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Clonal Capture of Mature *Tectona grandis* (teak) for Improved Germplasm Deployment in Papua New Guinea (PNG)

Anton Lata[1], Sylvester Kulang[2], Neville Howcroft[2] and Tony Page[3]

[1] Papua New Guinea Forest Research Institute, PO Box 314, Lae 114, Morobe Province, Papua New Guinea. Corresponding author alata@fri.pngfa.gov.pg
[2] University of Natural Resources and Environment, P O Box 30, Kerevat, East New Britain Province, Papua New Guinea
[3] Tropical Forests and People Research Centre, University of the Sunshine Coast, Locked Bag 4, Maroochydore DC, Queensland, 4558, Australia.

Abstract

Teak (*Tectona grandis*) is a priority species for plantation development in Papua New Guinea (PNG), although expansion of the planted area is constrained by a lack of high quality seed sources. To address this problem, clonal methods were used for capturing selected plus trees within existing plantations (9 candidates) and an existing clonal seed orchard (20 candidates). Truncheon cuttings were collected from the lower branches of each of the 29 candidate trees. Truncheons were cool-stored for 5 days during transportation before being planted in a potting medium that was a mixture of coarse sand and forest soil (at ratio 1:1 by volume) and placed under intermittent mist. Adventitious root development in the truncheons occurred over a period of 5 to 6 months, and successfully rooted truncheons were planted in a hedge garden and used as a further source for cuttings. Subsequent cutting experiments using softwood single-node cuttings evaluated the effects of (i) rooting media (coarse sand vs a mixture of coarse sand and coconut husk) in the non-mist propagators, and in the mist system, coarse sand, fine sand, jiffypot (coco pellets) and a mixture of perlite and coconut husk, (ii) cutting length (6, 8, 10 and 12 cm), and (iii) rooting ability of clones. After 12 weeks a significantly greater rooting percentage was recorded in a mixture of coarse sand and coconut husk (78% ± 3.95se) compared to coarse sand alone (52.3% ± 2.85se) in the non-mist propagators. Rooting percentage variation did not differ significantly across the rooting media in the mist propagation system. However, a greater rooting percentage was attained in jiffypots (85% ± 0.05se) compared to in coarse (64.6% ± 0.07se) and fine sand (65.3% ± 0.06se). For the cutting length experiment, s significantly greater rooting percentage (94% ± 0.04se) was recorded with the cutting length of 10 cm compared with 6 cm (50% ± 0.09se) and 8 cm (53.1% ± 0.09se) cutting lengths. At week 12 after insertion of cuttings in jiffypots, no significant variations in rooting percentages were found among the clones. Low rooting percentages were recorded across all clones. Nevertheless, cutting survival of these clones was significantly higher without producing roots at week 12 after insertion in jiffypots in the mist house. Clones obtained from leafy stem cuttings were successfully acclimatized and would be used in teak clonal seed orchard (CSO) establishment to become a source of high quality germplasm for planting in PNG.

Keywords: clones, genetic materials, clonal seed orchard, cutting, rooting cuttings

Introduction

Tectona grandis (teak) is an exotic commercial timber species introduced into Papua New Guinea (PNG) during the German colonial period between 1890 and 1900s (Howcroft 2005).

It is native to India-Burma, Myanmar, Thailand and Lao (Kaosa-ard 1981), and from the 1850s onwards it has been introduced throughout the tropics (FAO 1957) in regions such as Asia, West Africa, East Africa, Central America, South America (Gartner 1956), and the Pacific Island nations (PNG, Fiji and the Solomon Islands) (Pandey and Brown 2000).

Teak has been subjected to domestication and utilised as a plantation species on both small and large scales, owing to its high value timber (considerably the stem quality being important). The species is amenable to being grown in plantations, but Kjaer & Foster (1996) reported that tree improvement efforts for teak can be hindered by (i) low seed yield per tree, (ii) low germination percentage of seed, (iii) control pollination being difficult, and (iv) a long period of juvenility (i.e. flowering after age 6). To circumvent these issues the PNG Forest Research Institute (PNG-FRI) commenced a clonal program for selection of elite trees identified around the country.

This clonal approach to domestication was undertaken to secure valuable genetic materials within a clonal archive. Branches were harvested from selected trees from three sites and brought to a PNG-FRI nursery and propagated as truncheon cuttings. Successfully propagated truncheons were then established as hedged plants in a clonal archive, which has become the source of vegetative material for further propagation. The bulking of clones by leafy stem cuttings has been carried out for three reasons. Firstly, to address the issue of using seeds from unclassified sources by increasing the number of available improved materials as planting stock. Secondly, the clones produced would be used to establish new teak clonal seed orchards (CSOs) to supply improved seed to tree farmers. And finally, to establish resources to investigate the genotype by site interactions so that selections can be identified for further breeding. Genetic gains through clonal deployment of superior genets or families is well recognised for several plantation species, for example, *Pinus radiata* in New Zealand (Carson et al. 1990) and Australia (Cotterill et al. 1989), and *Pinus elliottii* improved for plantings in South East USA (White et al. 1993).

The technical aspects of vegetative propagation of teak is widely reported in the literature (e.g. Goh and Monteuuis, 1997 and Monteuuis *et al.*, 1995). This study uses an adaptive research approach to teak cuttings using locally-available materials. The present paper examines the effect of genotype, propagation media, cutting length and propagation environment in teak leafy stem cuttings. Two experiments are presented, the first combined experiments were rooting media tests using the mist and non-mist propagation systems, and second was cutting length.

Materials and Methods

Source genetic materials

The study site was at the PNG-FRI nursery in Lae, Morobe Province. A total of 29 unrelated parents were sourced from three sources: (1) Oomsis woodlot in Morobe Province, (2) Vunapaladig-Kerevat plantation in East New Britain Province, and (3) Kuriva plantation and CSO, in Central Province. Stems with a diameter of 1.8-2.0cm, a length of 40 to 50cm and with at least 2 dormant buds (truncheons) were collected from each of the selected trees. The ends of the truncheons were sealed with Vaseline immediately after harvest, before being wrapped together with sawdust in hessian bags. The preparation was well watered and packed in empty boxes, and transported over five days to the FRI nursery. During transport many of the dormant buds began to grow.

At the nursery the truncheons were planted into the plastic pots of 28cm width x 21cm length filled with a mixture of coarse sand and forest soil at a ratio of 1:1 by volume. Three truncheons were planted per pot with 10-15cm inserted into the potting medium. Potted truncheons were placed under intermittent mist for 5-6 months. Successfully rooted truncheons were transferred to nursery beds for a two-week sun-hardening and then transplanted in the clonal archive at a spacing of 2 x 2 m. These hedge plants (clones) were pruned regularly to promote multiple juvenile shoots suitable for cutting propagation.

Testing for Propagation Characteristics
Two propagation experiments were conducted with physiologically juvenile shoots harvested as single-node cuttings from the clonal hedge plants.

Experiment 1: 8 clones (4 cuttings per clone randomly assigned to two propagation media) and 2 propagation media (coarse sand and a mixture of coarse sand:coconut husk 1:1v/v) were examined. A total of 32 cuttings were set in a non-mist propagation system.

Experiment 2: 8 clones (4 cuttings per clone randomly assigned in the propagation tray containing one of the rooting media) and 4 propagation media (perlite:coconut husk 1:1v/v, coarse sand, fine sand and jiffypot) were examined. Jiffypot is a commercially prepared medium comprised of compressed cocopeat and was used to compare the performance of locally sourced propagation media. A total of 128 cuttings were set under an intermittent (10 seconds every 10 minutes) misting propagation system.

Experiment 3: 8 clones (4 cuttings per clone of each cutting length was randomly replicated twice in the propagation tray containing jiffypot) set in the misting system. A total 64 cuttings were set under an intermittent misting propagation system for 12 weeks prior to an assessment of rooting traits.

Response variables and data analysis
Cuttings in the three experiments were assessed 12 weeks after setting and the survival and rooted cuttings percentages were recorded. Data collected were collated into an excel spreadsheet, prior to processing using a Pivot Table. The rooting percentages were subjected to two-way analyses of variance (ANOVA) using the SPSS statistical software, version 17.0 (SPSS, 2007).

Results

Experiment 1
A significantly greater percentage of rooted cuttings were found in the coarse sand:coconut husk medium (78% ± 3.95se) compared to coarse sand alone (52.3% ± 2.85se) in non-mist propagators (Fig.1a).

Experiment 2
A significantly greater rooting percentage was attained in jiffypots (85% ± 0.05se) compared with all remaining media treatments. Rooting percentage in coarse (64.6% ± 0.07se) and fine sand (65.3% ± 0.06se) were found to be significantly greater than those set in a mixture of perlite and coconut husk (42%) (Fig.1b).

Experiment 3
Cuttings with a length of 10 cm had a significantly greater rooting percentage (94% ± 0.04se) than cuttings with a length of 6 cm (50% ± 0.09se) and 8 cm (53.1% ± 0.09se) (Fig. 2). Higher cutting mortality was also noted in the 6cm and 8cm cutting length treatments. Cuttings with

a length of 12cm had a rooting percentage (75%) found to be intermediate between, and not significantly different from, all remaining cutting length treatments.

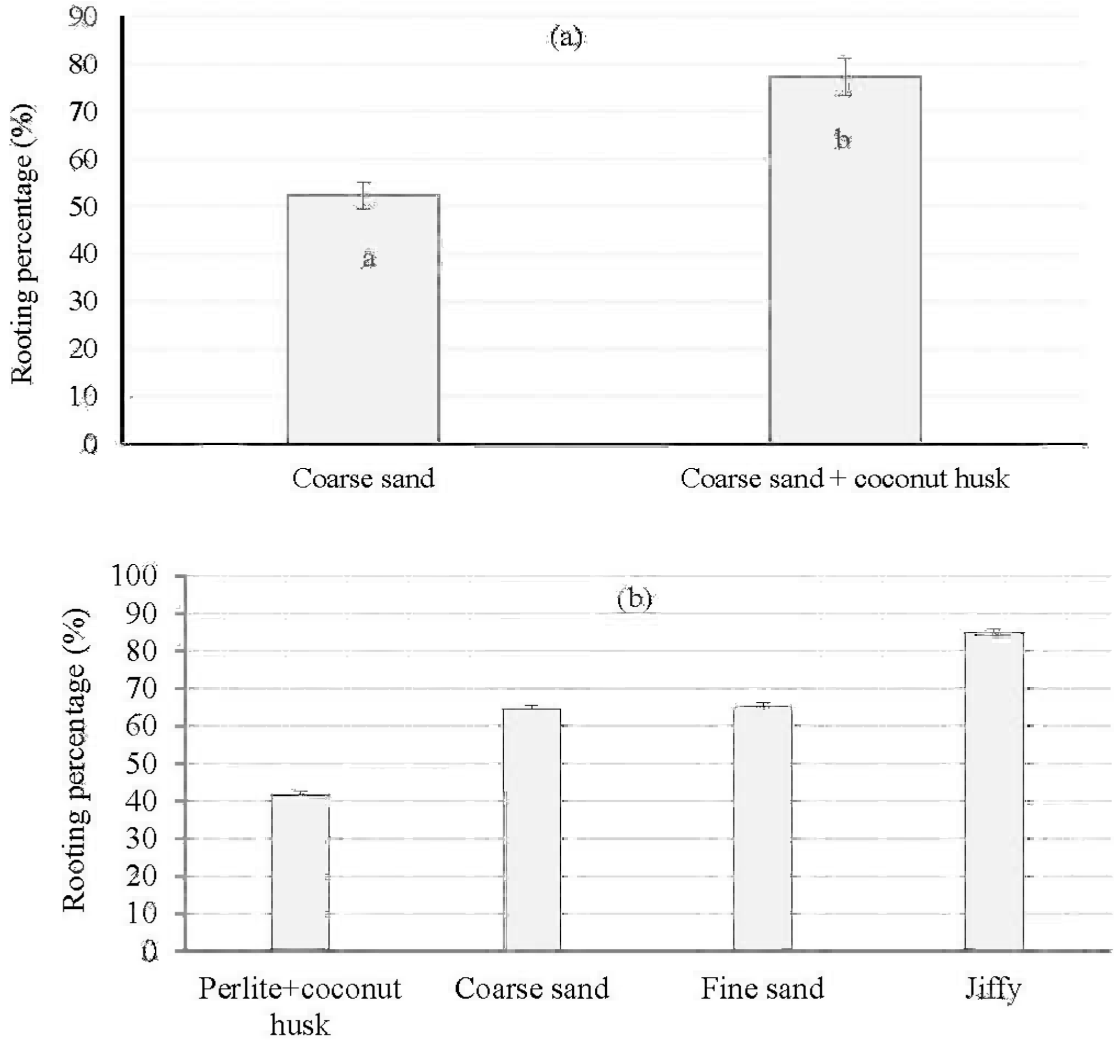

Figure 1. Effects of rooting media on rooting percentage of leafy stem cutting of *T. grandis* in non-mist (a) and (b) mist propagation systems at FRI-Lae, Papua New Guinea.

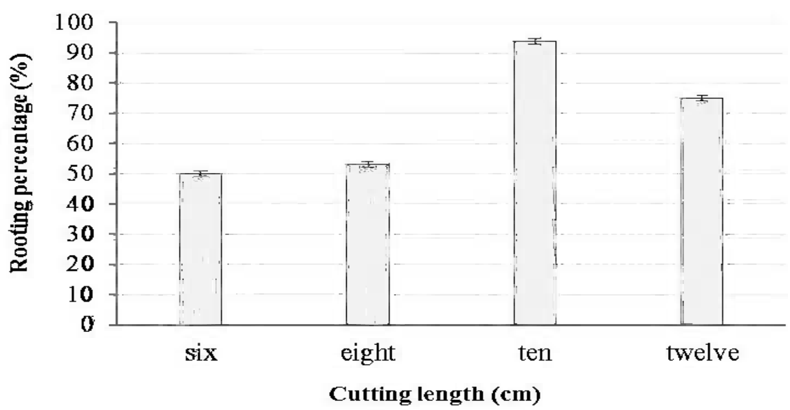

Figure 2. Effect of cutting length on rooting percentage (%) in leafy stem cuttings of *T. grandis* within mist propagation system

At week 12 after insertion of cuttings into jiffypots, significant variation in rooting percentages were shown among the clones (Fig. 3). Low rooting percentages were recorded across all clones, nevertheless, cutting survival of these clones were significantly higher without producing roots at week 12 after insertion in jiffypots in the mist house (Fig. 3).

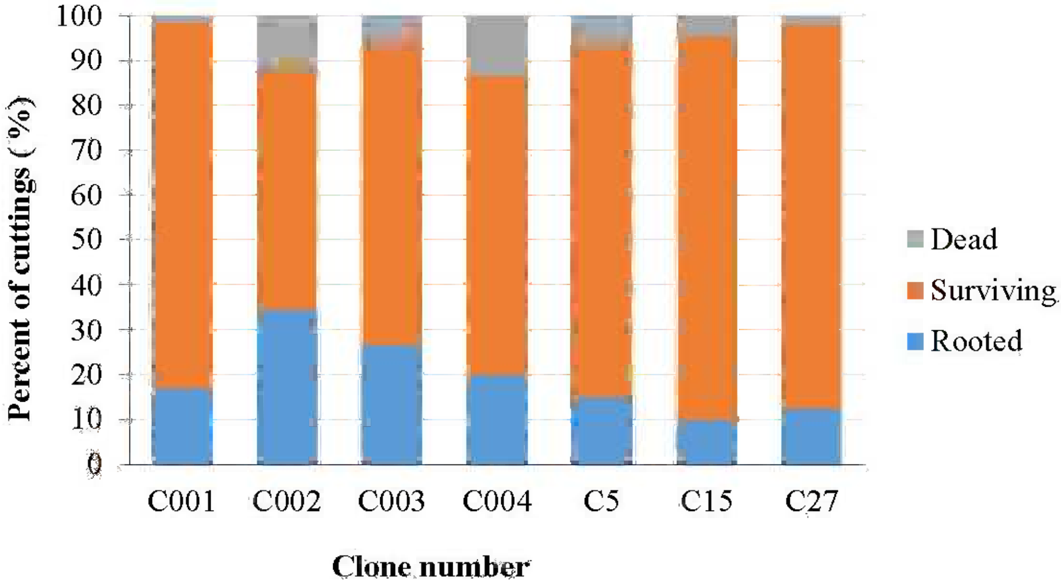

Figure 3. Clonal variation in percentage of rooted, surviving (but not rooted) and dead cuttings for *T. grandis* propagated in misting system after 12 weeks.

Discussion

Tree species differ in their stem cutting response to propagation media (Leakey *et al.* 1990). For example, in *Milicia excelsa* (Ofori *et al.* 1996) and *Irvingia gabonensis* (Shiembo *et al.* 1996), higher rooting percentages were recorded in sawdust than in the other media tested. This result is consistent with results obtained here with *T. grandis*, (i.e. higher rooting percentage (78%) in a mixture of coarse-coconut husk in the non-mist, and jiffypot (85%) in the mist propagation system). It is obvious that these rooting media provide sufficient water to prevent wilting of cuttings as a result of higher rates of water uptake in the cuttings (Loach 1986), consequently higher rooting percentages were attained.

In general, an optimum rooting medium is one with an adequate gas-filled pore space and oxygen diffusion rate sufficient for the needs of respiration (Andersen 1986). However, excess water may limit the diffusion of oxygen and thereby result in anoxia within the cutting base (Loach 1986). While rotting of the cutting base in the jiffypot and the mixture of coarse sand-coconut husk was observed in these experiments, it is clear that coconut husk can have a positive effect on rooting capacity provided it is not mixed with very light/coarse components such as perlite. The high percentage of cuttings surviving but not rooting by week 12 means that the propagation period is likely to be longer than conducted for this experiment. Further work with an extended propagation period is required to determine the true influence of the treatments in this experiment.

A cutting length of 10cm was found to have a higher rooting percentage (94%) compared with all cutting treatments and is recommended for further evaluation of cutting propagation in teak. Similar results were reported in *Triplochiton scleroxylon*, where long cuttings had a greater rooting percentage than short cuttings regardless of their position of origin (Leakey and Mohammed, 1985). In addition, single-node cuttings of *Hedera helix* with a stem length equal to the internode length recorded an increase in root number with increasing stem length (Poulsen and Andersen 1980). However, other factors such as interaction between leaf area and cutting length has to be considered as a cutting's carbohydrate content can influence rooting, as demonstrated in *Eucalyptus grandis* (Hoad and Leakey, 1993). Larger-leaved cuttings do require a greater stem volume for the storage of assimilates, as basal cuttings with a larger diameter had the greatest rooting percentage, demonstrating that cutting stem volume may in fact be more critical than length (Leakey et al. 1993).

One main factor influencing the induction of adventitious roots in cuttings is the clonal variation in rooting ability. In this preliminary study, there was no detailed investigation into this, as genetic effects are the least studied factors that control rooting by cuttings (Haissig and Riemenschneider, 1998). Clonal variation has effects on ramets' large scale multiplication for CSOs or planting programmes. The low rooting percentage recorded across all clones in this study is attributed to the duration of the experiment. It is possible that the assessment time needs to be extended to 16 weeks to allow for surviving cuttings (Fig. 3) to develop adventitious roots. Thus, the clonal variation in rooting ability recorded here was not easily explicable in the rooting percentages among the clones tested.

Conclusions

These results indicate that *T. grandis* is amenable to vegetative propagation using the techniques described. The rooting percentage of over 70% achieved in non-mist propagators using a mixture of coarse sand-coconut husk and over 80% rooting attained in jiffypot in the mist propagation system indicate that multiplication of planting stock (clones) for new teak clonal seed orchard establishment as well as satellite teak clonal establishment in PNG can be attained. The optimum cutting length was 10cm set in either mist or non-mist propagation systems. Propagation by stem cuttings can be an effective means of capturing plus tree clones. However, rooting ability varies between selected individuals, and a proportion may need to be discarded from subsequent clonal production because of propagation difficulties. This simple cutting propagation of teak is helpful in domesticating this species for the benefit of the PNG forest plantation sector.

Policy Implications

The establishment of the teak clonal seed orchard funded by the ACIAR projects in collaboration with the PNG Forest Authority (PNG-FA) will provide improved seed sources (e.g. from established CSO) so that improved seeds will be available for plantation forestry in PNG.

The following recommendations should be considered by the PNG-FA to attain the objectives as stipulated in the Vision 2050, in terms of planted forests expansion. Productive forest plantation with higher return depends on the quality of seed supply, thus PNG-FA should consider:

- Reviewing its policy on encouraging the use of improved seeds from selected plus trees in teak plantations or CSO for plantation development in the country;

- Reducing the proportion of plant materials derived from unimproved sources (e.g. any trees that are accessible to collect seeds or on forest floor);
- Including the introduction of teak genetic material from overseas origin to add genetic diversity to the local materials in the country;
- Providing sufficient resources to increase the number of CSOs not only for this exotic species but also other commercial timber species; and
- Producing and disseminating information on propagating mature teak to clients for woodlot and plantation development.

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