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TREE IMPROVEMENT THROUGH CLONAL FORESTRY
THE WEST COAST PAPER MILLS EXPERIENCE

The productivity of the plantation can be increased sustainably by promoting technology based plantations. Of late in India, clonal forestry is gaining acceptance among the progressive Foresters and Plantation Managers. Clonal technology is a strategy adopted in tree improvement programme to capture and exploit the best recombinations in a shortest possible time. The ultimate objective of tree improvement is to produce quality seeds. Seeds are the carriers of entire improvement made in one generation to the next generation. Keeping in view the improved superior seeds are the major source for propagation. Seeds from known sources mainly half sib seeds or full sib seeds are collected and propagated.

The principles and practices of plant breeding of trees are well established and they apply equally to industrial plantations and small holder agroforestry and community plantations also. The goal of tree improvement for agroforestry is to increase the effectiveness of land for productivity, suitability and sustainability of land use for rural communities. It consists of

- Germination of the species or geographic sources within a species in a given area.
- Kind and causes of variability within a species.
- Packaging the desired qualities into improved individuals.
- Mass production of improved individuals for planting purposes.
- Developing and maintaining a genetic base population for advanced generation.

Success in the establishment and productivity of forestry plantations is determined largely by species used and the source of seed within species. The higher gain in most of the forestry improvement programmes can be made by assuring the use of the proper species.

Half Sib Seed:
Selection and management of seed production areas is a commonly adopted strategy representing the first stage of tree improvement, after selection of the best species and provenances. Such seed production areas could be stands specially planted for seed production or they could

be existing stands specially managed for seed production, provided their genetic origin is appropriate.

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The origin of the stand must be known. In addition to a possible narrow genetic base, existing plantations often have a high incidence of hybrids, these being more common in stands which have been established using seed from exotic plantations. Another important question is isolation of the seed production area from potentially contaminating genetic sources.

Collection of seed from better than average stands which have been thinned early to remove inferior trees and to promote development of large crowns capable of heavy seed production is often the quickest and best interim measure to meet the need of large quantity of seed of known origin and with some genetic improvement.

Seed orchards are a means of obtaining large quantities of genetically improved seeds relatively cheaply by allowing selected outstanding trees (plus trees) or their progeny to cross, usually under natural conditions. Cutting from the plus trees are used to establish clonal seed orchards or seedlings raised from seed collected from the plus trees are used to make seedling seed orchard. In both cases, the orchards are isolated and managed for seed production. Clonal seed orchards are preferred. The hybrids can bring desirable characters of both parents. In this, hybrids of Eucalyptus grandis and Eucalyptus urophylla are more preferred. Eucalyptus grandis is fast growing and Eucalyptus urophylla is with greater resistance to fungal diseases and have greater coppicing ability.

In a clonal seed orchard, the seeds are produced by cross-pollination among the outstanding clones planted at a single plot. In clonal seed orchard, clones which flower at the same time need to be planted in randomised design to avoid selfing. The seeds collected from this orchard where one parent is known and other parent is unknown is called half sib seed. In full sib seed, both the parents are known and is possible only in controlled pollination. We collect mainly half sib seeds for our use at Nurseries.

Clonal Technology:
With a view to provide genetically superior, fast growing, disease resistant and best quality planting stock for improving the net returns from the plantations, research and development support is essential.

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The research and development project funded entirely by the Company for tree improvement through application of clonal technology was launched from 1995. 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 selection and multiplication of outstanding clones are as follows:

- Selection of candidate plus trees (CPTs) with most desirable features like fast growth, disease resistance, maximum girth and volume from the existing plantations which have large natural variation.

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CANDIDATE PLUS TREE

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The Candidate Plus Trees are selected based on the phenotypical characters like straight bole, fast growth, weak branches, disease-less small crown and the self-pruning capacity. Such trees are marked and taken for propagation.

- Preparation of propagules from stem cuttings of juvenile shoots of 30 to 35 days old coppice shoots or pollards.

- Prophylatic treatment of cuttings with fungicides and treatment of lower tips with suitable root hormones.

- Transplanting of treated cuttings in coco-peat media for rooting in Low Cost Mist Chambers under controlled environment.

The juvenile shoots of Eucalyptus and Acacia are brought to the processing unit early in the morning to avoid desiccation. The cuttings are washed with mild detergent and pure water. Then the cuttings are cut into 4” length with two internodes and the leaves are clipped to half to reduce the transpiration of water. These cuttings are kept in 2% fungicide solution for 10 minutes and later a fresh cut is given at the lower end. The lower end of the cutting is given a quick dip in the root hormone and transplanted in the media. For Eucalyptus, the root hormone is I.B.A. 4500 ppm and N.A.A. 2500 ppm for Acacia hybrid. Transplanted cuttings are kept in the Low Cost Mist Chambers without any delay.

Low Cost Mist Chambers:

Low Cost Mist Chambers are the pits dug in compact soil, generally of standard size of 12 m length, 1.3 m breadth and 27 cm depth. The pit is lined on all the sides using a single layer of bricks in vertical position. A layer of sand and pebbles is put at the bottom up to 7 cm thickness. Water is filled in the pit up to 2-inch height or in channels of 6-inch width and 9-inch depth on all four sides. The hydro-pit is covered with polythene sheet, kept like a tunnel using semicircular bamboo or cast iron frames. The fog collected on the inner surface of the polythene sheet will reduce the temperature and the drops formed due to condensation will fall on the leaf laminae and continue to keep the surface wet.

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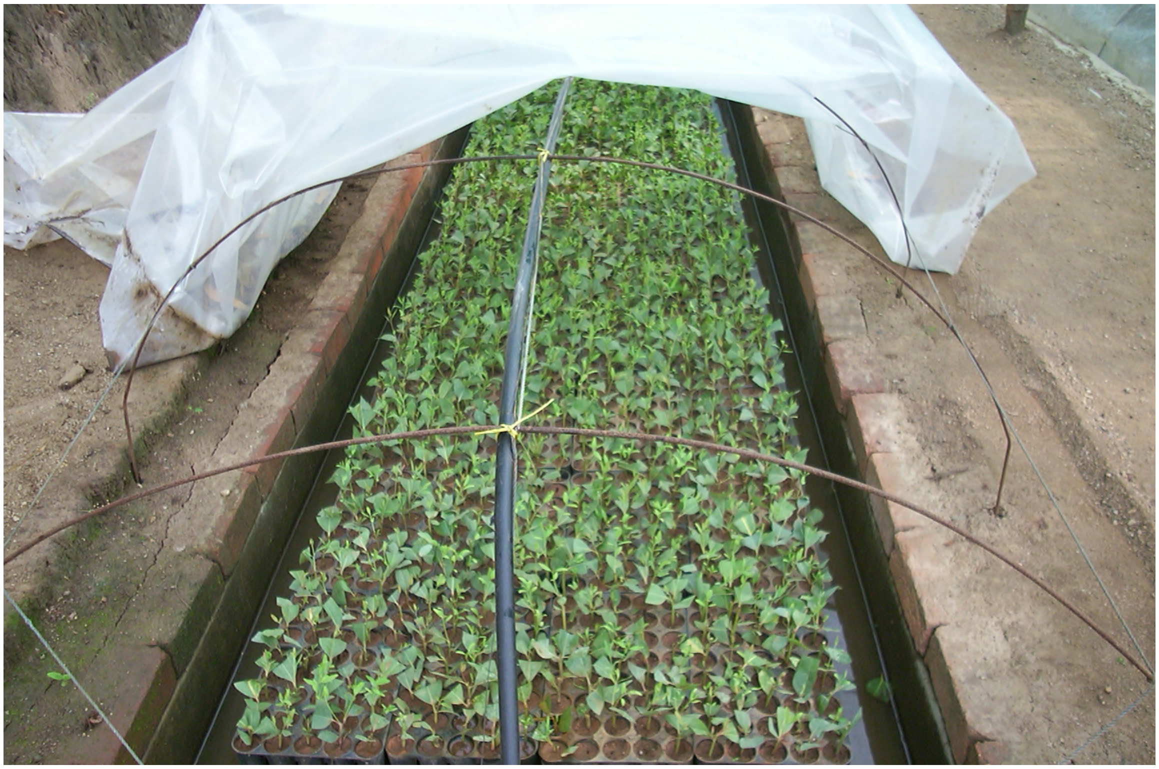

LOW COST MIST CHAMBER

- Under favourable conditions i.e. 80% humidity and 25 to 30 degree temperature, roots developed in 20 to 25 days.

- The rooted ramets are transferred to Shade House for acclimatisation and hardening.

- After 12 days the ramets are transferred to Open Nursery and are nursed for 2 to 3 months till they attain planting height.

- Clonal identity of each clone is maintained to assess the field performance of each clone.

Clonal technology for production of outstanding, high yielding, disease resistant planting stock of Eucalyptus, Acacia hybrid and Casuarina are successfully perfected and is being adopted on large scale for mass propagation.

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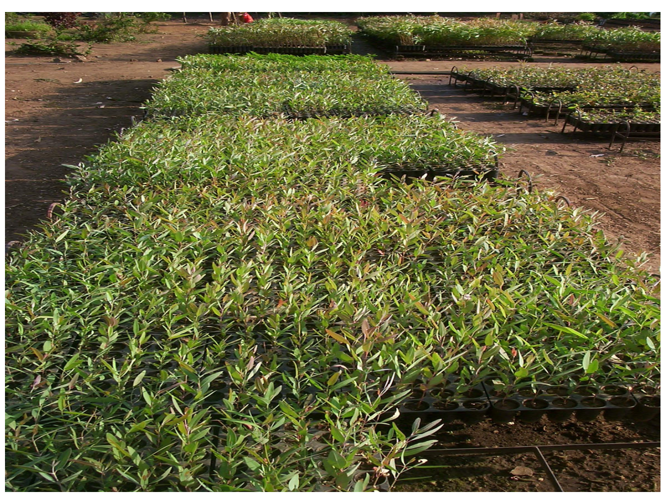
In Southern part of India, people cultivate Eucalyptus species, Acacia species and Casuarina in agroforestry system. Farmers grow Chilly, Cotton, Groundnut, Turmeric and Vegetables which are main cash crops.

Most of the natural forests of Eucalyptus grandis are in Northern New South Wales and Southern Queensland on coastal low lands and hills with an altitudinal range from sea level to about 600 Mtrs. Eucalyptus urophylla does not occur in Australia. It is found in large Indonesian island of Timor above 1000 Mtrs. and throughout Weter.

Hybrids of Eucalyptus grandis and Eucalyptus urophylla are common in plantations of both the species grown side by side. We collected seeds of grandis and urophylla from different known provenances and established mixed plantation of both the species. Seeds from these plantations were collected from outstanding trees of both the species for raising seedlings. The seeds were sown in Nursery with proper treatment. We observed good vigor in some of the seedlings at Nursery stage itself. These seedlings are segregated and planted in a separate plot. There were some trees with blend of characters of both grandis and urophylla. They are named hybrids. Outstanding hybrid individuals were propagated as rooted cuttings from basel coppice when these plus trees were felled. The clones were greatly superior in yield and quality to the land race. The clones thus produced are planted in different climatic and soil conditions at an espacement of 2 x 2 M in clonal testing area and 1 x 1 M in clonal multiplication area. The observations were recorded upto two years from all areas. The best performing universal clones are mass propagated taking the genetic material from clonal multiplication area.



HARDENED EUCALYPTUS RAMETS

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EUCALYPTUS C.M.A.

2 YEARS OLD EUCALYPTUS UROGRANDIS PLANTATION

Acacia hybrids between mangium and auriculiformis are obtained from the seed orchard of mangium and auriculiformis mixed plantation by the seeds collected from different provenances. One season of flowering

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coincides between mangium and auriculiformis. We collected seeds selecting mangium as the mother tree because it grows straight with weak branches having self-pruning capacity. The seeds are dibbled with proper treatment in the container. High vigor was noticed in some of the seedlings which were segregated and planted in separate plot. Depending on the growth record the best ones are selected and pollarded for vegetative propagation. The juvenile shoots of 35 days old were collected from the cut stumps at a height of 75 to 80 Cms. The apical cuttings collected were treated with mild detergent, fungicide and after clipping the leaves to half the cuttings were given a quick dip in the root hormone and transplanted in the containers. The containers are kept in low cost mist chambers and rooting is observed after 21 days. The rooted cuttings are shifted to shade house for hardening for 10 days. Then they are shifted to open Nursery area. The clonal ramets after hardening are planted at an espacement of 2 x 2 M in clonal testing area and 1 x 1 M in clonal multiplication area or gene bank. After observing the growth for two years, the best CPTs are selected and mass propagated.

ACACIA HYBRID & MANGIUM

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3 YEARS OLD ACACIA HYBRID PLANTATION

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ACACIA HYBRID C.M.A.

<u>CONTROLLED POLLINATION</u>:

With this technique, breeder can make more number of crosses in one flowering season only. In Eucalyptus when the flower bud reaches maturity, it gradually turns from green to yellow, and a split develops at the junction of the receptacle and the operculum indicating it is about to drop. Sometimes the pollen is shed inside mature flower buds before the operculum drops. This pollen is viable and can be present in sufficient quantity for cross-pollination and can give appreciable amount of fertilized seeds. When the fresh flower is used for pollination, the anthers brushed upon the stigma of the flower to be pollinated. The brush method is appropriate for special purposes such as experiments requiring mixtures of equal amount of different pollens or for receptivity test. One advantage is that it can ensure a mixture of pollen in case of non-viable pollen is collected from some flowers. We take pollen from matured flowers and use black paper for detecting the pollen shed after tapping the flower. The collected pollen is shed on the stigma of the flower to be pollinated by brush. Pollen from one male flower is sufficient for ten female flowers. The pollinated flowers are covered by thin white cotton cloth and the ends are tied at the bottom to the branch.

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The cloth should not touch the stigma. The cloth bags are labelled to know the species and the pollens used. During rainy season, the cloth is to be covered with transparent polythene sheet to avoid pollen wash by rain water. It will take about 3 to 4 weeks to fertilise after pollination. Then the cover can be removed.

The wood of each CPT is also tested for density, bark percentage, pulp yield, strength properties and lignin content. Based on the Pulpwood quality and rooting propensity of each CPT and performance in respect of growth, disease resistance, the most promising ones are taken for large scale multiplication. Through the Vegetative Propagation, all desirable superior genetic qualities of the mother plant are retained in the progeny.

Vegetative Propagation:

Vegetative or asexual production is the propagation of plant using vegetative tissues. This results in a plant that is genetically identical to the original “donor” plant. Vegetative Propagation occurs both naturally and artificially. Many plants spread through rhizomes, corms, bulbs, tubers and runners are the examples of natural vegetative propagation; whereas grafting, cutting and tissue culture comes under the category of artificial vegetative propagation.

Vegetative Propagation is one of the most important tool and widely used in tree breeding to manage breeding population more effectively. It has major advantage over sexual reproduction as a means of mass production. All the genetic components of “donor” plant can be captured and duplicated. Grafts, cuttings or micro-propagules of “donor” plant are brought together in a clonal bank where the genotypes are preserved for controlled pollination. The best trees can be vegetatively propagated and tested as clones and multiplied for commercial plantations. The gains will be substantial and fast, but unless it is backed by continued breeding and testing it becomes a dead end situation. Based on the suitability of the species, grafting, rooting of cutting and air layering have been traditionally used and advances have been made on other options like tissue culture, meristem and cell culture for multiplication of desired individual on large scale. Huge leap in short rotation plantation productivity offered by specific hybrids have been made operationally possible through the development of technique of Vegetative Propagation by cutting. The main advantages and importance of vegetatively propagated Eucalyptus, Acacia, Pines and Poplars etc. are namely uniformity, adaptation, cost and wood productivity.

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Uniformity:

Excellent uniformity can be obtained from the rooted cuttings with all the trees within one clone at a given age on the same site having same diameter, height and form; whereas plantations developed through seed route are highly heterogeneous in growth rate and form. Apart from being more even in growth and form, clonal plantation of Eucalyptus, Acacia & Poplar ensures greater per unit area productivity.

UNIFORMITY WITHIN THE CLONE

Adaptation:

Vegetative propagation provides opportunity for very close matching of selected clones to specific sites. Hybridisation between the species enabled selection of individual clone capable of growing very rapidly on the sites to which these clones are specifically adapted. The site adaptability will change and depends upon the degree of hybridisation between the species. The sites include marginal or degraded site also. The suitability of the clones has to be established on the different sites. Therefore, deployment of clones has to be restricted to the sites on which they were developed and on which they are known to do well. Site specific clones well adapted to particular sites combined with improved cultural practices increases the biomass production. The use of well

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adapted clones offers a means to rehabilitate denuded and degraded land.

Cost:

Cost advantage of Vegetative Propagation is the short term ability to quickly capture larger gains of additive and non-additive genetic variation. In this way, the breeding programme can greatly reduce the number of years and hence the most cost effective. The cost of production can be reduced with increased rate of success of rooting.

Productivity:

The outstanding advantage of use of cutting in many areas is the growth rate of plantations established and the same are almost 1 ½ to 2 times that of plantations established from unimproved seed available. Uniformity of Wood in turn can enable reduction in the manufacturing cost, better energy, efficiency and increase in product quality apart from increase in overall productivity.

Limitations:

The success of vegetative propagation is often dependent on the degree of juvenility of the tissues being propagated. The more juvenile the tree or part of a tree being propagated is, the easier it will be to propagate (particularly for rooting cuttings). However, often trees are only identified as genetically desirable for cloning at an older age. The only reliable way to propagate mature trees of many forest tree species is through grafting. The degree of maturation of tissue is affected by height (the lower in the crown the more juvenile the shoots) and "hedges" maintain juvenility. Juvenility can be partially restored in some species through repeated grafting of buds onto young rootstock.

Cloning with forest trees is commercially feasible only with those species which, when mature, maintain the ability to produce juvenile tissue. This tissue almost always emerges in the form of stump sprouts. With such species it is possible to make phenotypic selections on mature trees, fell the selected trees, then propagate those individuals (clones) from the juvenile sprouts which emerge from the stumps or from trees with juvenility maintained through regular hedging. The fact that rooted cuttings are physiologically more mature than seedlings has been used to advantage in some cases to produce trees that are less vulnerable to juvenile diseases or have better stem form with less taper. These can then be tested as replicated individuals. It is not surprising that most of the world's large, successful cloning programmes have emerged using trees with this capability, such as eucalyptus *(Eucalyptus* sp.), poplars *(Populus* sp.) willows *(Salix* sp.)., Chinese fir *(Cunninghamia lanceolata)* and Acacia hybrid.

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Over the recent past the emphasis has shifted invariably towards man made commercial forest to cater to the needs of forest based industries. Micro-propagation using Tissue Culture method provides unique opportunities to rapidly multiply the elite trees. To optimise the output of commercial forest an enhancement in the productivity of such plantation is desirable so as to meet the ever increasing industrial and domestic requirements. Though Tissue Culture offers great promise it may not be able to provide much to forestry in near future. The new ramets produced have to be carefully tested for long time. Then only the adaptability of ramets produced through Tissue Culture can be ensured.

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BULKING AND CLONING:

Nearly all vegetative propagation systems employed in commercial forestry, whether based on rooted cuttings, tissue culture, or somatic embryogenesis, have as their objective either to "bulk" valuable families or to "clone" valuable individuals (Ritchie 1994). Bulking involves making few copies of many individuals. This is normally done at the family level and clones among these family bulks of little or no interest. Cloning, in contrast, involves making many copies of few individuals. This is done at the genotype level, and individual genotypes (clones) are tracked through the process and into the field.

CLONAL DEPLOYMENT:

A key challenge of clonal forestry is how to capture the impressive gains associated with cloning without risking catastrophic plantation failures owing to narrowing of the genetic base - the often cited "monoculture" problem. Historically, there have been three approaches to clonal deployment in forestry: 1) monoclonal deployment, 2) mixed clone deployment, and 3) deployment in clonal mosaics. In monoclonal deployment, a large area of land is planted into only one clone. This method clearly gives the greatest clonal gains, but also carries the highest risk. By planting mixes of high yielding clones, high gains can be captured but with far less risk. However, when clones are planted in mixes, it is not possible to identify unique or abnormal clones within the mix, unless of course, every tree is tagged. For example, if a particular clone is maladapted so that many of its members die throughout the plantation, the maladapted clone will remain unidentified and there will be no way to remove it from the production base. Similarly, if a certain clone is particularly well adapted, its identification will also remain elusive.

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Clonal Mosaics in 1 ½ Years Old Eucalyptus Plantation

The third alternative, clonal mosaics, offers an attractive compromise. Here, clones are deployed in monoclonal blocks, but these are inter mixed with many other blocks containing different clones. This strategy captures the advantages of monoclonal plantations, but buffers risk by deploying many clones over small areas. In addition, the clonal boundaries may afford physical or biological barriers to destructive agents. With intelligent use of clones in forestry, it is also possible to create plantations, which carry much greater genetic diversity than natural stands. This is because artificial crosses can be made that could never occur in nature and these are then mixed in ways that nature could never accomplish.

Purpose of Vegetative Propagation:

- Allows propagation of many plants when seed production or germination is very low or when seed is very expensive.

- Only method of reproduction for sterile plants such as triploids, interspecific hybrids, and mutants of horticultural and forestry interest.

- Allows for cloning of trees with desired combinations of traits, or for preserving certain individuals.

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- Can sometimes obtain flowering at a younger age through vegetative propagation of more mature plant tissues than through seedlings.

- Used to combine desirable root characteristics with desirable shoot characteristics.

- To consolidate the interim genetic gain in breeding programmes.

- To mass multiply superior trees selected after careful population studies followed by clonal testing.

Importance of Vegetative Propagation:
The importance of vegetative propagation in forestry is well understood, but not so well established practically in our country. The transfer of non-additive characteristic is difficult through seed production approaches but is routinely possible through vegetative propagation (Zobel and Ikemori 1983). Therefore, it is attractive for achieving gains which have low heritabilities such as growth and cellulose yields. It is specially useful for utilising hybrids when mass production of hybrids is difficult. Vegetative propagation is an excellent approach for developing clonal forestry programmes (Vivekanandan, et al, 1983). It can eliminate inbreeds, provide adapted clones, mass produce valuable genotypes, control genetic diversity and more importantly, help in predicting yield in plantation programmes. The constraints in this approach pertain to biological problems related to maturation state of mother plant, cutting environments, condition of cuttings, survival and growth of cuttings.

Compared to agriculture, forestry is rather late in domesticating the plants. Vegetative propagation approaches can hasten the progress in production forestry. It is essential to develop aggressive management approaches in forestry to satisfy the demand for wood whether for fuel or for industrial purposes. The operations in forestry approaches developed through vegetative propagation has both gain as well risk factor. The manager must decide the extent to which the gain can be achieved within the acceptable level of risk (Toda, 1974).

Thus, yields of the order expected to be achieved in the coming 15 to 20 years, will come mainly through vegetative propagation of superior genotype and or from F1 generation plants. The expectation based on the present silvicultural characteristic can only be realised if they are supported by development of infrastructure for vegetative propagation of the superior biotypes or the developed genotype.

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Short Rotation Forestry:
Increasing productivity has been a permanent concern for foresters and clonal forestry has become a tool specifically for Eucalyptus, Poplar and Acacias which has resulted in shortening the harvesting cycle. Eucalyptus and Acacias can now be harvested after five years without sacrificing the quality of wood. It is amply proved that wood density or pulp yield is independent of growth rate. This also disproves the notion that faster growth will result in lower wood density and inferior pulpwood quality. The breast height density value of 13 to 15 years old trees were almost within a range of average tree values of basic density reported for younger trees. This implies that early tree selection and harvesting at the age of 3 to 5 years will be feasible to meet the minimum wood density requirement for Pulp Industry. In Eucalyptus the fiber length increases consistently with age although the rate of increase declines after five years and attains more or less constant value. The above observations suggest that the desired harvesting cycle for Eucalyptus and Acacias should be around five years.

Increasing the yield Per Hectare and hence reducing the unit cost of Wood is an important component of Sustained Commercial Forestry. To help to improve productivity, tree improvement strategies have been widely implemented in recent past. In addition, there is growing awareness of the significance of cultural practices in influencing genetic gain prediction from Tree Improvement Programme. This study examines the yield gain from improved genotype and cultural practices. Four factors which include genetic improvement level, the relationship between application of fertiliser, weed control and effect of soil amelioration by deep ripping were studied on degraded lands.

Most of the Indian soils have low fertility. It is often believed that the trees occurring in such an infertile environment are well adapted and would not benefit from increasing the site's fertility. In practice, it has been found that this is not the case with most of the plantation species. In fact, when growing conditions deteriorate in natural forest eco-system, e.g. a decrease in soil fertility, a forest community adapts to new environmental condition through species substitution. This change does not imply an inevitable decrease in productivity, because of nutritionally more efficient species can increase in dominance under normal conditions. But in India due to hostile biotic factors, forest eco-system deteriorates further. However, in short rotation forestry, the species are usually mono-specific and their productivity changes directly in response to environmental conditions. As a matter of fact, intensive production forestry can improve the soil conditions. Because the

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productivity of most of the commercial plantations is less than their potential it has been and remains possible to identify and ameliorate limiting factors, sometimes on large scale, e.g. by use of appropriate method of soil cultivation, fertilisation, weed control, etc.

<u>Site Preparation</u>:
Heavy duty bulldozer is deployed to clear stumps, branches and other debris from the site. This operation will loosen the top soil and creates conducive conditions for the development of microbial activities. The grubs and pest comes out of sub-soil and the birds feed on them. The stumps and debris are utilised for creating bunds across the slopes.

Birds Feeding on Grubs and Pests

Ripping is done along the contour. The depth of the trench is around 30 inches and width at the top is around 24 inches. A special device is attached to the ripper which rotates the soil and makes the soil loose. Thus, the ripped area is open to hot sun and strong sun rays kill pathogens, grubs, insects etc. and helps in soil weathering and amelioration. The rain water is not allowed to flow freely as it is obstructed by deep trenches created by ripping along the contour. This checks soil erosion and conserves moisture.

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Ripping and Bunding along the Contour

After site preparation and prior to the planting, the area scheduled for planting will be visited by the Staff and termite hills, if any, found will be destroyed mechanically and will be drenched with 2% Chloropyriphous.

Planting:
The Eucalyptus containers grown stock is planted by hand at a spacing of 2 Mts. x 2 Mts. Planting stock is forwarded from Nursery to the Planting Site in a specially designed truck where seedlings can be carried on shelves.

Weeding:
Eucalyptus is sensitive to weed competition and considerable efforts are made to ensure virtually total weed control. Not only do plantation begins with very clean site but through a combination of chemical, mechanical and manual means, the site is kept weed free until the point of crown closure which usually occurs at about 1 ½ years. Although confronted with broad spectrum weeds, grasses, tends to be most numerous and troublesome. Weed control begins immediately after planting.

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Intensive Weed Control between the Row

Biological Control of Weeds:

Silvipasture Experiment:
While taking industrial plantations the available unwanted weeds are removed and the space in between the two rows is used for growing nutritious fodder grass like stylosinthes scabra, hameta and bricarea etc. Silvipasture experiments are taken up on large scale while doing afforestation on degraded lands. The nutritious grass seeds of above species are collected from different sources and are broadcasted in between the two rows of tree crop before onset of monsoon. The grass seeds germinate and sprout during rains. This helps to check soil erosion and avoids unwanted weeds. The leguminous grasses help to enrich the soil by fixing atmospheric Nitrogen. The farming community around the afforestation area is provided employment while cutting the grass. The grass (fodder) is provided free of cost for feeding their cattle population.

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STYLO GRASS WITH EUCALYPTUS

Fertilisation:
The response to added fertiliser phosphorus is best obtained when all other factors limiting plant growth are eliminated. Thus it has already been stated, that best benefit from phosphorus fertilisation occurs when there is adequate soil moisture in the field. It has further been found that since nitrogen deficiency is a major factor in crop production under Indian conditions, no great benefit in crop yields is observed if phosphorus alone is added to nitrogen deficient soils unless nitrogen deficiency is also simultaneously corrected through the addition of nitrogen fertilisers.

The best response in terms of productivity improvement has been obtained from application of phosphorus when used in presence of nitrogen than in its absence. The greatest advantage is likely to be gained from application after planting or at the latest in years second or third, while the trees are still in relatively free growth.

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Soil testing for nutrient deficiencies is of limited use in forestry because tree roots explore large volumes of soil that are not easily or economically sampled. Of greater benefit and a more precise technique for predicting nutrient deficiency is that of foliage sampling. Soil sampling may still have a role in some circumstances.

The main deficiencies likely to occur in plantations are usually phosphorus, nitrogen, potassium, magnesium and boron while in localised areas manganese, copper, zinc and molybdenum may create problems.

Material and Method

Ten different plots of half acre were designed in the year 2000 on a representative site and planting was done in the month of June / July 2000. The plot details are as under:

1. **Control**
   1 x 1 x 1 cubic feet pits were dug and 500 seedlings were planted.

2. **Control**
   In a 1 cubic feet pit, 500 ramets of DLD 18 clones were planted.

3. 500 seedlings were planted in a ripped area and weeding and fertilisation was done.

4. 500 ramets were planted in a ripped area and fertilisation and weeding was done.

5. 500 ramets were planted in a pit of 1 cubic feet and only fertilisation was done.

6. 500 ramets were planted in a pit of 1 cubic feet and only weeding was done.

7. 500 ramets were planted in a ripped area.

8. 500 ramets were planted in a pit of 1 cubic feet and fertilisation and weeding was done.

9. 500 ramets were planted in a ripped area and only fertilisation was done.

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10. 500 ramets were planted in a ripped area and only weeding was done.

The above ten plots were clear felled in the month of October 2005 and after debarking the wood was removed to the factory within 3 days of harvesting and weight was recorded.

The average moisture content of each trip was around 42%.

The bar chart in Figure No.1 and 2 indicate in MT per ha productivity from every plot having different applications.

As narrated above, field trials were conducted on 2 ha degraded land near Dharwar in Karnataka. The rainfall and other details are given below:

2000 Rains	-	480 mm - No. of rainy days 34
2001 Rains	-	280 mm - No. of rainy days 30
2002 Rains	-	320 mm - No. of rainy days 39
2003 Rains	-	176 mm - No. of rainy days 32
2004 Rains	-	462 mm - No. of rainy days 50
2005 Rains	-	700 mm - No. of rainy days 70
Soil depth	-	60 to 80 Cms.
Espacement	-	2 M x 2 M
Soil	-	Red Lateritic Clay
Species	-	*Eucalyptus* hybrid
Fertilisation	-	D.A.P. & Urea 50 Grams each in two split doses applied during first & second year.

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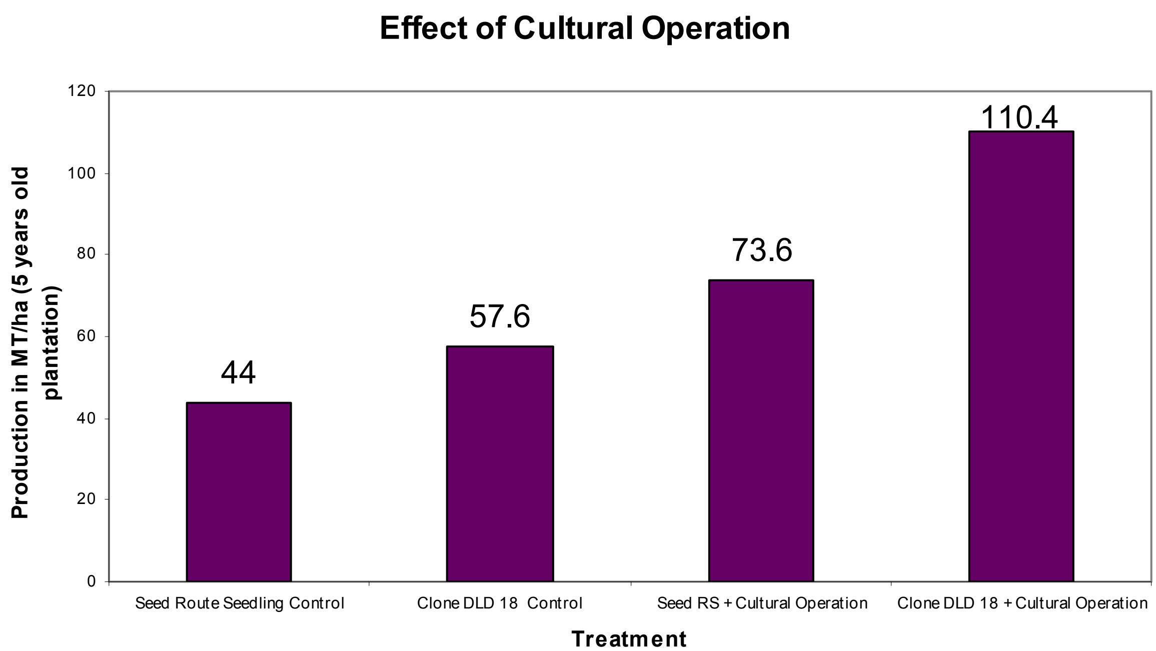
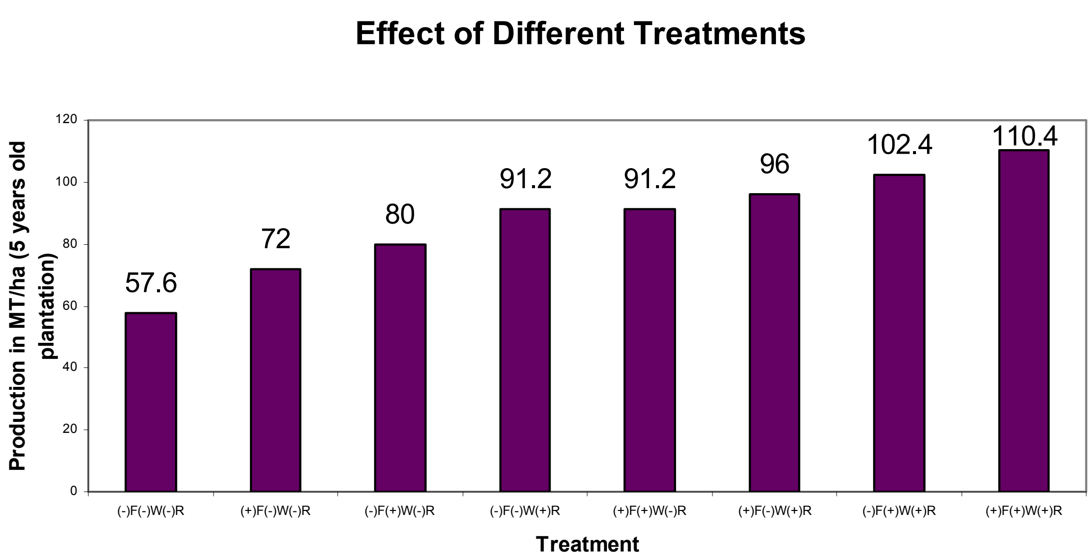


Cultural Operation = Fertilisation, Weeding and Ripping
Figure 1



W=Weeding, F=Fertilisation, R=Ripping
Figure 2

Result & Conclusion

The results from these trials were taken at the age of five years, provides important understanding of extent of yield gain associated with the genetically superior ramets vis-à-vis seedlings; associated with the cultural practices and their interaction during the post-planting activity. The observations indicate that productivity gain is to the tune of 92% due to cultural operations when associated with genetically superior material, whereas for seed route material it is 67%.

The cultural activities are not independent of each other. They have to be carried out simultaneously and are complementary to each other. Ignoring a single activity will hamper the overall productivity gain.

Benefits to the Community:

The soil conservation and water conservation measures observed by creating the bunds across the nalas, deep ripping along the contour have resulted in checking the soil erosion and 100% rain water harvest. This has enhanced the ground water level in the surrounding areas. Creation of pond and deepening of tank is done to meet the water requirement of cattle population of surrounding villages during summer. By this, about 700 families are benefited.

Silvipasture experiment on large tracts with fast growing nutritious grass seeds in the afforestation area is taken up. About four cart loads of grass per acre is available. This grass is cut at the Company's cost and is provided to the farming community of the surrounding villages free of cost. This meets the requirement of fodder for cattle population of 500 families in eleven villages. These villagers are objecting to allow others because there was drought continuously for two years. Because of our silvipasture experiment, the above villagers are not facing any problem and have not suffered shortage of fodder and fuel even during drought.

During planting, maintenance and harvesting, the local people are given employment. About 530 mandays/Ha. for plantation work and about 230 mandays/Ha. for harvesting work is provided to the local people only. The lops and tops are given free of cost to meet the fuel requirements of the local community. This has benefited nearly about 500 families.

Kulwalli Plantation Projection is thus stands as telling testimony to Company's constant commitment to community development.

ANNEXURE

We have identified following high yielding, fast growing and disease resistant clones of Eucalyptus and Acacia hybrid species.

- Eucalyptus terticornis - 23 Clones
- Eucalyptus pellita - 6 Clones
- Eucalyptus urograndis - 10 Clones
- Acacia hybrid - 28 Clones

We have established 51 acres of clonal testing area around Dandeli and Sarjapur near Bangalore. The gene banks for the tested superior genotypes are established around Dandeli to facilitate the mass production of desired genetically superior clones of Eucalyptus and Acacia hybrid species. We are establishing a Casuarina junghuhniana demonstration and field trial at Cuddalore in Tamil Nadu.

I. EUCALYPTUS TERTICORNIS:

Sl. No.	Name of the Clone	Rainfall	Adaphic Conditions
1	D1	Moderate rain & dry climate (Above 700 mm)	Sandy loam
2	D2	-do-	-do-
3	DLD 3	-do-	-do-
4	DLD 10	Low rain, dry climate, drought resistant (Upto 600 mm)	-do-
5	DLD 13	-do-	Clay
6	DLD 18	Moderate rain & dry climate (Above 700 mm)	Sandy loam
7	DLD 27	Low rain & dry climate (Upto 600 mm)	-do-
8	DLD 31	-do-	-do-
9	DLD 66	-do-	-do-
10	DLD 99	Moderate rain & dry climate (Above 700 mm)	-do-
11	DLD 127	-do-	-do-
12	DLD 128	-do-	-do-
13	DLD 130	-do-	-do-
14	ET 1	Low rain & dry climate (Upto 600 mm)	-do-
15	ET 2	-do-	-do-
16	ET 3	-do-	-do-
17	ET 4	-do-	-do-
18	ET 5	-do-	-do-
19	ET 6	-do-	-do-
20	ET 7	-do-	-do-
21	ET 8	-do-	-do-
22	ET 9	-do-	-do-
23	ET 10	-do-	-do-

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II. **EUCALYPTUS PELLITA:**

Sl. No.	Name of the Clone	Rainfall	Adaphic Conditions
1	P1	High rain & humid climate (Above 900 mm)	Sandy loam
2	P2	-do-	-do-
3	P3	-do-	-do-
4	P4	-do-	-do-
5	P5	-do-	-do-
6	P6	-do-	-do-

III. **EUCALYPTUS UROGRANDIS:**

Sl. No.	Name of the Clone	Rainfall	Adaphic Conditions
1	SA1	High rain & humid climate (Above 900 mm)	Sandy loam & clay soil
2	SA2	-do-	-do-
3	SA3	-do-	-do-
4	SA4	-do-	-do-
5	SA5	-do-	-do-
6	SA6	-do-	-do-
7	SA7	-do-	-do-
8	SA18	-do-	-do-
9	SA20	-do-	-do-
10	SA24	-do-	-do-

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IV. **ACACIA HYBRID (AURICULIFORMIS + MANGIUM):**

Sl. No.	Name of the Clone	Rainfall	Adaphic Conditions
1	SU1	Moderate to high rain & humid climate (Above 800 mm)	Lateritic soil
2	SU2	-do-	-do-
3	SU3	-do-	-do-
4	SU4	-do-	-do-
5	SU5	-do-	-do-
6	SU6	-do-	-do-
7	SU10	-do-	-do-
8	SU29	-do-	-do-
9	SU31	-do-	-do-
10	SU32	-do-	-do-
11	SU36	-do-	-do-
12	SU40	-do-	-do-
13	SU45	-do-	-do-
14	SU46	-do-	-do-
15	SU48	-do-	-do-
16	SU55	-do-	-do-
17	HT7	-do-	-do-
18	HT8	-do-	-do-
19	HT9	-do-	-do-
20	HT27	-do-	-do-
21	FC3	-do-	-do-
22	FC6	-do-	-do-
23	BC32	-do-	-do-
24	BC35	-do-	-do-
25	HR66	-do-	-do-
26	MM1	-do-	-do-
27	MM2	-do-	-do-
28	MM3	-do-	-do-