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GROWTH AND YIELD OF POPLAR (*Populus deltoides*) GROWN IN TELANGANA/ANDHRA PRASDESH


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Summary :

Poplar (Populus deltoides) is a temperate tree that occurs at latitudes above 28°N in its natural distribution range. The tree has been extensively grown by farmers on their fields in North India for matchwood production since four decades. The tree now finds usage for around three dozen products, paper making being its third major use. Available literature indicates suitability of poplar for a very large number of paper products.The present report is based on the systematic introduction of number of clones to some locations in Telangana and Andhra Pradesh at around 17°N latitudes. Variation has been recorded in term of growth and wood yield among the tried clones. Prediction equations have been developed to estimate weight (over bark and under bark) of two meter length logs based on their girth recorded at their thin, thick and mid ends. Its initial growth in Telnagana/Andhra Pradesh is satisfactory, however with age the tree height growth is less compared to those grown in North India. Even at the present level of growth, productivity and its better integration with intercrops, poplar could significantly contribute towards meeting the raw material needs of wood based including paper industry and also to provide better returns to growers in the south.

Poplar is a multipurpose tree that is used for around three dozen products. Different tree parts find different and multiple uses. The major portion of the main stem is converted into logs for peeling, some specialized products like manufacturing of cricket bats and artificial limbs after sawing. Veneers made from logs are converted into multiple products ranging from a small sized product like matchsticks or tooth picks to wood panels and composites. Middle sized logs are sawn in to billets for filling in ply-board, thinner ones finds use as pulpwood and still very thin as firewood. Lopped branches including foliage is chipped for firewood. Even roots and bark is extensively used as firewood domestically and industrially.

There are atleast four indigenous poplar species viz., *P. ciliata, P. gamblei, P. jacquemontiana var. glauca* and *P. laurifolia* to Indian Himalayas. *Populus deltoides*– a temperate tree grown in North India is an introduced poplar from U.S.A. Its culture has been promoted by a safety matches company-WIMCO (now merged with ITC) for matchwood production. It has been commercially grown for the last four decades in plains near Himalayan foothill (1). The tree is grown by thousands of farmers as cash crop along with traditionally grown agricultural crops. The tree has transformed rural economy in many parts of its culture (2). Numerous organisations including individual farmers observing its better performance in North India have tried to introduce it in other states and regions. The results of its growth performance at new locations have been mixed. A systematic introduction and monitoring of poplar clones were started recently in Telangana/Andhra Pradesh when number of clones were introduced from North India and planted on farm land with intercrops. Planting of poplar saplings in these locations is part of ITC PSPD forestry initiatives along with their ongoing plantations of *Eucalyptus, Leucaena* and *Casuarina* species for meeting raw material needs of its paper factories.

MATERIAL AND METHODS

Poplar saplings were procured in three stages viz., 2010, 2014 and 2015 planting

seasons in winter months. Five hundred saplings each of six clones viz., WSL 39, Wimco 81, Wimco 108, Wimco 109, Wimco 110 and Udai (3000 together) were procured from Wimco Seedlings, Rudrapur (now unit of ITC PSPD) and transported through road route on 23rd January 2015, There was also procurement of some saplings of WSL 32, WSL 39, WSL 22 L35, L36, G48, S7C8, S7C20, L30, L39, and evergreen clones during 2014 and those of evergreen, L 30, WSL 22, S7C8, S7C20 during 2010. Out of 3000 saplings of six clones procured during January 2015, 1240 were planted on the farmer's fields in four locations in Telangana/Andhra Pradesh and the remaining were made into stem cuttings to raise nursery inside the premises of Khammam factory (Table-I). The saplings were planted at 7x 3 m spacing at one field location and at 5x4 m spacing at other locations.

Saplings were planted during 2015 in four locations including one location in Bhadrachalam in Telangana, 2 locations in West Godavari District of Andhra Pradesh, and 1 location in Khammam District of Telangana. Earlier obtained poplar clones were planted inside old nursery site of Sarapaka Nursery of ITC PSPD, Bhadrachalam, Khammam, Telangana. The age of the field planted poplar was 12 and 24 months (planted in Feb., 2015), 15 and 27 months (planted with polybag plants in 7th July, 2014), and 60 and 70 months (planted during 2011 and Dec., 2010 respectively) when tree growth and yield were recorded (Table-I). The data on Girth at Breast Height (GBH) and height for 12 and 14 months growth for different clones planted in six sites was subjected to Analysis of Variance using MINITAB software to draw inferences on their growth. Sample trees of different clones and ages were harvested, converted into one and two meter logs, girth at thick and thin end of logs recorded, logs debarked and their fresh weight with and without bark were recorded. Prediction equations have been developed to estimate the fresh weight of logs (both under bark and over bark) based on girth at thick, thin and mid end. Mid girth of logs was estimated by taking average of thick end and thin end girth of logs.There were 120 logs of two meter and 13 logs of one meter. Generally one meter logs were made from the basal portion of tree stem. Prediction models were not developed for one m logs as their population size was small.

Table-I. Details of the field trials of poplar in Telangana and Andhra Pradesh

Location	Site No.	Clones	Planting time	No planted	Plantation site
Bhadrachalam	I	Wimco 108, Wimco 110	9-10 Feb., 15	180+200	Light black soil planted with chillies and pigeon peain the second season
Bhadrachalam	II	Wimco 81, WSL 39	17-19 Feb., 15	120+100	Red soil, fodder grass gown throughout the year
West Godavari (Jangaraddygudem)	III	Udai, Wimco 110	21-23 Feb., 15	200+200	Red soil field. Tobacco crop in both seasons
Khammam(Mehbubabad)	IV	Udai	9th Feb., 15	240	Red soil, Boundary plantation
ITC PSPD Sarapaka Nry	V	WSL32, WSL39, WSL22, evergreen, L35, L36, L 39, G48, S7C8, S7C20	25th July, 14	10 plants one each of mentioned clones	Single row on nursery boundary
ITC PSPD Sarapaka Nry	VI	Evergreen	Old (2011)	One plant	Left over plant
ITC PSPD Sarapaka Nry	VII	Evergreen, L 30, WSL 22, S7C8, S7C20	Dec., 2010	Old left over plants	Planted near the old propagation chambers

GROWTH PERFORMANCE

The survival of field planted poplar during first year of planting varies between 80-95% despite they were supplied on 23rd January from Rudrapur (Uttarakhand) and field planted during a period between 9th to 25th Feb., 2015 in four field locations. The package and practice for planting poplar in North India is to keep its saplings soaked in fresh water for 48 hours immediately after uprooting and before field planting. The mortality in the field was replaced during monsoon season by planting polythene bag maintained saplings. At site-I around 3% mortality, and around 10% at site-III was replaced with polythene grown saplings whereas, no mortality was replaced at site-II and site-IV. Such plants though left behind in growth but the operation has helped in maintaining the survival and confidence of growers.

The performance of poplar in these new sites is discussed in the light of age of trees, intercrops and clones. The growth performance of poplar in the early years is comparable with many of the plantations those are grown in North India (Table-II). However the average growth during latter stage is sub-normal than what is obtained in North Indian conditions. One major factor of slow growth is low latitude, very high temperature in summers and warm winters compared to North Indian

sites. The second important factor for poor growth could be low inputs these trees received on non-cultured land unlike that in North India where it is grown with intercrops and a lot of inputs given to intercrops are also available to poplar resulting in its good growth. In North India too, if some farmers do not grow these trees with intercrops and neglect their plantations the growth of trees is poor.

There was variation in growth due to clone type among the tried sites. For example, the best growth (GBH of 21.3 cm and height of 13.77 cm in first year and 43.6 cm and 14.4 m in 2nd year) was recorded for clone Wimco 110 at site-I where it was grown with intercrops in both years (chillies as first and pigeon peas assecond crop). The same clone planted at site-II had shown sub normal growth in major part that remained inundated with water for greater period and a few saplings on upland boundary were of excellent growth. This plantation has grown annual fodder as intercrop. At site-III, first crop of tobacco was grown during its planting and another crop of tobacco was planted during Nov. 2015 inside poplar. Among the tried clones,

Table-II. Summary of growth of poplar tried so far

Sr. No.	Age (months)	GBH(cm)	Ht (cm)
1	12	12.53	10.82
2	18	38.9	12.62
3	24	33.78	12.70
4	27	58.4	13.88
5	60	50.33	15.10
6	70	52.12	13.35
7	19*	35	9.10

- From coppice shoot of harvested tree

Wimco 110 and Wimco 108 had shown satisfactory and significantly better growth when compared to others. It would however be too early to claim clonal superiority as the performance of these two clones was excellent at site-I which was better maintained by the farmer and there was a little neglect in other sites.The performance of older poplar (Table-IV) was a little subnormal than that grown in North India. The area where these were planted inside Sarapaka nursery is not agriculture field and received low cultural inputs. The trees in around five year age have attained a height of around 17 m and girth at breast height (GBH) of around 55-60 cm.

Table- III Clonal variation in height and girth of one and two year trees

Site No.	Clone	GBH1	GBH2	Increment	Height1	Height2	Increment
1	Wimco 108	17.0	30.2	13.2	12.87	14.0	1.13
2	Wimco 110	21.3	43.6	22.3	13.77	14.4	0.63
3	Wimco 81	11.0	35.1	24.1	10.44	12.2	1.76
4	WSL 39	9.5	31.9	22.4	9.76	11.0	1.24
5	Udai	9.7	28.9	19.2	9.26	11.96	2.70
6	Wimco 110	9.4	33.0	23.6	8.80	12.60	3.46
SE Diff		0.23	3.574	3.55	0.358	0.617	0.528
CD.05		0.56	8.78	8.73	0.88	1.52	1.30

Table-IV: Performance of 1.5 years and 5 years old poplar planted in Sarapaka nursery

Location	**Age of trees (Yrs)**	**Site No.**	**Clone**	**18 months**		**24 months**		**Remarks**
				GBH (cm)	Ht (m)	GBH (cm)	Ht (m)	
Sarpaka new nursery site	1.5 years	VI	WSL 32	36	13.10	63	14.75	Planted as a single row on the boundary of eucalyptus nursery. Planted with poly bags plants
			WSL 39	42	13.25	52	15.30	
			WSL 22	24	7.85	34	12.50	
			Evergreen	36	11.90	52	15.40	
			L 35	38	13.15	48	14.00	
			L 36	43	13.65	52	13.80	
			L 39	48	14.70	59	14.00	
			G 48	44	13.80	60	15.60	
			S7C8	36	12.35	46	12.50	
			S7C20	42	12.50	60	14.50	
Sarapaka old nursery site	5 years	VII		5 years		70 months		ETP planted on the boundary of nursery
			Evergreen	58	16.60	60	14.50	
			L 30	53	14.50	59	14.75	
			WSL 22	56	15.80	62	14.50	
			L 39	53	15.70	62	13.25	
			S7C8	36	13.85	36	12.10	
			S7C20	46	14.15	59	14.90	

Short tree height in these trials could be attributed to a very large number of factors, one of which could below latitudinal range (<28°N). When this tree is grown much below its natural distribution range it tends to have high tapper with less height. Poplar in the present case was grown in Telangana/Andhra Pradesh at around 17°N latitude. Such phenomena of low tree height and high taper is even recorded in the southern limits of around 26-27°N latitude in North India. In some locations at low latitudes, trees can attain appreciable height and growth, if low latitude is compensated with high altitude and cooler conditions (3), which have not been the case in these trials.Evergreen clone has also given better growth, though last year introduced clones especially Wimco 110 is doing exceedingly well showing height growth of over 4 m in the current year.

Table-V- Yield of harvested trees during 2016

Clone	Age (months)	Girth (cm) of tree at		Tree Height (m)	Crown width (m)	Weight OB (Kg)	Weight UB (Kg)	Lop and top yield (Kg)
		Ground level	Brest height					
		Length of log 2 min each case						
G 48	27	85	60	15.60	2.6	118	97	13.5
WSL 39	27	80	62	15.30	3.1	151	132	17.5
WSL 32	27	85	63	14.75	3.5	156	133	19.0
S7C8	27	55	46	12.50	3.0	76	61	14.0
Ever green*	27	61	44	13.00	2.8	85	70	14.5
S7C15	27	73	60	14.50	2.5	126	102	17.5
L 35	27	59	48	14.00	2.5	90	78	15.5
WSL 22	27	48	34	12.50	2.5	64	53	12.5
L 36	27	67	52	13.80	3.0	101	86	13.8
L 39	27	76	59	14.00	2.5	119	106	13.8
Ever-green*	70	88	56	13.00	2.8	.113	94	18.3
		Length of log 1 m in each case						
WSL 22	70	93	62	14.50	3.0	192	164	19.0
L39	70	97	62	15.25	3.5	168	147	17.5
L30	70	85	59	14.25	3.5	130	113	17.5
S7C15	70	89	59	14.90	3.1	128	111	21.5
S7C8	70	65	36	12.10	2.6	65	55	15.5
Coppice of L 39	19	42	35	9.10	3.0	39	31	8.0

** Average of two trees*

At 27 months age the trees were having a crown spread of two to three meters, weight (OB) between 64 to 196 Kg and weight (UB) 53 to 133 Kg. In addition there was lop and top yield of 12 to 19 Kg per tree at the same 27 months age. These figures indicate that poplar has a potential to give around 50 Kg wood yield (including lop and top) per year which could significantly contribute towards farmer's income and wood needs of the industry. The old aged trees have not given proportionate yield also indicates that the tree could be grown for short rotation when it can be better integrated with agriculture crops in agroforestry. The farmers thus could get their food support from agricultural crops and additional money from tree harvest of trees at short intervals.

Table-VI. Summary statistics of 120 number 2 meter logs

Sr. No.	Parameter	Mean	Minimum	Maximum	St Deviation
1	Girth(OB) at thick end (cm)	37.18	10.0	97.0	17.70
2	Girth (OB) at thin end (cm)	29.77	8.5	97.0	15.43
3	Girth (OB) at mid (cm)	33.48	9.75	97.0	16.45
4	Girth (UB) at thin end (cm)	31.25	9.0	82.0	14.98
5	Girth (UB) at thin end (cm)	25.22	7.5	63.0	12.68
6	Girth (UB) at mid (cm)	28.24	8.25	72.0	13.76
7	Weight (OB) (Kg)	15.09	3.25	49.0	10.29
8	Weight (UB)(Kg)	12.82	3.25	43.0	9.02

The summary statistics of 120 logs of mixed clones given in Table-VI show a wide variation in thickness viz., Girth at thick end (OB) from 10.0 cm to 97 cm with mean value of 37.18 cm, girth at thin end (OB) from 8.5 to 97.0 cm with mean of 29.77 cm, girth at mid log (OB) from 9.75 to 97 cm with mean of 33.487 cm. Similar trend was observed for girth at thick, end thin end and mid portion when logs were debarked. The weight (OB) varied from 3.25 Kg to 49 Kg with mean of 15.09 per log whereas, weight (UB) varied from 3.25 kg to 43.0 Kg with mean value of 12.82 Kg per log. The higher values of standard deviation in the population of 120 logs show wide variation to capture the representatives of different sizes in estimation of the equations.

Table VII–Prediction equations for weight and bark thickness of logs

Sr. No.	Predicted trait	Constant a	Constant b	Trait used for prediction	Adj R^2
1	Wt(OB)	-3.22	0.492	Girth thick end (OB)	71.4
2	WT(OB)	-0.81	0.533	Girth thin end (OB)	63.2
3	WT(OB)	-2.30	0.519	Girth mid end (OB)	68.4
4	WT(OB)	-3.48	0.596	Girth thick end(UB)	74.9
5	WT(OB	-1.81	0.467	Girth thin end (UB)	69.0
6	WT(OB)	-2.89	0.640	Girth mid end (UB)	73.0
7	Wt (UB)	-3.33	0.433	Girth thick end (OB)	71.8
8	Wt(UB)	-1.26	0.470	Girth thin end (OB)	64.0
9	Wt(UB)	-2.55	0.457	Girth mid end (OB)	69.0
10	Wt(UB)	-3.54	0.524	Girth thick end (UB)	75.2
11	Wt(UB)	-2.53	0.595	Girth thin end (UB)	69.7
12	Wt (UB)	-3.05	0.563	Girth mid end (UB)	73.4
13	Girth thick end(UB)	0.526	0.823	Girth thick end (OB)	94.8
14	Girth thick end (UB)	3.730	0.919	Girth thin end (OB)	89.2
15	Girth thick end (UB)	1.640	0.880	Girth mid end (OB)	93.4
16	Girth thin end (UB)	-0.677	0.692	Girth thick end (OB)	93.0
17	Girth thin end (UB)	1.350	0.795	Girth thin end (OB)	92.7
18	Girth thin end(UB)	-0.061	0.749	Girth mid end (OB)	94.1
19	Girth mid end (UB)	-0.076	0.758	Girth thick end (OB)	94.9
20	Girth mid end (UB)	2.540	0.857	Girth thin end (OB)	91.8
21	Girth mid end (UB)	0.792	0.851	Girth mid end (OB)	94.7

The prediction models as given in Table-VII could be practically apply to estimate the desired log trait. These are based on 120 logs of two meter length and hence are based on fairly large population capturing the possible variation those were available for 2 m length logs. The Coefficient of Determination (Adj R2) is quite high and the model is statistically sound as their probability (P value 0.000) is statistically significant for all the given equations. For practical application of these models, an example is illustrated below

To estimate the weight (UB) of a log measured 68 cm at thick end, the equation number 7 given in Table-VII above could be applied

Wt (UB)= Constant a+ constant b* girth at thick end(OB)

Wt of log in kg=-3.33+0.433*68=26 Kg.

While further validating the developed model, equation No. 10 can be used to obtain Weight (UB) of the same log of 68 cm (GBH thick end). While converting log girth thick end (OB) to girth thick end (UB) equation No 13, gave a value of 56.49 cm. Thus the weight of the log having 68 cm girth (OB) at thick end and 56.49 cm girth (UB) at thin end is calculated from equation number 10 as below

Wt (UB)=-3.54+0.524*56.49=26 Kg which matches with the weight of log calculated with equation number 10 mentioned in the above para.

OTHER OBSERVATIONS

Poplar, planted in these locations, entered in dormancy during winter months and its leaf fall had set in during the month of December. In some cases trees were totally leafless by the end of December. Minor changes in leaf fall period may occur depending upon the local soil, moisture and other cultural conditions. Clone Wimco 108 has been observed to give a new flush during late February, 2016 in Sarapaka nursery. This is unusual behaviour of poplar to give flush so early. Winter 2015 was very warm during which the month November was recorded as the warmest in the history of mankind. February, 2016 again was a very warm month. This abnormal flushing could be part of this high temperature during this winter and needs to be validated with further observations. However, poplar being leafless at this latitude and climatic conditions where summer temperature goes very high is significant observation that may encourage its large scale culture on suitable and productive fields with intercropping during winters when trees are leafless. However, it would again be interesting to note how long the trees

remain leafless for selecting appropriate intercrops those could be integrated with its plantations.

The attack of a leaf eating insect-Clostera species was recorded on some trees in these plantations. The damage was though very low compared to what it does in North India where trees become leaf less when its infestation spread very fast during monsoon- and post-monsoon seasons. The larvae of the insect was also recorded on poplar planted in Sarapaka nursery. Three farmers growing these plantations had an exposure visit (through ITCPSPD) to poplar growing region, U.P. two years ago and therefore they tried to take good care of their plantations.

Poplar nursery grown inside company premises have existing introduced clones. The growth and conditions were good, height was excellent but girth growth was a little less. The low girth may be associated with close spacing of the plants planted in the nursery.Due care has been taken by the plantation team and farmers.

SUITABILITY OF POPLAR FOR PULP AND PAPER MAKING

In India, paper pulp is the third major use of poplars after panel products and firewood (Fig.I). The first successful commercial trial of use of poplar for paper making was done by Century Papers (Lalkuan) during 1980's when WIMCO from Bareilly Safety matches factory supplied truck-loads of central core left after peeling the logs. Thereafter waste of poplar from one commercial usage is finding commercial usage in another industry. Unlike Eucalyptus, Leucaena and Casuarina species for which many plantations are raised for exclusive pulpwood production, no poplar plantation is raised for paper pulp alone. Poplar raw material for paper pulp includes industrial wood waste or the left over material from plantations that does not find use in veneer and other industrial units using larger log dimensions. Poplar wood is traded in many grades. For example, over size logs (>60 cm in mid girth) is used in peeling industry, Undersize logs (<60 cm to > 45 cm mid girth) used in sawing industry and also partly in peeling industry, whereas, sizes below it are used in pulp and paper factories and for some other allied purposes.Unlike North India, the multiple usage of poplar is yet not developed in these locations and the wood from the existing trial plantations will certainly be for paper factory till a stage parallel usage of large sized timber/ logs is developed there.

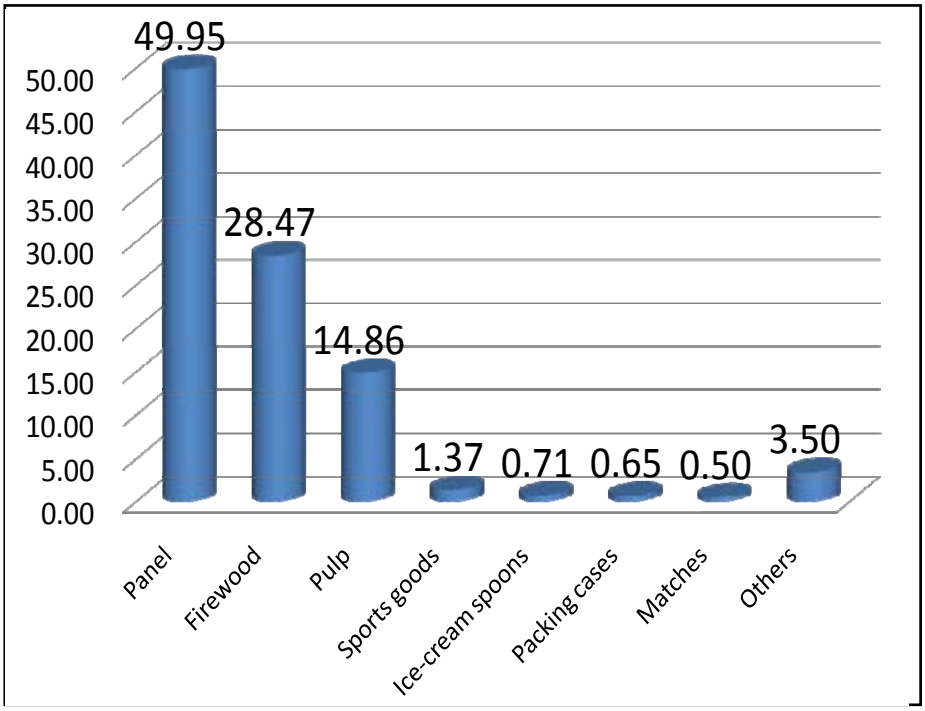

Fig. – 1 Major uses (%) of poplar

Kishwan and Kumar (4) quoted a survey of Yamunanagar area in Haryana where major portion of poplar wood produced in India is consumed, This locality has one paper industry viz., Ballarpur Industry Ltd., Yamunanagar. These authors mentioned the wood consumption potential of Ballarpur Industry Ltd. as 650 tonne/day. However wood consumption at the time of survey was 561-616 tonne/day and the sources of raw material includes poplar logs 21.2 tonne/day, poplar waste from plywood industry 252.6 tonne/day, eucalyptus 175.8 tonne/day, bamboos 105.8 tonne/day, and hardwood scrap 48.0 tonne/day. Thus about 45 percent of wood requirement of Ballarpur Industry Ltd., far making paper was met from poplar. During the crash of poplar wood prices, as has been the case during 2015, there was increased procurement of poplar wood, peeling waste etc. by all the paper factories located in poplar growing region and in some cases the material is also transported to some paper factories in the south. According to market sources, paper factories have increased the procurement of poplar wood/veneer waste/central core from veneer industry and the proportion of eucalytps in these industries has significantly declined.

The colour of poplar wood is white or off white. Poplar fills an important niche in the paper business in many countries. Poplar has acquired a considerable importance as a cellulose fiber for paper making because of its specific qualities on account of fiber dimensions, proximate chemical composition, lignin and hemicelluloses (5). Poplars have been extensively studied for pulp and paper making both at international and national levels. In a book "POPLAR", Chapter No. 13 is totally devoted to pulp and paper making from poplars (5). It reviews the existing literature of pulp and poplar

making in India and a little from some other countries. Poplar kraft pulps are particularly well suited for manufacturing fine papers because of their high opacity, good bulk, sheet formation and good printability. Guha et al(6) reported kraft pulp of satisfactory strength properties made from poplars. It also produces a brilliant white paper of high-quality printing as well as softest tissue paper. Any of the pulping method viz., mechanical, semi chemical and chemical (e.g. sulphate or soda or kraft process, and sulphite process) methods is commercially used for making pulp from poplar wood(7). Pulp mills designed for pulping hardwood can use up to 100% poplar (8). Prior to conversion to paper products, poplar pulps can also be blended with long-fibred softwood pulps to facilitate the development of wet strength on fast running paper machines.

Table-VIII – The major uses of poplar pulps fall into three categories (7)

Sr. No.	Category	Main type	Finished products
	First	Specialty paper products	Napkins, towels, absorbent tissues and fine paper grades
	Second	Softwood pulp blends	News paper and printing papers
	Third	Paper board	Paper board for packaging and building boards(insulation board, ceiling tiles) and roofing felt

Rai *et al* (9) reported that paper made from even 2-3 years old poplar is superior over eucalypts of same age. Rai and Ilam (10) further reported that high yield pulps from 2-3 years old samples with and without bark having satisfactory strength and optical properties could be prepared for use as major component in the furnish for making news print and cheap grade of printing paper. Singh *et al* (11) conducted studies on pretreatment of *P. deltoides* cold soda pulp both with nitric acid and chlorine before sulphonation by sodium sulphite and reported increased consumption of sulphite by the pulp. Rai *et al* (12) noted that poplars are particularly noteworthy in the production of high yield pulps for its good strength and excellent brightness vis-à-vis *L, leucoephala* (Su-babul) and *E. tereticornis*. Tewari (5) concludes that even young poplar holds an excellent promise as a source of cellulose fibers for making various grades of paper, fine papers, packing papers and newsprint.

Panshin and de Zeeuw (13) reported percentage of fibres to total volume as 53.1%. In India, Guha *et al* (6) has reported fiber length of poplar between 0.885 to 1.140 mm and the average fiber diameter between 0.22 to 0.24 mm. The clonal variation in wood anatomical characters of poplars for its end uses including paper making are well recorded (14-15,16). Labosky *et al*. (17), and Law and Rioux (18) investigated chemi-thermo-mechanical pulps (CTMP) produced from poplar hybrids. The pulps had a high proportion of very short fibres (e.g. <0.2 mm), but overall the CTMP pulps were of acceptable quality. Sierra-Alvarez and Tjeerdsma (19) demonstrated that good quality pulps, with about 55% yield, can be produced from short rotation hybrid poplars. Based on proximate chemical analysis carried out by Guha *et al* (6), Tewari (5) inferred that poplars are better source of cellulose fibers than eucalypts. Singh *et al* (20) reported that the milled lignin (MWL) of *P. deltoides* is composed of three basic building units in the order: guaiacyl>syringyl>p-hydrooxybenzaldehyde and contains 1.35, 0.45, 1.16, and 0.16 methoxyl, phenolic hydroxyl, aliphatic hydroxyl and carbonyl groups per C9 units, respectively. The molar ratio of syringeyl units is 1.6- a value which is very low in comparison to that of *Eucalyptus regans* but comparable with *E. tereticornis* and *E. grandis* grown in India. The hemicelluloses in *P. deltoides* mainly composed of xylose units (80.3%) and contain small amount of glucose (11.6%) and arabinose(8.1%) (21) which is quite high in comparison to hardwoods (20). Clones with low incidence of tension wood in poplar wood has a significant impact on paper quality (16).

One tree planted at old nursery site of Sarapaka nursery during 2010 was harvested during 2015 at 4.5 years age, that yielded 2.35 qtl pulpwood (with bark) and 2.05 qtl (without bark). Another tree that was broken during 2011 was sprouted and attained a height of 12.5 m and gbh of 33 cm in one year, 3 months and 26 days when it was harvested and yielded 31 kg wood with bark and 25.5 Kg wood without bark. The wood of these trees was used for making paper in the ITC PSPD, Khammam factory and paper produced was having better values for Kappa No. and brightness.

CONCLUSION

This is just a preliminary report based on a well-coordinated one year field trials and with some observations of around five year back introduced poplar in this region. It opens up new hopes in introduction of one of the ideally suited tree species for agroforestry in this region. It is reasonable to indicate that the tree would not have same growth as is recorded in the most intensive farm land use in North India since the input level for associated crops is very high and its culture is located near to its natural distribution latitudinal range. However, India is a wood hungry country and annually imports of wood and wood related products hasa huge monetary drain.The country faces wood famine now and then when we run out of

wood. The demand for pulpwood/wood is increasing and the supply is diminishing. The so-called paperless office would never happen, even computers have increased the use of paper. Recycling paper is taking place at a large scale but it can only be recycled so long before the process degrades the fiber.Fresh input of fibers would always be required at certain stage of recycling the paper

Poplar has been picked up as one of a few trees under diversification of agriculture sustainability project initiated by government of India and being implemented in the most productive states of Punjab, Haryana, and Western Uttar Pradesh. It is believed that agriculture productivity in these states have already achieved the upper limits. With each passing year, the water table is going down, excessive use of chemical and fertilizers is adding the pollution to soil and water. Agroforestry is widely believed as an effective land-use option for food, wood and environment security. Poplar fits in in this perspective and whatever yield the tree may give in this new geographical locations, it would be an additional advantage for sustaining high input agriculture, increasing wood availability for domestic and industrial use and also for saving the drain of exports costs for wood and wood related products.

Poplar is also one of efficient tree for phytoremediation of polluted sites (22). It is used for absorbing toxic chemicals present in soil irrigated with effluent water and such chemicals are absorbed by biomass which is converted into products made out of poplar wood.It therefore helps clean up toxic waste and to help reduce chemical infiltration into streams and aquifers. Paper industry has a huge exposure to effluent water that is generated from paper making process. In many countries the effluent water is used for irrigation of tree plantations.

There is transformation on poplar culture and its usage during the last four decades. Initially the rotation of the tree was fixed as 20 years, which has now been reduced to around six years with development and introduction of new productive, and site matched improved clones along with intensive inputs provided to crops grown along with poplar. The observations on the growth in Telangana/ Andhra Pradesh indicate that if the tree is grown for short rotation, it could be boon for farmers and wood based industry including paper industry. The tree can be well integrated with intercrops and it can provide remunerative returns to small growers who cannot grow exclusive tree plantations for the want of food from their small holdings.

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Plate-I : One year old poplar at site-I

Plate-II : One year old poplar planted with tobacco at site-III

Plant-III : Five year old trees at site-V

LETERATURE CITED

1 Dhiman, R. C. Contractual arrangements for sustaining agroforestry with special reference to WIMCO's poplar program (Chapter 8). In: Agroforestry: Present Status and Way Forward (Eds. S K Dhyani, Ram Newaj, Badre Alam and Inder Dev), ISBN 978-81-7622-349-2. Biotech Books, New Delhi, pp.135-168, (2015a)

2 Dhiman, R. C. Transforming Rural Uttar Pradesh through Integrating Tree Culture on Farm Land: A Case Study of WIMCO's Poplar Programme,LMA Convention Journal Vol. 8(1): 85-98 (2012)

3 Dhiman, R. C. Poplar culture in Zimbabwe. Consultancy report submitted to the Forestry Commission, Ministry of Environment and Natural Resources Management, Govt. of Zimbabwe, Harare (2015b)

4 Kishwan, J. and Kumar, D. Future of Poplar in India. Paper presented in First International Conference on "Future of Poplar Culture" organized by National Poplar Commission of Italy, Rome and FAO Rome. (November 13-15, 2003) (http://www.fao.org/forestry/6470-0e476a569c0c19869e4f7e5eb88ad3d17.pdf)

5 Tewari, D. N.Poplar. Chapter 13: Pulp and paper making pp. 188-199. Surya Publication Dehradun (1993)

6 Guha, S.R.D., Sharma, Y.K., and Kumar, K. Pulping of poplars. Indian Forester 99(5):296-301, (1973)

7 Balatinecz John, J.,Kretschmann David E.,Leclercq, A. Achievements in the utilization of poplar wood : guideposts for the future.Forestry Chronicle Vol. 77(2): 265-269(Mar./Apr. 2001)

8 Stanton, B., Eaton, J., Johnson, J., Rice, D., Schuette, B. and Moser, B. Hybrid poplars in the Pacific Northwest: the effects of market-driven management.Journal of Forestry100:28-33 (2002)

9 Rai, A. K., Sharma, K. K. and Dhawan, R. High density short rotation poplars for pulp and paper manufacturing. Indian Forester 117(3):213-224 (1991)

10 Rai, A.K. and Ilam, C. Grease proof paper from poplar. Journal of the Timber Development Association ofIndia 34(4): 18-26 (1988)

11 Singh, S. V., Rai, A. K. and Dhawan, R. Advances in Paper and Pulp Research inIndia. Publishers: I.C.F.E., Dehradun pp.200 (1991)

12 Rai, A. K. Sharma , K. K. Sharma,Y. K.High Density Short Rotation Poplars for Pulp and Paper Manufacture. Indian Forester 117(3): 213-224 (1991)

13 Panshin, A.J. and de Zeeuw, C.Textbook of Wood Technology 4th edn. McGraw-Hill, New York (1980)

14 Pande, P. K. and Dhiman, R. C. Variation in wood traits in micro and macro propagated plantation woods of Populus deltoides Bartr. Ex Marsh. Advances in Bioscience and Biotechnology 1(1):30-38 (2010)

15 Pande, P.K. and Dhiman, R.C. Variations in wood anatomical properties and specific gravity of half sib progenies of Populus deltoides Bartr. ex Marsh. Journal of Forestry Research23(3)(2012)

16 Parham, R.A. Robinson, K.W. and Isebrabds, J.G. Effect of tension wood on kraft paper from short rotation hardwoods. Wood Science and Technology11:291-303 (1977)

17 Labosky, R., Bowersox, T.W., Blankenhorn, P.R. Kraft pulp yields and paperproperties from first and second rotationsof three poplar hybrid clones.Wood Fiber Science15:81-89 (1983)

18 Law, K.N., Rioux, S. Five short rotation poplar clones grown in Quebec: Wood and paper making properties. In: Zhang S Y, Grosselin R, Chauret G(eds) Timber Management Towards Wood Quality and End Product Value. Proceedings of the CTIA-IUFRO International Wood Quality Workshop, Quebec,Canada, pp.VII.19-VII.28 (18-22 August 1997)

19 Sierra-Alvarez, R. and Tjeerdsma, B.F. Organosolv pulping of poplar wood from short rotation intensive culture plantations.Wood Fiber Science 27:395-401 (1995)

20 Singh, S.V., Rekha B., and Guha, S.R.D. Chemical composition of lignin and carbohydrates of Populusdeltoides. Cellulose, Chemistry and Technology 16:421-429 (1982)

21 Slavik, I. and Kuniak, L.The content of xylose units in cellulose Papier 24(5):271-174 (1970)

22 McCutcheon, S. C. and Schnoor, J. L.Phytoremediation, Transformation and Control of Contaminants. John Wiley and Sons, Inc, Hoboken, New Jersey (2003)