2. INTRODUCTION

Among the plant based sources, several species of bamboo are primarily used for paper making in India (Seth, 1972). More than 50 percent of bamboo produced in India is consumed by the pulp and paper industry to meet its approximate annual production of pulp and paper to the tune of 2 million tonnes (Tewari, 1988 and Singh et al., 1988).

With the expansion of the paper industry and diversification 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. Apart from the maximum use of bamboo in paper industry, other factors such as, initiation of river valley schemes for irrigation and power, development of command areas, industrial establishment, release of forest land for agriculture, shifting cultivation (slash and burn techniques) and gregarious flowering and seeding of bamboos have contributed towards lower production level of bamboo raw-materials for paper making, particularly in developing countries like India, Bangladesh, Burma, Thailand, Philippines and Indonesia (Sharma, 1988).
Consumption of various categories of paper and pulp in India was estimated by National Commission of Agriculture (NCA) for the year 2000 AD as (Anon, 1972):

- Newsprint : 10,14,500 tonnes
- Writing and printing paper : 27,26,000 "
- Industrial paper : 10,23,500 "
- Paper board : 8,59,500 "
- Rayon grade pulp : 12,76,000 "

The NCA also estimated the requirement of raw materials for paper industry for the year 2000 AD as:

- Bamboo : 35.46 lakh tonnes
- Hardwood : 82.04 " "
- Softwood : 23.90 " "
- Other fibres : 30.05 " "

The Development Council of Paper, Pulp and Allied Industries has estimated that by 2000 AD, the present installed capacity of the paper mills will reach 42.5 lakh tonnes per annum, as against the total expected consumption of nearly 47.8 lakh tonnes of raw materials in order to fully utilise the installed capacity. Considering the requirement of pulp and paper, there is a substantial gap between the demand and production, both for raw materials and finished products. It has been observed that the gap cannot be filled up unless adequate efforts are made for development of new pulpable raw materials (Anon, 1978 and Srivastava et al, 1984).
Indian paper industry though consumes maximum percentage of bamboo, wood is also internationally used as one of the principal raw materials in this industry. Non-wood materials such as straw, sugarcane bagasse and bamboo are used to the extent of 6% of the world production (FAO, 1979). It has been observed that the demand for wood is increasing tremendously with the increasing human population and has put pressure on the already over exploited temperate forests (Khurana and Khosla, 1982). Apart from bamboo, India's resources for long fibre materials such as conifers are also considerably limited (5-6%) and conifers alone cannot fill the gap of required raw materials (Sharma et al., 1987).

It is estimated that world paper and board consumption is expected to reach 315 million tonnes by 1995, representing an increase in demand of 160 million tonnes as compared to the requirement during 1976 to 1978. On this basis, there will be a deficit of paper and board to the tune of 6 million tonnes in countries like Latin America, Asia, Africa and the Middle East, which has been adequately elaborated as follows (Anon, 1981):

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<tbody>
<tr>
<td>1. Newsprint consumption</td>
<td>23644</td>
<td>30375</td>
<td>36445</td>
<td>43350</td>
</tr>
<tr>
<td>2. Printing and writing paper consumption</td>
<td>35323</td>
<td>48485</td>
<td>59560</td>
<td>72745</td>
</tr>
<tr>
<td>3. Other paper and board consumption</td>
<td>93776</td>
<td>131250</td>
<td>162825</td>
<td>198505</td>
</tr>
<tr>
<td>Total consumption</td>
<td>152743</td>
<td>210110</td>
<td>258830</td>
<td>314600</td>
</tr>
<tr>
<td>Surplus</td>
<td>1204</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total production</td>
<td>153947</td>
<td>210110</td>
<td>258830</td>
<td>314600</td>
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</tbody>
</table>
The increased shortfall of traditional pulping materials has led towards utilization of hardwood pulps from 5 million tonnes in 1974 to 8 million tonnes in 1985. Even the use of Eucalyptus had gone up during this period to 3 million tonnes indicating the impact of hardwood pulp used in paper industry (Levlin, 1986). It is further visualised that with the full capacity utilization of all the existing and proposed paper mills in the country, there will definitely be a time when shortage of pulpable raw materials will hinder the growth of this industry, unless a sustained supply of uniform raw materials at economic rate is maintained (Seth, 1972). Among other items of necessity, consumption of various types of papers viz. writing, printing, packing, newsprint, etc. is a good index of the progress of a nation. In this respect, India's per capita paper consumption is only 1.4 kg, while it is much at higher rate in countries like USA (205 kg), UK (106 kg), West Germany (84 kg), Japan (57 kg), USSR (16 kg), UAR (7 kg), Sri Lanka (2.5 kg), World (26.7 kg), etc.(Sagreiya, 1967 and Ghosh, 1986-87).

Considering the above facts, it is desirable to make a search for certain alternative pulpable materials and plantation of selected fast-growing plant species for biomass production, suitable for the pulp, paper and board industries (Anon, 1978 and Chaturvedi and Khanna, 1982). In this regard, attention has also been recently given on the selection and introduction of fastgrowing plants, which produce the much needed timber, firewood etc. to meet the growing demand of ever increasing population and wood based industries (Mathur et al, 1983). The strain in our forest wealth has tremendously increased, vitiating the very eco-balance in the country. In order to overcome the difficulties caused by the general price
hike, lack of adequate resources and time factor involved in harvesting long rotation crops, only alternative is to raising fastgrowing wood yielding plant species to meet the acute demand for manufacture of fruit boxes, matches, veneers, light furniture, fibre boards etc. apart from its uses in pulp and paper industry (Dullo, 1983). The decline in supplies of wood in many countries have prompted a closer examination of the possibilities in increasing the use of non-wood materials for pulp and paper production. The demand for pulp wood is likely to exceed the supply in near future even in developed countries like USA. Production of pulping raw materials in short rotation is also envisaged. Therefore, the prospect of cultivating annual plants, specifically for pulp production, is increasing (Rawlins, 1981 and Wood, 1981).

Investigations on suitability of using hard and soft woods for pulp and paper industry have been made by several workers, but very scant literature is available on the production of biomass from the fastgrowing pulp yielding plants (Chaturvedi and Khanna, 1982). Studies were, however, made on the suitability of some plants as a paper making raw material such as *Melia azedarach* (Singh et al., 1977), *Cupressus lusitanica*, Pines (Moorthy et al., 1977, Rao et al., 1978 and Sharma et al., 1987), *Eucalyptus* species (Penfold and Willis, 1961; Bhandari et al., 1982 and Chauhan and Bist, 1987), Poplar (Singh et al., 1981 and Sarma and Bordoloi, 1986), *Albizia moluccana* (Guha and Karira, 1981), *Acacia robusta* and *A. mellifera* (Bhandari et al., 1983), *Leucaena leucocephala* (Bhola and Sharma, 1982; Shukla, 1982 and Shukla et al., 1985), *Acacia auriculiformis* (Kumar et al., 1987), Cotton stalk (Pandey and Salikh, 1986), Kenaf (Sharma et al., 1983; Jeyasingam,
1983; Schoenthaler and Fuentes, 1983; Leekha and Thapar, 1983; Sharma et al, 1984 and Sarma et al, 1986), *Hibiscus mutabilis* (Negi et al., 1978), *Sesbania aculeata* (Markila, 1979) etc. On the other hand, no such adequate investigations seem to have been carried out with plants other than bamboo species grown under the climatic conditions of North Eastern region of India.

Therefore, the present investigation was undertaken to study the biomass yield of certain fastgrowing plants, which can suitably be used as raw material for pulp and paper industry. It is a well known fact that unlike agricultural or horticultural crops, forest tree plantations are raised and managed for optimum wood production. The principal yield components are plant height and diameter, which together determine the volume of harvestible timber (Venkatesh, 1982). In this investigation also the stem-wood (mainly overground bole or stalk) is considered for biomass yield.

The perennial plants considered in this investigation were planted in 1982, which exhibited substantially lower yield of biomass upto the age of 4 years (Sarma and Bordoloi, 1986 and 1987). Therefore, based on various parameters on growth, yield of biomass, evaluation of pulp and paper making qualities etc., initial screening of the five perennial plants were carried out and detailed investigation was made with the most promising plant (*Populus deltoides* G-3) at the age of 5 and 6 years. Similarly, screening was also done with five annual plants for two seasons and only the best one, *Hibiscus cannabinus* was used in this study. The results encountered are presented and discussed in this thesis.