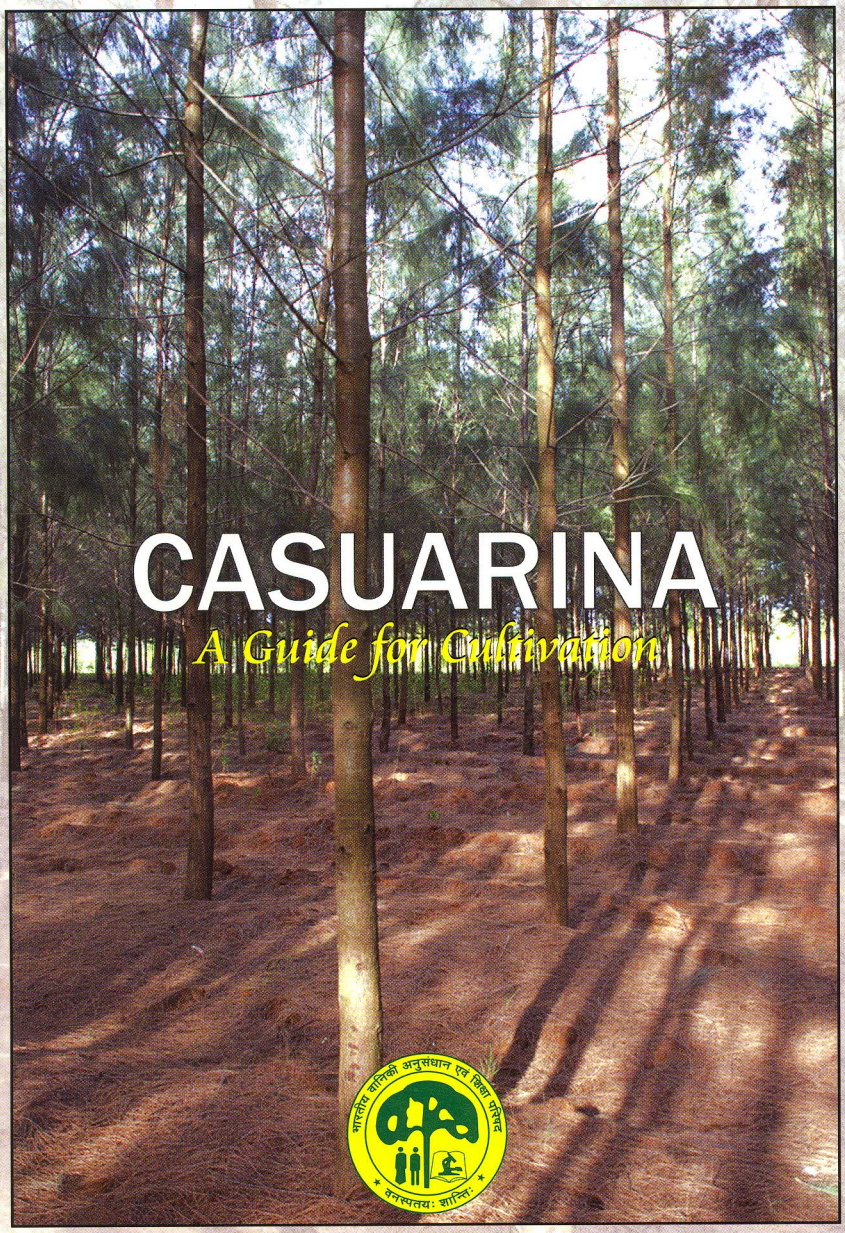
Money Spinning Trees 1



CASUARINA

A Guide for Cultivation

Institute of Forest Genetics and Tree Breeding

(Indian Council of Forestry Research and Education)

Coimbatore - 641 002

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A. Nicodemus

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(Indian Council of Forestry Research and Education)

COIMBATORE 641 002

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FOREWORD

Casuarina is a multipurpose tree cultivated in a range of agroclimatic conditions for more than a century. Nitrogen-fixing ability, good pulping traits for manufacture of paper, high calorific value of wood and short gestation period has made it a preferred crop for farmers in South India. The Institute of Forest Genetics and Tree Breeding has been undertaking research on casuarinas for nearly two decades. The salient findings from the field and laboratory experiments are compiled in this booklet for the benefit of farmers, forest departments and wood-based industries. By adopting the techniques outlined in this booklet the productivity of casuarina plantations can be significantly improved with minimal increase in input costs. I hope the vital information provided in this booklet will greatly influence casuarina cultivation practices to maximize returns from the plantations.

Dr. N. Krishna Kumar
Director, Institute of Forest Genetics and
Tree Breeding, Coimbatore.

Contents

CASUARINA

1. Introduction

Casuarina was introduced into mainland India in 1868 to meet increasing fuel wood demand by the then Collector of Kanara in Bombay Presidency. It now occupies a sizeable area in South India because of its ability to grow in a wide range of soil and climatic conditions including moisture and nutrient limited plantation sites. It is suitable for high density plantations (10000 stems per ha) and responds well to irrigation and nutrient application. Casuarina cultivation techniques are simple and not labour-intensive and hence cost-effective.

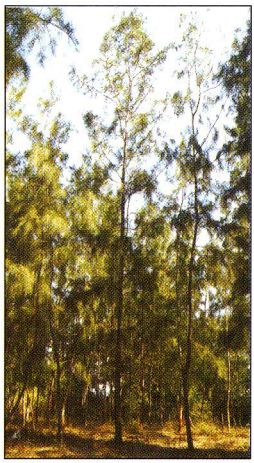

Fig. 1. A casuarina tree

Fig. 2. Casuarina growing in sea coast

2. Area and extent of cultivation

Although Casuarina is cultivated throughout South India, plantations are concentrated in the coastal areas of Andhra Pradesh, Orissa, Puducherry and Tamil Nadu which account for about 80% of total plantations. It is estimated that about 500,000 ha are planted with Casuarina in the above States. Growing Casuarina is also steadily increasing in inland areas where it is not traditionally grown. Shortage of farm labour, insufficient water availability for agriculture, non-remunerative prices for farm produce and growing tendency of absentee farming are the major reasons for farmers shifting to Casuarina cultivation. The increasing demand for Casuarina wood and steady raise in its price during the last 5 years have also made it a cash crop with assured returns in a short span of 3 to 5 years.

3. Botanical characteristics

The botanical name of casuarina species grown in India is *Casuarina equisetifolia*. It belongs to the family Casuarinaceae which includes about 90 species naturally distributed in Australia, South

East Asia and Pacific Islands. *Casuarina equisetifolia* is an evergreen tree with a straight stem and a conical crown made up of permanent, horizontal branches containing deciduous needle-like branchlets (a modified stem called cladode). Leaves arise in a whorl in each node, and are fused along the next internode and become free at the next node with teeth-like tips. Bark is smooth in young trees and may become fissured in older ones.

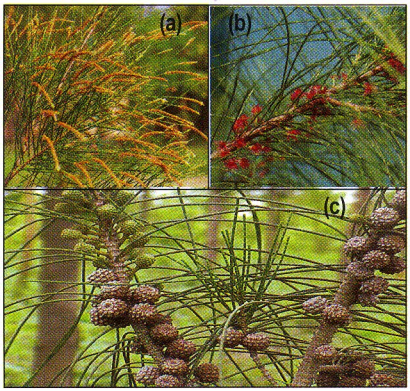

Fig. 3. Reproductive structures of casuarina: (a) male flowers; (b) female flowers; (c) fruits;

In India, trees are dioecious in nature, i.e. male and female flowers are produced in different individuals. Normally male and female trees have equal distribution but a small percentage of trees produce both the sexes in the same tree which are called monoecious trees. Pollination is effected by wind. The entire inflorescence develops into an infructescence commonly called as 'cone' or 'fruit' in about 3-4 months. Each fruit has 30 to 40 seeds. In India casuarina trees generally flower twice a year during June - July and November – December followed by fruit maturation in September – October and February – March respectively.

4. Cultivation

The method of cultivation varies in different areas but some of the basic features like high density planting (1x1 m spacing) and short rotation period (3 to 4 years in irrigated and 4 to 6 years in dry lands) are common in all places. The following is the generalized description of cultivation practices for casuarina.

Nursery techniques

Casuarina is predominantly planted as bare-root seedlings and the nursery is raised in two stages. The first stage is called primary nursery which is from seed sowing to production of 1-2 months

Box 1. Where to grow Casuarina?

Casuarina is ideally suited for coastal areas and sandy loam soils though it also grows well in inland areas and other soil types. It prefers good drainage but seasonal waterlogging for 3-4 week is tolerated. Though it survives in clayey and black cotton soils, growth is stunted. The preferred soil pH is 6.5 to 7 but it can withstand 4.5 to 9.5 and rainfall from 700 to 3500 mm per year. Casuarina can be grown from 0 to 800 metres above sea level. It thrives under maximum temperature from 37.5 to 47.5°C and minimum temperature from 7.5 to 17.5°C . Being a tropical tree Casuarina does not tolerate frost.

old seedlings. The second stage is known as secondary nursery which involves transplanting of seedlings from primary nursery and growing them for the next 3 to 4 months.

Nursery activities should start 4-5 months ahead of field planting date if bare root seedlings are used and 3-4 months before if containerized (polybag / root trainer) plants are preferred. The nursery area should be well lit throughout the day and devoid of any shade from nearby trees or buildings. In general the surroundings of the nursery should be kept weed-free to avoid attracting insects and pathogens.

Sowing of seeds

Casuarina seeds are small and a kilogram has around 6 lakh seeds, but about half of them may actually be immature seeds which usually do not germinate. Germination is generally around 30% and up to 100,000 seedlings are obtained from a kg of seed depending upon source of seed and nursery efficiency.

Seeds are sown in raised sand beds (called 'mother beds') of the size 10 x 1 metre. Generally no pretreatment is necessary for casuarina seeds. In each bed about 250 g of seeds are evenly spread by mixing with fine sand. A thin layer of sand is applied over the seeds. The sand bed is covered with rice straw to prevent washing off of seeds while watering. Water is provided through a rose can or a sprayer. A suitable repellent is applied along the periphery of the bed to prevent ants from removing the seeds.

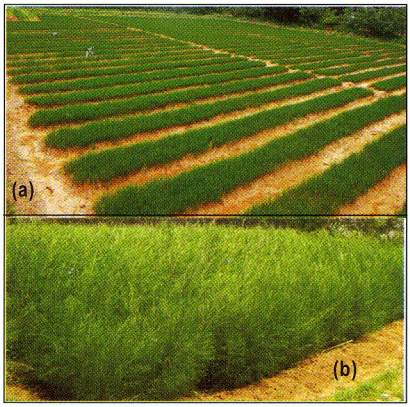

Fig. 4. Casuarina nursery: (a) primary beds; (b) secondary beds with fully-grown seedlings.

Germination and transplantting

Seeds start germinating from the 5th day and the straw is removed on the 7th day. They are grown in the mother beds for the next 4 to 6 weeks. The beds have to be kept moist by watering through rose can once or twice a day but water stagnation should be avoided to prevent fungal diseases.

After 4 to 6 weeks when the seedlings attain 8 to10 centimetres height they are transferred either to a secondary bed or polythene bags. Secondary beds are also of the same size as the mother beds but in addition to sand, farm manure and soil (2:1:1) are also added to increase nutrient availability and water holding capacity. They can be watered either through rose can or flood irrigation depending upon the size of the nursery. But water stagnation should be avoided.

Seedlings pricked from primary beds are transplanted to the secondary beds at

Box 2. Fact File on Casuarina

Biological nitrogen fixation :

Symbiotic nitrogen fixation through Frankia : 40-60 kg per hectare per year.

Wood Properties

Physical properties	Mechanical Properties	Pulping traits
Wood density (4 years age) : Irrigated : 698 kg m^{-3} Rainfed : 703 kg m^{-3}	Static bending, centre loading : Equivalent fibre stress at elastic limit : 373 kg cm^{-2}	Lignin : 29%
Moisture content : 47-67%	Modulus of elasticity (1000 kg cm^2) : 114	Holocellulose : 69%
Calorific value : 5000 kcal kg^{-2}	Impact - max, drop 23 kg hammer : 124 cm	Pentasons : 16%
Bark : 2-3 mm (8-10% of woody biomass)	Max : compressive strength parallel to grain : 115 kg cm^{-1}	Ash : 0.3%
	Hardness : side : 677 kg	Fibre length : 1036µ
	Shear - max. shearing strength parallel to grain : 115 kg cm^{-2}	Fibre wall thickness 5.3µ
	Tension perpendicular to grain: Radial : 37 kg cm^{-2} Tangential : 44 kg cm^{-2}	

Durability and resistance to insects

Moderately durable when exposed to weather, Susceptible to ambrosia beetles but resistant to powder-post beetles and dry-wood termites. Susceptible to subterranean termites. Susceptible to marine borers even after treatment with creosote / diesel oil (Burgess 1966).

approximately 4 cm apart. Though it is a common practice to plant more than one seedling per planting point, it is strongly recommended to plant only one plant in a point to raise vigorous and healthy seedlings. Seedlings are grown in the secondary beds for 3 months to obtain a height of 30 to 45 cm and a collar diameter of 3 to 5 mm.

Growing seedlings in polybags and root trainers is better than bare root seedlings especially for planting in rainfed areas. Seedlings raised in containers establish well in plantations and record vigorous growth in the first year. Polybags (size: 15 x 8 cm) filled with a potting mixture of sand, farm manure and soil in a ratio of 2:1:1 are suitable for raising casuarina seedlings. Seedlings may attain plantable size within 2 months but can be maintained for another 4 to 6 months if planting is delayed.

Vegetative propagation

Outstanding casuarina trees can be propagated by rooting of young shoots ('sprigs'). Such plants produce uniform superior growth in plantations. Sprigs collected from selected trees are trimmed to 8-10 cm length (Fig. 5) and washed in a 5% solution of fungicide like Bavistin™. The lower portion of the shoot is treated with a rooting hormone

Fig. 5. Rooted cuttings

Indole butyric acid (commercial name: Seradix B™). The treated cuttings are placed in root trainers containing vermiculite or composted coir pith and kept in mist chamber or propagation chambers made of polythene sheets. Rooting occurs in 15 to 20 days and then transplanted into polybags or root trainers and grown in the same way as seedlings.

Inoculation of Frankia

Casuarina is a nitrogen-fixing tree through symbiotic relationship with an actinomycete called Frankia. It fixes atmospheric nitrogen in special structures in the roots called nodules (Fig. 6). It is necessary to ensure infection of Frankia in casuarina seedlings for vigorous growth as well as to increase their adaptability to planting conditions.

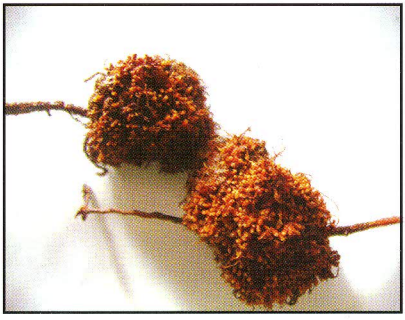

Fig. 6. Root nodules of casuarina

Frankia can easily be inoculated by adding topsoil from casuarina plantations to the mother beds. Alternatively it can be inoculated at the time of transplanting into secondary beds or containers. Freshly collected nodules from casuarina trees are ground into a fine paste, dissolved in clean water and filtered to make an inoculum. Roots of seedlings pricked from mother beds are first washed in water and then dipped in the inoculum for about 30 minutes before transplanting. Application of biofertilizers like Phosphobacterium, *Pisolithus tinctorius* and *Glomus fasciculatum* also improve the seedling quality.

Plantation Management

Since casuarina is planted as bare-root seedlings, planting them just before or during the rains ensures high survival especially under rainfed conditions. Where irrigation is available, it is recommended to plant one month before the rain and provide water once or twice a week. This will help the plants to establish well before the arrival of monsoon and grow faster than those planted during the rain.

Land is ploughed well and seedlings are planted in small holes made through crowbar or V- shaped pits made by a

pickaxe. Alternatively, the field is flood irrigated and the seedlings are planted in the same way as paddy is transplanted. If polybag-grown seedlings are used, digging of pits of 30 cm^3 size is necessary to ensure that the root portion up to the collar region is covered by soil. The spacing between trees and rows is generally 1 metre and such spacing accommodates 10000 plants per hectare (4000 plants per acre). Casualties are periodically replaced up to 3 months after planting. Manual weeding is undertaken twice in the first year.

Fertilizers

The composition, amount and frequency of fertilizer application for casuarina greatly varies between regions and even among farmers within the same region. Fertilizer application is generally restricted to irrigated plantations. Fertilizers will have the maximum effect if applied during the peak growing period of 12 to 24 months. In Andhra Pradesh, 50 kg of urea and 50 to 100 kg of DAP is applied per acre one year after planting. The quantity is increased to 100 kg of urea and 100 to 150 kg of DAP in the third year. In coastal Tamil Nadu and Puducherry, 150 kg of DAP is applied per acre at 6-12 and 18-24 months. Another recommendation is to apply 11 kg of urea and 94 kg of super phosphate at four stages: immediately after establishment, 6, 12 and 18 months after planting.

Insect and disease incidence

Casuarina has only a few major insect and disease incidences which can lead to economic loss. The common insect problem in casuarina plantation is attack by the stem borer, *Indarbela quadrinotata*. The larvae dig up deep tunnels in the main stem especially at the junction of main stem and branch (Fig. 7a). They remain inside the tunnel during day time and emerge out in night and feed on the bark. Although the trees generally survive, the pole quality is affected by severe infection. Affected trees are also prone to breaking at the point of infestation during heavy wind. Chemical control of this insect is difficult since it resides within the tunnel.

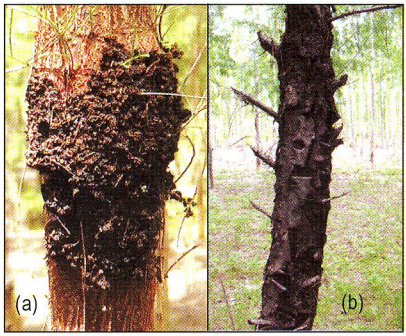

Fig. 7. Pests of casuarina: (a) borer attack; (b) blister bark disease

Wilt or blister bark disease caused by *Trichosporium vesciculosum* results in drying up of trees followed by large scale death. Affected trees show symptoms of drying of leaves followed by 'blisters' on the main stem (Fig. 7b). At advanced stages these blisters burst open releasing black spores. The disease is more prevalent in dry areas and usually occurs in plantations older than 4 years age. Hence this is not considered as a serious problem in irrigated casuarina plantations. There is no effective

control measure once the infection has occurred but removing and burning the infected tree can prevent further spread of the disease.

Pruning and intercropping

Pruning of side branches is usually carried out between first and second years and second and third years. The expenditure for pruning is met by the sale of pruned material. It is also a common practice in Tamil Nadu to intercrop groundnut or water melon in the first year well before the tree crown starts closing in and cause shade effect to agriculture crop (Fig. 8). The plantation establishment cost is generally recovered from the agriculture crop. It also helps to keep the field weed-free.

Fig. 8. A young casuarina plantation intercropped with groundnut.

Rotation period

The commonly followed rotation period is 4 years with irrigation and 6 years under rainfed conditions. But the duration varies greatly in different areas and between farmers. Soil quality, water availability, amount of rainfall, farmers' economic needs and the prevailing market demand and price influence the age at which the crop is harvested. In a few places of coastal Tamil Nadu irrigated casuarina is harvested as early as 2.5 years of age whereas Forest Department plantations without irrigation are retained up to 8 years. Once harvested, the stumps are dug out and the land is prepared for the next planting. The widely planted casuarina variety does not produce coppice growth (as in the case of Eucalyptus) and hence more than one crop is not possible from same plantation.

Yield

Wood production varies greatly across locations, cultivation techniques adopted and age at which harvested. Plantations with irrigation and fertilizer application yield 100 to 150 tonnes of air dried wood (up to 25 cm girth) per hectare (40 to 60 tonnes per acre) in 4 years. Under rainfed conditions an average yield of 75 to 100 tonnes per hectare is obtained in 6 years (30 to 40 tonnes per acre) depending upon soil quality and amount of rainfall during the cultivation period. An additional 12 to 17 tonnes of miscellaneous wood is produced per hectare in the form of branches, tops and roots. At the time of harvest the average height of the tree is 12 m and girth is 25 cm. The best trees may measure 20 m height and 50 cm girth.

Marketing and pricing

All parts of casuarina trees are useful and are readily sold on-farm for various end uses. Sale of produce is generally

Box 3. Economics of Casuarina Cultivation

The following table provides information on expenditure involved in Casuarina cultivation for 4 years and the expected income in a coastal location.

Operation	Expenditure (Rs. per hectare)	Income (Rs. per hectare)
First year		
Land preparation	7500	
Farm manure	5000	
Cost of seedlings	2500	
Planting cost	5000	
Weeding (twice)	7500	
Irrigation and watch and ward	2500	
Second year and third years		
Cost of fertilizer	5000	
Application of fertilizer	2500	
Pruning of branches	5000	
Irrigation and watch and ward	5000	
Sale of Pruned material		5000
Fourth year		
Irrigation and watch and ward	2500	
Cost of harvesting @ Rs. 200 per MT	22000	
Sale of wood 30 MT poles @ Rs.4000 per MT 70 MT poles @ Rs.2200 per MT 10 MT poles @ Rs.2000 per MT		2,94,000
Total Income		2,99,000
Total expenditure	72,000	
Net income	2,27,000	

Note :

1. Cost of cultivation for intercrop and income from it are not included.
2. Cost of water and electricity (if applicable) are not included.
3. Planting cost will increase marginally if polybag grown seedlings are used with corresponding increasing in wood harvested.

done on plantation-basis. The trader fixes the price based on the assessment of stocking, estimated recovery of wood for poles, pulpwood and fuel. The income from the sale of residual wood like branches, tops and roots offset the harvesting cost. Poles (up to 20 cm girth) are the most valuable end product fetching between Rs.3500 and 5000 per tonne depending on the quality of poles, place of availability and prevailing demand. Pulpwood prices remain more stable than that of poles from Rs.2000 to 2300 per tonne. Fuelwood is priced between Rs.1500 and 2500 based on local demand and dryness of wood.

5. High Yielding provenances and landraces

Trees growing naturally in a particular area over a period of time develop

specific characteristics in response to prevailing soil and environmental conditions.

Casuarina grows naturally in drastically different environments in many countries in the continents of Asia and Australia and also in many small islands in the Pacific Ocean. They possess different adaptations to soil and environmental conditions and show variation in growth when planted outside their native areas. Natural populations occurring in a particular

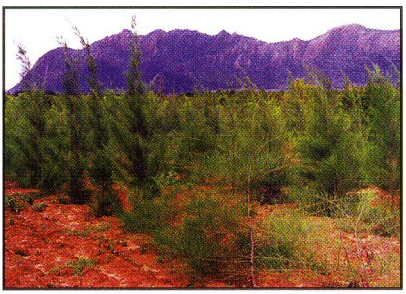

Fig. 9. Variation in growth and form: (a) Kenyan provenance; (b) Thailand provenance

geographical area are called 'provenances' and generally referred to by their location name. A natural population found in Ela Beach of Papua New Guinea is called Ela Beach provenance of casuarina. Similarly populations cultivated outside the natural distribution area for many generations are called landraces. Casuarina is not native to mainland India and the local population is called Indian landrace. There may be differences in various characters even within the Indian landrace from different areas.

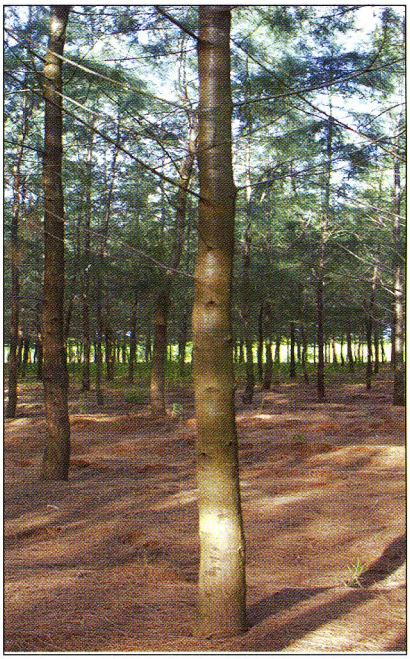

Fig. 10. Six year old trees of Thailand provenance (planted as seedlings) in dryland.

The Institute of Forest Genetics and Tree Breeding (IFGTB), Coimbatore has made an extensive collection of provenances and landraces from 15 countries spread in three continents (Africa, Asia, and Australia) with the support of Australian Tree Seed Centre. Forty provenance and landrace seedlots were tested in field trials in different places located in the States of Andhra Pradesh, Orissa, Puducherry and Tamil Nadu. These tests showed that a few provenances and landraces possess better growth, form and wood traits (up to 40%) compared to the local Casuarina. It is also possible to select varieties for planting in coastal and inland sites and also for specific characters to suit various end uses like

pulpwood, fuelwood, poles, wind-breaks and planting in difficult sites like salt-affected and mined areas.

Growth and wood density

What is generally measured as height and diameter growth in plantations help us to calculate the volume of wood produced. But casuarina is not traded in terms of volume as in the case of timber species where the price is fixed on cubic feet or cubic metre basis. Casuarina is sold on weight basis (rupees per tonne of wood). Weight of wood is a function of volume (size of trees) and density of wood. Wood density of casuarina varieties range from 660 to 800 kg per cubic metre. Indian variety has a density of 690 kg at 4 years age. Provenances from Australia have the highest density of 800 kg followed by Kenya (730), Papua New Guinea (727) and Solomon Islands (720).

The Thailand provenance has a density of 685 kg per cubic metre. This means the weight of a unit volume of Australian provenance will be 16% higher than local casuarina. If the wood production is assessed based only on volume the expected economic returns may not be realized.

Since Thailand provenance is faster growing than all other varieties, its slightly lower density does not affect wood production. On the other hand, wood produced by Kenyan landrace is greater than local variety although both produce same volume of wood due to differences in their density. Hence while choosing a variety for increased wood production both volume and wood density should be taken into consideration. It may be noted that light wood although results in low wood production may be preferred for papermaking if it is associated with

Box 4 How to distinguish *Casuarina equisetifolia* and *C. junghuhniana*?

Character	C. equisetifolia (Rs. per hectare)	C. Junghuhniana (Rs. per hectare)
Bark	Dark; smooth	Pale brown; fissured
No. of leaf teeth per whorl	7-8	9-11
Sex expression	Monoecious or dioecious	Dioecious
Length of male spike (cm)	0.5-4	2-5
Size of female inflorescence (cm)		
Length	1-1.5	0.5-1
Breadth	0.2-0.4	0.1-0.3
Fruit colour	Green turning to brown on maturity	Pale brown turning to grey on maturity
Fruit size (cm) : length	1-4	1-1.5
breadth	0.9-1.3	0.3-0.7
Seed size (mm)	6-8	2.5-4.5
No. of seeds per kilo	6 lakhs	16 lakhs
Needle colour in seedlings	Dark green	Yellowish green

superior pulp quality. However this area needs further research and acceptance from paper industries to offer better prices after working out the merits of such wood. In the absence of such special arrangements it is safe to remain conventional and choose varieties with medium to high wood density.

Stem straightness

Next to growth and density, straightness of the stem is an important character determining the value of the crop in casuarina. Since casuarina is widely preferred for scaffolding, construction of houses and as a prop for banana plants, poles are better priced than pulp and fuelwood. All care must be taken to produce trees with straight stem to increase pole quality and thereby increase returns per tonne of wood produced. The main stem should be vertical and devoid of pronounced bends particularly in the first two thirds of height from ground level. Pole quality is influenced by genetics (variety chosen), environment (insect attack) and cultural practices (spacing between trees) adopted. The local casuarina possesses good stem form. Varieties from Kenya and Papua New Guinea also produce straight stems. They generally obtained a score of 5 and above when assessed for straightness in a 6-point scale (score 6 – vertical and straight stem without any major bends). The Thailand and Malaysia provenances have above average straightness (score 4 to 5). Choosing the varieties on the basis of their fast growth and wood density is unlikely to result in loss of pole quality.

Fig. 11. A 5-year old clonal plantation of Thailand junghuhniana clone (irrigated).

Tolerance to borer attack and wilt disease

Insect attack and disease incidence can be prevented by planting varieties tolerant to them (e.g. Australia and Kenya).

6. Casuarina junghuhniana :

A Promising New Species

Clonally propagated junghuhniana

The only other species of Casuarinaceae family, which has been grown in India, is *Casuarina junghuhniana*. A natural hybrid of *C. equisetifolia, C. junghuhniana* was first introduced in 1951 as rooted cuttings of a single clone from Thailand in the name of *C. junghuhniana*. It is a male clone and hence produced no seeds. Propagation is through air-layering, rooted cuttings and of late reportedly by tissue culture. Vegetatively propagated plants are sold at Rs.4 to 8 per plant (see Box 5). It is a fast growing clone both in coastal and inland sites with a conical crown and a straight stem. It also has coppicing ability. With irrigation it grows 5 m

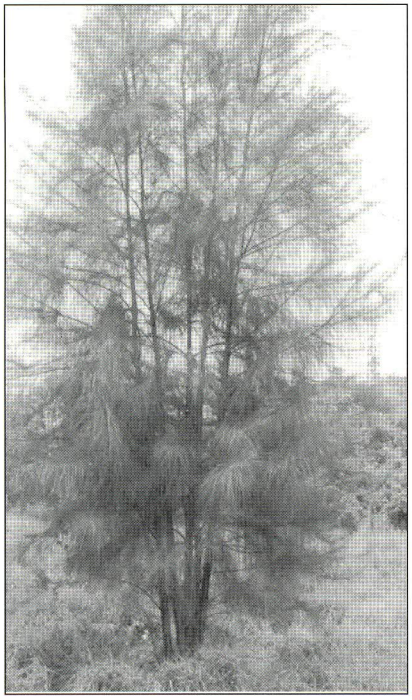

Fig. 12. A coppiced tree of *C. junghuhniana* (Timor Variety)

height and 15 cm girth in the first year. At the age of 5 years the height is around 20 m and girth 50 cm.

It is generally claimed that each tree of this clone will produce 200 kg of wood in 4 years. But as discussed in the previous section, the amount of dry wood produced is greatly influenced by the density of the wood. The junghuhniana clone has a wood density of 592 kg at 4 years' age, which is about 100 kg less than the local casuarina (*C. equisetifolia*). Moisture content (i.e. difference between green weight and dry weight) in junghuhniana is 84% whereas local casuarina has only 62% of water. But increase in volume growth and preference for poles due to excellent stem straightness may compensate reduction in wood density. Since large plantations of junghuhniana clone are yet to be harvested and sold, it remains to be seen how much yield and economic returns this clone can give.

Box 5. Commercially available *Casuarina junghuhniana* clone

At present paper industries and other commercial organisations supply clonally propagated *C. junghuhniana* plants apart from Tamil Nadu Forest Department. This is a single male clone, reported to be a hybrid between *C. equisetifolia* and *C. junghuhniana*. It was introduced from Thailand in 1951 through FAO's Regional Office in Bangkok. About 100 rooted cuttings each were first planted in Marakkanam (Tamil Nadu) and Sriharikota (Andhra Pradesh). The Marakkanam plot maintained by the Tamil Nadu Forest Department survived and became the source of all trees of this clone planted so far. DNA fingerprinting in IFGTB showed that the Marakkanam clone and those supplied by the commercial nurseries are the same.

This is a fast growing clone attaining an average height of 5 metres height in one year with irrigation. It has a straight stem and a symmetrical crown. It is drought tolerant but prone to attack by borer insect and wilt disease. It has a lower wood density (592 kg per cubic metre at 4 years age) than *C. equisetifolia* (690). Various claims are made that each tree of this clone will yield up to 200 kg of wood in 4 years. But data from large harvested plantations are not available. The best trees of C. equisetifolia produce 50-60 kg wood in 4 years.

Fig. 13. Fast growth of a Casuarina plantation raised with seed orchard seeds (left) Compared to unimproved seeds (right)

Seed propagated junghuhniana

IFGTB has introduced 6 new provenances of *C. junghuhniana* from East Timor. Since these varieties have both male and female trees they can easily be propagated through seeds. Timor Casuarina showed faster growth than local Casuarina. It was found highly drought tolerant and suitable for inland areas and rainfed conditions where it recorded 36% faster growth than local casuarina. Although it performed well in irrigated areas, the straightness of stem needs further improvement.

Timor casuarina has a wood density of 689 kg per cubic metre with a moisture content of 63% almost similar to the local casuarina. This means there will not be any reduction in wood production in terms of weight due to differences in wood density. It has a thick bark which helps in retaining moisture under dry conditions and also provides defense against attack of insects and fungal pathogen. Timor casuarina coppices well and has the potential to produce more than one crop from a single planting. When a four year old tree is cut it produces a tuft of coppice shoots within two months. Of these 3 to 6 stools develop into vigorously growing stems (Fig. 12) and increase wood production in the second crop compared to the first one.

7. Tips to Increase Yield

Although wood production and the net income from Casuarina plantations seem to be high they can still be increased by adopting suitable planting techniques. The amount and quality of wood produced is determined chiefly by the variety used, site quality and cultivation practices adopted.

Selection of varieties

The choice of variety will mostly depend on the site location and quality. Coastal and inland areas need different varieties and highly drought prone areas should

be planted with suitable variety. The Institute of Forest Genetics and Tree Breeding supplies seeds from seed orchards located in coastal and inland areas of Tamil Nadu and Puducherry. Seeds from a particular orchard is chosen based on the location, soil type and water availability in the proposed planting site. On-farm tests showed that seeds from orchards produced 13% more wood in drylands and 28% in irrigated lands compared to local seedlots.

Almost all the seedlings available in local nurseries are from unknown sources. These seedlings are of good physical quality and their productivity can be considerably increased by selection in the nursery. Rejecting the weakest 25% of seedlings can significantly increase survival and growth in the plantations. Inoculation with Frankia for adequate development of root nodules in seedlings is essential especially for dry land cultivation.

Cultivation practices

With the present cultivation practices, 4000 trees in an acre produce a maximum of 60 tonnes of wood, which amounts just 15 kg of wood per tree. The major reason for such poor average wood production is that only about 40% of the trees in a plantation significantly contribute to wood production. The rest are weak trees which do not produce merchantable wood. Bare-root seedlings from an unimproved seed source exhibit tremendous variation in initial growth. If the seedlings do not grow uniformly in the first 6 months, weak seedlings caught between vigorously growing neighbours will not be able to grow into healthy trees. Within a year the canopy closes in and the weak trees are suppressed forever. This problem should be addressed by planting uniform sized seedlings and ensuring even growth among them especially in the first 6 months after planting.

Casualty replacement should be completed within one month after planting. Here too seedlings grown in large sized polybags should be used to fill the gaps to maintain uniformity in plant size. If small seedlings are planted adjacent to big seedlings planted one month earlier, the former is likely to get suppressed by the neighbours and thus denying the benefit of casualty replacement.

Since stocking is high in Casuarina plantations, intense competition for resources exists among the trees. Fertilizer application ensures optimal availability of nutrients for all trees so that they can express their full potential leading to increased wood production per unit area. Since casuarina is a nitrogen-fixing tree, the composition of fertilizers should carefully be decided to balance nitrogen with the other important nutrient, phosphorus. Adopting a row-column design (i.e. 1.5 to 2 m between rows and 1 to 1.5 m between trees) for planting will reduce competition for light and increase nutrient uptake.

Box 6. Organisations involved in Casuarina Research and Development		
S.No.	**Organisation and contact details**	**Services available**
1.	Institute of Forest Genetics and Tree Breeding, PB 1061, Coimbatore 641 002, Tamil Nadu. Phone : (0422) 2484100; 2484194	Supply of genetically improved seeds from orchards and superior clones; training/ consultancy for orchard establishment and clonal propagation. DNA fingerprinting of clones.
2.	Forest College and Research Institute, Tamil Nadu Agricultural University. Mettupalayam 641 301, Tamil Nadu. Phone : (04254) 222010	Supply of seeds and seedlings; training on nursery, clonal propagation and plantation development
3.	Tamil Nadu Forest Department Deputy Conservator of Forests (Genetics) Bharathi Park Road, Coimbatore-641 043. Phone : (0422) 2434791	Genetically improved seeds from orchards; superior clones.
4.	Andhra Pradesh Forest Department, Regional Forest Research Centre, Lalacheruvu 533 106, Rajahmundry, AP. Phone : (0883) 2442813	Genetically improved seeds from orchards; superior clones.
5.	West Coast Paper Mills Limited Field Office, 56 Rajaji Street, Cuddalore O.T. 607 003, Tamil Nadu Phone : (04142) 2337224; 9443237224	Supply of seedlings at subsidized rates; purchase of pulpwood.
6.	The Andhra Pradesh Paper Mills Limited, Rajamundry 533 105, Ap. Phone : (0883) 2471831-38	Supply of seedings and clone at subsidized rates; purchaseof pulpwood.
7.	Tamil Nadu Newsprint and Papers Limited, Kagithapuram 639 136, Karur District, Tamil Nadu. Phone : (04324) 277001-10.	Supply of seedings and clone at subsidized rates; contract farming; purchase of pulpwood.
8.	Seshasayee Papers and Boards Limited, Pallipalayam (Erode) 638 007, Namakkal District, Tamil Nadu. Phone : (04288) 240221-28.	Supply of seedlings and clone at subsidized rates; contract farming; purchase of pulpwood.
9.	JK Paper Mills, Jaykaypur 765 017, Dist. Rayagada, Orissa. Phone : (06856) 222050; 222070; 233456	Supply of seedlings at subsidized rates; purchase of pulpwood.

8. Suggested Further Reading

Gurumurthi, K. Nicodemus, A. and Siddappa, 2001. Casuarina Improvement and Utilizations. Institute of Forest Genetics and Tree Breeding, Coimbatore 641 002. 218p.

ICFRE, 1994. Production of high yielding varieties of *Casuarina equisetifolia*. Institute of Forest Genetics and Tree Breeding, Coimbatore 641 002. 11p.

Ravichandran, V.K. Durai, R. and Chandrasekaran, P. *Savukku Sagubadi* (Casuarina cultivation – in Tamil). TNAU, Cuddalore. Tamil Nadu. 50p.

For further information contact

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Institute of Forest Genetics and Tree Breeding

The Institute

Institute of Forest Genetics and Tree Breeding (IFGTB) is a forestry research institution under the Indian Council of Forestry Research and Education, an autonomous body of the Ministry of Environment and Forests, Government of India. Its primary aim is to increase productivity of plantation forests through application of genetic, breeding and biotechnological tools. Mainstream research carried out in the fields of Genetics and Biotechnology is supported by other disciplines like Silviculture, Seed Technology, Entomology, Pathology, Agroforestry and Biodiversity. IFGTB has made significant contributions during last two decades in increasing plantation productivity of widely grown industrial and multipurpose trees like Acacia, Casuarina, Eucalyptus and Teak by developing genetically improved seeds and superior clones.

"Money Spinning Trees" Series

This series of booklets introduces the income generation potential of fast-growing trees to encourage their cultivation by farmers and other tree growers. Results from recent research are provided as guidelines to increase wood production and economic returns from plantations. In particular the availability of various provenances, varities and clones is discussed to enable users to choose them specific to their planting site and intended end use. It is hoped that this series will serve as a bridge between researchers in IFGTB and all user groups involved in tree cultivation for constant interaction and further improvement.