# Poplar for pulp and paper industry in north east India

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**ABSTRACT**

The paper highlights the steadily increasing demand of paper and pulp-based allied products alongwith fast depletion of raw materials for pulp and paper industry. To augment supply of pulping materials, experimental planting of poplar *(Populus deltoides G-3)* was tried at Regional Research Laboratory, Jorhat from 1982 to 1989. Meteoriological data of Jorhat, various parameters of growth, yield of biomass and pulp, number of branches per plant, photosynthetic area, nitrogen and carbohydrate contents in Poplar have been listed year-wise.

A progressive increase in all the characters have been recorded with the increase in age, though current annual increment (CAI) and mean annual increment (MAI) decreased gradually. Nitrogen and Carbohydrate contents are increased with age. The photosynthetic area increased due to more number of leaf per plant, however, individual leaf area gradually decreased with age. In case of over ground part, bole exhibited maximum weight (62 to 82%) per plant. The prominent increse in growth characters, CAI and MAI at the age of 3 years, make the Poplar harvestable at 4th year with the average biomass (59.217 t/h) and pulp (43.020%) yields. Poplar will be a very good source of raw material for pulp and paper industry particularly for North East India.

## INTRODUCTION :

With the expansion of paper industry and diversi fication of its products such as paper boards, pulp based roofing materials and many other such products during the last three decades, the demand for bamboo has gone up quite considerably and hence the existing bamboo forests in the country are unable to meet the entire requirement of the paper industry (Sharma, 1978 and Anon, 1987). On the other hand, utilisation of forest based softwood and hardwood is also increasing significantly due to which there is remarkable depletion of conventional raw materials,causing a major bottleneck towards the growth of this industry, not only in India but also in some other countries (Sharma, 1988 and Sarma *et al*, 1989). Apart from soft-wood, use of hardwood pulp of Eucalyptus had gone up to 3 million tonnes during last few years in paper industry (Levlin, 1986). Unless a sustain supply of uniform raw materials at economic rate is maintained, the paper industry will suffer even it will suffer badly when the full capacity utilization of all the proposed paper mills in the country is considered (Seth, 1972).

Great importance has been given to the selection and introduction of plant species, which grow fast and produce the much needed timber, firewood, raw material for paper etc. to meet the growing demand of ever increasing population and wood based industries (Mathur *et al*, 1983). In view of general price hike, lack of adequate resources and time factor involved in

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harvesting long rotation crops, the only alternative is to raise fast growing species to meet the acute demand for manufacture of fruit boxes, matches, veneers, light furniture, pulp, fibre boards and even for light construction pruposes in villages (Dulloo, 1983).

Poplar is considered to be a suitable species because of its adaptability to temperate Himalayan region (Singh *et al*, 1984). The genus *Populus* is widely distributed in areas with cooler climate in the northern hemisphere. The natural forests of Poplar exist in Canada and United states. Poplar plantation have been initiated in countries like France, Italy, Hungary, Yugoslavia, Romania, Germany, Belgium, Turkey Syria, Iran, Iraq. Afganistan, Lebanon, Israel and on smaller scale in India (Dalal and Trigotra, 1983).

In view of the demand and scarcity of raw materials for pulp and paper industry, plantation of Poplar (*Populus deltoides* G-3) was made under the climatic conditions of Jorhat, Assam to evaluate as an alternative source for paper making and results are presented in this paper.

## Materials and Methods :

Studies were carried out at Regional Research Laboratory, Jorhat during April 1982 to March 1989. The original stock of *Populus deltoides* G-3 was received from M/s. Western India Match Company (WIMCO), Dhubri, Assam. Cuttings were developed from the well adoped provenance of Jorhat. Saplings of Poplar were transplanted on 15th April, 1982. Plants were spaced at 1.5 × 1.5 m. Yearly harvest was made for 7 years (1, 2, 3, 4, 5, 6, and 7th year). Plot size was 6 × 6m The experiment was laid out in a randomised block design with 4 replications. Total plots were 28. Uniform dose of N, P and K @ 160, 80 and 60 kg/ha/yr respectively were applied. Data were recorded on various parameters of growth, yield of biomass and pulp, availability of nitrogen in growing shoots of each year and carbohydrate concentration etc. at 7 different stages of growth for comparing the yield factors to determine a stage at which the harvesting of Poplar can be made with optimal yield of biomass and pulp.

Data on growth and yield of biomass were recorded as per Chaturvedi and Khanna (1982). Leaf area measurement was made with the help of LI-COR Portable Area Meter, Model LI-3000 in square centimeters. TAPPI Standard methods were used for analysis of pulp and Paper (Anon, 1970). Samples from yearly growing tip of Poplar were collected and analysed for nitrogen by Kjeldahl's method (Vogel, 1979). Carbohydrate and sugars was estimated following the indole reaction method of Ashwell (1957), taking glucose as standard. Moisture content of the wood was determined by oven dry (O.D.) method. Oven dry weight was obtained by drying at $103 \pm 2°C$ untill no further moisture loss occurred and a stable weight was reached. Annual increment was determined as per the method described by Misra (1968) with a modification that in this case the weight of the ariel part alone was considered.

The general weather conditions of Jorhat, i.e. mean monthly percentage of rainfall, temperature, sunshine and relative humidity were presented in Table-1.

## Results and discussion :

Data recorded in Table 2, 3 and 4 revealed that the growth characters are increased with the age. Bole exhibited maximum weight (62 to 82%), whereas branches and twigs contributed 14 to 26% and that of leaves 3 to 7% per plant. Similar findings were also observed by Kaul *et al* (1983) with Poplar.

Investigations on harvesting of Poplar at different stages of growth exhibited that there had been a progressive increase in plant height, DBH, number of branches and leaves, biomass and pulp yield with the increase in harvesting age. Though the total leaf area per tree significantly increased, the average individual leaf area decreased with the age. Although, plant height exhibited an apparent progressive increase, it was, however, noted that the current annual increment (CAI) and mean annual increment (MAI) gradually reduced with the increase in age. The CAI and MAI in regards to plants height reduced fast with the age, however, in case of plant diameter these were progressively increased upto the age of 4 years then decreasing. In case of branching pattern, an abrupt increase was observed in the primary and secondary branches at the age of 3 years, thereafter, there was a gradual increase with the age. Same was the case with number of leaves per plant, though the individual leaf area decreased with the increasing age of Poplar. The total leaf area per plant, as calculated, was found to increase prominently at the age of 3 years.

Nitrogen, as estimated in the yearly growing shoots, showed a steady increase with the age of Poplar. Carbohydrate concentration in plants at different stages of maturity revealed a slight increase with the increase in harvesting age. A spectacular increase in yield of biomass was observed at the age of 4 years, after which the increase was steady. It was found that the yield of pulp increased with the age of the plant, but the increase percentage was progressively decreased along with the age.

Table — 1 Average monthly meteorological data of Jorhat.

| Met. parameters Months | Rainfall (m m) | Temp. °C | | Sunshine hours | Relative humidity % | |
|---|---|---|---|---|---|---|
| | | Max. | Min. | | Morning | Evening |
| January | 21.45 | 22.36 | 9.40 | 6.10 | 96 | 57 |
| February | 32.05 | 23.99 | 11.93 | 6.27 | 94 | 54 |
| March | 77.96 | 27.51 | 15.51 | 6.75 | 91 | 52 |
| April | 193.77 | 28.62 | 19.06 | 9.92 | 91 | 63 |
| May | 279.04 | 29.92 | 21.86 | 5.12 | 92 | 70 |
| June | 327.10 | 31.55 | 24.20 | 4.57 | 92 | 74 |
| July | 383.70 | 32.19 | 24.69 | 4.78 | 93 | 74 |
| August | 341.93 | 32.07 | 24 66 | 5.14 | 93 | 74 |
| September | 255.13 | 31.25 | 23.96 | 5.07 | 95 | 74 |
| October | 116.52 | 29.37 | 21.03 | 5.73 | 96 | 71 |
| November | 27.30 | 26.37 | 15.35 | 5.16 | 96 | 64 |
| December | 11.81 | 23.35 | 10.65 | 6.05 | 96 | 60 |

Table — 2 Biomass distribution and yield of Poplar per plant.

| Age of Poplar (yrs.) | Overground fresh wt. (kg./plant) | | | Total fresh biomass (kg/Plant) |
|---|---|---|---|---|
| | Bole | Branches + Twigs | Leaves | |
| 1. | 1.130 | 0.520 | 0.225 | 1.875 |
| 2. | 2.870 | 0.870 | 0.610 | 4.350 |
| 3. | 8.550 | 1.675 | 1.070 | 11.295 |
| 4. | 24.000 | 9.000 | 6.000 | 39.000 |
| 5. | 47.000 | 10.000 | 9.000 | 66 000 |
| 6. | 64.000 | 12.500 | 11.600 | 88.100 |
| 7. | 75.000 | 15.000 | 13.000 | 103.000 |

Table—3 Mean plant height, DBH, number of branches and leaves per plant, leaf area, availabilty of nitrogen and carbohydrate in growing shoots, biomass and pulp yields at different maturities of Poplar.

| Age of Poplar (Year) | Plant Height (m) | DBH (cm) | No. of branches/plant | | No. of leaves/ plant | Leaf area ($cm^2$) | calculated area of leaves per tree ($cm^2$)* | Nitro-gen mg/g | Carbo-hydrate (%) | Calcul-ateddry bio-mass (t/ha)* | Bleached pulp yield (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Primary | Secondary | | | | | | | |
| 1. | 2.210 | 2.250 | 1.25 | 0.75 | 114.50 | 241.586 | 27661.362 | 4.25 | 16.25 | 10.105 | 41.520 |
| 2. | 3 500 | 4.750 | 4.50 | 7.50 | 308.75 | 239.019 | 73797.114 | 6.25 | 17.25 | 20 274 | 42.102 |
| 3. | 6.120 | 8.120 | 14.25 | 45.25 | 1078.00 | 186.936 | 201517.008 | 6.75 | 17.75 | 29.620 | 42.845 |
| 4. | 10.508 | 15.200 | 18.50 | 56.25 | 2366.25 | 141.791 | 335512.953 | 7.50 | 18.00 | 59.217 | 43.020 |
| 5. | 11 100 | 15.492 | 21.50 | 66.50 | 3591.00 | 127.251 | 456958.335 | 9.75 | 18.25 | 64 280 | 43.500 |
| 6. | 11.668 | 16.370 | 25.25 | 76.75 | 4708.75 | 121.074 | 570107.183 | 10.75 | 18.75 | 69 218 | 44.120 |
| 7. | 12.060 | 18 410 | 27 50 | 85.25 | 5742.25 | 106.336 | 610607.892 | 11.75 | 19.50 | 73.120 | 44.320 |
| SEm± | 0.030 | 0.173 | 0.431 | 0.395 | 4 038 | 0.115 | 244.700 | 0.380 | 0.324 | 0 947 | 0 035 |
| CD at 5% | 0.063 | 0.364 | 0.907 | 0.831 | 8.483 | 0.243 | 514.100 | 0.799 | 0.681 | 1.990 | 0 074 |

*Total number of plants per hectare was 4350 under the spacing 1.5 × 1.5m.

Table—4 Current annual increment (CAI) and mean annual increment (MAI) of height, DBH, biomass per hectare and pulp yield at different stages of harvest in Poplar.

| Harvesting age (Year) | Plant height (m) | | DBH (cm) | | Dry biomass (t/h) | | Bleached pulp yield % | |
|---|---|---|---|---|---|---|---|---|
| | CAI | MAI | CAI | MAI | CAI | MAI | CAI | MAI |
| 1. | 2.210 | 2.210 | 2.250 | 2.250 | 10.105 | 10.105 | 41.520 | 41.520 |
| 2. | 1.290 | 1.750 | 2.500 | 2 375 | 10.169 | 10.137 | 0 582 | 21.051 |
| 3. | 2.620 | 2.040 | 3.370 | 2.706 | 9.346 | 9.873 | 0.743 | 14 281 |
| 4. | 4.388 | 2.627 | 7.080 | 3.800 | 29.597 | 14.804 | 0.175 | 10.755 |
| 5. | 0.592 | 2.220 | 0.292 | 3.098 | 5.063 | 12.856 | 0.480 | 8 700 |
| 6. | 0.568 | 1.944 | 0.878 | 2.728 | 4.938 | 11.536 | 0.620 | 7.353 |
| 7. | 0.392 | 1.722 | 2.040 | 2.630 | 3.902 | 10.445 | 0 200 | 6 331 |

It was observed that from third year onwards, branching increased giving more leaves and leaf area along with higher yield of biomass. The higher biomass yield can be attributed to the increasing number of branches and foliage. In Poplar, winter dormancy starts from December onwards (Temp Max-23.35°C and Min-10.65°C) and the plants become more or less dormant during January (Temp. Max-22.36°C and Min -9.40°C). During this period, senescence of leaves occurs. The subsequent growth of branches occurs mainly due to rise of temperature and physiological activities in the plant system. For increasing shoot growth the importance of nitrogen has been emphasised by Oland (1959) and Mason and Whitfield (1960). They observed in apple that the need of nitrogen was very high at the time shoot growth. Along with nitrogen, the demand for photosynthate also increases with the age of the plant, which is met by the increase of leaves (Sweet and Wareing, 1966). The photosynthetic products are later translocated to the branches which acts as reserve food material for subsequent growth in the following years.

The low content of nitrogen in the tissues of young shoots may be due to the support of new growth. This new growth is mainly stimulated by the stored nitrogen of previous years (Olend, 1959; Taylor and May, 1967 and Tromp, 1970). Ward and Blaser 1961) reported that regrowth depends upon the carbohydrate reserves and photosynthetic leaf area. The high carbohydrate accumulation occurs in branches after leaf fall and acts as reserve food for subsequent metabolism and growth. The carbohydrate reserves are translocated with the rise in temperature (27 to 32°C) and photoperiod (6 to 9 hours) and are used in the production of new photosynthetic area (Mitchell, 1970). Present findings are in conformity with the observations made by the above workers.

Higher biomass at the age of 4 years can be attributed to the abrupt increase in plant height, DBH, number of branches and Photosynthetic area (total leaf area) in poplar. Similar results were also reported by singh (1980) in *Shorea robusta* and found that the growth and yield of biomass were slow at the early stage. The MAI after 3 and 4 years study in *Leucaena leucocephala* showed a rising trend with maximum increment between 3rd and 4th year (Pathak *et al* 1981)

The present findings clearly indicated that there had been an increase in pulp yield with the increase in age, but the increase percentage showed a progressive decrease with the age of the plant.

It can be concluded that harvesting of Poplar could be done from the age of 4 years onwards with optimum yield of biomass (59.217 t/h) and pulp (43.020%) and may be used as alternate source of raw material for pulp and paper industry, particularly in North East India.

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