Bhadrachalam Clones of Eucalyptus – An Achievement of ITC*

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Abstract

ITC Limited - Bhadrachalam Paperboards Division has successfully implemented a major research and development project begun in 1989 with a view to improving the productivity and profitability of plantations and making farm forestry an attractive land use option. The major research and development emphasis has been on genetic improvement of planting stock and improvement in the “package of practices” used by growers. Significant gains in productivity of eucalyptus have been achieved through vegetative propagation and cloning techniques and exploitation of existing useful variation. These clones, developed in India for the first time, are known as ‘Bhadrachalam’ clones. Productivity of clones released for commercial plantations, ranges between 20 and 58 cubic meter per hectare per year under un-irrigated conditions compared to 6 to 10 cubic meters per hectare per year productivity of eucalyptus plantations raised from available seed sources. Several intra-specific and inter-specific hybrids of eucalyptus have been developed through controlled pollination. Development and deployment of locality-specific, high-yielding, fast-growing and disease-resistant clones has been followed by rapid adoption and raising of large-scale commercial clonal eucalyptus plantations. Between 1992-2001, nearly 14 million clonal saplings were supplied to farmers and Forest Departments covering 8000 ha of plantations. Current production capacity is 6 million saplings per year. This paper discusses the success story of development and commercial scale deployment of high yielding, fast growing and disease resistant clones of Eucalyptus and the promotion of technology-based clonal farm forestry plantations in India. Policy issues and reforms concerning registration of clones of tree species, registration of nurseries, certification of improved tree seed and clonal planting material, regulatory mechanisms and transit rules for harvesting and marketing of farm grown wood etc. are also discussed briefly.

INTRODUCTION

ITC Limited’s Bhadrachalam Paperboards Division uses 160,000 MT of Eucalyptus wood per annum in its furnish for manufacturing the pulp and paperboard along with Leucaena, bamboo and secondary fiber. A plan to grow 10,500 ha over a period of 7 years was developed to meet the raw material requirements of the mill on a continuous and sustainable basis in the year 1989.

The prevailing scene at that time on eucalyptus seed route plantations were grim as the foliar blight disease caused by Cylindrocladium spp. was quite prevalent in plantations. Termites caused large-scale seedling mortality in plantations of a young age. The outcome was that the survival of trees in plantations at harvest stage was 30 to 50 per cent in many cases and the productivity was 4 to 6 m$^{3}$/ha/yr which was extremely low. The other reasons for poor productivity were hybrid breaking, close spacing, lack of availability of quality seeds, primitive nursery practices, mismatching of species and provenance’s to site, lack of follow up of correct package of practices etc., (Kulkarni,
Farmers were afraid to take up plantations due to eucalyptus controversy (Rajan, 1987). Due to low yields, the plantations were also not economical to the farmers as an alternative farming option. Furthermore, the farmers did not prefer to plant polypot seedlings in their farmlands and farm forestry plantations were becoming unpopular inspite of the incentives, subsidies and National Bank for Agriculture and Rural Development (NABARD) loans given to the farmers. This adverse scenario changed in the year 1989 when the company decided to adopt root trainer technology coupled with clonal propagation of eucalyptus (Kulkarni and Lal, 1995) by launching the Tree Improvement Programme. The results achieved so far are detailed in this paper.

MATERIALS AND METHODS

The experimental site and clonal research station is located at 17° 40' N latitude and 81° E longitude. The altitude of the place is 100 m above mean sea level. The climate is sub tropical with annual rainfall of 1033 mm, mostly from southwest monsoon. The maximum temperature is 49 °C and minimum 10 °C. The predominant soil types are red sandy and black cotton soils. Soils are either normal or alkaline. Saline soils are also found.

By importing seeds from CSIRO (Australia) in the years 1986, 1990, 1994 and 1995 provenance trials were raised. Candidate plus trees of *E. tereticornis* Smith. and *E. camaldulensis* Dehnh. were mainly selected from Government and Farm Forestry plantations. Selected plus trees were propagated vegetatively from coppice cuttings in mist chambers. Root trainer technology was adopted for the production of plants. The successful ramets were planted in Gene Banks known as Clonal Multiplication Areas (CMA) at an espacement of 1 x 1 m. The clonal testing trial areas (CTA) were planted at 3 x 2 m spacing in RBD with 3 replications. Promising clones were shortlisted from CTA’s for growth, disease resistance and pulp and paper qualities. Clonal Seed Orchards (CSO) adopting the permutated neighborhood design (Srimathi, et. al., 1984) were established. Clonal demonstration plots were raised under the extension scheme. Inter and intra-specific hybridization was carried out between selected best clones and other species of eucalyptus. Half and full-sib progeny trials were laid out. Promising hybrids were cloned and planted in multilocational trials. Genotype x Site interaction studies for various clones were carried out on normal and refractory sites. A gene repository is also established for conserving various types of clones.

RESULTS AND DISCUSSION

Clonal technology research and development

With a mission to achieve improvements in productivity and profitability of plantations, the company focused on genetic improvement of planting stock and improvement of the package of practices. Major gains in productivity of eucalyptus plantations have been achieved in the short span of 12 years through applications of cloning techniques for gainful exploitation of existing useful variation.

Gene Resources. At the beginning of the programme, the main handicap faced was the non-availability of a wide genetic base for the improvement of eucalyptus. Therefore, a “Breed the best with the available best” strategy was followed. The genetic base deployed for improvement is given in Fig 1.

Candidate Plus Tree (CPT) Selection. The selection of the most desirable tree with characteristics such as straightness of stem, annual growth rate, disease resistance, crown structure, wood density, fiber morphology, cellulose/lignin balance, bark to solid wood, under bark relationships etc were considered. Trees were selected from Government (Andhra Pradesh Forest Development Corporation - APFDC) and farmers’ plantations. Starting with the cloning of 64 CPTs during 1989, more than 650 CPTs and 247 full sib CPTs have been selected and cloned by now. Out of 86 promising clones qualified so far, 54 (63%) have come from the provenance seeds source obtained from CSIRO, Australia and 32 (37%) from local Mysore gum. The provenance’s that gave maximum clones are 8 KM NW Black Mountain and 1 KM N of Laura (Fig 1).
Figure I. Gene resource for TIP

**BASE POPULATION**

- *E. teriticornis*
  - Black mount – 60
  - Kennady River – 5
  - Mt. Molley – 26
  - Ruthcreek – 31
  - Mysoregum – 299

- *E. simulata*
  - Laura – 44
  - Kennady – 39

- *E. camaldulensis*
  - Katherine river – 19
  - Maxwelton – 8
  - Petford – 32
  - Kennady River – 32

- *E. urophylla* – 12
- *E. grandis* – 2
- *E. alba* – 1
- *E. pellita* – 1
- *C. torelliana* – 1

618 CPT’S

**PRODUCTION POPULATION**

86 PROM CLONES

**BREEDING POPULATION**

- CSO-7
- INTRA-217
- INTER-30

HYBRIDIZATION

**WOOD PRODUCTION POPULATION**

HYBRID CLONES

NEW EUCA FORESTS

CTA
CMA
G x E
SILVI TRIALS
**Clonal Testing and Promising Clones.** Clones were evaluated from CTAs for comparative genetic superiority and G x E interactions. Nearly 123 trial plots in a 29 ha area have been established since 1989 in various soil types. 86 promising clones were shortlisted from the above trials. In the beginning of the programme, clones were planted without due regard to site. After a gap of 3 to 4 years, it was discovered that some clones were doing well and some were not in a given site. This was the biggest challenge faced by the research team, i.e., the matching of clones to specific sites. In general, black soils (normal, alkaline and saline) require specific clones such as clone 1, 10 and 130 which adapt well, but clone 10 doesn’t tolerate saline sandy soils this leads to high mortality (up to 90) which was observed at 2 years age at Tungtur (Prakasham Dist in A.P). However, in the same plot clone 411 and 413 were performing well with high productivity and survival. Normally, CPTs selected from black soil are to be tested first on black soil itself and later on other soil types as clones exhibit a strong affinity to the site of their origin. For example, clone 351, that was selected from black soil gave a yield of 22 cum/ha/yr on similar site compared to 6 cum/ha/yr on red soil (Table 1). These are a few examples, which open new vistas for future research in clonal forestry relating to genotype site interactions.

Now there has been a slight change in clonal testing policy to make the farm forestry business more lucrative and farmer friendly. Therefore, clonal testing is now directly taken up in the farmer’s field for obtaining higher yields with short rotation (at 2 to 3 years) by providing irrigation, fertilization and close spacing. Furthermore, to develop future clones with higher productivity over the exiting ones, bench marking is practiced by the introduction of check clones apart from seedling control in CTA 21 and 83.

**Table 1. Performance of two clones 3 & 351 on red and black soils.**

<table>
<thead>
<tr>
<th></th>
<th>Red soil</th>
<th>Black soil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clone 3</td>
<td>Clone 351</td>
</tr>
<tr>
<td>CAI at age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>14.2</td>
<td>7.9</td>
</tr>
<tr>
<td>2</td>
<td>24.7</td>
<td>4.9</td>
</tr>
<tr>
<td>3</td>
<td>11.7</td>
<td>5.7</td>
</tr>
<tr>
<td>4</td>
<td>14.8</td>
<td>5.4</td>
</tr>
<tr>
<td>MAI at 4 years</td>
<td>16.3</td>
<td>6.0</td>
</tr>
</tbody>
</table>


**Disease Resistance.** The outbreak of diseases caused by various fungi on Eucalyptus in nursery and field were studied. The main pathogens recorded are *Cylindrocladium* spp. and *Alternaria* spp. Clones resistant to disease are identified from CTA and nurseries. Disease resistant clones short-listed are Cl. 1, 3,6,7,288, and 316.

**Productivity of clones.** The survival percentage of the majority of clonal plantations is reported to be more than 95 per cent, which is unheard of in Indian forestry (Kulkarni and Lal, 1995). The productivity of “Bhadrachalam” clones range from 24 to 58 m³/ha/yr compared to 6 to10 m³/ha/yr from seedling origin plantations (Fig. 2 to 4). Apart from increases in productivity by 4 to 6 times the rotation period is reduced by half (Fig. 5). Therefore, the farmers are now harvesting plantations at 4 to 5 years instead of 7 to 8 years.
Figure 4

ITC BHADRACHALAM PAPERBOARDS LIMITED, SECUNDERABAD, INDIA
CURRENT ANNUAL INCREMENT: CTA23 : AGE: 6 YEARS
LOCATION: BHADRACHALAM

Figure 5.

CAI and MAI for Clone No 7
Clonal Multiplication Areas (Gene bank). Since 1989, the CPT material has been first planted in the Gene banks. For large-scale commercial production of plants, a gene bank of promising clones was established in 26 ha with nearly 0.2 million ramets. The clones were planted in blocks at closer spacing of 1 x 1 m. Gene banks are coppiced at 2 years age for obtaining the propagule for multiplication.

Clonal Demonstration Plots. Clonal demonstration plantations raised by the company resulted in large-scale adoption of genetically superior "Bhadrachalam" clones of eucalyptus by the farmers and State Forest Departments / Forest Development Corporations. Since 1989, nearly 24 ha of clonal demonstration plots have been established at various places in Andhra Pradesh. As seeing is believing, farmers meetings were regularly held in these plots which enabled them to pick and choose the clones most suited to their land.

Clonal Seed Orchards. Clonal seed orchards with the best "Bhadrachalam" clones covering an area of 0.71 ha have been planted in two plots for the production of genetically improved seed. Yearly, 5 to 10 kgs of improved seed is being collected and distributed to growers. Fresh CPTs are now being selected from the CSO seed source plantations as selections with new recombinations resulting from CSO seeds will produce the next generation of clones. Six CPTs have already been selected for cloning.

The major problem encountered in raising CSO was that the neighboring fast growing clones suppressed the slow growing clones. Thus planting in a mosaic design did not serve the purpose. Another problem encountered was non-synchrony in flowering resulting in restricted gene exchange.

Hybridization. To develop Eucalyptus for the future, the hybridization programme was initiated in 1994. A breeding orchard was set-up with cleft grafted plants of *E. tereticornis*, *E. camaldulensis*, *E. alba*, *E. urophylla* and *E. grandis*.

Grafting. The selected material was multiplied in large numbers by cleft grafting. The graft union was successful between *E. tereticornis* Smith. root stock and scion material derived from *E. alba*, *E. camaldulensis* and *E. urophylla*. Graft incompatibility, however, was noticed in the case of *E. torelliana*. At 7 years of age, the grafts in the breeding orchard have attained a maximum GBH of 58 cm and height of 10 m. The best results of grafting were obtained in the months of August to November. Almost all the grafts flowered at 2 to 3 years age.

Hybrid Development. In 1970 the Forest Research Institute, Dehra Dun developed inter-specific hybrids between *E. tereticornis* Smith. and *E. camaldulensis* Dehnh. (Venkatesh, 1977 & 1981). These FRI 4 and 5 hybrids were field tested on large scale. However, there was no improvement in wood yield because the productivity did not exceed 10 cum / ha / yr. These di and tri-specific hybrids of *E. tereticornis*, *E. camaldulensis*, and *E. grandis* were as good or as bad as parents. In case of Mysore gum there was already hybrid breaking taking place. Hence, earlier efforts on hybridization did not produce required results.

In the present case however the strategy followed was to introduce new provenances from Australia and select CPTs for desired characteristics and involve short-listed promising clones in hybridization. At first, inter-specific hybridization was attempted to combine desirable complementary attributes of promising clones and eliminate defects, keeping in view the customers (grower/mill) viewpoint viz. high yields (volumetric productivity), felling cycle of 3 to 5 years (economic rotation), adaptability to sites, superior wood quality and uniformity of raw material. The clones with well-defined traits (Table 2) were included in the breeding programme.
Table 2. Clonal characters for hybridization

<table>
<thead>
<tr>
<th>Clear bole</th>
<th>High productivity</th>
<th>Adaptable to refractory sites</th>
<th>Disease resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,4,6,7,27,122,22, 265, 266, 272,274, 275, 284, 286,288, 290, 292, 316 and 319.</td>
<td>3,6,7,10,105,130,265,26 6,272,274,284,290,292,316 and 319.</td>
<td>1,10,71,105,115, 116,128,130,223, 266,271,272,274, 285,290,316,405, 411 and 413.</td>
<td>1,3,6,7,288 and 316.</td>
</tr>
</tbody>
</table>

Development of inter-specific hybrids such as *E. tereticornis* Smith. x *E. urophylla* Blake.; *E. tereticornis* Smith. x *E. grandis* Muell.; *E. tereticornis* Smith. x *E. camaldulensis* Dehn.; *E. tereticornis* Smith. x *E. alba* Reinw. and *E. tereticornis* Smith. x *E. toreliana* Muell. were attempted. One of the major problems encountered in breeding *E. urophylla* is that the flowering coincides with the rainy season (August) leading to flower drop (before and after fertilization). Therefore, *E. urophylla* is considered to be the male donor parent as the pollen is collected in the month of August and is stored and used for pollination in the months from October to January on other Eucalyptus species. Seeds of Urograndis and Teretigrandis were obtained from Shell Forestry, U.K. In CTA at the age of 2 years, Teretigrandis has produced 9 cum / ha / yr. If Teretigrandis and Urogandis adapt well to drought conditions and produce maximum volume of wood then it will be the better choice for pulp and paper mills compared to *E. camaldulensis* and *E. tereticornis*.

By controlled pollination between the best 32 clones of *E. tereticornis* the derived full-sib hybrids have shown good heterosis at 1 to 2 years age. The full-sib progeny trial showed a maximum if 33% improvement over the parents for production of wood volume. Based on the performance of full-sibs, elite full-sib trees were selected and cloned. Nearly 247 full-sib hybrid trees have been cloned. These hybrid clones have been tested on various sites. Heterobeltioisis studies on 18 hybrid clones showed maximum of 82% improvement in wood volume production over the best parent. A few hybrid clones from the crossing of clone 6, 10 & 27 gave hybrid clones 2011, 2014, 2045, 2050, 2052, 2053, 2120, 2121, 2149, 2155 and 2156 which are totally devoid of the defects and surpassed in growth. In addition, some of the clones showed a narrow crown which is required for closer planting at a spacing of 3 x 1.5 m enabling harvesting of trees at 3 to 4 years age.

**Improvement for Pulp and paper quality.** As soon as the CPT was selected it was first tested for proximate chemical analysis and strength properties. A few clones have given 49 per cent screened yield compared to 45 per cent from seed route plantations. Over the last two years much emphasis has been laid on improving the fiber quality by hybridizing clones with the best fiber properties. The best fiber for papermaking is derived from species like *E. globulus*, *E. grandis*, *E. deglupta*, *E. urophylla* etc. apart from their high growth potential. Therefore, a few high yielding “Bhadrachalam” clones are now being hybridized with the above species to achieve twin objectives of improving fiber properties and inducing drought resistance so that new hybrids developed are adaptable to sub-tropical agro-climatic conditions.

**Clonal Nursery Infrastructure.** For a successful clonal forestry programme a good nursery is a pre-requisite. A modern clonal nursery with an annual production capacity of 4 million eucalyptus ramets was established at ITC Bhadrachalam with indigenous technological know how. Vegetative propagation protocols were standardized and root trainer technology was adopted for mass multiplication. Presently, the infrastructure for clonal propagation includes 31 mist chambers covering an area of 3100 m², hardening area of 900 m² and 25,000 m² for open nursery. The clonal technology with root trainer has given considerable improvement in the production of quality planting stock as well as resulting in the improvement of productivity. The experience gained in the clonal root trainer nursery is quite rewarding and successful. The root development is better than seedlings raised in poly pots as root coiling is totally avoided as multiple roots formed in the hiko-pots. The out planting results were quite high thereby increasing survival and productivity. Though the cost initially appeared high for clonal root trainer nursery, in the financial
analysis the ROCE and RONA were high. Moreover, the investment is paid back many times due to lower handling, cultural and transport costs, on top of improved plantation productivity and quality of produce.

**Improved Package of Practices.** Apart from the superior genetic quality of the planting stock, site quality, adaptability of the clones to specific sites, implementation of the improved package of practices and effective protection of plantations from damage by pests, diseases and cattle are also important factors which determine the overall productivity of the plantations. Therefore, the Company developed an improved package of practices for raising and maintenance of clonal eucalyptus plantations and demonstrated the benefits of the same to the farmers. Study of soil profiles and analysis of soil samples is carried out to match adaptable clones to the planting sites. Deep ploughing of the soil with disk ploughs or mould-board ploughs in both directions is recommended for preparing the fields for transplanting of clonal saplings. Spacing of 3 x 2 m is recommended for the production of poles and pulpwod, and larger spacing is desirable for production of timber from clonal eucalyptus plantations. Transplanting in 30 x 30 x 30 cms pits is carried out during the early parts of the monsoon rains so that plants establish and grow well benefiting from the good moisture availability throughout the monsoon rains. Soil in and around the planting pit is treated with 2 ml of Chloropyriphos in 1 litre of water to prevent damage to the young clonal saplings by termites during the critical establishment stage. Application of botanical pesticides like Kodesa (*Clistanthus collinus*) for controlling termites was introduced as an eco-friendly replacement to chemical pesticides. Cultural practices recommended include timely weeding and soil working, protection against damage by insect pests and cattle and raising of leguminous crops in between the 3 meter wide planting rows for green manuring. In addition, intercultivation with cotton, chilli, tobacco pulses and even paddy was encouraged during the first year of planting which gives additional earnings to the farmers. As most of the soils in India are deficient in nitrogen and phosphorus, application of fertilizers to supplement availability of these deficient plant nutrients is recommended. Soil and water conservation measures like raised field boundaries and staggered trenches are recommended in well-drained planting sites for holding the rainwater. However, in low lying areas or poorly drained heavy black cotton soils, drainage has to be improved during the rainy season.

**Emergence of Eucalyptus Clonal Plantations.** The Company distributed more than 14 million clonal saplings to growers from 1992 to 2002. More than 8000 ha of clonal plantations have emerged over a period of 8 years under the farm forestry programme of the Company alone. Around 2000 ha is second rotation coppice plantation totaling to 10000 ha. In addition, 8000 ha of plantations have been raised by AP Forest Development Corporation. The 'Bhadrachalam' clones have been planted all over India by forest departments/Corporations and other paper mills and farmers over 7000 ha. Therefore, the all India figure of clonal plantations today is around 25000 ha. Through company promoted farm forestry plantations alone an asset worth Rs. 1000 million has been created (Table 3). Through clonal farm forestry activity nearly 40000 jobs have been created in the form of production of planting material, planting and maintenance, logging and transport.

<table>
<thead>
<tr>
<th>Year</th>
<th>Plants sold</th>
<th>Area (Ha)</th>
<th>Coppice crop (Ha)</th>
<th>Total area (Ha)</th>
<th>Assets creation (Rs. million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992-93</td>
<td>27028</td>
<td>16.6</td>
<td></td>
<td>16.6</td>
<td>1.7</td>
</tr>
<tr>
<td>1993-94</td>
<td>61670</td>
<td>39.5</td>
<td></td>
<td>39.5</td>
<td>4.0</td>
</tr>
<tr>
<td>1994-95</td>
<td>233076</td>
<td>161.4</td>
<td></td>
<td>161.44</td>
<td>16.1</td>
</tr>
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<td>1995-96</td>
<td>415435</td>
<td>239.4</td>
<td></td>
<td>239.43</td>
<td>23.9</td>
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<td>1996-97</td>
<td>1020000</td>
<td>790.5</td>
<td>16.6</td>
<td>807.1</td>
<td>80.7</td>
</tr>
<tr>
<td>1997-98</td>
<td>1293069</td>
<td>759.2</td>
<td>39.5</td>
<td>798.66</td>
<td>79.9</td>
</tr>
<tr>
<td>1998-99</td>
<td>2073000</td>
<td>1204.0</td>
<td>161.44</td>
<td>1365.44</td>
<td>136.5</td>
</tr>
<tr>
<td>1999-00</td>
<td>2281011</td>
<td>1354.7</td>
<td>239.43</td>
<td>1594.14</td>
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<tr>
<td>2000-01</td>
<td>2626582</td>
<td>1578.7</td>
<td>790.5</td>
<td>2369.18</td>
<td>236.9</td>
</tr>
<tr>
<td>2001-02</td>
<td>3348000</td>
<td>2009.6</td>
<td>759.16</td>
<td>2768.76</td>
<td>276.9</td>
</tr>
<tr>
<td>Total</td>
<td>13378871</td>
<td>8153.62</td>
<td></td>
<td>2006.63</td>
<td>10160.25</td>
</tr>
</tbody>
</table>
These clonal farm forestry plantations are acting as carbon sinks. Nearly Rs. 810 million of carbon credit is estimated for the project being proposed under the Clean Development Mechanism (CDM) for carbon sequestration, which will help the farming community to grow more plantations and help in carbon mitigation.

**Awards and Recognition.** The Company’s efforts and contributions for promoting forestry research and clonal farm forestry plantations have been recognized with four prestigious awards:

- The Vantech Industry Rolling Trophy for Research and Development – 1995, Award by Confederation of Indian Industry, Southern Region.

**POLICY ISSUES AND RECOMMENDED REFORMS**

The authority to register and certify the clones for forestry species still does not exist in India. This may lead to dilution of improved tree cultivars due to unscrupulous trade. Mix-up of clones can jeopardize the entire tree improvement effort. Similarly, developing legal mechanism for registration of nurseries, certification of gene banks and clonal planting stock are yet to be evolved and handled by an independent and competent agency under Government of India.

Some bottlenecks are experienced for harvest of farm-grown wood as they require felling permission and transit permit. Andhra Pradesh is the only state that has declared Eucalyptus, Casuarina, Leucaena as agricultural produce, removing hurdles in harvesting and transport of material by forming Agriculture Market Committees. However, AMCs are not very effective and are not serving the farmer / industry's cause. In line with AP Government’s identification of major pulpwood species as agricultural produce other state and central Governments may consider declaring farm forestry trees as agricultural produce and the Pulp and Paper industry can be given the status of Agro-based Industry.

Tax (Sales/Purchase) & Income Tax to be taken out to help the grower (farmer) in the interest of growing trees in the farm land, contributing to socio-economic and ecological well-being.

The Aracruz Eucalyptus Tree Improvement Programme is well known throughout the world with the improvement in productivity from 33 to 70 cum/ha/yr. The country with the largest plantation resources now is Brazil where hard wood plantations cover 2.5 million ha and soft wood plantation 1.5 million ha, raised with high yielding tree cultivars. This development of short rotation woody crops for commercial purposes has given three main advantages to the pulp and paper industry viz., low cost of raw material, reliability and sustainability of wood supply along with uniformity of biological material, i.e. pulpwood.

In India Clonal Plantations covering 1.25 million ha, or 33 per cent of the degraded forest areas in Andhra Pradesh alone, can yield 25 million tonnes of pulpwood annually. That would be sufficient for meeting India’s entire pulp and paper requirements projected at 8.5 million tonnes by 2010-2011, based on 70 per cent wood based fibre furnish. Likewise, high yielding short rotation clonal plantations on 20 million ha. of waste lands / degraded forest lands could meet country’s current firewood requirements on a sustainable basis. That would minimize biotic pressures on remaining natural forests and conserve their rich bio-diversity. In addition to restoring marginal lands to high sustainable productivity, clonal plantations will generate vast employment opportunities for the rural poor,
contribute to environmental amelioration and help conservation of precious soil and water resources. Such plantations will also create opportunities for significant value addition through local processing of plantation wood and save large amounts of scarce foreign exchange used to import of wood based products. Hence, appropriate forest policies need to be devised for raising plantations on farm / degraded forest or wastelands to bring a "Brown revolution" to our country.

The company is trying to get Forest Stewardship Council Certification for farm forestry plantations. Though group certification is possible, presently the FSC has not framed rules for certification of farm forestry activities taken up in agricultural land. Both India and the Asia-Pacific region should consider the framing of rules enabling FSC certification.

Baselines and rules for Carbon sequestration under Clean Development Technology through farm forestry plantations need to be framed under forest policy.

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