PROPAGATING TEAK BY CUTTINGS AND MICROCUTTINGS

Olivier Monteuuis

Natural teak (*Tectona grandis* L.f.) occurs within 9° to 26°N latitude, and 73° to 104°E longitude in the deciduous forests of central and southern India, Myanmar, northern Thailand and Laos (White, 1991). It has been introduced to other Southeast Asian countries (e.g., Indonesia, Sri Lanka, Vietnam, Malaysia, Solomon Islands), to Africa (especially to Ivory Coast, Nigeria, Togo), and more recently to Central and South America (e.g., Costa Rica and Brazil) (Behagel, 1999). Its great popularity is due its attractive and durable wood, one of the most prized in the world. Consequently there is a gap between current demand and resource supply (Dupuy, 1990). This makes the large-scale pro-duction of good quality teak planting stock a high priority (Wellendorf and Kaosa-ard, 1988; Mascarenhas and Muralidharan, 1993).

Teak has been traditionally multiplied by seeds (Mascarenhas *et al.*, 1987; Kaosa-ard, 1986). The purpose of this paper is to review what can be expected from vegetative propagation by rooted cuttings produced from stock plants in the nursery, or from in-vitro issued microcuttings.

RATIONALE FOR PROPAGATING TEAK

Propagation by cuttings or microcuttings – the basic difference here is in the size of the shoot portion used, which must ultimately produce in both cases adventitious roots (Davis *et al.*, 1988) – are vegetative propagation techniques. As such, they represent the same basic characteristics as other asexual propagation methods (Zobel and Talbert, 1984). Their main feature consists in duplicating, theoretically indefinitely, genotypes while preserving through mitotic divisions their original genetic make-up. This contrasts with propagation through seeds, which results in genetically distinct individuals.

Vegetative propagation can be useful for research as well as for production purposes, as developed by Zobel and Talbert (1984) and more extensively by Ahuja and Libby (1993 a and b). As far as production aspects are concerned, vegetative propagation can be useful for

- establishing clonal seed orchards; and
- producing rooted cuttings for establishing plantations.

Establishing Clonal Seed Orchards

Clonal seed orchards of teak have been set up in several countries including Ivory Coast (Dupuy and Verhaegen, 1993), Thailand (Wellendorf and Kaosa-ard, 1988), Sri Lanka (Tilakaratna and Dayananda, 1994) to produce genetically improved quality seeds. The cloned seed producers are mostly obtained by bud grafting, notwithstanding grafting incompatibility problems that may occur between the seedlings used as rootstock and the scion (Emmanuel and Bagchi, 1984; Bagchi *et al.*, 1991). Such problems can be overcome by using shoots from genetically unselected stock (Tilakaratna and Dayananda, 1994). This will result in the production of 'illegitimates', which is likely to depreciate the genetic quality of the seeds produced. Because of their similarity, illegitimates are usually difficult to distinguish from grafts. Another problem is that illegitimates pollute the genetic quality of the seeds produced by 'legitimates'.

Such problems should not be underestimated for teak (Bagchi *et al.*, 1991; Tilakaratna and Dayananda, 1994). They do not occur when the cloned seed producers are produced on their own roots, as they either grow or die without the risk of producing illegitimates. Thus, teak cuttings can be profitably used for establishing 'safe' clonal seed orchards that are beneficial as 'seed production for sound breeding programs populations' (Zobel and Talbert, 1984).

Wood Producing Populations

Production of teak planting stock by seeds remains severely handicapped due the following factors:

- only limited seed production possible (Wellendorf and Kaosa-ard, 1988, White, 1991);
- late flowering stage. In teak, straight stems, which determine its market value, depend on the capacity of the terminal meristem to remain vegetative as long as possible (White, 1991). Its conversion into the flowering stage induces fork formation, as the result of a true dichotomy process;
- low germination rates (Kaosa-ard, 1986; Mascarenhas *et al.*, 1987; White, 1991);
- substantial variability among individuals, even among half-sibs, within progenies, with regard to traits of major economic importance such as growth, stem form, wood pattern (Bedel, 1989; Dupuy and Verhaegen, 1993; Mascarenhas and Muralidharan, 1993); and
- limited knowledge of the inheritance of significant traits, and consequently, some uncertainties surrounding the time constraints associated with sound breeding programs (Wellendorf and Kaosa-ard, 1988).

Propagation by cuttings can produce superior individuals in large quantities while preserving their original and desired characteristics. It should thus receive special attention. Two options can be considered, i.e. bulk or clonal propagation.

BULK PROPAGATION VERSUS CLONAL PROPAGATION

Definition

Bulk propagation consists of vegetatively propagating a group of mixed genotypes without maintaining any individual identification. This can be useful for increasing the number of juvenile genotypes of presumably high and similar genetic value, derived for example from controlled pollination.

In clonal propagation, by contrast, the genotypic identity is preserved through successive propagation cycles, which may last several centuries.

Comparative Advantages and Disadvantages

The main advantage of bulk compared to clonal propagation is that it is not necessary to clearly identify each genotype or clone. Practical constraints and management requirements of clonal propagation, especially when large number of clones are involved, should not be underestimated.

The vegetative propagation of a mixture of unidentified genotypes maintains a certain degree of genetic variability depending on the number of genotypes involved at the beginning, which is likely to induce an overall heterogeneity in the final wood producing populations. This seems especially true for teak considering genotype variability. However, successive generations of serial propagation, may induce eventually a significant reduction of the original genetic base. This is due to genotypic differences in the multiplication rates, i.e. in the capacity to produce suitable shoots with good potential for adventitious rooting.

Clonal propagation involving accurate genotypic identification prevents such risks, in addition to a number of other advantages associated with cloning of forest trees (Zobel and Talbert, 1984; Timmis, 1985; Ahuja and Libby, 1993a and b). On the other hand, genotypes selected for clonal propagation may display physiological maturation symptoms such as a drastic reduction, and even the total loss, of the potential for adventitious rooting (Rauter, 1983; Timmis, 1985; Wareing, 1987). A physiologically juvenile – or rejuvenated – status is a prerequisite for the successful rooting of cuttings. The basic requirement for success in teak propagation by rooted cuttings is the capacity for adventitious rooting (Monteuuis *et al.*, 1995). It appears that once rooted teak cuttings develop, 'true-to-type' and good uniformity can be expected. Exhibiting homogenous superior traits such as growth rate, stem form, straight bole length and other important wood characteristics is a strong economic incentive for developing teak clonal

plantations (Zobel and Talbert, 1984; Wellendorf and Kaosa-ard, 1988). Such uniformity cannot be expected from plantations set up from seedlings, or even from bulk propagation.

Besides, clonal propagation of teak seems particularly useful to increase our knowledge of basic genetic parameters, such as genotype x site interaction, heritability upon which depends eventually the quality of teak plantations (Wellendorf and Kaosa-ard, 1988; Bagchi, 1995; Gogate *et al.*, 1998).

PROPAGATION BY ROOTED CUTTINGS

This refers to propagation in nursery conditions in contrast to in-vitro or tissue culture.

State of the Art

An efficient technique for root cuttings from teak with various ages – including flowering, i.e. physiologically mature, individuals (Hackett 1985; Wareing 1987) – was developed from 1992 to 1994 in Sabah, Malaysia, during a joint project between Innoprise Corporation Sdn Bhd and Cirad-Forêt.

Researchers of the project focused on clonal propagation to assess any genotypic influence on adventitious rooting ability. Notwithstanding interclonal variations, average rooting rates of 70 percent were obtained from several thousand cuttings collected from mature genotypes intensively managed as container-grown plants once the mobilization phase – the most critical step (Monteuuis, 1989 and 1993; Monteuuis *et al.*, 1995) – had been successfully carried out. Realistic assessments based on experimental data established that 40 rooted cuttings on average could be produced annually per plant. This corresponds to 600 rooted cuttings per m^2 (fifteen plants per m^2) provided a few basic conditions are fulfilled.

Limiting Factors

Such encouraging results depend on:

(i) suitable nursery facilities as described by Monteuuis *et al.* (1995), consisting mainly of two adjacent shaded areas, i.e.

- one for intensively managing the container-grown plants (Hartmann *et al.*, 1997); and
- a second one equipped with a reliable mist-system (Hartmann *et al.*, 1997) needed for rooting the cuttings and weaning the plants before out-planting.

(ii) efficient mobilization techniques as described in Monteuuis *et al.* (1995), for rejuvenating physiologically the mature genotypes. This is important for improving their adventitious rooting ability and capacity to produce suitable shoots to be successfully rooted.

The ability of teak to be propagated by rooted cuttings varies among different genotypes (Monteuuis *et al.*, 1995), which has also been reported for other species and termed 'interclonal variations' (Monteuuis, 1989). This aspect warrants further investigations based on genetically wider experimental samples, although it seems reasonable to assume that success rates higher than 50 percent can be ultimately obtained for any genotype independent of its age.

(iii) adapted stock plant management to stimulate the production of shoots with the highest potential for adventitious rooting, which can be easily characterized by distinctive morphological traits (Monteuuis 1995; Monteuuis *et al.*, 1995). This must be considered as the determining factor for ensuring good rooting scores, although it does frequently not receive sufficient attention. It requires special care and skills.

IN-VITRO PROPAGATION BY MICROCUTTINGS

The availability of the well-equipped Plant Biotechnology Laboratory within the Innoprise Corporation Sdn Bhd/Cirad-Forêt project prompted us to explore the prospects of propagating teak in tissue culture conditions via miniaturized cuttings or so-called microcuttings.

State of the Art

In principle, the micropropagation technique is similar to propagation by rooted cuttings in the nursery. Thus, shoot production occurs via axillary budding to limit the risks of somaclonal variations with regard to genotypic fidelity (Haines, 1994). Ultimately, microcuttings need to produce adventitious roots to survive and to develop autonomously after the acclimatization phase (Davis *et al.*, 1988).

Simple tissue culture protocols were used to facilitate replication by non-tissue culture specialists, and to improve cost-effectiveness and productivity for large-scale applications. The technology developed (Monteuuis *et al.*, 1998) allows the mass micropropagation in in-vitro conditions of any genotype, either in bulk or clonally, through axillary-produced microshoots with an exponential multiplication rate of three to four at the end of every two months. Once the cultures have reached the stabilization phase (Bonga and Aderkas, 1992) 50 to 60 percent of the microcuttings can root spontaneously on the sole multiplication-elongation culture medium. The rooting-acclimatization phase was achieved in nursery conditions under a mist-system with an average success rate of above 90 percent. Mortality during cultivation in the nursery, before the plants were sufficiently developed for out-planting, was negligible. Based on this procedure more than 100,000 microcuttings (Goh, personal communication) have been produced and have developed into vigorous and true-to-type vegetative offsprings.

Limiting Factors

Micropropagation obviously requires an adequate laboratory incurring considerable fixed and variable costs. Proper nursery facilities including a reliable mist-system are also needed for producing acclimatized plants. Efficient and cost-effective protocols suitable for mass micropropagation must be available. Introduction of appropriate explants, i.e. nodal shoot portions collected from selected outdoor plant material remains, is critical. Otherwise success rates may not exceed 30 percent (Monteuuis *et al.*, 1998).

Finally, staff must be properly trained for laboratory work and management. Attention needs to be paid to precision, cleanliness, rigor and the ability to manipulate miniaturized plant material in conditions free of any contamination.

DISCUSSION

This review has focused on the experiences made during a joint project of Innoprise Corporation Sdn Bhd and Cirad-Forêt. Researchers demonstrated that it is possible to propagate different teak genotypes of various ages by cuttings and microcuttings. Success rates are sufficiently high and compatible for the cost-effective production of planting material on a large scale.

The planting material can be selected according to field criteria, which must definitely override the ability to propagate by rooted cuttings considering that:

- performance in the field or economically significant traits are not necessarily positively correlated with the performance of adventitious rooting. Focusing too much on reproductive traits, such as the potential for adventitious rooting, can reduce the genetic gain regarding wood quality (Haines and Woolaston, 1991).
- capacity for propagation by rooted cuttings can be improved by optimizing exogenous and endogenous parameters, which are liable to interact (Rauter, 1983). Exogenous factors include environmental aspects such as relative humidity of the atmosphere and the rooting substrate, light conditions, temperature, and soil fertility. Endogenous aspects are mainly influenced by the physiological status of the planting material, particularly by the degree of physiological maturation (Monteuuis, 1989). Rooting responsiveness according to the type of cutting (Hartmann *et al.*, 1997; Monteuuis, 1998) is likely to influence the interaction between exogenous and endogenous factors.

This is a fundamental consideration, which must warrant efforts to optimize the efficiency of vegetative propagation techniques that ultimately determines the quality of clonal plantations (Zobel and Talbert, 1984; Timmis, 1985; Ahuja and Libby, 1993 a and b). The relevant success rates indicate that there is scope for improving teak plantations, especially through clonal forestry (see Zobel and Talbert, 1984; Ahuja and Libby, 1993 a and b). The potential benefits of clonal forestry compared to what can be expected from bulk or seed propagation lie in

- the possibility to obtain good rooting rates even for mature genotypes; and
- minimal 'C effects' responsible in many species for depreciation within clone variability (Timmis, 1985).

Adapted propagation protocols for cuttings and microcuttings within the same project allow for a more reliable comparison between these two options. The tissue culture option was conceived in a simpler way than other in-vitro procedures (Mascarenhas and Muralidharan, 1993; Sunitibala Devi *et al.*, 1994) being aware of the advantages of rooting the microshoots produced in-vitro in the nursery (Kaosa-ard *et al.*, 1987; Monteuuis and Bon, 1987; Kaosa-ard and Apavatjrut, 1988). This was done to cope with the economic constraints of large-scale mass production. Micropropagation requires a substantial initial investment for establishing a proper tissue culture laboratory. However, its activities can be easily extended to the use of molecular markers (Bon and Monteuuis, 1996). Such markers can be used for genetic or physiological investigations to increase the efficiency of tree improvement and propagation programs (Monteuuis, 1989; Haines, 1994). Although the amortization period of such a laboratory must not be underestimated, micropropagation does not require, unlike the nursery option, a stock plant orchard. Any orchard needs to be large enough and intensively managed to reach production rates similar to those obtained via the tissue culture venue.

Proper stock plant management is the key factor in teak propagation by rooted cuttings (Monteuuis *et al.*, 1995; Monteuuis *et al.*, 1998). Only a special type of cutting can root satisfactorily, unlike in tissue culture conditions where every mononodal portion of the microshoots can be successfully used. In fact, tissue culture techniques are more efficient for mass propagation than the nursery option where wider spacing and longer time are needed to obtain the same productivity. This is particularly true for mature genotypes whose ability to be propagated by rooted cuttings depends on the efficiency of proper rejuvenation treatments (Hackett, 1985; Wareing, 1987; Monteuuis *et al.*, 1995). Ultimately mass clonal propagation by micropropagation may be more cost-effective than propagation by rooted cuttings in the nursery. In addition, micropropagation allows for:

- gene banks or germplasm storage (Bonga and Aderkas, 1992; Haines, 1994) in much more restricted space than in the traditional conservation stands, whose management is expensive; and
- sending in-vitro plants to different destinations and to expand market prospects considerably.

Based on practical experiences, it seems that the best solution consists in combining an intensively managed nursery with an in-vitro laboratory. Within this scenario, the nursery can be useful

- for preconditioning/securing the plant material to be introduced in-vitro (Bonga and Aderkas, 1992); and
- for rooting, acclimatizing and raising the in-vitro issued microshoots for planting, stump production and sale.

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MANAGEMENT OF IMPORTANT INSECT PESTS IN TEAK PLANTATIONS IN THAILAND

Chaweewan Hutacharern

Teak (*Tectona grandis* L.f.) is the most valuable hardwood species in Thailand. Its plantations are numerous and account for more than two thirds of the forest plantations throughout the country. The large-scale plantations trigger numerous pest problems. Teak serves as a host to many insect pests: 280 species in India (Tewani, 1992), 72 species in Thailand (Hutacharern and Tubtim, 1995) and 28 species in Malaysia (Inthachat, 1997). Only a few of insects cause significant economic losses in Thailand's teak plantations. They include the teak beehole borer (*Xyleutes ceramicus* Walker), the teak canker grub (*Acalolepta cervina* Hope), the red coffee borer (*Zeuzera coffeae* Walker), the teak defoliator (*Hyblaea puera* Cramer) and the teak skeletonizer (*Paliga damastesalis* Walker).

Teak beehole borer only causes serious damage to teak plantation in Northern Thailand. The red coffee borer attacks mostly the succulent shoot of fast growing trees in moist areas. There is also evidence that teak grown beyond the northern part of Thailand is prone to red coffee borer attacks. The teak canker grub, the teak defoliator and the teak skeletonizer are pests throughout the country.

The pests discussed below are divided into two groups: stem borers and defoliators. The insects in each group are often controlled by similar methods. It is crucial to understand the biology of each insect before opting for a particular management program.

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