PLANT IMPROVEMENT & SEED PRODUCTION PROJECT

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ICSB / CIRAD-Forêt

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1. 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 expiry of the second phase (July 1992 to July 1997). The objectives of PISP are as follow:

Short term objectives :

- To develop a plant improvement strategy of rattans, high-value timber species, and industrial timber species
- 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
- To develop the technical capability in plant improvement and seed/other planting material production of ICSB

Long term objectives :

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

Personnel

In 1999 there was a further decrease in the number of staff to 26 compared to 36 in March 1999. The reduction was mainly due to the departure of 9 casual staff and one French volunteer, without replacements. Willfrid Schueller ended his 14-month volunteership in May 1999. The staff line-up as end of February 2000 is as follows:

Position	ICSB	CIRAD-Forêt
Senior Scientist	1	1
Junior Scientist		
Senior Forest Ranger	1	
Forest Ranger	3	
Casual labourer	20	
TOTAL	25	1

The reduction in casual staff, a problem already signalled during the Steering Committee Meeting of 1999, has jeopardised some of the routine work in the project, particularly for maintenance of field plots and annual assessment of field trials, as well as implementation of new research activities.

1. RATTANS

1.1 GENETIC IMPROVEMENT

Activities on rattans have been minimised since 1998 following the reduction in the casual staff. In 1999, the activity mainly concentrated on field maintenance of the established trials. A 100%-census was done in all PISP rattan genetic trial plots (25.4 ha) with the aim of determining survival after a number of years in the field (Table 1). The survival percentage varied according to the location of the trials. Species like *Calamus manan* has the highest mortality (up to 85%) whereas *C. caesius* is the most intact species as indicated by its low mortality. Attacks by mammals (elephants and porcupines) are probably the main cause of high mortality in *C. manan* and *C. subinermis* plots. It is recommended to convert all genetic trial plots that have mortality more than 40% into resource stands.

Table 1. Result of 100% survival census of rattan genetic trial plots

Species	Plot no.	Type of trial	Area (ha)	Date planted	Total plants	No. of progeny/ provenance	% mortality as Jul 1999
C. manan	CMB1	Progeny 1	0.2	Feb 92	100	5	13.0%
C. manan	CMB2	Progeny 2	0.2	Feb 92	104	4	16.3%
C. manan	CMB3	Progeny 3	0.1	Feb 92	90	3	10.0%
C. manan	CMB4	Progeny 4	1.3	Jan 93	1000	20	15.0%
C. manan	CMB5	Progeny 5	0.5	Jun 94	400	20	85.5%
C. manan	CMB6	Progeny 6	0.2	Jun 94	180	6	69.4%
C. manan	CMB7	Progeny 7	0.2	Jun 94	180	9	33.3%
C. manan	CMB8	Progeny 8	0.4	Jun 94	300	30	40.3%
C. manan	CMB9	Progeny 9	0.3	Nov 94	210	7	67.6%
C. manan	CMB10	Progeny 10	0.4	Aug 95	288	36	18.4%
C. manan	R1	Resource 1	0.3	Jun 94	197	6 (bulk)	82.2%
C. manan	R2	Resource 2	0.3	Jun 94	256	14	79.9%
C. manan	R3	Resource 3	0.3	Jun 94	244	8	83.6%
C. manan	R4	Resource 4	0.4	Jun 94	310	12	49.4%
C. manan	R5	Resource 5	0.2	Jun 94	170	17	47.1%
C. manan	R6	Resource 6	0.4	Nov 94	300	6	80.3%
C. manan	R7	Resource 7	0.1	Jan-98	107	2	73.8%
C. subinermis	CSB1	Progeny 1	0.1	Jul 91	75	5	53.3%
C. subinermis	CSB2	Progeny 2	0.2	Jul 91	165	3	17.6%
C. subinermis	CSB3	Progeny 3	0.3	Jul 91	240	6	28.8%
C. subinermis	CSB4	Progeny 4	0.2	Dec 91	150	5	10.0%
C. subinermis	CSB5	Progeny 5	0.9	Feb 93	700	14	21.1%
C. subinermis	CSB6	Progeny 6	0.2	Jun 94	180	6	5.6%
C. subinermis	CSB7	Progeny 7	0.6	Jun 94	450	30	20.7%
C. subinermis	CSB8A	Progeny 8A	0.5	Nov 94	432	72	5.6%
C. subinermis	CSB8B	Progeny 8B	0.5	Nov 94	432	72	3.2%
C. subinermis	CSB9	Progeny 9	0.3	Aug 95	200	20	10.5%
C. subinermis	CSB10	Progeny 10	0.6	Oct 96	448	16	49.3%
C. subinermis	CSC1	Proven. 1	0.6	Dec 90	420	6	28.3%
C. subinermis	R1	Resource 1	0.3	Jun 94	200	4 (bulk)	11.0%
C. subinermis	R2	Resource 2	0.2	Jun 94	170	9	10.0%
C. subinermis	R3	Resource 3	0.1	Aug 95	50	1	24.0%
C. subinermis	R4	Resource 4	0.5	Dec 94	394	74	8.9%
C. subinermis	R5	Resource 5	0.2	Oct 96	120	6	35.0%
C. subinermis	R6	Resource 6	0.3	Jan-98	206	10	8.3%
C. caesius	CCB1	Progeny 1	1.0	May 91	645	43	4.5%

Table 1 (continued)

Species	Plot no.	Type of trial	Area (ha)	Date planted	Total plants	No. of progeny/ provenance	% mortality as Jul 1999
C. caesius	CCB2	Progeny 2	0.8	May 91	525	35	5.9%
C. caesius	CCB3	Progeny 3	0.9	Jun 91	625	25	7.7%
C. caesius	CCB4	Progeny 4	0.6	Sep 91	400	10	14.5%
C. caesius	CCB5	Progeny 5	0.9	Dec 91	600	40	8.2%
C. caesius	CCB6	Progeny 6	1.1	Dec 91	700	35	14.3%
C. caesius	CCB7	Progeny 7	1.0	Dec 91	660	33	29.1%
C. caesius	CCB8	Progeny 8	0.5	Oct 96	400	16	10.3%
C. caesius	CCB9	Progeny 9	0.5	Oct 96	432	16	8.3%
C. caesius	CCC1	Proven. 1	0.3	May 92	270	9	12.2%
C. caesius	R1	Resource 1	0.5	Jun 91	300	60	9.7%
C. caesius	R2	Resource 2	0.1	Sep 91	50	10	30.0%
C. caesius	R3	Resource 3	0.3	Dec 91	200	40	17.0%
C. caesius	R4	Resource 4	0.2	Dec 90	100	1 (bulk)	28.0%
C. caesius	R6	Resource 6	0.1	Aug 95	50	1 (bulk)	22.0%
C. caesius	R7	Resource 7	0.1	Aug 95	100	1	21.0%
C. caesius	R8	Resource 8	0.1	Oct 96	40	2	0.0%
C. optimus	R1	Resource 1	0.3	Aug 96	213	2	28.6%
C. optimus	R2	Resource 2	0.2	Jan 98	152	5	78.3%
C. ornatus	COB1	Progeny 1	0.2	Aug 95	180	20	2.2%
C. ornatus	R1	Resource 1	0.1	Aug 95	100	1	3.0%
C. ornatus	COB2	Progeny 2	0.3	Jan 98	270	30	58.1%
C. trachycoleus	CTB1	Progeny 1	3.3	Dec 90	2627	31	48.6%
		Total	**25.4**		**19,157**		

1.2 SILVICULTURE

A second census was done with the participation of the Plantation and Pest/Disease units, in an area of 1,945 ha. This was part of the proposed Benta Wawasan C area, which overlaps with the Luasong rattan plantation area. The result of the census indicated that survival percentage of *C. caesius* and *C. trachycoleus* was 59%, and 71% for *C. subinermis*. The yield per ha at 8 years age were estimated as 0.21 metric ton (mt) for *C. caesius*, 0.26 mt for *C. trachycoleus* and 490 3-m sticks for *C. subinermis*. Detailed report is presented in Appendix 1.

2. TREES

A list of the most important field trials for tree species of interest is attached in Appendix 2.

2.1 ACACIAS

2.1.1 Growth assessment

The usual assessment of the growth in the Acacia seedstands in Tiagau has been carried out, as well as routine maintenance and seed collection. Results of the growth assessment are presented in Table 2.

Table 2. Growth assessment of the Acacia Seedstands in Tiagau.

Species & plot	Age (yrs)	No. of Living trees	Mean height (m)	Mean diameter (cm)	HMAI (m/yr)	DMAI (cm/yr)
Acacia mangium (PNG)	10.1	129	32.7 (2.4)	34.8 (6.1)	3.2	3.5
SSO1 (planted 1990)	10.0	159	34.2 (3.2)	33.3 (6.3)	3.4	3.3
SSO2 (planted 1990)	10.1	127	31.3 (3.6)	34.2 (5.7)	3.1	3.4
SSO3 (planted 1990)						
Average			***32.7***	***34.1***	***3.2***	***3.4***
SSO4 (planted 1997)	2.6	1100	12.3 (1.8)	10.1 (3.2)	4.8	3.9
A. crassicarpa						
SSO1 (planted 1990)	9.9	82	27.5 (3.2)	34.1 (5.7)	2.8	3.4
SSO2 (planted 1990)	9.9	110	28.3 (2.9)	33.7 (6.4)	2.9	3.4
SSO3 (planted 1990)	9.9	87	29.6 (2.1)	34.8 (5.1)	3.0	3.5
Average			***28.5***	***34.2***	***2.9***	***3.4***

Note: Value in parenthesis indicates standard deviation

2.1.2 Seed Production

The *Acacia crassicarpa* in the seedstands fruited heavily in 1999 and 2000. Twenty kg of the seeds collected in July 1999 and February 2000 were sold to Sabah Forest Industries (SFI) near Sipitang, together with 30 kg of 1996-collected PNG's *A. mangium*. The current stock of *A. crassicarpa* and *A. mangium* seeds at PISP's storage room are 9.2 kg and 43 kg, respectively.

2.1.3. Vegetative propagation – Acacia hybrids

The research on vegetative propagation has continued from what was initiated in 1998, with emphasis on rooting and survival of A. hybrids cuttings. The intrarameal cutting order along the shoot and several soil types were compared. Overall rooting rate was 83%, with little variation among intrarameal order: internodes 1 to 4 are all suitable for cuttings. Some differences of rooting rate were observed among clones, with the less performing clone providing a rooting percentage of 71%, still satisfactory. Survival rate after transplanting varied between 60% and 80%, and was influenced by the soil type. In addition it is suspected that watering under mist and during hardening play a role in the survival of the cuttings (Appendix 3).

2.1.4 *Acacia mangium* clone n. 5 – Open-pollinated seedlings versus in vitro plantlets

In 1996 a trial comparing in vitro plantlets of clone n. 5 to its open-pollinated seedlings where established in the field. Yearly assessments were carried out and the results published in the previous Steering Committee Meeting Reports. In 1999 we made the last assessment of the trial, showing that still no differences in growth, form and variability can be observed between the two treatments. A joint paper is being prepared by O. Monteuuis for publication in a scientific journal.

2.1.5. Establishment of a new clonal trial for *A. mangium* and A. hybrids

A new clonal trial has been established in Taliwas under the care of J. Gidiman and A. Galiana (PBL). This trial includes *A. mangium* and hybrid clones, as well as a control of open-pollinated seedlings (Origin : Ex-Tiagau SSO2, from Papua New Guinea), disposed both in a random complete blocks (3 repetitions, 16 plants per experimental unit) and a monotree blocks design (10 repetitions, 25 treatments). Details of the trial are published under the PBL's report.

2.1.6. Statistical analysis of the *A. mangium* progeny trials in Tiagau

The three seed orchard of the PNG provenance of *A. mangium,* planted in Tiagau in 1990 (SSO1, SSO2 and SSO3) were analysed according to a genetic model, in order to carry out a selection for the establishment of a second generation seed orchard (PNG SSO4, described below). There were 56 families in three to six repetitions per site and three sites. The heritability for height, diameter, fork and straightness is reported in Table 3. A heritability of 0.45 or 0.50 has to be considered very promising for family selection.

Table 3. Heritability estimation for several characters in *A. mangium.*

Variable	Mean number of trees within repetition	Variance within progeny	Heritability (narrow sense)	Heritability (broad sense)	F-test
Height	8	0.14	0.12	0.20	0.11 (ns)
Diameter	8	1.86	0.45	0.50	0.00 (**)
Fork	8	0.06	0.23	0.32	0.02 (*)
Straightness	8	0.01	0.16	0.24	0.05 (*)
Volume	8	0.10	0.50	0.53	0.00 (**)

Note : (ns)=non-significant ; (*)=significant ; (**)=highly significant.

A ranking of the families were also done for different characters, and a multicharacter selection index developed (attached in Appendix 4) in order to select the best families for the next improvement generation (see below).

2.1.7. Assessment and maintenance of the second-generation seed orchard of *A. mangium*

From the above study, a second-generation seed orchard of *A. mangium* was established in 1997, with open-pollinated seedlings of the best 20 families of the SSO1, SSO2 and SSO3 progeny trials in Tiagau (PNG provenance, planted in 1990). The 20 families where selected from 58 families present in the trials, according to a multisite genetic analysis of their growth (diameter and height) and form (straightness and branching) at 6 year after plantation (based on data collected in 1996). The list of the planted materials as well as the growth performance is given in Table 4. Based on the genetic parameters of par. 2.1.6, one can expect that this stand (PNG SSO4) will have a performance superior to the one observed in the SSO1, SSO2 and SSO3 of 3% in height, 14.3% in diameter, 13.4% in forking, 7.6% in straightness and 33.5% in volume.

The trial was established according to a modulo tiles design (10 repetitions), in order to have always the largest distance among trees of the same families and to avoid inbreeding. The experimental unit included eight trees, but this number must be brought down to only one tree per plot so that to avoid inbreeding. A first selectively thinning at 50% intensity is planned for year 2000 in order to allow the trees to expand their crown. A second thinning leaving only one tree per plot is planned for year 2002, and the first seed collection for 2003. A family effect is already observed in height growth and straightness, and this can be used in a further step of improvement (III-generation seed orchard).

Through genetic analysis of this trial, and assuming to keep in the final seed orchard one tree per family (now there are 8, so the selection is at 12.5%) we can predict a genetic gain in the seed output of the trial SSO4 of at least 8.5% in height, 3.7% in diameter, 14.7% in forking, 16.6% in straightness and 9.6% in volume. Assuming that the genetic gains obtained by the two steps of genetic improvement (through first and second generations) can be simply added, the seeds collected on the SSO4 should provide an increase of 43% in volume as compared to the original PNG provenance. It will be very interesting to verify the actual gain with a field trial.

Table 4. List of the materials and performances in the PNG SSO4 trial

PISP AM Tree Number	Location of the parent tree	Original Family Number	Number of trees in the trial	Diameter	Height	Straight-ness	Fork
32	PNG SSO 2	485	45	10.97	12.36	1.48	1.20
14	PNG SSO 1	784	62	8.93	10.58	1.63	1.09
133	PNG SSO 2	1087	50	10.98	11.98	1.73	1.39
134	PNG SSO 1	1089	58	10.05	12.55	1.40	1.25
110	PNG SSO 2	1099	59	10.09	12.51	1.41	1.16
124	PNG SSO 2	1134	48	9.86	12.52	1.41	1.12
131	PNG SSO 2	1176	52	10.69	12.67	1.52	1.14
111	PNG SSO 1	1186	56	10.51	12.67	1.31	1.14
6	PNG SSO 2	1188	61	9.24	12.01	1.47	1.28
114	PNG SSO 2	1237	57	9.97	12.97	1.22	1.05
152	PNG SSO 2	1260	54	9.66	12.05	1.40	1.10
155	PNG SSO 1	1267	45	10.55	11.95	1.49	1.22
4	PNG SSO 2	1275	60	10.33	12.34	1.60	1.30
20	PNG SSO 3	1276	50	11.38	13.20	1.57	1.32
5 (clone n. 5)	PNG SSO 2	1278	71	10.11	12.23	1.38	1.10
121	PNG SSO 1	1284	52	9.37	11.91	1.52	1.35
7	PNG SSO 2	1285	64	9.99	12.56	1.61	1.11
15	PNG SSO 1	1287	58	10.34	12.60	1.49	1.06
147	PNG SSO 3	1289	50	9.36	12.42	1.77	1.09
1	PNG SSO 3	16631	48	8.99	11.68	1.61	1.19
Probability level of :			*Family effect*	0.2033	***0.0026***	***0.0030***	0.1888

2.2 OCTOMELES SUMATRANA (BINUANG)

The effect of the three thinning treatments applied in September 1998 to the *Octomeles sumatrana* trial in Taliwas (5 ha) were studied in 1999 (Appendix 5). The three thinning intensities (20, 30 and 40% of the number of trees) did not provide differential growth to the respective blocks, neither for diameter nor for basal area. The trial seems to react very slowly to thinning, and as the lack of difference between treatments shows, there may be a limiting element other than competition hindering the growth of this species.

2.3 TECTONA GRANDIS (TEAK)

2.3.1 Commercial Production

RBJ was committed to supply 34,000 Teak to Kulumpang Development Sdn. Bhd (KDSB), in relation to that PISP was asked to initiate production of cuttings to meet a portion of the demand before August 1999. A lot of efforts were diverted to refurbish the stock plants as PISP had stopped producing cuttings commercially in 1998, and also to ensure the misting systems were in good working condition. In August, PISP contributed about 13,000 Teak cuttings to several buyers including KDSB. Another 13,000 cuttings were transferred to Taliwas for the Forest Research and Regeneration (FRR) planting programme.

A detailed record was maintained and a paper was written to highlight some of the parameters during the course of the commercialisation (Appendix 6). The average rooting success of cuttings was 63.2% and the production cost was RM1.07 per cutting.

2.3.2. Volume and yield estimation in the FRC's Yield Plots

In December 1998 a scientific paper on teak growth was presented at the "Seminar on High Value-Timber Species for Plantation Establishment – Teak and Mahoganies" held in Tawau (Appendix 7). Following positive commentaries on the paper and in order to collect more reliable data, in 1999 we carried out ourselves, in collaboration with FRC, a new assessment of the teak yield plots established from 1926 to 1977 in Sabah. Five days were spent visiting and measuring the yield plots in Sibuga and Gum Gum (Sandakan), Bandau (Kota Marudu) and Racangan-Tass and Jalan Apas km 15 (Tawau). A scientific paper is under preparation for publication in an international journal.

2.3.3. Assessment of the provenance/progeny trials

The assessment of the Teak provenance/progeny trials in Taliwas (planted in 1997) has been done, with notation of growth, form and flowering. Genetic variability is large, that is promising for selection. The plant materials formerly developed in Ivory Coast perform better than the natural provenances, with an advantage of 10% in diameter, 10% in height, above 50% in straightness and 25% in volume (paper presented at the Steering Committee Meeting of 1999).

Flowering

In June 1999, 28 months after planting, 94 trees (5.7%) were flowering. The pattern of flowering was not random, as can be seen on Table 5. The Papua New Guinea true provenance was by far the earliest flowering, followed by few Indian, Thailand and Ivory Coast progenies collected on plus tree graftings in the clonal seed orchard of Ivory Coast. However this did not show in height growth (in contrast to what would have been expected according to the negative effect of early flowering described in literature), the PNG seedlot ranking 8th out of 41 in terms of height and 4th in diameter.

It is also worth noting that the PNG seedlot is the only true provenance ranking quite well in between the superior Ivory Coast material (Table 6). It would be worth to collect more information about the origin of this material for which at present little is known. In the same way, it should be also worth to try some Indonesian provenances such as Unjung Padang, which is located in another humid climate similar to the one found in Sabah.

2.3.4. Comparison of propagation methods

A trial comparing teak clones propagated by micro- and macro-cuttings was established in Taliwas in September 1998. It included 20 treatments and five repetitions, with a bulk of seedlings as a control.

In December 1999 the trial was assessed by the FRR Unit. Even if it is premature to draw conclusion, we publish the result of the assessment at one year after plantation (Appendix 8).

The comparison of treatments in this trial is rather unbalanced : there are only three treatments common to micro- and macro- propagation (clones TG3, TG7 and TG8), and the seedlot used as a control comes from a completely different genetic origin. For this reason, in 1998 a second more robust « comparison of propagation method trial » was planned. PISP bought fresh seeds from FRC (provenance Kota Marudu) and germinated part of them. These seedlings were then used to prepare edge-plants from which to collect micro- and macro- cuttings. In this way, the genetic origin of the three materials (seedlings, micro- and macro-cuttings) would be the same, and the comparison more robust. However the introduction in the vegetative propagation cycle has not started yet. To date, 134 hedgeplants are available at PISP for this experiment.

Table 5. Flowering pattern in the Teak provenance/progeny trial in Taliwas, at 27 months after planting.

Country of origin	Location of origin	Type of material	seedlot	number of flowering trees (out of 45)
Papua NG	PNG Brown River	True provenance	**PNG**	16
India	Chandrapur	True provenance	**8367**	1
India	Virnoli-Gilalegundi-Karadibetta	True provenance	**8832**	1
India	Virnoli-Gilalegundi-Karadibetta	True provenance	**8833**	1
India	Maukal-Masale Valley	True provenance	**8844**	1
India	Maukal-Masale Valley	True provenance	**8668**	0
India	Sakrebail	True provenance	**8823**	0
India	Virnoli-Gilalegundi-Karadibetta	True provenance	**8824**	0
India	Virnoli-Gilalegundi-Karadibetta	True provenance	**8831**	0
India	Maukal-Masale Valley	True provenance	**8835**	0
India	Maukal-Masale Valley	True provenance	**8836**	0
India	Maukal-Masale Valley	True provenance	**8838**	0
India	Maukal-Masale Valley	True provenance	**8839**	0
India	Maukal-Masale Valley	True provenance	**8841**	0
India	Maukal-Masale Valley	True provenance	**8842**	0
Country of origin	**Location of origin**	**Type of material**	**Family (grafted plus-trees)**	**number of flowering trees (out of 45)**
India	Maukal-Masale Valley	ex-situ - Ivory Coast	**9452**	10
Thailand	Nuoi Na Soon-Ban Phai Lai	ex-situ - Ivory Coast	**9458**	10
India	Maukal-Masale Valley	ex-situ - Ivory Coast	**9459**	9
India	Virnoli-Gilalegundi-Karadibetta	ex-situ - Ivory Coast	**9443**	6
Ivory Coast	Bamoro-Korondekro	ex-situ - Ivory Coast	**9416**	6
India	Virnoli-Gilalegundi-Karadibetta	ex-situ - Ivory Coast	**9446**	4
India	Purunakote	ex-situ - Ivory Coast	**9457**	4
India	Nilambur-Nellicutha	ex-situ – Ivory Coast	**9434**	4
India	Nilambur-Nellicutha	ex-situ - Ivory Coast	**9442**	3
Tanzania	Mtibwa	ex-situ - Ivory Coast	**9426**	3
Tanzania	Kihuhwi	ex-situ - Ivory Coast	**9431**	3
Ivory Coast	Bamoro-Korondekro	ex-situ - Ivory Coast	**9463**	3
India	Nilambur-Nellicutha	ex-situ - Ivory Coast	**9437**	2
Tanzania	Kihuhwi	ex-situ - Ivory Coast	**9412**	2
Thailand	Nuoi Na Soon-Ban Phai Lai	ex-situ - Ivory Coast	**9439**	2
Laos	Pak Lay East	ex-situ - Ivory Coast	**9454**	1
India	Nilambur-Nellicutha	ex-situ - Ivory Coast	**9417**	1
India	Nilambur-Nellicutha	ex-situ - Ivory Coast	**9435**	1
India	Virnoli-Gilalegundi-Karadibetta	ex-situ - Ivory Coast	**9450**	0
India	Nilambur-Nellicutha	ex-situ - Ivory Coast	**9411**	0
India	Nilambur-Nellicutha	ex-situ - Ivory Coast	**9418**	0
India	Nilambur-Nellicutha	ex-situ - Ivory Coast	**9429**	0
India	Nilambur-Nellicutha	ex-situ - Ivory Coast	**9440**	0
India	Nilambur-Nellicutha	ex-situ - Ivory Coast	**9445**	0
India	Maukal-Masale Valley	ex-situ - Ivory Coast	**9430**	0
India	Maukal-Masale Valley	ex-situ - Ivory Coast	**9432**	0

Table 6. Seedlot performance (averages) in the Teak provenance / progeny trial in Taliwas (km 18), 25 months after planting. Data ranked by height.

Ex-situ	Seedlot	Height	Diameter	Straightness (*)	Bending	Branching	Breakages	Fork	Flowering
Ivory Coast	**9443**	11.8	11.4	0.24	0.02	0.12	0.05	0.24	0.14
Ivory Coast	**9412**	11.2	10.4	0.09	0.03	0.26	0.03	0.22	0.05
Ivory Coast	**9439**	11.1	10.7	0.22	0.10	0.17	0.00	0.17	0.05
Ivory Coast	**9437**	11.1	10.6	0.28	0.11	0.19	0.00	0.06	0.06
Ivory Coast	**9426**	11.0	10.9	0.15	0.08	0.13	0.00	0.05	0.08
Ivory Coast	**9430**	11.0	10.9	0.15	0.03	0.18	0.03	0.12	0.00
Ivory Coast	**9445**	11.0	10.5	0.14	0.07	0.13	0.02	0.07	0.00
True Provenance	**PNG**	10.9	10.9	0.14	0.05	0.06	0.00	0.05	0.41
Ivory Coast	**9416**	10.8	9.6	0.35	0.08	0.28	0.02	0.08	0.13
Ivory Coast	**9435**	10.8	10.5	0.31	0.03	0.11	0.02	0.03	0.03
Ivory Coast	**9431**	10.8	10.0	0.19	0.15	0.27	0.00	0.11	0.06
Ivory Coast	**9418**	10.8	9.9	0.11	0.04	0.11	0.00	0.16	0.00
Ivory Coast	**9429**	10.7	10.4	0.22	0.05	0.09	0.00	0.05	0.00
Ivory Coast	**9463**	10.6	10.7	0.09	0.00	0.16	0.03	0.09	0.07
Ivory Coast	**9434**	10.5	10.1	0.16	0.05	0.14	0.05	0.14	0.11
True Provenance	**8823**	10.5	10.1	0.47	0.02	0.22	0.04	0.08	0.00
Ivory Coast	**9440**	10.5	10.6	0.32	0.11	0.17	0.14	0.17	0.00
True Provenance	**8832**	10.3	9.8	0.37	0.14	0.28	0.00	0.18	0.03
True Provenance	**8824**	10.3	9.7	0.52	0.10	0.37	0.06	0.29	0.00
True Provenance	**8831**	10.1	10.0	0.37	0.10	0.19	0.00	0.07	0.00
Ivory Coast	**9452**	10.1	10.3	0.44	0.27	0.22	0.00	0.11	0.19
Ivory Coast	**9459**	10.0	10.4	0.47	0.03	0.13	0.03	0.06	0.22
Ivory Coast	**9417**	10.0	9.6	0.19	0.05	0.09	0.00	0.04	0.02
Ivory Coast	**9446**	10.0	10.5	0.17	0.17	0.17	0.04	0.14	0.14
True Provenance	**8833**	10.0	8.9	0.59	0.18	0.12	0.00	0.03	0.03
Ivory Coast	**9454**	10.0	10.5	0.17	0.06	0.31	0.00	0.08	0.03
Ivory Coast	**9458**	9.8	10.1	0.26	0.04	0.03	0.00	0.31	0.23
True Provenance	**8836**	9.8	9.6	0.42	0.19	0.17	0.00	0.03	0.00
Ivory Coast	**9442**	9.8	10.4	0.13	0.02	0.19	0.02	0.07	0.07
True Provenance	**8842**	9.7	9.0	0.28	0.25	0.06	0.04	0.08	0.00
Ivory Coast	**9450**	9.7	9.8	0.27	0.02	0.07	0.07	0.10	0.00
Ivory Coast	**9457**	9.7	10.5	0.32	0.13	0.14	0.00	0.14	0.14
True Provenance	**8838**	9.6	9.2	0.57	0.22	0.11	0.00	0.03	0.00
Ivory Coast	**9432**	9.6	9.7	0.26	0.10	0.25	0.08	0.05	0.00
True Provenance	**8839**	9.6	9.9	0.60	0.34	0.06	0.08	0.08	0.00
True Provenance	**8668**	9.5	9.3	0.25	0.14	0.35	0.00	0.11	0.00
True Provenance	**8367**	9.4	7.9	0.54	0.15	0.03	0.03	0.03	0.00
True Provenance	**8844**	9.4	9.0	0.19	0.13	0.05	0.00	0.07	0.03
Ivory Coast	**9411**	9.3	10.3	0.07	0.04	0.11	0.19	0.16	0.00
True Provenance	**8835**	8.8	9.8	0.32	0.31	0.10	0.04	0.04	0.00
True Provenance	**8841**	8.6	8.1	0.52	0.13	0.15	0.00	0.04	0.00

(*) Note: The trees were given a note for several form characters (straightness, bending, branching, breakages), as follows: 0=no defect, 1=minor defect, 2=major defect making improbable the tree's recovery. For example, a seedlot with an average note for branching of 0.03 (9458) is less branching than a seedlot with an average note of 0.37 (true provenance 8824).

5. Origin trial

The Teak origin trial, planted in 1997 with six *in vitro* « origins » (some clones and some bulks), and two bulks of macro-cuttings (Table 7) in four repetitions has been assessed and maintained. Some « origins » and especially clone n. 9 differ from the other especially in morphology and in architecture. A large variability is still observed within clones, meaning that teak growth and architecture are quite site-dependent. The need to have access to a good genetic selection appear to be more important for this species.

Table 7. List of the treatments planted in the "origin trial" in Taliwas in 1997.

n.	Treatment	Acronym
1	IVC Unjung Padang (Bulk)	IVCUP
2	IVC Perlis (Bulk)	IVCBul
3	IVC Solomon Island clone 1	IVCSI1
4	IVC Solomon Island clone 9	IVCSI9
5	IVC Ivory Coast (Bulk)	IVCICB
6	IVC Solomon Island (Bulk)	IVCSIB
7	Macrocuttings, Perlis (Bulk)	VPPERB
8	Macrocuttings, Solomon Island (Bulk)	VPSIB

2.3.6. CCT Plots - instructions

Instructions for the management and analysis of the Teak CCT-plots trial planted in Luasong in 1997 are attached in Appendix 9. A first assessment of the trial, to be used as a reference for later assessments, and a thinning of all treatments except one (control) are planned for early 2000.

2.4 KHAYA IVORENSIS

The three old *Khaya ivorensis* plots were assessed for growth and a new demonstration plot was established in September 1999. A new 1.4-ha demonstration plot was planted in the open with seedlings and cuttings from the 8 years old provenance trial (KIV1).

2.4.1 Provenance trial

The provenance trial (KIV1) comprising three provenances from Ivory Coast (Bonuoa, Mopri and Yapo) and one provenance from Kulim, Kedah was established in September 1990. The design was Randomised Complete Block with 3 x 3 trees per plot and 10 replications on the same location. Thinning was conducted in December 1996 to reduce the plot size to 5 trees.

The Ivory Coast provenances maintained their superiority to Kulim provenance (Table 8). This variation is consistent since the early age of the stand.

Table 8: Growth of 9.4 years old *Khaya ivorensis* – Open planting (KIV1)

Provenance	Mean Height (m)	Mean DBH (cm)	HMAI (m/yr)	DMAI (cm/yr)
Bonuoa	22.6 (2.8)	23.3 (4.5)	2.4	2.5
Mopri	22.6 (2.9)	22.4 (4.7)	2.4	2.4
Yapo	23.1 (2.8)	24.1 (4.4)	2.5	2.6
Kulim	20.7 (2.9)	19.2 (4.6)	2.2	2.0

Note: Value in parenthesis indicates standard deviation

2.4.2 Progeny Trials

Two progeny trials of *K. ivorensis* were established in 1991 under logged-over forest using seedlots from Ivory Coast (also Bonoua, Mopri and Yapo provenances). The distance between the planting points was 4.5 m and 9 m apart between the rows. The first trial (KIV3, Table 9) tested 9 progenies in a 3 x 3 Balanced Lattice design and the second (KIV4, Table 10) tested 12 progenies in a Rectangular Lattice design. All the 9 progenies in KIV3 were included in KIV4.

Table 9: Growth of 8.8 years old *K. ivorensis* – Line planting (KIV3))

	No. of Living Trees	Mean HT (m)	Mean DBH (cm)	HMAI (m/year)	DMAI (cm/year)
Average	268	14.9 (4.4)	14.3 (5.5)	1.7	1.6

Note: Value in parenthesis indicates standard deviation

Table 10: Growth of 8.8 years old *K. ivorensis* – Line planting (KIV4))

	No. of Living Trees	Mean HT (m)	Mean DBH (cm)	HMAI (m/year)	DMAI (cm/year)
Average	147	9.0 (4.6)	7.7 (4.3)	1.0	0.9

Note: Value in parenthesis indicates standard deviation

2.4.2 New seedstand – commercial plantation in Compt. 268

In 1998, about 120 ha of *Khaya ivorensis* and few hectares of other high-value timber species were planted in compartment 268, Luasong. The planting included the establishment of two seedstands, with separate progenies from selected provenances (Mopri and Yapo, Ivory Coast). In 1999 an assessment of the planting was done based on temporary and permanent yield plots (Appendix 10). An overall survival of 88% and an average height of 1.3 m were found, and have to be considered as quite positive taking in account the fact that maintenance was very delayed for this stand (more than one year) and the surrounding forest is quite dense. Along roadside the growth of *Khaya* is better than deep inside the blocks, translating the need of the tree for light and competition-free space. However, even if growing slower, these data indicate that *Khaya* stands quite well the conditions of line-planting and, being a high-value timber (mahogany) it is very suitable for forest enrichment.

From these observations we can draw two main recommendations :

1) to keep going with the proper maintenance of this high-value stand, adding if possible shade adjustment (total elimination of all non-commercial trees) ; when considering the value of this stand it must be noted that it will be a very rare if not the only selected seed source for *Khaya* in South-East Asia.

2) for next enrichment plantings of this type, to take in account the density of the stand to be enriched, giving priority to burned areas (easily spotted on aerial photographs) and roadsides (more light, easier access, easier survey and inventory, easier maintenance and harvesting).

2.5 XYLIA XYLOCARPA

X. xylocarpa is a heavy hardwood occurring naturally in India, Myanmar, Indo-China and Thailand. Its hard and durable wood is normally used for heavy construction purposes. This species was planted in September 1990 as an introduction species both in the line and open planting. It gained recognition as a potential plantation species due to its fast growth and good stem form especially in the open planting plot. The species performed even better than *K. ivorensis* in the open planting, although with greater wood density (*X. xylocarpa* > 800 kg/m^3, *K. ivorensis* ~ 450 kg/m^3).

The growth of *X. xylocarpa* on open planting was double the one of line plantings under logged-over forest (Table 11).

Table 11: Growth of 9.3 years old *Xylia xylocarpa*

Trial	No. of Living Trees	Mean height (m)	Mean diameter (cm)	HMAI (m/yr)	DMAI (cm/yr)
XXY1 (Open-planting)	37	25.2 (2.4)	22.3 (4.5)	2.7	2.4
XXY2 (Line-planting)	97	11.1 (3.3)	11.5 (4.6)	1.2	1.2

Note: Value in parenthesis indicates standard deviation

2.5 CEDRELA ODORATA

Cedrela odorata is another "mahogany" species that is very suitable for forest enrichment as well as for open planting. In Luasong open and line planting, the growth is very fast, the timber is of very good quality, and it is a shoot-borer-free mahogany species (Matsumoto, pers. comm. and personal observation).

Given the growth of *C. odorata* in the demoplot, it is foreseeable that in open planting this species can provide harvestable timber at year 10. It can be a valid substitute to *Acacia* species in term of short-rotation plantings, providing in addition a more valuable product (mahogany sawn timber).

Given the scarcity of good quality *C. odorata* seeds in Asia, an effort to establish a seedstand similar to the one established for *Khaya* should provide very profitable for LFC.

3. OTHERS

3.1. Soil Analysis

In order to better understand the growth pattern of Teak in Sabah, a thorough soil sampling was carried out in 1999 in the Teak experimental plots. The soil samples were sent to the KDC laboratory of Kulumpang Devlpt. For chemical and physical analysis. The results of the analysis and a short commentary are provided in Appendix 11.

3.2. New land for Teak open planting in Taliwas

The harvesting of the pine, eucalyptus and gmelina plots in Taliwas in 1999 has liberated around 35 ha of space for Teak planting. Unfortunately the harvesting operation was carried out without much care for the soil (indiscriminate use of heavy bulldozers), which was unnecessarily compacted and turned upside-down. This can be expected to expose the steep land to soil erosion, and also to heavily disturb the growth of the next forest crop.

In addition, the harvester did collect only the commercial trees, with the smaller, unhealthy and defectuous trees left standing. This will most probably disturb the new planting operation as well as the growth of the next forest stand.

According to instruction from the management this land will be planted with Teak, especially selected clones in separate blocks. The production of the Teak cuttings has already started in Taliwas and Luasong (See FRR report).

3.3. Auditing mission for CIRAD-Forêt

The PISP has received a two-day mission, composed of Mr. Delay (Director of the Functional Ecology and Evolution Centre, National Centre for Scientific Research [France], M. Schmithüsen (Chair of Forest Policy and Forest Economics at the Swiss Federal Institute of Technology) and Mr. Freud (economy and sociology, CIRAD), for the evaluation and auditing of the CIRAD-Forêt's research activity in Tawau.

3.4. Training

Dr. Bacilieri (CIRAD-Forêt) attended a 8-day training course on advanced techniques of molecular biology and molecular markers at the Agetrop laboratory in Montpellier, France.

Mr. J. Gidiman attended a one-month training course in biometry and forest experimentation in CIRAD-Forêt, Montpellier, France.

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PROPOSITIONS OF PLANS OF OPERATIONS FOR COOPERATIVE WORK

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