct bearing on long-term sustainability and productivity of soils, being a viable option for eco-restoration and maintenance of soil resources for obtaining ecosystem services. The overall productivity, soil fertility improvement, soil conservation, nutrient cycling, microclimate improvement, and carbon sequestration potential of an agroforestry system, are generally greater than that of an annual system.

The International Poplar Commission (IPC), a statutory body within the framework of the Food and Agriculture Organization of the United Nations (FAO)promotes poplars and willows in 38 member countries including India. It plays an important role in the development of timber sectors in rural areas, largely through the transfer of knowledge on poplar and willow cultivation and the exchange of technologies and breeding material.

During the past about 5 years, the prices of wood that have reduced drastically from around Rs 1200/q to Rs 500/q caused heavy losses to the farmers and discouraged them growing of poplars.Poplar based wood industries and related units employ about one lakh people who are earning about Rs.900crores annually. Annual turnover of this market suggests that about Rs.500crores is going back to the farmers.

Research priority needs to be given to develop agroforestry models which are resilient to changing climate, beneficial to soil health and economical to the farmers. Disease resistant and fast growing clones should be made easily available to the farmers at nominal cost. Unlike trees of forests or wastelands, poplar is grown on agricultural lands with crops; therefore, participation of farmers in research on poplar cultivation is of vital importance. During the workshop a wide range of issues were discussedby experienced and top ranking scientists and the adminitrators in the field of forestry and agroforestry. The areas included silviculture of poplar and crop compatibility, genetical improvement of planting material of poplar and thirdly the utilization of wood of poplar for varied uses.

Valuable suggestions of the farmers growing poplar on their farms for several years, and those industrialists dealing with poplar wood for decades, were received for consideration in the preparation of this informative document. Policy issues whichemerged would be taken up with the Govt. for suitable consideration in the interest of the farmers and the wood industries in Haryana and adjoin states.

DEVELOPMENT OF POPLAR CLONES IN INDIA

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Poplars have been a species on whose improvement and collection of germplasm, I spent all my life. In 1976, when we started with a project on natural provenance collections of *Populus ciliata*, followed by open pollinated seed collections and then hybridization between resistant varieties for galls on leaves and branches and leaf rust, the Forest Research Institute had already imported a number of clones from Italy, England and Netherlands and distributed to various institutes and universities. But meanwhile cottonwood plantations were growing at a rapid rate and had already become quite popular as they could produce moderate quality veneer logs at short rotation period of 6 to 8 years achieving high productivity of 20-25 $m^3ha^{-1}yr^{-1}$. Many districts of Punjab, north-western Uttar Pradesh, and parts of Haryana and Uttarakhand, had become hub of poplar cultivation where assured and ample irrigation facilities were available. Because poplars are deciduous; winter crops can easily be grown along with poplars throughout the species rotation period.

Commercial scale plantations of poplars under agroforestry were expanding under WIMCO-sponsored farm forestry projects since 1984 with financial assistance of the NABARD. It was imperative to enrich the gene-pool of the species to replenish it with fast growing new clones as old become susceptible to diseases or lost their vigour. Trial of 60 clones of poplar (*Populus deltoides* and *P.×euramericana* from America, Australia, Germany, Italy and the Netherlands) was established at Gangapur Patia (Lal Kuan) in Tarai region of U.P., in February 1985, besides that at UHF, Solan. Consequentlyin 1989, under an IDRC of Canada's programme seed of cottonwood (*Populus deltoides*) was imported from USA to develop indigenous clones for plantation on farmer lands. Similar attempt was made by the FRI in 1995 under World Bank Free project. The process of cultivar development in poplars, to replenish old fading clones, is presented here to understand clonal development process in collaboration with state forest department and ICFRE.

BREEDING STRATEGIES

The breeding strategies for almost all species are dependent on the genetic resources and genetic diversity available in the species. In nature, evolution is a continual change that occurs in species with best surviving and reproducing spread their genes more effectively than the others, who get eliminated. Repeated spread of these genes, over time, leads to changes in the whole species. Thus, naturally the first step involves the identification of the natural genetic variation in the species and its assemblage in common garden for further exploitation. Thus, collection of identified superior genotypes or populations in poplars and bringing them together at one place is an easy step due to its amenability to vegetative propagation and establishment of a clonal multiplication garden, first step towards improvement. Other steps involved in were the collection of genetic diversity, i.e., collection of seed and then evolving diversity through hybridization and exploitation of heterosis would follow for development of more clones needed from time to time for replacement of ageing clones in plantations.

India is endowed with five or six native species, which has now become controversial since many authors agree to disagree with the number of endemic, natural or naturalized species or question the species nativity due to lack of extensive stands, as some species grow in hostile environments or in inaccessible areas of forests. Various ecotypes/biotypes of some species exist from tall majestic trees with more than 30 m height and 50 cm DBH to stunted trees of 10 m height and 20 cm DBH, e.g in *P. euphratica* and *P. ciliata* depending on site conditions and altitude, thus providing a rich resource of genetic diversity. The wide distribution of many poplar species, frequent introgressive hybridization, and a long history of cultivation and ease of vegetative propagation has led to much confusion in the nomenclature of poplars world over. Numerous synonyms exist; hybrids and cultivated varieties have often been named as species. Thus, species counts for the genus in the world

ranges from the low 20 to over 80, depending on the authority. Generally 30 species are well recognized of which six species have authentically beenrecorded from India with large number of species and cultivars being introduced from time to time as research initiatives.

However, many authors have questioned the authenticity of even these six species in India, due to their naturalization or adaptation characteristics, but *P. euphratica, P. ciliata, P. jaquemontiana* var. *glauca* and *P. gamblei* are the undisputed species (Fig. 1). Theorigin of *Populus alba* has been questioned by some though commonly planted in Kinnaur and Ladakh, with some wild stands in areas of Himachal Pradesh. The native populations of *P. balsamifera* L. have been reported from hostile environments of the cold desert in north-western Himalaya in Jammu & Kashmir and Himachal Pradesh. The natural hybrids of *P. suaveolens* with *P. ciliata* also exist. So, the only species requiring verification remains *P. tacamahaca* with acceptance of *P. nigra* var. *afghanica* or *P. nigra* cv 'Italica' as naturalized species. But fortaxonomically distinction these species have been reported from India by different taxonomists.

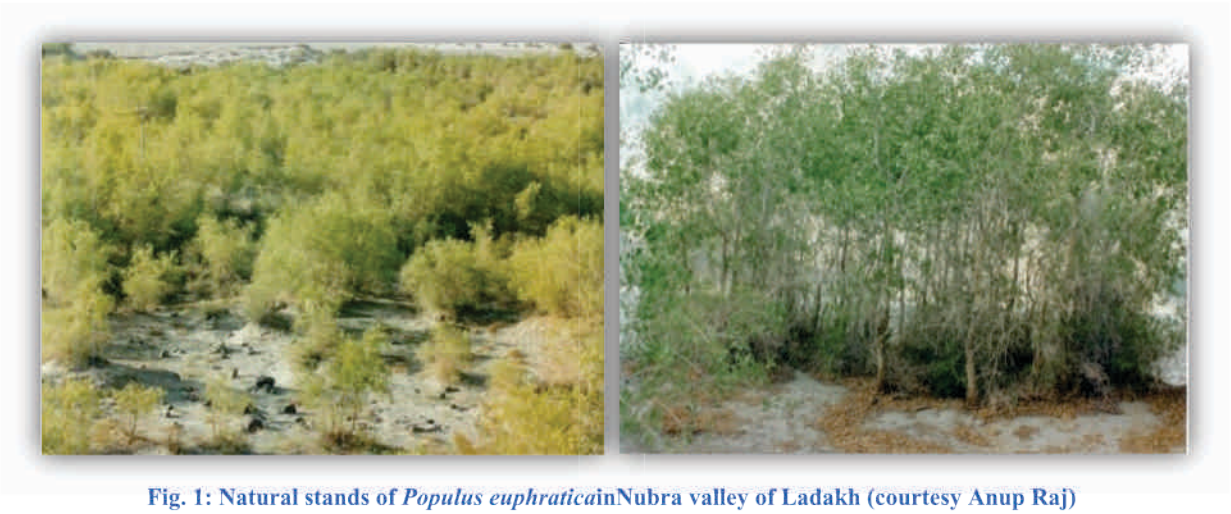

Fig. 1: Natural stands of *Populus euphratica*inNubra valley of Ladakh (courtesy Anup Raj)

GENETIC RESOURCES

There are few other distinct species like *Populus deltoides*, the most widely cultivated species on farm lands under captive cultivation, *P. yunnanensis, P. trichocarpa, P. nigra, P. tremuloides, P. maximowiczii, P. simonii,* and *P. grandidentata*, which have been introduced in India from time to time either to serve as a source of alternative species for planting or as a source material for increasing productivity, but are the available gene pools for manipulative breeding and clonal improvement. The clonal material legally registered with International Poplar Commission comprising *P.* 'Canescens', *P.* 'Eugenei', *P.* x *euramericana* cv.'I-214', 'I-455', 'I-67', 'I-67/55', 'I-145';*P.* 'Lux', *P.* 'Oxford', *P.* 'Regenere', *P.* 'Robusta', *P.* 'Roxbury', and *P.* 'Serotina' have also been brought into India from time to time.

Besides at least 440 illegitimate clones (still not registered with IPC) of cottonwood species and hybrids were introduced and tested in northern India from 1958 to 1983. Fifty genotypes of EL series were selected from seed of *P. deltoides* received from the USA in 1982 but excepting EL-114 all other were discarded. Mutation breeding was also initiated to develop desirable mutants in poplars. In addition, a large collection of approximately 200 *P. deltoides* clones from throughout the eastern United States were sent by the U. S. Forest Service at St. Paul, MN, to the Uttar Pradesh Forest Research Division, Lalkuan in 1986, and >150 clones were received by the Forest Research Institute, Dehradun from Germany, Italy, United Kingdom, Netherlands and Australia.

POPULATION IMPROVEMENT

Seeds from 83 plus trees of *Populus ciliata* were collected from the states of Jammu & Kashmir, Himachal Pradesh and Uttarakhand during different years (50 families during 1991 and 33 families during 1992) and after raising nurseries, the selections were made based on stem straightness, rust resistance and gall infestation of leaves. Only one clone could be selected for rust resistance

(Surkhigala-5) and one for leaf gall resistance (Chhatri-3), and 45 clones were selected for growth form. The best clone selected (Surkhigala-5) had almost three times more growth than of average clones.

Several attempts have been made for seed collection for *Populus deltoides* Bartr. Ex. Marsh ssp. *deltoides* (eastern cottonwood) from the USA. Initially, the Dr. Y.S. Parmar University of Horticulture and Forestry, Solan with the help of the IDRC, and USDA Forest Service collected seed from 103 sources in the states of Texas, Lousiana and Mississippi which was raised in India at Parmar University (Fig. 2, 3) and in China at Nanzing Forestry University. Based on their nursery performances, selections were made amongst clones akin to our photoperiodic and environmental conditions and at many places the plantations have also been raised from these indigenously selected clones. After extensive and rigorous selection, 300 clones were selected from which 25 clones were used in the All-India Co-ordinated trials under the FREE Project on poplars by the ICFRE and 100 clones were given to M/S Wimco Seedlings Ltd. for adaptive trials.

Some open pollinated selections (e.g. clones of L-series, WSL-series, etc.) made in India from the progenies of G-48 and D-121 mother clones were expected to become popular. In order to increase productivity of *P. deltoides* and to widen the genetic base of plantations, Forest Research Institute (FRI) Dehradun had initiated a tree improvement programme under which (a) about 40 promising clones were selected in first stage. Later on, open pollinated seeds from 104 candidate trees growing in 44 natural stands in the USA were brought at the FRI, Dehradun. From these 69 clones designated as FRI-AM series from 10 provenances were selected out for further trials.

Fig. 2: Germinating seedlings of *Populus deltoides* and *P.ciliata* families

Fig. 3: Pricked out seedlings of a *P. ciliata* and *P. deltoides* families

The average diameter of these clones ranged from 20 to 45 cm at Nalagarh, Paonta Sahib and Narainti. The best performing clones which emerged from these trials were FRI-AM-53,-70, -51, -6 and -45, which outperformed tested G-48 clone. Various centers working with poplar improvement have recommended different clones for plantations and it is left to the better judgment of the farmers to choose their clones judiciously. The data on some of the demonstration plantations have shown very promising results. There were significant differences among clones for height and diameter growth along with crown shape; i.e., crown width, leaf quality and photosynthesis rate. Suitable clones recommended by UHF are given in Table 1 as refered under summary part.

BREEDING AND DEVELOPMENT OF NEW CLONES OF POPLAR

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The foundation of genetic improvement of poplar began in 1965 when India became the member of the International Poplar Commission and thereby, constituted the National Poplar Commission with the sole objective of cultivating poplars extensively. European and euramerican poplar clones were introduced for the first time in 1950 and hybrid clones Serotina, Gelrica, Robusta and *P.* × *berolinensis* were tested in the hills of Uttar Pradesh. The number of clones introduced by FRI, Dehradun reached 440 by 1983.

New clones were developed by open pollination between clones (4 B clones - G-3, S7C1, S7C15, S7C20 and 3 @ clones G-48, D-121 and S7C8) and the seedling progenies were raised, cloned and named as "L" series by UP State Forest Department and "WSL" series by WIMCO. WIMCO Seedling Ltd. has got registered 6 new clones- WSL-22, WSL-27, WSL-32, WSL-39, WSL-A26 and WSL-A49 with the International Poplar Commission, Italy during 2000. Some clones have also been developed by controlled breeding by the FRI, Dehra Dun, Uttar Pradesh State Forest Department, Haldwani, WIMCO seedlings Limited, Rudarpur and UHF, Solan.

All India Co-ordinated Research Project (AICRP) on poplar improvement was started with head quarter at FRI, Dehradun and 27 coordinating centres (State Agricultural Universities, State Forest Departments and ICFRE Research Institutes) are working on poplar improvement program.Seven clones of poplar (*Populus deltoides*) have been developed and released for cultivation in Punjab. Clones PL-1 to PL-5 are recommended for cultivation in central region of Punjab and clones PL-3, PL-6 and PL-7 for south-western region (www.pau.co.in).

There are 100 clones of *Populus deltoides* from different countries namely, USA, India and Australia; majority of clones are from USA and some of the clones are selections from various parts in India and one clone is from Australia. The sources of plant material are given in Table 2.

Table 2: Sources of poplar germplasm

Clone Code	Name of clone	Location	Country	Latitude	Longitude
PD1	Solan-2	UH&Forestry, Solan (HP)	India	30^{0}51'N	76^{0}11' E
PD 2	126/86	Lalkuan, Uttarakhand	India	29^{0}23'N	79^{0}53' E
PD 3	HYB-3	UH& Forestry, Solan (HP)	India	30^{0}51'N	76^{0}11' E
PD 4	4400	Intersection of HWY 59 on Brazos, Texas	Texas, USA	29^{0}30'N	95^{0}40'W
PD 5	8101	Jonesville LA	Louisiana, USA	31^{0}00'N	91^{0}50'W
PD 6	5502	South of HWY 110 on Louisiana	Louisiana, USA	30^{0}00'N	91^{0}30'W
PD 8	7000	At Simmesport LA	Louisiana, USA	30^{0}30'N	91^{0}30'W
PD 9	9002	Miss. Rt. 465 W. of Redwood MS	MS, USA	32^{0}50'N	91^{0}00'W
PD 10	PD-1N	Unknown			
PD 11	4709	Intersect. of HWY59 Brazos, Texas	Texas, USA	29^{0}30'N	95^{0}40'W
PD 12	PD-48	Rohru Selection (HP)	India	31^{0}20'N	77^{0}75' E
PD 13	6300	LA Rt. 417 of Morganza & N. of Melville	Louisiana, USA	30^{0}10'N	91^{0}30'W
PD 14	10200	Delta Expt. Forest, Stoneville MS	MS, USA	33^{0}00'N	91^{0}00'W
PD 15	1400	Mumford, Robertson Co. Tx.	Texas, USA	30^{0}40'N	96^{0}30'W
PD 16	42-N	Nalagarh Selection (HP)	India	31^{0}04'N	76^0 70' E
PD 18	Ranikhet	Ranikhet (Uttarakhand)	India	29^{0}64'N	79^0 43' E
PD 19	1001	Mumford, Robertson Co. Tx.	Texas, USA	30^{0}40'N	96^{0}30'W

PD 20	1100	Mumford, Robertson Co. Tx.	Texas, USA	30^{0}40'N	96^{0}30'W
PD 21	154/86	Lalkuan, Uttarakhand	India	29^{0}23'N	79^0 53' E
PD 22	52/85	Lalkuan, Uttarakhand	India	29^{0}23'N	79^0 53' E
PD 23	9800	Near Lake Albermale Rt. 465 MS	MS, USA	33^{0}00'N	91^{0}00'W
PD 24	9607	Near Lake Albermale Rt. 465 MS	MS, USA	33^{0}00'N	91^{0}00'W
PD 25	6503	LA Rt. 417 of Morganza & N. of Melville	Louisiana, USA	30^{0}10'N	91^{0}30'W
PD 26	47-N	Nalagarh Selection (HP)	India	31^{0}04'N	76^0 70' E
PD 27	6600	South of Simmesport on Rt. 417 LA	Louisiana, USA	30^{0}10'N	91^{0}30'W
PD 28	9000	Miss. Rt. 465 W. of Redwood MS	MS, USA	32^{0}50'N	91^{0}00'W
PD 29	36-N	Nalagarh Selection (HP)	India	31^{0}04'N	76^0 70' E
PD 30	60-N	Nalagarh Selection (HP)	India	31^{0}04'N	76^0 70' E
PD 31	0200	Burleson Co. Tx. TAMU FARM	Texas, USA	30^{0}40'N	96^{0}30'W
PD 32	PDX-100	Unknown			
PD 33	T1-19-24(49)	Unknown			
PD 34	4601	Intersect. of HWY59 Brazos, Texas	Texas, USA	29^{0}30'N	95^{0}40'W
PD 35	9501	N. of Brunswick on Rt. 465 MS	MS, USA	33^{0}00'N	91^{0}00'W
PD 36	6400	LA Rt. 417 of Morganza & N. of Melville	Louisiana, USA	30^{0}10'N	91^{0}30'W
PD 37	4900	Intersect. of HWY59 Brazos, Texas	Texas, USA	29^{0}30'N	95^{0}40'W
PD 38	51-G	Unknown			
PD 39	L-80	Lalkuan, Uttarakhand	India	29^{0}23'N	79^0 53' E
PD 40	FS-65	L-34/82 X G-3	India	29^{0}23'N	79^0 53' E
PD 41	FS-71	L-34/82 X G-3	India	29^{0}23'N	79^0 53' E
PD 42	FS-35	110702 X S7C20	India	29^{0}23'N	79^0 53' E
PD 43	FS-74	L-49 X G-3	India	29^{0}23'N	79^0 53' E
PD 44	L-153	Lalkuan, Uttarakhand	India	29^{0}23'N	79^0 53' E
PD 45	L-70	Lalkuan, Uttarakhand	India	29^{0}23'N	79^0 53' E
PD 46	FS-24	110702 X 113324	India	29^{0}23'N	79^0 53' E
PD 47	22/86	Lalkuan, Uttarakhand	India	29^{0}23'N	79^0 53' E
PD 48	200/85	Lalkuan, Uttarakhand	India	29^{0}23'N	79^0 53' E
PD 49	57	Krotz Springs LA	Louisiana, USA	30^{0}00'N	91^{0}30'W
PD 50	PD-90	Rohru Selection (HP)	India	31^{0}20'N	77^{0}75' E
PD 51	0700	Burleson Co. Tx. TAMU FARM	Texas, USA	30^{0}40'N	96^{0}30'W
PD 52	200/86	Lalkuan, Uttarakhand	India	29^{0}23'N	79^0 53' E
PD 53	Solan-1	UH& Forestry, Solan (HP)	India	30^{0}51'N	76^0 11' E
PD 54	1008	Mumford, Robertson Co. Tx.	Texas, USA	30^{0}40'N	96^{0}30'W
PD 55	0900	Mumford, Robertson Co. Tx.	Texas, USA	30^{0}40'N	96^{0}30'W
PD 57	FRI-PD-OP-9	Open pollinated seed of L-34/84(Uttarakhand)	India	29^{0}23'N	79^0 53' E
PD 58	OP-30	Open pollinated seed of D-171 (Uttarakhand)	India	29^{0}23'N	79^0 53' E
PD 59	OP-32	Open pollinated seed of L-200/84 (Uttarakhand)	India	29^{0}23'N	79^0 53' E
PD 60	FRI-PD-OP-10	Open pollinated seed of L-34/84(Uttarakhand)	India	29^{0}23'N	79^0 53' E

PD 61	OP-34	Open pollinated seed of L-200/84 (Uttarakhand)	India	29^{0}23'N	79^0 53' E
PD 62	OP-8	Open pollinated seed of L-34/84(Uttarakhand)	India	29^{0}23'N	79^0 53' E
PD 63	OP-33	Open pollinated seed of L-200/84 (Uttarakhand)	India	29^{0}23'N	79^0 53' E
PD 64	95-048-001	Unknown			
PD 65	40-N	Nalagarh Selection (HP)	India	31^{0}04'N	76^0 70' E
PD 66	T-70	Roanoke River, Rich Sq., NC	NC, USA	36^{0}13'N	77^{0}23'W
PD 67	T-12	Roanoke River, Rich Sq., NC	NC, USA	36^{0}13'N	77^{0}23'W
PD 68	T-117		USA		
PD 69	T-81	Clinch/Tenn. R., Oak Ridge,TN	Tenn., USA	35^{0}55'N	84^{0}24'W
PD 70	T-14	Roanoke River, Rich Sq., NC	NC, USA	36^{0}13'N	77^{0}23'W
PD 71	T-41	Saluda River, Silverstreet, SC	Newberry, SC,USA	34^{0}14'N	81^{0}41'W
PD 72	T-35	Saluda River, Silverstreet, SC	Newberry, SC,USA	34^{0}14'N	81^{0}41'W
PD 73	T-6	Tombigbee River, Fulton, MS	MS, USA	34^{0}19'N	88^{0}25'W
PD 74	T-95	Tombigbee River, Columbus, MS	MS, USA	33^{0}31'N	88^{0}30'W
PD 75	T-77	Ashley,EdistoR.,Summerville, SC	Newberry, SC,USA	32^{0}52'N	80^{0}13'W
PD 76	T-7	Tombigbee River, Fulton, MS	MS, USA	34^{0}19'N	88^{0}25'W
PD77	T-100	Tombigbee River, Columbus, MS	MS, USA	33^{0}31'N	88^{0}30'W
PD78	T-104	Unknown	USA		
PD 79	T-44	Saluda River, Silverstreet, SC	Newberry, SC,USA	34^{0}14'N	81^{0}41'W
PD 80	T-93	Tennessee River, Paris, TN	Tenn., USA	36^{0}11'N	88^{0}10'W
PD 81	T-45	Saluda River, Silverstreet, SC	Newberry, SC,USA	34^{0}14'N	81^{0}41'W
PD 83	T-78	Tennessee River, Paris, TN	Tenn., USA	36^{0}11'N	88^{0}10'W
PD 84	T-15	Roanoke River, Rich Sq., NC	NC, USA	36^{0}13'N	77^{0}23'W
PD 85	T-28	Roanoke River, Rich Sq., NC	NC, USA	36^{0}13'N	77^{0}23'W
PD 86	T-36	Saluda River, Silverstreet, SC	Newberry, SC,USA	34^{0}14'N	81^{0}41'W
PD 87	PXE-4	Unknown			
PD 88	PXE-5	Unknown			
PD 89	H-16	UH& Forestry, Solan (HP)	India	30^{0}51'N	76^0 11' E
PD 90	T-58	Tombigbee River, McInt., AL	Washing., USA	31^{0}16'N	87^{0}57'W
PD 91	T-107	Unknown			
PD 92	T-40	Saluda River, Silverstreet, SC	Newberry, SC,USA	34^{0}14'N	81^{0}41'W
PD 93	G-48	Australia	Australia	31^{0}00'N	99^{0}30'W
PD 94	900	Unknown			
PD 95	9606	Near Lake Albermale Rt. 465 MS	MSpi, USA	30^{0}30'N	91^{0}30'W
PD 97	1007	Mumford, Robertson Co. Tx.	Texas, USA	30^{0}30'N	91^{0}30'W
PD 98	6500	LARt.417,Morganza&N.of Melville	Louisiana, USA	30^{0}30'N	91^{0}30'W
PD 99	7001	At Simmesport LA	Louisiana, USA	30^{0}30'N	91^{0}30'W
PD 100	7002	At Simmesport LA	Louisiana, USA	30^{0}30'N	91^{0}30'W

GROWTH CHARACTERISTICS

Among growth traits, five major clusters were formed(Table 3).No particular trend of clonal distribution according to their respective geographical locations was seen among growth traits. There was random distribution of USA clones in all clusters whereas among Indian locations, particular

dominance of clone distribution from Uttarakhand region was seen in all clusters.Clonal groups based on characters are given in Tables 4 and 5.

Table 3: Clones in each cluster for growth traits

Cluster	No. of clone	Clones included
1	26	PD1, PD2, PD6, PD9, PD15, PD19, PD21, PD24, PD33, PD34, PD36, PD37, PD38, PD41, PD53, PD71, PD74, PD75, PD77, PD79, PD86, PD91, PD92, PD94, PD98, PD99
2	18	PD10, PD16, PD20, PD22, PD25, PD28, PD39, PD47, PD52, PD57, PD58, PD65, PD73, PD78, PD88, PD90, PD93, PD97
3	18	PD3, PD5, PD11, PD18, PD27, PD31, PD32, PD43, PD46, PD49, PD50, PD54, PD55, PD62, PD63, PD70, PD83, PD87
4	16	PD4, PD8, PD12, PD13, PD14, PD29, PD30, PD35, PD51, PD64, PD67, PD72, PD76, PD81, PD84, PD95
5	17	PD23, PD26, PD40, PD42, PD44, PD45, PD48, PD59, PD60, PD61, PD66, PD68, PD69, PD80, PD85, PD89, PD100

Table 4: Clones in each cluster for wood traits

Cluster	No. of clone	Clones included
1	49	PD1, PD2, PD3, PD5, PD6, PD10, PD11, PD13, PD14, PD15, PD16, PD21, PD23, PD27, PD34, PD38, PD39, PD42, PD44, PD47, PD48, PD50, PD51, PD53, PD55, PD57, PD59, PD63, PD64, PD66, PD67, PD68, PD69, PD70, PD71, PD72, PD73, PD75, PD77, PD78,PD79, PD80, PD82, PD87, PD88, PD90, PD92, PD94, PD98
2	1	PD35
3	27	PD12, PD18, ,PD19, PD24, PD25, PD28, PD29, PD31, PD33, PD36, PD37, PD41, PD45, PD46, PD49, PD52, PD58, PD61, PD65, PD74, PD84, PD86, PD89, PD97, PD99, PD100
4	10	PD9, PD20, PD32, PD43, PD54, PD60, PD81, PD85, PD91, PD93
5	8	PD22, PD26, PD30, PD40, PD62, PD76, PD95

Table 5: Cluster mean for wood traits

Wood Attributes	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V
Moisture content (%)	87.10	66.74	102.10	94.20	92.20
Bark thickness(cm)	0.17	0.47	0.15	0.13	0.09
Wood:Bark	12.95	3.41	18.05	18.80	33.48
Bark (%)	16.76	47.24	15.13	12.99	8.95
Wood (%)	83.24	52.76	84.87	87.01	91.05
Specific gravity	0.37	0.37	0.37	0.41	0.36
Fiber length (mm)	0.90	1.15	0.91	0.91	0.81
Holocellulose (%)	74.31	72.75	74.87	73.89	72.02
Lignin (%)	24.80	22.62	24.33	23.11	26.08

HYBRID CLONES OF *POPULUS DELTOIDES*

Promising clones based on data from hybrid families were selected in 2017 and were planted in the nursery along with known clones to evaluate their performance. A total of 22 clones were planted in the randomized block design with three replications (Table 5).

CONTROLLED BREEDING

Controlled breeding was carried out during 2013-2015.The experimental material comprised ten males clones (S_7C_{11}, 82-42-5, PIP-209, L-124/86, S_7C_1, S_7C_4, PIP-208, PIP-220, PIP-214 & L-17/92) and seven females clones (G-48, S_1, S_7C_8, kranti, PIP-204, PIP-208 & S_7C_{15}) of *Populus deltoides* obtained from the forest department, Uttarakhand. Intraspecific crosses were attempted using different male and female combinations. About 18 crosses were successful (Table 6).

Table 6: Performance of growth characteristics in one-year old nursery

CloneNo.	Clone name	Height(cm)	Diameter (cm)	Volume(cm^3)
1	G_{48}x S_7C_{11}	282.94	2.25	1248.93
2	G_{48}x 26N	282.50	2.35	1304.37
3	G_{48}x 26N	255.00	2.38	1286.82
4	G_{48}x 17/92	303.50	2.05	1035.12
5	G_{48}x 17/92	270.92	1.96	883.17
6	G_{48}x UD-88	302.00	1.86	841.05
7	G_{48}x UD-88	319.67	2.43	1534.72
8	G_{48}x S_7C_1	314.72	2.41	1459.88
9	G_{48}x 124/86	278.67	1.67	624.44
10	S_1 x 17/92	326.00	2.52	1706.02
11	S_1 x 17/92	327.67	2.54	1786.77
12	S_1 x S_7C_{11}	325.17	2.64	1825.13
13	S_1 x S_7C_{11}	207.50	1.90	594.30
14	S_1 x S_7C_4	317.83	2.57	1722.53
15	Kranti x 39N	317.81	2.74	1976.93
16	L-62/84 x L-17/92	259.72	1.78	668.40
17	L-62/84 x L-17/92	247.00	2.13	896.48
18	L-62/84 x L-17/92	273.33	2.03	917.70
19	S_2x 25N	319.17	2.53	1694.36
20	S_7C_8 x L-17/92	297.00	2.50	1505.59
21	G-48	221.67	1.60	466.15
22	WSL-22	228.33	1.57	485.98
	CD at 5%	35.60	0.35	493.76

DISTINCT UNIFORMITY AND STABILITY (DUS) GUIDELINES

A clonal bank of poplar clones was established in Naganji nursery of Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, HP. About 15 clones (L-30/06, L-621/84, G-48, L-6105, S_7C_{15}, S_7C_8, WSL-22, WSL-39, 6503, 5503, 1007, L-200/86, PL-3, PL-6 and PL-7)in three replications following the design of RBD (Randomized Block Design) were planted in the experimental area of the Department. The spacing between the clones was 60 x 60 cm. The DUS guidelines consisting of 22 characters have been published by PPV & FRA, New Delhi in 2017.

CONCLUSION

Lot of germplasm has been either introduced or generated after the introduction of G-48 and G-3 clones in the country during 1950's. Though number of clones after G-48, have been released by different agencies like Uttrakhand Forest Department; PAU, Ludhiana; WIMCO, Rudarpur, etc, no concerted effort has been made to test these clones by a common agency in different agroclimatic conditions.

BIOLOGICAL INTERVENTIONS FOR GERMPLASM ENHANCEMENT: POPLAR AND OTHER TREES

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Exact nature of the flowering hormone "florigen" was not known till the dawn of this century (2000) when it was conclusively demonstrated that the 'Flowering Locus T' (FT) protein is the flower inducing molecule in flowering plants. The FT protein is coded by the FT gene. Now it is well established that FT gene is conserved (present) in all dicot and monocuts. Upon receipt of suitable environment signal FT protein "florigen" is expressed in leaves and then transported to the sheet apical meristem which turns reproductive and produces flowers.

Hectic efforts by the plant molecular biologists and reproductive physiologists have put to use this landmark discovery. Advances that have direct impact on tree-breeding are outlined here.

Firstly, it is possible to convert a commercially important lineage of tree to "constant flowering" by introducing (genetically transforming) and over expressing a FT gene Thus, it transformed flowers within the first year of its growth. The juvenile period of 5 to 10 years is knocked out. The 'constant flowering lines' with desirable traits can be readily used in breeding programmes (Zhang *et al.,* 2010).

Secondly, another important 'virus induced transfer' (VIT) protocol has been developed. In this even the trees that are resistant to the standard transforming procedures of genetic engineering can be made to flower early. In the VIT a suitable virus is transformed with FT gene and is used as a vector. It is allowed to infect the tree of concern where it expresses the FT gene and and makes the tree to flower precociously. This approach does not involve creation of transgenic trees per se and is more promising (Mc Garry *et al.,* 2017).

Species like *Jatropha, Malus, Eucalyptus, Gossypium* and *Populus* have been successfully made to flower precociously using the above techniques. This has envinced the interest of tree breeders for use in the foreseeable future.

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POPLAR CULTIVATION IN HARYANA: CHALLENGES & SOLUTIONS

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Poplar *(Populus deltoides)* was introduced by the WIMCO in 1976 for diversification of species under agroforestry and also as a substitute for *Eucalyptus* as the controversy against later was at peak at that time. However, very soon it was realized that the poplar is not a competitor of *Eucalyptus* but rather they are complementary to each other.

It was estimated that around 1.34 crore poplar ETPs (entire transplants) were grown in the state during 2011-12. The WIMCO and Haryana State Forest Department were leading nursery growers. Yamuna Nagar district was a major poplar nursery growing area in the state (767 acres) followed by Karnal (176 acres) and Panipat (100 acres). The percentage of poplar ETPs grown varies from 60% in Yamuna Nagar district followed by 13% in Karnal, 9% in Ambala, 7% in Panipat, 7% in Panchkula and the remaining in Sonepat, Kaithal and Rohtak districts. Poplar nursery has become a profitable business and a number of private poplar nurseries have mushroomed around Yamunanagar and Kurukshetra districts. It is estimated that about two million plants of poplar are raised in private nurseries. In Yamuna Nagar district maximum poplar nurseries are grown in Chhachhrauli tehsil followed by Bilaspur, Jagadhari and Mustafabad tehsils.

About five million poplar plants were raised every year in Haryana till 2010 and there remained about 60,000-hectare area under poplar on rotation basis. The productivity per hectare is 30m^3/ha/year. The farm grown wood is sold on diameter basis i.e., over, under, sokhta and fuelwood. It is being sold at present at an average rate of about 600 rupees per quintal, which was as high as Rs 1000 per quintal in Yamuna Nagar market till sometimes ago.

TRENDS OFPOPLAR CULTIVATION

Poplar cultivation has seen ups and downs in Haryana. After bringing prosperity to its growers, in 2001 its prices crashed to bottom low of 90 rupees a quintal, something equal to rates of green fodder. There was almost no planting for two years. The prices again fell in 2010-2011; and poplar cultivation again got a setback. Haryana Forest Department did not raise any poplar plant in its nurseries from 2013 to 2017. But with the issuance of new licenses, there are signs of improvement in the situation. The prices of poplar wood which had fallen to 400 rupees have now increased to 600 rupees per quintal. It is expected these prices will improve further.

CARBON SEQUESTRATION BY POPLAR IN HARYANA

Annually, poplar is planted in Haryana on about 10,000 (ten thousand) hectares. About 50,000-hectare area always remains under poplar. The scientists of PAU, Ludhiana have assessed the biomass and carbon sequestration potential of poplar-wheat agroforestry in Punjab. They reported that the annual productivity of poplars was recorded maximum after fourth year and later the annual wood increment decreased (42.4, 39.8 and 35.6 m^3/ha/year after 4th,5^{th} and6^{th} year, respectively). The enrichment of soil through litter and roots enhanced the organic carbon in the surface layer of soil (0-15 cm) under poplar trees as compared to open fields with wheat crop alone. The carbon storage potential in agroforestry system was recorded very high in comparison to sole crop.

IMPROVEMENT IN PEELING MACHINE (SPINDLELESS)

For the peeling of the veneers, in the conventional peeling machines, the bark was first removed manually and then the clean log was peeled with old machines. These machines after peeling left a thick baton behind and did not peelend to end. This resulted into the wastage of lot of wood.

Recently, spindle less Veneer Log Peeling Machines have been introduced in Yamuna Nagar. These machines are fast, more accurate, comparatively safer, very efficient and and they peel the log to thumb's thickness.

This machine is the first step to manufacturing veneer and plywood. This machine is mainly used for smaller diameter wood (logs) to peel into core veneer and face veneer. This machine is giving continuous ribbon of veneer of uniform thickness. With the introduction of spindle less machines, the rotation age for the felling of poplar has come down from six to three years. Logs above 90 cm girth were considered fit for peeling in conventional machines and this much girth was achieved in about six years and hence the rotation in poplar was considered six year.

ECONOMICS OF POPLAR CULTIVATION

The data related to economics of poplar was collected in 2015. It was found that the income from poplar wood production was Rs. 76,600/- to 81,900/- per acre per annum and from intercropping was from Rs. 44,000/- to Rs. 45,000/- per acre per annum. The total income recovered was Rs. 1, 20,000 to Rs. 1, 25,000/- per acre per annum. If we reduce the cost of production from these figures @ Rs. 20,000/- per acre per annum then the income will be Rs. 1,00,000/- per acre per annum. The prices have however, slightly fallen down at present, but they are now showing an upward trend.

MARKETING OF TIMBER

Reason for the vibrant agroforestry and agroforestry-based wood industries in Haryana is the fact that the farmer and industry friendly atmosphere exists in the state. There are no timber transit rules in the state and the farmers of Haryana do not have to take any permission from forest department for felling and transportation of species like *Eucalyptus*, poplar and other on farm grown species.

The *Arhati* (timber trader or middle man) and *Mandi* system still prevails but farmers and industries are happy with the system because it is a win-win situation for everybody. With the middlemen system, the farmers do not have to wait and get money for their produce immediately after the sale. The middle men have developed a system whereby they pay money to the farmers immediately but they may wait to get money from the industry.

The hidden part of the story is that some portion of the wood is declared as "kaat" or rejected by the middle men. This wood is sold to the industry at fairly good price. The farmer is at some loss in this case but he does not mind. While industrialist gets this wood at little cheaper rate, the recovery of the wood is almost ninety per cent. Middlemen get big share in this deal and they are not to share it with the farmers.Very interesting fact as regards the supply of farm-based wood is that Jagadhari-Yamunanagar timber market gets only about 20% of its wood supply from Haryana and the remaining 80% comes from adjoining states of Uttrakhand, Uttar Pradesh, Punjab and Himachal Pradesh.

About 2000 wood trolleys are traded every day in Jagadhari and Yamuna Nagar towns. 30 to 40 hectares of poplar are felled every day in Haryana. Another 60 to 75 hectares of poplar are felled every day in adjoining areas of Yamuna Nagar in Punjab, UP, Uttrakhand and Himachal, which reaches this timber market. An estimated 25,000trees are felled every dayin and around Jagadhari-Yamuna Nagar. Considering 250 felling days: 250 x 25000=62, 50,000 (Sixty two lakhs and fifty thousand) trees of poplar alone are felled annually.

LICENSING OFWOOD BASED INDUSTRIES (WBIs)

By order dated 29/30th October, 2002, Hon'ble Supreme Court of India directed closure of all unlicensed saw mills and prohibited opening of any new saw mill without prior permission of the Central Empowered Committee (CEC). Prior to these directions, WBIs in the state were operating

without the licenses and there were no regulations in place. In compliance of the directions as mentioned above Haryana Forest Regulation of Wood Based Industries Rules, 2005 were enacted and licenses to WBIs in Haryana were initially granted in the year 2007 after the approval from Central Empowered Committee (CEC) appointed by the Hon'ble Supreme Court of India. The distribution of these units category wise is given in Table 7.

Table 7. Types of wood based industries in Haryana

WBI Category	Saw Mills	Veneer Units	Plywood Units	Others	Total
Units established prior to 30.10.2002	3886	218	324	61	4489
Units established after 30.10.2002	433	85	52	27	597
Total	4319	303	376	88	5086

POLICY SUPPORT FOR DEVELOPMENT OF AGROFORESTRY

1. **Plantation on farmers' field by the Department:**

   The Forest Department established poplar plantations in the recent past as per suitability of the site at no cost and also did maintenance for one year. After one year, the plantations were handed over to the farmer for further maintenance.

2. **Providing saplings at nominal rates:**

   Forest Department provided the saplings of poplar at nominal rates which has been helping farmers to carry out plantations at their own.

3. **The issue of minimum support price (MSP):**

   Time and again, the demand is raised by the farmers and sympathizers to announce MSP for farm gown wood in the state for the benefit of the farmers. The problem with the department is that if buys the wood from the farmers, the question arises as to what will it do of that wood? The department does not have processing units and hence, can't buy and store the wood. Being a perishable good, department can't buy and then sell the wood. Moreover, we want both the farmers and the industries flourish. The department leaves no chance to act as facilitator between the two as and when the need arises.

4. **Purchase Price Scheme of HFDC:**

   Haryana Forest Development Corporation fixes and revises the purchase price of trees at every six months. This scheme is acting like a minimum support price for tree growers and regulating the prices of timber in the market so that the tree growers can get maximum income for their produce.

5. **No permission required for felling of farm grown wood:**

   Farmers in Haryana are not required to take permission for felling of poplar from their farms. It has created an atmosphere of freedom in the minds of farmers and encouraged them to grow poplar in a big way.

REASONS FORSLIDE DOWN OFWOOD PRICE

Many reasons can be attributed to downfall of prices of poplar wood. Some of these are listed below:

1. The worldwide recession in economy has decreased the demand of plywood and board but production level of industry is same thus, market price of these finished products came down.
2. Govt. of India has put timber in the OGL list that facilitated cheap import of timber and pulp.

3. New Zealand pine was available at very cheap rate at Kandla Port, which was used in block wood production as blocks. Plywood and block wood of Yamuna Nagar was being supplied all over India but the main market is in Gujarat and Maharashtra. Thus, block wood producers of Gujarat have an edge over producers of Yamuna Nagar. New Zealand pine is an agroforestry crop and used to make sleepers; scrap material after conversion is exported to India at very cheap rate.
4. There was imbalance in dynamic demand and supply in the local market in favour of the buyers of the poplar i.e. there is more supply than demand. Cheap poplar wood was also coming from J&K.
5. Poplar not being the best choice for veneering gives way to *Eucalyptus*, which is harder, more durable and heavier than poplar veneer. Even if poplar veneers are used for plywood manufacturing, it should be of best quality, meaning straight clean clear bole of adequate thickness. Since poplar is the species which is not self-pruned as opposed to *Eucalyptus*, it becomes very difficult for a normal farmer who has very little technical knowledge of growing poplar, to prune poplar trees properly.
6. Prices between mid Decembers to mid March are generally low due to cheap availability of labour. There is also subtle variation in the weight of the timber during the dormant period i.e. in winter; weight is 5% more than the weight in summer. Similarly, rate in morning is higher than in evening within the same day.

CURATIVE MEASURES

1. Peeling units are essential integral part of plywood unit. The size of peeling units is 4 ft width which needs to be raised to 8 ft by setting up new peeling units. In this way the face veneers which are imported right now can be manufactured locally and that too at half the prices and also saving the foreign exchange. In case larger peeling units are allowed and face veneers are manufactured here then one lakh cubic meterround timber (RT) of poplar and *Eucalyptus* can be utilized, which will reduce the supply demand gap and push upwards the prices of raw material.
2. Allowing more saw mills or peeling units won't solve the problem of decreasing raw material prices but regulated supply coupled with modernizing the existing infrastructure will definitely boost the sickening industry. There is therefore, scope of improvement in which zero spindle peeling units should replace the existing waste creating units, adopting bigger peelers to produce face veneers inhouse, enhancing capacity of dlight presses and delinking pressing units from the licensing mechanism may solve the enigma.
3. Generally New Zealand pine is being used in boards and it is available @ Rs. 400 per cubic feet. This imported species can be replaced with locally grown *Ailanthus excelsa* costing about Rs. 40 per cubic feet. This wood will be equally effective as border block of board.

PRODUCTION POTENTIAL OF POPLAR AGROFORESTRY SYSTEMS AND ISSUES RELATED TO ITS SUSTAINABILITY

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Growing of poplar has been supported by industries as its wood has more than three dozen uses. Poplar is a fast-growing agroforestry tree and has compatible with the crops because of its deciduous nature. Wheat is most preferred crop followed by sugarcane during initial years while poplar - turmeric combination has been found to be the best in the later stage. Poplar has become a part and parcel of farming systems. Yamuna Nagar district has abundant of poplar trees particularly along the river Yamuna.

Poplar is planted as bund plantation and in blocks. The recommended distance for planting is 3 m apart in the case of bund planting and 5 m x 4 m or 4 m x 4 m in the case of block planting. However, the farmers conduct new experiments on their own for spacing depending upon whether they want to give importance to crop or to trees. They themselves have discovered the multitier systems combining trees, horticulture and agriculture crops. It was being harvested after six to seven years after planting.

With the induction of the modern peeling machines by the industries, which now use spindle less technology of peeling, the log is peeled to two mm width. As a result, the harvesting age has been reduced to three years with enhanced number of plants on unit area.Farmers have resorted to high density plantations with intention to remove alternate plants for paper industry after three years and remaining for plywood industry after five years.

The authors have a vast experience with farmers who have been growing poplar.Based upon research work, intensive field observations and consultations with the farmers, we propose several issues for discussion. We collected intensive data in the district of Yamuna Nagar and a part of it has been given inTable 8.

HIGH PRODUCTION POTENSIAL OF POPLAR AGROFORESTRY SYSTEMS

Combining the yield of poplar and the crops, these systems are highly productive. Intercopping in poplar-based system plays an important role to make it sustainable. Farmers grow sugarcane with poplar in the first year. Sugarcane average yield may be 350 q/acre (Rs. 1, 08,500) approximately. In second year during *Rabi* season, wheat is most suitable and economical because poplar sheds leave during winter. Average yield of wheat may be 17 q/acre (Rs. 27,625) and in summer fodder crops can be taken and approximate yield may be 70qt/acre (Rs. 7,000). Third year, wheat yield may be 14 q/acre (Rs. 22,750) and fodder be 60 q/acre (Rs. 6,000). Fourth year wheat yield is 12 q/ acre (Rs. 19,500). In fifth and sixth year, turmeric will be the most suitable. Yield of turmeric may be 50 q/acre (Rs. 60,000).

It is emphasized here that there should be genuine support price for poplar wood. At least farmer should get 4-5 lakhs on fifth year (Rs. 1.25 lakhs/acre/yearis earned from sugarcane in general). It can only be done if average price of poplar wood is Rs.700/q i.e. Rs. 1100-1200 over size and Rs. 500-600 *Sokhta*.Turmeric price should be at least Rs. 12/kg.Our studies indicate a high potential for biomass production by poplar plantations (Tables 8).

The litterfall increases significantly with the increase in age of tree. Our observations show that in a 2- year plantation, litterfall in November was 139 g/m^2 while in December it was 165 g/m^2. Maximum litter fall was recorded in 7- year old plantation being 246 g/m^2 in November and 307 g/m^2 in December. The total litterfall ranged from 318 g/m^2 in 2 years old plantation to 553 g/m^2 in 7 years old. At the age of 2 years, biomass into bole was estimated 17.91 kg/tree and in branches 26.81kg/tree. Total weight of bole and branches in trees increased from 44.73 kg/tree in 2 years old

plantation to 187 kg/tree in 7 years old plantation. Total weight of bole and branches in trees increased from 16.99 t/ha in 2 years old plantation to 74.08 t/ha in 7 years old plantation; bole constituted 57 per cent in 7 years old plantation.

The grain yield was 2.75, 2.42 and 1.96 t/ha/year in the interspaces of trees of 3-,4-, and 6-year old plantations. The production of sugarcane in 2 years old plantation was 14.98 t/ha/year, out of which 9.6 was stem, 4.6 leaves and 0.77 roots t/ha. Biomass of *Barseem* was 12.90 t/ha in 4 years old plantation and that of turmeric was 5.25 t/ha in the interspaces of 3 years old plantations. The entire biomass of barseem and 71 percent of turmeric was transported out of the system. At 5 years age, poplar could be potentially used for mitigation of climate change due to their promising growth and higher carbon sequestration.

Table 8: Productivity (t/ha/year) of trees and crops in poplar agroforestry systems

Tree and intercrops	Age of poplar plantations (year)					
	2	3	4	5	6	7
Poplar trees						
Bole	6.80	3.37	4.26	6.64	5.39	5.80
Branch	10.18	5.07	5.13	5.97	4.81	4.04
Leaf	3.18	3.05	5.18	5.49	5.35	5.53
Sub-total	20.16	11.49	14.57	18.10	15.55	15.37
Sugarcane						
Stem	9.60	-	-	-	-	-
Leaf	4.61	-	-	-	-	-
Roots	0.77	-	-	-	-	-
Sub-total	14.98	-	-	-	-	-
Wheat						
Straw	-	5.25	4.11	-	3.24	-
Grain	-	2.75	2.42	-	1.96	-
Roots	-	1.35	10.9	-	0.88	-
Sub-total	-	9.35	7.62	-	6.08	-
Berseem	-	-	12.90	-	-	-
Turmeric						
Rhizome	-	-	-	-	-	3.75
Leaf	-	-	-	-	-	1.59
Sub-total	-	-	-	-	-	5.34

GENERAL ISSUES

1. Poplar growers are losing interest rapidly in growing of poplar trees at their farmlands as a result soon there will be shortage of farm wood and lakhs of families depending on wood industries will suffer in addition to the loss of govt. revenue.
2. There are approximately 700 units of ply/board making units, peeling units and saw mills in Yamuna Nagar district for which sustainability is a big question.
3. Net annual carbon sequestration of fast growing poplar is to the extent of 8 Mg C ha^{-1} yr^{-1}. Poplar plays an important role in absorption of CO_2. Therefore, poplar plantations are extremely important for the environment.

SUGGESTIONS FOR THE FARMERS

1. Poplar growing soils need phosphorus anddeficiency increases maturity from 6 to 10 years
2. Some farmers grow poplar trees in narrow spacing and try to take more trees per acre, which adversely affects the crops yield and also creates glut in the market. A proper spacing should be followed as per the standard recommendations.

3. Spacing of poplar should be 10 m × 2 m (10 m row to row and 2 m plant to plant) in north- south direction. Farmer can also take paired row i.e. 18 m ×2 m × 2 m (18 m row to row and 2 m plant to plant).Farmer should grow 200 or less than 200 poplar trees in an acre.
4. There should be new plantation geometry of poplar in the fields as suggested above so that combine harvester can harvest wheat. Manual harvesting of wheat in these fields decreases farmer' income drastically.
5. Fertilizer management is very important for the growth of poplar. Farmers apply fertilizers only for inter crops and do not include the requirement of poplar as a result fertility of the soil is depeletd after a few rotations and then yield of crops and of poplar decreases. There is need to apply fertilizers for poplar also to attain the good growth.
6. Poplars need to be irrigated at frequent intervals during summer.Due to presence of inter crop i. e. Wheat at ripening stage of crop; farmers cannot apply irrigation, which adversely affect the growth of poplar trees. This problem can be addressed by making bunds along poplar rows and irrigation can be applied in channels. Likewise farmer can also apply fertilizer through bunds.

GOVERNMENT CONSIDERATION

1. Transit passage charges of Rs. 35/t in 2012 now increased to Rs.75/t, should be reduced.
2. The contractors charge 5% commission from the factories which needs to be reviewed.
3. Poplar of other States should be stopped by imposing tax on them from which subsidy can be given to farmers.
4. Leaf defoliator is a big and fast spreading problem in poplar especially in Chhachrouli block of Yamuna Nagar. Its heavy attack may affect the growth up to 25 %. Insecticides for poplar growers should be made available easily and at subsidized rates.
5. State Poplar Development Board/Commission should be constituted to monitor day to day issues related to poplar cultivation and marketing having ensured buy back system.
6. There should be genuine support price for poplar wood. At least farmers should get Rs. 4-5 lakhs on fifth year (nowadays 1.25 lakhs of sugarcane is being produced per acre).It can be done with average price of Rs.700/q i.e. Rs.1100-1200 over size and Rs.500-600 of *Sokhta*.
7. Whatever crops (medicinal plants, spices, vegetables, etc.) are suggested to grow in these fields should be easily saleable or stored or processed.
8. Rs. 12/kg MSP should be fixed for turmeric crop by the Govt. and it should be purchased by the HAFED or any other cooperatives.
9. Govt. should ensure that a processing plant is established for easy approach of farmers.
10. Govt. should give some support to poplar nurseries and should promote private/govt. nurseries and make sure that they are producing right clones/variety.
11. Govt. owned manufacturing unit for wood processing should be established at block level.

SCIENTISTS CONCERNS

1. There is an urgent need to develop pests and diseases resistant varieties.
2. New fast growing poplar varieties that mature in 4-5 years should be developed.
3. Farmer should be educated for getting crop with poplar in summer also if possible because only wheat is being grown in poplar fields after 2nd year. Sugarcane is there only for first 2 years. There should be R & D advice unit on poplar in Yamuna Nagar.
4. Government can make societies of poplar growers, which can educate farmers time to time. Even they can help in getting right insecticides on subsidized rates and can help in spraying those in fields timely as sugar mills are doing this in sugarcane fields.

POPLAR TREE GAINS POPULARITY: IT CAN BE SUSTAINED?

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NEED FOR AN AGROFORESTRY SYSTEM

- Need toincrease forest cover area in the state and the country
- Better option for land/crop diversification involving the food grains and commercial crops
- More return in terms of food, fodder, wood and allieds
- Higher addition of organic carbon in soil and sequestration of excessive atmospheric carbon
- System is eco-friendly, sustainable and remunerativeto the farmers and the industry

WHY THE POPLAR?

- Short rotation and suitable tree in agroforestry
- Easy management practices for cultivation and utilization
- Deciduous during winter (better sunlight to rabi crops)
- Mycotrophic in nature and potential economic alternative
- Fast nutrient recycling by decomposition and mineralization of leaf litter
- Contribution to environmental improvement and judicious use of resources
- Compatibility with agricultural crops like wheat, berseem, sorghum, sugarcane, potato, etc.

SPECIES OF POPLAR IN INDIA

Indigenous species of poplar occur in the Himalayan region in northern part of India. *Populus ciliata* species is distributed from Kashmir to Arunachal Pradesh at 1300 to 3000 m altitude. This is the most widespread species of native poplars. Trees usually occur on the banks of water courses. *P. gamblei* occurs at 600 to 1100 m altitude in Arunachal Pradesh. *P. jacquemontii var glauca* is distributed in Tonglo in Sikkim and EasternNepal at an altitude of 2500 to 2900 m. It has bisexual flowers. *P.rotundifolia* is distributed in Bhutan Himalayas close to Indian border at 2300 to 3050 m altitude. *P.euphratica* occurs in Ladakh region of Jammu and Kashmir and extends to the Punjab and Sindh (Pakistan), Tibet, Afghanistan, Iran, Iraq and Turkey. *P.alba* occurs in Pooh division in Kannaur, Himachal Pradesh and parts of Kashmir and Laddakh.

SUCCESSFUL CLONES

Initially, the successful clones of U.P. Tarai were introduced in Punjab. These clones (IC, G-3, G-48, and D-121) did very well on farms land. Very recently, some more clones S_7C_1, S_7 C_8, S_7 C_{20} and 73/532 have been reported promising in these states. In Haryana, promising clones reported were IC and G-3. CP-82-4-1 and CP-86-6-2 clones of *P. deltoides*are better than G-3. Early findings have indicated that clones S_7 C_{15}, G-3 and G-48 are good for line as well as block plantation. Indigenous clones L-88 and L-89 appear to have potential for growth in row planting but need more care and maintenance as compared to other clones.

Although, almost all clones of *P. deltoides* growing successfully in particular area are suitable for agroforestry. Some clones (A-26, A-343, T-75, T-94, T-185, 73/53-3, 3276, 3294 and 3297), which are more favorable for this purpose as they shed their leaves before the starting of sowing period of agriculture crop and flush after harvesting. However, they cautioned that the clones were suitable to Dehradun or similar climate. For north-west plains of U.P., suitable clones are G-3, G-48, D-121, D-61, D-67, S_7 C_8 and S_7 C_{15}.

About 90 percent of the poplar plantations in India are based on clones G-48, D-121, S7C15 and G-3. The yield of clone G-3, which once used to be the most popular clone, is declining due to attack by leaf blight disease. This clone is giving way to other clones, e.g., S_7C_8, Uday, L-34/82 etc.

WOOD-BASED INDUSTRIES IN YAMUNANAGAR

Haryana State has been pioneering in social and farm forestry. West India Match Company (WIMCO) needed soft wood like poplar to make match boxes and match sticks. Climate and soil of northern Haryana, western UP and Punjab states arequite suitable for fast growth of poplar. Extensive canal irrigation also helped since poplar requires lot of water. Due to intensive canal irrigation system, water table is very high in these areas, which facilitates the growth of poplar in the region. To meet its demand, WIMCO introduced poplar in the State and encouraged the farmers to grow poplar. Poplar being a very good species for agroforestry was readily adopted by both big as well as small farmers of the region. Wheat, the main *Rabi* crop can easily be cultivated along with poplar plantation because poplar becomes leafless during winter thus, allows most of the sunlight for the agriculture crop. This provided the farmers annual returns in terms of wheat and lump sum amount at the end of rotation (7 to 10 years) of poplar trees in terms of timber along with fuel wood on regular basis. Although poplar reduces the production of wheat (15q/acre in place of 17-18q/acre) but the advantage of timber production was far greater than the loss in grain production.

RECESSION IN PRICE OF TIMBER

There are four main reasons for downfall of poplar wood prices. Firstly, world-wide recession in the economy has decreased the demand for plywood and board but production level of industry was same thus market price of these finished products came down. Secondly, Govt. of India has put timber in the OGL list, which facilitated cheap import of timber and pulp. Thirdly, New Zealand pine was available at very cheap rate at Kandla Port, which was used in block-wood production as blocks. Plywood and block-wood of Yamunanagar was being supplied all over India but the main market is in Gujarat and Maharashtra. Thus, block wood producers of Gujarat have an edge over producers of Yamuna Nagar. New Zealand pine is an agroforestry crop and used to make sleepers; scrap material after conversion is exported to India at very cheap rate.Fourthly, there was imbalance in dynamic demand and supply.

Poplar not being the best choice for veneering gives way to *Eucalyptus*, which is harder, more durable and heavier than poplar veneer. Even if poplar veneers are used for plywood manufacturing, it should be of best quality, meaning straight clean clear bole of adequate thickness. Since poplar is the species which is not self-pruned as opposed to eucalyptus, it becomes very difficult for farmers who have little technical knowledge of growing poplar, to prune poplar trees properly.

The prices of poplar wood showed a downward trend during the period 1995-2003. The progressive, large farmers who could take the risk continued with farming at a reduced quantum. This development reduced the area under poplar farming which ultimately reduced the production of poplar wood in north India. This corrective action of the market helped in stabilizing the prices of poplar wood. Besides this general downward trend in the prices of the poplar wood, there is a small seasonal variation also which becomes significant from the farmers point of view. Prices from December, 15 to March, 15 are generally low due to cheap availability of labour. There is also subtle variation in the weight of the timber during the dormant period i.e. in winter; weight is 5% more than the weight in summer.

MARKETING AND ECONOMICS

A survey was conducted for collecting the data on fluctuation in the market price of poplar tree from 1980 to 2018 from contractors, farmers and field functionaries. The minimum rate was found during the year 2004 i.e. of rupees 155, 85, 70 and 70 for over-size, under-size, *Sokta* and *Dandi*, respectively whereas, the maximum rates were found during the year 2014 i.e. rupees 1400, 900, 500 and 300, respectively for over-size, under-size, *Sokta* and *Dandi*.

Some farmers have obtained three times higher income from poplar and agricultural crops combinations than pure agriculture. Poplar has been found more economic with the combination of different crop such as sugarcane, wheat, sorghum and vegetables as compared to paddy-wheat rotation. The income from the field of poplar-based agroforestry and mono-cropping system has been estimated and data given in Table 9 and 10.

CULTIVATION OF POPLAR IN NORTH-WEST INDIA: SOCIO-ECONOMIC AND POLICY ISSUES

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Two powerful forces drive the trend towards tree planting: economics and environmental concerns. The economic returns on planted forests, especially high-yielding intensively managed forests are sufficient to continue to induce substantial investments in plantation forestry .Thus, the trend towards planted forests and tree breeding imply that huge volumes of forest products will be produced from relatively small areas of land. Consequently, most of the natural forests would remain for biodiversity conservation and other purposes.

P. deltoides has achieved very high growth rates in agroforestry systems with mean annual increment at six years exceeding 35 tons ha^{-1}. These high rates were achieved under favourable site conditions, intensive irrigation and other cultural operations. Research on poplars as an agroforestry species was started in 1960s by Forest Research Institute, Dehra Dun, WIMCO and Haldwani centre of State Forest Department. Farmers adopted its cultivation in the 1970s. The credit for taking this tree to farmers for widespread cultivation goes to WIMCO. The company started an extension project for massive cultivation of poplars in Punjab, Haryana and Western UP from 1976 onwards. This project received financial support of NABARD during 1984-1995 and the company carried on its extension services independently thereafter.

VOLUME AND WEIGHT ESTIMATION OF POPLARS

The author was involved in a study to estimate biomass productivity and carbon sequestration potential of *P. deltoides* in Punjab. We have developed regression equations for various tree components for G-48, Uday and S_7C_{15} clones. Total biomass of poplar (fresh weight) through regression equations as follows:

LnWt= -2.145+2.361*LnD+0.2696*LnH; R^2=0.967; Where, LnH = Natural logarithm, Wt = Weight of biomass in kilogram,D =diameter of tree in meters, and H = total height of tree in meters. Farmers are usually interested in the weight of their standing trees. This helps them to negotiate the value of their standing trees with prospective buyers. Therefore, based on the above data a user friendly regression equation was developed and weight of tree at selected girth at breast height was worked out and put in a tabular form as shown in Table 12.

Table 12: Weight of standing trees in Punjab

GBH (cm)	63	69	75	82	88	95
Weight (kg)	235	360	449	534	645	731

Based on the regression: LnWt = -4.734+2.460, LnGBH; R^2=0.959.

FOREST REPRODUCTIVE MATERIAL (FRM) CERTIFICATION

Research has shown that if forests are to be of increased value including the aspects of stability, adaptation, resistance, productivity and diversity, it is necessary to use reproductive material, which is genetically superior and phenotypically suited to the plantation site and must be of high genetic quality. The author was one of the contributors to the report on forest reproductive material submitted in 2008 to the Indian Council of Forest Research and Education, Dehradun.

The object of the certification of tree seed and plants, called as Forest Reproductive Material (FRM) is to maintain and make available to the practicing forester/agroforester sources of seed, plants and other propagation materials of superior provenances and cultivars so grown and distributed as to insure the genetic identity and high quality of seed and plants. Seed cost is a very small proportion of plantation establishment cost and plantation projects can afford to purchase the best seed rather than the cheapest. The evidence seems overwhelming that whenever, there is a substantial afforestation programme, tree improvement (both provenance research and individual selection) in tropics will more than pay for itself.

Table 9: Income from poplar plus intercrops and sole crops

Year	Intercrops	Yield/ Acre (q)	Rate/q (Rs))	Total Income (Rs.)	Total expenditure(Rs.)	Net Returns (Rs.)
2004-05	Sugarcane	350	205	71,750	20,500	51,250
2005-06	Sugarcane	250	205	51,250	15,000	36,250
2006-07	Wheat-Sorghum	15-35	850-80	12,750+2,800	16,000	-450
2007-08	Wheat-Sorghum	12-30	900-90	10,800+2,700	17,000	-3,500
2008-09	Wheat-Sorghum	12-16	1100-100	13,200+1,600	17,500	-2,700
2009-10	Poplar harvested (300 over size)			8,00,000	10,500	7,89,500
Total income				**966850**	**95,500**	**8,70,350**

Table 10: Income from sole crops

Year	Intercrops	Yield/ acre (q)	Rate/ Quintal (Rs)	Total income (Rs.)	Total expenditure (Rs.)	Net Returns (Rs.)
2004-05	Sugarcane	350	205	71,750	20,500	51,250
2005-06	Sugarcane	300	205	51,250	15,000	36,250
2006-07	Wheat-Paddy	18-26	850-820	36,620	26,500	10,120
2007-08	Wheat-Paddy	18-27	900-960	39,420	27,000	12,420
2008-09	Wheat-Paddy	17-28	1,100-1,000	46,700	28,000	18,700
Total income				2,55,990	1,19,000	1,36,990

Addition of leaf and other crop residue to the soil in agroforestry is 2-5 times higher than monoculture of crop; due to which soil fertility increases (Table 11).

Table 11: Status of soil properties in mono-cropping and agroforestry system

Year	Soil pH		EC (mmhos)		OC (%)		P(kg/ha)		K(kg/ha)	
	Mono crop	Crop+ poplar	Mono crop	Crop+ poplar	Mono crop	Crop+ poplar	Mono crop	Crop+ poplar	Mono crop	Crop+ poplar
2004-05	8.81	8.82	0.29	0.30	0.52	0.51	29.1	29.0	350	345
2005-06	8.90	8.79	0.31	0.29	0.50	0.53	29.3	28.7	349	350
2006-07	8.91	8.60	0.33	0.27	0.51	0.57	30.7	27.1	339	390
2007-08	8.87	8.21	0.30	0.21	0.50	0.63	30.9	17.3	340	430
2008-09	8.97	8.08	0.31	0.17	0.50	0.69	3102	14.7	331	480

POLICY AND INSTITUTIONAL ISSUES

The fall in price of poplar wood during the past one year has significantly reduced the interest of farmers in poplar cultivation. Some poplar growers are now turning towards *Eucalyptus*. The points which require the attention are given below:

- There is no regulatory mechanism to ensure supply of certified nursery stock to the growers. Some kind of certification mechanism is required to be put in place to check sale of physically or genetically inferior stock to the growers.
- Unlike agricultural crops, facility of minimum support price for wood of poplar, or any other agroforestry species, is not provided by the government. This leads to exploitation of growers.
- Providing facility of credit and insurance as is available in case of traditional agricultural crops needs to be extended to cover tree cropping.
- Research grants from users (industries, farmers, forest corporations) to research institutions is absent and same needs to be initiated. This vogue in agriculture sector in India since long.
- Crop plan should be initiated for proper marketing.
- Tree register should be maintained.
- MSP may be fixed of tree species.
- Marketing facility may be provided at the nearest place.

REMOVING CONSTRAINTS TO TREE GROWING

A number of constraints to tree growing have been removed in recent years. For instance, the earlier restrictions imposed by the Central Empowered Committee of Supreme Court on setting up of wood using units based on agroforestry trees have been considerably relaxed. Like agricultural crops, they should also give due attention to agroforestry plantations providing research, training and extension services. Undoubtedly, the WIMCO has been a pioneer in promoting the cultivation of poplars including the provision of quality planting stock. In recent years, the Government of India has introduced a scheme that subsidizes the growing of trees by farmers. The scheme started by the Ministry of Agriculture and Farmers Welfare is "CSS-Grant-in-aid to State Forest Development Agency for implementation of Sub- Mission on Agro-Forestry" under the umbrella of National Mission for Sustainable Agriculture (NMSA) with a focus to enhance income of farmers and also to diversify land use from agriculture to agroforestry to certain extent. The funding pattern between the Centre and the States is 60:40. The scheme is operational since 2016-17 and farmers are given financial assistance at the rate of 50% of the total cost of plantation. As per my information, so far three States have participated in the scheme and Punjab is one of them.

FLUCTUATIONS IN PRICE OF WOOD

During the last 4-5 years, we have witnessed a steady decline in the price of wood in the region leading to distress sale. The price of poplar wood, for instance, fell from Rs 1100-1200 per quintal (over 60 cm girth) in 2012-13 to around Rs 400 early in 2018. A similar trend was also observed for small-sized wood in the corresponding period with price dropping from Rs 800-900 per quintal (under 60 cm) to some Rs 300 per quintal. Recent months have seen a revival and current price for over 60 cm girth is Rs 650-700 per quintal.

DECISION SUPPORT SYSTEM (DSS)

Farmers are generally not aware of the trends in expansion in crop production. As a result, they go for growing only those crops which his neighbor is growing. This creates a situation of over production at times. The situation is soon recovered and many farmers shift their cropping pattern based on the prevailing market trends in favor or against that crop. The situation is more complex in case of trees as they are of long gestation period and trends in price change appears over a period of time when they had already planted trees and wait till the time they get reasonable price for their produce. To avoid such a situation, a Management Information System of Decision Support System is required in case of poplar and other tree culture and utilization that may capture the demand and supply scenario and plantation trends based on which farmers may make reasoned decision to plant trees and maintain equilibrium in demand and supply.

SUGGESTIONS

1. Policy reforms for integrated development of agroforestry and wood based industries for establishing technology based plantations.
2. Agricultural universities and state agriculture and forest departments should strengthen agroforestry extension services and research be conducted for development of attractive agroforestry models, developing genetically superior high yield clones of appropriate tree species and compatible/shade tolerant varieties of crops.
3. Registration of nurseries and certification of tree planting material to prevent degradation in tree growth and duping of unsuspecting farmers by unscrupulous traders.
4. Bringing farm grown wood in the purview of Agriculture Produce Marketing Committee (APMC) Act for transparency in sale of wood.
5. Formulate autonomous price fixation committee
6. Develop grading and trading rules. Encourage direct purchases and sales of wood between producers and consumers
7. Declare poplar and other farm grown trees an agriculture produce under agriculture industry
8. Plough back a part of revenue generated from poplar based industry in supporting farmers to sustain poplar culture

POPLAR AGROFORESTRY TECHNOLOGIES

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National Forest Policy (1988) recommended having a minimum of one-third of country's total geographical area under forest tree cover to maintain the ecological balance, covering 60 per cent of hilly areas and 20 per cent of plain areas under forest/trees. However, the existing forest and tree cover in the state is only 6.59 per cent of total area, which is not sufficient to meet the requirement of forest-based products and for maintaining the ecological balance. Large-scale adoption of poplar-based agroforestry system in Punjab has already demonstrated that such a system can increase the area under forest in an economically viable way. Crops can be grown successfully under poplar throughout its rotation; in *Rabi*season (wheat, oats, barseem, etc.) and in *kharif* season only shade tolerant crops (turmeric, mentha, maize, bajra, sorghum, cowpea, etc.) are more compatible.

The soil type and irrigation facility are two important factors that help in deciding the site for poplar plantation. Poplar requires loam to sandy loam deep fertile and well-drained soil with neutral pH. It does not grow well on saline, alkaline, water logged and heavy clay soils. Frequent irrigation is required for the optimum growth of trees. Thus, poplar can be successfully grown in almost all of central Punjab and more profitably in 'bet' areas. Trees could be planted on field boundaries or in a block. Small or marginal farmers prefer boundary plantation and trees should preferably be planted in north – south row direction at a distance of 3 m. Big and marginal farmers generally follow 5 m x 4 m spacing for block plantation that accommodates 200 plants per acre. It is recommended to increase distance between rows (8m) and decrease distance with in rows (2.5m) accommodating almost same number of plants per unit area but significantly increasing area to plant intercrops. The wider strip (8 m) should be used for growing crops and it should be in north-south row direction. The yield reduction of intercrops in wider spacing is less as compared to crops grown at 5 x 4 m spacing.

RECOMMENDATIONS FOR FARMERS

- **Poplar clones**: PL-1,PL-2,PL-3,PL-4,PL-5, PL-6,PL-7, L-47/88 and L-48/89 are recommended for commercial cultivation in central-plain region and L-48/89 in semi-arid region of Punjab.
- **Spacing and geometry of trees**: Plant at 8 m x 2.5 m spacing with 8 m wider strip in north-south direction to minimize the negative effect of tree shade on intercrops.
- **Crop combinations:**K*harif* season(cowpea, pearl millet, moong, mentha and arvi);*Rabi*season(wheat, potato, barley, oats, berseem and mustard) and annual crops (sugarcane, turmeric and lemon grass) recommended as intercrops with poplar trees.
- **Fertlizers application:** In soils with medium in available N, apply 23 g N (50 g urea) and 39 g P_2O_5(85 g DAP) in each pit at the planting time of poplar. Apply 78 g N (170 g urea) in 1 m diameter ring around the tree during 1st year, 120 g N (260 g urea) in 2 m diameter ring during 2nd year and 161,198, 239,281 g N (350, 430, 520 and 610 g urea), respectively in 3 m wide strip (1.5 m on each side of tree row) during 3rd, 4th, 5th and 6th year of tree growth, respectively. Time of application is also important. Every year, apply 1/3rd urea during May after harvesting of wheat, 1/3rd urea in July and the remaining 1/3rd urea in September. There is no need of P application to poplar every year.
- **Zinc application:** The deficiency of Zn is exhibited in the nursery by interveinal yellowing of recently matured leaves. Apply 40 kg zinc suphate heptahydrate (21%) or 25 kg zinc sulphate monohydrate (33%) per acre in Zn-deficient soils at the planting time of nursery. Repeat the dose after 2 years. In the plantation apply 100, 200 and 300 g/plant zinc sulphate heptahydrate or 65, 130 and 190 g/plant zinc sulphate monohydrate in Zn-deficient soils during 1st, 3rd and 5th year of poplar growth in 1 m diameter basin, 2 m diameter basin or 3 m wide strip (1.5 m on each side of tree row), respectively around the plants after harvesting of the rabi intercrop.

- **Pest's control:** DMoth appears during March-April and peak activity is from July-October from overwintering pupae. The larvae eat away all the tissue of the leaves leaving the veins. Spray in nursery and plantation on appearance of larval damage during July and October with Quinalphos 25 EC @ 4 ml/litre or Profenophos @ 2 ml/litre using 500 litres of water per acre. Plough the field 2–3 times in December to bury pupae in soil debris.

PRODUCTIVITY OF POPLAR AGROFORESTRY SYSTEMS

The overall productivity of a system is one of the important factors that decide the success of any system. Systematic planting of fast growing trees has pushed the productivity levels to many folds. In this region, productivity up to 50m^3/ha/yr has been achieved through intensive management practices of poplar-based agroforestry system compared to 1.0 m^3/ha/yr of Indian forests. In an agroforestry system, the competition among different components is high and it often leads to reduction of crop yield as compared to crop grown in open. The percent yield reduction of crops often increases with the age of trees and it varies from 10 to 46 per cent from first to six-year-old plantation (Table 13).

Table 13. Wheat yield (PBW 343) under different aged poplar plantations

Ttree age (year)	Mean height (m)	DBH (cm)	Grain yield/acre (q)	Yield reduction (%)
1	8.3	7.4	17.6	10.2
2	12.6	14.6	16.2	17.5
3	15.7	17.3	14.7	25.3
4	18.2	20.1	12.8	24.8
5	18.9	21.2	12.3	37.5
6	21.1	22.8	10.5	46.6
Control (under open conditions): 19.6 q/acre				

The monetary losses in terms of crop yield are often compensated from the sale of wood at end of rotation. Timber yield from 5-year poplar block plantation varies from 450-550 q / acre depending on the management practices followed by different growers. Poplar based agroforestry system is economically viable and could be adopted as one of the viable options of crop diversification provided the poplar wood prices remain more than Rs 600/quintal. Caution is that this system is economically viable only under appropriate site conditions and with execution of proper culture and management practices.

REASONS FOR SLUMP IN POPLAR TIMBER PRICE

- No minimum support price (MSP) for farm grown timber
- No timber marketing infrastructure exists in the State, like the one for agricultural produce.
- Marketing system is not transparent, commission agents often exploit farmers
- No large-scale plywood/ medium density fibre board/ paper/ paper pulp mill in the State.
- Low price of poplar wood since 2012, a long slump period, discouraged small and medium farmers.
- Some poplar plantations have been raised from poor growing stocks, leading to poor quality of trees and ultimately less economic returns.

POLICY INITIATIVES NEEDED

- The marketing infrastructure for farm grown timbers need to be developed (for example, Punjab Mandi Board/ Punjab State Forest Development Corporation)
- Minimum Support Price (MSP) for farm grown timbers should be announced by the State government.
- Large scale paper mill/plywood/ plyboard/ laminated wood need to be established in the state.
- Ensure quality nursery planting stocksof poplar for the farmers.

ECONOMIC ANALYSIS OF POPLAR AGROFORESTRY SYSTEMS

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CARBON SEQUESTRATION

Poplar agroforestry has tremendously higher carbon storage potential than sole agriculture. A long term 8 years (2007-2015) study was conducted on poplar with tree spacing of 5 x 4 m, 10 x 2 m and 18 x 2 x2m at CCS HAU, Hisar (29°09' N latitude and 75°43' E longitude at an elevation of 215 m above MSL), situated in the semi-arid region of north-western India with irrigation facility of canal water. The results indicated thatpoplar agroforestry improved aggregation of soil through production of significant quantity of organic matter in the form of leaf biomass. The extent of improvement may be affected by the age of the poplar trees. The soil showed 39.7 per cent more organic carbon than sole crop. The sequestration was 119, 101 and 84 per cent higher at 5x4 m, 10 x2 m and 18 x 2 x2 m spacing of poplar than sorghum-berseem crop rotation in sole agriculture, respectively. Due to less crop biomass production in cowpea-wheat crop rotation in sole crops, carbon storage under agroforestry was 139, 121 and 98% higher at 5x4 m, 10x2 m and 18 x2 x2 m (18 m row to row and 2 m plant to plant in paired rows) spacing than the sole crops, respectively. The mean rate of carbon storage in agroforestry has been found to be 113% higher than sole agriculture.

The rate of carbon storage was found to be 25.2t/ha/year in poplar agroforestry system and 11.8t/ha/year in sole agriculture. Moreover, the carbon stored in tree component is locked for a long time whereas the carbon in crops is locked for a short period only. The study showed that carbon stocks contribution of woody perennials is higher in systems involving closer spacings (5x4 m). In the initial year, the woody component has lesser biomass per hectare however; with the advancement of age of poplar carbon stocks increase considerably thereby increasing the total shares in overall carbon stock of poplar-based agroforestry system.

ECONOMIC ANALYSIS

Economics of poplar agroforestry system planted at 5×4 m, 10×2 m and 18×2×2 m (18 m row to row and 2 m plant to plant in paired rows) spacings at a rotation of eight years was calculated. At 12% discounted rate, net present value (NPV) and internal rate of return (IRR) were found higher in 10×2m spacing with benefit cost ratio (B:C ratio) of 1.98 and 2.22 with cowpea-wheat and sorghum-berseem rotation, respectively followed by 5×4 m spacing (Table 14,15,16).

Table 14: Economics of cowpea-wheat crop rotation in poplar agroforestry system (Rs./ha)

Particulars	5 × 4 m	10 × 2 m	18 × 2 × 2 m	Control
Input cost of trees	3,64,110	3,64,110	3,64,110	0
Input cost of crops	2,97,614	2,98,627	2,99,363	7,73,552
Total costs	6,61,724	6,62,738	6,63,474	7,73,552
Returns from trees	13,67,000	13,67,000	10,34,620	0
Returns from crops	3,44,978	3,87,719	4,20,394	6,85,222
Total returns	17,11,978	17,54,719	14,55,014	6,85,222
Net present value (discounted at 12%)	3,34,293	3,58,133	2,55,004	-43,280
B: C ratio (discounted at 12%)	1.92	1.98	1.70	0.9
Internal rate of return (%)	48	54	50	71

Maximum returns from agricultural crops in 8 years rotation was obtained under paired row (18×2×2m) spacing but inferior trees growth in 18×2×2m spacing affected the economic returns from this spacing. Generally, sole poplar plantations are not managed properly as in agroforestry system. Regular cultural practices like timely irrigation and fertilizers application in agricultural crops provide more appropriate environment for growth of poplar trees. However, the sole poplar at a spacing of 5×4m and 10×2m performed above average with B: C ratio of 1.31 each (Table 16). Therefore, growing of sole poplar is not economical as compared to poplar with agricultural crops.

Table 15: Economics of sorghum-berseem crop rotation in poplar (Rs./ha)

Particulars	5 × 4 m	10 × 2 m	18 × 2 × 2 m	Control
Input cost of trees	3,64,110	3,64,110	3,64,110	0
Input cost of crops	2,42,050	2,4,4985	2,49,638	6,91,109
Total costs	6,06,160	6,09,095	6,13,748	6,91,109
Returns from trees	13,67,000	13,67,000	10,34,620	0
Returns from crops	4,02,532	4,33,336	4,85,730	7,54,116
Total returns	17,69,532	18,00,336	15,20,350	7,54,116
Net present value (discounted at 12%)	3,96,815	4,09,673	3,14,782	45,880
B: C ratio (discounted at 12%)	2.20	2.22	1.93	1.13
Internal rate of return (%)	71	70	73	12

Table 16: Economics of sole poplar plantation (Rs. /ha)

Particulars	5 × 4 m	10 × 2 m	18 × 2 × 2 m
Input cost of trees	4,45,983	4,45,983	4,45,983
Returns from trees	8,95,000	8,95,000	7,35,216
Net present value (discounted at 12%)	76,110	76,110	18,490
B: C ratio (discounted at 12%)	1.31	1.31	1.1
Internal rate of return (%)	20	20	14

STRATEGY FOR IMPROVING INCOME OF POPLAR GROWING FARMERS

The price of poplar wood in the market is extremely sensitive to many known and unknown forces.The measures suggested toovercome these problems are:

- Development of agroforestry cooperatives and facilitating open auction of wood at farmland
- Strengthening of extension wing of forest department, quality control and certification of planting material
- Implementation of National Agroforestry Policy, 2014 in Haryana and rationalization and relaxing of transit rules for poplar wood
- Regulating import under open general license, increasing capacityof processing poplar wood industries
- Establishing more plywood units in different areas to absorb increased supply of poplar wood.
- Healthy buyer-seller linkage is crucial for the development of sustainable agroforestry-industry model.

CONCLUSION

- Eight yearpoplar plantation has attained significantly more girth at 5 m×4 m and 10 m×2 m spacings than paired row planting (18 m ×2 m ×2 m) and soil showed 39.7% more organic carbon than sole agriculture.
- In poplar agroforestry system, the green fodder yield of *Kharif* season crops decreased significantly after one year of poplar plantation however, in winter season crops yield decreased considerably after three years of plantation and average reduction in yield of barseem and wheat reached up to 50 per cent under different spacings over control (sole wheat without poplar tree) at 8-year age of poplar plantation.
- Poplar agroforestry system at 8 years age was found to sequester 113 per cent more carbon than sole agriculture. The rate of carbon storage was found to be 25.2t/ha/year in poplar agroforestry system and 11.8t/ha/year in sole agriculture.
- After eight years, maximum B: C ratio of 1.98 and 2.22 was found in poplar planted at 10 m ×2 m spacing with cowpea-wheat and sorghum-*berseem* rotation, respectively over 5 m ×4 m and 18 m×2 m×2 m spacings. Growing of sole poplar is not economical as compared to poplar with agricultural crops.

POPLAR AGROFORESTRY IN INDIA: POTENTIAL & POLICY ISSUES

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POPLAR REVOLUTINIZED PRODUCTIVITY AND ENVIRONANMENTAL AMELIORATION

- Development and growth of wood-based industries in forest deficite states such as Haryana, Punjab and Uttar Pradesh
- Value addtion by local processing and supply of useful products including plywood and paper to society
- Greening of India, improving tree cover, carbon sequestration and environmental amelioration
- Creation of vast employment opportunities, conservation of foreign exchange and increased revenues.
- Much needed diversification of agriculture sincefarm grown poplars and eucalypts supply nearly 80-90% of industrial roundwood for plywood, veneers, and paper and panel product industries

NATIONAL FOREST POLICY (33% TREE COVER) REMAINS A DREAM

Restoration of degraded forest lands to high sustainable productivity in time bound manner through technology based plantations where ever feasible.

- Promote development of agroforestry plantations on massive scale based on economically attractive and environmentally safe models based on genetically improved planting stock.
- Government should adopt innovative policies to address bottlenecks hanpering expansion of agroforestry plantations and ensure holistic development of agroforestry to harness vast untapped potential
- Government should strengthen R & D and teachnical extension services related to agroforestry plantations

HUGE DOMESTIC DEMAND FOR TIMBER AND WOOD-BASED PRODUCTS

- Imports of cum wood and wood-based products into India were 6.7 and 0.4 million tones, respectively.
- Value of imports was Rs.13, 367crores during 2014-15 compared to 6,350crores during 2010-11.
- Our farmers can attain it producing farm grown timbers with suitable incentives through innovative policies.

ROLE OF FARMERS IN IMPROVEMENT OF TREE COVER OUTSIDE THE FORESTS

- Productivity of intensively managed agroforetsry plantations is very high and quality of timber is better because of progressive adoption of genetically improved planting stock.
- Productivity of poplar plantations on farm lands in north-western India also ranges from 20-25cu.m/ha/yr.
- Haryana Forest Department and Pragati Biotechnologies based at Jallandhar are promoting clonal *Eucalyptus* plantations in north India.
- Many farmers have already achieved trend setting productivity levels exceding 50 cubic m/ ha/yr from intensively managed poplar and eucalyptus clonal plantations.

- Wood based pulp/ paper mills and ply/ veneer industries meet most of their industrial wood requirements from farm forestry plantations all over India except paper mills in north-eastern region.
- Trees outside forests in Punjab have 612 lakh stems with growing stock of193 lakh cubic meter.
- Sustainable harvest of timber from trees outside forests is 15lakh cum as compared to 1.2 lakh cum per year from govt. forests in Punjab.
- In Haryana, sustainable harvest of timber from community and farm lands is 28 lakh cubic meter (94%) compared to1.9 lakh cubic meteri.e. (6%) per year from govt. forests.

MAJOR CONSTRAINTS FOR AGROFORESTRY DEVELOPMENT

- Long gestation period for tree crops and market uncertainties
- Absence of regulated timber markets for transparent trading
- Small and fragmented land holdings and limited choice of profitable agroforestrymodels
- Non-availability of genetically improved planting stock and efficient extension services
- Subsidized or low-cost poor genetic quality seedlings have made precious land under productive
- Difficulties in getting long term bank loans and insurance of plantations

GOVERNMENT POLICIES INHIBIT GROWTH OF AGROFORESTRY

- Unrestricted import of timber of any species under OGL, and ban on export of logs of farm grown timbers
- Restricted licensing of new wood-based industries and expansion/modernization of existing units
- Restrictive regime in respect of felling of farm grown trees and cumbersome transit permits in many states
- No systems in place for certification of seed, registration of nurseries and clonal planting stocks
- Without Govt. support, Rs.1800 crores of farmers in four poplar growing states eroded during 2000 to 2005
- Farmers in Haryana alone lost rupees 210 crores annually on 14 lakh tonne poplar logs with drop of Rs.1500/t prices or a whopping Rs.840 crores loss in 4 years slowing new agriforest plantations
- Cyclic price crash & long gestation of farm grown wood needs redressal by government urgently

KEY MOTIVATING FACTORS FOR FARMERS TO ADOPT AGROFORESTRY

- Farmers must get significantly higher returns from agroforestry compared to traditional crops
- Sustainable long-term market demand and regulated timber markets
- Ensuring knowledge of plantation technology and efficient availability of extension services for guidance
- Availability of genuine,high-quality, fast growing, disease andpest resistant clones for planting
- Long term bank finance at reasonable terms of interest and repayment

STRATEGIES FOR LARGE SCALE DEVELOPMENT OF POPLAR AGROFORESTRY

- Government should promote integrated development of plantations; wood-based industries and regulated timber markets. Plantations should concentrate around existing and planned future wood-based industries

- Government should set up regulatory authority comprising experts, economists, farmers and wood-based industry persons to determine reasonable and remunerative basic prices of farm grown wood for farmers
- Government should revise ceiling limits for agricultural land holdings upwards at least for waste lands
- Promote involvement of corporate sector in production of high quality planting stock and promotion of plantations through innovative policies and incentives
- We should emulate the examples of WIMCO&ITC for promotion of poplars/clonal eucalyptus plantations
- Genetically improved high yielding and fast-growing clones should be adopted by all states
- State forest/agriculture departments should strengthen agroforestry extension services and R & D for regular development of new superior clones
- Forest Departments must stop supplies of poor quality subsidized seedlings which make scarce land under-productive and lead to poor quality of wood, low yields and little profits
- Promote both block and single line avenue plantations of suitable tree pecies including poplars

CENTRAL AND STATE GOVERNMENTS SHOULD REVIEW THE POLICIES

- Plan for integrated development of agroforestry and establishment of new and modernization of existing wood-based industries
- Free farm grown timber species from hassles of felling permits and timber transit permits in all states
- Establish regulated timber market yards in major timber trading towns for ensuring transparent timber trade and remunerative prices for farm grown wood of each grade
- Permit export of farm grown timbers and processed wood products
- Arrange for registration of nurseries and certification of genetically improved clones / planting stock to prevent duping of farmers by unscrupulous traders
- High priority should be accorded by the ICFRE, ICAR, agricultural universities and State Forest Departments for strengthening agroforestry extension services and research including regular development of new superior clones
- Research should have high focus for development of economically attractive agroforestry models, genetically improved planting stock including high yielding clones of suitable tree species and shade tolerant varieties of crops
- Govt. of India and the NABARD should promote investments into agroforestry sector through innovative policies, fiscal incentives and tax benefits
- Banks should facilitate flow of bank credit for agroforestry projects including nurseries producing high quality planting stock / genetically improved clonal saplings
- Government andthe NABARD should also help the farmers benefit from international funding support for plantations as carbon sinks
- Liberalize ceiling limits on agricultural land holdings at least for waste lands for promoting flow of investments for promoting reclamation and improving productivity of such lands on sustainable basis
- Government should permit import of only specified species of durable hardwoods under the OGL to protect legitimate interests of farmers growing fast grown timbers under agroforestry system
- State forest departments should stop production and supply of subsidized clones of poor genetic quality which keep the scarce land resources under- productive

SUSTAINING POPLAR CULTURE AND UTILIZATION IN HARYANA

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Haryana is among the leading states in poplar culture and utilization in India. In fact, Haryana is having a very large cluster of poplar based industrial units which directly and indirectly help the poplar culture to flourish not only within the state but also in the adjoining locations. This cluster attracts poplar wood from all over the poplar growing region. It acts as a barometer for wood prices in the country as a result many growers and wood traders keep a tract of the trends in wood prices in Yamuna Nagar wood market and plan their business according to changes occuring here.

EVOLUTION OF POPLAR CULTURE IN THE STATE

There was no evidence of growing introduced or native poplars in Haryana till 1971 when first poplar sapling of eastern cottonwood (*P. deltoides*) was brought by the WIMCO Ltd. from its nursery in Uttar Pradesh and was planted near the Forest Guest House, Yamuna Nagar. The first large scale plantation of around 2000 saplings was planted on the farm of Mr. Kalsia (Kalsia Farm near Chhachhrouli, Yamuna Nagar) during 1974. Mr. Kalsia associated with WIMCO Match industry management was impressed with the performance of the trees planted by the company in and around Bareilly Match factory and came forward for its planting. These samplings were lifted from WIMCO nursery grown in Bareilly (Uttar Pradesh), transported and planted here.

The company picked up poplars for promotion as match wood species and started its cultivation in association with farmers on their farms. Latter on, WIMCO created a specialized organization *viz*., Agro Farm Forestry Division (AFFD) in 1977 by recruiting around 350 professional specialized in agriculture, forestry, marketing and legal disciplines, many of which were also posted in the state of Haryana to promote poplar plantations of farm fields in association with production of agriculture crops. This attempt was the first to formalize organized agroforestry much earlier than the definition of this integrated tree crop production was coined as agroforestry. Wimco Seedlings Ltd. created in 1984 by WIMCO and its principle company Swedish Match, supported poplar culture through effective R&D and in expansion of its culture thereafter.

First poplar nursery in the state of Haryana was grown during 1978 which also served as the feeding nursery for supplying saplings to the adjoin state Punjab.WIMCO Seedlings is continuously growing poplar nurseries in the state since then. Private poplar nurseries started mushrooming 1995 onward when WIMCO started direct sale of poplar saplings and many private and government institutions started growing and selling poplar saplings. This decentralization of nursery production and sale helped a great deal in expansion of poplar culture within and outside the state of Haryana.

Presently, Haryana is the fourth major state in poplar culture which has a share of around 10-15% of total poplar planted in the country. Major poplar culture in the state is around river Yamuna. It is extensively planted in Yamun Nnagar district, and partially in Karnal, Panchkula, Ambala, Kurukshetra, Panipat and Kaithal districts. There are also some farmers who grow poplar in Sonipat, Rohtak and Faridabad districts. Some isolated plantations are also seen in Hissar, Sirsa, Fateihabad, Gurgaon andJind districts.

CLONES OF POPLAR IN HARYANA

Initially IC series clones were planted in the state during 1970's. Soon these clones were replaced firstly with G-3 and then with G-48 in 1980's. During 1990's, 'S' series clones especially S7C15 and S7C8 found favor among famers. Indigenously developed *Udai* became more poplar in many areas in Haryana. The new WSL series clones were released during 2002 and among them WSL-22, WSL-32 and WSL-39 became much popular in the state during the first decade of 21st century. WIMCO Series clones especially WIMCO-110, WIMCO-109 and WIMCO-108, WIMCO -81 and WIMCO-83 are now more popular than the old ones. Large scale infection of *Melampsora* rust during last couple of years on many clones calls for replacement of susceptible clones with resistant ones.

EVOLUTION OF POPLAR UTILIZATION IN THE STATE

Yamuna Nagar has been an established timber market from the times when it was a part of undivided Punjab. There was a timber depot in Yamuna Nagar. Here timber used to be transported through floating in Yamuna waters from hills (now Himachal Pradesh) and collected, stored, auctioned and traded in this town. WIMCO used to have a splint making unit at Ambala which used to process, Semul wood in old days. Some panel industrial units located in the state started procuring poplar wood from WIMCO promoted plantations. The simple modus operandi was to get such plantations evaluated from WIMCO staff and pay 10-15% higher price to the grower panel industry as this industry could realize better price than safety matches. On termination of WIMCO-NABARD project, panel industry started freely procuring wood from poplar growers and soon developed it as a life line for this industry. During 1990's many of plywood industrial units shifted from north eastern states, found poplar as readymade and much needed raw material for this industry. Haryana is now developed not only major user of poplar wood but also supplier of semi-finished products like veneers and batons for ply-board for the industry located in other parts of the country. Similarly, it receives poplar wood and veneers from other parts of country where poplar is grown and processed.

TRENDS IN POPLAR WOOD PRICES

Almost all parts of poplar tree have commercial value and are traded in the market. Their prices fluctuate on day to day basis, seasonally and periodically. A single factor that determines the prices of its produce is demand and supply scenario existing on a particular wood trading day.

Most of the trees are harvested during the day, wood converted into tradable grades, transported to the mandi during nights and sold early in the morning each day. Any disruption like religious functions like *Kamwari, Ramzan* and other eventualities like road blockades, processions, and floods temporarily disrupt the process and affect the wood prices during that particular period. On the other hand, increased supply as a result of excessive poplar damage due to heavy winds at times lowers the wood prices in the mandies.As poplar is largely grown along with agricultural crops, there are two dominant harvesting seasons when wood supply increases i.e., pre-wheat sowing and post-wheat harvesting seasons when bulk of poplar is harvested.

Wood prices declines from normal trends during these windows and increases during other periods. Over the longer period, we have noticed three depressed phases of poplar wood prices. Poplar was planted mainly under WIMCO-NABARD project till 1995. Towards the end phase of this project, there was a great degree of uncertainty regards continuity of poplar wood procurement by WIMCO and hence there were some depression inits prices around 1995. Soon poplar culture was taken over by the market forces as most of the panel industry shifted from north-eastern states started using poplar grown in Indo-Gangeticplains. As there were no restrictions on felling and transportation on poplar wood in the state of Punjab and Haryana, whereas, the state of Himachal had relaxed these rules for poplar along with five other species, poplar culture and its utilization fast expanded initially in Yamuna Nagar and in some other locations in due course.

During the beginning of first decade of current stage, there was a great degree of uncertaintyon the unlicensed panel industry regards their registration due tojudicial activism. This was the main reason for crash in poplar wood prices during 2001-2004, though other factors like over production of poplar wood and its supply were also equally important. An all times minimum price for poplar wood was recorded in the Yamuna Nagar*Mandi* during 2004. Soon central and state governments reactivated, formulated rules and regulations for registration of panel industry based on wood demand and supply and the prices of poplar wood started increasing 2005 onward and accordingly poplar culture also started expanding.

Poplar culture expanded uninterrupted till 2013, when poplar wood supply and its utilization were well synchronized. Poplar wood (over size) witnessed all times high prices of over Rs. 1200/qtl during March 2011. Soon, market started sensing over supply of poplar wood and there was slow and gradual decline in its prices till Nov., 2017. A minimum of poplar wood prices (over size) of less than Rs. 500/q was recorded during August to October 2016. Poplar plantations also started getting set back from 2013 and continued till the last planting season i.e., 2017-2018 winters. Sensing the positive sentiments in upward movement of poplar wood prices, there is a renewed interest in poplar growers, and there were increased poplar plantationsduring the current planting season. It appears that poplar growers would now have *ACHHE DIN* (good days) till a stage when there would be again over production may be after a decade period as has been during the recent phase or due to some unforeseen factor which may initiate decline in poplar wood prices any time earlier.

PROBLEMS AND PROSPECTS OF POPLAR CULTURE IN INDIA

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Commercial poplar crop (*Populus deltoides)* in India occupies a small geographical area at national level but makes a highly significant and unique contribution to socio-economy of north-west Indian plains. Estimated area under commercial poplar in India during 2015 was 2, 70,000ha. Wood from poplar is the backbone of a thriving industry of plywood, board, match and paper units of varying scales of operation. Poplar has immensely contributed to environmental and economic well-being of north India and has reduced pressure on forests. There is a considerable scope for augmenting the role of poplar in ecology and economy of the country.

PRICE OF POPLARAND EXPLOITATION BY MIDDLEMEN

Duringpast five years, the price of poplar wood has declined considerably. A steep fall occurred during 2002 to 2004. In December 2006, the price rose to Rs. 600-650 per quintal for oversized wood. The price varied around Rs. 1200 per quintal during 2011-2012. The price crashed in 2013-14 and the present prices are close to the minimum of the decade.The middlemen provide service to the growers and smoothlyhandling lengthy and difficult procedures of harvest and transport farmers take the easier step of selling the standing poplar trees to middlemen at a much lower price than offered at the buying centre of the industry or wood market. Thus, an unreasonably large share of profit accruable to the grower goes to the middlemen.

HARVEST, TRANSIT AND MARKETING OF WOOD

The government has tried to facilitate easier harvest and transit of poplar wood, particularly in parts of Uttar Pradesh where it was much more difficult than in Haryana and Punjab. The new system involves obtaining of revenue document proving cultivation of poplar by the farmer. The document is supplied to the Divisional Forest Officer who uploads the document on the e-web created for this purpose and permission is granted by the state forest department. However, procedure consumes lots of time and puts hassles in the way of farmers.Mandi Samiti tax @ 2% is imposed on poplar wood even when the wood does not physically go to the mandi as it is often transported directly from farm to the industry. The tax is avoidable; removal of this tax can provide some relief to the grower. *E-Way* bill and GST should be introduced on poplar wood at all places to overcome hurdles from police and forest departments.

INDUSTRIES

An environment of trust between industry and farmers can be developed if the industry determines the ratio between the price of wood and price of finished product and links wood price to the end product.Industry is also at the receiving end of an under developed market. Ungraded material reaches the industry. The industry is required to do multitasking which leads to wastage of machinery, space and manpower in grading, preparing and pre-processing of poplar wood. The rate of wastage is high which increases the cost of production.Development of newer value-added products may fetch a higher price of poplar products, and eventually higher price of poplar wood, in the market.The control on establishment of new wood-based industries and expansion of existing industry is now vested with the states.

EVOLUTION OF NEW CLONES

Genetic improvement of poplar is underway at many organisations, including Forest research Institute, Dehradun and new clones have been produced through hybridisation as well as through import of seeds from natural stands in the USA.Seed was collected from 104 candidates plus trees in

44 stands covering 10 states in the south- eastern parts of USA in collaboration with Mississippi State University. The progeny was raised and evaluated at the FRI, Dehradun. About 100 clones were produced out of it (Table 17).

Production of new clones through intraspecific hybridisation in *Populus deltoides:* Employing clones with superior rotation-age volume, intraspecific hybridisation has been carried out. The progeny of 41 control crosses was tested in nursery trials and 211 clones were selected out of it for conducting field trials. Progeny of 19 open-pollinated families was also evaluated in nursery and 89 clones were identified for field tests.

Plant height, stem diameter trunk volume had low to moderate (0.21 to 0.41) broad sense heritability (h^2) values. Sylleptic branch number showed high genetic advance (77.53%) despite moderate h^2. In nursery trial, the h^2 estimates were moderate to high h^2 (0.61 to 0.69) for growth traits. It is possible to apply selection on the basis of principal component analysis (PCA) accounting for a large part of the total variance in the observed growth relying on trunk volume followed by stem diameter, plant height and sylleptic branch number. The promising clones *viz*. FRI-AM-53, -70, -51, -6 and -45 outperformed the control clone G-48. Stem diameter showed high (0.97) genetic correlation with trunk volume and proved to be a reliable criterion for selecting for trunk volume. The set of 25 most promising clones based on PCA1 ranking will be effective for selection of clones at age of three years. Wider testing of clones is required to be done to recommend the best clones for different environments.

Table 17: Source of clonal material and parental origins of poplar tried at the FRI, Dehradun

Number of		Clone name	Location in the USA	County
Families	Clones	(suffix for FRI-AM-)		
1	5	4, 66- 69	Tombigbee River, Columbus, Missisipi	Lowndes
2	8	6, 7, 9, 10, 77, 78, 81, 82,	Tombigbee River, Fulton, Mississippi	Itawamba
2	20	12-15, 17-19, 21-23, 27, 30-34, 87, 89, 105, 115	Roanoke River, Rich Square, NC	Northampton
2	3	35, 37,95	Ashley/Edisto River, Summerville, SC	Dorchester
1	11	40, 41, 44-46, 48-53	Saluda River, Silverstreet, SC	Newberry
1	5	57-60, 64	Tombigbee River, Tupelo, Mississippi	Lee
1	6	70-74, 76	Tombigbee River, McIntosh, Alabama	Washington
3	6	91-93, 96, 109, 110	Tennessee River, Paris, Tennessee	Benton
1	4	97, 98, 100, 101	Clinch/Tenn. River, Oak Ridge,Tennes	Roane
1	1	111	Apalachicola River, Quincy, Florida	Gadsen
-	2		C_1 (G-48), C_2 (UDH-47-7) (checks)	
15	**71**		**10 locations**	**10provinces**

Limited funds for research are a major handicap in focused research. Research support from industry is simply absent. Indian Council of Forestry Research and Education (ICFRE), Dehradun has introduced poplar in Vaishali, Bihar on a large scale under Samudai Adharit Samanvit Van Prabandhan Evam Sanrakshan Yojna (Bihar Project) during 2006-2012. Extension activity has now spread to other suitable districts of Bihar state.

ROAD AHEAD

- Poplar culture faces a huge challenge in present times. There are concerns about lowering of water table in north India which is attributable to several factors; blame has also been put on cultivation of fast-growing trees like *Eucalyptus* and poplar. There is a lack of evidence to say that poplar or other trees waste water. Farmers themselves are looking for fast-growing trees with less water requirement. Cultivation of Burma *Darek* (*Melia dubia*) is gradually picking up in many areas.
- In order for poplar to remain an attractive planting species, the industry needs to give a fair price to poplar growers for poplar wood. Linking wood price with the price of end product can be workable option. More poplar-based industrial units need to be established in areas other than Yamunanagar. This would provide alternative market to poplar growers to sell their wood. Plywood units existing in Lucknow, Raebareli and similar areas in Uttar Pradesh and Bihar have indicated the author about shortage of poplar wood in those areas. Simpler harvest and transit rules would enable industries in such places to easily procure poplar wood from other districts/states for the benefit of growers as well as industry.
- Unlike other trees that are grown on forest land or uncultivated land, poplar is grown on agricultural fields with agricultural crops. Hence, participation of farmers in research on poplar cultivation is of vital importance. Progressive farmers should support field trials on their farms. Severe problems of insect pest and diseases wherever observed in poplar nurseries and plantations may be brought to the notice of Head, Forest Protection Division, Forest Research Institute, Dehradun (phone 0135-2752676, 2752672).
- Research on diversification of poplar usage is of utmost importance. Research and industry need to coordinate to develop newer products.
- Removal of *Mandi Samiti* tax and its replacement with e-Way bill and GST at all places may overcome hurdles on poplar wood marketing from police and forest departments.

SCENARIO OF INSECTS AND DISEASES OFPOPLAR IN PUNJAB

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Poplars are prone to the attack by various insect pests among which several defoliators, sap suckers, borers and bark eaters attack these species in nurseries and plantations. Important insect defoliators are:*Closterafulgurita (Walker), C restitura (Walker), Phalanta (Atella) phalanta, Trabala vishnou, Orygia postica, Asphadastis cryphomycha*and leaf webber. Among the borers, poplar stem borer, *Apriona cinerea* and bark eating caterpillar, *Indarbela quadrinotata* Walker are serious threats to poplar. Over 100 insect species have so far been recorded by different workers causing damage of various intensities to poplars in India.

INSECT PESTS OF POPLAR

1. Poplar defoliators (PD): *Clostera fulgurita* is a major defoliator of poplar resulting in severe damage in nursery as well as plantations. The incidence of the insect was recorded in all agro-climatic zones. The peak period of activity is from July to November with two distinct peaks during July and October. Population of this pest is more during second peak.Defoliator'spopulation followed trend similar as of its incidence. The moths are grey brown with larger forewings (3.6-4.6 cm wing expanse), white irregular markings on the anterior half. Male moth has an anal tuft of hairs. It lays light yellow coloured eggs in clusters formed of many rows on the leaves and twigs (rarely). Full grown larva is pale brown covered sparsely with short pale hairs. Pupa is obtect and dark brown in colour. The female pupa is larger than the male. There are 10 generations per year.

2. Phalanta leaf feeder: *Phalanta phalanta* causes heavy damage by eating away all the leaf tissue. This is a minor defoliator of poplar and the peak activity period is limited from July to September. Adults are light brown with black spots on the forewings and the hindwings. The larvae are creamish initially and finally turn brown in the later instars. There are black spines like structures all over the larval body. They eat the leaf wholly without skeletonising it. The pupation takes place on the leaves, branches and trunk. The pupa is fluorescent green in colour.

3. Poplar leaf webber: *Asphadastis cryphomycha* eats away all the leaf tissue by webbing two leaves together and feeding inside. Newly hatched larvae are creamy white with shining black head, which changed to greenish yellow with light brown head in the fifth instar. The prepupae are broad anteriorly and tapering posteriorly. The colour of the pupa is yellow initially which changed to dark brown finally. The general body colour of the moth is dusky brown; the forewings are light brown with irregular black spots dorsally, having one black band on ventral side and fringed with black hairs at apical margins.

4. Bark eating caterpillar: *Indarbela quadrinotata* is a serious and major pest. Extent of damage caused by this insect may be up to 30 per cent. The attack is more pronounced in plantations where it causes heavy qualitative and quantitative loss. The neglected plantations are more prone to the attack of this insect. Repeated and severe attack by this insect for 2-3 years results in complete death of the plant. The peak activity period of the pest extends from July to October. The larvae of the insect are usually nocturnal feeders. In the field, first instar larvae are dirty brown while the full grown caterpillars (5-6 cm in length) have pale brown to brown body with dark brown head capsule.

5. Poplar stem borer: *Apriona cinerea* makes circuitous tunnel/gallery formations in the branches and stem of the host plants, make the plants weak and unsuitable for timber purposes. The trunk and branches are hollowed out. Mostly 1-3 years old plants are more prone to attack and older ones are free from attack. In the nurseries the grubs bore through the stools and make circuitous galleries downwards. Generally single grub is found in the nursery plants. In the plantations, the galleries extend from the branches, trunk and finally to the roots. Circular holes at 10-12 cm distance can be seen on the branches/trunk. The grubs are active up to October.

6. **Termites:** The incidence of termites may be up to 80 per cent.It is a very serious pest which can wipe out the entire population of trees if not controlled in time.

DISEASES OF POPLAR

1. Drechslera leaf spot caused by *Drechslera maydis*: Drechslera leaf spot of poplar is a serious disease especially in nursery causing premature defoliation. The disease starts as minute specks of light brown colour on lower leaves of the plant. These enlarge to form spots of size 0.4 –0.8mm. The spots are light brown with dark purplish brown margins that may be surrounded by chlorotic area. Medium to large sized spots have ring type pattern. The disease appears in rainy season. The disease is more serious in nursery sown in the same place year after year.

2. Myrothecium leaf spot caused by *Myrothecium roridum*: Myrothecium leaf spot of poplar occurs in nurseries near the riverbed during hot and humid months. Spots on leaves are round to oblong or irregular shaped, 5 to 20 mm in diameter, which are light brown in the center with dark brown margins. Spots coalesce to form bigger patches giving blight appearance. Spots are characterized by the appearance of sporodochia in the center of the spots as raised, rounded structures which are initially white and later turned olive green to black in colour.

3. Cercospora leaf spot caused by *Cercospora populina*: Brown to dark brown round spots of variable sizes appears on leaves, the centre of which contains a dark speck giving a dot like appearance. The colour of the spots is same on both the sides. The spots coalesce to form bigger patches, to give blightened appearance. Premature defoliation is very common due to this. The disease is more during the month of August and September.

4. Alternaria leaf spot caused by *Alternaria alternate*: The disease starts as minute spots of brown colour with dark margins. These spots merge with each other to form large irregular patches. A close observation of spots show ill defined concentric rings. The maximum incidence may occur up to 90 per cent.

5. Cutting rot caused by *Botryodipolodia palmarum&Cladosporium lunata*: Cutting rot is a serious disease of nursery. The infection appears on the cuttings as black raised areas having pycnidia in it. These pycnidia release millions of spores of the fungus when they absorb water. Black discoloration and fungal mass below the bark can be seen. Browning of the wood portion and rotting is also common. Ultimately the cutting along with the roots rots and sprouts wilts lead to the death of the plant. The disease intensity appears to increase with the termites' injury to the cuttings.

6. Stem canker and die back caused by *Botryodiplodia*: Stem canker is characterized by sunken lesions on the bark, on southern side of main trunk facing the scorching sun during the day time. The bark is predisposed to the fungal attack by sun burns and bark becomes thin and dry. Disease can be easily identified from the black pycnidial bodies on the sunken bark which can cause further spread of the disease. Due to oozing of sap in some plantations bark starts rotting and attacked by weak pathogens like *Phomopsis* sp. and *Botryodiplodia* spp. Injuries due to tractor or farm operations or pruning, etc. predispose the plant to attack of the canker fungi.

DAMAGE BY *NEELGAI (BOSELAPHUS TRAGOCAMELLUS)*

Neelgai or blue bull damages young plants in the nursery and in the plantation by removing the bark or sometimes by breaking the stem. It is worth mentioning that *Neelgai* is a protected animal under Indian Wildlife Preservation Act-1971 and can't be killed. The plants can be protected from this mammal by maintaining cleanliness by removing the weeds and heap of its pallets, so the animal herd is forced to change its place of resting and herding, raising live fence with *Euphorbia*, agave, *Opuntia,Caesalpinnia,* etc. along the boundary and*Chhapa* binding (wrapping) with date palm leaves ensures hundred percent protection of plants.

Small polythene bags filled with about half glass of water tied on the stem provide very effective control. These polybags produce some sound, which drives *Neelgai* away from the fields.

MONKEY *(MACACA MULATTA)*MENACE

Rhesus monkey damage the plants by breaking the stems of young plants while roaming or while trying to eat the larvae of the insects feeding on the leaves of poplar. Only barbed wire fence can keep them away. They are also protected animals under wildlife act and can't be killed without permission of chief wildlife warden of the respective states.

UNIT WIMCO SEEDLINGS – AN EXPERTISE FOR QUALITY POPLAR PLANTING STOCK AND PLANTATIONS IN INDIA

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Wimco seedlings are the popular name in the arena of agroforestry plantations in the country for last four decades. Wimco Seedlings (WS) is a Unit of Paper boards and Specialty Division of ITC Ltd. known for its high yielding poplar clones that are grown in agroforestry model in North Indian states. Wimco Seedlings is a premier industrywhich produces and supplies quality planting material of commercial use to the farming community and other stakeholders. It holds the badge of promoting agroforestry in the country which not only has economical and social impact on the lives of people but also has ecological significance to the local ecosystem and environment as a whole.

The tangible benefits of the agroforestry plantations include supplementary income from the farm land in addition to the agriculture crops, more flow of the cash income and enhanced social status of the agrarian community. While the intangible benefits are improved microclimate, local ecosystem and the environment by way of soil enrichment, carbon sequestration and ecological amelioration.WS has helped farmers by sustaining farm income with its operational advantage in four states viz. Punjab, Haryana, UP and Uttrakhand with large team of dedicated and experienced managers and staff resulting many "Success Stories" of the farming community involved.

Populus is a genus of about 40 species of deciduous flowering plants in the family Salicaceae, native to most of the northern hemisphere and out of them six are indigenous to Himalayas. But none of the six species are suitable for wide cultivation for timber production in India. Some species of poplars found in Europe and USA have long been grown in commercial plantations as an industrial wood. Theational scenario of dwindling industrial raw material supplies from forests and in particular the acute shortage of match wood experienced from early sixties onwards was a signal for the wood-based industries to begin a search for alternative sources of wood.

The then Wimco Limited, impressed by the potential of poplar plantations raised in the *Tarai* by UP Forest Department, began investigating thepossibilities of raising poplars in the agriculture sector, to enable grow match wood as an agroforestry crop under a mutually profitable arrangement with farmers. In its quest for developing a practical agroforestry model based on poplars as would be acceptable to the farmers, Wimco sincerely began embellishing the model followed by the forest department.The first requirement was to find a superior poplar clone which could reduce the harvest rotation to a maximum of eight years, while attaining dimensions suitable for industrial uses.

PIONEERING WORK ON CLONES TESTING

Wimco imported a number of poplar clones from 1965 to 1979 and subjected them to field performance trials over a wide region, wherever possible in collaboration with the UP-ForestDepartment. It was providential that Prof. L.D. Pryor from Australia while inIndia (1968) visited theWimco Match factory at Bareilly and appreciating the work on agroforestry being conducted by the match industry, advocated testing of G-3 and G-48 clones in the foot plains of the Himalayas. Later G-3 and G-48 clones of P.deltoides were imported by M/s WIMCO Limited fromAustralia during July 1969. Cuttings were multiplied and were handed over for field testing toResearch Wing of Uttar Pradesh Forest Department during 1973.

Test peeling of clone G-3 was done during 1981, when it was consideredsuitable for match splints. On the basis of its growthperformance inTarai andplains of Uttar Pradesh and its suitability for match splints, its cultivation was advocated on farmers' fields. The wide adaptability of clones G-3 was responsible for introduction of poplars under agroforestry of north Indian plains.

COMPATIBLE CROPS WITH POPLAR

Subsequent poplar breedingprogramme at WIMCOled to releaseof 15 indigenously developed clones from its improvement programme for field planting. These clones viz., Udai, Kranti, Bahar, WSL 22,

WSL A/26, WSL 27, WSL 32, WSL 39, WSL A/49, Wimco 62, Wimco 81, Wimco 83, Wimco 108, Wimco 109 and Wimco 110 can easily be integrated with any winter crop coinciding with the winter months poplar planting. Crops like sugarcane (1st year), moong, urd, lady's finger, gram, peas etc may be easily intercropped with Poplar plantations. In the Region of Intensive Poplar Culture (RIPC), there exist very successful agroforestry models with wheat, turmeric, menthe, etc. Thus, WIMCO made poplars; the first and the foremost agroforestry species by extending its cultivation in the irrigated farmlands of north-western India. The company continues to contribute to the farming community of poplars and is presently the biggest producer of quality planting propagules of poplar clones and patronized by the discerning farmer

SILVICULTURE OF POPLAR

on land preparation, occupation of fields with intercrops and other field conditions. The most common spacing adopted is 5 m x 5 m or 5 m x 4 m or 7 m x 3 m or 8 m x 3 m in blocks and 2-3 m apart in lines and boundary plantations across the poplar growing region. Wider spacing favours growing agricultural crops with higher yields for longer period then closer spacing. Poplar grown in block plantations produces better quality timber with circular stem, less knots and other defects and therefore fetches higher price in the wood markets. Silviculturally, poplar grows better under mild competition in stands, whereas, trees tend to become branchier, if planted wide apart especially on boundaries. Poplar is extremely fast grown and attains marketable size timber at very young age. It is generally harvested at 6-8 years of rotation which sometimes is extended from four to twelve years. The tree is mainly grown as a cash crop for sale of timber to wood-based industry.

EXTREMELY FAST GROWTH

Good growing plantations attain 5 m average height and 5 cm average diameter per annum. Poplar logs of thick girth size are sold at higher prices throughout the RIPC. Percentage of logs with thick girth sizes increases with increase in the harvesting age of trees. The ratio of over (over 60 cm mid girth) and under size logs (between 50-60 cm mid girth) varies from 55 per cent in 5 years old trees to 95 per cent in 10.5 years old trees. Poplar logs are usually processed when these are fresh. Almost all components of poplar trees including logs, roots, lops and tops along with bark separated at processing sites or at harvesting sites are sold in the market. These are sold on weight basis which is recorded just before finalizing the deal for sale/purchase.

ECONOMICS

Poplar based agroforestry is reported to be economically viable and more profitable than many other land use options with minimum risks. The economical returns from poplar farming fluctuates with marketing conditions for sale of tree and intercrop yield components.
In general, 3 to 4 quantals per tree weight is recorded in case of 7-8 years old plantation. On average 200 nos. of trees are planted per acre and there by around 500 quantals of wood may be obtained, which fetches Rs. 3.4 lakh with expected market rate to be around Rs.700 in five years from now.Poplar is generating goods that include timber, firewood, fodder, leaf manure, etc. The use of poplar wood is now diversified to around three dozen products of which panel products, firewood, paper pulp, match splints, sports goods, artificial limbs are the major ones.

USES

Poplar wood is used for manufacturing around three dozen products. Poplar has now developed a complete use of its all tree components. Even leaves and foliage with thin branches are lopped and converted into chips for sale to wood-based industry as fire wood. Paper pulp is the third major use of poplar wood after panel industry and firewood in India.

ENVIRONMENTAL IMPACTS

In addition to this, its farming helps in sequestration of harmful gases into wood biomass and soil, locking greenhouse gases inproducts made from its wood; substituting sustainably grown firewood for fossil fuels in domestic and industrial use; bioremediation of soil, air and water by absorbing pollutants; conserving soil and water along the ecologically sensitive areas.

POPLAR FOR ENHANCED INCOME AND ENVIRONMENTAL AMELIORATION IN THE COLD ARID REGION OF LADAKH

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Due to small land holding and low productivity, people are dependent on very limited crops. Because of harsh climate conditions, natural forests are spread on a very limited area. These are sporadically present near banks of the rivers streams (Indus and Shyoak) and glacial melt outlets. Although man made plantations have a history to reckon with and area is increasing gradually yet the forest area is small which cannot improve the climate of the area significantly. The people of the area have now realized the importance of the trees in ameliorating/stabilizing and rendering the climate more conducive not only for humans but also for animals and crops.

POTENTIAL OF POPLAR

Forests are neither available/affordable nor accessible for utilization in the area. The tree resource in the region is very limited (important genus like *Populus, Salix, Elaeagnus, Morus, Ulmus,* etc.). The narrow provision of species in the region though may not provide the diverse range of goods but these trees can provide the much required services. Farmers have income generating opportunities from plantations. These plantations provide solid wood, several other products and values. Poplar and willow is two major farm grown timbers, which are used as renewable resource and not uprooted on harvesting, rather allowed for regeneration through coppice.

Populus nigra having a straight stem and narrow crown dominates on the farm lands (Fig.4) whereas other three species (*P. balsemifera, P. alba* and *P. euphratica*) with spreading branches are not common on farm lands but occur in forest areas. These species also contribute substantially for fuel and fodder for the region. *Populus euphratica* and *P. alba* are available in Nubra valley, whereas, *P. balsemifera* is common in Leh and lower areas. Very big trees of *P. balsemifera* are available in Leh and surrounding areas. Since conditions are quite harsh in uncultivated area, therefore, tree biomass requirements for domestic use have to be met from agricultural land itself.

Farmers believe that the yield of crops is lower when these are grown in association of poplar trees except *P. nigra* which has little impact on inter-cultivated crops due to straight stem and narrow crown. Therefore, *P. nigra* is most suitable and acceptable for on farm planting and it provides higher economic returns as compared to other tree species. However, little systematic work has been initiated and needs to assess the value chain of poplar.

Over the last few years, farmers/monasteries have resorted for the large scale plantations of willows and poplars as fast growing trees in Ladakh region (Leh and Kargil) as part of drive to reforest the region and create an adequate local supply for fuel and timber besides improving the environment. Their efforts have shown enormous potential for mass forestation in the region and indeed it would make a considerable difference in overall tree coverage in the region. Timber is imported from other parts of the country, which would never be cheaper than what could be made available locally; therefore the trees are raised in blocks as well as on field bunds. Poplar offer good quality of forage for the animals, which is a scarce resource for large number of domestic animals in the region.

Plantations in Ladakh region are perceptional at different stages of development. People are confronted by very basic issues of material and service benefits of trees, instead focus has shifted to tackle next generation of issues like precipitation in the form of rain would increase in case the area is brought under plantations.

Myths/misunderstanding/misinterpretation/misinformation (M's) have discouraged the farmers for big plantations that tree plantation would lead to enhanced precipitation in the form of rain, which would be catastrophic in this fragile ecosystem. At present 0.029 per cent forest/plantation, which is quite meager area to be worth appreciating and even big efforts are required to bring it to one per cent and still it would not impact the M's for increased plantation.

Fig. 4: Poplar a dominant tree on farm land in Ladakh region

DIVERSIFICATION IN TRADITIONAL AGRICULTURE

Diversification in traditional agriculture should receive high priority with high value crops and inter-cultivated perennial components to keep the population involved in land based activities. Booming tourism has led the people to abandon and and look for other means of earning through tourism. In this regard, integration of perennial components on farm lands including forest/fruit trees could be viable option for the population. Large scale plantations may ensure much deficit oxygen in the region, fodder and fuel apart from securing the land from further degradation.

Guinness World Record for planting one lakh willow plants in a day (9814 volunteers raised 99103 willow plants near CAZRI RRS Leh Stakna research farm) is indicative of peoples support for forestation. The non-governmental organizations have made some successful efforts in rehabilitating the degraded lands but their efforts are required to be supplemented and complimented by the institutional financing and technological inputs. The measures to build mechanism for developing and strengthening institutions support for achieving mass adoption through strong value chain would boost the initiative. Intensively managed poplar and willow plantations can be a major help to the region striving for more favorable balance of timber trade. Ancestors in Ladakh have introduced these plants and we need to carry forward the legacy and enrich the resource base. The need for sound technical knowledge and mass awareness require focused emphasis.

FOREST DEPARTMENT COOPERATION

Extending area under seabuck thorn (*Hipphophae*ssp.) through natural regeneration cannot be accounted success of the state forest department for making area green. Recent development of transferring seabuck thorn from forest to horticulture department would require more concerted efforts from department on other tree species. Private plantations are well managed, while neighboring forest area apparently not of same status, which indicates that achieving excellence in plantation does not necessarily require additional investment. There is need to pay more focused devotion to serve the cause. Despite challenges farmers have shown that the prospects of plantations success are bright and there is need to put concerted efforts to achieve the greenery in cold arid region as well.

At present, no specific clone has been identified for plantations and even the management practices are old age practices, which need to be refined including post harvest processing. The changing climate may pose challenges not for inter-cultivation but increased humidity may require proper processing as well. Crude traditional methods are in use for making estimates, which requires be assessing and digitizing to watch the interest of the adopters. Due to resource constraint, each and every tree component has economic value. At present, poplar logs are mainly used for the roofing purpose and low humidity has least impact on its longevity. A lot more is required to be done to get the direct (timber, small wood, fodder, etc.) and indirect benefits (micro-climate amelioration, oxygen supply, carbon sequestration, soil enrichment, recreation, etc.) of poplar agroforestry in cold arid region of Ladakh.

NATIONAL AGROFORESTRY POLICY 2014

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Agroforestry is an effective land use system which contributes to food, nutritional and environmental security and helps in mitigating the green-house gas (GHG) emission through microclimatic modification and carbon sequestration. Beside its multifarious use as food, fuel, fodder, fibre and timber, it enables smallholder farmers to optimize their land use. Also agroforestry has significant potential to provide employment and additional income to farmers.

NATIONAL AGROFORESTRY POLICY (NAP) 2014

Fortunately, the above mentioned obstacles were recognized and India launched National Agroforestry Policy in 2014, which is first of its' kind globally. The major objectives of the National Agroforestry Policy are to:

- Encourage and expand tree plantation in integrated manner with crops and livestock to improve productivity, employment, income and livelihoods of rural households, especially small holder farmers.
- Protect and stabilize ecosystems, increasing forest/tree cover and promote resilient cropping and farming systems to minimize the risk during extreme climatic events.
- Meet the raw material requirements of wood based industries.
- Supplement the availability of agroforestry products such as the fuel-wood, fodder, non-timber forest produce and small timber of rural and tribal populations, thereby reducing the pressure on existing forests.

Since the launch of NAP in 2014, considerable progress has been made in terms of putting it into practice. To implement the recommendations, an inter-ministerial committee has been set up. Department of Agriculture Cooperation & Farmers Welfare (DAC&FW) under the Ministry of Agriculture and Farmers Welfare (MOA&FW) is now the nodal Ministry for implementing agroforestry. The Ministry is playing a significant role in the promotion of agroforestry. It has taken a policy decision to include trees in all its programmes and this will significantly increase tree-planting on farms. Efforts are on to issue guidelines on the production and supply of high-quality planting material and accreditation of nurseries producing agroforestry planting material.

SUB-MISSION ON AGROFORESTRY (SMAF)

In order to implement the policy, a dedicated scheme "Sub-Mission on Agroforestry" is launched with aim "*HAR MEDH PAR PED*" during 2016-17. The Sub-Mission on Agroforestry has broad interventions of:

- Nursery development for quality planting material
- Plantation on farm boundaries as peripheral and boundary plantation;
- Low density plantation and high density block plantation
- Capacity building & trainings

Relaxation of transit regulations is pre-requisite for assistance under Sub-Mission on Agroforestry (SMAF). The SMAF is focused to achieve increase tree cover to enhance carbon sequestration, enrichment of soil organic matter, availability of quality planting material, improvement in livelihood and productivity enhancement of crop and cropping systems.

Adoption of agroforestry will help in maintaining the productivity of the soil, reducing Green House Gas emissions through carbon sequestration, adaptation and mitigation measures for climate change and for creating additional source of income for farmers. Besides, this will contribute towards achieving country's committed Nationally Determined Contribution (NDC) for creating additional carbon sink of 2.5 to 3 billion tons through additional tree cover.

NEED FOR POPLAR AGROFORESTRY SYSTEMS

The intensive cropping system has ensured food security of the nation but this system has resulted in depletion of native nutrient reserves, under-ground water table, emergence of multi-nutrient deficiencies and resurgence of insects and diseases. Such an over-exploitation has accentuated the need for diversification from this over exhaustive cropping system. One of the viable options for crop diversification is the adoption of agroforestry. In such a scenario only economically viable multi-purpose trees that are compatible with agriculture crops can be adopted. Poplar plantations or bund planting has been a success story of agroforestry systems providing environmental safety and economical security apart from proving livelihood to lakhs of people.The downfall in the price of wood has discouraged the farmers in the recent years for planting trees with enthusiasm. It is therefore, necessary that the Govt. should ensure a remerattive price of farmer's wood by making policies.

PATHWAYS TO ACHIEVE THE OBJECTIVES

- Mainstreaming agroforestry in agriculture policies and strategies
- A dedicated corpus be created to leverage resources available under various schemes/programs/missions in undertaking focused and synchronized interventions for agroforestry sector particularly in meeting the gaps and up-scaling the efforts in a coordinated manner.
- States to create enabling environment and legislation and simplify regulations related to forestry, land use & land tenure, especially those linked to harvesting and transportation of trees grown on farms.
- States have to identify about 20 commonly grown trees species which can be grown on farmlands for the economic and ecological benefits of the farming community. These species have to be notified for exemption from any state regulatory regime, especially on growing, harvesting and transit.
- States to ensure a secured land tenure system, safeguarding the interest of small and marginal farmers and create a sound base of land records and data for developing an MIS for agroforestry for a transparent and non-controversial operational system.
- Public private partnership (PPP) to be encouraged for road side/canalside/barren community land/other non-forest waste lands for promotion of agroforestry to provide opportunities of economic returns and contributing ecological services.
- Providing quality and certified planting material, at local level through promotion of nurseries, duly registered and accredited by a third party, by involving government/private sector.
- Data collection with source of agroforestry produce at National level byrecognized statistical organizations (viz. CSO, NSSO) to be done to have legality data of source of agroforestry produce to facilitate hassle free harvesting/transport/traceability of source/chain of custody.
- Agroforestry research to be encouraged, both in government and private sector, particularly for multipurpose indigenous species with higher nitrogen-fixing ability, so as to meet the

local needs for fuel, fodder and timber as well as improving the soil health. It should also focus on developing market driven models suitable to different ecological conditions to encourage farmers for adopting agroforestry as a viable enterprise.

- National Research Centre for Agroforestry (NRCAF) may be upgraded to anational level institute of agroforestry with regional setups in major agro-climatic zones of the country. Agroforestry research wing of ICFRE also be strengthened and taken advantage of to provide stimulus and create an enabling environment for the growth of private research and extension services.
- Appropriate extension mechanism equipped with scientific setup involving State Agriculture Universities (SAUs), *Krishi Vigyan Kendras* (KVKs), *Van Chetna Kendras,* etc. be put in place for agroforestry. Cost-effective extension models may be devised involving farmer's groups, NGOs, public/private agencies, Farmer Producer Companies, etc. to disseminate knowledge/information of this sector. Encouraging agroforestry as a course curriculum in school education and motivating youths to grow and conserve trees.
- National Bureau for Plant Genetic Resources (NBPGR) to focus on conserving, monitoring and providing guidelines for germplasm exchange of agroforestry species.
- Marketing infrastructure including market information system to be put in place with active collaboration of the private sector. Contract farming, Public Private Partnership, Special Purpose Vehicles mechanisms may also be explored to promote and upscale agroforestry. Road side/canal side/barren community and/other non-forest waste lands to be encouraged for plantation of agroforestry tree species to provide opportunities of economic returns as well as contributing towards ecological benefits. These activities may be promoted through public private partnership mode.
- Agroforestry farmers also to be considered eligible for incentives on input subsidy, post-harvest management facilities, interest moratorium etc. as are being provided to farmers growing agricultural crops.

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