IPPTA

Silver Jubilee International Seminar & Workshop
Appropriate Technologies For Pulp & Paper Manufacture
In Developing Countries.

New Delhi - 1989

MAN-MADE PLANTATIONS
– THE WHY AND HOW OF IT

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Abstract

The Development Council for Paper and Allied Products have estimated that the demand for paper by 2000 AD will be atleast two times the production of 1987.

However, it is prudent to note at this juncture that the satellite imageries of our forest area indicate that it constitutes only 11% of the total land mass. Even among this area effective forest thatcan be considered "well managed" is only 44%.

As it is the per capita forest in our country is as low as 0.11 hectares as compared to a world average of 1.03 hectares. Even the annual increment is only 0.5 cubic metres/ha as compared the world average of 2.1 cubic metres/ha.

Thus, with rapid increase in demand for paper, the pressure on existing forests is bound to increase. The development of additional resources to the tune of 29.01 lakh tonnes, in addition to the current rate of 32.10 lakh tonnes will be needed. Generation of this within a short period of 12 Years to follow will be an uphill task by any standard.

The need for more and more man-made plantations is no more a luxury and is the need of the day.

In addition to new plantations, the productivity of the existing stands also needs to be boosted. This will be possible only through scientific management of plantations.

The paper deals with all aspects of man-made plantations including identification of the needed land, the financial requirements to be mobilised, the choice of species, types of planting stock, weed management and nutritional augmentation. The benefits derived from a demonstration plantation of 300 ha are presented. The paper also documents the advantages which could be derived by the adoption of modern Bio-technological techniques like genetic Engineering, Tissue Culture and Manipulation of Tree Form and Structure.

1. Introduction

The importance of sustained availability of paper needs no special emphasis. Although the per capita consumption of paper in our country is quite low when compared to the developed countries with the increase in population and the rate of literacy,the demand can only be on-the-rise, in the years to follow.

The Development Council for Paper and Allied Products have estimated that the demand for paper by 2000 AD is likely to be two times the production in 1987. Thus, there will be a growing need for additional sources of raw material. Table 1 indicates the demand projections for paper and allied products.

2. Availability of Forest Based Raw Material

2.1 Current Availability

Forest based raw materials constitute nearly 50% of the totalraw materials being consumed by the paper industry. Over the last decade, the industry has been facing a declining availability of these resources. They have been trying hard to adapt themselves to the changing scene in the raw material availability. They have been exploring different technologies from time to time to suit the raw material available. The furnish has undergone drastic changes from predominantly bamboo to a mixture of wood, bagasse, waste paper etc. The current rate of availability of forest resources is to the tune of 32.1 lakh tonnes per annum.

However, the furture availability of the raw material on a sustained basis is far from encouraging. Recent statellite imageries of our forests have clearly indicated that they constitute only 11% of the total land mass in our country. Even among this area the effective forest that can be considered **"well managed"** is only 44%.

The per capita forest in our country is as low as 0.11 hectare as compared to the world average of 1.03 hectare. The annual increment which, in other words, means the quantum of forests that can be cut and made available to the enduser, is 0.5 cm/ha as compared to the world average of 2.1 cm/ha(2).

Nearly 85% of the forest produce is consumed as fuel as compared to 2% which is available to the industry. In view of the inadequate management of the existing forests and the ever increasing demand for fuel,it is bound to become morescarce in the years to come. Moreover, in View of the long gestation period for the recent plantations to yield, the produce are not likely to be available in the near future. It is apparent, therefore, that there can be no apreciable increase in the raw material availability to the industry in the immediate future.

2.2 Future needs and the Shortfalls in Availability

Table 2 indicates the extra raw materials that need to be mobilised to cope with the expected rate of production of paper in the years to follow. Currently, the consumption patterns of raw materials indicate that 70% of the furnish in large pulp and paper mills is derived from hardwoods and the balance from bamboo. Hence we can assume that the extra raw materials that need to be mobilised would include these two in a similar proportion.

As can be seen from the above table, the amount of paper that can be produced from the available raw materials far outstris the likely availability.

The development of additional resources to the tune of 29.01 lakh tonnes, in addition to the current rate of production of 32.1 lakh tonnes in the next 15 years to any standard. Increasing the availability by fresh plantations is right now very difficult in view of the long gestation period involved and the financial needs. However, the need for large scale man-made plantations is no more a luxuryand is imperative if the future needs are to be taken care of. In the meanwhile, as per the recommendations of the Raw Material Committee of Development Council, all steps need to be taken to increase the productivity of the existing stands. For example, the productivity of the bamboo plantations can be increased from the current 1.5 t/ha to 1.9 t/ha by rejuvenation alone. This can increase the availability by 30%. Similarly, all steps need to be taken to enhance the coppicing ability of the hardwood plantations. The coppicing decreases with the age of the trees and hence the stocking of the plantations decrease with each felling. Care must be taken to refill the gaps with fresh seedlings. These steps can alleviate the problems to a certain extent.

3. Strategy for Man made Plantations

As mnentioned earlier, the need for man-made plantations is the need of the day. Experience in countries like Brazil, Korea, Australia and New Zealand have conclusively shown that large scale plantations can be raised in lands other than the natural forests.

As a pre-requisite to such a proposition a scrutiny of the land mass available in our country and the use to which they have been put to will be helpful.

3.1 Land Availability and Requirement for Man-made Plantations

As per the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, the category of land under different uses in 1980 was as follows :

Distribution of Land Mass in the Country[4]

S.No	Category of land	%
1.	Area under forest	22.0
2.	Area under non-agriculture	5.8
3.	Barren and uncultural land	7.2
4.	Permanent pastures	4.1
5.	Misc. tree crop	1.3
6.	Culturable waste & fallow	13.5
7.	Agricultural land	46.1
		100.0

As is evident from the above table, nearly 828 lakh hectares of land in our country representing 26% of the total land mass is virtually producing nothing. The land requirement for the production of pulp wood to cater to need of production of paper anticipated at 2000 AD can be calculated as follows :

	(lakh tonnes)
- Expected paper production (including newsprint)	41.12
- Assuming 70% of the Production will be from wood	28.76
- Requirement of air dried wood based on 2.65 t/t of paper	76.28
- Forest raw material available	32.10
- Forest raw material to be generated	44.18
- Wood equivalent at 30% moisture and 15% bark	88.00
- Assuming an annual increment of 5 T/ha/year; and require (80/5) lakh hectares	16.00

As such, the above figures indicate that this is only 2% of the waste land in the country. Availability of such land within a lead distance of 100 km from a mill needs to be identified. If the land is within 15-30 km from the mill, the possibility of using the mill effluent for irrigation can be considered. Typically, for a 50,000 tpa paper mill using nearly 90% forest raw material as the furnish, the land reuirement has been estimated to be 32000 ha. in unirrigated land with a crop rotation of 8 years and an average yield of 40 t/ha[5]. Such land should be made available on a long term lease or a reasonable rent, or an arrangement to share the produce.

In order to maintain the envirnomental and ecological balance, 2-3 different pulpwood species can be identified so that a mixed plantation is possible.

3.2 Financial Implications

As detailed above, it is assumed that even in the years to follow, the furnish for manufacture of paper mill follow the existing pattern of 70% wood and 30% bamboo the financial requirements have been computed and are indicated in Table 3.

In raising plantations for paper indsutry, the Development Council, in a recent meeting with Forest officials, Paper mills, NABARD and Wasteland Development Board favoured establishing of **man-made plantations.** In this scheme, the Wasteland Development Board would make land available to landless labourers, NABARD would offer financial assistance and the Paper mills woul be involved in the managerial assistance and in guaranteeing a fair end-price.

4. Scientific Management of Man-made Plantations

Forest management is primarily concerned with utilising the available resources in the most efficient way possible. Afforestation projects vary greatly in size, methods and species to be grown. The factors that are involved and their relative importance vary greatly depending onthe objective. Routine operations sometime become wasteful, while everyone is satisfied with seeing if the trees survive planting and can be seen to be growing. The questions that one need to really ask, but seldom asked are :

-- Can these trees grow better than they are growing now?
-- Can they be raised more economically?

The most important resources utilised in the afforestation programmes are labour, capital, tree and land. The efficiency lies in bringing these together in the right quantities, a the right time and in the right place. The correct and optimal quantities of the species, locality and timing determine the productivity and the economic viability.

The successful management of such a project is greatly faciliatated by sound preliminary planning. The basic principles involved in identifying and appraising the project are the same irrespective of the size of the project. It is only the degree of detail and the factors, which need to be taken into account, that vary.

The project can attain its objectives if the resources can be properly controlled and allocated. It is of utmost importance to do every thing possible to keep costs down, early in the stages of planting itself, when this can be done without adversely affecting growth of future costs.

The technical decisions to be made during the planting or establishment phse, more or less in chronological order are :

-- Choice of species/provenances
-- Type of planting stock
-- Nursery practices
-- Ground preparation methods
-- Planting methods
-- Spacing
-- Weed control methods
-- Nutrition

4.1 Choice of Species and Provenances

A number of environmental factors ultimately determine the economic viability of any afforestation programme. The soil pH, moisture, texture and fertility are of paramount importance in choosing the right species. In addition, the altitude, temperature and annual mean rainfall are very important. In our country, one of the main reasons for vast land masses remaining unproductive is the arid environmental conditions that prevail in these areas.

Even in places where sufficient rainfall occurs, yet other factors may be the constraint. For example, in Kerala which receives a mean annual rainfall exceeding 2000 mm, *Eucalyputs tereticornis* has fared badly[7]. Fungal disease problems have taken a heavy toll. Cylidrocladium blight and pink disease are the most prevalent. Field trials for alternate species were taken up to identify the suitable species for this area and a few species have been identified as suitable. They are *Albizia falacataria, Acrocapus fraxinifolius, Gmelina arborea* and *Trema orientalis*

A number of provenances of *Eucalyptus grandis* were also introduced. The germ-plasm for the same was obtained from CSIRO, Australia. They were screened for their adaptability,productivity and disease resistance. Some of these have already attained the half rotational period of five years and have been performing better than the local varieties. Provenance No. 11247, 11681, 11996and 12081 have performed well. Most of the other provenances have been at different stages of growth and the ones that are promising include 12409, 13016, 13017, 13019, 13020, 13022, 13024, 12081, 10693, 11891, 12462, 13289 and 13326. The provenance number 13022 is worth special mention here as it crossed the 400cm mark by the end of the first year itself as compared to the 150 cm of other conventional varieties.

4.2 Types of Planting Stock and Nursery

Conventionally, the type of planting stock to be used is determined by the species that have been indentified for the area. The principle types of planting stock used are :

-- Direct broadcasting of the seeds
-- Tubed seedlings
-- Potted seedlings
-- Bare rooted seedlings
-- Transplants
-- Rooted cuttings and
-- Others

Considerable savings in the economic inputs can be achieved by suitably altering the nursery technique based on the prevailing local environmental and other conditions. The 'Low Cost Regeneration Technique' perfected by the Fungus Investigation Unit in Kerala for Eucalyptus, demonstrated that upto 40% reduction in the costs can be achieved. The alterations involved are :

- Direct dibbling of the seedlings into the polypots
- Reducing the time duration of the nursery
- Reducing the size of the polypots and
- Increasing the number of seedlings per bed

The type of alterations would obviously vary from place to place. For instance, the planting in an arid area would warrant the need for older and 'hardened' seedlings.

4.3 Weed Control

The degree of the weed competiton in the first year of establishment largely depends on the fertility of the site and the type of site preparation. Some sepcies make sufficient height growth when compared to the weeds and thus may not face competition for light while the slow growers can be completely suppressed. The competition for the nutrients and water would, however, continue.

When the weed growth is heavy and the tree growth is slow, the cost of the weeding oeprations may be very high. Experience reveals that this alone can constitute as much as 30% of the total costs. In such cases, a decision has to be made as to the type of weeding tobe employed. Some of the types of weeding are :

-- Spot weeding
-- Line weeding
-- Mechanised weeding
-- Use of selective herbicides

Factors like the weed intensity; the terrain, labour availability, etc wold determine the type to be employed.

The effect of different types of weeding in a heavily weed infested grassland area, on Eucalyptus was studied. Mammaty weeding the entire area was as good as complete scrapping of the weeds for a width of 0.5 m on either side of the planted row was evident. This again contributed to the reduction of the establishment costs.

4.4 Nutrition

Mineral elements aid in increasing the photosynthetic and other metaolic activities of the plant. These, in turn, increase the biomass produced. The principle macro nutrients required are Nitrogen, Phosphoros and Potassium. In addition, a number of micronutrients like boron, zinc, copper, manganese and others are also required for good growth.

Fertilisers are expensive and it is imperative to gain a knowledge as to the quantity and type of application beforehand. Studies on the influence of the macro nutrients, of varying quantities, on the growth potential of Eucalyptus has been carried out. Potassium at 25g/plant was added to all the combinations as a basal dosage.

The pits were re-exposed and the fertilizers were mixed with the soil and the pits were closed with this mixture and the seedlings planted. The results indicated that there is the possibility of increasing the growth of the seedlings easily two or three fold by judicious nutritional augmentation(7).

5. Bio-Technology and its Applications in Forestry

The issue of increased economicial forests is crucial. It appears that, if the future demands for wood have to be met, it will require better management of available land base. Results indicate that a simple switching over to intensive forest management can boost productivity considerably. The yields of Douglas fir could be increased by 70% nd that of Loblolly pine by 300%(8).If a simple technique of intensive management can make such alterations there must be scope for increasing the productivity still further by improving the efficiency of the basic biological processes involved. The various functions that operate in the trees which can give significant boost to the growth, yield and quality are :

- The tree form and structure
- Photosynthetic efficiency
- Processes governing the growth and dormancy cycles
- Avoidance of water stress
- Cambial production of the wood
- Respiratory processes
- Capacity to seek and acquire nutrients and water

Bio-Technology basically involves the manipulation of these processes at the basic gene or DNA level. The phenomenal success that has been achieved with the crop plants like tobacco in the recent years indicate that a similar possibility is possible with respect to the tree crops also. If results are to be obtained within a short period of time, the answers lies only in genetic engineering.

The asexual reproduction of offsprings which are exact copies of the parent is termed 'cloning'.The trees can be clonally propagated and the offsprings could be put to field trials for testing for testing in about one third the time that is required by the conventional breeding techniques. In addition, it should be necessary to go through the cycle only once to effect a significant gain rather than wait for successive cycles to pool desirable genes. However, there are a number of experimental barriers yet to be overcome.

5.1 Genetic Engineering

Selection of traits presupposes that it exists in the genetic make-up of the individual under study. New methods involve the introduction of new specific chosen gene or DNA into th cell. The cells from which the cellwalls have been removed are termed 'protoplasts'. The possibility of protoplast cultures would offer the interesting possibility of integrating genetic engineering with the well established techniques of tissue culture. It is a lot easier to introduce new genes into the protoplast rather than the plant cell. Researchers in several laboratories have been able to regenerate whole crop plants from transformed cells bearing foreign 'Marker' genes.

5.2 Tissue Culture

Traditionally vegetative propagation by various cuttings is used to clone trees with desirable traits. However, the major problem with this technique is that the selection of superior trees must come only after the trees have reached maturity, at which time, propagation by cutting becomes a problem.

Tissue culture offers an alternative for cloning superior trees. Plant cells excised from almost any part of the tree can be used for regeneration of seedlings by suitably altering the growth hormones in the laboratory. The problems encountered with tree crops is not so much with respect to the development of calls under controlled conditions but is more connected with inducing them to differentiate. Nevertheless, over 200 woody species have been established in callus cultures.In 25 cases, complete seedlings have been developed[9].

Beyond cloning, plant cell cultures offer the potential to rapid screening and selection of desirable genotypes in the laboratory. Traits such as growth efficiency, photosynthetic efficiency, stress tolerance, disease resistance, frost, drought, salinity heavy metal and other herbicide tolerances can be easily screened in tissue culture. Further,fundamental research may disclose biochemical traits of cultured cells that correlate with the cellulose, hemicellulose, lignin, extractive content, fibre quality and other factors thus widening the potential for rapid laboratory evaluation of new genotypes.

5.3 Manipulation of Tree Form and Structure

One of the important fields where genetic engineering hve an important role to play is in altering the 'Body Plan' of the trees. The "narrowed crown phenotypes" illustrates one of the morphological variants. The phenotype seems to be controlled by a single dominate gene. These trees grow strongly in height and thickness and the branch growth is reduced. Finnish researchers, working with Scotts pine and Norwary spruce, have reported that the narrow crown phenotypes showed 25% more growth in height and 45% more in the yield, whencompared to their normal counterparts with similar basal area([10]).

From a forest manager's point of view, the advantages are tremendous as he can increase the number of trees per unit area, and at the same time, derive the benefits of higher yield and the need for lesser thinning uring the life cycle of the trees.

6. Conclusions

As the standard of living of our rural poor improves and the rate of literacy increases, the need for paper and paper products are also bound to increase.

The pulp and paper industry is already facing a severe shortage of forest based raw materials like hardwoods and bamboo and the gap is sure to widen in the years to follow. The increasing population has been consuming more and more forest products as a main source of energy and unless an alternate resource is identified and made available to them the pressure on forests is bound to continue.

The need for raising more man-made plantations is the need of the hour and can be the only alternate available to the industry if sustained production to meet the growing demand is to be met. Massive afforestation programmes need to be taken up on a warfooting. This calls for a cohesive functioning of all the concerned. The government has to make the land available, the financial institutions to make funds available as "soft" terms and the endusers, namely, the industry offer managerial assistance and guaranteed price for the produce. The advantages that canbe reaped from intensively managed planatations has been well demonstrated in a number of countries. The success story of the Brazilians with their eucalyptus plantations is a case in point. The mean annual increment which they have been able to achieve is nearly ten times what we have been able t obtain. Some of the crucial inputs which are required to bring about this are :

- The allotment of land to the industry for captive plantations.
- The availability of soft loans from the financial institutions.
- Involvement of the landless labourers in raising the plantations
- Participation of the industry in offering managerial assistance and in assuring a fair price to the produce
- The need for establishment of sound research and development facility to identify the site characteristics, choice of species, provenances and other management techniques like espacement, thinning cycles, coppicing vigour etc.
- Incorporation of bio-technology which offers number of efficient and novel methods to boost productivity.

7 Acknowledgements

I gratefully acknowledge the valuable guidance and unqualified support extended to me by the management of SPB Projects nd Consultancy Limited, Madras.

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TABLE 1

DEMAND PROJECTIONS FOR PAPER, PAPER BOARDS & NEWSPRINT[1]

(Lakh tonnes)

Year	Paper & Paper Board	Newsprint	Total
1987	16.40	4.65	21.05
1990	19.09	5.49	24.58
1995	24.59	7.02	31.61
2000	31.68	9.44	41.12

TABLE 2

THE AMOUNT OF RAW MATERIAL THAT NEED TO BE MOBILISED IN FUTURE[3]

(Lakh tonnes)

Year	Raw material Available			Demand For Paper, Paper boards & Newsprint	Paper that Can be produced	Extra Raw material needed
	Bamboo	Wood	Total			
1987	19.0	13.1	32.1	21.05	12.11	8.94
1990	19.0	13.1	32.1	24.45	12.11	12.34
1995	19.0	13.1	32.1	31.61	12.11	19.50
2000	19.0	13.1	32.1	41.12	12.11	29.01

TABLE 3

TOTAL FINANCIAL INSVESTMENT REQUIRED ON FOREST PLANTATIONS[6]

year	Investment for bamboo Rejuvenation	Investment for bamboo Plantation	Investment for wood plantation
1991	--	128	--
1992	400	299	635
1993	800	513	1352
1994	1200	641	2145
1995	1200	769	3014
1996	1200	897	3958
1997	1200	1038	4978
1998	1200	1191	6100
1999	1200	1356	7273
Total	8400	6832	29505
Total Investment required at present day costs by 2000 Ad (Rs. lakhs)			44737