ESTABLISHMENT OF MIXED RAINFOREST SPECIES ON DEGRADED LAND - A CASE STUDY FROM THE COASTAL LOWLANDS OF NORTHEASTERN AUSTRALIA

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APPLEGATE, G.B. & ROBSON, K.J. 1994. Establishment of mixed rainforest species on degraded land - a case study from the coastal lowlands of northeastern Australia. Four treatments consisting of a control, mulching (bagasse), 1 m clear Growtubes (treeshelters) and 1 m white Growtubes, were applied to rainforest species planted as an even-aged mixture on a degraded site on the tropical lowlands of northeastern Australia. The seven species planted, which ranged from shade-intolerant to shade-tolerant species, were *Eucalyptus pellita, Grevillia baileyana, Toona australis, Flindersia bourjotiana, Flindersia brayleyana, Flindersia pimenteliana* and *Cardwellia sublimis.* A month after the treatments were applied, poor survival was noted in the bagasse treatment for all species except *E. pellita* and *G. baileyana.* Height measurements taken at age seven months showed that *E. pellita* reached in excess of 2.5 m (bagasse and control) while the other species (except *T. australis*) produced their greatest height in the two Growtube treatments.

Key words: Rehabilitation - degraded land - Australia - mixed species plantation

APPLEGATE, G.B. & ROBSON, K.J. 1994. Penubuhan spesies hutan hujan campuran pada tanah ternyahgred - kajian kes dari tanah pamah pantai di timur laut Australia. Empat rawatan yang terdiri daripada kawalan, sungkupan (hampas tebu), 1 m 'Growtubes' jernih (pelindung pokok) dan 1 m 'Growtubes' putih telah diberikan pada spesies hutan hujan yang ditanam sebagai campuran sama umur di kawasan ternyahgred di tanah pamah tropika timur laut Australia. Tujuh spesies yang ditanam terdiri daripada spesies yang boleh tahan teduh dan tidak tahan teduh ialah *Eucalyptus pellita, Grevillia baileyana, Toona australis, Flindersia bourjotiana, Flindersia brayleyana, Flindersia pimenteliana* dan *Cardwellia sublimis.* Sebulan selepas rawatan-rawatan tersebut diberikan, rawatan hampas tebu untuk kesemua spesies kecuali *E. pellita* dan *G. baileyana* mencatatkan survival yang lemah. Ukuran tinggi pada umur tujuh bulan menunjukkan bahawa *E. pellita* mencapai ketinggian melebihi 2.5 m (hampas tebu dan kawalan) sementara spesies yang lain (kecuali *T. australis*) mencapai tahap yang paling tinggi pada dua rawatan 'Growtubes'.

Introduction

The first European to visit the wet tropics of northeastern Australia was the explorer G. E. Dalrymple in 1873 (Frawley 1983). Soon after Dalrymple's visit, timber getters arrived in search of the valuable cabinetwood, red cedar (*Toona australis*). Their arrival heralded the beginning of development and exploration in the region. Clearing of forest land for grazing, and agricultural development for sugar cane, dairying and bananas followed. During the land-clearing period little thought was given to erosion control, land-use suitability, or maintenance of forests in reserves. As a result, most of the remaining forests are in reserves where the land is unsuitable for agriculture.

Land-suitability surveys recently carried out in one municipality (Mulgrave Shire) on the coastal lowlands of northeastern Australia indicate that about 1500 ha, or 11% of total land available excluding urban areas, mountains and mangroves, is unsuitable for sugar cane production (the dominant agricultural activity in the area), and better suited to tree production (Holz 1985). This percentage is indicative of the land-use situation throughout the coastal lowlands, where some land is currently being used for purposes for which it is unsuited in the long term. Some of this cleared land has already gone out of production and is lying idle and covered in grass and woody weed species (Applegate & Bragg 1988).

As the general public in the region become more aware of the value of the natural environment and the need for better land-use practices, there is support at all levels in the community for the replacement of tree cover on unproductive and marginal agricultural land. As a result, many landholders want to plant trees which have the potential to provide not only income from the sale of high value tropical timbers, but also intangible benefits to the environment in the form of wildlife habitats, soil protection and water conservation.

The reclamation and rehabilitation of degraded or unmanaged tropical land can involve a range of strategies and techniques. These depend not only on the objectives of management but also on the nature and condition of the degraded land involved.

This paper describes the initial stages of a study involving the simultaneous establishment of mixed native rainforest species on a degraded site on the coastal lowlands of northeastern Australia. The overall aim of the study was to provide data on reclamation techniques using mixtures of native rainforest species, in order to assist in restoration of the original forest structure and natural succession processes.

Coastal lowland environment

Climate

The coastal lowlands in the wet tropics of northeastern Australia are a narrow strip of coastal land between latitudes 16°S and 19° S (Figure 1) with an altitudinal range from 0 m to approximately 80 m a.s.l. One location characteristic of the lowlands is South Johnstone where the monthly mean temperatures range from 18.3 °C (July) to 28.0 °C (January), and the average annual rainfall is 3263 mm (Anonymous 1975) with March being the wettest month, when precipitation reaches 650 mm. There is a four-month period from July to October when average monthly precipitation falls below 100 mm (Figure 2).

Soils

The soil parent materials of the lowlands include granite, basalt and metamorphics containing slate, phyllite and schist (Murtha 1986). Most of the degraded sites where intensive management has been abandoned are on the poorer basalt soils and on soils of metamorphic origin. The basalt soils, which are characterised by Tropeptic Haplorthox (kraznozem), have a dark, reddish-brown clay loam A horizon, and a dark red B horizon to 90 cm which may be either a weak and blocky, or a massive light clay (Murtha 1986).

The metamorphic-derived soils on abandoned areas have been described as Typic Paleudult (red podzolic soil) and Typic Haplorthox soils (red earths) (Murtha 1986).

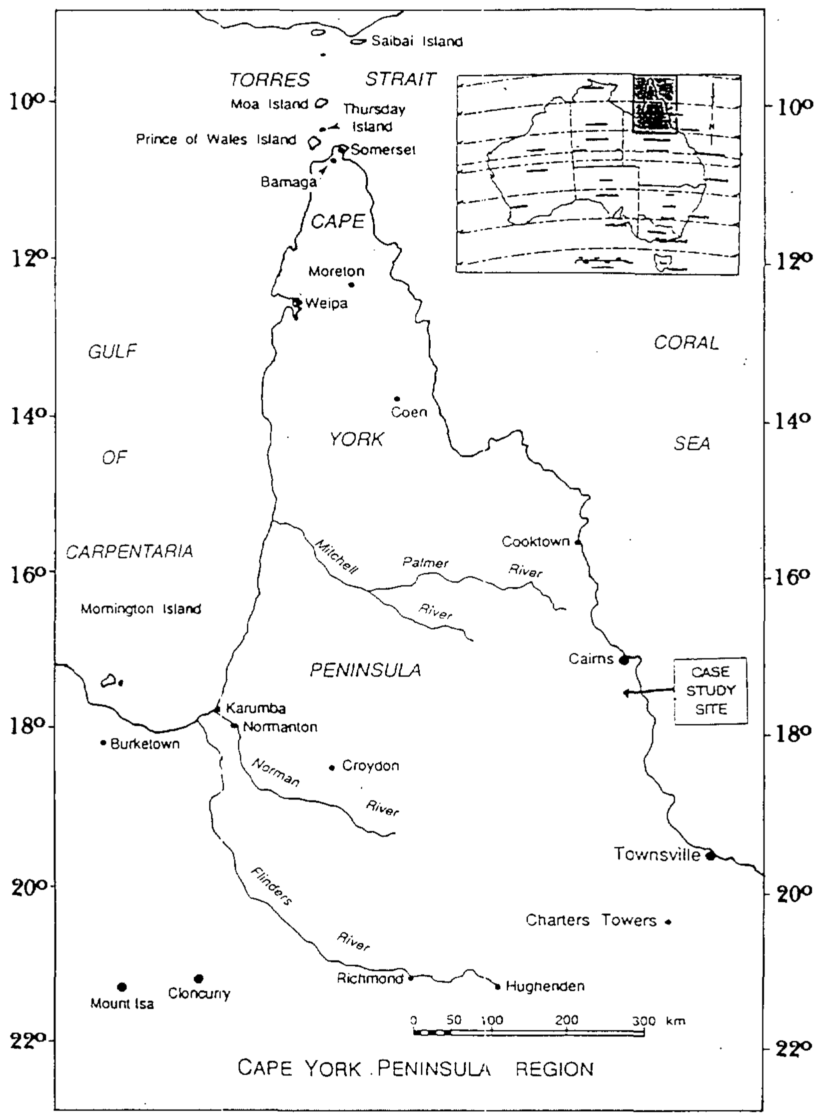

Figure 1. Location map of study site in northeastern Australia

Vegetation

Prior to European settlement, most of the coastal lowlands, where kraznozems, red earths and podzolic soils are found, were covered in tropical rainforest, mapped by Tracey (1982) as complex mesophyll vine forest (Webb 1978). This forest type is characterised by evergreen species usually occupying many layers, with some species occupying only sub-canopy locations. Buttressed roots, woody vines and epiphytes are common. Because of the high incidence of cyclonic activity in the area, much of the remaining rainforest has broken canopies, with "climber towers" covered in vines giving a characteristic appearance which has led these forests to be called "cyclone scrubs" (Unwin *et al.* 1986).

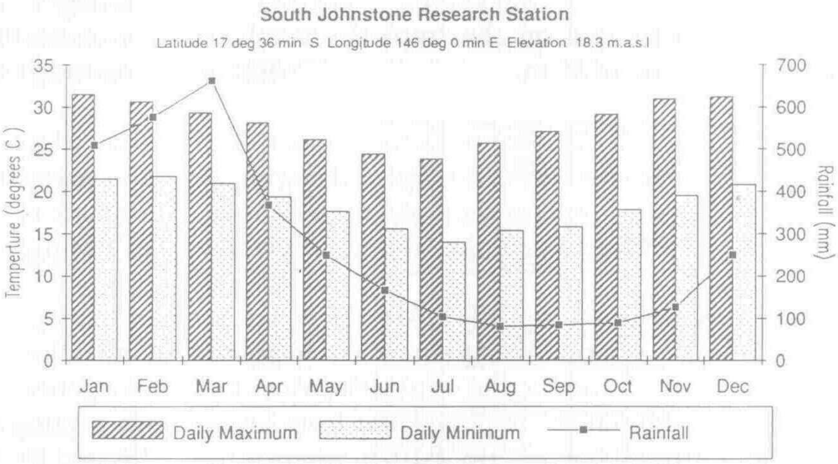

Figure 2. Meteorological data for South Johnstone Department of Primary Industries Research Station

Source: Anonymous 1975.

Social factors

The last decade has seen an increasing community awareness of the non-timber value of trees, as well as of the range of timbers they produce. The current socio-economic changes, in addition to societal pressures for better, more sustainable land uses in the region, place pressure on landholders to consider diversifying current activities, and placing unproductive and marginal land under tree cover. Private landholders showing an interest in tree planting are given technical and financial assistance from the Queensland Forest Service (Tree Care Programme), the Queensland Department of Primary Industries and Greening Australia. National government funding is also available for research projects associated with improving the effectiveness of tree-planting programmes.

Materials and methods

Study objectives

The study aims at identifying methods suitable for restoring and rehabilitating degraded tropical land on the coastal lowlands of northeastern Australia by

- identifying appropriate establishment methods for mixed rainforest species
- testing species survival and growth using different establishment techniques
- testing species interactions when grown with other rainforest species
- identifying suitable species for particular sites and soil types

Site

The study site is located on the tropical coastal lowlands of northeastern Australia at an elevation of 80 m. a.s.l., latitude 17° 38' S and longitude 145° 55' E (See Figure 1).

The soils are Tropeptic Haplorthox (kraznozems), described as red gradational textured soils derived from a thin basalt cap overlying metamorphic parent material (Murtha 1986). The soil is well structured, and is deficient in organic matter and nutrients as a result of leaching and erosion, both common in this high rainfall zone.

The original complex mesophyll vine forest was cleared for dairy production in the early 1950s, as was most of the forest in the remainder of the valley. Dairying was the principal land use on the site until 1966, when there was a general decline in the industry throughout the region. Apart from low-intensity grazing for beef cattle, the site remained unused until 1976, when it was cultivated for banana production for four years. From 1980 until 1989, the site was abandoned and became covered in *Panicum maximum* (Guinea grass).

Reclamation method

The trial was designed with four primary treatments, each comprising a single plot with a mixture of rainforest species planted simultaneously in the same configuration in each plot (see Figure 3).

The treatments consisted of (1) a control; (2) mulching along the tree row using a thick layer (1 m wide and 30 cm deep) of bagasse (a by-product of the local sugar cane industry); (3) 1 m white Growtubes (treeshelters) on shade-tolerant species; and (4) 1 m clear Growtubes on shade-tolerant species (Applegate & Bragg 1989). All plots received chemical weed control using glyphosate sprayed along the planting row at a rate of four litres per hectare.

The rainforest species chosen ranged from those that are shade-intolerant and fast-growing, to comparatively slow-growing shade-tolerant species. They are: *Eucalyptus pellita, Toona australis, Grevillia baileyana, Flindersia bourjotiana, Flindersia brayleyana, Flindersia pimenteliana* and *Cardwellia sublimis.*

Each plot contained eight rows of 20 trees with spacings of 2.7 m between rows and 1.2 m between trees within rows, giving a stand density of 3090 trees per hectare (see Figure 3). *T. australis* and *E. pellita,* although planted in the Growtube treatment plots, did not have Growtubes erected over them. One of the major considerations in positioning species within plots was to site the *E. pellita,* a fast-growing, high-light-demanding species with a relatively small crown, approximately 5 m apart (Figure 3). Two configurations involving *E. pellita* were replicated twice in each plot. Those rows without *E. pellita* were replicated four times in each plot (Figure 3). Other considerations included positioning *T. australis* and shade-tolerant species such as *C. sublimis* close to *E. pellita. T. australis* was positioned on the assumption that the partial shade from the *E. pellita* canopy would assist in reducing the incidence of attack from the shoot tip borer *Hypsipyla robusta.* This borer attacks the growing shoot tips of members of the Meliaceae family, and is most active in open-grown situations in the wet tropics region of northeastern Australia.

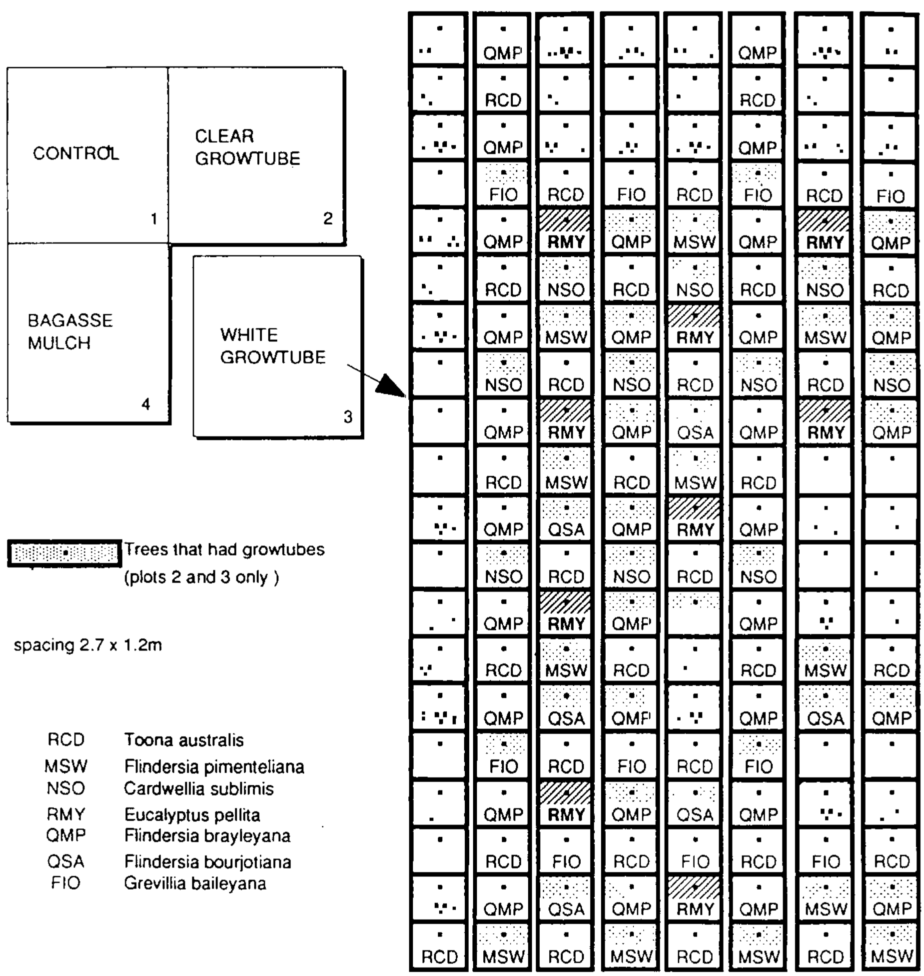

Figure 3. Layout of the four plots in relation to each other, and the location of individual species in the plots, which is the same in each of the four plots

The site was prepared by burning the grass, ploughing, and then sowing a cover crop of *Brachiara decumbens*, a tropical pasture grass which is readily managed. The trees were raised in small black plastic containers 15 cm long, and were planted at the beginning of the wet season.

The trees were fertilised with 200 g of diammonium phosphate (D.A.P., 17% N, 19% P) per tree. The treatments were applied one month after planting. The establishment cost to the end of year one including all labour, but excluding the cost of plants, was approximately A$ 1500 per ha.

Community input

Funding for the trial was provided by the National Afforestation Programme (a National research-funding government agency); the landowner who provided labour for some of the establishment and also funds for maintenance; and the Queensland Forest Service, through its research programme for protection and rehabilitation.

Although the trial is on private land, its establishment involved a wide range of people. Other landholders wanting to undertake similar tree planting exercises, members from local tree-planting groups, forestry personnel and the landholder co-ordinated their activities to plant the trees, transport the bagasse and erect the Growtubes. The community support and interest that such a project creates is an indication of its perceived importance to the community.

The trial is being used extensively as a demonstration for a range of individuals, including politicians, public servants, and landowners who have an interest in the results of mixed rainforest tree plantings.

Initial results and discussion

While the overall survival and establishment of trees in the four treatments were satisfactory, the treatment effect on some species was marked.

Four months after establishment, tip borers attacked the *T. australis* and similar attacks occurred throughout the remainder of the first year. At eleven months the site was affected by a tropical cyclone, which resulted in minimal damage to the planting, although some species such as *G. baileyana* suffered from wind throw. Cyclones are an integral part of the environment in northeastern Australia and need to be taken into account with any form of forest management in the region (Unwin *et al.* 1986).

Survival

Survival counts taken a month after the application of the four treatments indicate marked treatment effects. All *E. pellita* and *G. baileyana* survived in the bagasse treatment, but the survival of *G. baileyana* decreased by 14%, averaged over all treatments, following the cyclone at age eleven months. For the other high-light-demanding species, *T. australis*, survival was poor in both the bagasse treatment (22%) and the control (12%).

The three species of *Flindersia (F. brayleyana, F. bourjotiana* and *F. pimenteliana)* show differing results. For each of these species, survival was poorest in the bagasse treatment. *F. pimenteliana* showed 100% survival in the white Growtubes, 70% survival in the clear Growtubes, 55% survival in the bagasse plot and 50% in the control. *F. brayleyana* and *F. bourjotiana* each had 100% survival in the white Growtubes, clear Growtubes and the control, while the bagasse treatment resulted in 40% and 80% survival respectively for these two species.

The most shade-tolerant of the species tested, *C. sublimis*, showed 81, 87 and 91% survival for the white Growtubes, clear Growtubes and control treatments respectively. Again the bagasse treatment produced the poorest results with only 19% of trees surviving.

The poor survival of the slower growing species in the bagasse treatment was unexpected. Bagasse is a by-product of sugar cane and it attracted local rodents to the plantings. There was visual evidence to suggest that the rodents burrowed beneath the bagasse and ate or destroyed the roots of the young slower growing species. While the results from the trial suggest that composting with bagasse jeopardises survival, observations made in other plantings using different compost material do not support the findings from this current trial.

Height growth

Total height was measured for all trees at age seven months. For *F. bourjotiana*, *F. brayleyana* and *C. sublimis* analyses of variance showed significant treatment effects ($p \leq 0.05$) in height at age seven months between the four treatments. *T. australis* and *E. pellita*, although planted in the Growtube treatment plots, did not have Growtubes erected over them. The shoots of *T. australis* were first attacked by tip borers at age four months; so later height growth was not used for comparison with other species.

Figure 4 shows the height development of the trees at age seven months for the seven species and their treatments. *E. pellita*, which had only two treatments, grew taller than the other species. *G. baileyana*, which had all four treatments, was the next tallest, followed by *F. bourjotiana*, *F. brayleyana* and *F. pimenteliana*. The shade-tolerant *C. sublimis* was the slowest growing species in all treatments. Figure 4 shows that the magnitude of the treatment effect between species was similar for all treatments. For example, the difference in height between *G. baileyana* and *F. bourjotiana* in the white Growtubes was similar to the difference in height for the same two species in the bagasse treatment.

Mean heights at age seven months show that the Growtube treatments produced the best height growth for *G. baileyana, F. bourjotiana, F. pimenteliana* and *C. sublimis*. *F. brayleyana* grew better in the clear Growtubes than in the white Growtubes. The next best treatment for all species was bagasse, followed by the control, except for *C. sublimis* which grew taller in the control than with the bagasse (Figure 4).

Results from other research involving Growtubes generally support the findings from this trial that Growtubes have a positive effect on both survival and early growth rate of rainforest tree species (Applegate & Bragg 1989). Interactions between species have not been analysed, and the trial is still too young to make any conclusions on species-site interactions.

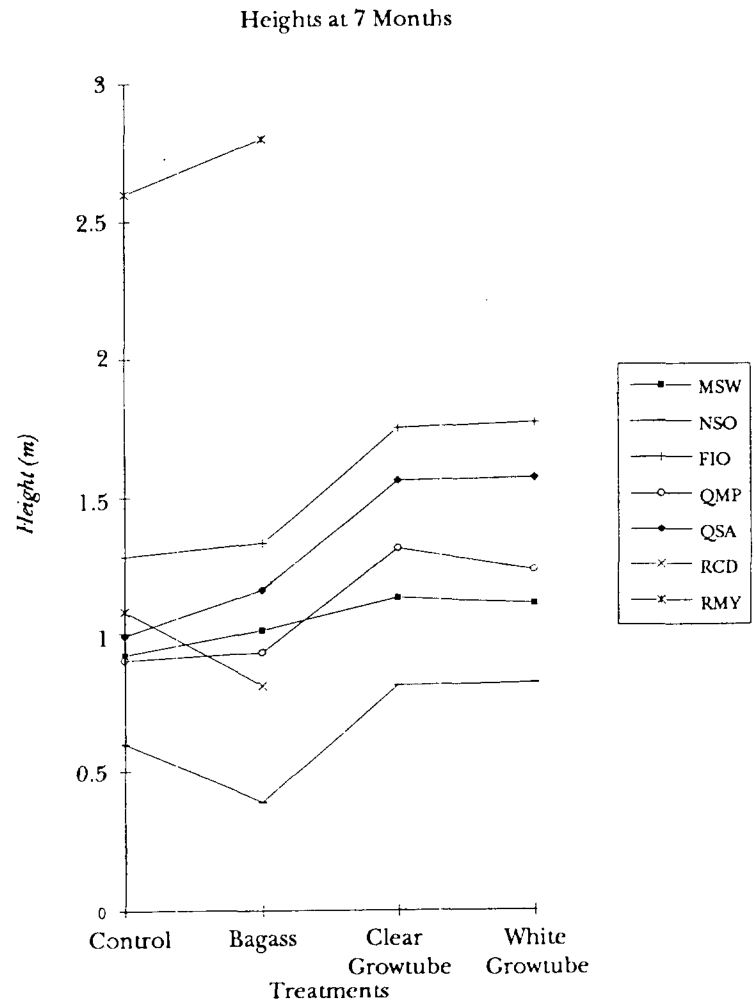

Figure 4. Height at age seven months of *Eucalyptus pellita* (RMY), *Grevillia baileyana* (FIO), *Flindersia bourjotiana* (QSA), *Flindersia brayleyana* (QMP), *Flindersia pimenteliana* (MSW), *Toona australis* (RCD) and *Cardwellia sublimis* (NSO) planted with four treatments: 1) control; 2) bagasse (compost); 3) 1 m white Growtubes (treeshelter); 4) 1 m clear Growtubes

Conclusion

The initial results from this trial indicate that successful establishment of mixed rainforest tree species planted simultaneously is possible on degraded sites on the coastal lowlands of northeastern Australia. Survival was generally enhanced by the use of Growtubes, while bagasse was detrimental to the survival of all species tested. Growth rates were enhanced using both white and clear Growtubes, with some species showing over 35% improvement. For most species, bagasse produced slightly taller trees compared with the control at age seven months, while the reverse occurred in *C. sublimis* at the same age.

Acknowledgements

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