PLANT IMPROVEMENT & SEED PRODUCTION

PROJECT

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Steering Committee Meeting n° 9

(March 1998)

ICSB / CIRAD-Forêt

INTRODUCTION

The PISP Project was started in 1989 after the signing of the first Memorandum of Understanding between ICSB and CIRAD-Forêt. In 1997, PISP has entered the third phase of the collaboration after the expiry of the second phase (July 1992 to July 1997). The objectives of PISP are as follow:

Short term objectives

1. To develop a plant improvement strategy of rattans, high-value timber species, and industrial timber species

2. To develop a seed/planting material production programme for rattans, high-value timber species, and industrial timber species to meet the seed and other planting material requirements of ICSB

3. To develop the technical capability in plant improvement and seed/other planting material production of ICSB

Long term objectives

4. To develop commercial seed production stands/orchards, on a joint venture basis, to meet the seed/other planting material requirements of state, national or international institutions

5. To improve the technical capability at LFC to the level necessary to

   - be consistent with ICSB's objective of LFC into a centre of excellence for tropical forestry management, development and research, and

   - enable ICSB/CIRAD-Forêt to undertake expertise in the relevant fields if the opportunities arise.

Personnel

The French volunteer scientist, Philippe Pajon ended his term at the end of May 1997 after serving with PISP for 14 months. The replacement was first scheduled to arrive in December 1997, but was later postponed to April 1998. Charles Garcia (PISP's Team Leader for ICSB) was transferred to the Luasong Forestry Centre (LFC) Project to act as Project Manager taking effect from 1st July. David Alloysius took up the PISP co-leadership. Rukiah Kadir (Laboratory Assistant) was also transferred to the LFC Project from 1st August, to take up clerical work. Three permanent staffs (Arbani Mamang, Jumansah Selamat and Yapdi Tajab) were promoted from Forest Labourers to Forest Rangers. The staff line-up as end of February 1998 was as follows:

Position	ICSB	CIRAD-Forêt
Senior Scientist	1	1
Research Officer	1	
Senior Forest Ranger	1	
Forest Ranger	4	
Casual labourer	34	
TOTAL	41	1

One Senior Forest Ranger and 5 casual labourers are currently placed in Taliwas, Lahad Datu.

Summary of the research activities on rattan and trees

To facilitate the review of the PISP's programme, a summary list of the activities carried out by PISP during the period 1995-1997 is reported in Appendix 1. The total planted experimental area for the genetic improvement programme for rattans sums up to 22.4 ha, while the area for rattan silviculture covers some 9.7 ha. For trees the experimental area is 59.0 ha.

1. RATTANS

1.1 Genetic Improvement

1.1.1 Establishment of field trials

Progeny trial/resource stand

There was no seed collection activity in 1997. Some new trials were established at the end of 1997 to transfer material collected in 1996 to the field. As usual, the progeny trials were established with seedlots, germinated at the same time, to enable the comparison of performances between families; resource stands were established with planting materials (seedlings or saplings) of different ages. Summaries of the trials are reported species by species in Appendices 2 to 5.

Table 1. Rattan trials established in 1997

Species	Type of planting	Plot number	No. of progeny	No. of seedling	Planted date
Calamus ornatus	Progeny trial	COB2	30	270	Dec 1997
C. subinermis	Resource stand	R6	11	227	Dec 1997
C. manan	Resource stand	R7	2	120	Dec 1997
C. optimus	Resource stand	R2	5	150	Dec 1997

Living collection

Two additional species were planted in the Luasong's Wild Rattan Conservation Area, the area where species with less or no commercial value are planted. The total number of species as end of February 1998 is 23.

Table 2. Rattan species planted in Wild Rattan Conservation Area in 1997

Species	Origin	No. of seedling	Planted date
Daemonorops sparsiflora	Ranau	20	July 1997
D. microstachys	Pulau Sebatik	5	July 1997

1.1.2 Assessment of established trials

The rattan annual growth assessment for 1997 was delayed due to some other work that was considered at higher priority such as the establishment of Teak trials, that needed to be completed in time. Nevertheless some trials that have been analysed are presented hereafter.

Calamus manan

As in the previous years' assessments, no difference were detected between the progenies. One of the interesting facts about all the trials is the large range of variation in growth within progenies. Some progenies, for instance, has a range of height between 0.5m to 20m and about half of them possessed a height of less than 5m. This reflects that more than half of the population is still at the rosette stage, an early development phase where almost no stem length is expected. Some of the individuals have outstanding growth, pushing the average height of the current assessment almost to the double as compared to the last year's assessment (1996's assessment: CMB1=3.8m, CMB2=6.5m, CMB3=5.9m). The most likely source of growth variation is the shade and competition heterogeneity in the logged-over forest where the trials were established. Shade adjustments were carried out almost yearly, however to create homogeneous open conditions in the forest is very difficult if not impossible.

2

Table 3: Mean height and survival percentage of *C. manan* trials

Trial no.	No. of Progeny	Age (yr)	Mean height (m)	Survival (%)
Progeny 1 (CMB1)	5	6.0	7.5 (5.3)	90.0
Progeny 2 (CMB2)	4	6.0	11.5 (6.9)	89.4
Progeny 3 (CMB3)	3	6.0	10.2 (5.7)	89.0

Note: Value in parenthesis indicates standard deviation

Calamus subinermis

The *C. subinermis* trials registered a very slow growth, with a mean annual increment (HMAI) in height of less than 1 m/yr. Under optimal growing condition, *C. subinermis* could grow as fast as 5 m/yr at age of 4 years. The most likely explanation may be the same than for *C. manan*, i.e. excessive shade and competition in the forest. Some excess seedlings of the trials were planted near PISP office at almost the same time, and they have a growths of more than 5 m/yr just after 4 years. The area near the PISP office is relatively open compare to the inside of the forest.

A preliminary analysis of the *C. subinermis* trials showed that there was a family effect for the number of suckers per clumps. This results will be reported later on, once the analysis is completed.

Table 4: Mean height, mean sucker and survival percentage of *C. subinermis* trials

Trial no.	No. of Progeny	Age (yr)	Mean height (m)	Mean sucker	Survival (%)
Progeny 1 (CSB1)	5	6.6	3.5 (3.3)	1.32 (0.62)	66.7
Progeny 2 (CSB2)	3	6.6	7.1 (5.4)	1.77 (1.30)	87.3
Progeny 3 (CSB3)	6	6.6	1.6 (1.9)	1.35 (0.83)	70.0
Progeny 4 (CSB4)	5	6.2	2.5 (3.1)	1.24 (0.66)	91.3
Progeny 5 (CSB5)	14	5.0	2.2 (2.7)	1.36 (0.83)	87.9
Provenan. 1 (CSC1)	6	7.2	10.9 (8.3)	1.46 (1.15)	82.4

Note: Value in parenthesis indicates standard deviation

Calamus caesius

The analysis of the seven *C. caesius* progeny trials presented last year has been finalised and will be soon presented for publication on a scientific journal.

1.1.3 Reproductive biology of rattans

Control pollination of *Calamus manan*

First attempt of control pollination (CP) in *C. manan* has been made in March 1996. However the experiment was terminated due to the destruction of the flowers under observation because of fallen tree branches. In January 1997, another experiment was initiated in order to conclude the previous experiment. The objectives of the current experiment were:

i. To develop a CP technique for *C. manan*
ii. To evaluate the suitability of different type of materials as pollination bag
iii. To test simple pollen storing methods in CP of *C. manan*.

The experiment has been installed in a 7 year-old *C. manan* plantation at LFC. Due to lack of resources, only one female plant and one male plant were put under observation. Both plants had already flowered several times when this experiment was started. The female plant had 5 inflorescences. Three types of pollination bags (PB) were tested:

i. Cotton cloth bag – Home-made PB using white cotton material with a mesh size of 50μm. The size of this PB was 20 cm x 50 cm.
ii. Cotton liner bag – Home-made PB using normal cotton liner with a mesh size of 0.5 mm. The size of this PB was 20 cm x 50 cm.
iii. Clear plastic bag - Commercial clear plastic bag of 12" x 15" in size.

Pollen used for this CP experiment were either fresh (collected and used within 30 minutes) or stored for 22 hours at 4°C inside close-tinted glass bottles.

Nine partial inflorescences were selected within the five inflorescences on the female plant. Nine PB were also prepared to cover the selected partial inflorescences, and the PB were numbered as PB1 to PB9. The allocation of the treatments were as follows:

Table 5. Correspondence PB to treatments

PB material	Fresh pollen	Stored pollen	No pollen (control)
Cloth	PB1	PB2	PB9
Liner	PB4	PB3	PB7
Plastic	PB5, PB6	Not available	PB8

All PB were installed about a week before the opening of the pistillate flowers. Hand pollination was done when flowers were at the anthesis stage for both of the plants. The sequence of the CP could be summarized as follows:

Opening of the PB
Transfer of pollen onto the stigma by using cotton buds
Re-installation of the PB after the hand-pollination
Count of the number of pollinated flower buds inside the PB.

For the control (PB7, PB8, PB9) all the steps were undertaken but no pollen was transferred into the stigma.

All the PBs were removed permanently from the partial inflorescence when the stigmas were brownish which indicated that flowers were not receptive any more. About one month after the removal of the PB, a count of the number of developed fruits on the hand-pollinated partial inflorescences was started. Since *C. manan* fruits need about 16 months (64 weeks) to reach maturity, as far as mid-1998 this experiment is yet to be completed. The preliminary results at the time of the writing of this report are presented in Table 6.

Table 6. Preliminary result of on going CP experiment of *C. manan*

PB no.	PB material	Pollen type	No. of Pollinated flower	No. of fruits after 5 weeks	No. of fruits after 15 weeks	No. of fruits after 26 weeks
PB1	Cloth	Fresh	298	23 (7.7)	16 (5.4)	12 (4.0)
PB2	Cloth	Stored	129	30 (23.3)	5 (3.9)	0
PB3	Liner	Stored	203	41 (20.2)	22 (10.8)	16 (7.9)
PB4	Liner	Fresh	93	13 (14.0)	2 (2.2)	0
PB5	Plastic	Fresh	111	1 (0.9)	0	0
PB6	Plastic	Fresh	31	12 (38.7)	0	0
PB7	Liner	No pollen	240	38 (15.3)	2 (0.8)	0
PB8	Plastic	No pollen	263	16 (6.1)	0	0
PB9	Cloth	No pollen	225	65 (28.9)	0	0

Note: Value in parenthesis indicates percentages

Some preliminary conclusions derived from this early result are:

i. Hand pollination is possible for *C. manan*
ii. Stored pollen at 4°C for 22 hours could be used for pollination of *C. manan*.
iii. Plastic is not a good material for the pollination bag.

1.2 Silviculture

1.2.1 Nursery

Two principal experiments for rattans have been established in the PISP's nursery in 1996. In 1997, btoh these trials have been measured for the second and last time and then concluded.

Fertiliser and soil components

The first experiment (Appendix 9) studied the effect of different fertilisers and soil components at the nursery stage. The fertilisers were: NPK and Agroblen at two dosages (5 and 10 grams/plant); the soil treatments included 4 dosages of sands and compost in addition to the top soil. The design was a two-factors RBC with three repetitions. The experiment clearly indicated that 5 grams of Agroblen added to a top soil was the best treatment for all the species tested (*C. manan*, *C. subinermis*, *C. ornatus*). The other treatments gave a higher mortality or a slower growth. Agroblen, even if more expensive than NPK, allows to save the manpower needed for the monthly application required from the latter. Because the watering regime in the main nursery is more difficult to control than in the PISP nursery, we still advice the addition of a low portion of sand (10%) to the top soil. This will allow to avoid the compaction and subsequent breakage of the polybags in case of a low watering, and drainage in case of excessive watering.

Light

The second experiment (Appendix 10) dealt with the shade requirements of four species: *C. ornatus*, *C. merrillii*, *C. manan* and *C. subinermis*. The experiment clearly indicated that three of the species (batu, lasun and palasan, prefer high light intensities of around 70% (that means a Sarlon net giving 30% of shade). Conversely, at higher intensities manau suffered more mortality and grew more slowly. For this species is better to use a Sarlon net at 70% of shade, at least for the first 13 motnhs in the nursery. This experiment also gave obvious hints on the different ecological requirement of these species.

Others

Other minor experiments concerned the observation of the growth of rattans in sub-optimal conditions (i.e. large polybags, abundant fertiliser and care). The stem length, diameter, number of suckers per plant and the number of leaves have been recorded every three months. The preliminary report on this study has been published in the Steering Committee Report of the last year. Late 1997, we transferred some of these plants to the field, and we are keeping them under constant observation. This experiment will allow to know the plastochrone, the correlation among this, the diameter, the length and the number of suckers, and the dynamics of growth (in particular the exit of the rosette stage) under sub-optimal conditions. One of the first results was that the polybag size plays an enormous role on the rattan development. This prompted us to implement further research on the nursery techniques and plant preparation for plantation (see below).

1.2.2 Plantation

Age (and size) of the plants at plantation

This experiment (Appendix 11) started in 1996, with the objective to find the optimal age (and consequently size) of the plant at plantation. The species studied was *C. caesius*, of which a large number of overgrown seedlings was available in the nursery. The experiment was planted by the conventional line planting under a quite open logged-over dipterocarp forest. The main result of the study was that what we previously considered as "overgrown" seedlings (i.e. with a stem height of around 1 meter and an age of more than 16 months) can in fact perform well in the field. The soft and slender stem did not suffer particular pest attacks or breakages. Probably the main reason of the success of the 20 months-old plants

(average height just below one meter) was that these plants went already out of the rosette stage, thus recovering faster in the field than the youngest ones. We however would not suggest to go beyond the limit of 1 meter of height or 20 months of age, because the connected problems (compaction, leaking and breakage of the soil in the polybag, difficulties in the plant manipulation) can overcome the growth advantage.

Comparison of bare root against big and small polybag plantation

In a previous experiment we observed that the size of the polybag played a very important role on the subsequent growth of rattans in the field. However, the plantation of large polybags (10' x 15') is unpractical because of their weight and cost. With this experiment (Appendix 12) we wanted to compare the performance of different polybag sizes (6' x 9' and 10' x 15') and of a bare root plantation (that avoid to bring along the heavy polybags) for *C. subinermis*. The poor performances of the plants planted bare roots indicated that this technique is not suitable for Luasong, and the conventional 6' x 9' polybag is the best solution. Again, the excellent result obtained with large polybags encouraged to find better performing polybags, and for 1998 we are planning to implement a study of root trainers.

Environmental variability and rattan growth in the field

In the previous Steering Committee Report we already reported a preliminary report of the effect of light and competition on rattan growth. In 1998 this study has been presented at the Seminar: "Management of Secondary Forests in Indonesia (Bogor, 17-19 November) and will be published in the Proceedings. The main conclusion of this study are that both low light intensities and competition from sourrounding trees (especially dipterocarps) can be severe limiting factors for rattan growth. This brought us to implement a study of shade regulation in the field by means of liana cutting and non-commercial-tree-girdling (see below).

Shade adjustment

In 1996, six plots of 60 x 70 meters (three treated and three controls) were established on a old C. subinermis line planting. Lianas were cut and the non-commercial trees girdled. The trial was assessed thrice (Aug-96, Oct-96 and Aug-97), by measuring the mortality of the gridled trees, the evolution of the light intensities (with LICOR sensors), and the rattan growth. The experiment (reported in Appendix 13) indicated that:

- our girdling technique is quite effective, having killed about 80% of the treated trees

- the death of the trees brought a major change in the light intensity reaching the soil, much more than the liana cutting

- the gain in rattan growth obtained by shade adjustment as compared to control was of 18% over the whole experiment.

The gain in growth may seem not important, but it has to be considered that at the moment of the experiment, this plantation was already three years old, and many plants have been stagnating at the rosette stage for long time. Probably the rattan response would have been better had the treatment been applied earlier.

To find out if this last hypothesis is true, in 1997 eight additional shade adjustment plots (4 treated, 4 controls) have been established by the Silviculture Unit in the field. The results will be available in 1998.

1.3 Harvesting and yield

1.3.1 Harvesting trial of a 8-year-old *C. caesius* stand

Three 1-ha plots were harvested in the oldest *C. caesius* plantation in Luasong. The report for the first 1ha plot is presented in Appendix 14. The total gross cane yield extracted from the plot was 0.15 ton. Out of this, 43% or 65 kg were of good grade (mature) whereas the remaining 57% or 92 kg were classified as poor quality cane (immature). The finding of this study suggested that *C. caesius* in Luasong plantation needs more than 8 years before to be ready for commercial harvesting.

6

1.3.2 Yield plots

In 1991, the PISP established in the field a number of permanent plots (17 for sega, 14 for batu and 23 for irit) for the study of rattan growth and the construction of yield tables. Irit (*C. trachycoleous*) was later discarded from the plantation because of its low performance. The permanent plots are still identifiable in the field, but have not been measured in the recent years.

Because from a previous analysis of the growth curves it appeared that 1991-planted rattans are now entering in a phase of steady growth, from 1995 onward we decided to measure the plots with a two year period. *C. subinermis* plots have been measured in 1996, and in 1997 we measured the *C. caesius* plots. The data have been sent to CIRAD-Foret-France (Mr. Deleporte) for analysis and the results are expected to come back soon.

1.4. Pest and diseases

Following an outbreak of pest attacks on *C. ceasius* in 1996, the LFC's Pest and Diseases Unit (ICSB) carried out two surveys of the status of the rattan plantation, the first one in March 1997 and the second in September 1997. In addition, they surveyed the experimental harvesting of the sub-block 217A (see above). A report of the findings on *C. caesius* is attached in Appendix 15.

The main conclusion was that the attack of middle 1996 has been quite severe, and was generated mainly by several beetles' species. In 1997 the attack was over, and all the observable damages could be referred to as "old attacks". The beetles population was apparently not progressing in the plantation, maybe due to some cyclic fluctuations linked to the climate. A yearly checking of the plantation will be carried out from 1998 onwards.

The attack has the characteristic to destroy the shoot; later the sucker will root downward and then die off. Chemical control of pests is both ineffective and costly in rattan line-planting. Therefore, the only way to salvage the infested rattans is to conduct a selective harvesting.

2. TREES

2.1 Industrial Species

Acacias

Growth assessment

All the *Acacias* trials were kept under full maintenance despite the species were not listed as priority species for rehabilitation in Luasong. Annual growth assessments were conducted and the results are summarized in Table 7. The growth of *A. mangium* is slightly better compared to other Acacias.

Table 7: Height and diameter of *Acacias*

Species and plots	Age (yrs)	No. of Living trees	Mean Height (m)	Mean DBH (cm)	HMAI (m/yr)	DMAI (cm/yr)
A. mangium (PNG)						
SSO1	7.8	135	26.2 (2.6)	31.3 (5.4)	3.35	4.00
SSO2	7.8	166	27.0 (2.7)	30.7 (5.5)	3.45	3.92
SSO3	7.8	137	27.1 (2.8)	31.3 (4.5)	3.46	3.99
(QLD)						
SSO1	7.7	158	24.1 (3.4)	28.9 (7.3)	3.14	3.77
SSO2	7.7	154	26.0 (3.2)	32.4 (5.2)	3.38	4.21
SSO3	7.7	310	24.1 (3.7)	28.3 (6.7)	3.15	3.70
Average			**25.8**	**30.5**	**3.32**	**3.93**
A. crassicarpa						
SSO1	7.7	108	22.5 (2.6)	30.1 (5.0)	2.93	3.90
SSO2	7.7	127	23.5 (2.3)	28.5 (6.1)	3.05	3.70
SSO3	7.7	116	24.2 (2.0)	29.3 (4.8)	3.14	3.80
Average			**23.4**	**29.3**	**3.04**	**3.80**
A. auriculiformis						
SSO1	7.7	208	22.3 (3.2)	23.9 (5.3)	2.90	3.12
SSO2	7.7	255	23.0 (2.5)	23.1 (5.7)	2.97	2.98
SSO3	7.7	187	22.0 (2.4)	25.3 (6.0)	2.87	3.30
Average			**22.4**	**24.1**	**2.91**	**3.13**
A. aulococarpa	6.2	297	15.8 (3.4)	23.9 (5.0)	2.25	3.86

Note: Value in parenthesis indicates standard deviation

Seed collection

There was no seed collection made on the *Acacia mangium* seed orchards in 1997, mainly because a large stock was already available and there was no proper demand from buyers. The current *A. mangium* seed stock in the PISP cool room is of about 160 kg, mostly from the 1996 collection. Germination tests were done for all the seedlots in stock and it was found that the germination ability was still at 60%. Seed collection was pursued for *Acacia crassicarpa* in response to the current demand by potential buyers such as Sabah Forest Industries (SFI).

Plot Establishment

A statistical analysis of the growth performances (diameter and height) and of the form (branching and straightness) of the trees in the PNG Seedstand/Provenance/Progeny trials (SSO1-SSO2-SSO3) allowed a multi-factorial ranking of the families. The open-pollinated seeds of the best 20 families in this ranking were collected and planted in a second-generation seed orchard. The planting was made in July on an area of 1.2 ha of the former EuSO's SSO2 at Tiagau. This plot carries the name of *A. mangium* SSO PNG4. The detailed planting design is attached in Appendix 8.

8

Field trial of seedling vs. micro-propagated *Acacia mangium*

This experiment had the principal objective to evaluate two propagation method for *A. mangium*: from seeds and from tissue culture. Several superior trees have been collected and introduced in vitro conditions by the Plant Biotechnology Laboratory (PBL) in 1995, and one clone (n. 5) was responsive enough to supply the material for the experiment. The experiment was planted in November 1996 and assessed twice. The results of the second assessment, one year and four months after plantation, are reported in Appendix 16.

The main finding was that there was no difference between seedlings and micro-cuttings of clone n. 5, either for survival, diameter, height or stem form. Also the hypothesis of a better uniformity of clonal material could not be confirmed. Two possible explanations: 1. maternal effects in seeds covered the genetic differences brought by the unknown paternal contribution; 2. environmental effects are more important for *A. mangium* growth than genetic effects. Both these hypothesis need to be tested in a larger experiment.

Study of the heart rot disease on *Acacia mangium*

A core sampling of three Acacia trials (two *A. mangium* and one *A. auriculiformis*) was carried out in 1996 by the PISP to study the incidence of the heartrot disease on Acacias. In 1997, we carried out the statistical analysis, which is reported in Appendix 17. The main results were:

- *A. mangium* is much more sensitive to the disease than *A. auricoluformis*

- However at age 6 the portion of attacked wood was not very important, and will not affect much the production of paper pulp if this has to be the final wood product. The disease may further progress with the age of the trees

- We did not detect any genetic effect involving a resistance to the disease; by contrast a block effect was present, suggesting that there is some environment conditions favorising the disease.

Octomeles sumatrana (Binuang)

Pre-thinning assessment

Two silviculture trials *Octomeles sumatrana* were planted in 1995 at KM13, Taliwas. The average height all over the two trials is reported in Table 8.

Table 8: Growth of 2.5 years Binuang at Taliwas

No. of Plants	Age (yr)	Mean HT (m)	Mean DBH (cm)	HMAI (m/yr)	DMAI (cm/yr)
2253	2.5	8.2 (1.9)	11.9 (2.9)	3.29	4.76

Note: Value in parenthesis indicated standard deviation

As the effects of the treatments were soon evident, both the trials were declared closed in 1997. Therefore, we decided to transform the area containing the two experiments in a thinning trial. Prior to the blocking partition and the attribution of the treatments to each block, we conducted a pre-assessment of the stand measuring both diameter and height. We then sent the data to CIRAD-Foret France (remote sensing team) where they prepared and sent us back contour maps for both diameter and height. One of the maps is reported in the Figure 1 below. The map still has some default (as dead trees were accounted for in the contour calculation, which is not correct). Once the problem fixed, we will be able to draw the

block partition according to the pre-existing stand conditions. We hope to be able to carry out the thinnings before end 1998.
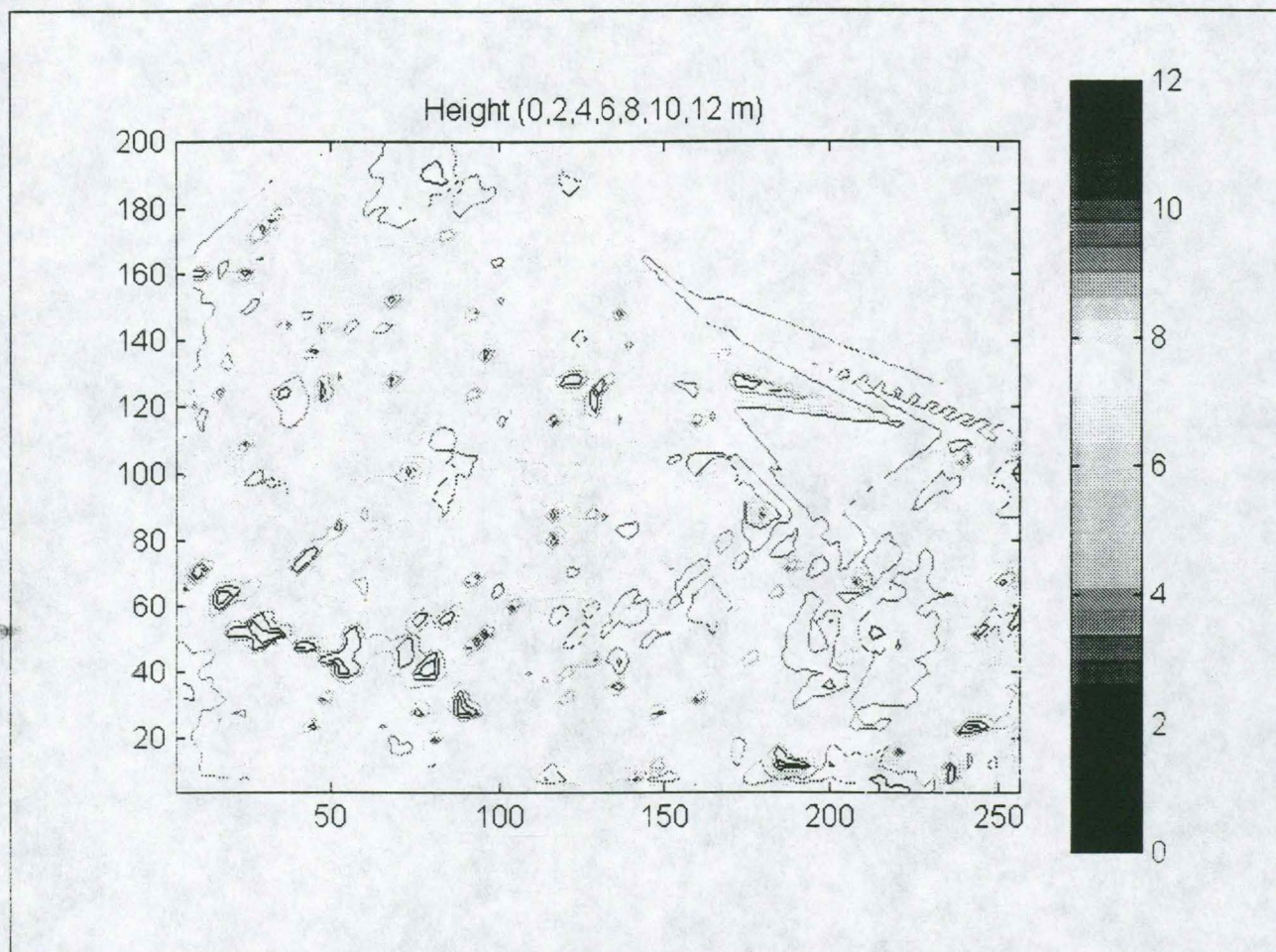
Figure 1. Contour map of the binuang trial (km 13, Taliwas, according to height of individual trees (MatLab software, original in colour).

2.2 High-value Species

For high-value timber species, the PISP activities focused mainly on three species, namely *Tectona grandis* (Teak), *Khaya ivorensis* and *Xylia xylocarpa*.

Tectona grandis

Commercial Production

The commercial production of Teak was handed over to the Nursery unit in May 1997. However the acclimatization of plantlets from PBL is still under the PISP responsability. About 9,000 macro- and micro-cuttings of Teak were sold from Luasong in 1997. Another 25,000 were used for establishment of trials in Taliwas and Luasong.

The old stock-plants/edge-plants park in the PISP's nursery were replaced with new plants, which are now managed not in bulk but in separate clonal lines. The reason for the replacement laid on the ageing of the edge-plants, which decreased their re-sprouting ability.

10

Provenance/progeny trials

Two major provenance / progeny trials have been established for Teak in 1997. The two trials, one on the hilly slopes of Luasong (5.3 ha), the other on a flat (occasionally submersible) site in Taliwas (5 ha), were interconnected by common progenies. The replication was decided for several main reasons: 1. for safety reasons against accidents (fire, etc.); 2. to study the genotype*environment interaction, 3. to produce two different selected varieties of Teak. The details of the two trials are reported in Appendix 18.

Near the trials, demoplots with the principal accessions have also been established. Please note that the Luasong trial and demoplot also included, as much as it was possible, "origins" and clones propagated by the Plant Biotechnology Laboratory. Because of the scope of the trials, clones were only used for buffer, which will however accompany the trial for its whole existence. A detailed map of the clone positions has been distributed earlier to the PBL. The summary of the planting is presented in Table 9.

Table 9. List of Teak trials established in 1997

Type of trial	Trial no.	Location	Date planted	Remarks
Provenance/progeny	TGR1	Taliwas	Mar 1997	41 seedlots/22 provenances
Provenance/progeny	TGR2	Luasong	May 1997	41 seedlots + 1 *in vitro*/26 provenances
Demo Plot	DEMO1	Taliwas	Mar 1997	18 seedlots
Demo Plot	DEMO2	Luasong	May 1997	10 seedlots, 3 *in vitro*, 1 cutting

The trial in Taliwas has been fenced for protection against damages from elephants. The survival rate at the end of 1997 was good, more than 95%. Some of the dead trees have also been replaced if available in the stock. Both of the trials are weeded and treated regularly.

Silviculture trial - Correlated Curves Trend (CCT) Plot

CCT plot is a forestry trial designed to find the optimal thinning regime for trees in plantation. The establishment of a CCT Plot for Teak in Luasong started in August and was completed in November 1997. The trial was established near the Luasong's Teak Progeny/Provenance trial, and accommodates about 13,000 seedlings and plantlets. The total planted area was 7 ha. Table 10 lists the materials used to establish the trial, that prior to planting was carefully mixed up to build an homogeneous bulk. A technical note with the map of the trial is currently under preparation and will be delivered soon.

Table 10: List of materials planted in the CCT Plot at Luasong

No	Seedlots	Origin
1	8807823	India Sakrebail Karnataka
2	8807824	India Virnoli Vir. Karnataka
3	8807831	India Karadibetta Karnataka
4	9410140	India Nellicutha
5	9410150	India Vernalirge
6	9410152	India Masale Valley
7	4314	Solomon Island
8	5212	Solomon Island
9	Bulk	Solomon Island
10	Microshoots (PBL)	Clone 9
11	Microshoots(PBL)	Perlis
12	Microshoots (PBL)	M1
13	Microshoots (PBL)	PNG
14	Microshoots (PBL)	Ujung Pandang
15	Microshoots (PBL)	Mixed

11

Growth assessment

The Teak provenance/ progeny trial at Taliwas was assessed at four months after planting. The growth of the plants for the first three months after planting was negligible due to the long drought that affected the area. So the assessment at four months can be considered as the initial assessment after planting (t=0).

Thirty-three trees of a 9 year-old Teak stand at the Luasong's demonstration plot were also measured. The mean height was 16.7 m and the mean DBH was 25.3 cm. This is equivalent to a growth rate of 1.85 m/yr and 2.81 cm/yr, for height and DBH respectively.

Other trials

Other minor trials with different purposes have been established: 1. an origin trial in Taliwas by FRR (Jikos Gidiman), using few "origins" propagated by the PBL (reported in the FRR's paper). 2. a comparison of the performance of teak in open and line planting, using the clone n. 9 from PBL (Luasong, 311), planted by the Silviculture Unit (reported in appendix 19 by B. Majingin); 3. a soil compaction trial (not assessed yet); 4. a stump trial in Taliwas (C. Garcia).

In addition, the results of the trials carried out in 1996 and early 1997 on teak germination have been analysed and summarized in Appendix 20.

Khaya ivorensis 🖝

Khaya ivorensis is included as one of the priority species for plantation in Luasong due to its good growth in both open- and line-planting trial plots, as well as its tolerance to shoot borer attack. A pilot plantation of this species was established in one of the compartment in Luasong plantation as follows:

1. in October, 32 kg of seeds were received from Ivory Coast through CIRAD;

2. 20 kg were germinated upon arrival, and the germination was quite good (50%);

3. the remaining seedlots were first stored at 4°C, and germinated later; however the passage from 4°C (CIRAD-Foret cool room, France) to open air (airport, quarantine) and then to 4°C again (PISP's cool room), probably damaged the seeds, as the germination of this last batch was very poor.

The 32 kg of seeds included 19 progenies plus a bulk of the two best African provenances (Mopri and Yapro). A controlled mixture of the 19 progenies and of the bulk was planted by the Plantation Unit as a seed stand for the future needs of ICSB (compt. 268 A and B). A number of trees from the 19 families and from the bulk were also sent to the PISP nursery for vegetative propagation.

Provenance trial

One provenance trial (KIV1) comprising 3 Khaya provenances from Ivory Coast (Bonuoa, Mopri and Yapo) and 1 provenance from Kulim, Kedah was established in September 1990. The design was a Randomized Complete Block with 3 x 3 trees per plot and 10 replications. A thinning was conducted in December 1996 to reduce the plot size to 5 trees. An assessment at year 7 indicated that Yapo and Mopri have better growth than Bonuoa, and that the local Kulim provenance had the poorest growth.

12

Table 11: Growth of 7.4 years old *Khaya ivorensis* – Open planting (KIV1)

Provenance	Mean height (m)	Mean DBH (cm)	HMAI (m/yr)	DMAI (cm/yr)
Bonuoa	16.2 (2.4)	19.3 (3.4)	2.19	2.60
Mopri	16.7 (1.7)	20.4 (2.8)	2.26	2.76
Yapo	16.7 (1.9)	20.6 (3.3)	2.26	2.77
Kulim	14.5 (2.1)	16.1 (3.0)	1.95	2.17

Note: Value in parenthesis indicates standard deviation

Progeny Trials

Two progeny trials were established in line planting in 1991, using progenies of *K. ivorensis* from Ivory Coast. The spacing at planting was of 4.5m by 9m. The first trial (KIV3) tested 9 progenies in a 3 x 3 Balanced Lattice design and the second (KIV4) tested 12 progenies in a Rectangular Lattice design. All the 9 progenies in KIV3 wee included in KIV4.

Generally the growth in KIV3 was better than in KIV4. Both trials are under logged-over forest but the shade in KIV4 is heavier due to the presence of large trees in the area. The shade adjustment of July 1996 did not affected much the opening as large dipterocarp trees were still blocking the sunlight.

Table 12: Growth of a 6.6 year-old *K. ivorensis* – Line planting (KIV3))

	Survival (%)	Mean HT (m)	Mean DBH (cm)	HMAI (cm/yr)	DMAI (cm/yr)
Average	85%	11.4 (0.79)	10.7 (1.16)	1.71 (0.16)	1.61 (0.17)

Note: Value in parenthesis indicates standard deviation

Table 13: Growth of a 6.6 years old *K. ivorensis* – Line planting (KIV4))

	Survival (%)	Mean HT (m)	Mean DBH (cm)	HMAI (cm/yr)	DMAI (cm/yr)
Average	80%	6.8 (1.52)	5.6 (1.63)	1.03 (0.23)	0.85 (0.24)

Note: Value in parenthesis indicates standard deviation

Xylia xylocarpa

As for *K. ivorensis*, this species was given considerable attention due to its fast growing especially in the open-planting trial. *Xylia xylocarpa* is found naturally in Indochina (Laos, Vietnam, Thailand) and its heavy wood is used for general construction material and for railway slippers. Wood sampling from 5 year-old trees indicated that the wood density is of about 700 kg/m^3.

In the two experiments established in September 1990, the open-planting trial out-performed the line-planting trial. The trees in the open-planting (XXY1) were planted with spacing of 3.5m x 3.5m and in line-planting (XXY2) at a spacing of 3m x 9m. The open-planting plot was thinned in April 1996, reducing the stand density of 50%.

In the line-planted plot, a shade adjustment was done in July 1996 in order to liberate the Xylia trees. It is not possible to conclude on the effect of liberation as a proper control does not exist. The lower performance of trees where the shade is heavier suggest however that future planting of trees under

13

logged-over forest should adopt a silviculture support, especially shade adjustment at the early establishment phase.

Table 14: Growth of 7.3 years old *Xylia xylocarpa*

Trial	Mean height (m)	Mean diameter (cm)	HMAI (m/yr)	DMAI (m/yr)
XXY1 (Open-planting)	20.3 (1.3)	20.5 (3.0)	2.77	2.81
XXY2 (Line-planting)	8.3 (3.1)	7.9 (3.6)	1.15	1.09

Note: Value in parenthesis indicates standard deviation

Vegetative propagation - *Khaya ivorensis* and *Xylia xylocarpa*

Both *K. ivorensis* and *X. xylocarpa* were identified as potential species for line planting in Luasong. As seed supply for these species is limited, the development of a method for mass production of these species was required: the vegetative propagation (VP) technique is seen as the proper alternative. One of the main task for PISP in 1997 was to develop VP techniques for these two species.

The research started from basics, such as experiments to evaluate coppicing ability, size and origin of explants, and rooting rate of cuttings. The experiments in 1997 concluded that:

i.   Cuttings can be produced from coppices of felled tree.

ii.   The size of the cuttings should be between 4 cm to 6 cm in length

iii. In the present conditions, rooting takes between one to two months. Five to 6 months are needed to produce plantable-size cuttings for both species.

iv.   The average rooting was 48% for *K. ivorensis* (out of 981 cuttings) and 44% for *X. xylocarpa* (out of 720 cuttings)

Since all the explants were taken from trees that re-sprouted after a thinning operation, the planting materials produced from these experiments should not be used as hedge plants for mass production. Once the vegetative propagation techniques are fully developed, hedge plants would be created from superior trees selected in the field trials.

Inventory of the tree plantation in Luasong

Guidelines for the inventory of the Luasong's tree plantation has been prepared by a joint (informal) collaboration between ICSB (plantation), CIRAD-Foret (inventory) and JIRCAS (entomology). The objective was to know the performances of several tree species (*Swetenia macrophylla, S. mahogany, Cedrela odorata, Khaya ivorensis*) in the Luasong line planting, by collecting the maximum useful information at a minimum cost. The guidelines were published and are joined here in Appendix 21.

The inventory has covered by now five compartments (some 800 ha), but only the data of three compartments has been entered on the computer. Once the information will all be loaded, the data analysis will be carried out by the join team of scientists (Bacilieri-Matsumoto-Alloysius-Garcia).

14

List of activities carried out by PISP in the period 1995-1997.

- Rattans

Silviculture

Seed technology – germination and storage trials
Fertilizer trials both in the nursery and in the field
Containers and substrate trials
Size and age of the plants at plantation trial
Light trials in the nursery and shade adjustment trials in the field
Study of the relationships among environment and rattan growth
Yield plot for the establishment of growth tables
Harvesting and maturation studies

Genetics

Collection and establishment of provenance/progeny trials and conservation stands
Collection of genetic material for the genetic diversity study
Controlled pollination
Floral biology, phenology, sex-ratio studies

- Trees

Acacias

Measurement and statistical analysis of the old progeny trials
Establishment of a second generation seed orchard (20 best families of SSOs)
Genetics of the heart-rot disease
Establishment of a tissue culture material trial
Seed collection in the old progeny trials (SSOs)
Seed testing and cleaning

Octomeles sumatrana

Establishment and assessment of site preparation and weeding trials
Transformation of the above trials into a single thinning trial (in progress)

Teak

Establishment of two inter-connected provenance/progeny trials (total: 11 ha)
Establishment of a Correlated Curve Trend Plot (7 ha) and other minor silv. trials
Improvement of the vegetative propagation technique
Commercial production of cuttings
Contribution to the feasibility study for the Teak commercial production
Seed technology – study and improvement of the germination technique

Khaya ivorensis

Improvement of the vegetative propagation technique – now operative
Thinning and measurements of the old provenance trials

Xylia xylocarpa

Observation of the good performances and purchase of new seed batches
Trials for the vegetative propagation technique – now operative

Swetenia macrophylla, S. mahogany, Cedrela odorata, Khaya ivorensis

Systematic observations in the line planting, statistical analysis

Trials/seedstands of *C. manan* at Luasong Forestry Centre (as end of February, 1998)

Trial/ seedstand no.	Date of planting	No. of provenance/ progeny	Total plants	Planted area (ha)
Progeny 1 (CMB1)	Feb 92	5	100	0.20
Progeny 2 (CMB2)	Feb 92	4	104	0.20
Progeny 3 (CMB3)	Feb 92	3	90	0.10
Progeny 4 (CMB4)	Jan 93	20	1000	1.25
Progeny 5 (CMB5)	Jun 94	20	400	0.50
Progeny 6 (CMB6)	Jun 94	6	180	0.22
Progeny 7 (CMB7)	Jun 94	9	180	0.22
Progeny 8 (CMB8)	Jun 94	30	300	0.38
Progeny 9 (CMB9)	Nov 94	7	210	0.26
Resource 1	Jun 94	6 (bulk)	197	0.25
Resource 2	Jun 94	14	256	0.32
Resource 3	Jun 94	8	244	0.31
Resource 4	Jun 94	12	310	0.39
Resource 5	Jun 94	17	170	0.21
Resource 6	Nov 94	6	300	0.38
Progeny 10 (CMB10)	Aug 95	36	288	0.36
Resource 7	Dec 97	2	120	0.15

Trials/seedstand of *C. subinermis* at LFC (as end of February, 1997)

Trial/ seedstand no.	Date of planting	No. of provenance/ progeny	Total plants	Planted area (ha)
Progeny 1 (CSB1)	Jul 91	5	75	0.10
Progeny 2 (CSB2)	Jul 91	3	165	0.20
Progeny 3 (CSB3)	Jul 91	6	240	0.30
Progeny 4 (CSB4)	Dec 91	5	150	0.19
Progeny 5 (CSB5)	Feb 93	14	700	0.90
Progeny 6 (CSB6)	Jun 94	6	180	0.22
Progeny 7 (CSB7)	Jun 94	30	450	0.56
Progeny 8A (CSB8A)	Nov 94	72	432	0.54
Progeny 8B (CSB8B)	Nov 94	72	432	0.54
Provenance 1 (CSC1)	Dec 90	6	420	0.63
Resource 1	Jun 94	4 (bulk)	200	0.25
Resource 2	Jun 94	9	170	0.21
Resource 4	Dec 94	74	394	0.49
Progeny 9 (CSB9)	Aug 95	20	200	0.25
Resource 3	Aug 95	1	50	0.06
Progeny 10 (CSB10)	Oct 96	16	448	0.56
Resource 5	Oct 96	6	120	0.18
Resource 6	Dec 97	11	227	0.28

Trials/seedstand of *C. caesius* at LFC (as end of February, 1997)

Trial/ seedstand no.	Date of planting	No. of provenance/ progeny	Total plants	Planted area (ha)
Progeny 1 (CCB1)	May 91	43	645	1.00
Progeny 2 (CCB2)	May 91	35	525	0.80
Progeny 3 (CCB3)	Jun 91	25	625	0.90
Progeny 4 (CCB4)	Sep 91	10	400	0.60
Progeny 5 (CCB5)	Dec 91	40	600	0.90
Progeny 6 (CCB6)	Dec 91	35	700	1.10
Progeny 7 (CCB7)	Dec 91	33	660	1.00
Provenance 1 (CCC1)	May 92	9	270	0.30
Resource 1	Jun 91	60	300	0.45
Resource 2	Sep 91	10	50	0.08
Resource 3	Dec 91	40	200	0.30
Resource 4	Dec 90	1 (bulk)	100	0.15
Resource 5	Jun 94	1 (bulk)	50	0.01
Resource 6	Aug 95	1 (bulk)	50	0.06
Resource 7	Aug 95	1	100	0.13
Progeny 8 (CCB8)	Oct 96	16	400	0.60
Progeny 9 (CCB9)	Oct 96	16	432	0.67
Resource 8	Oct 96	2	40	0.06

Trials/seedstand of *C. ornatus* at LFC (as end of February, 1997)

Trial/ seedstand no.	Date of planting	No. of provenance/ progeny	Total plants	Planted area (ha)
Progeny 1 (COB1)	Aug 95	20	180	0.23
Resource 1	Aug 95	1	100	0.06
Progeny 2 (COB2)	Dec 97	30	270	0.34

Trials/seedstand of *C. optimus* at LFC (as end of February, 1997)

Trial/ seedstand no.	Date of planting	No. of provenance/ progeny	Total plants	Planted area (ha)
Resource 1	Aug 95	2	187	0.28
Resource 2	Dec 97	5	150	0.19

List of tree trial plots

Species	Trial	Trial no.	Location/Plot	Area (ha)	Date planted
Tectona grandis	Provenance/progeny	TGR1	Taliwas / KM18	5	Mar-97
Tectona grandis	Provenance/progeny	TGR2	LFC/Compt. 311C	5.3	May-97
Tectona grandis	Origin trial (PBL)	--	Taliwas km 13	1	May-97
Tectona grandis	CCT/thinning	TGR3	LFC/Compt. 311B&D	7	Aug-Nov 1997
Tectona grandis	Line/open planting	--	LFC/Compt. 311C	1.2	Jan-97
Tectona grandis	Soil compaction	--	LFC/Compt. 311C	1	Jan-97
Tectona grandis	Stump trial	--	Taliwas km 13	0.3	Jan-97
Acacia mangium (PNG)	S. Stand/Prov./Prog.	SSO1/2/3	LFC / Tiagau	3	Feb-90
A. mangium (QLD)	S. Stand/Prov./Prog.	SSO1/2/3	LFC / Tiagau	3	Apr-90
A. mangium (PNG)	S. Stand/Prov./Prog.	PNG4	LFC / Tiagau	1.2	Jul-97
A. mangium clone n. 5	In vitro/seedlings	--	LCF/Nursery	1.3	Nov-96
A. crassicarpa	S. Stand/Prov./Prog.	SSO	LFC / Tiagau	3	Apr-90
A. auriculiformis	S. Stand/Prov./Prog.	SSO	LFC / Tiagau	3	Apr-90
A. aulococarpa	S. Stand/Prov./Prog.	SSO	LFC / Tiagau	3	Nov-91
Octomeles sumatrana	Species trial	OS1, OS2	Taliwas / KM 13	5	Apr-96
Gmelina arborea	Progeny trial	GAR1, GAR2	LFC / Tiagau	5	Apr-91
Khaya ivorensis	Provenance (Open)	KIV1	LFC / Tiagau	0.5	Sep-90
K. ivorensis	Progeny (Line)	KIV3	LFC / Tiagau	1	Jun-91
K. ivorensis	Progeny (Line)	KIV4	LFC / Tiagau	0.5	Jul-91
Xylia xylocarpa	Species trial (Open)	XXY1	LFC / Tiagau	0.4	Sep-90
X. xylocarpa	Species trial (Line)	XXY2	LFC / Tiagau	0.3	Sep-90
Eucalyptus pellita	Seed Stand	EUSO	LFC / Tiagau	8	Nov-92
			TOTAL	59.0	

20

Planting details of *Acacias* Seedstand/Provenance/Progeny trials at LFC

Species	Origin	Plot	Area (ha)	Planting Date	Initial tree no.	Current tree no.
A. mangium	PNG	SSO1	0.63	Feb 90	840	135
		SSO2	0.83	Feb 90	1100	166
		SSO3	0.68	Feb 90	900	137
	QLD	SSO1	0.71	Apr 90	940	158
		SSO2	0.66	Apr 90	880	154
		SSO3	1.39	Apr 90	1850	310
A. crassicarpa	PNG/QLD	SSO1	0.96	Apr 90	1280	108
		SSO2	1.05	Apr 90	1400	127
		SSO3	3.07	Apr 90	1410	116
A. auriculiformis	PNG	SSO1	0.86	Apr 90	1140	208
		SSO2	1.13	Apr 90	1500	255
		SSO3	0.75	Apr 90	1000	187
A. aulococarpa	PNG	SSO	1.39	Nov 91	1855	298

Planting detail of Acacia mangium SSO PNG4

Trial   : *Acacia mangium* SSO
Trial name   : *Acacia mangium* PNG4
Planting date   : July 1997
Location: Tiagau A12
Spacing : 3m x 3m
Area   : 1.2 ha
Design   : Systematic block
                  7 complete blocks, 2 incomplete blocks

List of families:

Family no.	PISP *AM* No.	Collected from	Original seedlot no.
1	14	PNG SSO1	BVG 784
2	4	PNG SSO2	BVG 1275
3	15	PNG SSO1	BVG 1287
4	5	PNG SSO2	BVG 1278
5	111	PNG SSO1	BVG 1186
6	7	PNG SSO2	BVG 1285
7	6	PNG SSO2	BVG 1188
8	134	PNG SSO1	BVG 1089
9	133	PNG SSO2	BVG 1087
10	110	PNG SSO2	BVG 1099
11	131	PNG SSO2	BVG 1176
12	155	PNG SSO1	BVG 1267
13	32	PNG SSO2	BVG 485
14	147	PNG SSO3	BVG 1289
15	20	PNG SSO3	BVG 1276
16	1	PNG SSO3	BVG 16631
17	121	PNG SSO1	BVG 1284
18	124	PNG SSO2	BVG 1134
19	114	PNG SSO2	BVG 1237
20	152	PNG SSO2	BVG 1260

Effect of different fertilizers and soil components at the nursery stage (update and conclusion)

R. Bacilieri, P. Pajon, D. Allyosius, W. Malandi, 1998

Introduction

In the CIRAD-Foret/ICSB Steering Committee Meeting Report of the last year (1997), we presented a preliminary study on the effect of fertiliser and soil composition on rattan growth at the nursery stage. In this paper we present the data of the second assessment of the trial and its conclusion.

In this experiment, we compared the usual fertilizer (NPK granules) with a slow release fertilizer (Agroblen) applied only once after transplanting, at two dosages. In order to assess the advantage of adding sand and compost to the usual soil, and also to assess the interaction between the fertilizer and the soil components, this experiment also tested four different soil mixtures.

Material and method

This experiment started on April 5, 1996 for *Calamus subinermis* and *C. ornatus*, and July 20 for *C. manan* . The plants were potted in 6'x9' polybags at 1-2 leaf stage. All the plants were under a 50% sarlon net, watered once a day.

List of fertilizer treatments:

    1) Control: NPK blue: 3-4 granules / polybag / month for small plants,
         7-10 for middle plants and 18-20 for big plants. **F1**

    2) Agroblen: 5g/polybag after transplanting **F2**

    3) Agroblen: 10g/polybag after transplanting **F3**

The Agroblen fertilizer was added in the polybags just after transplanting the seedlings. The granules were mixed with the soil at the top of the polybags.

For the fertiliser factor, we decided to not establish a control as the comparison between NPK and no fertiliser has already been carried out many times in the past, showing without any doubt that no fertilisation always results in a very slow growth as compared to a NPK treatment.

List of soil treatments:

1) Control: 100% top soil from river edge	**S1**
2) 80% top soil + 20% sand	**S2**
3) 60% top soil + 40% sand	**S3**
4) 70% top soil + 20% sand and 10% saw dust (Batu and Lasun) 50% top soil + 20% sand + 30% saw dust (Manau)	**S4**

The mixture was manually prepared and the proportions were measured in volume and not in weight. Each experimental unit included 20 rattan seedlings and each treatment was replicated 3 times. Overall, per species, the experiment included:

20 plants * 3 fertilizer * 4 soil components * 3 repetition = 720 plants per species

The first assessment (March 1997) was carried out 11 month after transplanting for *C. subinermis* and *C. ornatus* and after 8 month for *C. manan*. For this assessment, 3 characters were measured: mortality, shoot length and basal shoot diameter.

The second assessment was done four months later (July 1997), 15 months after transplanting for *C. subinermis* and *C. ornatus* and 12 months after transplanting for *C. manan*. For this assessment, only the mortality and the shoot length have been measured. In fact, analysing the first assessment's data, we observed that, being correlated one to each other, diameter and height gave essentially the same information. The data have been analysed with the SAS software (SAS Institute Inc. 1988).

Results

Mortality

The statistical model used for this analysis was:

$$Yijk = X\ldots + Xi.. + X.j. + X\ldots k + error$$

i = fertilizer
j = soil
k = repetition

The statistical model and the fertilizer effect were significant for all the species; by contrast, the soil effect was not significant (data not shown). The frequency of mortality by fertilizer and species is presented in Table 1 below.

Table 1. Mortality rate ranked by species and fertiliser treatment, over the two assessments.

First assessment	C. manan		C. subinermis		C. ornatus	
F1 (NPK 10 granules per month)	0.20	A*	0.42	A	0.39	A
F2 Agroblen 5 grams	0.02	B	0.14	B	0.24	B
F3 Agroblen 10 grams	0.06	B	0.31	C	0.43	A
LSD (least significant difference)	0.07		0.06		0.13	

Second assessment	C. manan		C. subinermis		C. ornatus	
F1 (NPK 10 granules per month)	0.63	A	0.62	A	0.46	A
F2 Agroblen 5 grams	0.13	B	0.15	B	0.27	B
F3 Agroblen 10 grams	0.27	B	0.32	C	0.50	A
LSD (least significant difference)	0.09		0.02		0.02	

(*) Duncan grouping

For all species, the normal NPK fertilizer induced a considerable mortality, that increased over the time as the NPK application was repeated monthly. The conventional NPK treatment is to be considered already toxic. For all species, the higher F3 Agroblen dosage induced higher mortality if compared to the F2 treatment.

Shoot length and shoot diameter

At the first assessment, shoot length and shoot diameter gave similar results because they are intrinsiquely correlated (please see the Steering Committee Report of 1997). The differences in diameter among treatments were less important than for length, but the treatments' ranking was similar. The next part will only shows the results concerning the shoot length.

The statistical model used for this analysis was:

$$Yijk = X... + Xi.. + X.j. + X.k. + Xij. + X.jk + Xi.k + Xijk + error$$

> i = fertilizer
> j = soil
> k = repetition

For all species, the analysis of variance (Table 2) showed that both the statistical model and the fertilizer (FER) effects were significant at the 0.01 error rate. The soil effect (SOIL) was highly significant for Manau, slightly significant for Batu (with an error rate at 0.09) and not significant for Lasun. The repetition effect (REP) was significant in Manau and Batu but not in Lasun. The interaction FER*SOIL, the study of which was one of the main objectives of the study, was not significant in any of the species.

3

Table 2. Analysis of variance showing the significance level of the effects, for each species.

Calamus manan

Source	DF	Type III SS	Mean Square	F Value	Pr > F
REP	2	199.563	99.781	11.97	0.0001
FERT	2	1094.009	547.004	65.64	0.0001
SOIL	3	1083.971	361.323	43.36	0.0001
REP*FERT	4	302.544	75.636	9.08	0.0001
FERT*SOIL	6	78.949	13.158	1.58	0.1515
REP*SOIL	6	325.072	54.178	6.50	0.0001
REP*FERT*SOIL	8	496.755	62.094	7.45	0.0001

Calamus subinermis

Source	DF	Type III SS	Mean Square	F Value	Pr > F
REP	2	299.919	149.959	7.55	0.0006
FERT	2	524.878	262.439	13.22	0.0001
SOIL	3	122.015	40.671	2.05	0.0964
REP*FERT	4	122.236	30.559	1.54	0.1898
FERT*SOIL	6	96.667	16.111	0.81	0.5613
REP*SOIL	6	118.086	19.681	0.99	0.4305
REP*FERT*SOIL	11	191.556	17.414	0.88	0.5629

Calamus ornatus

Source	DF	Type III SS	Mean Square	F Value	Pr > F
REP	2	32.918	16.459	1.29	0.2759
FERT	2	265.008	132.504	10.40	0.0001
SOIL	3	55.654	18.551	1.46	0.2260
REP*FERT	4	28.816	7.204	0.57	0.6878
FERT*SOIL	6	52.308	8.718	0.68	0.6624
REP*SOIL	6	16.112	2.685	0.21	0.9733
REP*FERT*SOIL	12	229.732	19.144	1.50	0.1202

NOTE: DF=degrees of freedom. SS=sum of squares; Pr>F=probability rate of the hypothesis of a difference among treatments.

Fertilizer effect:

The effect of the fertiliser treatments on the shoot length is given in Table 3 below. In a similar way than for mortality, Agroblen showed to be the more suitable treatment for all species compared to NPK. The higher Agroblen dosage did not give an appreciable increase in growth if compared to the lower dosage. At the first assessment, we doubted that the Agroblen dosage of 5 grams could not be enough to last over the whole duration of the nursery stage. The second assessment showing that there is no differences between the 5 and 10 grams applications, we can conclude that either the 5 grams is sufficient for the whole period, or that the 10 grams dosage was uneffective because it was leaked and/or degraded without being utilised by the plant. For Manau, the Agroblen treatment resulted in an increase in growth of 40%.

Table 3. Shoot length (cm) ranked by fertiliser treatment and species, over the two assessments.

First assessment	C. manan		C. subinermis		C. ornatus	
F1 (NPK 10granules per month)	9.5	A*	7.5	A	14.0	A
F2 Agroblen 5 grams	11.3	B	12.1	B	16.0	B
F3 Agroblen 10 grams	11.8	C	11.7	B	14.5	A
LSD (least significant difference)	0.5		0.9		0.9	

Second assessment	C. manan		C. subinermis		C. ornatus	
F1 (NPK 10granules per month)	12.71	A	12.7	A	17.38	A
F2 Agroblen 5 grams	17.00	B	15.4	B	19.51	B
F3 Agroblen 10 grams	17.83	C	16.5	B	19.07	B
LSD (least significant difference)	0.8		1.2		1.0	

Soil effect:

For Lasun, we could not detect any soil effect, probaby because of the high mortality, especially for some of the combinations (80% of mortality for fertilizer F1 x soil S1 x repetition R2). The average height over the four soil treatments for Lasun was consistently around 18.4 cm. Table 4 only shows the results for Batu and Manau.

Table 4. Shoot length (cm) ranked by soil treatment and species, over the two assessments.

First assessment	C. manan		C. subinermis	
S1 100% soil	13.6	A	11.2	A
S2 80% soil + 20% sand	10.9	B	11.1	A
S3 60% soil + 40% sand	9.7	C	10.7	A B
S4 70% soil + 20% sand + 10% saw dust or 50% soil + 20% sand + 30% saw dust	9.6	C	9.9	B
LSD (least significant difference)	0.6		1.0	

Second assessment	C. manan		C. subinermis	
S1 100% soil	19.7	A	15.2	A
S2 80% soil + 20% sand	16.7	B	15.6	A
S3 60% soil + 40% sand	15.1	C	15.9	A B
S4 70% soil + 20% sand + 10% saw dust or 50% soil + 20% sand + 30% saw dust	14.5	C	14.4	B
LSD (least significant difference)	0.8		1.2	

For Manau, the top soil without any mixture gave the best results: the shoot length was 18% higher compared to the best of the mixtures (S2). The higher the sand proportion was, the less was

the growth. This could be explained by a diminution of the soil retention capacity for water and mineral components.

The soil effect on Batu was not really significant ($\alpha=0.09$), but it was interesting to note the difference between this species and Manau, the former preferring more clayey soils, the second apparently preferring more sandy soil.

The mixture top soil, sand and saw dust always performed very bad, probably because: 1) the retention capacity of this material is poor; 2) the nitrogen content is also very low, so that a portion of the nitrogen in the media is absorbed during the decomposition of the saw dust into compost; 3) the process (2) acidifies the soil; 4) finally, an alternative explanation is the possible presence of toxic elements as resins in the saw dust.

Interaction fertiliser*soil

At the first assessment, the interaction soil*fertiliser was only significant for Manau (Steering Committee Report, 1997). However, even this effect disappeared over the second assessment. We do not show the results here.

Conclusion

- There is a strong correlation among diameter and shoot length ($r^2>0.75$ for all species); it is possible to interpret the experiment only by measuring the shoot length, thus saving time.

- The treatments with Agroblen 10 grams and with a monthly application of NPK resulted in much higher mortality compared to the treatment with Agroblen 5 grams.

- The two treatments with Agroblen 5 and 10 grams resulted in similar plant performances. Both of these treatments did however considerably better than NPK.

- The soil effect was highly significant only in Manau, that demonstrated to prefer top soil with neither sand nor compost. In Batu, even if the significance of the differences was light, the pattern was the reverse: this species seemed to prefer more sandy soils.

- The interaction soil*fertiliser was not significant over the duration of the experiment, so that the best fertiliser (or conversely, soil) will be always the best treatment no matter which soil (or fertiliser) is used.

Summarising, we are confident that a fertilisation with 5 grams of Agroblen is the best treatment for all the above rattan species. Agroblen, even if it is more expensive than NPK, allows to save the manpower needed for the monthly application.

The top soil was the best soil for Manau; the other two species were relatively indifferent to the soil treatment, so that the same soil can be adviced for all species.

The only consideration that needs to be added is that the watering regime in PISP was finely regulated. This is not always the case in the main nursery, where sometimes in the past we observed an excess of water, resulting in "floaded" polybags. In this case, the addition of a low portion (10%) of sand can help to drain the water without affecting too much the growth. If the top soil is too clayey (that is oftent the case in Luasong) the use of a low portion of sand can also help

to: 1) avoid soil compaction, 2) avoid breakages of the polybags and consequently of the roots; 3) avoid difficulties to water the polybags once the soil is dry.

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Effect of the shade treatment on rattan growth at the nursery stage (update and conclusion)

R. Bacilieri, P. Pajon, D. Allyosius, W. Malandi, 1998

Introduction

Last year we presented a preliminary study on the optimal shade requirements for rattans at the nursery stage (CIRAD-Foret/ICSB Steering Committee Report, 1997). In 1998 we carried out the second and last assessment of the trial, and here we present its results and conclusion.

This experiment aimed to assess the light requirement at the nursery stage for 4 commercial large-diameter rattan species:

- *Calamus ornatus* (rattan Lasun)
- *C. merrillii* (rattan Palasan)
- *C. manan* (rattan Manau)
- *C. subinermis* (rattan Batu)

Material & method

In this experiment, we compared 3 different sarlon nets with a shade percentage (as specified by the manufacturer) of 30%, 50% and 70%. Our own measurements (by using 10 calibrated LICOR quantum sensors) allowed to estimate the actual shade given by each of the three Sarlon nets once installed in the nursery (Table 1).

Table 1. Estimation of the actual shade given by the Sarlon nets as compared to the manifacturer specifications.

Manufacturer specification shade value	Actual shade value (PISP nursery)	Minimum value (over 8 sensors)	Maximum value (over 8 sensors)
30%	39%	36%	42%
50%	58%	56%	62%
70%	78%	73%	83%

In the experimental nursery reserved for this experiment, the shade variation within each single Sarlon net was of about 5% of the total variation. This was an indication that the whole installation was good.

Three replications (R1, R2 and R3) were used; each experimental unit included 33 plants. The species were randomly arranged within repetitions in order to minimise the competition effect for light. The plants were all raised in the same conditions, by using a slow release fertiliser and 6' x 9' polybags.

The experiment started just after transplanting the seedlings from the seedbeds to the polybags, in June 1996. The first assessment (February 1997) occurred 8 month after transplanting and 2 characters were measured: the shoot length (length between the collar and the last leaf insertion) and the collar diameter. At the second assessment (July 1997), as the diameter was found to be highly correlated with the shoot length and essentially gave similar results, we only measured the shoot length.

The different shade treatments and repetitions were compared by using a variance analysis and then the ranking tested by using a Duncan test. The data were analysed species by species. The statistical model used included 2 factors, repetitions and shade, plus the interaction repetition*shade.

Results

For all species, the model was higly significant. All the main factors (shade and repetitions) and the interaction repetition*shade significantly affected the growth of all species. Only for batu the interaction rep*shade was not significant. Results of the analysis of variance per experimental factor are given in Table 2.

Table 2. Analysis of variance showing the significance level of the effects for each species. Second assessment, 13 months after transplanting.

Calamus manan

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SHADE	2	2187.470	1093.735	97.51	0.0001
REP	2	103.145	51.572	4.60	0.0109
SHADE*REP	4	449.560	112.390	10.02	0.0001

Calamus ornatus

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SHADE	2	473.330	236.661	28.53	0.0001
REP	2	272.488	136.244	16.42	0.0001
SHADE*REP	4	239.659	59.914	7.22	0.0001

Calamus subinermis

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SHADE	2	486.353	243.176	34.51	0.0001
REP	2	58.490	29.245	4.15	0.0167
SHADE*REP	4	46.475	11.618	1.65	0.1621

Calamus merrillii

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SHADE	2	2187.470	1093.735	97.51	0.0001
REP	2	103.145	51.572	4.60	0.0109
SHADE*REP	4	449.560	112.390	10.02	0.0001

The rankings of the treatments in terms of shoot length at the first and second assessment are given in Table 3.

Table 3. Shoot length (cm) ranked according to the shade treatment.

First assessment	C. ornatus		C. merrillii		C. manan		C. subinermis	
30% shade	10.9	A*	12.7	A	5.6	A	9.8	A
50% shade	10.0	B	11.2	B	6.5	B	9.4	A
70% shade	11.5	A	10.0	C	10.4	C	10.4	B
LSD	0.6		0.6		0.7		0.5	

Second assessment	C. ornatus		C. merrillii		C. manan		C. subinermis	
30% shade	18.1	A	21.1	A	9.8	A	17.4	A
50% shade	14.7	B	15.7	B	10.2	A	14.6	B
70% shade	15.9	C	14.7	C	14.5	B	14.7	B
LSD	0.9		1.0		1.1		0.5	

NOTE: * Duncan ranking. LSD: Least significant difference.

The first thing to note is that batu, lasun and parasan clearly did better under high light intensity (i.e. low shade percentages), while manau behaved in the opposite way. It is also interesting that the response of the species to the light treatment evolved with the time, lasun and batu seeming quite indifferent to the light at the first assessment, and showing their light demand later.

Finally, it has to be reported that the mortality had been quite low (<10%) for all species and all treatment, except for the higher light intensities applied to manau. In this case the mortality was of 21% under a shade of 50%, and 29% under a shade of 30%. Under the higher light intensities, manau not only grew more slowly, but also suffered higher mortality.

Collar diameter

The collar diameter was measured for all the plants at the first assessment. Table 4 shows the treatment effect on collar growth, as well as the correlation among the two characters, collar diameter and shoot length.

Table 4. Collar diameter (mm) ranked according to the shade treatment at the first assessment only. The correlation (r^2) among diameter and shoot length is also given.

First assessment	C. ornatus		C. merrillii		C. manan		C. subinermis	
30%	11.7	A*	14.0	A	7.8	C	14.0	A
50%	10.1	B	11.4	B	9.9	B	13.0	B
70%	11.4	A	11.7	B	11	A	13.5	A B
LSD (2)	0.6		0.7		0.6		0.6	
correlation of collar diam. with shoot length	**0.58** 0.0001**		**0.61** 0.0001		**0.73** 0.0001		**0.38** 0.0001	

Note: *: Duncan test. LSD: Least significant difference. ** probability of $r^2 \neq 0$

At the first assessment, the ranking over treatments for the collar diameter was quite coherent with the ranking obtained for shoot length. However the relative differences among treatments were less important. The correlation values among shoot length and collar diameter were high for most of the species, excepted maybe *C. subinermis*. For this reason, we decided to not measure the collar diameter at the second assessment.

By comparing the collar data at the first assessment and the shoot length data of the second assessment, the coherence among rankings is even more stricking, especially for batu.

Conclusion

The experiment is considered concluded. The results clearly indicated that three of the species (batu, lasun and palasan) clearly preferred high light intensities of around 60-70% (just to remember, the Sarlon net was sold as a 30% shade, but our measurement indicated that the actual shade was of 39%).

Conversely, manau at higher light intensities suffered of more mortality and grew more slowly. For this species it is better to use a Sarlon net at 70% shade, at least for the first 13 months.

Field performance of seedlings of different ages at plantation: *Calamus caesius*

R. Bacilieri, P. Pajon, B. Majingin, 1998

Introduction

This experiment was established in 1996, with the main objective to find the optimal age (and size) of seedlings for plantation. Furthermore, because of the availability at that time of a large number of overgrown seedlings in the nursery, we have been asked to study if these latters can survive and perform correctly in the field.

Material and method

The experiment was etablished in the PISP experimental area for rattan (A10, compartment 311), on November 1996. The experiment was established by the conventional line planting design, under a quite open mixed forest (dipterocarps + pioneers). The seedlings were chosen in the main nursery according to their transplantation (from the germination beds) date. The seedlings, raised in 6'x9' polybags in the main nursery, were then planted in circular holes of the size of the polybag.

The experiment was a randomized complete blocks with three repetition.

List of treatments (age of the seedlings at the plantation period):

|	
1) 6 month-old seedlings	(60 plants)
2) 12 month-old seedlings	(60 plants)
3) 16 month-old seedlings	(60 plants)
4) 20 month-old seedlings	(60 plants)
5) 24 month-old seedlings	(60 plants)

The trials was assessed three times, once just after plantation (December 1996), later in February 1997 and the third time on July 1997. The two measured characters were the survival and the shoot length.

Results

In term of survival, the best results were obtained by the 12 and 16 month-old seedlings, with a 100% survival. The youngest plants (6 month-old) recorded the higher mortality (9%), while the mortality of the two older classes (20 and 24 month-old plants) was at about 4%.

The comparison of the growth curves of the various treatments showed that the best performing classes were the two oldest ones, 20 and 24 month-old plants (Figure 1). The best current increment (slope of the curve) was obtained by the 20 month-old plant.

Figure 1. Growth of plants with different ages in the field
(plantation date : November 1996)
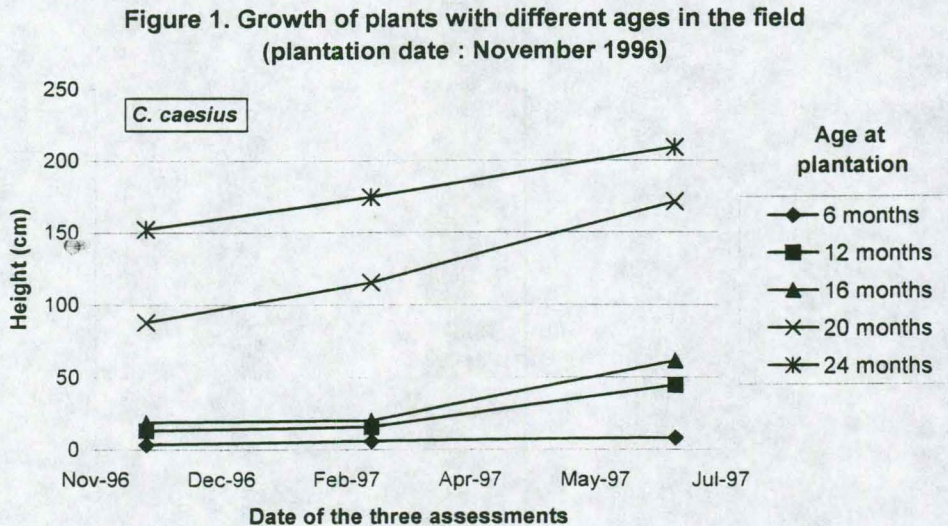
Discussion and conclusion

From our experiment it appears that what we previously considered as "overgrown" seedlings, can in fact perform well in the field. Our former hypothesis was that these older seedlings, having at the moment of planting a very soft and slender stem, would suffer mortality and insect damages. The mortality having be reasonably low, this hypothesis can now be discarded.

The reason of their good growth as compared to younger seedlings (that can be appreciated by comparing the curve's slopes) is probably that these seedlings went already out of the slower growth period (the rosette stage), and were able to promptly recover in the field.

We will have now to study if this result is confirmed on a longer observation period, and how long is the lower portion of the stem that will have to be discarded at the harvesting time because of its too small diameter.

Plantation Technique for *Calamus subinermis*: Comparison of Bare Root against Big and Small Polybags Plantation

R. Bacilieri, P. Pajon, B. Maginjin, 1998

Introduction

According to a former experiment on *Calamus caesius* (ICSB/CIRAD-Foret Steering Committee Report, 1997) the size of the polybag has a large influence on the subsequent performance of the plants in the field. That was however a preliminary experiment, with a small number of plants. Furthermore, larger polybags are more difficult to manipulate, so that the suggestion to increase their size can not be implemented in the field without bringin along supplementary costs for their transportation.

The experiment presented here was aimed to study more precisely the effect of the nursery techniques on another rattan species of interest, *C. subinermis*. At the same time, in order to find a solution to the difficulties linked to the manipulation of the heavyiest polybags, we wanted to see it it is possible to raise the seedlings in large polybags but to plant them bare roots (discarding in such a way the weight of the soil).

Material and Methods

The experiment was a split-plot with two factors and repeated thrice. The factors and their corresponding treatments were:

Factors (code)	Treatments (code)	Number of plants
Polybag size (1)	15' x 10' (1)	24
	6' x 9' (2)	24
Planting method (2)	With soil (1)	24
	Bare roots (2)	24

This experiment was prepared in the PISP nursery. To check if the conditions there was similar or not to those of the main nursery, we added to the experiment a control from this latter, consisting of 24 plants of the same age, raised in 6' x 9' polybags and distributed over the three repetitions. The trial was planted on January 1997, and assessed twice, the first time just after

planting, and later in August 1997. The measured character was the total height of the plants, obtained by adding the height of all the stems within a clump.

A preliminary analysis of the first assessment showed that there were not significant differences among treatments at the time of the establishment, except from the fact that the larger polybags accelerated slightly the growth; this effect was however part of the experiment and was accounted for in the split-plot scheme.

The trial analysis was carried out according to the split-plot technique, with the treatments niched within the factors. The plants prepared in the PISP nursery with 6' x 9' polybag and planted with soil (2-1) were compared to the control from the main nursery in a separate analysis of variance.

Results

This experiment showed that the larger polybags were doing significantly better than smaller ones, and that planting with soil was significantly better than planting bare root plants (Table 1). There was not any block effect; by contrast, the polybag size, the planting method and their interaction effetcs were all significant.

Table 1. Statistical analysis of the split-plot scheme. Dependent variable: total height.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	6360.699	908.671	38.64	0.0001
Error	82	1928.289	23.515		
BLOCK	2	34.032	17.016	0.72	0.4881
POLYBAG	1	723.533	723.533	27.94	0.0340
PLANTING METH	1	4628.123	4628.123	196.81	0.0001
POLYB*PLAN METH	1	708.677	708.677	30.14	0.0001

In spite of the quite obvious results of above, it was however interesting to observe the quite large differences (always highly significant) among treatments (Table 2). The plants raised in large polybags and planted bare roots also suffered a 25% of mortality, while in all the other treatment the mortality was zero.

Table 2. Number of trees, average and standard deviation for the total height (cm) within treatments.

Polybag	Planting method	N	Mean	SD
10' x 15'	*With soil*	24	30.46	5.48
10' x 15'	*Bare roots*	18	10.33	4.35
6' x 9'	*With soil*	24	19.04	4.45
6' x 9'	*Bare roots*	24	10.20	4.91

By contrast, we did not observe any differences among seedlings raised in a similar way (small polybags planted with soil) in the main nursery (height=20.41) and in the PISP nursery (height=19.04; data not shown).

Discussion and Conclusion

One minor finding of the experiment was that there were no differences among plants raised in the PISP nursery and in the main nursery. This proves that the results obtained in the PISP can be applied in the main nursery straight away.

It is still early to make the final conclusion about this trial. Of course the best result obtained with large polybags and plantation with soil suggests that this material should be the preferred one. However their weight makes their handling impossible at the commercial planting scale. Because at seven months after planting the results obtained by bare root plantation was bad enough to discourage the use of this technique, the best present alternative remain to plant small polybags with soil. This experiment however encourage once again to find better performing polybags, and we plan to study in the near future the use of "root trainers" polybags

SOME EXPERIENCES FOR SECONDARY FOREST ENRICHMENT THROUGH RATTAN PLANTATION IN SABAH[1]

R. Bacilieri*, D. Alloysius**, B. Maginjin**, P. Pajon* and C. Garcia**

* CIRAD-Forêt/Tawau, PO Box 60793, 91017 Tawau, Sabah, Malaysia

** Innoprise Corporation Sdn Bhd, PO Box 60793, 91017 Tawau, Sabah, Malaysia

SUMMARY

In 1987, Innoprise Corporation Sdn Bhd (ICSB), embarked in a large scale project for the enrichment of a logged-over forest through rattan plantation. In 1989, CIRAD-Forêt joined the project to bring scientific assistance to the research on rattan silviculture and genetics. The plantation method consisted of rattan line planting under logged-over forest. This system showed however some limitations, mainly due to the lack of control on competitors (as surrounding trees, bamboo and lianas) and on the environmental variability (extremely large at the site), that resulted in rattan stands with heterogeneous growth.

Studies of the effect of environmental variability on rattan growth, and of methods to control it, started since 1994. A first study focused on the observation of correlation among rattan growth and a number of environmental variables. The study showed that competition from surrounding dipterocarp trees was the main element of the variability of rattan growth. It allowed defining which forest types are more suitable for rattan enrichment. Another study focused on the effect of light on rattan growth. Trials have been established both in the nursery and in the field. The nursery trials showed that each rattan species has special requirements in terms of light. The field trials allowed to quantify the gain in rattan growth that can be obtained through shade adjustment interventions. Both these studies gave to the ICSB's rattan project important information for an improved plantation management.

INTRODUCTION

Secondary forest rehabilitation will be one of the main concerns for tropical forestry in the near future. The common experience of Innoprise Corporation Sdn Bhd (ICSB) and CIRAD-Foret in Sabah (Malaysia), even if focusing on a non-timber forest product as rattan, may cast some light on the problems of the forest enrichment technique, and be of interest to researchers and foresters involved in this difficult task.

ICSB is a Sabah-based company, managing a forest concession of about 900.000 hectares. In 1987, as part of its forest management effort, ICSB embarked in a large scale rattan planting project: 40.000 ha of a secondary dipterocarp forest were to be enriched with rattans. CIRAD-Forêt joined the project in 1989, bringing scientific assistance to the research on rattan silviculture and genetics. The collaboration was concretised by the creation of a research structure named Plant Improvement and Seed Production Project (PISP), based in Luasong. Nasi & Monteuuis (1992) and Nasi (1994) gave first descriptions of the work carried out by PISP.

The four large diameter species included in the research programme were: *Calamus manan*, *C. subinermis*, *C. ornatus* and *C. merrillii*. The system implemented for commercial plantation was to plant rattans in lines under the logged-over forest. This system seemed easier to manage than other systems of rattan plantation under fast growing tree species, for a number of large trees that could support without damage the rattans were still present in the forest, and no silviculture treatment that could disturb or be rendered difficult by the thorny rattans was planned for this forest. However, the method showed some limitations, resulting in rattan stands with heterogeneous growth.

Rattans, as other palms, have a peculiar pattern of growth: in the first stage of development, called establishment phase (or rosette stage), the stem diameter and the number of roots increase, but stem elongation is negligible; once the stem has attained a maximum, the second phase of development may start with a significant aerial growth of the stem. The establishment phase may last few months up to several years according to species and environment conditions.

Continuous checking of the rattan plantation in Luasong showed that, together with "normal" growing rattans, 5 or 6 years after the plantation there were still quite a large proportion of rattans still in the establishment phase, i.e. with almost no elongation. Even if it was common to find fast and slow growing plants just side by side, some plantation compartments were doing significantly better than others.

With the objective of understanding the reasons behind such variability, PISP started to study the effect of environment conditions on rattan growth. Preliminary observations seemed to point to canopy opening, and hence to the light reaching the planted rattans, as an important element for rattan growth. Little was known, at that time, about the optimal shade requirement for rattans. In nature, rattans are found under forests with a relative light intensity (RLI) as low as 0.5 to 5%. However, the pattern of growth of rattans in these conditions was not known. At young stages, the optimum RLI requirement seems to be higher, between 50% and 85% (Wan Razali *et al.* 1992, Budiman & Nana 1988). Finally, no information at all was available on the effect of competition from surrounding trees and of environmental variability on rattan growth.

In order to improve our knowledge on the matter, in 1995 we established, as described here, two experiments, one in the nursery and one in the field, analysing the effect of light on rattan growth. A third study reported in this paper focused on the observation of correlation among rattan growth in the commercial plantation and a number of physical environment variables as light, soil, slope, etc., and biotic variables as stand density, species composition, and competition.

2

MATERIAL AND METHODS

The secondary forest and the rattan planting technique

The Luasong's rattan plantation is established under a secondary forest that had been logged-over by a timber company about 20-25 years ago. The forest is composed by a variable ratio of dipterocarps and pioneer trees: some compartments, only lightly logged-over, are now largely dominated by dipterocarps, while others, where the harvesting had been more intensive, are now dominated by pioneers. The elevation is from 50 to 450 meters above sea level; the average annual rainfall is 2,500 mm (1966-1972); the topography is very irregular, often with steep slopes; soils belong to the Orthic Acrisol and Distric Nitosol families (FAO/UNESCO classification, 1974).

The nursery technique for rattans consists of: a) germination of the rattan seeds in sand beds; b) 1 to 3 months after germination, transplanting of the seedlings in plastic polybags under Sarlon nets; c) 9 to 18 months after transplanting, plantation of the seedlings in the field. For plantation, strips of 4-5 m of width were opened under the logged-over forest by cutting all the plants but the commercial trees. Two lines of rattan were then planted within the strip. The spacing along the row was of 2.5 meters, and the distance among strips 5-6 meters, giving a planting density of 800 plants/ha.

Effect of light on rattan growth in the nursery

The experiment was aimed to assess the light requirement at the nursery stage for 4 commercial large-diameter rattan species: *C. ornatus*, *C. merrillii*, *C. manan* and *C. subinermis*. Three different Sarlon nets, according to the supplier specifications with RLIs of 30%, 50% and 70% were compared. Prior to the experiment, our team re-assessed the RLI given by each of the Sarlon nets by using 10 calibrated LICOR quantum sensors combined with a data logger. Eight sensors were installed under each of the Sarlon net for a whole day. Two sensors were installed in a fully open space and used as an open-sky reference. Five-second-interval readings were then integrated over the 12 hours of measurement. This gave us a more precise estimation of the RLI given by each of the Sarlon nets, that were 22%, 42% and 61% respectively. In our experiment, the variation of RLI within each single Sarlon net was of about 5% of the total variation.

Each treatment for each species was repeated three times; the experimental unit included 33 plants. The seedlings were transplanted from the seed beds when they were about 1 cm tall. The plants were all raised in the same conditions, by using a slow release fertiliser and 6' x 9' polybags. The experiment started just after transplanting the seedlings from the seedbeds to the polybags. The first assessment occurred 8 month after transplanting and the second 1 year after transplanting. The only measured character has been the shoot length (length between the collar base and the insertion of the last leaf).

The different RLI treatments and the repetitions were compared by using a variance analysis, and their ranking tested with a Duncan test. The statistical model used for each species included 2 factors:

$$Yijk = X... + Xi.. + X.j. + Xij. + error$$

where $X...$ = general mean; $Xi..$ = RLI effect; $X.j.$ = repetition effect; $Xij.$ = interaction RLI*repetition; *error* = residual.

Effect of light on rattan growth in the field: shade adjustments

To evaluate the role of the canopy cover on the slow growth of rattans, in 1996 we carried out a canopy manipulation experiment. In a compartment planted in 1993 with *C. subinermis,* three rectangular plots (A2, A4, A6) of 60x70 meters have received the shade adjustment treatment. Twenty meters apart from each of the three plots, control plots of the same size have been established, without treatment (A1, A3, A5).

The shade treatment was carried out in Septembre 1996 as follows: i) all the non-commercial trees with a DBH less than 15 cm were cut with conventional methods (axes, chain saw); ii) the non-commercial trees with a DBH larger than 15 cm were girdled; iii) all the lianas and bamboos that could affect the rattan growth were eliminated; iv) all the small commercial trees (DBH<20 cm) with a bad form were eliminated.

In the centre of the six 60x70 plots, smaller plots of 30x30 meters have been identified for the measurements: 1) the light, with LICOR quantum sensors, 2) the rattan length, 3) the mortality of the girdled trees. The light measurements were carried out by placing eight LICOR sensors along a planting line, one every four rattans, for a 12-hours period. The subsequent RIL estimation procedure followed what has been described above. The trial has been assessed three times: i. before the shade treatment (August 1996); ii. just after the treatment (October 1996), iii. one year after the treatment (August 1997). The rattan growth and light data of the three repetitions were analysed both by a two way-ANOVA, with treatments and blocks as factors, and by three independent one-way-ANOVA, one for each repetition.

Environmental variability and rattan growth

This series of observations was carried out between 1995 and 1996 on a *C. subinermis* stand planted in 1991. One hundred sampling points were established over a compartment of about 150 ha. A stratified sampling (where, in order to avoid over-representation of very shaded situations, we established two strata of canopy opening), and a random sampling within each layer were used to draw the position of each point. The centre of each plot was established on the middle line among the two rattan lines. In each sampling point we measured:

- the length [LEN] and the survival of the two nearest rattans.

- the slope [SLO], the bearing [BEA], the aspect [ASP].

- the light, with the help of pictures taken by a Fish-eye [SH1] and read by digital scanning.

- the soil conditions (we described three horizons: Ao [SOM], A1 [SOA] and B [SOB]).

- the forest type [FOR], the percentage of dipterocarps [DIP], other timbers (OT) and pioneer trees (100-DIP-OT).

- the species, the diameter and the distance (from the centre of the sampling point) of each trees within a circle of 10 m radius.

From the point n. 6 of above, we calculated: the number of trees/ha (NT), the basal area/ha (BA) and a competition index (CI) calculated, for each plot, as:

$$CI=\sum(\text{diam}_i / \text{dist}_i),$$

where diam_i and dist_i were respectively the diameter and the distance from the centre of the plot of each ith tree within the sampling circle (Steneker & Jarvis 1963). This arbitrary index allows weighting the competition given by a neighbour tree according to its diameter and distance from the rattan. The nearer and larger the tree, the larger its weight on the CI, and vice versa.

The relationships among rattan growth and the environmental factors have been studied by linear regression and factorial correspondence analysis (SAS 1996).

RESULTS

Effect of light on rattan growth in the nursery

For all the species, significant different responses (at the 0.01% risk level) to light treatments in the nursery were detected. The repetition effect was in general not significant, except for *C. ornatus*. The average shoot length of each species under each RLI treatment is shown in Table 1.

Table 1. Response of rattan seedlings to different shade regimes, 8 and 12 months after transplanting. Shoot length, measured (in cm) from the base of the collar to the last leaf insertion.

8 MONTHS AFTER TRANSPLANTING	*C. ornatus*	*C. merrillii*	*C. manan*	*C. subinermis*
RLI=61%	10.9 a*	12.7 a	5.6 c	9.8 a
RLI=42%	10.0 b	11.2 b	6.5 b	9.4 a
RLI=22%	11.5 a	10.0 c	10.4 a	10.4 B
LSD	*0.6*	*0.6*	*0.7*	*0.5*

1 YEAR AFTER TRANSPLANTING	*C. ornatus*	*C. merrillii*	*C. manan*	*C. subinermis*
RLI=61%	18.1 a*	21.1 a	9.8 a	17.4 a
RLI=42%	15.9 b	15.6 b	10.2 a	14.7 b
RLI=22%	14.8 c	14.6 c	14.5 b	14.4 b
LSD	*0.8*	*1.0*	*1.2*	*0.6*

Note: * Duncan ranking (two treatments are significantly different if they have a different letter). LSD: Least significant difference among two treatments.

It is interesting to note the differences among species and among assessments. *C. manan* clearly grew better under low light intensities, while *C. merrillii* preferred more light. The gain in growth under the best treatment was of 48% for *C. manan* and 45% for *C. merrillii*. For *C. ornatus* and *C. subinermis*, the light requirements seemed to evolve through time: at the first assessment these species did better under low light, while later they required more abundant light.

Effect of light on rattan growth in the field: shade adjustment

The girdling of all the adult non-commercial trees has been quite effective in our experiment, gradually killing about 80% of the treated trees (most of the trees died within a six months period). As it can be seen in Figure 1, the death of the girdled trees brought a major change in the light percentage reaching the soil (and hence the young rattans). By contrast, cutting the small non-commercial trees, the small commercial trees with a bad form and lianas and bamboo, did not have a very significant effect on the canopy opening.

On average, the RLI at the seedling level before the shade adjustment treatment was of only 3.0% (standard deviation, sd=3.9%); one year after the treatment, the RLI averaged 20.7% (sd=15.4%). The shade adjustment was the most effective in plot n. 2, where the RLI evolved from 2% to 31%.

Concerning rattans, it has to be noted that unfortunately, two plots, A2 and A4 (both treated by shade adjustment) were visited by elephants (November 1996), that destroyed about 10% of the plants. Because of the importance of the damages, we had to discard these plants from subsequent measurement and analysis. The damages concentrated on the tallest rattans; thus the results of these two plots were in some way biaised downward.

A two-way ANOVA on rattan length after treatment, with blocks and treatments as factors, showed that the three repetitions bore significant differences in rattan length among them even before the shade treatment, probably due to the heterogeneous environment conditions. Consequently, the three "repetitions" could not any longer be considered as such. Rather, they were analysed by three independent one-way-ANOVA. Results from this analysis are shown in Table 2. A graphic representation of the evolution of rattan growth before and after the treatment is shown in Figure 2.

Table 2. Effect of shade adjustment on rattan growth, one year after the treatment, as compared to the control. Mean height in centimeters.

	Control[1]	Shade adjustment[1]
Repetition 1	Plot A1: *67.2*	Plot A2: *76.8* [ns]
Repetition 2	Plot A3: *66.6*	Plot A4: *96.8* [*]
Repetition 3	Plot A5: *212.3*	Plot A6: *231.4* [ns]

Note: Significance level of the difference among (1) and (2): ns = not significant; * = 0.10.

The gain in rattan growth obtained by shade adjustment as compared to control was 18% over the whole experiment. The differences among shade adjustment treatment and control were in general not significant at the statistical analysis. One of the main reasons of the lack of significance is that even within repetitions, there were still a lot of variability both in the environment and in the rattan size. However, all the three repetitions showed the same pattern, i.e. rattans respond positively, even if in a low measure, to the increased light. The exclusion of the tall plants destroyed by elephants without doubt lowered the average of the plots 2 and 4, leaving less difference among treatments. Finally it has to be

noted that, at the moment of the experiment, this rattan plantation was already three years old, and many plants had been stagnating for long time at the rosette stage. Probably the rattan response would have been more important had the treatment been applied earlier.

Environmental variability and rattan growth

A standard analysis of variance revealed that the differences in rattan length among the 100 plots were significant at the 0.001 level. Multiple regression among the rattan length and the whole set of the above characters gave a correlation coefficient of 0.48, that means that by mean of the environmental description we are able to predict 23% of the variation in rattan growth. The ranking of the characters according to their correlation with the rattan length was reported in Table 3.

The characters linked to the forest density (BA, NT and DIP), and in particular the Competition Index, were well linked with the rattan growth. The light (SH1) was also related to the growth, but in a minor measure. In general, the lower the competition, the density, the shade and the percentage of dipterocarps, the better the rattan growth. The relationships among rattan growth and BA and CI were represented in Figure 3.

A second group of variables (ASP, SOA, BEA, OT, SLO, SOM and SOB) showed no significant effect on rattan growth. A factorial correspondence analysis (not shown) confirmed this pattern.

The specific contribution of dipterocarp and pioneer trees to the competition index and to the rattan growth has been explored further. Bacilieri *et al.* (in preparation), have shown that competition from dipterocarp trees have a much more important effect on rattan growth than competition from pioneers trees.

Table 3. Correlation coefficients of the measured environmental variables with the rattan growth, and their significance level.

Variables	Correlation with Rattan length	Significance level
CI	-0.45	0.0001
BA	-0.35	0.001
NT	-0.33	0.01
SH1	0.31	0.01
DIP	-0.31	0.01
FOR	0.20	ns
ASP	-0.19	ns
SOA	0.16	ns
BEA	-0.13	ns
OT	0.09	ns
SLO	-0.09	ns
SOM	0.07	ns
SOB	0.01	ns

CONCLUSION

The secondary forest enrichment practice, adding a plus value to forests that have been impoverished by logging, may be interesting both from the economic and social point of view, and for the conservation of the forest itself. However this task is made difficult by the intricate combination of biotic and abiotic factors typical of the tropical natural

forest: competition from surrounding plants, close canopy covers, steep slopes, low nutrient contents and high environment variability often intrinsic to marginal lands, etc.

In this situation, our experiments allowed us to better understand the plants and plantation requirements. First, it appeared that the two major elements playing a role on rattan growth in the enrichment plantation were the light and the competition from surrounding trees, while we were not able to detect any effect by other factors as slope, topography and soil composition.

Furthermore, the study of the effect of environment variation on rattan growth showed that competition from surrounding trees (especially dipterocarps) was more important than the effect of light. One reason for this may be that light is a difficult-to-measure parameter, because of: a) its variation along the year, b) the difficulty to know which radiation length is most used by the plant, c) the difficulty to measure the diffuse radiation, etc. Another important reason may be that competition, in addition to the light effect, may summarise also other effects due to competition for nutrients, water and space availability, etc.

Figure 3 may be seen as an indication that there is a threshold in stand density (around 25 m^2 of basal area) and competition (CI=125) beyond which the rattan can not grow (we recall that the rattans were planted, in this compartment, 5 years before our observations). Below this threshold there is still much to do to improve the rattan growth; however, it is not worth to plant where the stand is denser. The gain in rattan growth that, in the Luasong's conditions, can be achieved by selecting the forest stands to be planted according to their density is given in Table 4. Another way to see these results is to consider the capital that can be saved by not planting the points were the stand is too dense and the rattan growth is expected to be poor.

Table 4. Percentage of gain in rattan growth that can be achieved, in the Luasong conditions, by selecting the points to be planted according to their density. Also given are the percent of sampling points that had a given density and their mean rattan length. Rattan should not be planted in forest compartments or sub-blocks with a basal area exceeding 25 m^2 (in our sample, 34% of the sampling points have a basal area superior to 25 m^2). A gain in the rattan growth of 32% may be predicted if these points were avoided.

Sampling Point Basal Area	Mean rattan length at that given Basal Area	% of improvement compared to the general mean of the compartment	% of sampling points falling in this category
lower than 15 m^2	518 m/ha	55	38
lower than 20 m^2	432 m/ha	39	57
lower than 25 m^2	441 m/ha	32	66
lower than 30 m^2	410 m/ha	23	75
lower than 35 m^2	394 m/ha	18	80
lower than 40 m^2	372 m/ha	11	85

Estimating the competition in the forest with a sufficient approximation seems not a very heavy task. In addition, one may consider that on small plots the competition index and basal area are tightly correlated, and that measuring the local basal area with classical methods (both in the field or by using aerial photos) can give good estimation of the local competition.

A procedure to mark, before planting, the point to be planted according to the forest density has already been tested and has shown feasible. In practice, a trained forest ranger walks along the lines and labels the points to be planted; the workers then follow with the plantation operation. On a larger scale, the aerial photo interpretation can discriminate among compartments according to their suitability for planting.

The light experiments also gave useful information. The result of the nursery experiment will allow to apply light treatments specific to each species. Furthermore, even if the light requirements may evolve during life stages, some rattan species appeared to be more shade tolerant than others. The plantation can thus tune the species distribution in the field by matching the species light requirements with the compartment characteristics.

In spite of the problems of the experimental design and of the damages in the shade adjustment experiment, it has been possible to demonstrate that rattans respond positively to canopy manipulation. A better response might be expected if the treatment was applied earlier than in our case, just after plantation. Shade adjustment may profit, by the way, to other valuable tree species in the forest. Its cost/benefit balance is now under evaluation at Luasong.

The combination of the information on competition and light effect helps to optimise the rattan plantation technique. An accurate choice of the compartments and points to be planted, together with appropriate shade adjustments, may significantly improve the rattan performances in the ICSB's commercial plantation.

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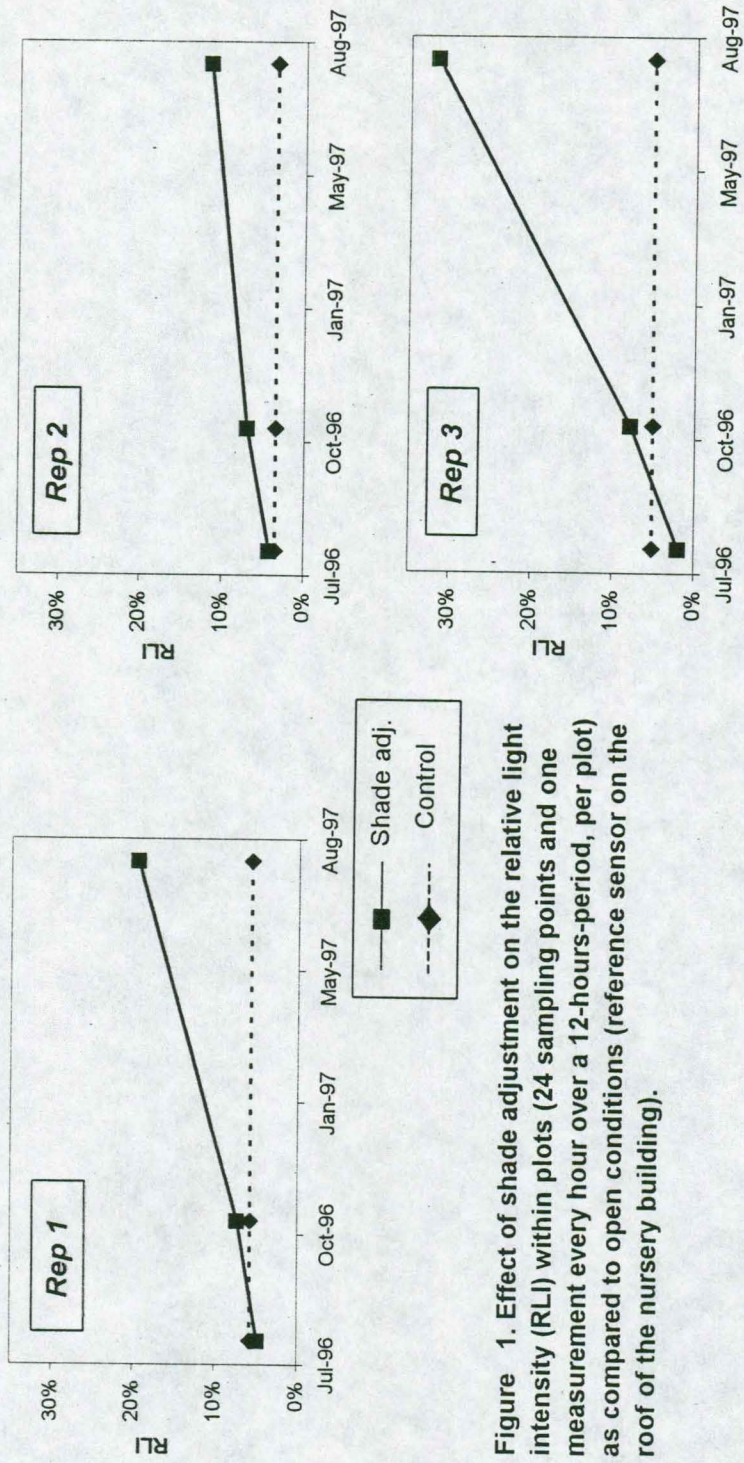
Figure 1. Effect of shade adjustment on the relative light intensity (RLI) within plots (24 sampling points and one measurement every hour over a 12-hours-period, per plot) as compared to open conditions (reference sensor on the roof of the nursery building).
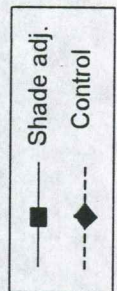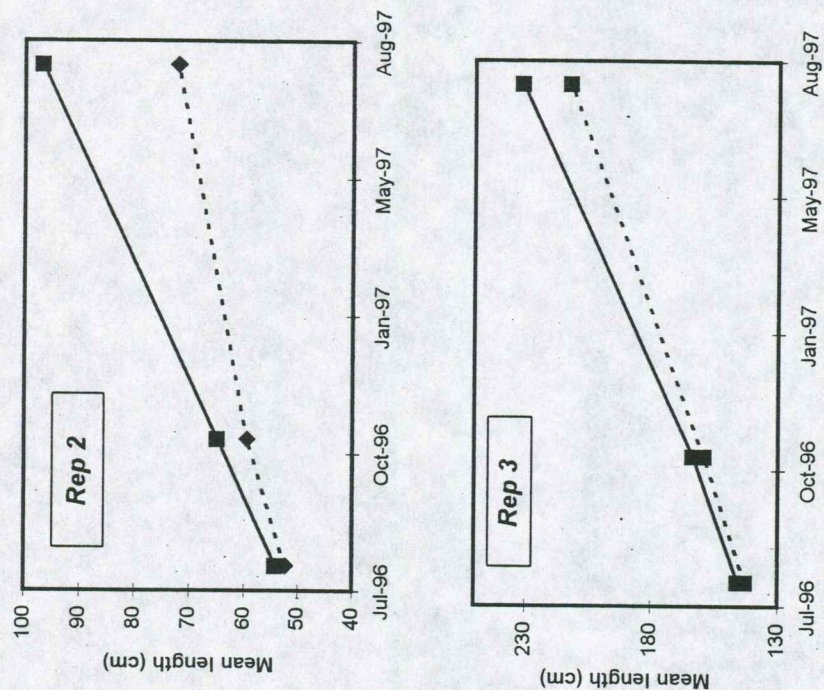
Figure 2. Effect of shade adjustment, as compared to control, on rattan growth. Means for each plot (control and treatment) within each repetition (1, 2 and 3).
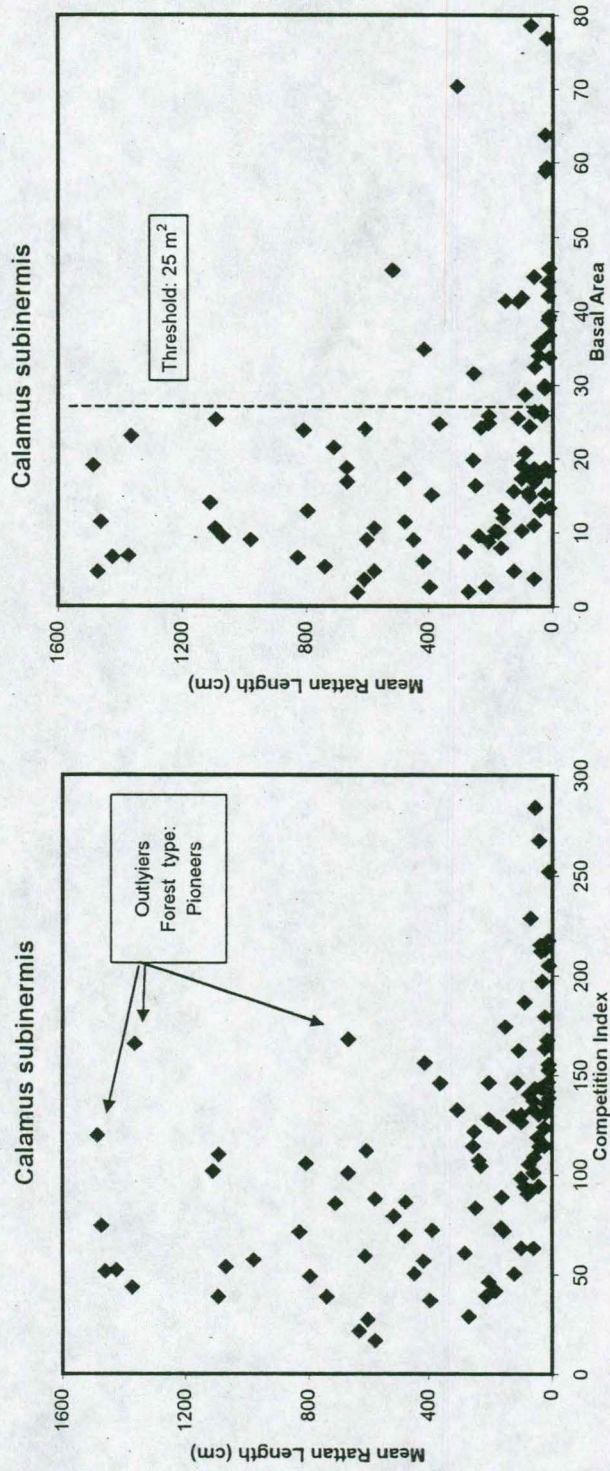
Figure 3. Relationships among rattan length growth and two forest descriptors, the basal area and the competition index. The relationship with CI is improved if only the dipterocarp trees are considered.

HARVESTING TRIAL OF 8 YEARS OLD *Calamus caesius* (rotan sega) AT LUASONG FORESTRY CENTRE

David Alloysius
Plant Improvement & Seed Production (PISP)
February 1998

INTRODUCTION

Calamus caesius or rotan sega is one of rattans that being planted at Luasong Forestry Centre's plantation (LFCP). Rotan sega dominated about 70% of the total planted area of almost 11,000 ha (as December 1997), thus could be considered as a major species for LFCP. The oldest rotan sega in LFCP is about 8 years old (planted in early 1990), and it should due for harvesting, according to several assumptions (LFC Financial Appraisal, Wan Razali *et. al.* 1992). In January 1998, a harvesting trial was planned for the oldest block, with the objective of determining the actual yield per hectare. Four sampling plots of 1 ha each were demarcated, and selective harvesting was planned according to certain criteria.

This paper serves as a preliminary report, which describes the results from the first 1-ha plot.

MATERIAL AND METHOD

Detail of sampling plot

> Sub-block 217A, Luasong Forestry Centre Plantation
> Field planting was made in January to February 1990
> Sampling plot size was 1 ha (100m x 100m)

Harvesting

The harvesting teams consisted of Forest Rangers and casual labourers. They were instructed to harvest any cane with minimum estimated stem length of 20 feet. The canes were debarked (removed of sheath) *in-situ,* and transported to the river for washing.

Processing

The canes were cleaned by rubbing the surface with normal kitchen span, inside running river water. The wet canes were fumed with sulphur dioxide over-night and dried under sun for about two weeks.

Grading

There were two steps in grading. The first grading was done to separate good-grade and the inferior-grade cane. Good-grade canes possessed a yellowish surface, heavier and minimal or no shrinkage. Canes were classified as inferior-grade when they suffered high shrinkage rate, as a result of losing high amount of water. The first grading was actually

to separate mature canes with immature canes. There were few canes rejected due to defects but the amount is negligible.

The second grading was to separate the good-grade canes according to diameter size. Two size categories were used:

> Below 7 mm and
> 7 mm and above.

Although the current usable diameter limit was not known, but we assumed that the range is between 7 – 12 mm.

Measurement

The length of canes were measured using 30m measuring tapes, to provide the following parameters:

> Total stem length (gross length after drying)
> Total good-grade length (length of good cane)
> Total length of good-grade cane with diameter < 7mm
> Total length of good-grade cane with diameter of 7mm and above.

The weight of the canes were measured using 100kg balancing machine, to give the following parameters:

> Weight of inferior-grade canes (rejected after first grading)
> Weight of good-grade cane
> Weight of good-grade cane with diameter <7 mm
> Weight of good-grade cane with diameter of 7 mm and above.

Indexes to convert length (m) to weight (ton) were calculated for good-grade canes and its two diameter classes.

RESULTS

The total length of stem extracted from the plot was 8,455 m. Out of this, only 3,110 m was good-grade or mature. The weight of the good-grade canes was 65 kg and the inferior-grade canes was about 92 kg. This cumulated the total gross weight to152 kg or 0.15 ton.

Canes with diameter < 7mm contributed about 41% of the weight of good-grade canes. This category is normally classified as under-sized cane, therefore would fall under different price category. The index to convert length to dry weight was calculated as 47851. This means that 47,851 m of canes are needed to produce one ton of good-grade cane. The summary of the important result is presented in Table 1.

Table 1. Measured parameters of good-grade cane from 1 ha plot at LFCP

Parameters	Whole length (usable)	< 7 mm	≥7 mm
Stem length (m)	3110	1457	1653
Weight (kg)	65	27	38
Conversion index	47851	53963	43509

DISCUSSION

The gross yield of 0.15 ton per ha is relatively low if we compare with the harvesting yield of 0.71 ton per ha from the 0.37 ha plot when preparing the site for the telecommunication building (Alloysius 1996). Several possibilities could explain this variation:

1. The current harvesting was a selective harvesting with certain stem length limit, whereas harvesting in the telecommunication site was blanket harvesting

2. The cane weight of the current harvesting was based on real measurement using weighing machine. The yield from the telecommunication site was estimated by conversion of length-weight commonly used by several authors (Wan Razali *et. al*. 1992). The conversion was 36,000 m to make a ton of dried cane. If we adopt the conversion index that we derived from the current data (47851), the yield from the telecommunication site is decreased to about 0.53 ton per ha.

3. The current harvesting trial was done in an area which planting method is single row, whereas the study in the telecommunication site was a double-row planting method. Theoretically the double-row planting method should increase the rattan growth rate, therefore more yield is expected from the area .

These reasoning also explains the variation in the net yield (good-grade cane) from the two study cases (current study = 0.065 ton/ha, telecommunication = 0.14 ton/ha).

The current harvesting data could be used as a guideline for management to decide the running and future direction of the LFCP project. As a matter of analyzing, we conservatively assume that:

1. The current market price of processed cane of sega (dried & sulfured) is RM2,500 per ton,

2. The inferior-grade canes could be sold half the price of the usable canes i.e. RM1,250 per ton,

3. Canes with diameter less than 7 mm could fetch three-quarter of the market price i.e. RM1,875 per ton and

4. This 1-ha plot is the average reflection of all area planted with rotan sega at LFCP.

3

Therefore the expected yield in money-term from first harvesting of 8 years old rotan sega would be:

$$(0.092 \times 1,250) + (0.027 \times 1,875) + (0.038 \times 2,500) = \textbf{RM192.50 per ha}$$

Even if we assume that all the harvested canes are of the highest grade (RM2,500 per ton), the amount that we could expect would be only **RM375 per ha**, which is still low for such a long rotation crop. Of course we have to deduct several costs like harvesting and processing to this amount, in order to reflect the actual net income.

Rotan sega is a multiple-cane species, therefore second and subsequent harvests could be expected in the future but the timing is not known. I personally feel that the rattans need time to recover and to reproduce, especially with the disturbance that had been created during harvesting. We recommend to maintain this sample plot for future harvesting, and to observe the response of the plants upon multiple harvest.

CONCLUSION

The result from this harvesting trial indicated that the earlier assumption suggesting 8 years as a good age for harvesting for planted rotan sega is questionable, at least for LFCP case. This assumption could still be used if the yield assumption of 0.5 – 1 ton per ha is revised according to the finding of this trial.

Hopefully we could produce more meaningful results after the completion of the next sampling plots.
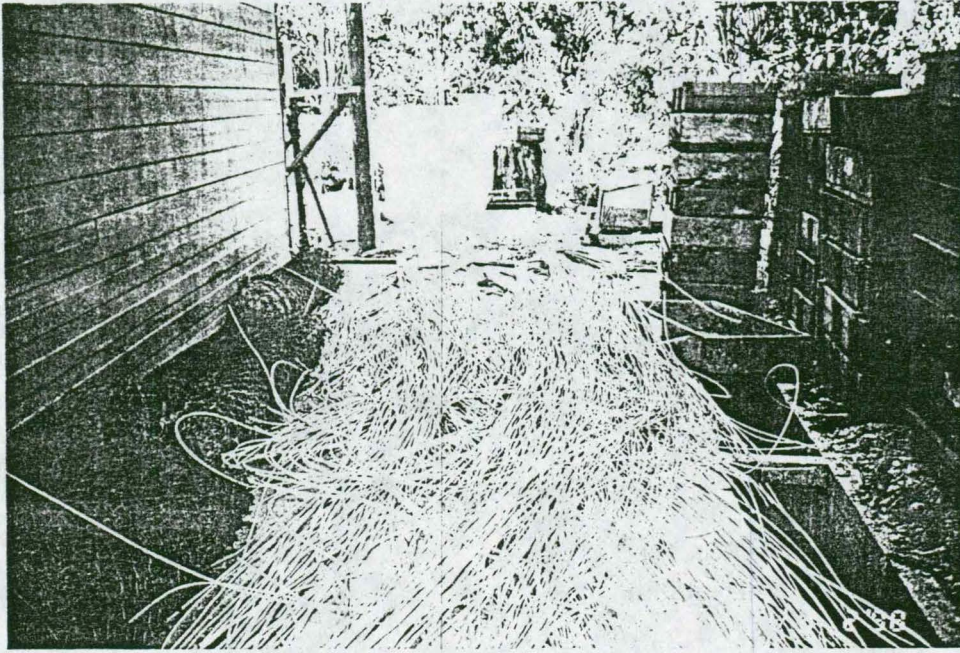
Photo 1. Processed cane of *Calamus caesius* harvested from 1ha sampling plot at LFC plantation
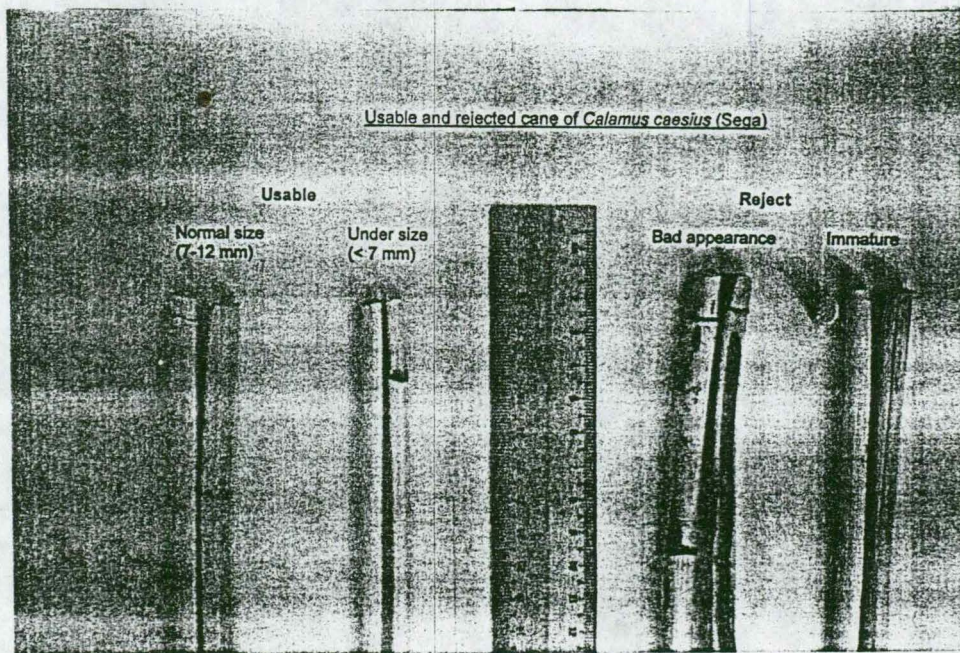
Photo 2. Classification of canes according to quality (appearance & maturity) and diameter size

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SURVEY OF PESTS ON *Calamus caesius* IN LUASONG PLANTATION

James Rubinsin Kotulai
Forest Pest & Disease Control Unit

INTRODUCTION

Rakyat Berjaya Sdn. Bhd. has been actively planting several commercial rattan species since 1990 at Luasong Forestry Centre. To date, over 11,000 ha has been planted with *Calamus caesius*, *C. manan*, *C. subinermis*, *C. ornatus* and *C. merillii*. Of that planted area, a total of 178 sub-blocks covering an area of 6,381.78 ha have been planted with *C. caesius*.

In March 1997, one of the PISP rattan trial plots inside the project area was found being severely attacked by insects, which fed on the young shoot. To verify the status of damage in the other blocks within the plantation, a survey was conducted in April 1997 for all the blocks planted with *C. caesius*.

Due to time constraint, the first survey was not able to record a sufficiently representative number of clumps or stems planted in each sub-block. Therefore, to verify the results of the first survey by taking more clumps and stems, a second survey was conducted in September 1997. This exercise was also meant to check the status of infestation in the plantation.

In January 1998, a decision was made to carry out harvesting trial on the oldest *C. caesius* stands in Sub-block 217A, planted in early 1990. The main objective of the trial was to determine the actual yield per hectare of an 8-year old rotan sega plantation. In the studies, four plots of 1 ha each were harvested. During the harvesting of the third plot in February, the Forest Pest & Disease Control Unit was involved to record any infestation on the harvested canes. This paper presents the results of all the exercises carried out on *C. caesius*.

MATERIAL AND METHODS

Pests Survey

In the survey, only one sub-block from each block was surveyed to represents a particular block. At the time of survey, a total of 45 blocks were either whole or partially planted with *C. caesius*.   In each sub-block, a team of three or five persons, depending on the available manpower, were send for inspection throughout the area. A number of rattan clumps were carefully observed and recorded for infestation. The number of infested stems per clump, parts infested, freshness of attacks and agent of pests were also recorded.

Harvesting Trial

In the harvesting trial, it was decided that all the canes with a minimum stem length of 20 feet have to be harvested within the 1 ha plot. During the exercise, the harvesting team was divided into few groups and due to commitment in other equally important and urgent activities, the P & D Unit has only been able to sent two casual labourers to participate in the harvesting of the third plot in February 1998. For the purpose of pest assessment, all the harvested canes were observed for possible infestation. The total canes recorded by the P & D Unit, however, would not represent the overall harvested canes from the third plot as we have only monitored two out of the three harvesting groups.

RESULTS

1st Survey

4,535 clumps were sampled from the all 45 sub-blocks. Out of that total, 2,031 or 45% clumps have more than two stems infested. The most seriously infested sub-blocks were 216A, 217A, 241B, 239B, 207A and 229A with infestation rate of 95.00, 92.31, 82.35, 80.72, 79.13 and 78.75%, respectively (Table 1).   Of the 16,997 infested stems, 3,771 (22.19%) were infested in sub-blocks 234A, 216A and 233D. These three subblocks were the ones with the highest infestation rate: 49.18, 49.13 and 47.00%, respectively.

It is obvious that for the insects, the shoot is the most preferred portion of the rattan stand. In the survey, 66% of the attacks was found at the upper portion of the rattan stems (Table 2).

2

It was found that 84% of the damages that affected the 3,771 stems was due to 'old attacks'; pest agents are thought to be no longer present in the sub-block during the survey period.

Throughout the survey, insects were identified to be the major cause of damage, followed by mammals (squirrels or possibly rats) with an incidence of 46.33 and 32.27%, respectively (Table 3). Other pests, such as porcupine, elephant and monkey as well as mortality due to negligence during maintenance works were recorded to be minor.

The scarab beetles of the genus *Chalcosoma* has been frequently found feeding on the shoots. Throughout the survey, other beetles were also found on the rattan shoots, among which; snout beetle, (family Curculionidae), primitive or straight-snouted weevil, (family Brentidae), leaf beetle, (family Chrysomelidae).

Injuries to the rattan canes caused by squirrels or possibly rats were often noticed. These mammals use to cut and eat the upper part of the stems or shoots.

2nd Survey

In the 1st survey in April 1997, six sub-blocks (sub-blocks 207A, 216A, 217A, 229A, 239B and 241B) recorded infestation rate of more that 79%. However, the samples collected were too small and could not represent the actual total planted rattan in that sub-blocks. Therefore, a 2nd survey was conducted to verify the results of the 1st survey.

At the 2nd survey, within the all 6 sub-blocks planted with *C. caesius* we observed 7,511 clumps. Out of that total, 2,221 (30%) clumps had more than one stems being infested. The most seriously infested sub-blocks were 217A and 216A with 89 and 69%, respectively (Table 4).

Out of 31,506 rattan stems recorded (Table 5), only 4,943 (16%) were infested. In the survey, sub-block 207A was the most attacked (38%) followed by sub-blocks 216A and 217A with 18 and 17%, respectively. Of the 4,943 infested stem, only 34 found to be new attacks (Table 6). Once again, insect of the group beetles were identified to be the major pest (Table 7)

Harvesting Trial

A total of 177 canes out of 65 clumps were extracted. This figure, however, did not represent the total harvest from this 1 ha plot as we only monitored two of the three harvesting groups. Out of the 65 clumps harvested, 30 clumps (46.15%) were infested. Of the 177 canes extracted, 77 (43.50%) were infested mostly by insect. There was no fresh infestation recorded.

DISCUSSION AND RECOMMENDATION

Infestation of insect pests and particularly beetles on rattan in Sabah has been recorded previously. At Sejati Plantation in Telupid, SAFODA rattan plantation in Batu Putih and Poring Hot Spring Ranau, infestation of beetles (particularly the three-horned beetles) on rattan was found to be common (Chung, 1994).

From the 1st survey it was found that the beetle infestation was not progressing. Based on our observations on the infested canes which categorized as *old attacks*, the infestation occurred probably before middle of 1996 and the pests population has not been building up since then. The reasons for such sudden disappearance of pests in the rattan plantation are not known. However, in any ecosystem, migration is normal for particular organisms to search and compete for foods. In the case of our rattan plantation, the production of new shoots, which most probably is concentrated during the raining season in March through June every year has attracted pests particular insects of the group beetle. Because of the abundance of foods, population reproduction become faster and thus caused greater damage to the rattan plantation. Due to the high reproduction rate of the beetles, the their population density at larval stage became abundant which caused another migration of natural enemies such as parasites and predators. Maybe, the built up of natural enemies' populations has caused the drastic disappearance of the beetle pest.

The 2nd survey in September 1997 and then the harvesting trial in February 1998 have given us further assurance that there is almost no fresh infestation in the plantation. However, to be more cautious, continuous checking on possible pest outbreaks is necessary. In this regard, similar survey at intervals of at maximum one year should be carried out for each planted species.

The attack has the characteristic to destroy the shoot; later the sucker will root downward and then die off. However the rotting process does not take place at least for the next six months after the infestation. Chemical control of pests is both ineffective and costly in rattan line-planting. Therefore, the only way to salvage the infested rattans is to conduct a selective harvesting.

REREFENCE

Chung, A.Y.C. 1994. Insect Pests of Rattans in Sabah. Forest Research Centre, Sepilok.

Table 1: Total infestation on *C. caesius* in the 1st survey

Sub-Block	YOP	Total Clump	Infested Clump		Total Stem	Infested Stem	
			Total	%		Total	%
194D	1992	190	92	48.42	563	152	27.00
195C	1992	30	1	3.40	137	3	2.19
196B	1992	60	15	25.00	221	22	9.95
197B	1992	140	60	42.85	395	93	23.54
199E	1992	108	46	42.59	216	66	30.56
200B	1991	120	68	56.70	510	107	20.98
201A	1991	100	59	59.00	247	82	33.20
202A	1991	80	29	36.25	580	49	8.45
203C	1991	74	39	52.70	650	69	10.62
204B	1991	76	25	32.89	143	24	16.78
205E	1991	289	94	32.53	803	114	14.20
206I	1991	196	104	53.06	1,316	283	21.50
207A	1991	115	91	79.13	505	225	44.55
208A	1991	100	26	26.00	394	40	10.15
209G	1991	86	53	61.63	627	124	19.78
210A	1992	157	65	41.40	420	87	20.71
211B	1992	175	69	39.43	334	77	23.05
214C	1991	166	62	37.35	450	99	22.00
215B	1991	69	46	66.70	428	87	20.33
216A	1990	60	57	95.00	458	225	49.13
217A	1990	13	12	92.31	205	50	24.39
218D	1992	123	69	56.18	371	97	26.15
219D	1992	31	7	22.58	154	14	9.09
227D	1991	80	27	33.75	277	32	11.55
228B	1990	60	25	41.70	363	42	11.57
229A	1990	80	63	78.75	263	94	35.74
230A	1991	47	35	74.47	393	67	17.04
231A	1992	65	21	32.31	127	37	29.13
232D	1992	46	7	15.22	452	57	12.61
233D	1992	66	40	60.61	217	102	47.00
234A	1992	82	52	63.41	427	210	49.18
235C	1993	160	69	43.13	504	88	17.46
237A	1993	84	56	66.70	243	102	41.98
239B	1993	83	67	80.72	375	105	28.00
240A	1993	100	48	48.00	256	62	24.22
241B	1993	85	70	82.35	200	91	45.50
243D	1993	100	50	50.00	349	74	21.20
244B	1993	120	48	40.00	409	73	17.85
246D	1996	65	29	44.62	210	36	17.14
247B	1993	88	48	54.55	445	80	17.98
250B	1993	116	56	48.28	532	146	27.44
251A	1993	131	14	10.69	188	15	7.98
309C	1994	160	33	20.63	283	40	14.13
310C	1994	71	19	26.76	228	22	9.65
311E	1994	88	7	7.97	129	7	5.43
TOTAL		4,535	2,031	44.79	16,997	3,771	22.19

YOP = year of planting

Table 2: Parts and freshness of infestation on *C. caesius* in the 1st survey.

Sub-Block	YOP	Total Infested Stem	Parts infested				Freshness of attacks			
			Stem	%	Shoot	%	New	%	Old	%
194D	1992	152	45	29.61	107	70.39	25	16.45	127	83.55
195C	1992	3	2	66.67	1	33.33	2	66.67	1	33.33
196B	1992	22	7	31.82	15	68:18	0	0.00	22	100
197B	1992	93	24	25.81	69	74.19	15	16.12	78	83.87
199E	1992	66	35	53.03	31	46.96	13	19.69	53	80.30
200B	1991	107	50	46.73	57	53.27	18	16.82	89	83.18
201A	1991	82	20	24.39	62	75.61	1	1.22	81	98.78
202A	1991	49	19	38.78	30	61.22	0	0.00	49	100
203C	1991	69	13	18.84	56	81.16	0	0.00	69	100
204B	1991	24	2	8.30	22	91.70	7	29.17	17	70.83
205E	1991	114	52	45.61	62	54.39	12	10.53	102	89.47
206I	1991	283	122	43.11	161	56.90	18	6.36	265	93.64
207A	1991	225	27	12.00	198	88.00	37	16.45	188	83.55
208A	1991	40	18	45.00	22	55.00	5	12.50	35	87.50
209G	1991	124	27	21.77	97	78.23	11	8.87	113	91.13
210A	1992	87	40	45.98	47	54.02	12	13.79	75.	86.21
211B	1992	77	36	46.75	41	53.25	0	0.00	77	100
214C	1991	99	31	31.31	68	68.69	43	43.43	56	56.56
215B	1991	87	25	28.74	62	71.26	3	3.45	84	96.55
216A	1990	225	23	10.22	202	89.78	2	0.89	223	99.11
217A	1990	50	25	50.00	25	50.00	2	4.00	48	96.00
218D	1992	97	31	31.96	66	68.04	22	22.86	75	77.32
219D	1992	14	2	14.29	12	85.71	8	57.14	6	42.86
227D	1991	32	19	59.38	13	40.63	0	0.00	32	100
228B	1990	42	15	35.71	27	64.29	2	4.76	40	95.24
229A	1990	94	50	53.19	44	46.91	14	14.89	80	85.11
230A	1991	67	20	29.85	47	70.15	1	1.49	66	98.51
231A	1992	37	22	59.46	15	40.54	13	35.14	24	64.86
232D	1992	57	25	43.86	32	56.14	2	3.51	55	56.49
233D	1992	102	12	11.76	90	88.24	0	0.00	102	100
234A	1992	210	17	8.09	193	91.90	169	80.48	41	19.52
235C	1993	88	17	19.32	71	80.68	11	12.50	77	87.50
237A	1993	102	46	45.05	56	54.90	29	28.43	73	71.57
239B	1993	105	73	69.52	32	30.48	13	12.38	92	87.62
240A	1993	62	32	51.61	30	48.39	13	20.97	49	79.03
241B	1993	91	18	19.78	73	80.22	26	28.57	65	71.43
243D	1993	74	40	54.05	34	45.95	12	16.22	62	83.78
244B	1993	73	47	64.38	26	35.62	0	0.00	73	100
246D	1996	36	15	41.67	21	58.33	0	0.00	36	100
247B	1993	80	37	46.25	43	53.75	0	0.00	80	100
250B	1993	146	64	43.83	82	56.16	37	25.34	109	74.66
251A	1993	15	0	0.00	15	100	0	0.00	15	100
309C	1994	40	20	50.00	20	50.00	4	10.00	36	90.00
310C	1994	22	10	45.45	12	54.55	0	0.00	22	100
311E	1994	7	1	14.29	6	85.71	5	71.43	2	28.57
TOTAL		3,771	1,276	33.84	2,495	66.16	607	16.10	3,164	83.90

YOP = year of planting

Table 2: Parts and freshness of infestation on *C. caesius* in the 1st survey.

Sub-Block	YOP	Total Infested Stem	Parts infested				Freshness of attacks			
			Stem	%	Shoot	%	New	%	Old	%
194D	1992	152	45	29.61	107	70.39	25	16.45	127	83.55
195C	1992	3	2	66.67	1	33.33	2	66.67	1	33.33
196B	1992	22	7	31.82	15	68.18	0	0.00	22	100
197B	1992	93	24	25.81	69	74.19	15	16.12	78	83.87
199E	1992	66	35	53.03	31	46.96	13	19.69	53	80.30
200B	1991	107	50	46.73	57	53.27	18	16.82	89	83.18
201A	1991	82	20	24.39	62	75.61	1	1.22	81	98.78
202A	1991	49	19	38.78	30	61.22	0	0.00	49	100
203C	1991	69	13	18.84	56	81.16	0	0.00	69	100
204B	1991	24	2	8.30	22	91.70	7	29.17	17	70.83
205E	1991	114	52	45.61	62	54.39	12	10.53	102	89.47
206I	1991	283	122	43.11	161	56.90	18	6.36	265	93.64
207A	1991	225	27	12.00	198	88.00	37	16.45	188	83.55
208A	1991	40	18	45.00	22	55.00	5	12.50	35	87.50
209G	1991	124	27	21.77	97	78.23	11	8.87	113	91.13
210A	1992	87	40	45.98	47	54.02	12	13.79	75	86.21
211B	1992	77	36	46.75	41	53.25	0	0.00	77	100
214C	1991	99	31	31.31	68	68.69	43	43.43	56	56.56
215B	1991	87	25	28.74	62	71.26	3	3.45	84	96.55
216A	1990	225	23	10.22	202	89.78	2	0.89	223	99.11
217A	1990	50	25	50.00	25	50.00	2	4.00	48	96.00
218D	1992	97	31	31.96	66	68.04	22	22.86	75	77.32
219D	1992	14	2	14.29	12	85.71	8	57.14	6	42.86
227D	1991	32	19	59.38	13	40.63	0	0.00	32	100
228B	1990	42	15	35.71	27	64.29	2	4.76	40	95.24
229A	1990	94	50	53.19	44	46.91	14	14.89	80	85.11
230A	1991	67	20	29.85	47	70.15	1	1.49	66	98.51
231A	1992	37	22	59.46	15	40.54	13	35.14	24	64.86
232D	1992	57	25	43.86	32	56.14	2	3.51	55	56.49
233D	1992	102	12	11.76	90	88.24	0	0.00	102	100
234A	1992	210	17	8.09	193	91.90	169	80.48	41	19.52
235C	1993	88	17	19.32	71	80.68	11	12.50	77	87.50
237A	1993	102	46	45.05	56	54.90	29	28.43	73	71.57
239B	1993	105	73	69.52	32	30.48	13	12.38	92	87.62
240A	1993	62	32	51.61	30	48.39	13	20.97	49	79.03
241B	1993	91	18	19.78	73	80.22	26	28.57	65	71.43
243D	1993	74	40	54.05	34	45.95	12	16.22	62	83.78
244B	1993	73	47	64.38	26	35.62	0	0.00	73	100
246D	1996	36	15	41.67	21	58.33	0	0.00	36	100
247B	1993	80	37	46.25	43	53.75	0	0.00	80	100
250B	1993	146	64	43.83	82	56.16	37	25.34	109	74.66
251A	1993	15	0	0.00	15	100	0	0.00	15	100
309C	1994	40	20	50.00	20	50.00	4	10.00	36	90.00
310C	1994	22	10	45.45	12	54.55	0	0.00	22	100
311E	1994	7	1	14.29	6	85.71	5	71.43	2	28.57
TOTAL		3,771	1,276	33.84	2,495	66.16	607	16.10	3,164	83.90

YOP = year of planting

Table 3: Agents of pest on *C. caesius* in the 1st survey.

Sub-Block	YOP	Total Infested Stem	Pest					
			Insect	%	Squirrel	%	Others	%
194D	1992	152	60	39.47	67	44.08	25	16.45
195C	1992	3	2	66.67	0	0.00	1	33.33
196B	1992	22	13	59.09	1	4.55	8	36.36
197B	1992	93	70	75.26	0	0.00	23	24.73
199E	1992	66	31	46.96	2	3.03	33	50.00
200B	1991	107	40	37.38	45	42.06	22	20.56
201A	1991	82	45	54.88	25	30.49	12	14.63
202A	1991	49	26	53.06	22	44.90	1	2.04
203C	1991	69	28	40.58	15	21.74	26	37.68
204B	1991	24	17	70.83	3	12.50	4	16.70
205E	1991	114	53	46.50	32	28.07	29	25.44
206I	1991	283	129	45.58	125	44.17	29	10.25
207A	1991	225	70	31.11	120	53.33	35	15.55
208A	1991	40	9	22.50	15	37.50	16	40.00
209G	1991	124	117	94.35	0	0.00	7	5.65
210A	1992	87	51	58.62	6	6.89	30	34.48
211B	1992	77	30	38.96	9	11.69	38	49.35
214C	1991	99	43	43.43	21	21.21	35	35.35
215B	1991	87	28	32.18	49	56.32	10	11.49
216A	1990	225	102	45.33	85	37.78	38	16.89
217A	1990	50	25	50.00	22	44.00	3	6.00
218D	1992	97	49	50.52	25	25.77	23	23.71
219D	1992	14	5	35.71	1	7.14	8	57.14
227D	1991	32	0	0.00	19	59.38	13	40.63
228B	1990	42	21	50.00	17	40.48	4	9.52
229A	1990	94	63	67.02	28	29.79	3	3.19
230A	1991	67	17	25.37	27	40.29	23	34.33
231A	1992	37	20	54.05	9	24.32	8	21.62
232D	1992	57	9	15.79	16	28.07	32	56.14
233D	1992	102	77	75.49	3	2.94	22	21.57
234A	1992	210	86	40.95	94	44.76	30	14.29
235C	1993	88	38	43.18	39	44.32	11	12.50
237A	1993	102	53	51.96	37	36.29	12	11.76
239B	1993	105	11	10.48	57	54.29	37	35.24
240A	1993	62	32	51.61	15	24.19	15	24.19
241B	1993	91	49	53.85	38	41.76	4	4.39
243D	1993	74	25	33.78	24	32.43	25	33.78
244B	1993	73	24	32.88	24	32.88	25	34.25
246D	1996	36	0	0.00	28	77.78	8	22.22
247B	1993	80	24	30.00	30	37.50	26	32.50
250B	1993	146	100	68.49	21	14.38	25	17.12
251A	1993	15	14	93.33	1	6.67	0	0.00
309C	1994	40	25	62.50	0	0.00	15	37.50
310C	1994	22	15	68.18	0	0.00	7	31.82
311E	1994	7	1	14.29	0	0.00	6	85.71
TOTAL		3,771	1,747	46	1,217	32.27	807	21.40

YOP = year of planting

Table 4: Total Infestation on *C. caesius* in the 2nd survey and harvesting trial (figure in the parenthesis is for harvesting trial).

Sub-Block	YOP	Total Clump	Infested Clump		Total Stem	Infested Stem	
			Total	%		Total	%
207A	1991	439	391	*89.07*	2838	1075	*37.88*
216A	1990	1251	865	*69.14*	13121	2359	*17.98*
217A	1990	1197 (65)	379(30)	*31.66(46.15)*	3234(177)	563(77)	*17.41(43.50)*
229A	1990	1034	225	*21.76*	2569	225	*8.76*
239B	1993	1590	74	*4.65*	3454	319	*9.23*
241B	1993	2000	287	*14.35*	6290	402	*6.39*
TOTAL		7511	2221	*29.57*	31506	4943	*15.69*

YOP = year of planting

Table 5: Parts and freshness of infestation on *C. caesius* in the 2nd survey and harvesting trial (figure in the parenthesis is for harvesting trial).

Sub-Block	YOP	Total Infested Stem	Parts infested				Freshness of attacks			
			Stem	%	Shoot	%	New	%	Old	%
207A	1991	1075	107	*9.95*	968	*90.05*	19	*1.77*	1056	*98.23*
216A	1990	2359	579	*24.54*	1780	*75.46*	12	*0.51*	2347	*99.49*
217A	1990	563(177)	93(0)	*16.52(0)*	470(77)	*83.48(100)*	3(0)	*0.53(0)*	560(77)	*99.47(100)*
229A	1990	225	19	*8.44*	206	*91.56*	0	*0.00*	225	*100*
239B	1993	319	72	*22.57*	247	*77.43*	0	*0.00*	319	*100*
241B	1993	402	68	*16.92*	334	*83.08*	0	*0.00*	402	*100*
TOTAL		4943	938	*18.98*	4005	*81.02*	34	*0.69*	4909	*99.31*

YOP = year of planting

Table 6: Agents of pest on *C. caesius* in the 2nd survey and harvesting trial (figure in the parenthesis is for harvesting trial).

Sub-Block	YOP	Total Infested Stem	Pest					
			Insect	%	Squirrel	%	Others	%
207A	1991	1075	1075	*100*	0	*0*	0	*0.00*
216A	1990	2359	2081	*88.22*	278	*11.78*	0	*0.00*
217A	1990	563(77)	561(73)	*99.64(94.81)*	1(4)	*0.18(5.19)*	1(0)	*0.18(0)*
229A	1990	225	222	*98.67*	0	*0.00*	3	*1.33*
239B	1993	319	227	*71.16*	26	*8.15*	66	*20.69*
241B	1993	402	373	*92.79*	27	*6.72*	2	*0.49*
TOTAL		4943	4539	*91.83*	332	*6.72*	72	*1.46*

YOP = year of planting

Acacia mangium clone n. 5: field comparison of *in vitro* plantlets against open pollinated seedlings.

R. Bacilieri, P. Pajon, O. Monteuuis, 1998

Introduction

This experiment was established with the main objective of evaluating two propagation method (tissue culture and seeds) in *Acacia mangium*. The hypothesis to test was that clonal propagation of superior trees gives more homogeneous and better performing material than seeds obtained by the same trees, which contain an unknown male contribution.

In 1995, The Plant Biotech Laboratory (PBL) selected in the PISP's *A. mangium* seed orchards (Tiagau) few superior trees to be propagated by tissue culture in the PBL. In 1996, the production of *in vitro* plantlets from one of these trees, the clone n. 5, was sufficient to establish a field trial. The results of the second assessment, one year and four months after plantation, are reported here.

Material and methods

The experiment consisted of two treatments: *in vitro* plantlets of clone n. 5 (T1); open pollinated seedlings from clone n. 5 (T2). The two treatments have been planted (November 1, 1996) in a randomised complete block design with three repetitions (R1, R2, R3), at a spacing of 3 x 3 meters. Around the trial, a two line buffer (B) has been planted with seedlings obtained from a non selected seed bulk. The map of the trial is given in Figure 1.

At this assessment, the following characters have been measured:

1) DBH (diameter at breast height), in cm

2) Height, in cm

3) Branching (note: 0=no branching, 1= aerial branching, 2= branching from the base)

4) Straightness (note: 0=straight, 1=slightly crocked, 2= very crocked)

The trial has been assessed twice, once on the July 1, 1997, and later on March 5, 1998. The analysis of the first assessment has been distributed earlier (Bacilieri, 1997). The second assessment has been analysed as follows:

1) A two-factors (repetitions and treatments) analyse of variance was performed to compare the diameter and height of T1 and T2 over the trial;

2) The treatments' ranking for diameter and height was tested with a Duncan's test;

3) The variation between plants within treatments was studied by a Bartlett's test;

4) The other two characters (branching and straightness), consisting of a qualitative coding, was studied by a non-parametric analysis (Wilcoxon χ^2 test).

5) Diameter and height data of both T1 and T2 have then been individually compared with the internal buffer line B1 by means of a Student T-test. In fact, even if the non selected material was only planted in the buffer and not in the experimental design, the comparison among selected and not selected material might be interesting, provided appropriate cautions are taken during the interpretation.

For details of the statistical analysis please refer to Sokal & Rohlf (1981) and to the SAS documentation (SAS Institute, 1988).

Results

The analysis of variance showed that there were not significant differences between treatments or blocks neither for diameter nor for height (Table 1). The significant interaction (repetition*treatment) was just due to the fact that one treatment (T1) was superior to the other (T2) in one repetition (R2) but not in the other two (R1 and R3; not shown); however, because the main effects were not significant, this has to be attributed to the low number of trees within the experimental unit rather than to a real interaction.

The ranking of the treatments showed a slightly better performances of seedlings as compared to micro-cuttings; however the Duncan's test revealed (in concordance with the analysis of variance) that the differences in ranking was not significant (Table 2).

TABLE 1. Analysis of variance for the RBC design. Treatments: micro-cuttings versus seedlings. Measured characters: diameter and height

Dependent Variable: Diameter

Source	DF	Sum of squares	Mean square	F Value	Pr > F
Model	5	40.794	8.158	2.48	0.0436
Error	51	167.658	3.287	--	--
Repetition	2	1.275	0.537	0.19	0.8243
Treatment	1	6.628	5.528	2.02	0.1617
Rep*Treat	2	32.125	15.052	4.89	0.0114

Dependent Variable: Height

Source	DF	Sum of squares	Mean square	F Value	Pr > F
Model	5	134003.377	26800.575	2.45	0.0456
Error	51	557047.500	10922.500	--	--
Repetition	2	29745.536	14872.768	1.35	0.2654
Treatment	1	11214.858	11214.858	1.03	0.3157
Rep*Treat	2	88735.009	44367.505	4.06	0.0231

2

TABLE 2. Average and ranking for diameter and height between micro cuttings and seedlings. Duncan test for ranking.

Dependent Variable: Diameter

Treatment	Number of trees	Mean	Critical Range	Duncan Grouping
Seedlings	30	8.087	0.965	A
Micro cuttings	27	7.404	0.965	A

Dependent Variable: Height

Treatment	Number of trees	Mean	Critical Range	Duncan Grouping
Seedlings	30	820.50	55.65	A
Micro cuttings	27	792.41	55.65	A

As for the other two measured characters, straightness and branching, the non-parametric test of differences (Wilcoxon χ^2 test) showed that, also in this case, there were no significant differences between treatments or blocks (data not shown).

The hypothesis of a lower variation in micro-cuttings (that have all the same genotype) as compared to seedlings (that have different genotypes) could not be validated by this experiment (Bartlett test, Table 3). In fact, micro-cuttings were only slightly more homogeneous in terms of height growth, but sligthly less homogeneous in diameter, as compared to seedlings. The fact that the differences were not significant has more to be attributed to the small size of the experiment than to a true lack of difference. A larger experiment is needed to definitely validate or reject this hypothesis.

TABLE 3. Bartlett's test of the hypothesis of a difference in the variance between treatments.

Dependent Variable: Diameter

Treatment	Number of trees	Variance	Chi square χ^2	$Pr>\chi^2$
Seedlings	30	3.39	0.266	0.501
Micro cuttings	27	4.03		

Dependent Variable: Height

Treatment	Number of trees	Variance	Chi square χ^2	$Pr>\chi^2$
Seedlings	30	14087.78	1.099	0.294
Micro cuttings	27	10005.25		

Outside of the plan of the experiment, we compared the growth of the (vegetative or sexual) progenies of clone n. 5 with the bulk of seedlings used for the most internal line buffer. In our other Acacia trials (Seed Orchards, Tiagau), the buffer usually performed better than the inner treatments, mainly because these plants have more space and more light. However, in this experiment the bulk of seedlings in the buffer grew considerably slower than the progenies of clone n. 5. Even if this comparison was not included as a main treatment, we can assume with some degree of confidence that clone n. 5 is a true superior genotype.

Table 3. T-test of the differences between micro cuttings, seedlings of clone n. 5 and seedlings from unselected bulk (buffer).

Comparison micro-cuttings / bulk of seedlings.

Variable: Diameter	Number of trees	Mean	Std Dev.	T-test	DF	Prob > T
Micro cuttings	27	7.404	1.713	1.818	47	0.0754
Seedlings (unselec. Bulk)	22	6.341	2.280			

Variable: Height	Number of trees	Mean	Std Dev.	T-test	DF	Prob > T
Micro cuttings	27	792.407	122.422	2.123	47	0.039
Seedlings (unselec. Bulk)	22	712.272	141.722			

Comparison seedlings clone n. 5 / bulk of seedlings.

Variable: Diameter	Number of trees	Mean	Std Dev.	T-test	DF	Prob > T
Micro cuttings	30	8.085	2.003	2.928	50	0.005
Seedlings (unselec. Bulk)	22	6.341	2.280			

Variable: Height	Number of trees	Mean	Std Dev.	T-test	DF	Prob > T
Micro cuttings	30	820.500	100.029	3.231	50	0.002
Seedlings (unselec. Bulk)	22	712.272	141.722			

Conclusion

At one year and four months after plantation, we could not observe any significant difference among micro-cuttings or seedlings of *A. mangium* clone n. 5. Possible explanations for this are:

1. maternal effects, tha are quite common in forest trees. Maternal effects make a progeny more similar to the maternal than to the paternal parent tree. Most of the times, these are due to the aploid genotype of chloroplasts and mithochondria, that are generally maternally inherited, and also to the quantity of reserves that the maternal plant has been able to build and store in the seeds. Maternal effects usually disappear with the ageing of the plant. In later assessments, we will probably be able to see a more clear difference.

2. the small size of the experiment, both in term of number of plants and of number of maternal trees (only one, clone n. 5). At the period of the experiment, other superior trees have failed to propagate, mainly because of a slower reactivity to tissue culture. As these problems will be overcome, a larger experiment can be established.

3. A high sensibility of *A. mangium* to environmental effects. This has to be considered when thinking of propagation strategy. Again, a larger experiment will help to better evaluate the genotype and environment effect on *A. mangium* growth.

Figure 1. Map of the Acacia trial near the Luasong river: Comparison of *in vitro* plantlets (clones) against seedlings (open pollinated progeny) of clone n. 5 (*A. mangium*)

Planting date 1/11/96   File:c:\cirad\acacia\am5\amclon5.doc

Spacing 3m by 3m.

Line/col number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	B	B	B	B	B	B	B	B	B	B	B	B	B	B
2	B	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B
3	B	B1	R1 T1	R1 T1	R1 T1	R1 T1	R1 T1	R1 T2	R1 T2	R1 T2	R1 T2	R1 T2	B1	B
4	B	B1	R1 T1	R1 T1	R1 T1	R1 T1	R1 T1	R1 T2	R1 T2	R1 T2	R1 T2	R1 T2	B1	B
5	B	B1	R2 T2	R2 T2	R2 T2	R2 T2	R2 T2	R2 T1	R2 T1	R2 T1	R2 T1	R2 T1	B1	B
6	B	B1	R2 T2	R2 T2	R2 T2	R2 T2	R2 T2	R2 T1	R2 T1	R2 T1	R2 T1	R2 T1	B1	B
7	B	B1	R3 T1	R3 T1	R3 T1	R3 T1	R3 T1	R3 T2	R3 T2	R3 T2	R3 T2	R3 T2	B1	B
8	B	B1	R3 T1	R3 T1	R3 T1	R3 T1	R3 T1	R3 T2	R3 T2	R3 T2	R3 T2	R3 T2	B1	B
9	B	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B1	B
10	B	B	B	B	B	B	B	B	B	B	B	B	B	B

Nursery

Luasong river

B and B1 = buffer lines, 80 seedlings
T1 = clone 5 from the lab: 30 plantlets
T2 = seedlings (OP seeds collected on clone 5)
R1, R2 and **R3** = repetition 1, 2 and 3

← ● N
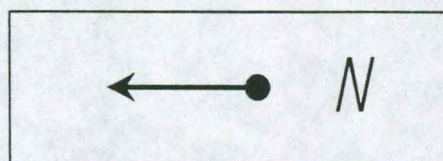
Literature

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Sokal, R.R., and F.J. Rohlf. 1981. Biometry. II° Edition, Freeman & Co., New York.

Study of the Heart Rot Disease on Acacias species by Tree Core Sampling

Philippe Pajon and Roberto Bacilieri [1] ,1998

Introduction

Acacia mangium and other closely related *Acacia* species have recently gained in importance in the reforestation programmes of humid tropics of South-East Asia. The trees are planted mainly for pulpwood production, however they may be suitable for panel production and in some cases they can be used as sawn timber (construction and even furnitures).

One of the main problems of these *Acacias* species group is the heartrot disease, that attacks the centre of the trunk, sometime on almost the whole length (Ibrahim *et al.*, 1994). The loss in volume can be important, especially if the final product is sawn timber.

In the present paper, we studied the incidence and variation of the heart rot disease on the two more promising *Acacias* species used in the Luasong Forestry Centre: *A. mangium* and *A. auriculiformis*. The availability of 6-year-old progeny trials in Luasong allowed us to apportion the variation of the disease among the genetic differences between provenances and families, and the environment (blocks).

Material and methods

The heart rot incidence has been studied on three Acacia progeny trials:

- *Acacia mangium*, origin Papua New Guinea (PNG), trial SSO1
- *Acacia mangium*, origin Papua New Guinea, trial SSO2
- *Acacia auriculiformis*, origin Papua New Guinea and Queensland (QLD), trial SSO1

These progeny trials were planted in February 1990 in Tiagau, Luasong; the core sampling was done in July 1996. The initial planting density was 2.5 * 3 meters (1333 trees / ha). Three thinnings have been carried out:

- October 1991: 3 out of 5 trees thinned
- January 1992: 1 tree out of 2 thinned
- February 1996: some of the worse families were thinned (5% of the trees)

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[1] CIRAD/Foret/ICSB, PISP, Luasong. Po Box 60793, 91017 Tawau, Sabah, Malaysia

The thinning were always selectives (thinning of the worse trees) and quite intensive in order to induce an abundant flowering for seed production. The characteristics of the trials at the moment of the study are summarised in the following table:

	Number of Families	Number of trees per family	Number of different geographic origins
A. mangium PNG, SSO1	56	6	15
A. mangium PNG, SSO2	46	6	15
A. auriculiformis PNG & QLD, SSO1	52	4	8

Each of the trees of these trials was sampled with an increment borer, 1 meter above the soil level. At the same height, we measured the diameter of the stem at the position of the core holes. Then, in order to calculate the portion of the trunk diameter infected by the disease we applied the following formula:

$$Rot\ note\ =\ \frac{Length\ of\ the\ sample\ infected\ by\ the\ heart\ rot}{Diameter}$$

The rot note data were first studied by using an analysis of variance. However, the distribution of the variable was far from the normal, even after a arcsin transformation. For this reason, we also studied the variable by using non parametric statistics (SAS, 1996).

Results

A. mangium seems much more sensitive to the disease than *A. auriculiformis*: 36% of the *A. mangium* trees were infected compared to 8% in *A. auriculiformis*. For the contaminated trees, the proportion of roted wood is also less important for *A. auriculiformis*: only 10% compared to 16% in *A. mangium*.

TABLE 1. Summary of the heartrot attack data on two Acacia species.

	Number of sampled trees	*Number of infected trees*	*Percentage of infected trees*	*Portion of wood damaged by the heart rot (calculated only on the infected trees)*
A. mangium PNG, SSO1 and SSO2	310	111	36%	16 %
A. auriculiformis PNG & QLD, SSO1	208	16	8%	10 %

In *A. auriculiformis*, the incidence of the disease was low; a study of the distribution of the attacks within and between treatments (blocks, provenances and families) was not possible because of the low number of attacked trees.

For *A. mangium*, a preliminary study of the heartrot variable showed that its distribution was far from normal (Figure 1). The ordinary analysis of variance in not the most appropriated method to be used in this context as one of its main assumption, the normality of the variable distribution, is violated; it can however give hints on the partition of the variation between effects (in this case trials, blocks within trials, provenances and families within provenances). To study the differences of the heart rot incidence with more precision we also used a non-parametric test (Kruskal-Wallis, SAS, 1988).

Figure 1. Distribution of the heartrot values over the two A. mangium trials, SSO1 and SSO2
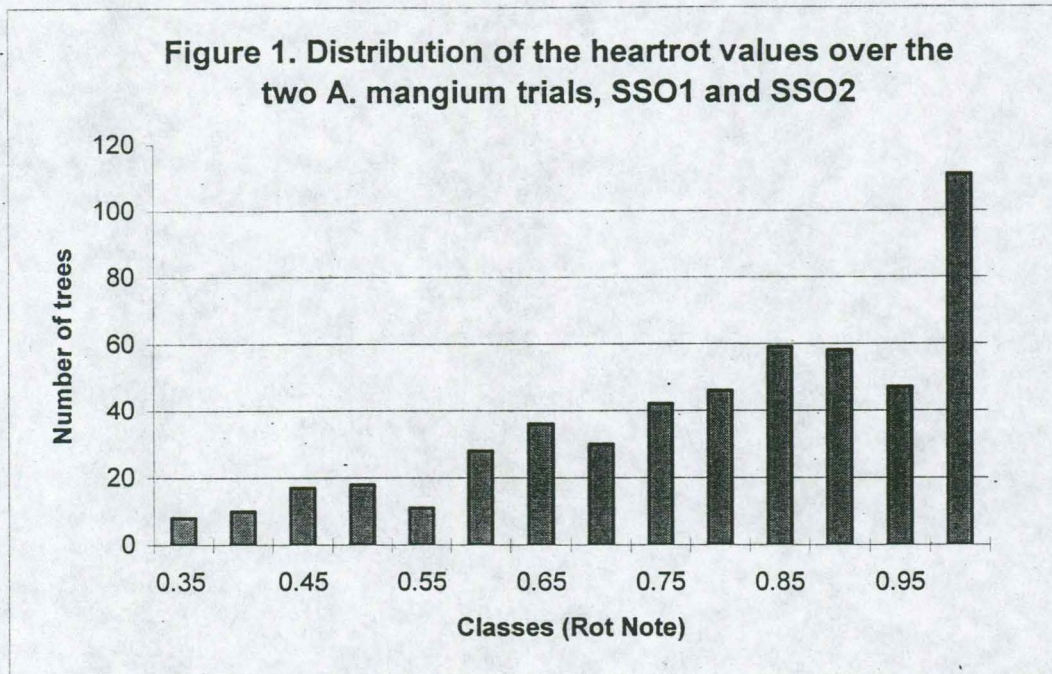
The analysis of variance (Table 2), where the trial and block effects were slightly and very significant respectively, showed that probably a site effect played a role in the distribution of the disease. By contrast, it was not possible to evidence any genetic effect (neither from provenances nor from families). This result was confirmed by a non-parametric test (Kruskal-Wallis), that even if less detailed is to be considered more precise in this case (Table 3).

TABLE 2. Analysis of variance of the incidence of the heart rot disease over the two Acacia trials (SSO1 and SSO2).

Dependent Variable: Rot Note

Source	DF	Sum of squares	Mean square	F Value	Pr > F
Model	49	0.569	0.0116	1.01	0.4679
Error	221	2.548	0.0115	--	--
Trials	1	0.038	0.038	3.33	0.0696
Blocks(Trial)	6	0.205	0.034	2.95	0.0084
Provenances	10	0.053	0.005	0.46	0.9137
Families(Prov)	32	0.279	0.009	0.76	0.8252

TABLE 3. Non-parametric tests (Kruskal-Wallis) of the differences of the heartrot incidence between treatments (trial, blocks, provenances, families), for *A. mangium* in the Tiagau's trials SS01 and SS02.

Level	Number of trees	χ^2	DF	$Pr > \chi^2$
Trial	271	0.0325	1	0.8567
Block	271	16.167	7	0.0235
Provenance	271	4.5506	10	0.9191
Family	271	34.666	41	0.7468

In Table 4, the ranking of the blocks according to the weight of the disease attack is shown and tested by a Duncan test. The ranking being significant (in particular the difference among blocks 2 and 5 in trial SSO2), there remains to study which are the most important environment factors affecting the disease's distribution. On the other hand, the Duncan's test of ranking confirmed that the differences among families were not significant (not shown).

TABLE 4. Average and ranking of the variable RotNote in the two trials, SSO1 and SSO2, and in the blocks within the trials. Duncan test of the ranking.

Treatment	Number of trees	Mean	Critical Range	Duncan Grouping (Trial / Block)	
SSO1	105	0.955	0.0263	A	
Block 3	31	0.963	0.034		A
Block 1	38	0.960	0.036		A
Block 2	36	0.942	--		A
SSO2	166	0.935	0.0263	A	
Block 5	35	0.985	0.059		A
Block 3	38	0.958	0.062		A B
Block 1	34	0.925	0.064		A B C
Block 4	28	0.906	0.065		B C
Block 2	31	0.891	--		C

NOTE: Duncan test: means with the same letters are not significantly different

Conclusion

Conclusion of this study can be summarized as follows:

- It was not possible to find any difference among families or provenances in terms of sensitivity to the heartrot attacks. It is probably not worth to include the character "resistance to the heartrot disease" as a selection criterium.

- In one of the two trials, a site effect was present. It may be due to differences among blocks in soil humidity, in the previous pattern of distribution of the fungus, or simply to chance. This result contrasts with the study of Brahim *et al.* (1994), which failed to find a site effect even with a large scale sampling. A more detailed study of this effect can be conducted on the large scale Sabah Softwood's plantation.

LITERATURE

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Appendix 18

Teak Progeny / Provenance testing in Taliwas and Luasong (Sabah, Malaysia)

Roberto Bacilieri, Philippe Pajon, Charles Garcia

Plant Improvement and Seed Production Project, Luasong Forestry Centre
PO Box 60793, 91017 Tawau, Sabah, Malaysia

Introduction

The interest of Teak as high value timber tree species has been confirmed in the past. In Sabah, for the time being the genetic resource is very poor. On the other hand, the ICSB's plantation and marketing programme concerning Teak has to be based on a large field-tested genetic base.

Collection

Collection of new Teak genetic material has been achieved in 1996 by PISP and PBL with the purpose of expanding the genetic resource of this species in Sabah. Seeds were bought both through CIRAD-Forêt (seven digits numbers in the list in Table 1[1]), or in the market, and then distributed for germination to the PISP nursery or to the Plant Biotech Lab (PBL) according to the quality of the material. The seeds came from two sources: 1) true provenances, collected mainly *in situ* in natural forest stands; 2) progenies collected in a (multi-provenance) clonal seed orchard in Ivory Coast. The pedigree of the seedlots is drawn in Figure 1. In total, we collected 78 accessions, the list of which, together with the geographic names, is given in Table 2.

Germination

The seeds were germinated both in the PISP's nursery or in PBL, under *in vitro* conditions (Pajon *et al.*, 1997). In PISP, we used two methods of germination: 1) "cracking method", extracting the seeds by cracking the fruits, and then germinating the seeds in Petri dishes with additional fungicide and insecticide treatment; 2) "soaking/drying method", an alternation of

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[1] Later on, we just dropped from the code number the three middle digits which were redundant, i.e. 9410134 became 9434.

water-soaking (over night) and exposition to sunlight (during the day) of the whole fruits, over seven days, followed by normal sowing in seedbeds. In PBL, the seeds, after extraction from the fruits, were germinated under *in vitro* conditions, into test tubes in the dark; later the plantlets were transferred under myst system for acclimatation. After these treatments, the seeds were transferred in polybags. The germination results obtained in PISP were given in a previous paper (Pajon *et al.*, 1997).

Only 57 out of the 78 accessions gave enough plant material for their establishment in the progeny/provenance trials. Concerning the 21 remaining accessions, some did not germinated at all; the others were established in resource stands near the Luasong trial.

Trial plantation

For both the two trials, we choose to establish the treatments (progenies or provenances) in a partially equilibrated incomplete block design (Williams & Matheson 1996), an experimental design allowing to reduce the size of the blocks, and, being as equilibrated as possible, to compare all the accessions with approximately the same precision.

The replication of the test over two different sites was decided for security reasons, i.e. if one trial is destroyed by an accident (fire, drought, floods, elephants, pests and diseases, etc.), the material is not lost. Furthermore, the replication will allow to carry out i) two different selections, to obtain both a lowland (Taliwas) and a hill (Luasong) variety, and ii) by comparing common accessions in different environments, to study the *genotype x environment* interaction

Taliwas

In Taliwas (km 18 on the road from Silam to Danum Valley), the first week of March 1997 we planted 41 accessions (listed in Table 3). The site is flat, on the bottom of a valley, near a river, rarely (once a year or less) flooded for short periods (2-4 days); the elevation is around 40 m over the sea level. The layouts of the Taliwas trial and detail of the experimental design are given in Figure 2 and 3 respectively. A demoplot with the most important accessions has been planted nearby the trial (see the map in Figure 4).

Luasong

The Luasong trial has been planted the last week of May 1997 with 42 accessions (list in Table 4). The site is slopy, with some ravins that have been filled with buffer; the elevation is around 150 m over the sea level. The position and form of the blocks (repetitions) takes in account the topography; in particular the repetition 2 has been planted longitudinally to cover the ridge of the

hill, that is dryier and rocky (Figure 5). The experimental layout is given in Figure 6. The 42 treatments included:

i) 26 progenies or provenances common to the Taliwas trial (8367, 8668, 8823, 8824, 8831, 8832, 8833, 8839, 8844, PNG, 9411, 9412, 9418, 9426, 9430, 9435, 9437, 9440, 9443, 9446, 9450, 9452, 9454, 9457, 9459, 9463)

ii) 16 progenies or provenances that could not be planted in Taliwas due to their late development stage, or to insufficient planting material; among these, there was the Perlis *in vitro* propagated origin (Perlis bulk, PBL reference).

Because of the topography of this trial, that needed a large quantity of plants for the buffer, and the availability at that time of large quantities of *in vitro* propagated material in the PISP nursery, we decided to build up the buffer with the *in vitro* material. The origins (PBL references) used were: i) clone n. 9, ii) Solomon Islands bulk, iii) Perlis bulk. The advantage of planting clonal material in the buffer was double: it allowed 1) to have an homogeneous buffer, producing an homogeneous competition over the treatments; 2) to test the clonal material on a scale larger than in the previous trials.

A demoplot with the most important accessions has been planted nearby the trial (see the map, as well as the list, in Figure 5); note that in the demoplot we included some material from cuttings and *in vitro* tissue culture, that will allow a first rough comparison among the propagation methods (for example, Solomon Islands material was from seeds, cuttings and *in vitro* culture).

LITERATURE

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Williams & Matheson, 1995. Experimental design and analisys for use in tree improvement. CSIRO Information Service, 314 Albert Street, East Melbourne Victoria 3002, Australia.

lot 1 PISP	Sep-96
seedlot n.	grams
8304167	334
8606568	656
8606569	292
8807822	661
8807823	336
8807824	678
8807831	669
8807832	666
8807833	335
8807835	674
8807836	333
8807838	442
8807839	667
8807841	333
8807842	757
8807844	657
9410109	378
9410110	354
9410111	354
9410112	354
9410113	352
9410114	703
9410115	406
9410116	711
9410117	405
9410118	407
9410119	406
9410120	409
9410121	352
9410122	355
9410123	358
9410124	356
9410125	357
9410126	356
9410127	359
9410128	355
9410129	348
9410130	719
9410131	359
9410132	355
9410133	359
9410134	358
9410135	357
9410136	358
9410137	351
9410138	357
9410139	713
9410140	713
9410141	357
9410142	358
9410143	721
9410144	357
9410145	359
9410146	358
9410147	358
9410148	359
9410149	355
9410150	358
9410151	357
9410152	360
9410153	358
9410154	359
9410155	358
9410156	358
9410157	356
9410158	357
9410159	357
9410160	356
9410161	359
9410162	353
9410163	711
9410164	354
Total	31217

lot2 PISP	Dec-96
seedlot n.	grams
8807822	600
8807823	700
8807824	600
8807831	600
8807833	700
8807844	600
9410109	300
9410111	300
9410112	301
9410113	277
9410115	281
9410122	255
9410125	299
9410129	278
9410130	279
9410135	300
9410136	265
9410138	300
9410140	600
9410144	288
9410146	300
9410150	279
9410151	300
9410152	292
9410153	300
9410154	302
9410155	251
9410159	300
9410161	317
PARE	1500
PNG	3500
S.I. 4314	3500
S.I. 5212	6500
SEGAMA	1500
Total	27264

lot1 PBL	Sep-96
seedlot n.	grams
8304167	330
8606569	291
8807823	335
8807833	335
8807836	332
8807838	441
8807841	332
9410109	378
9410110	354
9410111	353
9410112	354
9410113	351
9410115	306
9410117	305
9410118	306
9410119	306
9410120	309
9410121	351
9410122	354
9410123	358
9410124	355
9410125	356
9410126	356
9410127	358
9410128	355
9410129	347
9410131	359
9410132	355
9410133	359
9410134	358
9410135	357
9410136	358
9410137	350
9410138	357
9410141	357
9410142	357
9410144	357
9410145	358
9410146	358
9410147	357
9410148	359
9410149	355
9410150	358
9410151	356
9410152	360
9410153	358
9410154	358
9410155	357
9410156	358
9410157	356
9410158	357
9410159	357
9410160	355
9410161	359
9410162	353
9410164	354
Total	19615

lot2 PBL	Dec-96
seedlot n.	grams
8606568	1200
8606569	1200
9410110	290
9410116	297
9410117	300
9410119	288
9410120	300
9410123	300
9410124	261
9410126	300
9410128	300
9410131	267
9410132	185
9410133	265
9410141	310
9410142	300
9410145	300
9410147	300
9410148	300
9410149	300
9410156	300
9410157	287
9410158	248
9410160	307
Total	8705

Table1:

List and weight (in grams) of the teak seedlots received in September 1996 (lot 1) and December 1996 (lot 2) in PISP and PBL. Description of the origins is given in the text and in the following tables. For more convenience, in the following tables we dropped the 3 middle digits of the seedlots numbers which are redundant. Most of the material has been bought from CIRAD-Foret (numbers 8304167 to 9410164). Other material has been sent by FRR (Lahad Datu) or bought in the market.

True Provenances

seedlot n.	Provenance
8304167	India Chandrapur Maharastra
8606568	Thailand Mae Huat Lampang (wild)
8606569	Thailand Mae Huat Lampang (plant)
8807822	India Sakrebail Karnataka
8807823	India Sakrebail Karnataka
8807824	India Virnoli Vir. Karnataka
8807831	India Karadibetta Karnataka
8807832	India Gilalegundi Karnataka
8807833	India Virnoli Vir. Karnataka
8807835	India Maukal Karnataka
8807836	India Maukal Karnataka
8807838	India Maukal Karnataka
8807839	India Maukal Karnataka
8807841	India Maukal Karnataka
8807842	India Maukal Karnataka
8807844	India Maukal Karnataka
PARE	Indonesia Pare Pare
PNG	Papua New Guinea ex Brown River
SI 4314	Solomon Island Arara
SI 5212	Solomon Island Viru
SEGAMA	Sabah, Malaysia
PERLIS	Perlis, Malaysia (*in vitro*)

Table 2:

List of the seedlots, with their geographic origin, for the two types of material: true provenances (bulks), and families from a clonal seed orchard (Ivory Coast), established with plus trees selected in a multiprovenance trial (Ivory Coast). Please note that among the true origins, one (Perlis) was propagated by tissue culture of a bulk of seeds (PBL). More detailed descriptions (geographic coordonates, altitude, rainfall, etc.) are available in PISP, PBL or in the Seed Laboratory of CIRAD-Foret.

Progenies of the Ivory Coast Clonal Seed Orchard

seedlot n.	provenance	origin of the clone
9410109	Ivory Coast	India Nellicutha
9410110	Ivory Coast	India Nellicutha
9410111	Ivory Coast	India Nilambur
9410112	Ivory Coast	Tanzania Kihuhwi
9410113	Ivory Coast	India Nilambur
9410114	Ivory Coast	Ivory Coast Bamoro
9410115	Ivory Coast	Senegal Djibelor
9410116	Ivory Coast	Ivory Coast Kokondekro
9410117	Ivory Coast	India Nilambur
9410118	Ivory Coast	India Nilambur
9410119	Ivory Coast	India Nilambur
9410120	Ivory Coast	India Nilambur
9410121	Ivory Coast	India Nilambur
9410122	Ivory Coast	India Nellicutha
9410123	Ivory Coast	India Nellicutha
9410124	Ivory Coast	Tanzania Mtibwa (Morogoro)
9410125	Ivory Coast	Thailand Huoi-Nam-Oon
9410126	Ivory Coast	Tanzania Mtibwa (Morogoro)
9410127	Ivory Coast	Thailand Huoi-Nam-Oon
9410128	Ivory Coast	India Nellicutha
9410129	Ivory Coast	India Nellicutha
9410130	Ivory Coast	Thailand Mae Huat
9410131	Ivory Coast	Tanzania Kihuhwi
9410132	Ivory Coast	Thailand Pong Salee
9410133	Ivory Coast	Tanzania Kihuhwi
9410134	Ivory Coast	India Nellicutha
9410135	Ivory Coast	India Nellicutha
9410136	Ivory Coast	India Nellicutha
9410137	Ivory Coast	India Nilambur
9410138	Ivory Coast	Tanzania Mtibwa (Morogoro)
9410139	Ivory Coast	Thailand Huoi-Nam-Oon
9410140	Ivory Coast	India Nellicutha
9410141	Ivory Coast	India Nilambur
9410142	Ivory Coast	India Nilambur
9410143	Ivory Coast	India Vernolirge
9410144	Ivory Coast	Thailand Mae Huat
9410145	Ivory Coast	India Nellicutha
9410146	Ivory Coast	India Vernolirge
9410147	Ivory Coast	India Nellicutha
9410148	Ivory Coast	India Nellicutha
9410149	Ivory Coast	Thailand Pong Salee
9410150	Ivory Coast	India Vernolirge
9410151	Ivory Coast	Tanzania Bigwa
9410152	Ivory Coast	India Masale Valley
9410153	Ivory Coast	Tanzania Bigwa
9410154	Ivory Coast	Laos Paklay
9410155	Ivory Coast	Thailand Ban Cham Pui
9410156	Ivory Coast	India Purunakote
9410157	Ivory Coast	India Purunakote
9410158	Ivory Coast	Thailand Ban Pha Lay
9410159	Ivory Coast	India Masale Valley
9410160	Ivory Coast	Tanzania Bigwa
9410161	Ivory Coast	Laos Paklay
9410162	Ivory Coast	India Purunakote
9410163	Ivory Coast	Ivory Coast Bamoro
9410164	Ivory Coast	Thailand Ban Pha Lay

Table 3:
List of the material planted in the progeny provenance trial
in Taliwas Km 18

seedlot n.	Provenance	
8304167		India Chandrapur Maharastra
8606568		Thailand Mae Huat Lampang (wild)
8807823		India Sakrebail Karnataka
8807824		India Virnoli Vir. Karnataka
8807831		India Karadibetta Karnataka
8807832		India Gilalegundi Karnataka
8807833		India Virnoli Vir. Karnataka
8807835		India Maukal Karnataka
8807836		India Maukal Karnataka
8807838		India Maukal Karnataka
8807839		India Maukal Karnataka
8807841		India Maukal Karnataka
8807842		India Maukal Karnataka
8807844		India Maukal Karnataka
PNG		Papua New Guinea ex Brown River
9410111	Ivory Coast	India Nilambur
9410112	Ivory Coast	Tanzania Kihuhwi
9410116	Ivory Coast	Ivory Coast Kokondekro
9410117	Ivory Coast	India Nilambur
9410118	Ivory Coast	India Nilambur
9410126	Ivory Coast	Tanzania Mtibwa (Morogoro)
9410129	Ivory Coast	India Nellicutha
9410130	Ivory Coast	Thailand Mae Huat
9410131	Ivory Coast	Tanzania Kihuhwi
9410132	Ivory Coast	Thailand Pong Salee
9410134	Ivory Coast	India Nellicutha
9410135	Ivory Coast	India Nellicutha
9410137	Ivory Coast	India Nilambur
9410139	Ivory Coast	Thailand Huoi-Nam-Oon
9410140	Ivory Coast	India Nellicutha
9410142	Ivory Coast	India Nilambur
9410143	Ivory Coast	India Vernolirge
9410145	Ivory Coast	India Nellicutha
9410146	Ivory Coast	India Vernolirge
9410150	Ivory Coast	India Vernolirge
9410152	Ivory Coast	India Masale Valley
9410154	Ivory Coast	Laos Paklay
9410157	Ivory Coast	India Purunakote
9410158	Ivory Coast	Thailand Ban Pha Lay
9410159	Ivory Coast	India Masale Valley
9410163	Ivory Coast	Ivory Coast Bamoro

Table 4:

List of the material planted in the provenance / progeny trial in Luasong, compartment 311.

seedlot n.		Provenance
8304167		India Chandrapur Maharastra
8606568		Thailand Mae Huat Lampang (wild)
8606569		Thailand Mae Huat Lampang (plant)
8807822		India Sakrebail Karnataka
8807823		India Sakrebail Karnataka
8807824		India Virnoli Vir. Karnataka
8807831		India Karadibetta Karnataka
8807832		India Gilalegundi Karnataka
8807833		India Virnoli Vir. Karnataka
8807839		India Maukal Karnataka
8807844		India Maukal Karnataka
9410111	Ivory Coast	India Nilambur
9410112	Ivory Coast	Tanzania Kihuhwi
9410115	Ivory Coast	Senegal Djibelor
9410118	Ivory Coast	India Nilambur
9410120	Ivory Coast	India Nilambur
9410124	Ivory Coast	Tanzania Mt
9410126	Ivory Coast	Tanzania Mt
9410130	Ivory Coast	Thailand Mae Huat
9410133	Ivory Coast	Tanzania Kihuhwi
9410135	Ivory Coast	India Nellicutha
9410136	Ivory Coast	India Nellicutha
9410137	Ivory Coast	India Nilambur
9410140	Ivory Coast	India Nellicutha
9410143	Ivory Coast	India Vernolirge
9410144	Ivory Coast	Thailand Mae Huat
9410146	Ivory Coast	India Vernolirge
9410147	Ivory Coast	India Nellicutha
9410149	Ivory Coast	Thailand Pong Salee
9410150	Ivory Coast	India Vernolirge
9410151	Ivory Coast	Tanzania Bigwa
9410152	Ivory Coast	India Masale Valley
9410154	Ivory Coast	Laos Paklay
9410156	Ivory Coast	India Purunakote
9410157	Ivory Coast	India Purunakote
9410159	Ivory Coast	India Masale Valley
9410163	Ivory Coast	Ivory Coast Bamoro
PERLIS		Perlis, Malaysia (*in vitro*)
PNG		Papua New Guinea
S.I. 4314		Solomon Island
S.I. 5212		Solomon Island
SEGAMA		Sabah, Malaysia

FIGURE 1: Origin of the Teak Material in the Progeny / provenance Trials

Seeds from Provenances
(India, Tanzania, IC, Thai, Laos,
Senegal, Tanzania)

Seeds from Provenances
(Thai, PNG, SI, India,
Indon, Sabah)

⇓

⇓

Provenance trial in Ivory Coast

⇓

⇓

Selection of plus trees in the Prov. Trial

⇓

⇓

Grafting of the plus trees in a
clonal seed orchard (Ivory Coast)

⇓

⇓

Seed Collection

⇓

⇓

PISP
(non selected provenances)

PISP
(selected progenies/provenances)

↘

↙

Progeny / provenance trial in Taliwas
Replication in Luasong

Figure 2: Layout of the teak progeny within provenance trial Taliwas km 18

8824	9431	8841	8823	9416	9443	8833	8668	9412
9429	9459	9435	8367	9439	9437	9445	9442	
8838	9418	9452	9426	8839	8836	8835	9432	
9411	8832	8844	9457	9440	9463	9454	9450	
9434	PNG	9446	9417	9458	8831	9430	8842	

9434	8668	9412	9418	9435	9463	8842	
9431	8836	9446	8844	9430	8838	9440	8824	
8841	9417	9454	9457	8832	9443	9411	9458	
8831	8835	8367	9426	9450	8833	9432	9459	9442
9429	9439	9437	9445	9452	9416	PNG	8823	8839

9446	9430	9412	9418	8367	9411	PNG	9443	
9416	8831	8832	9439	9432	8668	9445	9458	
8824	8842	9435	8823	8838	8844	9417	8835	
9429	9450	9426	9452	8839	8841	9457	9459	
9463	8836	9442	9440	9431	9437	8833	9434	
							9454	

Note:

The experimental unit is composed of 6 lines of 5 plants. One line over two is filled with buffer that has to be chop down at the first thinning , 2 years after the plantation. For details on the experimental layout, refer to Figure 3.

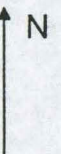| 9454	9454	9454	9454	9454
Bulk	Bulk	Bulk	Bulk	Bulk
9454	9454	9454	9454	9454
Bulk	Bulk	Bulk	Bulk	Bulk
9454	9454	9454	9454	9454
Bulk	Bulk	Bulk	Bulk	Bulk

N

Figure 3. Layout of the incomplete partially balanced block design (William & Matheson, 1996) of the Taliwas trial.

			rep 1					
8807824	9410131	8807841	8807823	9410116	9410143	8807833	8606568	9410112
9410129	9410159	9410135	8304167	9410139	9410137	9410145	9410142	buffer
8807838	9410118	9410152	9410126	8807839	8807836	8807835	9410132	
9410111	8807832	8807844	9410157	9410140	9410163	9410154	9410150	
9410134	PNG	9410146	9410117	9410158	8807831	9410130	8807842	

			rep 2					
9410134	8606568	9410112	buffer	9410118	9410135	9410163	8807842	
9410131	8807836	9410146	8807844	9410130	8807838	9410140	8807824	
8807841	9410117	9410154	9410157	8807832	9410143	9410111	9410158	
8807831	8807835	8304167	9410126	9410150	8807833	9410132	9410159	9410142
9410129	9410139	9410137	9410145	9410152	9410116	PNG	8807823	8807839

			rep 3				
9410146	9410130	9410112	9410118	8304167	9410111	PNG	9410143
9410116	8807831	8807832	9410139	9410132	8606568	9410145	9410158
8807824	8807842	9410135	8807823	8807838	8807844	9410117	8807835
9410129	9410150	9410126	9410152	8807839	8807841	9410157	9410159
9410163	8807836	9410142	9410140	9410131	9410137	8807833	9410134
						buffer	9410154

			rep 1					
subblock 1	1	subblock 2	2	5	5	7	7	7
1	1	2	2	5	5	7	7	buffer
1	1	2	2	5	5	6	6	
3	3	3	4	4	4	6	6	
3	3	3	4	4	4	6	6	

			rep 2				
subblock 1	1	2	buffer	5	5	6	6
1	1	2	2	5	5	6	6
1	1	2	2	5	5	6	6
3	3	3	4	4	4	7	7	7
3	3	3	4	4	4	7	7	7

			rep 3				
subblock 1	1	2	2	5	5	6	6
1	1	2	2	5	5	6	6
1	1	2	2	5	5	6	6
3	3	3	4	4	4	7	7
3	3	3	4	4	4	7	7
						buffer	7

Figure 4. Layout of the demoplot, planted in Taliwas km 18 just nearby the provenance / progeny trial.

PNG	PNG	PNG	PNG	PNG	PNG	PNG	PNG	PNG	PNG	PNG
9464	9464	9464	9464	9464	9464	9464	9464	9464	9464	9464
9412	9412	9412	9412	9412	9412	9412	9412	9412	9412	9412
PARE	PARE	PARE	PARE	PARE	PARE	PARE	PARE	PARE	PARE	PARE
SEGA	SEGA	SEGA	SEGA	SEGA	SEGA	SEGA	SEGA	SEGA	SEGA	SEGA
8669	8669	8669	8669	8669	8669	8669	8669	8669	8669	8669
5152	5152	5152	5152	5152	5152	5152	5152	5152	5152	5152
4314	4314	4314	4314	4314	4314	4314	4314	4314	4314	4314
8367	8367	8367	8367	8367	8367	8367	8367	8367	8367	8367
9442	9442	9442	9442	9442	9442	9442	9442	9442	9442	9442
9414	9414	9414	9414	9414	9414	9414	9414	9414	9414	9414
8844	8844	8844	8844	8844	8844	8844	8844	8844	8844	8844
8839	8839	8839	8839	8839	8839	8839	8839	8839	8839	8839
8835	8835	8835	8835	8835	8835	8835	8835	8835	8835	8835
8832	8832	8832	8832	8832	8832	8832	8832	8832	8832	8832
8824	8824	8824	8824	8824	8824	8824	8824	8824	8824	8824
8823	8823	8823	8823	8823	8823	8823	8823	8823	8823	8823
8822	8822	8822	8822	8822	8822	8822	8822	8822	8822	8822

N

Figure 5. Layout (4 pages) of the progeny / provenance trial in Luasong, compartment 311. The experimental unit is, as in Taliwas, composed of 6 lines of 5 plants. One line over two was filled with cuttings from a single clone (n. 9), that will be taken away at the first thinning. The buffer (all the empty cells) was build up with material from *in vitro* vegetative propagation (origins: clone n. 9, Perlis, Solomon Islands, the map of the buffer is available in PISP). Within the trial, the areas not suitable for the experimental comparison have been filled with the seedlots that could not be used for the trial (low plant number); these can be considered resource plots. A demoplot with the most important accessions was also established (bottom right of the map).

Page 1 of 4

PAGE 1

PAGE 4

9446

9463

8367

9415

8831

8861

9436

9433

9420

9451

9418

9432

9443

9367

9424

SEGA

9412

9426

9459

9456

8669

9411

9446

8824

PNG

9440

PNG

9424

9437

8832

8833

9433

8839

9412

9415

9446

9420

4314

8823

9444

List of the origins established in the demoplot

Ivory Coast (Tanzania): 9424

Ivory Coast (Tanzania): 9412

Ivory Coast (Ivory Coast): 9416

Ivory Coast (India Vernolirge): 9450

Ivory Coast (Thailand Pong Salee): 9449

Ivory Coast (Thailand Mae Huat): 9444

Ivory Coast (Laos): 9454

India Karnataka: 8833

Perlis, Malaysia (*in vitro*): PERL

Papua New Guinea (*in vitro*): PNGL

Papua New Guinea (seeds): PNGS

Solomon Islands 5212 (seeds): 5212

Solomon Islands (cuttings): S.I.C

Solomon Islands (*in vitro*): S.I.L

Figure 6. Layout of the experimental design of the Luasong Teak progeny / provenance trial.

	subblock1	subblock2	subblock3	subblock4	subblock5	subblock6	subblock7
repetition 1	PERLIS	9410157	9410143	9410150	8807831	8807823	9410137
	9410130	9410126	9410152	9410135	8606569	S.I. 5212	PNG
	8304167	8807822	9410156	9410136	9410133	9410144	8807832
	8606568	9410159	8807844	9410149	9410115	9410120	9410124
	9410147	9410151	9410118	9410163	8807839	S.I. 4314	8807833
	9410111	SEGAMA	9410154	8807824	9410112	9410146	9410140
repetition 2	9410152	PNG	8807824	SEGAMA	9410111	9410163	9410120
	8606568	9410154	9410130	9410140	9410144	9410136	8807844
	9410157	S.I. 5212	8807823	S.I. 4314	9410156	9410143	9410147
	8807832	9410137	8606569	8807822	9410126	9410146	9410159
	9410112	9410118	9410151	8807833	8304167	PERLIS	9410124
	9410135	9410150	8807839	8807831	9410115	9410149	9410133
repetition 3	9410154	PNG	9410130	8807822	9410151	8807844	9410150
	8807831	9410156	9410163	9410136	9410120	9410140	8807833
	PERLIS	9410126	S.I. 4314	9410133	8304167	9410135	9410147
	9410144	9410111	9410112	8606568	9410143	9410115	9410152
	8807824	8606569	SEGAMA	9410157	8807 32	9410149	S.I. 5212
	9410146	9410159	9410124	8807839	9410118	8807823	9410137

The Growth of *Tectona grandis* (Teak) in Line- and Open-planted Area at Luasong Forestry Centre

Boljen Majingin
Plantation Silviculture Unit
October 1997

INTRODUCTION

Tectona grandis belongs to the family of Verbenaceae. Known commonly as Teak, this high value tree is usually occurs in isolated tracts, hilly or undulating ground but sometimes on plains and alluvial flats. It thrives in very moist to dry tropical condition but grows best on well-drained and aerated soils. Teak cannot tolerate waterlogged ground or sites subject to prolong inundation. The size of Teak leaf, which is considered big relative to other tree species, indicated that this species is light demanding and requires plenty of growing space. Teak likes an occasional dry spell to promote the best growth.

Objective

The main objective of this trial is to compare the growth of Teak under line planting and open planting.

MATERIAL AND METHOD

This experiment started on 9 January 1997, in sub-block 311C of Luasong Forestry Centre's plantation area. Seven planting strips of 100 m length and 5 m width were established under logged over forest. Adjacent to this plot, an opened plot of 100m x 87.5m was established, and served as a control plot.

476 Teak seedlings of *in-vitro*-cultured Clone no. 9 supplied by PISP were planted in 2.5 m spacing. CIRP were applied into the planting holes prior to the planting. Out of the 476 seedlings, 238 seedlings were planted in the line planting plot and 238 seedlings in the open planting plot.

Field assessments were carried out 3 months and 6 months after planting in the field. During the 3-month-old assessment (known as Assessment I), general appearances of the plants were observed by visiting every trees in both plots. The characters considered in this observation were fertility, form, occurance of pest infection and mortality status. In the second assessment, grouping of the trees into height classes was also conducted, on top of the general appearance characters. This paper presents the results of these assessments.

RESULT AND DISCUSSION

Three months old (Assessment 1)

The general appearance of trees in the open planting plot was better compared to those in the line planting plot. The occurrence of pest infected trees was higher in the line planting plot. Table 1 summarised the result of this assessment.

Table 1: General appearance of line and open planted teak (3 months old)

Character	No. of line planted trees	No. of open planted trees
Fertile	205 (86)	227(95)
Crooked	0 (0)	0 (0)
Diseases	18 (8)	9(4)
Disturbance	7(3)	0(0)
Total	238 (100)	238 (100)

Note: Value in parenthesis indicates percentage of total trees.

Six months old (Assessment 2)

The second assessment showed that the trees were growing more vigorously in the open planted plot. This was supported by the higher number of crooked and slow growing trees in the line planting plot. The number of trees longer than 100 cm was only 2 in the line planting compared to 89 in the open planting plot. About 88% of the trees in the line planting plots were less than 50 cm in height.

The summarized results are presented in Table 2, Table 3 and Table 4.

Table 2: General appearance of line and open planted teak (6 months old).

Character	No. of line planted trees	No. of open planted trees
Fertile	141 (59)	208 (87)
Crooked	70 (29)	10 (4)
Diseases	6 (3)	2 (1)
Dead	21 (9)	18 (8)
Total	238 (100)	238 (100)

Note: Value in parenthesis indicates percentage of total trees.

Table 3: Grouping by height classes of line and open planted teak (6 months old).

Height class	No. of line planted trees	No. of open planted trees
> 100 cm	2 (1)	89 (41)
51 – 100 cm	22 (10)	104 (47)
< 50 cm	193 (89)	27 (12)

Note: Value in parenthesis indicates percentage of total trees.

Table 4: Mortality and mean height of line and open planted teak (6 months old)

Planting method	% Mortality	Mean height (cm)
Open planting	7.0	92.0 (35.2)
Line planting	8.8	31.8 (17.7)

Note: value in parenthesis indicates standard deviation

CONCLUSION

These preliminary results showed that Teak is growing better in open area compared to line planting area or partly shaded area. This trial will be continued to verify this finding as the trees grow older.

Appendix 20

Technical note on teak germination

Philippe Pajon[1], Doreen Goh[2] and Roberto Bacilieri[1]

Introduction

Teak (*Tectona grandis*) is a high value timber species that may grow well in Sabah (Malaysia). However, the research on genetic improvement and silviculture is at a very early stage in the State, as well as the collection of genetic material, that is still poor.

With the idea of expanding the genetic resources of Teak in Sabah and to allow subsequent selection and commercial production of good genetic materials, the PISP started in 1996 a programme to establish new Teak genetic collections and testing. Two provenance/progeny trials have been planned to be planted within the forest concession of ICSB, one in Luasong (Tawau) and one in Taliwas (Lahad Datu).

The first step was the importation of a number of seedlots from different geographic origins, obtained both from the commercial market or through CIRAD-Foret. The next step was the germination of the seeds. To avoid to waste the precious material, a research on seed germination has been implemented.

It is well known that the germination of Teak is not easy: in general, the germination percentage is low (5-20%), and the germination is scattered over long time (3 months to one year or more). In order to explain the bad germination results, some authors made reference to the existence of a physical or chemical dormancy (Gupta *et al*. 1975, Fairlamb & Davidson 1976).

Different methods have been tried in the past to overcome the problem: alternation of soaking in water and drying, scarification of the fruits, high temperature, treatment with sulfuric acid, with gibberellic acid, partial fermentation, etc. (see review in Vallauri 1994). However the results were not really satisfying, first of all because even in the best cases the germination rate was improved only to a small extent, secondly because the repeatability of the experiments was very low, i.e. two teams working on same or different seedlots came to very different conclusions (compare for example Behagel & Kadio 1995, with Vallauri 1994).

For this reason we decided to proceed with our own experimentation on Teak seed germination. Several methods have been compared: extraction of the seeds from the fruit by carefully cracking this latter (Dabral 1976), and subsequent germination in Petri dishes; water soaking and drying of the fruits (Vallauri 1994); soaking the fruits in sulfuric acid (Behagel 1993 and 1996, Behagel & Kadio 1995); *in vitro* germination on the extracted seeds.

[1] CIRAD/Foret/ICSB, PISP, Luasong. Po Box 60793, 91017 Tawau, Sabah, Malaysia
[2] CIRAD/Foret/ICSB, PBL, Po Box 60793, 91017 Tawau, Sabah, Malaysia

Material and Methods

In order to establish new genetic material in provenance / progeny trials, we germinated 72 different Teak seedlots. Most of the seedlots were collected in a clonal seed orchard in Ivory Coast (La Sangoué, CIRAD-Foret: seedlot numbers with 94... as first two digits). The rest of the seedlots were true provenance from India (numbers with 83... and 88.... as first two digits), Thailand (numbers with 86.... at the beginning), Papua New Guinea (PNG), Solomon Islands (SI...), Indonesia (PARE) and Sabah (SEGAMA). See Table 1.

The reception of the different seedlots has been scattered over several months. So we sequentially implemented the experiments according to the quantity of seeds received and to the results observed with the previous tests. Some of the comparison below are not orthodox because the treatments were done either on the same seedlots but at different times, or on seedlots more or less differing for their composition.

The first batch of fruits from the clonal seed orchard La Sangoué arrived in late August 1996; we received approximately 700 grams of fruits per seedlots and we split all the lots into 2 parts. The first half was germinated in the PISP nursery (Luasong, Sabah) by extracting the seeds from the cracked fruits, followed by germination in Petri dishes (method described below and referred hereafter as cracking method). This method was chosen because, according to Dabral (1976), it is the one giving the fastest germination. According to the germination rate of the first half of the seedlots, the second half was again subdivided into 2. The best seedlots were germinated in the nursery using the same cracking method and the worse ones (germination below 5 %) were sent to the Plant Biotechnology Laboratory (PBL, Tawau, Sabah) for *in vitro* germination (described below).

Later on, we were able to find in the market some seedlots (PNG, SEGAMA, PARE) on which to test other germination methods: water-soaking and drying, soaking in sulfuric acid (described below), cracking method.

Late December 1996, we received a second batch of fruits to complete the seedlots from the clonal seed orchard La Sangoué (approximately 300 grams per seedlot). Half of the seedlots (the best germinating ones according to the previous test) were germinated in the nursery after a soaking/desiccation treatment. The remaining seedlots were germinated *in vitro* in the PBL.

Description of the germination methods

1) Extraction of the seeds, germination in Petri dishes (cracking method)

This technique was derived with modifications from Dabral (1976). The fruits were soaked in water for few hours and cracked with a hammer in order to extract the seeds. This technique is time consuming: it takes 3 hours to extract the seeds from 300 grams of fruits.

The seeds were counted and placed into Petri dishes (diameter 9 cm) on a thick filter paper (50 seeds per box). We moistened the seeds with a mixture of water and fungicide (Thiram, 2 grams/liter) and we removed the excess of water by reversing the boxes. The Petri dishes were placed under a mist system in order to keep the temperature low. The moisture was nearly 100% and the light was about 5% compared to open conditions.

True Provenances

seedlot n.	Provenance
8304167	India Chandrapur Maharastra
8606568	Thailand Mae Huat Lampang (wild)
8606569	Thailand Mae Huat Lampang (plant)
8807822	India Sakrebail Karnataka
8807823	India Sakrebail Karnataka
8807824	India Virnoli Vir. Karnataka
8807831	India Karadibetta Karnataka
8807832	India Gilalegundi Karnataka
8807833	India Virnoli Vir. Karnataka
8807835	India Maukal Karnataka
8807836	India Maukal Karnataka
8807838	India Maukal Karnataka
8807839	India Maukal Karnataka
8807841	India Maukal Karnataka
8807842	India Maukal Karnataka
8807844	India Maukal Karnataka
PARE	Indonesia Pare Pare
PNG	Papua New Guinea ex Brown River
SI 4314	Solomon Island Arara
SI 5212	Solomon Island Viru
SEGAMA	Malaysia Sabah

Table 1:

List of the seedlots, with their geographic origin, for the two types of material: true provenances (bulks), and families from a clonal seed orchard (Ivory Coast), established with plus trees selected in a multiprovenance trial (Ivory Coast).

Progenies of the Ivory Coast Clonal Seed Orchard

seedlot n.	provenance	origin of the clone
9410109	Ivory Coast	India Nellicutha
9410110	Ivory Coast	India Nellicutha
9410122	Ivory Coast	India Nellicutha
9410123	Ivory Coast	India Nellicutha
9410128	Ivory Coast	India Nellicutha
9410129	Ivory Coast	India Nellicutha
9410134	Ivory Coast	India Nellicutha
9410135	Ivory Coast	India Nellicutha
9410136	Ivory Coast	India Nellicutha
9410140	Ivory Coast	India Nellicutha
9410145	Ivory Coast	India Nellicutha
9410147	Ivory Coast	India Nellicutha
9410148	Ivory Coast	India Nellicutha
9410111	Ivory Coast	India Nilambur
9410113	Ivory Coast	India Nilambur
9410117	Ivory Coast	India Nilambur
9410118	Ivory Coast	India Nilambur
9410119	Ivory Coast	India Nilambur
9410120	Ivory Coast	India Nilambur
9410121	Ivory Coast	India Nilambur
9410137	Ivory Coast	India Nilambur
9410141	Ivory Coast	India Nilambur
9410142	Ivory Coast	India Nilambur
9410156	Ivory Coast	India Purunakote
9410157	Ivory Coast	India Purunakote
9410162	Ivory Coast	India Purunakote
9410152	Ivory Coast	India Masale Valley
9410159	Ivory Coast	India Masale Valley
9410143	Ivory Coast	India Vernolirge
9410146	Ivory Coast	India Vernolirge
9410150	Ivory Coast	India Vernolirge
9410114	Ivory Coast	Ivory Coast Bamoro
9410163	Ivory Coast	Ivory Coast Bamoro
9410116	Ivory Coast	Ivory Coast Kokondekro
9410154	Ivory Coast	Laos Paklay
9410161	Ivory Coast	Laos Paklay
9410115	Ivory Coast	Senegal Djibelor
9410151	Ivory Coast	Tanzania Bigwa
9410153	Ivory Coast	Tanzania Bigwa
9410160	Ivory Coast	Tanzania Bigwa
9410112	Ivory Coast	Tanzania Kihuhwi
9410131	Ivory Coast	Tanzania Kihuhwi
9410133	Ivory Coast	Tanzania Kihuhwi
9410124	Ivory Coast	Tanzania Mtibwa
9410126	Ivory Coast	Tanzania Mtibwa
9410138	Ivory Coast	Tanzania Mtibwa
9410155	Ivory Coast	Thailand Ban Cham Pui
9410158	Ivory Coast	Thailand Ban Pha Lay
9410164	Ivory Coast	Thailand Ban Pha Lay
9410125	Ivory Coast	Thailand Huoi-Nam-Oon
9410127	Ivory Coast	Thailand Huoi-Nam-Oon
9410139	Ivory Coast	Thailand Huoi-Nam-Oon
9410130	Ivory Coast	Thailand Mae Huat
9410144	Ivory Coast	Thailand Mae Huat
9410132	Ivory Coast	Thailand Pong Salee
9410149	Ivory Coast	Thailand Pong Salee

Every day, we moistened the filter papers in the Petri dishes and removed the excess of water. This operation was aimed to rinse the seeds and the filter paper and also to apply a daily fungicide treatment. The rotted seeds were discarded. Once the seeds started to germinate (radicle = 2 to 3 millimeters), they were transplanted into polybags. The transplanted seedlings remained under the mist system until the emergence of the first leaves (2 cotyledons + new leaves).

2) Soaking and drying of the fruits (soaking/drying method)

This technique is well known, for Teak, to be an efficient method to increase the germination rate and speed (Vallauri 1994); however, it may give very variable results according to the seedlot.

The fruits were soaked in the water during the night and dried under the sun, on a plastic sheet, during the day. This operation was repeated 7 days before sowing the fruits. The fruits were then sown very superficially in a sand seedbed in the open. We covered the seedbed with a wire netting to prevent animal attacks. The germinated seedlings were counted and transplanted on a week basis at the 2 leaves stage.

3) In vitro germination (in vitro method)

In vitro seed germination was carried out according to a protocol developed in the Plant Biotechnology Laboratory (Tawau, Sabah). The tetracarpic fruits were washed several times and then cracked with a small hammer. Healthy seeds (usually 1 to 2 per pod) were extracted from within each chamber of the pod and immersed in distilled water until further manipulation. The disinfecting treatment called for soaking the seeds in 70% ethanol for 5 min followed by treatment with 0.1% mercuric chloride for 5 min. The seeds were then rinsed in sterile water three times and inoculated onto a basal culture medium in test tubes for germination. The test tubes were kept in total darkness at 26°C until germination, usually observed 5 to 7 days later.

It has to be noted that, in order to save space and material in the PBL, an intensive selection on the seed quality has been carried out. Approximately 40% of the seeds were thus discarded based on their appearance and color.

4) Soaking the fruits in sulfuric acid (sulfuric acid method)

The method was derived with modifications by Behagel (1996). The fruits were soaked for 6 hours in sulfuric acid at 96% diluted 10 times with water, and then rinsed overnight in running water. They were then sown in a sand seed bed under shade net giving a light percent of 15% compared to open conditions. This method has been tested and compared to the other treatments based only on a subsample of the seedlots.

Results and discussion

A single Teak fruit may contain one, two or (rarely) more seeds. For this reason, the germination percentage has been calculated here based on the number of seeds and not of fruits. With the cracking and *in vitro* methods, we had direct access to the count of the number of seeds

per fruit. Over all the seedlots, the mean number of seeds per fruit was of 1.44. For the soaking/drying method, the number of seeds per fruit has been extrapolated, seedlot by seedlot, on the basis of the counts obtained with the two other methods.

It has to be noted that not all the seedlots were germinated with all the three techniques. So the comparison among the three methods could be carried out both based on the total germination, and on the germination of those seedlots tested with all methods. In the same way, the dates of the different treatments did not exactly coincide. In particular, the cracking and *in vitro* methods have been tested upon the two batches of fruits from CIRAD-Foret, received one in September 1996 and one in December 1996; the soaking/drying has been tested only on the batch of December 1996. Further biases were generated by: 1) the fact that the seedlots given to the PBL for *in vitro* germination were selected, according to the cracking method, among the worst germinating ones, and 2) the fact that in the PBL the selection on the seeds was much stronger than in the PISP nursery (approximately 40% and 5% respectively).

In the Petri dishes, the germination started 3 days after sowing and ended 15 days after. Using the soaking/drying method, the germination in the seedbeds started two weeks after sowing (January 2, 1997), had a major peak at about 4 weeks (January 30, 1997) but continued for more than four months after sowing (Figure 1). A second, less important, germination peak was observed at about 3 and a half months (April 12, 1997). For the practical purpose of planting the provenance / progeny trials with homogeneous material, the germination was considered close after this last peak, even if the germination was pursuing at a low rate. In *in vitro* conditions, the first germinations were observed three weeks after inoculation and two months later the germination was considered finished.

Figure 1. Germination of Teak over time (soaking / drying method, 1997).
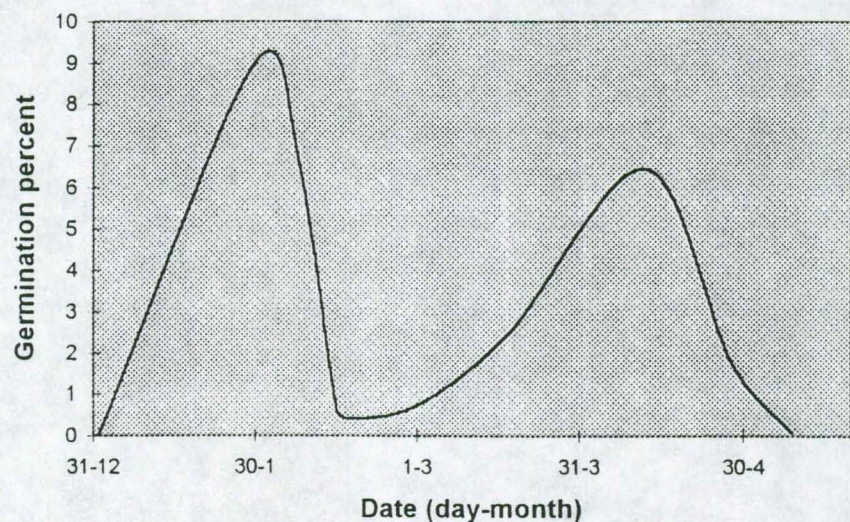
Germination rates by seedlot are reported in Appendix 1. In Table 2, the first column refers to the total germination and the second to the germination of the seedlots tested for the three methods (common lots).

Table 2: Comparison of the 3 germination techniques.

	Average germination (*number of seeds tested*)	Av. germination common lots (*number of seeds tested*)	Minimum to Maximum	Standard deviation common lots
Cracking method	4% (*44808*)	1% (*11760*)	0% to 31%	6%
Soaking/drying method	27% (*14294*)	20% (*10484*)	0% to 86%	28%
In vitro **method**	21% (*40337*)	21% (*11561*)	0% to 64%	16%

Overall, the best germination result was obtained by the soaking/drying technique. However, taking in account only the seedlots common to the three treatments (that means, as explained above, the worst germinating ones), the best result was comparably obtained by both the *in vitro* method and the soaking/drying method. The cracking method gave unexpected bad results, probably because of the physical damage to the germinants during transplantation and fungal attacks. The hypothesis of a chemical dormancy, broken by using the other two methods (that both require abundant soaking) but not with the cracking method, can not be discarded.

In Table 3, the results were shown subdividing the seedlots into 3 categories, according to the germination rate obtained with the soaking method. The soaking/drying method is better for the best germinating lots and the *in vitro* germination is more suitable for the lots with low germination (germination rate multiplied by 2 compare to soaking method).

After germinating the first half of the seedlots by the cracking technique, we tried several other fruits treatments; in particular, we compared the sulfuric acid method with the cracking and *in vitro* methods. The germination results of a test including about 1,000 seeds are summarized in Table 4.

Table 3:

Comparison of the 3 germination methods. Only the
seedlots germinated by the 3 techniques are compared.
The seedlots are classified into 3 categories according to
the germination percentage.

lot	seeds/g	% craking	% soaking	% in vitro
8807823	1.27	2%	75%	46%
9410152	1.43	0%	67%	45%
9410150	1.76	0%	66%	64%
9410112	1.05	0%	49%	30%
9410159	1.56	1%	31%	27%
9410154	1.33	0%	24%	38%
9410144	1.75	0%	24%	7%
8807833	1.24	0%	23%	24%
9410111	1.25	1%	18%	34%
	Average	1%	42%	35%

lot	seeds/g	% craking	% soaking	% in vitro
9410146	2.04	1%	14%	31%
9410136	1.51	1%	14%	39%
9410151	1.25	1%	13%	6%
9410129	1.01	5%	9%	32%
9410109	1.21	0%	6%	5%
9410135	1.81	3%	6%	26%
9410115	1.87	0%	5%	6%
9410155	1.96	0%	3%	3%
9410125	1.04	0%	3%	5%
9410161	1.64	0%	0%	4%
	Average	1%	7%	16%

lot	seeds/g	% craking	% soaking	% in vitro
9410113	1.91	0%	0%	0%
9410122	1.54	0%	0%	1%
9410138	0.52	0%	0%	0%
9410153	0.87	0%	0%	0%

General	Average	1%	20%	21%

Table 4: Comparison of the sulfuric acid method with the cracking and *in vitro* germination methods.

Germination technique	Germination % (nb seedlings / nb seeds)
Cracking method	9%
In vitro method	26%
Sulfuric acid method	0%

The fruits treated by the acid did not germinated at all. The other treatment ranked comparably to the previous test. This result was probably due to the damages inflicted to the embryos by the acid. In general, not all the seeds are at the same stage of development, they may be more or less mature, with a more or less thick mesocarp and endocarp. It seems then very difficult to regulate the acid concentration and duration of the treatment: for the thickest envelop the given treatment may be not effective, for the thinnest ones it may corrode the fruit and damage the embryo.

Finally, other small experiments have been carried on a small scale: heating the fruits in a oven, drying the fruits under the sun for different periods... None of these treatments gave satisfactory results.

However, by visual observation, we noticed a difference between the germination tests conducted under the shade nets, and those conducted in the open: these last often gave better results. The hypothesis to explain this result is that light and sun heating can help to break the dormancy of the seeds. This observation was partially supported by the two separate germination peaks obtained after the soaking/drying treatment (Figure 1). These seeds were sown in the open, and the two peaks corresponded to two very dry and sunny periods. The intermediate phase with low germination corresponded to the winter monsoon that brought heavy and continuous rain over all February 1997. Of course, this hypothesis needs to be confirmed by further experiments.

Table 5: Advantages and drawbacks of the different germination methods

	Advantages	Drawback
Cracking method	-Speed up the germination so that all the seedlings are very homogeneous in stage	- Work intensive because of the cracking operation with a hammer - Physical damage of the seeds by the cracking operation - Contamination problems in the Petri dishes - High mortality after transplanting due to the early stage of the seedlings (fragility of the radicle, pest and diseases)
Soaking/drying method	-Rapidity of the soaking/drying operation -Good germination results -Low mortality after transplanting	- Germination length: 3 months or more between the first and the last germination. -Risk of mixing the seedlots during the soaking/drying operation
In vitro **method**	-Limitation of the contamination problems -Good germination results -Poor mortality after transplanting	- Work intensive because of the cracking operation with a hammer - Physical damage of the seeds by the cracking operation - Cost of the operation due to the material required (test tubes, media, chamber…)
Sulfuric acid method		-Bad germination results -Even if in the literature some case of success have been reported, the risk to loose the seedlots is too important, and this method should be discarded

Conclusion

The advantages and drawbacks of the different methods were summarized in Table 5. The soaking/drying method gave satisfactory results for Teak seed germination, and was the less expensive technique both in terms of material and manpower. Some evidences were found that the exposition of the seeds to direct sunlight during the drying treatment and germination may enhance the germination. For seedlots that do not germinate well with the other techniques, the *in vitro* germination is a safe solution, giving good results in most cases.

The most important parameters that need to be studied further are:

- the number of cycles of the soaking/drying alternation

- the influence of the sun light during the drying treatment and the germination.

- the influence of the fruit conditions (maturation stage, age, hardiness of the endocarp, etc.) on the response to the different techniques.

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seedlot	number of seeds per gram of fruits	Cracking method		Soaking/drying meth.		In vitro method	
		Weight(g)	Germ %	Weight(g)	Germ %	Weight(g)	Germ %
8304167	1.34	334	14%			330	64%
8606568	0.88	656	14%			1200	30%
8606569	1.06	292	1%			1491	24%
8807822	1.13	661	11%	600	24%		
8807823	1.27	336	2%	700	75%	335	46%
8807824	0.97	678	12%	600	74%		
8807831	1.18	669	12%	600	60%		
8807832	1.55	666	16%				
8807833	1.24	335	0%	700	23%	335	24%
8807835	1.45	674	31%				
8807836	1.20	333	5%			332	23%
8807838	0.79	442	12%			441	26%
8807839	1.79	667	19%				
8807841	1.50	333	1%			332	48%
8807842	0.81	757	17%				
8807844	1.39	657	14%	600	15%		
9410109	1.21	378	0%	300	6%	378	5%
9410110	1.79	354	0%			644	9%
9410111	1.25	354	1%	300	18%	353	34%
9410112	1.05	354	0%	301	49%	354	30%
9410113	1.91	352	0%	277	0%	351	0%
9410114	1.46	703	4%				
9410115	1.87	406	0%	281	5%	306	6%
9410116	1.26	711	9%			297	12%
9410117	1.42	405	1%			605	20%
9410118	1.35	407	0%			306	55%
9410119	2.44	406	0%			594	12%
9410120	0.64	409	0%			609	24%
9410121	1.45	352	0%			351	0%
9410122	1.54	355	0%	255	0%	354	1%
9410123	1.37	358	0%			658	7%
9410124	0.67	356	0%			616	25%
9410125	1.04	357	0%	299	3%	356	5%
9410126	1.83	356	1%			656	15%
9410127	1.04	359	0%			358	13%
9410128	1.61	355	0%			655	6%
9410129	1.01	348	5%	278	9%	347	32%
9410130	0.91	719	13%	279	62%		
9410131	2.67	359	1%			626	16%
9410132	1.47	355	1%			605	20%
9410133	1.62	359	2%			644	13%
9410134	1.78	358	0%			358	24%
9410135	1.81	357	3%	300	6%	357	26%
9410136	1.51	358	1%	265	14%	358	39%
9410137	2.25	351	1%			350	42%
9410138	0.52	357	0%	300	0%	357	0%
9410139	1.90	713	6%				
9410140	1.26	713	8%	600	86%		
9410141	1.84	357	0%			667	9%
9410142	1.44	358	2%			657	14%
9410143	3.65	721	9%				
9410144	1.75	357	0%	288	24%	357	7%
9410145	1.72	359	0%			658	11%
9410146	2.04	358	1%	300	14%	358	31%
9410147	1.07	358	2%			657	17%
9410148	1.28	359	0%			659	21%
9410149	1.52	355	0%			655	19%
9410150	1.76	358	0%	279	66%	358	64%
9410151	1.25	357	1%	300	13%	356	6%
9410152	1.43	360	0%	292	67%	360	45%
9410153	0.87	358	0%	300	0%	358	0%
9410154	1.33	359	0%	302	24%	358	38%
9410155	1.96	358	0%	251	3%	357	3%
9410156	1.32	358	0%			658	27%
9410157	1.29	356	2%			643	33%
9410158	1.36	357	0%			605	13%
9410159	1.56	357	1%	300	31%	357	27%
9410160	2.01	356	0%			662	17%
9410161	1.64	359	0%	317	0%	359	4%
9410162	0.85	353	0%			353	0%
9410163	1.12	711	14%				
9410164	0.96	354	0%			354	7%
General Average			4%		27%		21%
Standard deviation			6%		28%		16%

GUIDELINES FOR THE
TREE PLANTATION INVENTORY

Dr. Roberto Bacilieri (CIRAD-Forêt), Dr. Kazuma Matsumoto (JIRCAS), Mr. Charles Garcia (ICSB)

May 1997

1.0 INTRODUCTION

These guidelines have been prepared after the decision taken during the 13° Luasong/Tawau Technical Group Meeting (May 5, 1997), to proceed with an inventory of the tree plantation in Luasong. ICSB needs to know the performances of trees in line planting in order to delineate the planting strategy for the future. This paper has as objective to underline the important elements to be included in the inventory and to optimise the procedure for the measurement and data analysis. It takes advantage of the past research experiences in Luasong (CIRAD-Forêt and ICSB: Study of the environmental effects on rattan growth; JIRCAS and ICSB: Study of the insect attacks on Meliaceae)

2.0 LIST OF COMPARTMENTS

After a survey of the existing data files in the Plantation Unit (compartment history), three major species have been identified as interesting for further planting: *Swetenia macrophylla*, *Cedrela odorata* and *Khaya ivorensis*. The list of the compartments and subblocks for each species is as follow:

1) *Swetenia macrophylla*: Compt. 218, subblocks B, C, D, E, F, G. (compt. 227 and 228?)

2) *Cedrela odorata*: Compt. 228, subblock A.

3) *Khaya ivorensis*: Compt. 230, subblocks A, B, C.

On the base of the available data, it is difficult to estimate the net planted area (sometimes the block boundaries have been moved, sometimes the block has been replanted with rattans, etc.). A first estimation, that needs to be further investigated with the help of the Plantation's Rangers, is:

1) *Swetenia macrophylla*: ~ 78 ha

2) *Cedrela odorata*: ~ 15 ha

3) *Khaya ivorensis*: ~ 53 ha

3.0 OBJECTIVES OF THE INVENTORY

It seems to us that the inventory should have two major objectives:

1) To evaluate the quality of the trees in terms of growth and form, in order to make a projection of their commercial value in the future.

2) To describe the factors playing a role in the determination of the wood quality: insect attacks, competition from other trees, light, etc.

4.0 SAMPLING STRATEGY

We would like to suggests for the inventory to be based on non-permanent plots. One of the best sampling strategy is as follows:

Figure 1

1) Systematically draw a number of spots for each block. For example: one spot every "*X*" meters, one line over "*Y*" (Figure 1). The distance among sampling points (*X*) and/or among lines (*Y*) should be adjusted to the size of the planted subblock, in order to have enough, but not too much, sampling points for a statistical analysis. From this point of view, 80-100 spots per block should be enough.
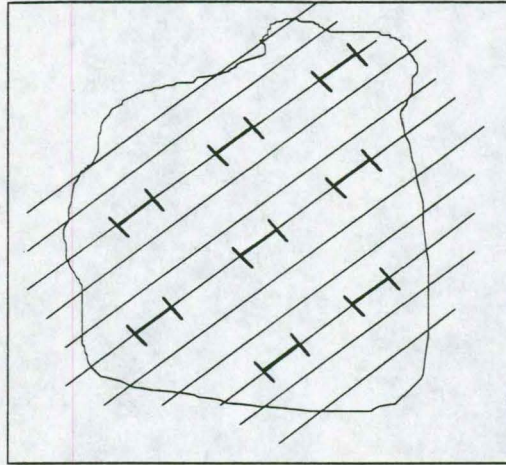
2) Once in the field, to identify the points the team must **strictly** stick to the two above parameters (*X* and *Y*), irrespective of the condition of the trees or of the forest (dead or alive, burnt or bad looking, difficult to access, etc.). All the points should be recorded and described, even if all the planted trees are dead.

3) The position (line number, spot number, distance from the road) of each point should be recorded.

Figure 2

4) One sampling point includes three (**3**) planted trees to be measured (Figure 2).
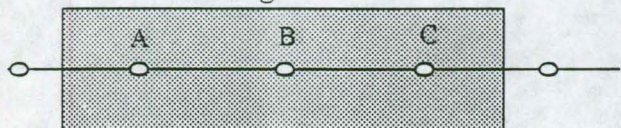

5.0 CHARACTERS TO BE MEASURED

We suggests the inventory to focus on the following measurements, to be taken, for each tree, on the main stem only:

1) Diameter at breast height.

Figure 3

2) Height of branching, where branching is defined as the point of insertion of a branch with a diameter at least 25% of the diameter of the main stem at the insertion point. This includes forking, when the main stem divides in two stems of almost equal diameter, both growing out of the vertical axis (Figure 3).

Figure 4
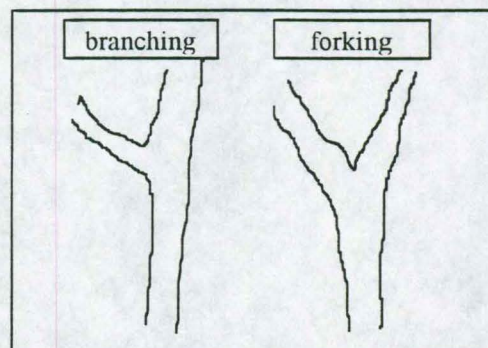
3) Height of major stem deformations other than branching, that in the future can compromise the use of the log (Figure 4).
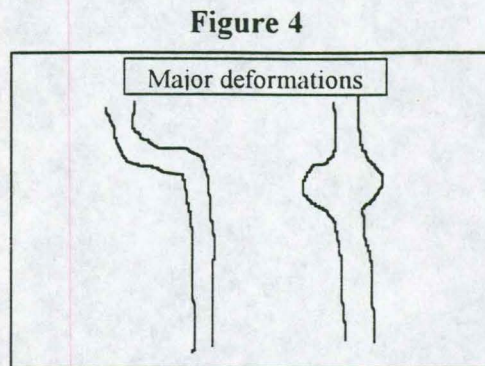
In each sampling point, the surrounding forest and environment must also be described according to the following:

1) Forest description, three classes:

        a) mainly a gap
        b) mainly pioneer species (record the dominant species)
        c) mainly dipterocarps or other timbers (record the dominant species)

2) Each surrounding tree with the canopy overshading (above vertical) the measured tree must be counted in one of two categories: a) pioneer species; b) dipterocarps+OT (Figure 5).

Figure 5
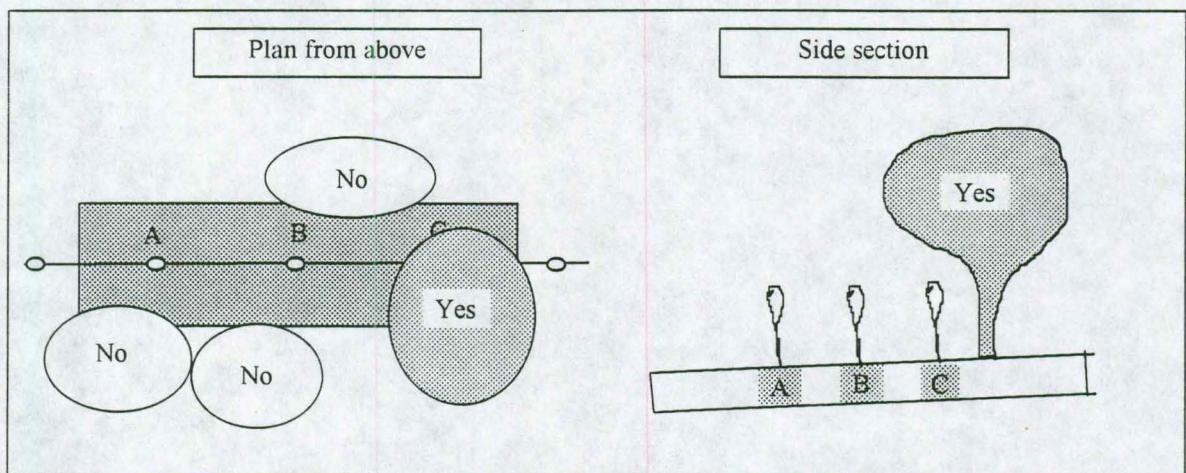
3) Each plot should be attributed to one of the following classes

        a) bottom of a valley
        b) slope
        c) ridge

6.0 DATA ANALYSIS

The frequency of deformations and branching can be studied according both to spatial coordinates (concentrated in few spots or evenly distributed, etc.) and to the environmental description (more deformation under heavy shade or under canopy gaps, etc.). The same applies for the analysis of growth (wet sites against dry sites; shaded against open sites, etc.). The data will be studied by the use of non-parametric statistics (non-parametric correlations, rank tests, etc.). Comparisons among species will also help to define the future planting strategy.