

Technology for Improving Productivity of Plantations

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STATUS OF FORESTS

Nearly 64 million hectare (ha) land or 19.4% of the geographical area of India is under forest cover. However, 25 million ha of this area comprise of degraded forest land with crown cover density less than 40% (Anon. 1991). Our forests have poor growing stock of 65 cum/ha, and very low volume increment @ 0.5 cum/ha/yr. Current productivity of forests at 32 million cum is far short of country's requirements of wood.

Intense biotic pressures lead to depletion of growing stock, poor regeneration and environmental degradation. Soil erosion, silting of river and reservoir beds and fury of flash floods is increasing. Maintenance of soil fertility, irrigation potential and life support systems are threatened, thereby limiting the scope for substantial increase in productivity of land on sustainable basis.

Because of increase in population and growth of industries, demand for wood and wood products is growing. According to FAO estimates, consumption of firewood and charcoal is projected at 344 million cum during 2010 compared to actual consumption of 255 million cum during 1991. Consumption of industrial roundwood and sawn timber will grow to 37 and 33 million cum respectively and wood-based panel consumption is likely to increase to 1.27 million cum by 2010. Consumption of paper, paperboards and newsprint is estimated at 5.67 million tonnes by 2010 (FAO, 1993).

As land resources are limited and subject to competing usages, the only way to increase production is to ensure substantial improvement in land productivity on sustainable basis. Restoration of green cover and attaining progressively increasing land productivity are most essential for

- narrowing the gap between future demand and availability of wood based products, timber and

firewood,

- sustaining the momentum of green revolution and life support systems,
- conservation of biodiversity, soil and water resources, prevention of floods and desertification; and
- environmental amelioration and ecological balance.

SUSTAINABLE DEVELOPMENT

Concerted efforts and urgent steps are required for restoring the green cover of India, improving land productivity and production of firewood, timber, pulpwood and other forest products. Sustained drive for tree planting is necessary to create raw material base for wood based industries, environmental amelioration and sustaining life support systems.

Innovative policy changes and sound strategies are required for improvement of land productivity and sustainable increase in production. Amongst others, those strategies should include the following :-

- restoration of growing stock of forests to optimum levels so that annual volume increment is progressively increased.
- urgent replanting of degraded forest areas with appropriate species and provenances matching the site and environmental conditions.
- innovative changes in Government policies to involve corporate sector and encourage private initiative for raising tree plantations.
- allocation of degraded plantable lands to wood based industrial units for long term development of plantations.

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suitable fiscal incentives and tax benefits for encouraging long term investment in plantations.

- scientific management of forests/ plantations and effective protection measures.
- use of improved, genetically superior seed from plus trees or seed orchards for raising nursery stock.
- improved nursery practices, including culling of inferior seedlings, use of high quality potting mixture and containers with root trainers.
- development of fast growing, disease resistant, locality specific clonal planting stock for species amenable to vegetative propagation ensuring fairly wide genetic base of clones.
- appropriate package of practices for management of plantations depending upon the species and site conditions.
- well planned result-oriented investments.

Innovative policy changes to encourage individual and corporate sector investments and involvement in large scale plantations will contribute immensely to improving land productivity and wood production in the country. Many developing countries like Brazil, Chile and Indonesia have wisely encouraged investment in plantations/forestry. These countries have made rapid strides in creating large and cost effective raw material base for sustained growth and development of their wood based industries. With large land and labour resources and good sunshine, there is no reason why India should lag behind.

WOODBASED INDUSTRIES

Availability of forest based raw materials like bamboos and hardwoods for the paper and newsprint industry, matchwood and plylogs from national forests has been declining continuously. Raw material shortage has been major constraint for expansion, growth and development of pulp, paper and plywood industries.

The production of paper and newsprint in India during 1991 was 2.4 million tonnes and consumption 2.58 million tonnes. Consumption is projected to increase to 5.67 million tonnes by 2010 as per FAO estimates (FAO, 1993). According to estimates of the Development Council for paper, pulp and allied indus-

tries, the projected demand of paper, paperboards and newsprint by 2010 shall be 6.3 million tonnes. Estimated actual production of paper and paperboards during 1992 has been 2.13 million tonnes and of newsprint 0.31 million tonnes compared to the installed capacity of 3.6 and 0.36 million tonnes respectively. Thus, the overall capacity utilisation in this sector has been 61% of the installed capacity. Major causes for poor capacity utilisation has been the non-availability of assured long term supplies of pulpwood.

Consumption of industrial roundwood is projected to increase from 25.8 million cum in 1991 to 36.9 million cum by 2010 AD. Similarly sawnwood consumption will increase from 17.4 million cum in 1991 to 33.4 million cum by 2010 AD. Wood based panel consumption is projected at 1.27 million cum during 2010, which will mean nearly threefold increase from 1991 consumption level of 0.44 million cum. Fuelwood and charcoal consumption is projected to increase to 344 million cum by 2010 compared to consumption of 255 million cum during 1991 (FAO, 1993).

India will not be able to meet the growing demand for fuelwood, sawn timber, industrial roundwood and woodbased products like plywood, paper and newsprint unless massive plantations programmes on degraded forest lands, supplemented with farm forestry projects, are launched with immediate effect. However, non-availability of land to the corporate sector for large scale plantations is a major constraint, which needs to be removed through suitable policy changes.

RAW MATERIAL CRISIS

Current supply of bamboo, pulpwood and logs from national forests is far short of the requirements of even existing wood based pulp, paper and newsprint, safety matches and plywood units. With increasing restrictions on normal silvicultural fellings in the forest areas comprising national parks and wildlife sanctuaries and hilly areas above 1000 meters altitude and increasing demand for non industrial usages; supply of bamboos, pulpwood, matchwood and veneer logs to industry from Government forests is further shrinking. Surplus bagasse and cereal straws are available only in limited quantities for pulp industry. There are severe limitations to usage of these materials because of their bulk, transport bottlenecks, poor storage and narrow

range of quality of paper/newsprint which can be economically produced.

Expansion of existing forest based pulp mills is held up for want of raw materials. No greenfield investments in this essential core sector are forthcoming in the absence of assured long term raw material supplies at reasonable costs. Plywood and veneering, safety match and many other forest based units are facing acute shortage of roundwood of appropriate industrial qualities. Large quantities of pulp, newsprint and veneer logs have to be imported. We cannot afford huge drain of scarce foreign exchange resources on import of pulp, newsprint and plywood/ logs, particularly when we do have the potential to grow enough woodbased raw materials. We must choose the option of achieving self-sufficiency through self reliance and technology based plantations.

ALLOCATION OF LAND FOR PLANTATIONS

The obvious answer should be to accept the challenge and lead India on the path of self reliance. An effective long term solution to enable wood based industries to meet their raw materials requirements is captive industrial plantations with well planned long term investments, intensive scientific management and genetically improved planting stock including high yielding disease resistant clonal saplings. Government should initiate policy reforms to allocate degraded forest lands to the wood-based industries for raising plantations and suitable guidelines should be framed for management of such plantations. Likewise, ceilings on agricultural land holdings should be liberalised in respect of wastelands which can be reclaimed and managed on sustainable basis under plantations.

Restoration of degraded forest lands and reclaimable wastelands to productivity through scientific afforestation will take pressures off the remaining natural forests. Industrial plantations will reduce dependence of wood based industries on natural forests and prevent the massive drain of foreign exchanged on import of pulp, wastepaper, newsprint and ply logs. Plantations will generate ample employment opportunities for the rural poor, improve availability of fuel wood, contribute to the greening of India and environmental amelioration. However, if we do not act fast on this option of self-reliance and self-sufficiency in industrial wood requirements through plantations, all the

aforsaid benefits will accrue to the exporting countries at India's cost.

Large tracts of degraded forest lands covering 31 million ha are available in the country. Part of the 100 million ha degraded wastelands outside the forest areas can be reclaimed for tree planting. Adequate degraded forest lands/reclaimable waste lands in large contiguous blocks should be allocated to wood-based industries for long term development through technology based plantations in the vicinity of the mills. Even though gestation period of returns from plantations is long and developmental costs/investments are very high; the corporate sector is keen to take up the challenge of raising captive plantations. Government should encourage the participation of corporate sector in greening of India through innovative policy changes, allocation of plantable degraded lands and suitable fiscal incentives for long term investments in plantations. Corporate sector will improve productivity of plantations through modern technology, intensive management and improved/clonal planting stock.

ROLE OF FARM FORESTRY/SOCIAL FORESTRY

Existing area under forests cannot meet national needs for firewood, timber and wood-based industrial raw materials even after restoration of degraded forests and substantial improvement in productivity. This is because the projected requirements of wood by 2010 AD are nearly 13 times the current productivity of forests. Hence, farm forestry, plantations along farm roads, farm boundaries and irrigation channels and village woodlots, will play key role in narrowing down gap between future demand and supply of wood.

Scarce land resources are subject to competing land usages and the tree species selected for farm forestry plantations must not only match the site and agroclimatic conditions, but also offer significant improvement in overall economic returns to land owners. The other prerequisites for successful implementation and expansion of farm forestry programmes are as follows:

- assured supply of genetically superior, high quality planting stock.
- effective technical extension services and appropriate package of practices.

- marketing support and buy back guarantees at remunerative price by promoters/ wood based industries.
- long - term bank finance at reasonable rates of interest.
- research and development support, including research on intercropping strategies.

Plantations outside the forest areas on vacant government lands, marginal agricultural lands, rail road and canal strips, community lands will be helpful for bridging the gap between demand and supply of wood. Part of the 100 million ha wastelands outside the forest areas could be reclaimed and planted with suitable tree species. However, major contribution to the national effort for achieving self-sufficiency in wood will be through agroforestry plantations.

PRODUCTIVITY OF PLANTATIONS

Mere planting of seedlings to achieve given physical targets is not going to solve our problems and save the natural forests. As land resources are limited and subject to competing demands for alternative usages, it is absolutely necessary that we raise successful plantations ensuring optimum levels of survival and growth rates through appropriate inputs, silvicultural and management practices and effective protection measures. We should be able to achieve best possible productivity from our limited land resources on sustainable basis for which the following important steps will be essential pre-requisites.

- choice of proper tree species keeping in view the edaphic and environmental conditions.
- appropriate package of practices for management of plantations depending upon the site conditions and silvicultural requirements of the species.
- suitable soil and water conservation measures and irrigation of plantations wherever feasible.
- genetically superior, high quality planting stock.
- inoculation of planting stock with appropriate strains of mycorrhizae/ rhizobium associated with chosen tree species.
- research and development support for continuous improvement of planting stock and package of practices.

- adequate site preparation before transplanting, prophylactic treatment of seedlings/planting pits for prevention of damage by termites/pests.
- sufficiently deep planting pits, transplanting during early part of monsoon rains in case of rainfed plantation, adequate weeding and soil working.
- effective protection measures to prevent damage by fires and grazing cattle.

IMPROVED SEED SOURCES

In case of plantation forestry, planting stock is raised in nurseries under controlled and congenial conditions unlike harsh and often hostile environment faced by natural wild seedlings. Nursery raised seedlings do not benefit from early natural selection. Each transplanted seedling, irrespective of its genetic qualities, is expected to grow and provide useful timber or other products. For short rotation tree crops like Eucalyptus and Casuarina grown for pulpwood/firewood, even intermediate thinnings are not provided for. Poor genetic quality of plants will adversely affect the productivity of scarce land resources throughout the rotation period and yield poor quality produce with low returns on investments. Therefore, for taking full advantage of geoclimatic conditions and productivity potential of the plantation sites, the genetic qualities, including growth rates, form, disease resistance and adaptability of planting stock, must be of the highest order.

Improvement of seed sources requires adoption of sound selection and breeding strategies, long term planning and investments. Following stepwise approach will ensure some gains which could be further enhanced on long term basis.

- demarcation of seed production areas/ establishment of seed stands.
- collection of seeds from candidate pulps trees selected based on superior phenotypic characters from natural forests and plantations representing best adapted provenances in case of exotics.
- identification of plus trees through half-sib progeny trials with seeds collected from candidate plus trees.
- raising of seedling/clonal seed orchards based on plus tree seeds or tested superior clones with fairly

wide genetic base.

- controlled pollination/ hybridisation for gainful exploitation of heterosis.

However, gains in productivity will be slow in case of traditional seed route breeding compared to the potential immediate gains through clonal planting stock multiplied from selected superior genotypes.

CLONAL PLANTING STOCK

Clonal technology primarily envisages taking advantage of the natural variation in tree species for immediate gains in productivity and quality of produce of new plantations. Important steps for tree improvement through vegetative propagation and cloning techniques involve selection of Candidate Plus Trees (CPTs) from existing plantation/ forests based on desirable phenotypic features; cloning of the CPTs through rooting of juvenile cuttings under controlled environment and field testing of the clones for selection of genetically superior, fast growing and disease resistant clones. The clonal planting stock based on such selected superior clones captures the desirable natural variations, resulting in substantial improvement in productivity and quality of wood of future plantations. Large scale usage of high yielding, disease resistant, fast growing and locality specific clonal planting stock can increase productivity and returns from farm forestry and forest plantations substantially. (Lal 1991 and Lal et al, 1992).

Since 1960, certain events have made clonal option the strategy of choice for most species of major importance in regeneration of renewable wood resources. Potential of quick gains and other advantages of clonal option have been recognised. Shortcomings of improvement strategies exclusively based on seed route have been realised. The effects of maturation state and phase change have been appreciated. We can now hold a clone in juvenile stage or return it to juvenility for propagule production through coppicing, hedging, etc. (Libby 1987). Use of juvenile coppice shoots or rejuvenated stock led to successful production of rooted cuttings under mist for cloning of many species. It is possible to take advantage of heterosis and exploit hybrid vigour to great advantage by selection, testing and cloning of outstanding inter-specific or intra-specific hybrids. These developments have opened vast possibilities and new vistas for sustainable

improvements in land productivity, yields and economic returns from plantations based on genetically superior, disease resistant clonal planting stock. Vegetative propagation techniques are now being used for gainful exploitation of natural variation of many important coniferous and hardwood species, and the pace needs to be accelerated.

Clonal option for species amenable to cost effective vegetative propagation, with due safeguards, offers fastest gains in the short run. Combination of cloning and long term breeding strategies provides immediate benefits, requisite genetic diversity and rich long term gains. Even comparatively high production cost of clonal planting stock, which is often one of the constraints to faster spread of clonal plantations, has been amply justified by gains in yields and improvement of wood quality in many cases (Lal 1992).

Substantial gains in productivity through applications of vegetative propagation techniques have been achieved in case of many tree species of Eucalyptus, Gmelina, Acacia mangium, Triplochiton, etc. (Leakey, 1987). Best known examples is Eucalyptus in Brazil where average productivity of clonal plantations ranges between 45-75 cum/ha/yr depending upon site qualities and mean annual increment upto 100 cum/ha/yr has been achieved with some of the outstanding clones on best sites (Campinhos et al, 1990; Lal 1992).

One of the successful clonal plantations project in India is based on *Populus deltoides* clones in the irrigated plains of North Western India in the states of Punjab, Haryana and Uttar Pradesh. Under a Farm Forestry project being implemented since 1984, with the refinance assistance of the National Bank for Agriculture and Rural Development (NABARD), currently about 4,000 ha are being planted with poplars annually (Jones and Lal, 1989).

R & D work for multiplication and improvement of teak, tamarind, semal, Gmelina and many other tree species and bamboos through vegetative propagation techniques is being carried out by the State Forest Departments and Research Institutes. The success story of irrigated clonal poplar plantations will now be repeated under rainfed conditions as well with the clonal planting stock of *Eucalyptus tereticornis* and Mysore gum developed through the private initiative and pioneering efforts of ITC Bhadrachalam Paperboards Limited in Andhra Pradesh.

ITC BHADRACHALAM EXPERIENCE

Research and development programme for application of clonal technology for improvement of eucalyptus planting stock was launched by ITC Bhadrachalam in July 1989. Nineteen clones of Eucalyptus tereticornis and Mysore gum were planted in the first clonal testing area at Bhadrachalam during September 1989. So far more than 300 candidate plus trees have been cloned and based on their performance in replicated field trials, 35 most promising, fast growing and disease resistant clones have been identified for mass multiplication. Some of these clones have attained mean annual increment of 18 cum/ha/yr (underbark volume) at 4 years age under rainfed conditions (Lal et al, 1992; 1993; 1994).

Clonal demonstration plantations have been established at six different locations in Guntur and Khammam districts and more demonstration plots are being planted. Improved clonal planting stock has been released to progressive farmers for field planting. Mist Chamber and related facilities are being expanded in a phased manner for supporting clonal farm forestry plantations programme and supply of improved clonal planting stock to state forest departments/forest development corporations.

Productivity of clonal eucalyptus plantations on conservative estimates under rainfed conditions is estimated to be 20-25 cum/ha/year compared to MAI of 10-15 cum/ha/year from farm forestry plantations raised from improved seed source, and 5-6 cum/ha/year MAI of forest plantations with ordinary seed at 7 years rotation.

Today, ITC Bhadrachalam can take legitimate pride in having largest stock of improved, promising and disease resistant clones of Eucalyptus in India. Supply of 0.12 million plants of selected 'Bhadrachalam' clones of Eucalyptus to AP Forest Development Corporation during 1994 monsoon rains will mark the beginning of 17,500 ha industrial plantations programme in Andhra Pradesh under a World Bank aided project.

The Federation of Andhra Pradesh Chambers of Commerce and Industry conferred on ITC Bhadrachalam an award for "The Best Technological Development in Research and Development by an Industrial/ Scientific Organisation in the State during 1991-92" in recognition of the company's R & D achievements in selection of outstanding eucalypt

clones. Encouraged by the success story of cloning eucalypt, the company has taken up cloning of Candidate Plus Trees of Casuarina and initial trials have been quite successful.

SOUND SILVICULTURE AND BREEDING SUPPORT

Because of uniformity in the genetic qualities of planting stock of each clone, it is reasonable to assume high degree of specificity of different clones for their comparative adaptability to different site qualities. Matching of selected, improved clones included in the production programme to specific sites through field testing and monoclonal plantations of best adapted clones in small blocks should improve productivity of plantations. There may not be serious risks in this approach for short rotation (6 to 7 years) plantations for pulpwood and firewood. However, risks associated with narrow genetic base of clonal plantations of species requiring long rotations need to be appreciated and suitable strategies must be adopted for minimising such future risks. A reasonably large number of genetically diverse clones should be included in the plantation programme. Apart from the productive potential of the clones, their adaptability to environmental conditions, resistance to potential pests and diseases, response to moisture stress, wind damage, etc, should also be given due importance in the development and deployment of clones for commercial plantations.

Plantations based on improved clonal planting stock must be backed-up by sound silvicultural and management practices to take full advantage of the favourable genotype-environment interaction for sustainable gains in productivity. Currently available best clones will often lead to a dead-end in productivity unless new and better clones are added to the plantation programme through a continuous ongoing process of selection of future clones. This will also involve introduction of new genetic material, which should include breeding for new variation through controlled pollination between selected clones and programme of hybridisation between species to take advantage of resultant heterosis through cloning of outstanding individual hybrid trees. Best clones of today should be replaced in due course with still better ones in future. With due precautions in respect of various apprehensions and risks expressed about clonal plantations, productivity levels can be substantially improved on a sustainable basis and desirable qualities of produce can be enhanced through clonal technology combined with

sound breeding strategies (Lal, 1992).

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SUMMARY

Forests in India are under intense biotic pressure leading to depletion of growing stock, low productivity and poor regeneration. Urgent restoration of green cover and sustainable improvements in land productivity are essential for meeting future wood requirements and maintenance of ecological balance. Government should encourage participation of the corporate sector in greening of India through innovative policy changes, allocation of land fiscal incentives for long term investments in plantations.

Improved genetically superior seedlings/ clonal planting stock, scientific management, well planned investments are required along with policy changes. Farm forestry will play an increasingly important role in bridging demand-availability gap. Genetically superior planting stock, marketing and R & D support, effective technical extension services and long term bank finance are essential for expansion of farm forestry programmes.

The challenge for meeting increased demands must be met through sustainable and appropriate forest development strategies. Intensive forest management practices, plantations of fast growing species, with improved clonal planting stock will ensure substantial immediate gains in productivity.

Long term breeding support, including hybridisation and gainful exploitation of heterosis through cloning, will revolutionise productivity of plantations with substantial improvement in desirable wood qualities. Sound silviculture and management practices, with due safeguards, are essential for enhancing gains from clonal plantations.

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