About the use of clones in teak

An analysis of the advantages of vegetative reproduction for teak plantations : Planting teak calls for having access to and making use of the best available plant material. This article highlights the restrictions inherent to the sexual and vegetative reproduction of this species, by helping to select the best techniques for creating large-scale plantations.

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Teak (*Tectona grandis*) has gained a worldwide reputation on account of the attractiveness and the durability of its wood. Market demand has prompted the establishment of plantations within and beyong its native countries. According to BALL *et al.* (1999), the earliest plantation of teak, apart from Java, has been traced back to 1680, date of its first introduction as an exotic species in Sri Lanka. Teak planting in India began in the 1840s, but main planting activity took off from 1865 onwards, also involving Myanmar and Indonesia. Nigeria was the first country outside Asia where teak was introduced in 1902, followed by Ghana in 1905, then Côte-d'Ivoire in 1929, while its introduction to Tropical America occurred first in Trinidad in 1913, then in Honduras, Panama and Costa Rica between 1927-1929. The reported teak plantation area was estimated at 0.89 million ha in 1970, reaching 1.72 million ha in 1980 and 2.2 millions ha in 1990, of which more than 90 % was situated in Asia (BALL *et al.*, 1999). Despite all these efforts invested in planting activity, teak timber resources currently available are far below the needs of the huge worldwide market demand (BALL *et al.*, 1999).

The venue of the last Teaknet meeting held in 1999 in Chiang Mai (Thailand) offered an opportunity to review the possible limiting factors responsible for this situation. Lack of planting stock, especially of superior quality, was unanimously identified as the primary cause of this deficit in teak timber, highlighting the limits of conventional ways of propagating teak by seeds, and consequently the urgent need to consider other alternatives for increasing the productivity of teak plantations. In this respect, vegetative propagation techniques, especially the clonal option (photo 1), merit special attention in view, on one hand, of the resulting advantages obtained for many species (ZOBEL, TALBERT, 1984 ; AHUJA, LIBBY, 1993), and, on the other hand, of the latest advances in vegetative propagation techniques for teak (GAVINLERTVATANA, 1998 ; GOH, 1999 ; MONTEUUIS, 1999 ; WHITE, GAVINLERTVATANA, 1999).

Photo 1. One year-old monoclonal teak plot in Sabah (East Malaysia, north of Borneo).
Parcelle monoclonale de teck de un an au Sabah (Malaisie orientale, nord de Bornéo).

OPTIONS FOR PRODUCING CLONES OF TEAK

GENERAL CONSIDERATIONS ABOUT CLONING

Cloning is a way of vegetative propagation occurring naturally in different tree species. It has been used for centuries by plant propagators to maintain or "fix", regardless of the successive generations, the superior characteristics of particular genotypes, referred to as cultivars for fruit trees and ornamental plants (HARTMANN *et al.,* 1997). The rationale of cloning forest trees has already been much discussed (ZOBEL, TALBERT, 1984 ; TIMMIS *et al.,* 1987 ; AHUJA, LIBBY, 1993). The main interest lies in the possibility to duplicate, in theory on an indefinite basis, through mitotic cell divisions, selected individuals, while preserving their whole genetic identity and structure. This is a fundamental difference with sexual propagation by seed in which each seedling is genetically different. In terms of plant improvement, cloning allows to capture and transfer to the asexually obtained offspring the integral genetic value – comprising both the additive and the non-additive components – of the selected donor tree (photo 2), also called ortet in forestry, from which they are derived (ZOBEL, TALBERT, 1984). This is of paramount importance in view of obtaining superior quality planting stock, since variations due to non-additive gene effects can exceed 50 % in certain forest tree species, especially affecting major features such as form, vigour, wood characteristics... which are known to be usually under polygenic control and not so well inherited sexually (TIMMIS *et al.,* 1987 ; CHELIAK, ROGERS, 1990).

Various vegetative propagation techniques can be considered for cloning, as described in HARTMANN *et al.* (1997), the success of which depends upon the specific characteristics of the ortet (MONTEUUIS, 1989).

GRAFTING AND BUDDING

With teak, grafting and especially budding with success scores as high as 100 % in Thailand (KAOSA-ARD, 1998), have been the most widely practiced techniques for establishing clonal seed orchards or ex-situ gene banks. This is a low-cost technology applicable to any teak genotype providing basic requisites are fulfilled (HARTMANN *et al.,* 1997).

Grafting or budding give rise to genetically "composite" plants (HARTMANN *et al.,* 1997), made up of the genotype of the rootstock and of the selected genotype of the grafted scion. For this reason, serious consideration must be given to the danger of producing "illegitimates" (BAGCHI *et al.,* 1991). These shoots, which can hardly be distinguished from the expected grafts as they look very much alike, are from the same genetic origin, usually unselected, as the stock they originate from. Their occurrence has been reported as noteworthy in teak, especially in the event of graft failure (BAGCHI *et al.,* 1991). In clonal seed orchards, such "illegitimates" are likely to depreciate the genetic quality of the seeds produced, firstly when collected directly from such unexpected "mothers", and secondly by polluting the genetic quality of the seeds produced by the surrounding "legitimates".

The consequences can be even more serious when such "illegitimates" are used as stock plants for large scale clonal propagation by cuttings for operational planting.

Another aspect associated with grafting or budding is the possible influence of the rootstock on the performances of the graft, for instance growth vigour which warranted for certain species, like apple trees, the adoption of cloned rootstocks in order to have a better control on the architectural development of the grafted cultivar, while improving the within-clone uniformity compared to the seedling rootstock option. This allows plantation density to be increased for improved yield from more accessible trees. Applications of such practices to teak seem worth considering for improving the productivity of clonal seed orchards.

Lastly, grafting can induce additional variability within clones due to the quality of the connection between the stock and the scion.

CLONING PLANTS ON THEIR OWN ROOTS

In view of this, it seems more advisable and safer to produce cloned plants of teak on their own roots which either grow or die, avoiding risks of obtaining illegitimates. The main prerequisite however remains the ability of the selected genotype to produce adventitious roots, which has been observed to decline for teak as for other species with increasing physiological ageing (MONTEUUIS, 1989).

□ Layers

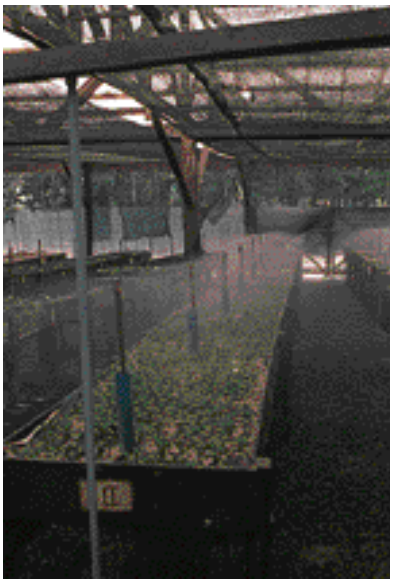
Successful propagation of teak by layering was reported for shoots sprouting from the stump of a 33-year-old felled tree (LAHIRI, 1985). Mound layering gave success rates ranging from 45 % to 81 % depending on the date of the experiment from 5 year-old felled teak trees (MONTEUUIS *et al.,* 1995), but such techniques are practically not adapted to large scale operations.

□ Cuttings

Propagation by rooted cuttings has been proven for many species to be the most practical technique for developing large scale clonal plantations (ZOBEL, TALBERT, 1984 ; AHUJA, LIBBY, 1993). In the same way as for

Photo 2. Candidate Plus Tree (CPT) for cloning.
Arbre « Plus », tête de clone potentielle.

Photo 4. Intensive cultivation of clones produced either by cuttings or microcuttings before planting.
Culture intensive de plants clonés, par bouturage ou par microbouturage, avant la plantation.



3.1. Mist-system for mass propagation by cuttings in nursery conditions.
Bouturage industriel sous brumisation en conditions horticoles.

3.2. *In vitro* micropropagation by microcuttings.
Micropropagation in vitro *par microboutures.*

Photos 3. Availability of efficient mass clonal propagation techniques.
Des techniques industrielles efficaces existent pour le clonage.

other species (MONTEUUIS, 1989), juvenile teak plants have shown a good potential for propagation by rooted cuttings in several countries in contrast to mature selected individuals (WHITE, 1991 ; DUPUY, VERHAEGEN, 1993 ; KJAER *et al.,* 1999). It has recently been demonstrated however that mature teak trees can be cloned by rooted cuttings with average success rates of 70 % obtained from several thousand cuttings tested in operational conditions (MONTEUUIS *et al.,* 1995). It has been concluded from this work that mass clonal propagation of mature teaks by rooted cuttings can be realistically envisaged, providing a few basic requirements are met (MONTEUUIS, 1999). These are principally the availability of a reliable and suitable mist-system (photo 3.1.), and special skills in stock plant management in order to stimulate the production of shoots with a high potential for adventitious rooting. In the conditions described, as an indicative figure, 40 rooted cuttings from mature selected teak genotypes could be produced annually per stock plant, which corresponded to 600 rooted cloned cuttings per square metre (MONTEUUIS *et al.,* 1995). Such scores can be objectively further improved.

□ **Microcuttings**

Several published accounts from various countries have established the possibility of cloning juvenile and also mature teak genotypes by microcuttings in tissue culture conditions at the experimental level (quoted by MONTEUUIS *et al.,* 1998). However, as far as we are aware, such procedures have not been used for large scale production, except in Thailand in the late 1980s for increasing the number of planting stock (KAOSA-ARD, 1998). A private Thai company has been following up this mass micropropagation of juvenile genotypes as a mixture, and referred to as "bulk propagation", for local markets and export, mainly in the form of "stumps" after cultivation of the tissue cultured shoots in local nurseries for several months (GAVINLERTVATANA, 1998 ; WHITE, GAVINLERTVATANA, 1999). These stumps consist of a few adventitious roots and differ in this respect from traditional stumps made of the tap root of the seedling it originates from. More recently, this company has started to micropropagate clones from mature selected trees referred to as "Elite" trees (GAVINLERTVATANA, 1998 ; WHITE, GAVINLERTVATANA, 1999). However, these selected clones are currently (1999) supplied only as a mixture (GAVINLERTVATANA, personal communication). Surprisingly, such superior tissue cultured plant material has been only rarely used in Thailand to date.

A tissue culture technique for clonally mass propagating mature teak genotypes was recently developed in Sabah, Malaysia (MONTEUUIS *et al.,* 1998), complementarily to the nursery technique mentioned above (MONTEUUIS *et al.,* 1995). The *in vitro* protocols were designed to be as simple as possible in order to be easily applicable, even by non-specialists, and to cope with the constraints of large-scale application, that is cost effectiveness, efficiency and high productivity (photo 3.2). Rooting was carried out in nursery conditions under a mist-system with more than 90 % of success rate on average. To date, more than 100,000 microcuttings have been produced through this *in vitro* technology including clones from mature genotypes (GOH, 1999). These microshoots were either sold locally after nursery cultivation until they had reached a stage suitable for field-planting (photo 4), or dispatched, after proper conditioning and under phytosanitary immunity, to overseas users for further acclimatization and cultivation.

RESEARCH USES

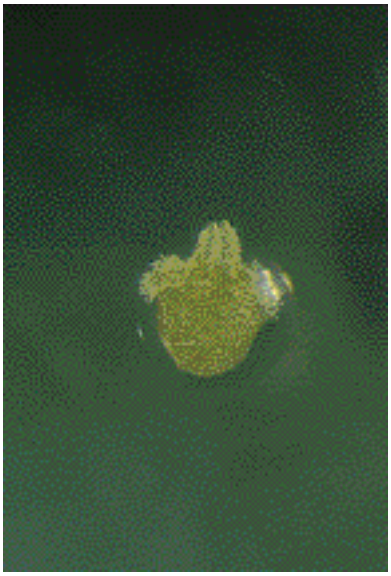
Availability of teak clones on their own roots must be objectively considered as a very valuable tool for improving our knowledge about teak, particularly in the field of genetics, without the experimental bias associated with grafted plants, as discussed earlier. Various kinds of information can be expected from the use of clones, ranging from basic to more applied levels (ZOBEL, TALBERT, 1984 ; AHUJA, LIBBY, 1993). Research areas of determining importance for the prospects of clonal plantations are worth particular attention.

WITHIN-CLONE VARIABILITY

One of the prime interests of using clones lies in the expected uniformity of all the characters among the clonal offspring issuing from the same original ortet genotype with the same genetic make-up (ZOBEL, TALBERT, 1984 ; AHUJA, LIBBY, 1993). This is of paramount importance in teak considering the high variability of many traits existing among seedlings, even when these latter are genetically related – half-sibs (DUPUY, VERHAEGEN, 1993).

Availability of clones allows rigorous assessment of the influence of various parameters on different characters in the absence of any unexpected genotypic interference as faced when using seedlings as experimental material (KJAER, FOSTER, 1996).

The capacity of rooted cuttings to develop ontogenetically "true-to-type" (TIMMIS *et al.,* 1987 ; MONTEUUIS, 1989) seems to be obviously the first area of investigation to concentrate on, starting with the ability to produce adventitious roots. Such studies involve endogenous and exogenous parameters likely to interact. In the absence of



5.1. Meristem after two weeks of *in vitro* culture on the initiation medium.
Méristéme à l'issue de deux semaines de culture in vitro *sur un milieu d'initiation.*

5.2. Mericlonal block three months after planting.
Bloc de plants mériclonaux trois mois après la plantation.

5.3 and 5.4. Mericlonal plants 18 months after planting.
Plants mériclonaux un an et demi après la plantation.

Photos 5. Production of "mericlones", each derived from a single shoot apical meristem of 0.2 mm in size introduced into tissue culture conditions.
Production de « mériclones » chacun provenant de la culture in vitro *d'un méristème apical de 0,2 mm.*

genotypic variability, the physiological aspects are logically assumed to play a key role in any deviation from the type observed, notwithstanding the influence of environmental parameters (MONTEUUIS, 1989). The possibility of producing by adapted *in vitro* techniques (MONTEUUIS in preparation) "mericlonal lines", each issuing from one single meristem excised from the cloned plants, offers the opportunity to investigate at a more advanced level the possible sources of within-clone variability (photos 5).

Photo 6. Intercropping teak and oil-palm : a need for long clear bole and narrow crown teak clones.
Cultures associées de teck et de palmier à huile. Il convient de disposer de clones de teck caractérisés par de longs fûts et des houppiers étroits.

In addition to these studies on cloning ability with regard to true-to-type development, within-clone variability investigations can be linked to many traits, incuding those of major economical incidence such as growth rate, trunk form, wood characteristics. Improving within-clone uniformity will reduce "C effects" (TIMMIS *et al.*, 1987) for more accurate genetic parameter estimates (KAOSA-ARD, 1998), with particular mention for broad sense heritability (AHUJA, LIBBY, 1993).

BETWEEN-CLONE DIFFERENCES

Teak can thrive in a wide range of ecological conditions (WHITE, 1991 ; BALL *et al.*, 1999), notwithstanding however significant provenance effects on several major traits (KAOSA-ARD *et al.*, 1998). Noteworthy within-provenance genetic variation can already be assumed from limited and young progeny or even newly established clonal trials (KJAER *et al.*, 1999). As for other species, between-clone differences, also referred to as inter-clonal differences (MONTEUUIS, 1989), may be observed during the clonal propagation process, which may require to adapt the propagation methods to reluctant genotypes. It is indeed hardly acceptable that capacity for clonal propagation by rooted cutting, which is practically liable to improvement, overrides selection based on field criteria of major economic significance. Experience has demonstrated that these interclonal differences of responsiveness to true-to-type cloning by rooted cuttings – or microcuttings – was mainly due to unadapted techniques, especially when starting from mature genotypes for which efficient physiological rejuvenation must be considered as a determining prerequisite (MONTEUUIS, 1989). Use of clones may help in optimizing true-to-type cloning techniques by focussing on physiological aspects.

Bearing this in mind, the possibility of obtaining uniform clones from any teak genotype in the absence of depreciating "C effects" must be objectively considered as a valuable opportunity to further investigate the extent to which these teak genotypes can be adapted to various environmental conditions. Such genotype × site interactions can be examined with respect to different characters, especially those of economical importance with a view to clonal plantations. These encompass architectural growth patterns that can be useful for optimizing planting density and spacing according to the clones established either in the form of monoclonal blocks or as mixed plantations (photo 6), such as intercropping with seedlings or other crops in the case of agroforestry systems, as developed for instance in Malaysia for oil palm (TEE *et al.*, 1995), in Vietnam for cashew and in Costa Rica for coffee and cocoa (BALL *et al.*, 1999). Access to this kind of information can be used for growth modeling and associated economic simulations on a more accurate and reliable basis than when working with seedlings. Clonal resistance to pests, stem borers and especially defoliators is also worth investigating, in relation to the environment owing to the considerable damage they may cause to large scale clonal plantations. The influence of the environment on different aspects of sexual reproduction deserves special consideration in relation to seedling production and its decisive impact on breeding strategies, as well as the attainment of the flowering state upon which clear bole length in teak depends (KAOSA-ARD, 1998). Lastly, resort to tissue culture clonal propagation will allow the dispatch of clones to various destinations and the setting-up of intercontinental clonal tests for a better assessment of genotypic adaptability.

GENETIC PARAMETER ESTIMATES

Using clones, especially on their own roots will greatly help geneticists to determine genetic parameters (ZOBEL, TALBERT, 1984 ; AHUJA, LIBBY, 1993), particularly broad sense heritabilities for economically important traits, considering the uncertainties of the heritability studies carried out so far with grafted clones or seedlings (HARSHAP, SORIANEGARA, 1977 ; GOGATE *et al.*, 1997). Genetic correlations among traits, or between juvenile and mature manifestations of the same characteristics, especially for wood characteristics, as well as the magnitude of "C effects", are also very useful information for adopting reliable tree improvement strategies, considering the urgent need for improved quality, higher productivity and shorter rotation plantations.

OPERATIONAL USES

In addition to their interest for research activities, teak clones can be profitably used for planting activities, basically through the production of improved quality seeds from clonal seed orchards, or of rooted cuttings for operational planting.

CLONAL SEED ORCHARDS

Clonal orchards of teak have been set up in many countries with the aim of producing as many genetically improved quality seeds as possible (KAOSA-ARD, 1998). The seed producers used have been thus far clonally propagated mainly by bud grafting, despite noticeable risks of illegitimate occurrences which may induce a noticeable depreciation of the genetic value of the seeds produced from these orchards, as developed above. Propagation of clones on their own root system will avoid such risks of obtaining illegitimates, which must not be underestimated in teak (BAGCHI *et al.*, 1991).

Besides this aspect, teak clonal seed orchards seem far from fulfilling the expectations of tree breeders, and more particularly of teak plantation managers (WHITE, GAVINLERTVATANA, 1999). The time required for reliable selection of clones with a good combining ability for characters of major economical value remains a serious impediment, in spite of alternative solutions for shortening the delays (KJAER *et al.*, 1999). For instance, improving clear bole length consists in deferring the attainment of the flowering stage ; in other words, it results in lengthening generation intervals. Low overall seed productivity from seed orchards, especially those established in Asian countries, remains a serious handicap (KJAER *et al.*, 1999). In Thailand for instance, 1 ha of clonal seed orchard can establish only 16 ha of plantations annually (KAOSA-ARD, 1991 ; quoted by KJAER, FOSTER, 1996). This is less than the quantity of seeds produced from natural stands and might be due to the fact that the clones are issued from "Plus" tree selection only, then established in different regions where environmental conditions are not optimal for seed formation (KAOSA-ARD *et al.*, 1998).

CLONAL WOOD PRODUCTION PLANTATIONS

□ Rationale

The rationale for developing clonal plantations of teak for wood production has been recognized several times (WELLENDORF, KAOSA-ARD, 1988). This is achievable today considering the possibility of clonally mass producing any selected teak genotype by cuttings (MONTEUUIS *et al.*, 1995) or microcuttings (MONTEUUIS *et al.*, 1998) with sufficiently high success rates to be compatible with large scale production in cost effective conditions. The availability of such vegetative propagation techniques is indeed a helpful solution for overcoming problems of lack of planting stock from seeds (KJAER *et al.*, 1999 ; WHITE, GAVINLERTVATANA, 1999), highlighting the superiority of cloning over the bulk option and being aware of the respective advantages and disadvantages of nursery and tissue culture techniques (MONTEUUIS, 1999).

In addition to these quantitative arguments, propagation by cuttings or microcuttings will ensure the production of clonal offspring of the same genetic quality as the original selected ortet they derived from. In contrast, the genetic superiority of plants obtained from seeds is more uncertain despite the severe space and time restrictions associated with conventional breeding programs as proposed by WELLENDORF and KAOSA-ARD (1988) and KAOSA-ARD (1998). From KJAER and FOSTER's assumptions (1996), it will take at least 50 to 70 years before genetically improved teak plantations can be harvested, without specifying the relevant gain. KJAER *et al.* recently (1999) further stressed the fact that such breeding strategies will remain greatly penalized by low seedling productivity. These aspects have been recently developed by WHITE and GAVINLERTVATANA (1999) who concluded that the "seedling route" "is outdated and actually represents a deterrent to wide scale increased productivity in teak plantations", and as such to commercial teak plantation investment. This unvarnished statement is based on practical data and reliable information gathered from long experience in teak genetic improvement by conventional methods. According to these authors, the magnitude of the real genetic gain associated with the seedling route has yet to be

clearly defined, and the basic question of knowing whether all the efforts made over the past decades have been worthwhile remains... This is undoubtedly a major concern for potential investors, for whom a rapid pay-off is a decisive argument. Practical and theoretical information supports the view that for teak greater genetic gain can be expected from the clonal forestry option than from seedling forestry, as demonstrated for other species (ZOBEL, TALBERT, 1984 ; TIMMIS *et al.*, 1987 ; AHUJA, LIBBY, 1993). The fact that major private companies have developed industrial plantations from selected clones (AHUJA and LIBBY, 1993) rather than from seedlings is a meaningful illustration of this.

Increased yield, higher uniformity for economically important traits and shorter rotations are all strong incentives for developing teak clonal plantations without much detrimental incidence on the quality of the end-use product (BATH, 1999). Properly selected and wisely deployed clones will thus maximize short-term returns from suitable planting sites, which are dramatically shrinking in surface area (BALL *et al.*, 1999). Utilization of clones can be profitably adapted to intercropping after proper selection, on crown form especially. Planting density and silvicultural practices must be defined accordingly, in the same way as for intensive management systems consisting in harvesting several times from the same stumps, taking advantage of the specific coppicing ability (MARTIN *et al.*, 1999). Such practices look very attractive for enhancing plantation yield similarly to the "ligniculture" systems considered for other species (TOUZET, 1981 ; MARTIN *et al.*, 1999), while significantly reducing planting and (micro)cutting costs. As regards these financial aspects, it has to be emphasized that clonal plantations generally require less planting stock than plantations established from seedlings, which compensates, at least to a certain extent, for the higher cost of (micro)cuttings.

□ Requisites

There is still a basic lack of reliable and concrete data on the practical use of teak clones which are highly needed before safely deploying clonal plantations as recommended by WELLENDORF and KAOSA-ARD (1988), being aware of the risks associated with clonal forestry (ZOBEL, TALBERT, 1984).

Firstly, the quality of the adventitious root system formed from cuttings must be seriously examined. In certain conditions, teak cuttings are prone to callus formation which may hinder the development of vigorous roots emerging directly from the shoot for a better vascular connection (HARTMANN *et al.*, 1997). Ultimately, the success of the plantations established from cuttings will depend on the capacity of the adventitious root system to ensure good anchorage to the soil, in other words, good plant stability, as well as a good physiological status compared to seedlings which have a tap root. This is a fundamental difference between embryogenesis- and organogenesis-issued plants (CHELIAK, ROGERS, 1990 ; HARTMANN *et al.*, 1997). Such root quality investigations are also applicable to microcuttings which in our case were rooted *ex-vitro* to produce roots physiologically more functional and more adaptable to natural conditions than those developed *in vitro* in agar (MONTEUUIS *et al.*, 1998).

In the same way as highlighted for other species (ZOBEL, TALBERT, 1984 ; AHUJA, LIBBY, 1993), the genetic uniformity of teak clonal plantations must be considered a major concern especially with regard to the following aspects :

· Clonal susceptibility to pests.

· Proper clone × site matching with regard to traits of major importance.

· Number and genetic relatedness of the clones used, which can be safely established as a space-time mosaic of monoclonal plantings (ZOBEL, TALBERT, 1984 ; WELLENDORF, KAOSA-ARD, 1988).

CONCLUSION

There is currently a basic deficit in teak timber resources while suitable planting sites are diminishing. The recent teaknet meeting held in Chang Mai (Thailand) in 1999 highlighted the need to develop more productive teak plantations than most of those established so far by conventional ways which seem to have reached certain limits in this respect. This should warrant the development of alternative options with particular emphasis on clonal plantations considering the potential gain which can be expected with reference to other species. Recent advances in clonal propagation technologies are strong incentives for intensifying actions along these lines, for which most of the information available so far is mainly speculative. Reliable knowledge and guidelines are urgently needed from practical clonal experiments before scaling up the process to clonal plantations for better teak resources management, taking into consideration the commercial as well as the biodiversity issues. ❑

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RÉSUMÉ

À PROPOS DE L'UTILISATION DE CLONES CHEZ LE TECK

Les ressources actuelles en bois de teck sont très insuffisantes pour satisfaire l'importante demande sur le plan mondial, en dépit des plantations réalisées plus ou moins récemment dans de nombreux pays tropicaux. La raréfaction des terrains adaptés à l'espèce constitue un argument supplémentaire en faveur d'une gestion plus intensive des plantations par rapport aux systèmes traditionnels en vigueur, fondés sur l'utilisation de semis. Dans ce contexte, l'intérêt du clonage mérite d'être considéré à plusieurs titres. Pour le clonage des génotypes de teck, diverses techniques de propagation végétative sont disponibles, grâce à la mise au point récente de protocoles qui permettent la production industrielle de clones par bouturage ou par microbouturage. Par ailleurs, la multiplication de clones « francs de pied » peut être mise à profit pour enrichir les connaissances sur l'espèce, notamment en génétique dont l'intérêt pour les plantations est manifeste. Ces nouvelles techniques de propagation clonale peuvent s'appliquer directement aux plantations, par exemple pour la mise en place de vergers à graines clonaux, dont l'identité génotypique est plus sûre que celle des vergers issus de greffage. Cependant, les problèmes liés à la qualité des graines produites et à leur quantité insuffisante ne sont pas encore solutionnés. La mise à profit de ces techniques dans le but de développer des plantations clonales industrielles pour la production de bois intéresse vivement les investisseurs. Les apports des progrès technologiques et l'utilité des informations leur paraissent évidents pour une meilleure valorisation du bois dans un contexte commercial très incitatif. Néanmoins, actuellement, l'essor de ces plantations clonales est encore freiné par la rareté des informations disponibles sur le plan expérimental.

Mots-clés : *Tectona grandis*. Clones. Plantations. Amélioration génétique.

ABSTRACT

ABOUT THE USE OF CLONES IN TEAK

Despite the more or less recent establishment of teak plantations in numerous tropical countries, there is currently a serious deficit in teak timber resources available to fulfill huge worldwide demand. The diminution of suitable planting areas is an additional incentive for developing noticeably more productive teak plantations than what has been done so far based on the use of planting material traditionally produced by seeds. In this respect, prospects associated with the use of teak clones is, objectively speaking, worth considering. There are several options for cloning teak genotypes, with special mention for the recent development of efficient mass clonal propagation methods by cuttings or microcuttings. Production of clones on their own roots can be used for research purposes aimed at improving our knowledge on teak, more particularly in the field of genetics with beneficial outcomes for the plantations. Such clonal propagation techniques can also be used at the operational level, for establishing for instance clonal seed orchards in safer conditions than by grafting or budding, despite the severe limitations as regards the quality and quantity of the seeds produced. Another alternative consists in developing clonal wood production plantations of improved yields, shorter rotations and homogenous quality. This option appears very attractive from the point of view of many investors, especially when considering the technological advances and findings for maximizing returns on the one hand, and commercial challenges on the other. More reliable data are still needed however at the experimental level before developing large scale clonal plantations of teak on a sound basis.

Key words : *Tectona grandis*. Clones. Plantations. Tree improvement.

RESUMEN

A PROPOSITA DE LA UTILIZACIÓN DE CLONES EN LA TECA

A pesar de las plantaciones de teca, más o menos recientes, acometidas en numerosos países tropicales, los recursos actualmente disponibles de madera de teca son ampliamente insuficientes para satisfacer la importante demanda mundial. El enrarecimiento de terrenos adaptados a esta especie es un argumento más a favor de la necesidad de intensificar la gestión de las plantaciones respecto de los sistemas tradicionales, todavía vigentes, basados en la utilización de semilleros. En este contexto, merece la pena considerar de forma objetiva el interés, en distintos niveles, de la clonación. Para la clonación de genotipos de teca, se pueden examinar varias técnicas de propagación vegetativa teniendo en cuenta las nuevas perspectivas posibilitadas por el reciente establecimiento de convenciones que permiten la producción industrial de clones de teca mediante estaquillado o microesquejado. La multiplicación de clones « francos de pie » puede aprovecharse para incrementar nuestros conocimientos sobre la especie, especialmente en el campo de la genética que presenta un evidente interés para las plantaciones. Estas nuevas técnicas de propagación clonal pueden emplearse también en las plantaciones, por ejemplo, mediante la creación de huertos clonales de simientes, que son más seguros en lo relativo a la identidad genotípica que los procedentes de injertos, pero que no por ello solucionan los problemas relacionados con la calidad de semillas producidas en número insuficiente. El aprovechamiento de estas técnicas en el desarrollo de plantaciones clonales industriales para la producción de madera suscita el interés de los inversores, conscientes de la importancia de los progresos tecnológicos y de las informaciones útiles para valorizar lo mejor posible esta madera en un contexto comercial en pleno desarrollo. No obstante, la expansión de estas plantaciones clonales se halla actualmente penalizada por la escasez de información disponible a escala experimental.

Palabras clave : *Tectona grandis*. Clones. Plantaciones. Mejoramiento genético.

SYNOPSIS

A PROPOS DE L'UTILISATION DE CLONES CHEZ LE TECK

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L'ensemble des plantations de teck – estimées à 2,2 millions d'hectares en 1990, dont 90 % se trouvent sur le continent asiatique – ne parvient pas à satisfaire l'importante demande de bois sur le plan mondial. De plus, la disponibilité en plants de qualité demeure bien inférieure aux besoins pour accroître les plantations et incitent au recours à la multiplication végétative. Plus particulièrement, la multiplication clonale devrait pallier les insuffisances liées à la production traditionnnelle de plants à partir de graines.

POSSIBILITÉ DE PRODUIRE DES CLONES DE TECK

L'intérêt fondamental du clonage réside dans la possibilité de régénérer, théoriquement à l'infini, des plants de même constitution génétique que la « tête de clone » (ortet) sélectionnée initialement. L'ensemble des caractéristiques originelles, normalement préservé au fil des générations successives de progagation clonale, garantit une meilleure valeur commerciale.

Différentes techniques de clonage sont possibles pour le teck, à commencer par le greffage qui est utilisé depuis longtemps pour mettre en place des vergers à graines de clones. Cependant, à cause des rejets de greffe, des risques existent d'obtenir des « illégitimes ». En revanche, la production de plants sur leurs propres racines, ou « francs de pieds », permet, entre autres avantages, de remédier à ce problème. Bien que le marcottage soit possible à partir de matériel âgé, la production en masse de matériel cloné à des fins de reboisement n'est possible, en réalité, qu'à partir de boutures ou de microboutures. Récemment, dans des conditions pilotes de propagation clonale industrielle, au Sabah, cent mille microboutures ont été produites *in vitro* et acclimatées avec plus de 90 % de succès.

INTÉRÊT POUR LA RECHERCHE

Comme c'est déjà le cas pour de nombreuses autres espèces, disposer de clones de tecks « francs de pieds » pourrait être très utile pour approfondir les connaissances sur cette espèce, jusqu'au génotype, de manière plus fiable qu'à partir de plants greffés. La variabilité intra-clonale devrait renseigner sur les potentialités de clonage conforme de l'espèce, en fonction de l'âge et de l'origine génétique des ortets d'origine, par comparaison aux populations issues de semis, éventuellement demi-frères, voire plein-frères.

La comparaison de plusieurs clones dans différents sites devrait permettre de cerner les interactions clones x environnement et de mieux sélectionner les clones en fonction de leur développement sur divers terrains de plantation. La sélection pourrait également porter sur le développement du couvert végétal, en vue d'une association avec d'autres plantes (plantations mixtes).

Enfin, l'utilisation de clones peut servir à évaluer un grand nombre de paramètres génétiques, telle que l'héritabilité (au sens large), notamment pour les critères ayant des répercussions économiques majeures.

INTÉRÊT POUR LES PLANTATIONS INDUSTRIELLES

Le clonage du teck peut être justifié dans le cas d'une production massive de plants de qualité génétique élevée, sous la forme de semis issus de vergers à graines clonaux, ou sous la forme de boutures ou de microboutures clonées.

La première option, privilégiée jusqu'à ce jour, est globalement et fréquemment décevante, du moins pour satisfaire les attentes des investisseurs privés qui sont intéressés par des plantations de qualité, hautement productives et exploitables le plus tôt possible.

Etant donné cette situation et l'enjeu économique, les plantations industrielles clonales paraissent plus attractives, surtout lorsque l'on se réfère au succès obtenu avec d'autres espèces forestières. La raréfaction des terrains disponibles pour le teck, les résultats des analyses technologiques du bois, les possibilités offertes par les nouvelles technologies de clonage et de valorisation du bois sont autant d'incitations à intensifier la culture du teck. De nombreuses informations sont attendues sur le plan expérimental qui devraient permettre d'établir sur de nouvelles bases des plantations susceptibles de répondre à la forte demande internationale, tout en garantissant une bonne gestion des ressources génétiques de l'espèce.