Département territoires,
environnement et acteurs
Cirad-tera

IRRDB SYMPOSIUM AND INDONESIAN RUBBER CONFERENCE NOTES AND COMMUNICATIONS

Conference Center of Novotel Bogo, Bogor, Indonesia 12-14 September 2000

E. PENOT

Octobre 2000

N° TERA 81/00
N° THI 65/00

CIRAD- CP
CIRAD-TERA

IRRDB Symposium
and
Indonesian Rubber Conference 2000
Notes et communications

Conference Center of Novotel Bogor, Bogor, Indonesia
12-14 septembre 2000

IRRDB : International Rubber Research and Development Board
Indonesian Rubber Conférence de IRRI : Indonesian Rubber Research Institute.

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Le 11/10/2000

IRRDB Symposium and Indonesian Rubber Conference 2000
Notes et communications

Résumé

La conférence annuelle de l'IRRDB (International Rubber Research and Development Board) est un lieu de présentation de l'état de la filière caoutchouc naturel et des principales recherches en cours dans le monde. Cette année elle a été couplée à un séminaire scientifique (IRC) organisée pat l'Institut de Recherche Indonésien (IRRI). La première journée a été consacrée à des présentations générales sur la filière hévéa en Malaisie, Thaïlande et Indonésie (les trois premiers producteurs mondiaux) et sur les perspectives de la filière pour la prochaine décade.
Le CIRAD a présenté dans la quatrième session de la seconde journée, centrée sur l'hévéa et l'agroforesterie, 2 communications sur les systèmes agroforestiers à base d'hévéa : résultats des essais sur les RAS 1 et 3 (Rubber Agroforestry Systems), respectivement présentés par D. Boutin et E. Penot. Une troisième communication générale sur l'agroforesterie a été faite par G Wibawa (IRRI/Sembawa).
Trois posters ont également été présentés sur le Cambodge (IRCC), le Vietnam (IRCV et l'Indonésie (CIRAD/SRAP/ICRAF).
On remarquera qu'il y a peu de vraies innovations ou nouveautés dans les communications et posters et pratiquement pas de prise en compte réelle des problèmes de production que rencontrent les petits planteurs. La recherche, de façon globale, semble déconnectée du monde de la production (plus de 80 % par les petits planteurs), ses contraintes mais aussi ses opportunités. Nous n'avons vu que trois communications et deux posters (Vietnam et Cambodge) à caractère socio-économique sur la problématique des petits planteurs. La majorité des autres communications est restée dans le vague, avec une approche très générale et sans apport d'alternatives ou de propositions de solutions.

Mots clés : IRRDB, hévéa, Indonésie, Vietnam, Cambodge, Agroforesterie.

1 - Introduction

La conférence annuelle de l'IRRDB (International Rubber Research and Development Board) est un lieu de présentation de l'état de la filière caoutchouc naturel et des principales recherches en cours dans le monde. Cette année elle a été couplée à un séminaire scientifique (IRC) organisée pat l'Institut de Recherche Indonésien (IRRI).

La première journée a été consacrée à des présentations générales sur la filière hévéa en Malaisie, Thaïlande et Indonésie (les trois premiers producteurs mondiaux) et sur les perspectives de la filière pour la prochaine décade (A.F.S. Budiman - International Rubber Study Group (IRSG)). L'impact des perspectives pour l'industrie du pneumatiques a également été revu par des représentants de Goodyear et Bridgestone. Michelin n'avait pas envoyé de représentant. La seconde journée a été dédoublée en deux sessions : pré-récolte (agronomie et socio économie) et post-récolte (technologie) (cf annexe 1).

2 - La participation du CIRAD

Le CIRAD a présenté dans la première session de la seconde journée 2 communications sur les systèmes agroforestiers à base d'hévéa : résultats des essais sur les RAS 1 et 3 (Rubber Agroforestry Systems), respectivement présentés par D. Boutin et E. Penot :

✔ Rubber agroforestry system-type 1 (RAS-1) : a strategy towards a productive "jungle rubber" de D. Boutin, E. Penot, G.Wibawa and R.Akiefnawati (CIRAD-CP, CIRAD-TERA, IRRI, ICRAF/SRAP. Présenté par D. Boutin.

✔ Rubber agroforestry system-type 3 (RAS-3) : a strategy to convert Imperata grassland de D. Boutin, E Penot & Ilahang (CIRAD-CP, CIRAD-TERA, ICRAF/SRAP). Présenté par E Penot.

Trois posters ont également été présentés :

✔ Smallholder rubber research programme in Cambodia : general presentation and preliminary results de Yin Song, A. Leconte et J.M..Eschbach (IRCC, CIRAD CP).

✔ The research approach on smallholder rubber development project in central highlands of Vietnam according to the first rural statement de Stephane Boulakia, (CIRAD-TERA).

✔ Does rubber trigger reforestation after deforestation, E. Penot (CIRAD-TERA).

Ces communications ont été présentées dans la 4eme session présidée par H. Omont, CIRAD-DRE, vice-président de l'IRRDB. Cette session était orientée sur les systèmes agroforestiers à base d'hévéa. Une présentation générale de ces systèmes et des travaux réalisés dans ce domaine a été faite par Gede Wibawa de l'IRRI. Toutes les présentations figurent en annexe 2 et 3.

Jérome Sainte Beuve (CIRAD-CP) représentait le programme hévéa. A. Leconte et D. Boutin (CIRAD-CP), S. Boulakia et E Penot (CIRAD-TERA) étaient présents.

3 - Quelques éléments marquants

La conjonction de ces deux réunions a permis de rassembler des chercheurs de 10 pays différents et des représentants des manufacturiers - deux parmi les trois plus grands - Goodyear et Bridgestone - soit environ 150 participants. Une quarantaine de communications orales a été présentée en provenance de 8 pays et une vingtaine de posters venant de 5 pays. Comme on peut le voir sur le tableau 1 (p 6 et 7) chaque pays a présenté 2 à 3 communications sauf le pays organisateur - Indonésie - qui a proposé 27 communications orales. Tout cela a eu des conséquences sur le niveau des communications présentées, considéré comme relativement faible et très disparate. A contrario, la valeur scientifique des travaux réalisés à l'IRRI a pu être appréciée à sa juste valeur.

L'Asie était bien représentée à l'exception notable des Philippines. L'Afrique n'était représentée que par le directeur de l'Institut de recherche sur le caoutchouc du Nigéria (RRIN) et l'Amérique du Sud totalement absente. Ceci montre bien la toute puissance de l'Asie et particulièrement de la Malaisie. Les deux journées du Board ont bien confirmé le rôle majeur de la Malaisie qui va récupérer le secrétariat de l'IRRDB - en terme de ressources humaines mais aussi de localisation.

Les thèmes abordés figurent sur le tableau 2 (p 8).

Quelques remarques se dégagent :

✍ la prédominance des études dans les domaines de l'agroforesterie, les effluents et l'amélioration variétale,

✍ les grandes thématiques d'aujourd'hui sont abordées mais les documents présentés sont d'une valeur très inégale.

✍ les deux manufacturiers ont présenté des résultats très similaires, fruits de longues recherches sur du caoutchouc provenant de plus de 20 usines différentes. Les deux indicateurs de qualité retenus dans leurs études sont identiques :

* distribution et masse moléculaire liés au module à 300%.
* acide gras (rosine acid) lié au pouvoir collant.

Pas une seule fois le mot PRI a été prononcé ; ceci doit nous servir pour notre réflexion sur la future stratégie à mettre en place au sein du programme hévéa. Si, sur le premier critère retenu, le programme hévéa possède une solide compétence, sur le second nous sommes totalement absents.

✍ le Malaysian Rubber Board (MRB) a présenté la situation de la filière caoutchouc en Malaisie qui fait apparaître :

* la contribution de plus en plus importante de l'exportation du bois d'hévéa au terme financier par rapport au caoutchouc naturel (2 fois plus) ;

* la diminution de la valeur des produits finis exportés entre 1998 et 1999 malgré l'augmentation sur le marché national,

* la confirmation de la stratégie du gouvernement malais d'accroître encore la transformation locale du caoutchouc naturel (550 000 T en 2020) et mais aussi du caoutchouc synthétique.

* l'objectif pour le caoutchouc naturel étant de passer de 350.000 tonnes consommées en 2000 à 500.000 tonnes dix ans après. Objectif très ambitieux dans la mesure où le niveau atteint en 2000 est inférieur à 1996, crise asiatique oblige.

* par contre, pendant cette période la consommation d'élastomère synthétique augmente de 45 000 tonnes à 56 000 tonnes.

* la part de marché la plus importante reste avant tout la production d'articles au trempé comme les gants, cathéters, etc La Malaisie reprend l'initiative sur le plan international en créant une norme de qualité (Standard Malaysian Gloves = SMG) norme de qualité qui a déjà eu l'aval de la Thaïlande.

* au cours d'une discussion avec le Dr ONG, il ressort que le RRIM, associé avec le RRIT, la Finlande et l'Allemagne, continue de travailler sur le sujet des protéines allergènes et comment diminuer l'allergénécité des gants.

✍ l'instabilité des prix du caoutchouc et cours maintenus bas depuis 1998 sur le marché international.

✍ le problème de maintien de l'offre à terme (dans une perspective de pénurie) et de replantation dans les principaux pays producteurs : Thaïlande et Indonésie. Paradoxalement, l'hypothèse probable de pénurie a été peu évoquée.

✍ la prise en compte des facteurs environnementaux et de la possibilité d'utiliser l'hévéa comme plante pour la séquestration du carbone (conversion des droits à polluer).

✍ la diversification de l'utilisation de la plante hévéa : les clones à double usage : bois et latex.

✍ les systèmes de culture agroforestiers à base d'hévéa clonal (mise au point de systèmes de culture a forte productivité et consommation limitée en intrants et travail).

✍ la possibilité d'adaptation de l'hévéa en zones marginales : zones côtières à sol de tourbe, zones à saison sèche marquée.

✍ l'identification de l'effet des génotypes et de l'environnement sur la production des clones.

✍ le développement et virulence du *Corynespora casiicola.*

✍ le contrôle du fomés

✍ le statut des travailleurs des plantations de Java Ouest.

✍ l'accélération de l'adoption des technologies développées pour l'amélioration du secteur de la production par les petits planteurs.

✍ les effets des coûts de transaction dans le marketing du caoutchouc.

En annexe 4 figure un résumé des conclusions de ces 5 jours de conférence publiés par l'IRRDB. Les proceedings seront distribués dés leur parution.

4 - Activités connexes

Parallèlement à la participation à la conférence, le CIRAD et l'ICRAF ont organisé une réunion entre les trois instituts de recherche IRCC (Cambodge), IRCV (Vietnam) et IRRI (Indonésie), le jeudi après midi dans les locaux de l'IRRI/Technologie de Bogor. Les objectifs de cette réunion étaient d'une part de permettre des échanges de vue entre les directeurs des trois instituts, avec le CIRAD et l'ICRAF, en particulier sur les possibilités de collaboration sur les thématiques communes liées aux petits planteurs et à leur développement, et d'autre part, d'explorer les possibilités de resserrer les liens entre les partenaires dans le cadre du projet SRAP (et du financement CFC) et des programmes d'expérimentation en milieu paysan mis en place dans les trois pays. Une telle collaboration permettrait de partager les résultats et d'obtenir plus rapidement et plus efficacement une bonne diffusion des résultats, voire des analyses régionales plus globales.

Enfin, une réunion plus informelle entre les chercheurs du CIRAD en appui a ces institutions a permis :

✔ de mettre au point des propositions d'expérimentations prochaines en milieu paysan pour la phase II du SRAP en Indonésie et en Thaïlande. Une fiche de travail devrait d'ailleurs être prochainement réalisée.

✔ de mieux replacer les thématiques de recherche dans les contextes assez différents des 3 pays concernés : Cambodge, Vietnam et Indonésie

✔ de procéder à des échanges d'information en particulier sur les techniques agronomiques testées ou prochainement mises en place dans les trois pays, et en particulier sur les plantes de couverture (réhabilitation des terres à *Imperata*) et les techniques agroforestières.

Tableau 1 : Répartition des présentations par pays d'origine

Conférence plénière			
Pays	Organismes	Nbre de communications	Total
Indonésie	IRRI BRUEC National Nuclear Agronomy Associations des planteurs Privés	19 5 1 1 1	27
Thaïlande	RRIT Institut de l'environnement Associations planteurs	1 1 1	3
Chine	CATAS South China University of tropical agriculture	1 2	3
Sri Lanka	Centre de recherche	1	1
France	Cirad	2	2
Malaisie	MRB	2	2
Organismes internationaux	IRSG IRRDB ICRAF	1 1 1	3
Etats Unis	Goodyear	1	1
Japon	Bridgestone	1	1
TOTAL			43

Posters			
Indonésie	IRRI BRUEC PTP Associations des planteurs	11 2 1 1	15
Philippines	SMU	1	1
Sri Lanka	Centre de recherche	1	1
France	CIRAD	3	3
Malaisie	MRB	1	1
Organisme international	ICRAF	1	1
			22

Tableau 2 : Répartition des présentations orales par thématiques

Répartition de présentations orales par thématiques	Nbre de présentation orales
Agroforet	4
Séquestration du carbone	1
Bois d'hévéa	1
Hévéa en zone marginale	2
Amélioration - exploitation	5
Maladie de feuille (dont *Corynespora*)	4
Modification chimique	3
Structure	1
End users	1
Effluent	4
Qualité	1
Allergie	2
Amélioration des procédés	3
Etude de marché	5
Politique de développement	3
	40

5 - Conclusion

On remarquera qu'il y a peu de vraies innovations ou nouveautés dans les communications et posters et pratiquement pas de prise en compte réelle des problèmes de production que rencontrent les petits planteurs. La recherche, de façon globale, semble déconnectée du monde de la production (plus de 80 % par les petits planteurs), ses contraintes mais aussi ses opportunités. Nous n'avons vu que trois communications et deux posters (Vietnam et Cambodge) à caractère socio-économique sur la problématique des petits planteurs. La majorité des autres communications est restée dans le vague, avec une approche très générale et sans apport d'alternatives ou de propositions de solutions.

Les tentatives de diversification (bois/latex) restent encore a démontrer. Celles sur la plantation d'hévéa en zones marginales (zones de marais à tourbes ou zones à saison sèches marquées) n'ont pas été abordées de façon très convaincante malgré des potentialités certaines.

Enfin les problèmes concernant les systèmes d'exploitation n'ont pratiquement pas été explorés. Par contre, les risques liés aux maladies de feuille par le *Corynespora* semblent préoccupants.

L'hypothèse de pénurie probable à l'horizon 10 ans n'a pas été abordée. Les cours actuels du caoutchouc, très bas, semblent capter toute l'attention. Il n'y a pas apparemment de prise en compte des stratégies à moyen ou long terme pour la filière. A signaler toutefois la présentation par deux des trois plus grands manufacturiers de deux indicateurs de qualité responsables de la variabilité de la qualité du caoutchouc naturel.

Le CIRAD, en collaboration avec l'IRRI, à travers le projet SRAP (Smallholder Rubber Agroforestry Project), a occupé un terrain important en Indonésie sur les alternatives au jungle rubber et à la monoculture par les systèmes agroforestiers clonaux. Le CIRAD a également montré son implication importante dans les projets de développement hévéicoles, financés par la Banque Mondiale, de pays émergents (Vietnam et Cambodge).

Annexe 1

CONFERENCE PROGRAM

Tuesday 12 September 2000

Gede & Pangrango Room

OPENING CEREMONY

08.00 Registration
09.00 Organizing Comittee Report
Welcome address, Dr Soekirman Pawirosoemardjo, Director Indonesian Rubber Research Institute
09.10 IRRDB Welcome Address, Mr Kevin P Jones, Secretary of IRRDB
Inaugurating and Opening Address followed by Official Opening to Exhibition and Poster Display, Dr Nur Mahmudi Ismail,
Minister of Forestry and Estate
10.00 Poster exhibition
Coffee break

INVITED PAPERS

PLENARY SESSION 1
Chairman :Dr Untung Iskandar
Director General of Forest Agency for Research and Development

10:30 Rubber plantation development policy in Indonesia (Dr Agus Pakpahan, Director General of Estate Crops)
The prospects of the world rubber industry in the new decade (Dr AFS Budiman, Secretary General of International Rubber Study Group)
11:1 Smallholders rubber plantation development in Thailand (Sunthorn Nikomrat, President of Rubber Holders' Co-operative Federation of Thailand)
11:30 Discussion
12:15 Poster exhibition
Lunch

PLENARY SESSION 2
Chairman : Datuk Dr A Aziz bin A Kadir
Chairman of the International Rubber Research and Development Board

13:15 Recent advances in tire technology and its impacts on natural rubber marketing (Itsuo Miyake, General Manager Tire Material Development, BridgestoneCorporation)
13:35 Will global warming or a lack of crude oil be the limiting factor for the rubber industry over the next 25 to 50 years ? (Mr Kevin P. Jones, Secretary of IRRDB)
13:55 Rubber industry development and domestic use of natural rubber in Malaysia (Dr Ong Eng Long, Malaysian Rubber Board)
14:15 paper from Goodyear

14:35 Discussion
15:20 Poster exhibition
Coffee break
17:00 End of Day One and Poster exhibition

DINNER AND CULTURAL SHOW

Meranti Restaurant

1.19 Dinner hosted by Minister of Forestry and Estate followed by Cultural Show

Wednesday 13 September 2000

PRE-HARVEST

Gede & Pangrango Room

CONCURRENT SESSION 1
Chairman : Dr Soekirman Pawirosoemardjo
Director of Indonesian Rubber Research Institute

08:00 Carbon sequestration in rubber : implication and model to fund continued cultivation (Dr S. Sivakumaran, Malaysian Rubber Board)
08:15 Planting system to optimize latex-timber production (Ir Nurhawaty Siagian, MS, Indonesian Rubber Research Institute IRRI)
08:30 The social status and availability of tappers in rubber estates : case study in South Sumatera and West Java estates (Ir Cicilia Nancy, MS, IRRI)
08:45 The possibility of NR development towards dry climate region in Indonesia (Dr Karyudi, IRRI)
09:00 Environmental and social significance of NR cultivation in marginal lands (J. Jacob, Rubber Research Institute of India)
09:15 Discussion
10:00 Poster exhibition
Coffee break

CONCURRENT SESSION 2
Chairman : Prof Chen Qiubo
Director of Chinese Academy of Tropical Agricultural Sciences

10:30 Quantifying genetical and environmental factors in determining rubber productivity (Dr Rasidin Azwar, IRRI)
10:45 Characteristics of growth and yield of recommended clones (Ir Aidi-Daslin Sagala, MS, IRRI)
11:00 Use of physiological parameters to assess optimum yield of rubber clones (Dr Sumarmadji, IRRI)
11:15 Rootstock-scion interaction induced the alterations in protein banding patterns of scion, and its correlation with genetic similarities of *Hevea brasiliensis* Muell Arg. (Dr Nurita Toruan-Mathius, Biotechnological Research Unit for Estate Crops BRUEC)
11:30 Acclimation of rubber seedling (Hevea brasiliensis) to different light intensities (A Ruhiyana, ICRAF)

11:45 Discussion
12:30 Poster exhibition
Lunch

CONCURRENT SESSION 3
Chairman : Mr Chakarn Saengruksawong
Director of Rubber Research Institute of Thailand

13:3 Genetic diversity of phyllosphere bacteria from rubber plant based on PCR-RFLP 16S- rRNA (Dra Nurhaimi-Haris, MSi, BRUEC)
13:45 Assays of *Corynespora casiicola* isolates originated from rubber clones having differential resistance and from papaw host (Ir Suwarto, MS, IRRI)
14:00 The virulence of *Corynespora casiicola* isolates to various recommended hevea rubber clones (Ir Aron Situmorang, MS IRRI)
14:15 Challenging problem and prospective use of biofungicide in the control of white root disease in *Hevea brasiliensis* (Dr T.W. Darmono, BRUEC)
14:30 Discussion
15:30 Poster exhibition
Coffee break

CONCURRENT SESSION 4
Chairman : Mr H Omont
CIRAD-CP

16:00 Rubber based agro forestry research in Indonesia (Dr Gede Wibawa, IRRI)
16:15 Rubber agroforestry system-type 1 (RAS-1) : a strategy towards a productive "jungle rubber" (Dr D. Boutin, CIRAD). Presented by D BOutin.
16:30 Rubber agroforestry system-type 3 (RAS-3) : a strategy to convert Imperata grassland (Dr D. Boutin, CIRAD)
Presented by E Penot
16:45 Discussion
17:30 End of session

Wednesday 13 September 2000

POST-HARVEST

Salak Room

CONCURRENT SESSION 1
Chairman : Dr L.M.K. Tillekeratne
Director of Rubber Research Institute of Sri Lanka

08:00 The preparation of saturated NR in latex form (Fu Xhin, South China University of Tropical Agriculture)
08:15 Preparation of raw material to produce special tyre (Yoharmus, IRRI)
08:30 Production of valuable compounds from *Spirulina platensis* biomass grown on media containing latex concentrate effluent (Tri Pandji, BRUEC)
08:45 Study of liquid waste processing using a sequencing batch reactor at a model scale (Dadi R. Maspanger, IRRI)
09:00 Environmental management in concentrated latex factory : a case study in southern Thailand (Pram Prasada Rao, Thailand Environment Institute)

09:15 Discussion
10:00 Poster exhibition
Coffee break

CONCURRENT SESSION 2
Chairman : Mr H. de Livonniere
CIRAD-CP

10:30 Structure and properties of oriented rubber (Nelly Rachman, Apriyanti Isanasari, Masatoshi Iguchi)
10:45 The effect of gamma rays radiation on the physical properties of NR- LLDPE blends (Iskandar Sudradjat, National Nuclear Energy Agency)
11:00 Optimal condition on chlorination of rubber gloves (Varaporn Kajornchaiyakul, Rubber Research Institute of Thailand)
11:15 Viscocity stabilization of NR with hydrazide derivatives (Nelly Rachman, IRRI)
11:30 Manufacturing solid bicycle tires to replace inflated tires (Ridha Arizal, IRRI)
11:45 Discussion
12:30 Poster exhibition
Lunch

CONCURRENT SESSION 3
Chairman : Dr N. M. Mathew
Director of Rubber Research institute of India

13:30 Research on production cost and competition force of NR in China (Fu Guohua, South China University of Tropical Agriculture)
13:45 Natural rubber prediction of production, consumption and trade in early 21st century in China
(Jusheng Jiang, Rubber Cultivation Research Institute of CATAS)
14:00 Accelerating rubber technology adoption in Indonesian rubber smallholdings (M. Supriadi , IRRI)
14:15 Transaction cost affecting the rubber smallholder on raw rubber marketing institutional choice (Uhendi Haris, IRRI)
14:30 Research prospects of allergenic proteins *Hevea brasiliensis* latex (Siswanto, BRUEC)
14:45 Discussion
15:30 Poster exhibition
Coffee break

CONCURRENT SESSION 4
Chairman : Dr Suharto Honggokusumo
Executive Director of Rubber Association of Indonesia

16:00 Drying rubber at low humidity and temperature (Azwin Anas, IRRI)
16:15 Implementation of raw coal for crumb rubber drying (Dadi R. Maspanger, IRRI)
16:30 The use of "split feeding" mixing to reduce heat built-upof truck tires without changing the formula of rubber ingredients
(Ridha Arizal, IRRI)
16:45 Rain guards for the rubber plantation (Dr L.M.K. Tillekeratne, Rubber Research Institute of Sri Lanka)
17:00 Discussion
17:45 End of session

Gede & Pangrango Room

CLOSING CEREMONY

17:50 Presentation of conclusion and policy implication of conference and symposium
18:05 Closing address

Annexe 2

Textes des 3 communications de la session 4 pre-harvest

Rubber based agro forestry research in Indonesia
(Dr Gede Wibawa, IRRI)

Rubber agroforestry system-type 1 (RAS-1) : a strategy towards a productive "jungle rubber"
(D. Boutin, E Penot, G.Wibawa and R.Akiefnawati CIRAD/IRRI/ICRAF).

Rubber agroforestry system-type 3 (RAS-3) : a strategy to convert Imperata grassland
(D. Boutin,E Penot, Ilahang CIRAD/ICRAF)

RUBBER BASED AGROFORESTRY RESEARCH IN INDONESIA

GEDE WIBAWA

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Abstract

Smallholder rubber area occupies 84% of the total rubber area in Indonesia. The system is related closely to the tradition of *ladang*, where farmers produce annual, biannual food crops during the first 2-3 years of rubber establishment. Advantage and disadvantages of the systems have been well documented. Due to the extensive management (low weeding, no fertilizers) of the rubber, especially between the annual intercropping phase and before opening, mixture of vegetation (timber trees, fruit trees, weeds) grow in the smallholder rubber garden. These rubber-based multi-strata systems, also well known as *jungle rubber*, were detected to be ecologically comparable to secondary forest, however the productivity of the system is low. The systems are classified as a complex agroforest. Several rubber based multi-strata experiments were carried out in Indonesia to respond farmers' short, medium and long-term goals. The principal components of the systems such as rubber planting material, intercropping practices, types of intercrops might be modified to increase the productivity, conserve a certain level of biodiversity and respond farmers' needs. Various annual intercrops planted under immature rubber plantation respond the short term needs. Types of intercrops planted by farmers were markets driven. Several multi purpose trees producing fruit, timber and/or latex such as *Paraserianthes falcataria*, *Eucalyptus deglupta, Acacia mangium, Salacca edulis,* and different rubber clones producing latex and timber may respond medium-term goals. The main rubber producing latex and timber take an important role in long-term goals. Water was detected as the main limiting factor of growth of the system. Rubber growth in double row system, until 39 months, intercropped with *P. falcataria at different densities,* was 14% lower than that planted without intercrop in a same planting system and 26% lower than that planted without intercrop in normal planting distance, in three years. To avoid the slow growth of rubber due to competition with perennial intercrops, the best planting time of rapid growth perennial intercrops is about two years after rubber planting, where the rubber girth is between 15 and 20cm. This time correspond to the end of the optimal period of annual intercrops. Rubber reach tappable size six years after planting and perennial intercrops may start to be harvested. Various results on other experiments related to rubber agroforestry systems developed in Indonesia were also presented.

I. INTRODUCTION

Smallholder rubber areas cover the most important (84%) rubber areas in Indonesia, which lie on most peneplains of Sumatra and portions of Kalimantan. These extensive smallholder land uses evolve from a purely shifting cultivation, base on annual food crops (mainly upland rice), in the early 1900-s to a specialization in rubber intercropped with food crops (upland rice, maize) or horticulture crops (banana, pineapple) after the 1920-s.

The systems are based on clear-felling of secondary forest with slash and burn method. During the first 2-3 years, annual food crops, mainly upland rice, are planted 2-3 weeks after burning. Un selected rubber seedlings are planted after finishing the planting of annual food crops.

In overall of the systems, the farm management is very low, in which during the annual intercrop phases (2-3 years), the land is managed relatively intensive but without fertilizers in both rubber and intercrops. After completion of annual intercrops, farmers abandoned the land to seek another portions of land to be planted with the same intercropping system based on rubber trees. Very low inputs and extensive farm management are adopted by farmers during the phase after stopping the annual intercropping and just before beginning of tapping. No fertilizers were applied and the weeding/slashing of the forest re-growths was done once to twice a year in the first two years after intercrop and maximum once a year before opening of tapping.

The consequences of this low farm management are:

- rubber growth is very slow and heterogeneous, where the tappable size of rubber may be reached after 8 to 12 years of rubber planting;
- rubber competes with secondary forest re-growths, however some useful trees may be kept by farmers due to its important economic value (fruits, rattans, medicinal trees, timber trees) in the future or,
- rubber grows with secondary forest re-growths that were rarely slashed by farmers during immature phase. The mixture of vegetation between rubber and forest re-growths lead the system to be a forest like environment, where some peoples called *jungle rubber,*
- productivity of rubber is very low, ranged between 500 to 650 kg dry rubber/ha/year or almost half of that produced by estate plantations (DGE,1997).

These extensive and low management systems developed toward a complex agroforests based on rubber trees. de Foresta and Michon (1996) defined complex agroforests as forest structures managed by farmers for the production of various forest and agriculture products on the same piece of land. Established through a complex succession of development and production stages involving the planting of crops as well as various commercial and useful tree species, agroforest mimic natural forest structures, with a complex structure and a closed or almost closed canopy dominated by few tree species. In other hand, simple agroforestry refer to associations involving a small number of components arranged with obvious, usually well ordered pattern: one or a couple of tree species, either as a continuous canopy, in equally distant lines or in edges, and some annual species for ground cover (Michon and de Foresta, 1998).

Beside of its low productivity, the existing smallhollder rubber agroforestry systems in Indonesia provide directly environmental benefits such as protection of soil and water resources and conservation of proportion of the forest bio-diversity. It has been recognized as a *best bet*[1] alternative to slash and burn (van Noordwijk *et al.*, 1995). Observation of rubber agroforests in Jambi by Hardiwinoto *et al.* (1999) and Taulana and Riva (1999) indicated that, 3-9 species of fast growing trees and between 17-30 fruits and timber tree species were found. The three most important fruit trees observed in rubber agroforest were durian (*D. zibethinus*), jengkol (*Phitecelobium jiringa*) and petai (*Parkia speciosa*).

Even in a rural development context these systems are important sources of income for farmers; require only low capital, labor and cash inputs and produce a diverse ranges of foods, fruits and timber, there is still a great needs to improve the productivity of the these systems with moderate changes in farmer' management. Improving plant productivity either rubber, food crops or other perennial intercrops (fruits, timber); understanding and incorporating of farmers' needs and constraints in developing its farming systems and understanding of bio-physical interaction in rubber based agroforestry system are needed.

II. RUBBER BASED AGROFORESTRY RESEARCH IN INDONESIA: Current situation

Most research activities carried out on rubber based agroforestry system, especially those defined to respond bio-physical questions have *simple agroforestry* characters. Quantification of factors determined the interaction inter and intra plants of the systems is very difficult when the number of plant components taken into account increase more than two. Most detail studies on tree/crops-tree interaction were carried out in station research, to permit to control the interested factors. Some researchers compared the results obtained at station level with those obtained at farmer level (Wibawa, *et al.*, 1997).

Characterization of rubber agroforests in term of greenhouse gas emission and sequestration, carbon stocks, nutrient balance, below and above ground biodiversity, in comparison with other land use systems (natural forest, logged over forest, rubber plantation, timber plantation, cassava and imperata) in portion of Sumatra (mainly Jambi) were well documented (see van Noordwijk, *et al.*, 1995 and Tomich, *et al.*, 1998). In term of greenhouse gas emission and sequestration, rubber agroforest is one of the important sinks of methane (methane consumption of about 0.09 $mg/m^2/hr$). Newly burnt forest soil reduces significantly the sink strength. Application of N (103.5 kg N/ha) on upland rice planted in between young rubber trees reduced significantly (17%) methane consumption by soil, compared to when upland rice received only 34.5 kg N/ha. However, increase N application increased rice yield (Zen, 1997).

Understanding to what happen at farmer' level on different aspects of the systems is very important to develop agroforestry models that may be adapted to farmers' needs and constraints. Below are certain examples of different research subjects that involve in enriching the information dealing in Rubber based agroforestry in Indonesia.

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[1] Thomas *et al.* (1998) define a best bet land use alternative as a way to manage tropical rain forest or forest derive land use that, when supported by necessary technological and institutional innovation and policy reform, somehow take into consideration the local private and global public goods and services that tropical rain forest supply.

A. Understanding factors determined rubber growth in rubber based intercropping systems.

Ample studies were carried out to answer the problems of hevea-based intercropping systems in different rubber producing countries either on agronomic aspects (Wibawa, *et al.*, 1985; Rosyid *et al.*, 1987,1993; Yusoff *et al.*, 1989; Buranatham *et al.*, 1992; Keli *et al.*, 1988,1989) or economic advantages (Barlow and Muharminto, 1982; Gouyon and Nancy, 1989; Hendratno *et al.*, 1990, 1992). Information regarding detail of agro-physiological processes which occur in *hevea* based intercropping systems are still lacking.

The research, funded by European Community (STD III) in collaboration with 4 other international research Institutes: CIRAD, Univ. Hohenheim, CATH and IDEFOR/DPL, was carried out at Sembawa Research Station (on-station research) and at farmers' lands (on-farm trial) around the station (latitude 3°8' and longitude of 104° 18'), between 1993 and 1997. The goals of the on-station research were to analyze quantitatively the effect of various intercrops on the growth of rubber. Both rubber and intercrops were not fertilized since the beginning of the experiment. The treatments comprise Rubber +: clean weeded interrow (A), Legume Cover Crops (LCC) (B), Upland rice-fallow (C), pineapples (D), pineapple + banana (E) and alang-alang (*Imperata cylindrica*)(F).

Results showed that the growth of rubber depend on the types of intercrop. The girth of rubber, until 30 months, of treatments rubber +: clean weeded soil (A), pineapple (D), pineapple + banana (E), were comparable, but there was a tendency of rubber growth of these last two treatments were slower than that of treatment A since 15 months. The slowest growth of rubber was found in the treatment Imperata (F). The two other treatments, Upland rice-fallow (C) and LCC (B), were lied between treatments of D, E and F. The treatments F, C, B and D, E were 10.5, 7, 5 and 3,3 months slower in girth growth than that of treatment A. In 1997 (42 to 45 months), where the second long dry period occurred in the region, rubber growth in all treatments were very low (Figure 1)

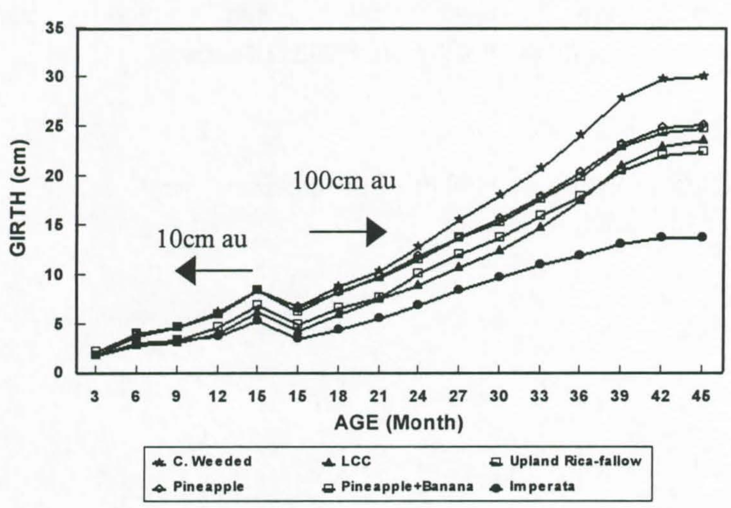


Figure 1. Girth of rubber at different ages and treatments.

The variation in rubber growth was mainly due to the competition on water and also on mineral nutrients. The low soil moisture during the dry period between May and September 1994 (9 month old rubber) confirmed that hypothesis. Figure 2 indicated that rubber girth increment was significantly correlated with soil moisture during that period.

The driest soil moisture was found in three treatments: legume cover corps (B), imperata (F) and natural grasses grew after upland rice (C). This was due to the evapotranspiration that was the highest in treatments of rubber + LCC, rubber + natural grasses that grew after upland rice, and rubber + alang alang. For the last treatment, the slowest growth of rubber might also be due to the allelopatic effect of Imperata (Figure 3).

The variation in girth increment was observed among treatments, where the best stem girth increment were around 2.2cm in the beginning of dry season (3-6 months) and only 0.9cm on dry season (6-9 months) and around 1.6cm by the end of dry season (9-12 months). During those same periods, the lowest girth increment was observed in LCC and Imperata plots. (Figure 4)

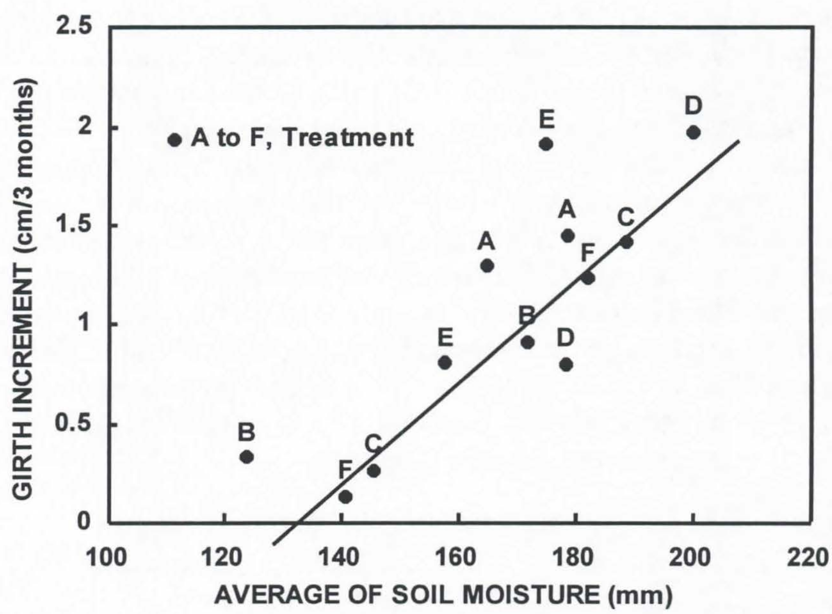
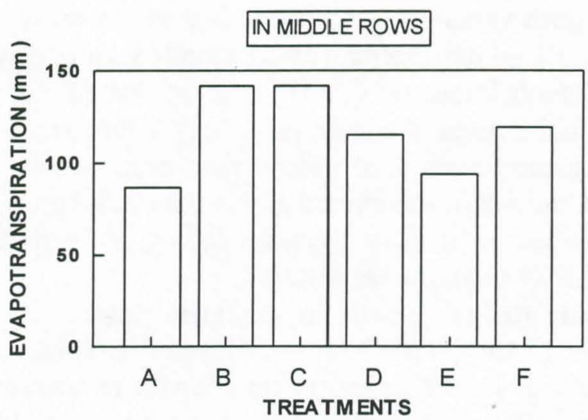


Figure 2. Effect of soil moisture on rubber girth increment (cm/3 months). The regression equation is $y= 0.0234x - 2.88$; $R^2=0.71$



A:Clean weeded, B:LCC, C:Fallow, D:Pineapple, E:Pineapple.+Banana, F:Imperata

Figure 3. Total evapotranspiration in the middle rows of different treatments, from 16 May up to 29 September 1994.

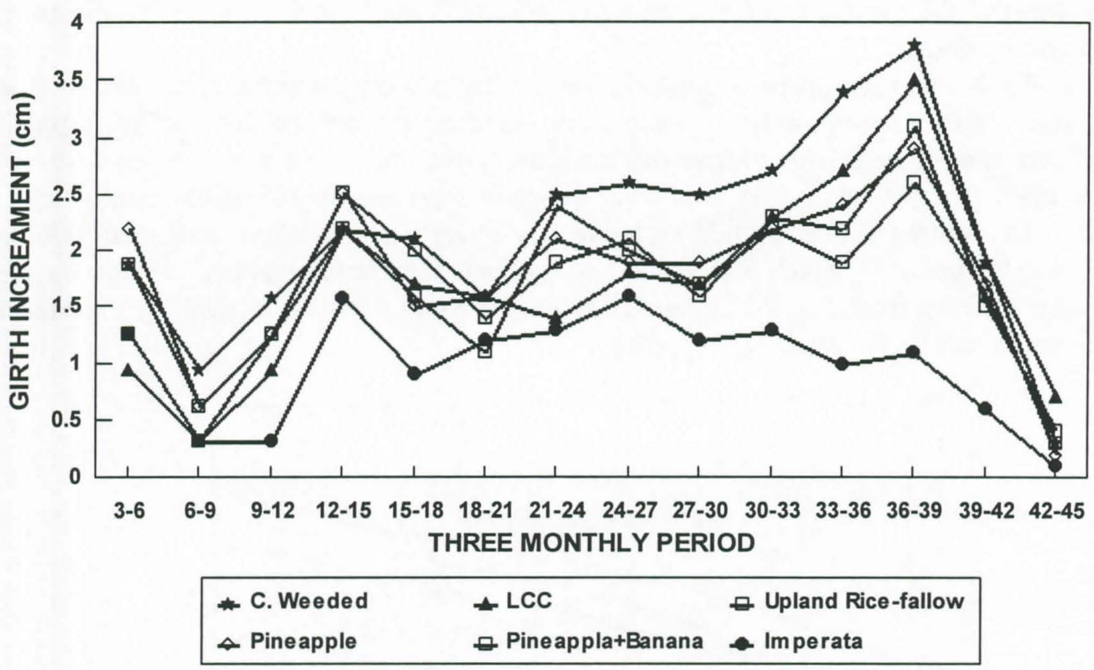


Figure 4. Three monthly girth increment at different treatments.

The smallest girth increment for all treatments occurred between June and September 1994 and 1997 (long dry periods) which was around 0.31cm in treatments B, C and F in 1994 and all treatments in 1997 and more than 0.6cm in treatments A, D and E in 1994. The rain that fell in October 1994 increased the stem diameter, except for that of rubber + imperata (F). During the wettest period, 24-27 months and 36-39 months, rubber girth increment in all treatments were more than 2cm, except for rubber + imperata which was around lower than 2cm. This indicated that intercrops influence the availability of water in the system and becoming the most limiting factor for the rubber stem growth, especially during dry period .

The high stem girth variation was observed in treatment of rubber + upland rice - fallow, especially during land preparation (21-27 months). During which the rubbers' stem grew more than 2cm/3months, this value was close to that of clean weeded plot. During fallow period, with natural grasses, the stem grew only 1.7cm/3months or closed to that of LCC plot. It means that the presence of upland rice, even without arranging its planting distance to rubber rows, did not influence negatively the rubber growth. The negative effect was finally due to the presence of natural grasses during dry periods. Pineapple started to compete rubber growth at 24 months after planting.

Until 50 months, rubber growth in treatment D and E were stills the same. Modification was made to the plots D (pineapple) and E (pineapple+banana) since 50 months, to see the effect of fertilizers on rubber growth. In treatment D, fertilizers were applied three monthly and the existing pineapple was slashed. In treatment E rubber was still not fertilized and the existing pineapple was not slashed at all. The vegetation condition of treatment F (Imperata) was change naturally. However the *Imperata* coverage to soil was still more than 65%. More than 20 species of other vegetation (fruits, timber trees, lianas, weeds) emerged in this treatment. Observation in June 2000, 78 months after planting, indicated that the coverage of Imperata was less than 5% and the tree species dominated the interrow coverage.

Rubber can be tapped at least six years after planting, without fertilizers, in South Sumatra, just by assuring no water competition occurred, for example by weeding. Applying fertilizers after 4 years, may compensate the slow growth of rubber due to competition with other intercrops (Figure 5). By analyzing the girth increment between 48 months and 78 month (30 months), rubber girth in all treatments increase about 18 cm, excepted fertilized rubber in treatment D, which increase 21cm. It means that during this period nutrients were the most limiting factors of the systems. The deeper root systems may increase the capacity of plant to exploit the deeper water source.

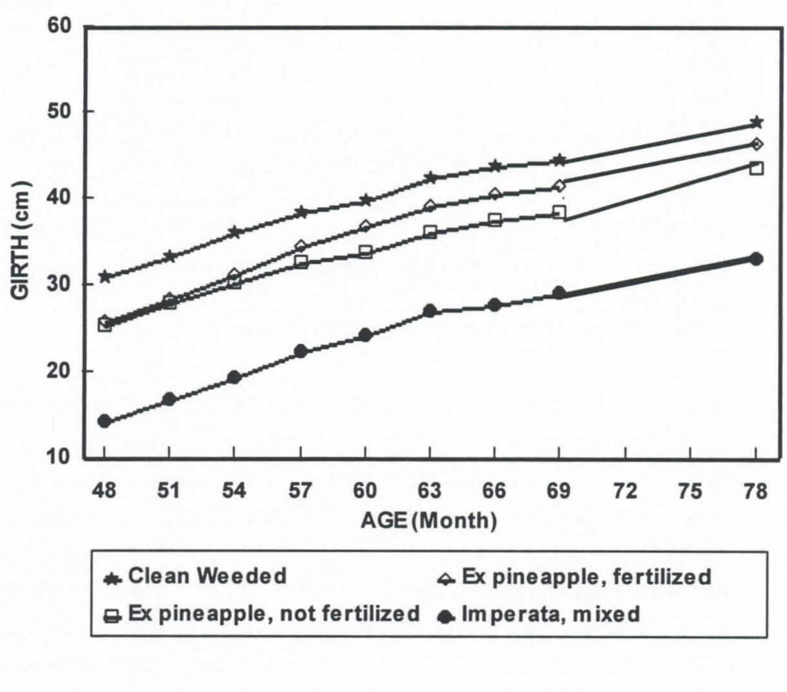


Figure 5. Rubber growth after modification of treatments was made.

B. Perennial intercropping in rubber plantation

Pulp industry in Indonesia needs timber at around 4.5 million tons/year. This quantity may be supplied from 18 - 22.5 million m^3 of Eucalyptus or Acacia timbers. To fulfill those needs, the forest plantation developed in Indonesia has to increase 150.000 ha/year and has to produce 200 m^3/ha/8years. This target of production may be very difficult to reach, as shown by the figure in South Sumatra that the realization of the forest plantation was only 46% of the target in 1992 (Kanwil Kehutanan Sumsel, 1992).

Rubber based perennial intercropping may respond that difficulty, by combining the need in short, mid and long-term goals of the planters. Modification of rubber planting distance, from normal spacing such as 6m x 3m or 7m x 3m to double row planting distance is needed to permit the integration of various fast growing tree species in rubber plantation.

The system is targeted to respond the need of short-term, mid-term and long-term goal of planters. In short-term goal, the annual intercrops may be planted under the main rubber trees for about 2-3 years; after that the fast growing trees replace the role of annual intercrops and the timber is targeted to be harvested 6 to 7 years later. In long-term rubber trees will produce latex for planters.

Various fast growing tree species such as *Paraserianthes falcataria*, *Peronema canesscen, Eucalyptus deglupta* and *Acacia mangium* that are use as raw material in pulp industry may be harvested 5 to 6 years after planting. In addition, different rubber clones, such as IRR series (IRR24, IRR39, IRR42) may produce either latex or timber, that could be planted, as intercrops, together with the main rubber tree at the same piece of land.

Several experiments, based on perennial intercropping in rubber plantation were carried out in Indonesian Rubb. Res. Station. Treatments consisted of comparing, firstly, rubber growth planted in normal spacing distance (5m x 4m or 6.7m x 3m) and double row (4m x 2m x 16m or 2m 6m x 14m), secondly rubber growth where in rubber planted with double rows, perennial intercrops such as *Paraserianthes falcataria* and latex timber clones were planted at the same time with the main rubber trees. Three, four and five rows of *P. faclataria* were planted in between double rows of *hevea*, while in other experiment unit, only three rows of latex timber clones were planted. In addition, the similar experiment was also carried out in Riau and in Sembawa to test broader types of perennial intercrop to be integrated in rubber plantation such as *Peronema canesscen, Eucalyptus deglupta, Acacia mangium* and *Tectona grandis* .

Below are the research results of the experiment carried out in Sembawa since 1997, on double row planting distance integrated with *P. falcataria* or various latex timber producing clones. Rubber growth (girth) planted in normal spacing (4m x 5m) was 14% higher than that planted with double spacing (4m x 2m x 16m), both without intercrop, 39 months after rubber planting. Rubber girth (double rows) in plot treated with three, four or five rows of *P. falcataria* was 14% lower than that in plot without intercrops (double rows) and 26% lower than that planted with normal spacing density, without intercrop (Figure 6). This means that *P. falcataria* compete highly the rubber growth if all tree components are planted at the same time.

Rubber clones producing latex and/or timber compete lighter than *P. falcataria* to the main rubber. Rubber girth in double row plot planted with various latex timber-producing clones was comparable to that planted without intercrop. Rubber girth in these treatments was 14% lower than that in normal spacing distance, planted without intercrop (Figure 7).

Water was the main limiting factor of the slow rubber growth in plot rubber + *P. falcataria*, especially during dry period between June to September. Intensity of leaf fall of the main rubber intercropped with *P. falcataria* was higher than that intercropped with latex timber clones. The total leaf fall was found in 37% population in plot of rubber + *P. falcataria*; 7% in plot without intercrop, double rows; 3% in plot of rubber + latex timber clones and none in control plot (normal spacing).

Girth of different latex timber clones ranged between 24cm (seedling of RRIC 101) and 30cm (IRR 24), while girth of P.falcataria ranged between 45cm and 52cm (Figure 8). This indicated that P.falcataria grow twice faster then average of rubber clones.

It seems that the main rubber has to grow first to become more competitive to intercrop, when it combined with the fast growing three like *P. falcataria*. Other experimental unit, carried out in Sembawa funded by the ASB project in 1996, show that when P.falcataria planted one row with a distance of 1.5m, 3m or 6m in row, in between 2 year old rubber, with 7m x 3m spacing distance, then no significant different of rubber girth was found, five years after rubber planting (Figure 9). This result was very encouraging, due to its potential to develop a more sustainable system in rubber plantation. Two years before integration of fast growing tree crops in between rubber, the annual intercrops can be planted as source of cash income for farmers.

Planting Salacca (*Salacca edulis*) *Pondoh* cultivar, in between rubber has also done in Sembawa Res. Station. Rubber growth was not affected by Salacca that was planted in between two-year-old rubber at 1, 2, 3 rows with planting distance of 2m within rows. Rubber reached a tappable size in all treatments at least five years after planting. Salacca was started to produced 3 years after planting . This result was comparable to that found in Thailand (Buranatham, et al., 1992). The manual crossing for Salacca was needed to increase the fruiting success of the plant.

The negative effects of Manau rattan (*Calamus manau*) planted under rubber was observed in many areas in North Sumatra, when Rattan was planted in between young rubber trees. Rattan climbed rubber trees and broke rubber canopy heavily. Reducing number of leaves at 3 to 6 times a year, to left between 5 and 6 leaves per plant, may reduce the negative effect of rattan. Rattan length increment under rubber was 2.5-3.2m/year, with average diameter of 27.2mm at 2m height, 7 years after planting (Husni, unpublished data).

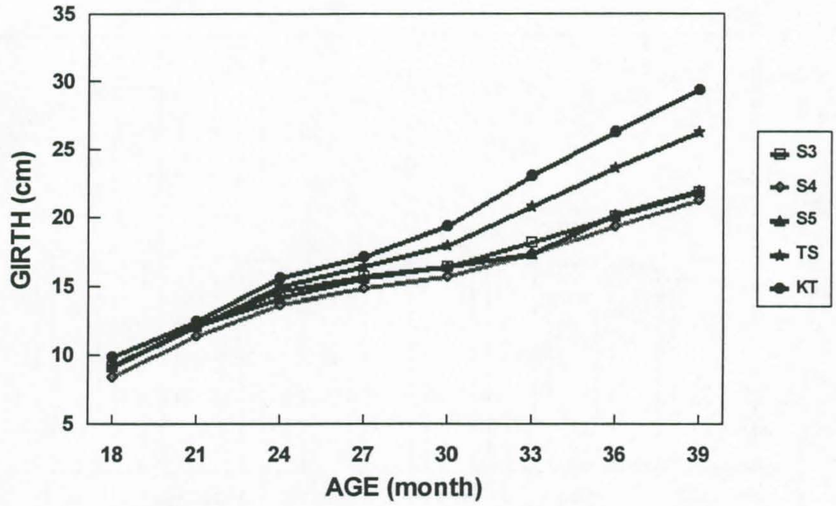
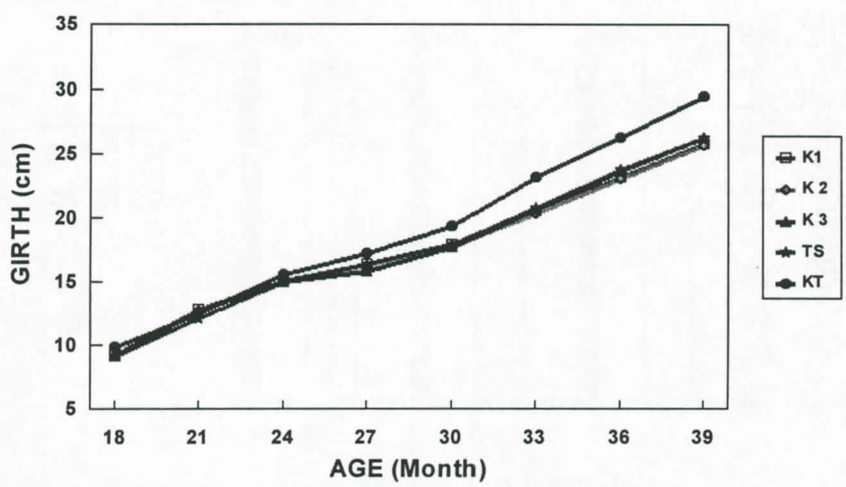


Figure 6. Effect on rubber girth of Sengon (*P. falcataria*) planted at 3 (S3), 4 (S4) or 5 (S5) rows in between rubber' double rows, compared to without Sengon (TS) and to rubber in normal planting distance without Sengon (KT)

Figure 7. Effect on rubber girth of various rubber producing latex and/or timber clones, planted in between rubber' double rows, compared to without Sengon (TS) and to rubber in normal planting



distance without Sengon (KT)

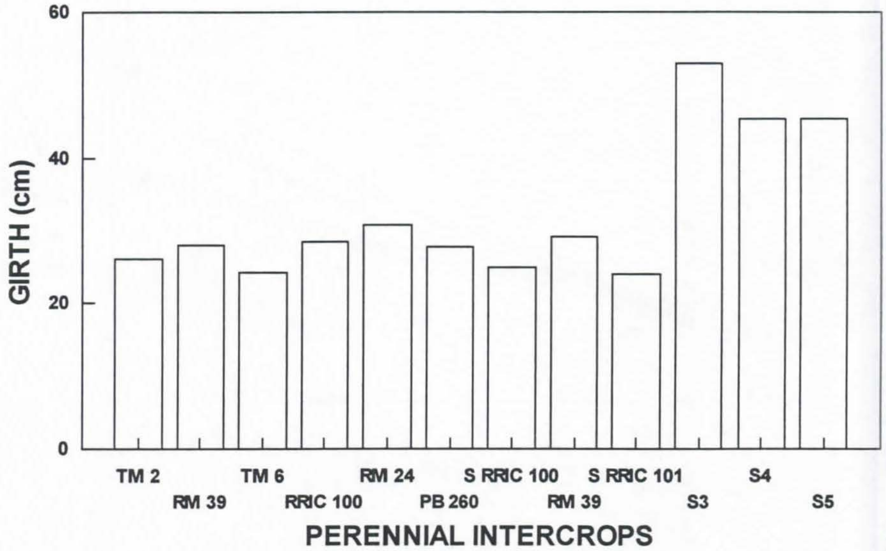
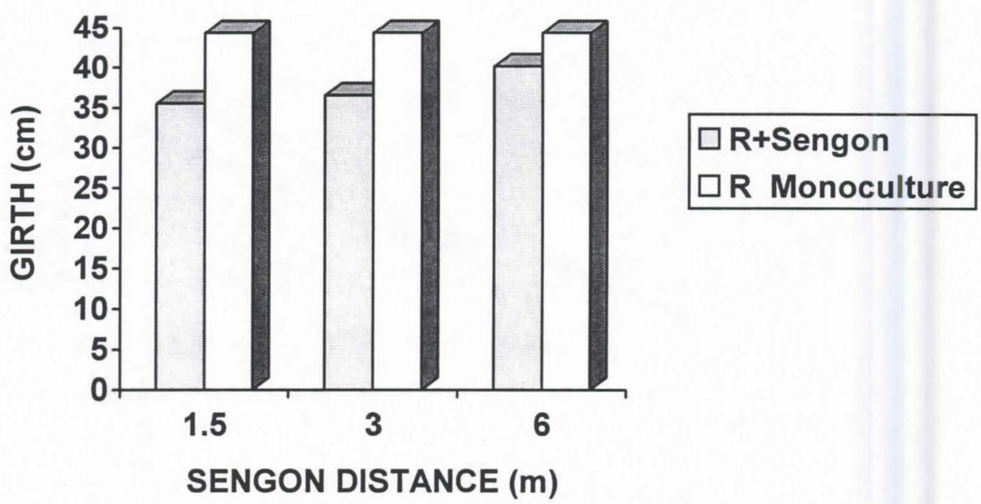


Figure 8. Girth of various rubber producing latex and/or timber clones and Sengon planted in between rubber' double rows, 39 months after planting.

Figure 9. Rubber girth at five years after planting and when at two years after rubber planting, Sengon was planted one row in between rubber rows at planting



distance of 1.5m; 3m or 6m within row.

C. Smallholder Rubber Agroforestry Project (SRAP)

This project was initiated through the research cooperation among Rubber Association of Indonesia (GAPKINDO), ICRAF, CIRAD and Indonesian Rubb.Res.Inst. since 1994 and funded by the USAID (Penot, 1994). Researches were carried out at three province of Indonesia Jambi, West Sumatra and West Kalimantan (see Penot and Wibawa, 1997 in more detail). This project will continued up to 2003, funded by CFC (Common Fund for Commodities) through IRSG.

SRAP aimed to recombine tehnical innovations into more productive and environmentally friendly rubber cropping systems through the use of agroforestry practices, clonal rubber and some selected inputs. SRAP has taken into account previous research and observations such as STD III in Indonesia, Gabon and Ivory Coast, and the previous studies from Anne Gouyon and its indonesian colleagues from IRRI/Sembawa (Gouyon 1995).

The main goals of the project were to test three types of rubber agroforestry systems at farmer levels, *called RAS1, RAS2 and RAS3*. The systems developed by considering the agro-climatic and social economic conditions of the local farmers. Number of participants was 100 farmers and covered 60 ha of farmers' lands in 27 trials.

In those three applied systems, the use of production inputs including chemicals and labors in managing the systems was minimal. The characteristics of the three RAS were described as follows (Penot and Wibawa, 1997):

1. **RAS1**: is similar to the current jungle rubber system described above, except the un selected seedlings that currently used in jungle rubber, is replaced by promising clonal rubber. The clones were tested to its competitiveness to the secondary forest re-growth. Different levels of weeding were tested, permitted to identify the minimum amount of management needed for the system.
2. **RAS2** : is a complex agroforestry system in which rubber and perennial timber and fruit trees are established after slashing and burning. This system is more intensive than the RAS1, where during the first 2-3 years, the annual food crops were intercropped in between rubber trees. Various crop combinations were tested including food crops, cash crops and timber trees.
3. **RAS3** : targeted to be developed on degraded land covered by *Imperata cylindrica* (Alang alang). The system is similar to RAS2, except the intensive annual intercropped is done just in the first year and after that rubber inter rows are planted with the combination of cover crops (mainly leguminous) and the fast growing tree species. The main idea of this system is to cover the soil as soon as possible with useful vegetation to limit the *Imperata* growth.

Part of the results are described below, especially on bio-physical aspects of the system. Preliminary results have been published at the Rubber Agroforestry systems workshop, held in Bogor, in september 1997 with ICRAF, IRRI and GAPKINDO (Penot *et al.*, 1999). The overall detail results are presented in other papers in this conference (boutin, 2000a and 2000b). In RAS1, under Jambi and West Kalimantan conditions, indicated that during the first two years the minimal strip weeding may be done every 4 months and after that every 6 months (Table 1). Note weeding of the forest re-growth was done only within rubber rows. Similar result on the possibility to reduce weeding intensities on rubber growth, compared to that currently used, was also reported by Suryaningtyas, *et al.*, (1997). These results means that low weeding intensity may reduce half of the cost of weeding, without loosing highly the girth growth. This strategy may respond farmers' constraints on cash money and labor.

Table 1. Effects of weeding intensity on rubber girth (cm) in Jambi and West Kalimantan, at 26 months and 42 months after planting respectively.

Weeding Intensity	Frequency/year JAMBI	Average girth at six replications 26 months (cm)	Frequency/year West Kalimantan	Average girth at eleven replications 42 months (cm)
Low	3 x first 2 years 1 x after 2 years	18.4 (98%)	4 x first 2 years 2 x after 2 years	23.5 (85%)
Medium	6 x first 2 years 3 x after 2 years	19.2 (103%)	6 x first 2 years 4 x after 2 years	25.2 (91%)
High	9 x first 2 years 6 x after 2 years	19.6 (105%)	8 x first 2 years 6 x after 2 years	25.8 (94%)
High + LCC	9 x first 2 years 6 x after 2 years	18.7 (100%)	8 x first 2 years 6 x after 2 years	27.6 (100%)

Source : Wibawa *et al.*, 2000. (modified)

The growth respond of four clones tested (PB 260, RRIC 100, BPM 1 and RRIM 600) on those weeding intensities was similar one each other and growth of those clones were better than that of seeding (Table 2). Better resistance of RRIC clone, compared to other clones, to water stress was published by Chandrashekar, *et al.*, (1998).

In RAS2, in Jambi, growth of rubber intercropped with fruit trees or with mixture of fruit and timber trees was 5 to 10% lower than that planted in monoculture with good maintenance. The slower growth of rubber (20% below) was found when rubber was planted in mixture with other perennial trees and the land was covered by shrubs (Table 3). In West Kalimantan, the respond of rubber growth on the presence of perennial intercrops (fruits, timber trees) in inter-rows was vary. However the difference of growth between rubber with intercrops and without intercrops was not significant (Table 4).

Table 2. Average girth (cm) of various clones/seedling at two levels of weeding intensity in Jambi (26 months) and in West Kalimantan (42 months).

Clone/seedling Material	Weeding intensity (Jambi), 26 months		Weeding intensity (West-Kalimantan), 42 months	
	3 x per year	6 x per year	4 x per year	6 x per year
PB 260	20.0	20.7	25.2	25.0
RRIC 100	18.5	19.8	22.4	24.2
BPM 1	19.2	21.7	21.2	22.2
RRIM 600	19.4	20.6	21.0	20.1
Seedling	15.2	17.0	16.2	14.0

Source : Wibawa *et al.*, 2000. (modified)

Table 3. Girth of rubber (cm) at different types of perennials intercrops in Jambi 26 and 32 months after planting.

Types of perennial intercropping	26 months	32 months
Rubber monoculture	21.5	27.3
Rubber + fruit trees	18.7	26.0
Rubber + mixture trees	19.0	25.2
Rubber + rubber seedling	17.0	24.4
Rubber + mixture trees and shrubs	16.4	21.5
Rubber + Imperata*	7.4	12.4

*) No maintenance done by farmer, *Imperata* existed since 1-year old..
Source : Wibawa *et al.,* 2000.

Table 4. Girth of rubber (cm) at different types of perennials intercrops in Trimulya and Sekadau, (West Kalimantan), 42 months after planting.

Types of perennial intercropping	Trimulya (42 months)	Sekadau (42 months)
Rubber monoculture	28.9	35.8
Rubber + durian	27.8	32.5
Rubber + rambutan	31.4	32.0
Rubber + durian & rambutan	26.8	38.1
Rubber + mixture trees	31.3	36.5
Rubber + Tengkawang	-	27.7
Rubber + Parkia	-	29.4

Source : Wibawa *et al.,* 2000.

In RAS3, the negative effect of *Imperata* on rubber growth was very significant. Rubber girth reduced 50% by *Imperata*, compare to rubber intercropped with *Mucuna* or *Flemingia* (Table 5). In all cases of this site, rubber growth was slow indicated by the girth of around 28cm, for 52-year-old rubber. This may be because of the influence of *Imperata* that was still present in LCC plots. Until 42 months, the reduction of growth due to planting of fast growing trees in between rubber trees was not significant. In some cases, growth of rubber was slightly better than that planted without intercrops (Table 6)

Table 5. Effect of cover crops and Imperata on rubber girth in Kopar (West Kalimantan) (cm).

Cover crops/ Imperata	Kopar (52 months)	% to Mucuna
Mucuna	28.8	100
Flemingia	28.5	99
Imperata	17	53

Source : Wibawa *et al.,* 2000.

Table 6. Effect of different type of fast growing trees on rubber girth (cm) in Engkayu and Trimulya (West Kalimantan) 42 months after planting

Type of vegetation	Engkayu	Trimulia
Without Intercrop	27.5	25.9
Acacia mangium	26.3	26.6
P.falcataria	32.3	27.3
Gmelina sp	26.0	26.9
Mixture trees	23.7	26.1

Source : Wibawa *et al.,* 2000.

In case of smallholder, based on the encouraging results described above, the benefits of the systems will be:

- technically, the productivity of the land will increase due to the use of clonal planting materials.
- economically, the cost of maintenance will be cheaper, compare to that in monoculture, due to its minimal input approach,
- ecologically friendly, due to its higher level of biodiversity,
- socially, the development of the system will be easier due to its adaptability to farmers' tradition.

D. Understanding farmers' strategies in determining rubber based farming systems.

Recently in the jungle rubber system in Jambi province in Indonesia, farmers have been observed to be practising a technique of rejuvenation eliminating the need for slash and burn. Locally known as *sisipan* (literally meaning inter-planting new plants within an existing stand) new rubber seedlings are transplanted over a number of years within gaps in forest to replace the dead, dying, unproductive and unwanted trees. A more permanent rubber agroforestry system is maintained. The system can be characterised by its natural forest like vegetation and generally consists of a range of development stages of rubber trees.

The *sisipan* method is not a new invention, but it has escaped researcher attention until recently. Some farmers in Jambi in Indonesia are known to have practised it for a number of decades. In majority of the cases, farmers who have adopted *sisipan* system also have field/s with the *slash and burn* system. The change in farmer practice from *slash and burn* system to a more permanent system raises many interesting questions.

What are the causal factors for change in farmer choice for rejuvenating jungle rubber? What is the permanence of this 'permanent' system; is it only an intermediate and temporary stage for prolonging the traditional *slash and burn* system whereby the system will revert to slash and burn once the conditions are more conducive? This work is a part of project activities carried out by ICRAF, University of Wales and Indonesian Rubb. Res. Inst./Sembawa Research Station under DFID (UK) funding.

Various factors have been identified to be the major causes for some farmers in Jambi to choose between slash and burn method and *sisipan* (Laxman *et al.*, 2000 and Wibawa *et al.*, 2000b). Factors determined why farmers choose *sisipan* are seem economic including capital and labour availability; accessibility of new land and vertebrate risk. Those factors influenced dependently one each others. Combination of factors such as continuity of income from the existing rubber garden; high cost of establishment of the new plantation prepared by slash and burn method; no land available to be cleared; high risk of pest damage (pigs, monkeys) and low cost of maintenance were the most determinant combinations for farmer decisions.

Farmers who can afford the initial establishment investment prefer the slash and burn approach which leads to the hypothesis that poor farmers prefer (or rather have no choice) the *sisipan* approach while richer farmers opt for the slash and burn practice. It seems that farmers whose household income primarily comes from rubber production will also prefer the *sisipan* method whereas farmers with diverse income source, hence with less dependence on rubber, are likely to choose the slash and burn method (Laxman *et al.*, 2000).

However, according to some authors, sisipan cannot be considered as a viable alternative, in particular before more productive (and competitive in terms of income) cropping systems such as oil palm or various clonal rubber based cropping systems. (Penot, 1999)

III. FUTURE RESEARCH AND DEVELOPMENT

There are still few data available on the multiple aspects of the systems; especially concerning rubber based complex agroforestry, however more than 100 various papers, publications or reports have been published by SRAP team. Adaptability of new clones to the 'jungle' like conditions where the competition on physical factors of growth (water, nutrients, light) will be more severe compared to that in monoculture estate management. What will be the plant component arrangement and maintenance (fertilizing, weeding) strategy of those specific clones to permit an optimal growth of the plants in the system? In term of pest and disease, is the complex rubber agroforest may have roles in reducing or increasing the development of pests and diseases?

Van Noordwijk and Lusiana (1999) work in a general model of tree soil crop interaction in agroforestry. The model called WaNuLCAS (water, nutrients and light capture). The model can be used in agroforestry systems ranging from hedgerow intercropping (alley cropping) on flat or sloping land (contour hedgerow intercropping), via (relay-planted) fallow to isolated trees in parkland systems. Adaptation of this model to the rubber agroforest conditions is still on going.

The ecological benefits of the systems are well known. Combining the yield productivity and environmental benefits are the ideal goal of the systems. With an integrated approach, timber industries that start to face on raw material shortage may joint with farmers to develop the systems by using community based management approach. Farmers can plant rubber that produces not only latex but also timber provided through latex timber clones that develop by breeders, combined with multi purpose tree species. The systems will be more adaptive to the farmers' conditions. Using the systems as a buffer zone of the forest is an issue that needs to be tested. The role of rubber based agroforestry on reducing the degradation of part of the tropical rain forests in Indonesia will be potential for the future development.

IV. CONCLUSION

Rubber based complex agroforestry research in Indonesia are still a new research domain that need to be integrated with various research activities, not only on agronomic or bio-physical aspects but also socio-economic and environmental benefits of the systems. Most rubber based agroforestry research activities carried out in station research have characteristics of simple agroforestry systems. This was due to the difficulty to determine interactions of various factors, when more than two plant components are present in the systems. Modeling may be a good tool to simplify the complex interactions that occur inside the systems. More quantitative data sets were needed to respond this objective. An international research cooperation has to be built to speed-up the availability of information to develop to farmers.

The systems are more adaptive to farmers' traditions and may respond the need for community based forest management in buffer zone areas, or in the degraded areas (logged over forest, imperata land). The systems respond to the short, medium and long run objectives of farmers by managing different types of plants at the same portion of land. By considering both plant yield productivity and biodiversity benefits, rubber based agroforestry systems are very prospective in the near future where the availability of tropical rain forest will be very limited.

V. REFERENCE

Barlow,C and Muharminto. 1982. Smallholder rubber in South Sumatra toward economic improvement. *Doc. BPP Bogor and ANU.* 78pp.

Boutin, D., Penot E,Wibawa G. and Akiefnawati R (2000a). Rubber Agroforestry Systems-type 1 (RAS1): a strategy towards a productive "jungle rubber". IRRDB annual conference, Bogor, Indonesia, IRRDB

Boutin, D., Penot E. and Ilahang (2000b). Rubber Agroforestry Systems-type 3 (RAS 3), a strategy to convert Imperata grasslands. IRRDB annual conference, Bogor , Indonesia, IRRDB.

Buranatham, W;S.Kongsripun and S.Shugamnert. 1992. Recent advances in multiple cropping with hevea in Southern Thailand. *Paper presented at 7th ANRPC Seminar*. Hat Yai. Thailand. 11p.

Chandrashekar, T.R., M.A. Nazeer., J.G. Marattukalam, G. P., G. P. Prakash. K. Annamalainathan and J. Thomas. 1998. An analysis of growth and drought tolerance in rubber during the immature phase in a dry subhumid climate. *Expl. Agric.* vol 34: 287-300.

de Foresta, H. & Michon, G. 1996. Tree improvement research for agroforestry: a note of caution. *Agroforestry Forum* 7(3): 8-10.

DITJENBUN. 1997. Statistik Perkebunan Indonesia 1995-1997. Karet. Jakarta. 56 pp.

Gouyon, A. (1995). Paysannerie et heveaculture: dans les plaines orientales de Sumatra: quel avenir pour,les systemes agroforestiers? INA-PG. Paris, France, INA-PG.

Gouyon, A. and Nancy, C. 1989. Increasing the productivity of rubber smallholders in indonesia: a study of agro-economic constrains and proporsals. *Paper for the Rubber Growers Conference*. 26pp.

Hardiwinoto S., D.T. Adriyanti, Swarno, H.B., Aris. D., M wahyudi. and M. Sambas. 1999. Stand structure and species composition of rubber agroforests in tropical ecosystems of Jambi, Sumatra. *Joint research between ICRAF and Univ. Gajah Mada*. 61 pp.

Hendratno, S. 1990. Batas-batas kelayakan finansial usaha perkebunan karet rakyat di Sumatera Selatan. *Lateks* 5(2):34-44. Pusat Penelitian Perkebunan Sembawa, Asosiasi Penelitian dan Pengembangan Perkebunan Indonesia.

Hendratno, S; M.Supriadi and M.J.Rosjid. 1992. Pengembangan usahatani karet rakyat di KPK Merlung Kabupaten Tanjung Jabung Jambi. *Lateks* 7(1):34-39.

Keli, J.Z. and La Serve, M de. 1989. Interet de vivriers intercalaire pour les petites et moyennes plantations hévéicoles de la basse Côte d'Ivoire. *RGCP*.

Keli,J.Z.;Omont,H.;Hainnaux,G. 1988. Bilan d'un cycle triennal de cultures vivrières en intercalairedes jeunes hévéas en Basse Côte d'Ivoire: I Comportement des cultures vivrières. *IRCA-Bimbresso* 18pp.

Michon, G. and De Foresta, H. 1998. Agro forests: incorporating a forest vision in agroforestryy. *In*: Louise E. Buck; J.P. Lassoie and E.C.M. Fernandes. (Eds.) *Agroforestry in Sustainable Agricultureal System*. CRC Press. Boca Raton, London, New York and washington, D.C. p: 381-406.

Penot, E. (1994). Improving the productivity of Smallholder Rubber Agroforestry Systems: sustainable alternatives. Project frame, general proposals and on-farm trial methodology. Bogor (IDN) :, ICRAF, - 28 p., 4 tabl. ST: Working Paper (IDN).

Penot, E., Wibawa G., Williams S. (1999). "Rubber Agroforestry Systems in Indonesia." Proceedings of the SRAP workshop, ICRAF/CIRAD, Bogor, September 1997.

Penot. E and G. Wibawa. 1997. Complex rubber agroforestry systems in indonesia : an alternative to low productivity of jungle rubber conserving agroforestry practices and benefits. *Proc. symp. on farming system aspects of the cultivation of natural rubber*. (*Hevea brasiliensis*). IRRDB. p :56-80.

Rosjid, M.J; Wibawa, G. and Gunawan, A. 1993. Pola usahatani terpadu pada perkebunan karet untuk meningkatkan effisiensi penggunaan lahan. Paper presented *on temu aplikasi paket teknologi usahatani* in BIP, Aceh.45pp.

Rosyid, J.M.; G.Wibawa; S.Arifin. 1987. Hasil dan rencana penelitian pola usahatani lahan kering di Sembawa dan Batumarta. in: Mahyudin Syam et al. (eds). *Risalah Lokakarya Pola Usahatani*, Buku 2. Badan Litbangtan. p:375-392.

Taulana, S and W. Faturrahman Riva. 1999. Non rubber tree species for enrichment of permanent rubber agroforest systems (PAS): A case study in Jambi. *Joint research between ICRAF and Pusat Penelitian dan Pengembangan Hutan*. 25pp.

Tomich, T. P., M. van-Noordwijk, Budidarsono, S., Gillison, A., Kusumanto, T., Murdiyarso, D., Stolle, F., Fagi, A.M. (Eds.) 1998. Alternatives to Slash-and-Burn in Indonesia, Summary Report & Synthesis of Phase II. *ASB Indonesia Report Number 8*. Bogor, Indonesia. 139pp.

Van Noordwijk, M. and B. Lusiana. 1999. WaNuLCAS 1.2. backgrounds of model of water, nutrient and light capture in agroforestry systems. *Working Document. ICRAF*. Bogor. 106pp.

Van-Noordwijk, M., Tomich, T., Winahayu, R., Murdiyarso, D., Suyanto, Partoharjono, S. and Fagi, A.M. 1995. Alternatives to Slash-and-Burn in Indonesia, Summary Report of Phase 1. *ASB Indonesia Report Number 4*. Bogor, Indonesia.

Wibawa, G ; D. Boutin and AFS. Budiman. 2000. Alternatif pengembangan perkebunan karet rakyat dengan pola wanatani. *Proc. Lokakarya dan Ekspose teknologi Perkebunan. Buku I. Model Peremajaan Karet rakyat secara Swadaya*. AP_2I. p: 89-98.

Wibawa, G.; M.J. Rosyid; Suryatna Effendi;T. Subagio. 1985. Increasing of land productivity of red yellow podzolic soil through rubber based farming system. *Proceeding of International Workshop on Croppiong/Farming System*. Sukarame, Indonesia

Wibawa, G; S. Hendratno; M.J. Rosyid; A. Budiman and M. van-Noordwijk. 2000b. The role of socio-economic factors in farmer decision making: factors determine the choice between Permanent Rubber Agroforestry Systems (PRAS) and Cyclical Rubber Agroforestry System (CRAS) by farmers in Jambi and South Sumatra. *A progress report. Joint research ICRAF-SE Asia and Sembawa Research Station*. 43 pp.

Wibawa, G; Thomas, D. Tambunan, M.J. Rosyid and A. Gunawan. 1997. Study of the component interactions in hevea based intercropping systems. *Proc. Symp. On farming System aspects of the Cultivation of Natural Rubber*. (*Hevea brasiliensis*). IRRDB. p :25-40.

Yusoff Mohd.Noor,M.;A.W.Mahmud; A.T.Bachik;E.Zainol;M.Norhayati; H.M.Johari and N.Grundon. 1989.Intercropping under young rubber. *Proc.RRIM Rubber Growers'Conference*. p:166-180.

Zen, H.K. Z.A. 1997. serapan metana (ch_4) pada pertanaman padi gogo dengan iklim mikro dan tingkat pemupukan N yang berbeda. *Ringkasan Thesis Doktor, Pasca Sarjana IPB*. 48 pp.

Rubber Agroforestry Systems-type 1 (RAS1): a strategy towards a productive "jungle rubber"

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Abstract

In Indonesia, most of the rubber area owned by smallholders is exploited under an extensive system called: "jungle rubber", where rubber is cultivated at minimum cost. The average production under such system is low if compared to rubber estate (500 vs. 1500 kg of dry rubber/ha/year) because of the unselected rubber seedlings used in the system.
Jungle rubber has been described as "complex agroforestry system" rich in biodiversity. In 1994 E. Penot proposed an alternative called "Rubber Agroforestry Systems" where many traditional practices are maintained but some technical innovations are introduced in particular the use of budded rubber to increase latex production

In SRAP (Smallholder Rubber Agroforestry Project) an approach called "Rubber Agroforestry System-type 1" (RAS 1) was tested in farmers fields, using a participatory approach, in order to evaluate the effect of various factors and the acceptability of techniques by farmers. Factors studied concerns: weeding intensity on the rubber row, type of planting material and the effect of fertilizers on rubber growth.

After 4 years of experimentation, results confirm that budded rubber grows satisfactorily in jungle rubber environment and its girth size is similar to estate conditions. Weeding requirement can be highly reduced where natural vegetation re-growth is fast. Intensive weeding on rubber row was not found to increase significantly rubber growth. Out of 4 rubber clones and seedlings tested the best girth growth was obtained by PB 260 and RRIC 100 clones.

The SRAP experiment network confirmed that farmers might adopt easily RAS type-1 strategies as maintenance cost and labor requirement are limited. The Rubber Agroforestry Systems (RAS) approach must be promoted intensively in rubber sector to accelerate the transformation of Indonesian jungle rubber areas into productive rubber agroforests.

Introduction

In Indonesia, smallholders mostly cultivate rubber in a extensive system called "Jungle rubber". Rubber is part of the farmers' strategies in slash-and-burn practices and most of cleared land in Sumatra or Kalimantan is converted into rubber after growing few food crops for one or two years. The system is highly extensive and need minimum investment in both inputs and labor. Planting material is obtained from local seeds or seedling taken in jungle rubber. Rubber plants are left for 5 or 6 years as a fallow and slashing of vegetation is done when rubber trees are developed enough. Rubber is tapped at 8 to 12 years old according to rubber development and local environment.

Jungle rubber has been described as "complex agroforestry system" and was found as a rich reserve of biodiversity (de Foresta, 1992). The system is also highly inexpensive as establishment and maintenance costs are very low (Gouyon, 1995). In 1994, E. Penot proposed an alternative called "Rubber Agroforestry Systems" (Penot, 1994) where many traditional agroforestry practices are maintained but some external technical innovations are incorporated from the monoculture cropping pattern to improve the productivity of the system. The use of budded clones is one of the major components to guaranty gains in rubber productivity. Budiman stressed the need for alternative development to guaranty the future of jungle rubber in Indonesia (Budiman, Penot et al., 1994).

Jungle rubber ensures the living of millions of farmers in Indonesia and allow the development of rubber on more than 3 millions hectares in Sumatra and Kalimantan. However, the use of unselected seeds limits latex production compared to cropping systems, either monoculture or agroforestry, using clones. Poor tapping practices hamper rubber production and bark regeneration. Poor practices are mostly: high frequencies of tapping, large and frequent wounds in tapping panels, and the simultaneous use of two panels (fishbone tapping).

In SRAP[1] (Smallholder Rubber Agroforestry Project) an approach called "Rubber Agroforestry System-type 1" (RAS 1) was tested in farmers fields. Trials using a real participatory approach were established in order to evaluate the effect of various factors in a new environment. Experiments with farmers enable to test the acceptability of improved agroforestry based technologies by farmers. The potential of adoptability of RAS was supposed to be high as RAS technologies, in particular RAS 1 type, are relatively close current farmers' practices. The final aim is to provide technical recommendations to farmers, better adapted to their constraints. Preliminary results on RAS trials in West-Kalimantan were presented at IRRDB annual seminar in 1996 (Penot and Wibawa, 1996)

Material and methods

Experiments were established in farmer fields under participatory approach. Protocoles have been discussed with all farmers before implementation. Farmers' groups similar to "group of interest" have been created according to trial type. Various aspects of the experiments: objectives, treatments, and field practices were therefore discussed every year with participants in order to adapt the trials to local constraints.

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[1] Smallholder Rubber Agroforestry Project, a project in Indonesia supported by USAID, Gapkindo, IRubRI, CIRAD and ICRAF SE Asia Regional Research Program

Main hypothesis:

Grafted rubber can grow under conditions of minimum maintenance and low input level in an environment similar to jungle rubber conditions. Weeding frequency is limited and weed control is done only on the area of the rubber row in order to obtain a normal growth of rubber. In other words, the secondary forest re-growth in the inter-row is not more competitive than the usual cover crop (*Pueraria phaseolides*) used in monoculture.

Three factors were studied in RAS type-1 experiments:

- Effect of the level of maintenance (weeding) on clone grafted rubber in jungle rubber environment: (RAS 1.1 trial series).
- Performances of different clones in jungle rubber environment (RAS 1.2 series): clones comparison.
- Effect of various amounts of fertilization on rubber growth in jungle rubber environment (RAS 1.3 series)

Experimental design

Randomized block design was used in trials. All treatments are settled in each farm, a farm being a replicate. A treatment consists of an average area of 0.10 ha and a farm has a size about 0.50 ha planted in rubber. Each trial has generally 3 to 6 replications, located in the same area (village), in order to decrease environmental variability.
RAS 1 trials were established in two provinces of Indonesia: Jambi and West Kalimantan. In Jambi some farms-replications (village of Rantau Pandan and Muara Buat) were severely attacked by wild pigs and monkeys and data analysis does not included these farms.

Results and discussion

- **Effect of weeding frequency on rubber growth (RAS1.1 trials)**

Weeding was performed at various frequencies on the rubber planting row. Natural vegetation in the inter-row was left uncontrolled except at close proximity of rubber trees. The control plot is the high frequency of weeding with LCC[2] (*Pueraria phaseolides*) in the inter-row as recommended in smallholder development project in Indonesia. RAS 1.1 trials were established in two provinces of Indonesia: Jambi and West Kalimantan. Results are summarized here after:

[2] LCC = Legume cover crops

Table 1. Effect of weeding frequency on rubber girth (cm) at 36 months with PB260 clone.

Province	No. of Replic.	Treatment			
		High weeding +LCC	Low Weeding	Medium Weeding	High Weeding
Jambi	6	29.1	28.6	29.3	30.3
Girth (%)		(100)	(98)	(101)	(104)
West Kal	6	28.4	25.3	29.0	28.8
Girth (%)		(100)	(89)	(102)	(101)
All	12	28.8	27.0	29.2	29.6
Girth (%)		(100)	(94)	(101)	(103)

The frequency of weeding for low, medium and high weeding was respectively of 4, 6, and 8 weedings in year 1, then 2, 4 ,6 weedings in year 2 and 1, 3 ,4 weedings in year 3 and following years. Some farmers did not strictly apply weeding schedule but a gradient of different levels of weeding between plots was maintained. In West Kalimantan low weeding frequency obtained inferior performances due to *Imperata* competition in two plots. Under medium and high weeding, the natural re-growth in the inter-row does not affect rubber growth and performances are similar even better than using LCC. Natural re-growth maintains moisture in the soil, which favors rubber growth. It confirms also our hypothesis concerning the competition between rubber and forest re-growth: this competition is not significant.

In conclusion, weeding can be restricted to the rubber row only and frequency of weeding can be restricted to 6 weedings per year during the first year (in particular if the field is invaded by *Imperata*) then 3 to 4 weedings per year afterwards. Natural vegetation in the inter-row does not affect rubber growth and performances were found similar those obtained under standard estate practices using legume cover crops and high frequency of weeding. It should be noted that the frequency of weeding is not the only factor influencing rubber growth as weeds species (*Imperata*, grasses or broad leaves weeds) and the quality of weeding at the proximity of young rubber plant have also some incidence on rubber growth.

- **Performance of different rubber clones in RAS-type 1 environment (RAS1.2 trials)**

Different rubber clones were tested in RAS type-1 environment to verify if clonal rubber performs well under conditions of limited maintenance and inputs. Rubber clones were selected for their production performances, fast growth and tolerance to *Colletotricum* leaf disease.

Table 2. Growth performances of different rubber clones in RAS type 1 environment-rubber girth (cm) after 36 months.

Province (No. of plots)	Rubber planting material				
	PB 260	RRIC 100	RRIM 600	BPM 1	Seedling
Jambi (5)					
Low weeding	32.6	31.0	30.3	30.4	23.9
High weeding	35.0	32.8	30.8	29.3	25.2
West Kal. (4)					
Low weeding	27.2	24.1	22.4	22.1	17.5
High weeding	26.8	26.0	23.2	21.0	15.0
Average (9)					
Low weeding	29.9	27.6	26.4	26.3	20.7
High weeding	30.9	29.4	27.0	25.2	20.1
Average					
All plots	30.4a	28.5a	26.7b	25.7b	20.4c
(%)	(100)	(94)	(88)	(85)	(67)

Rubber clones grow faster than rubber seedling either under high weeding or low weeding conditions. PB260 and RRIC 100 performed better than RRIM 600 and BPM1 and confirmed growth performances already observed in research stations. Seedlings, which are believed to be better adapted to adverse conditions, had a smaller girth than rubber clones and did not perform as expected.

Rubber clones have performed satisfactorily under RAS type-1 environment therefore, clonal rubber can be recommended in RAS type-1 environment assuming that weeding is regularly performed on the rubber row.

- **Effect of fertilizers in RAS type-1 environment (RAS 1.3 trial)**

As RAS type-1 is established after jungle rubber, soils are considered as moderately fertile. Different fertilizer regimes were tested in Jambi to assess the benefits of fertilizer use. In Kalimantan, it was clear that fertilization for the first 3 years was necessary to guaranty a good rubber growth. However, it was not so clear for our sites in the Jambi province. The initial question was: is fertilization in RAS1 needed for rubber in Jambi conditions?

Table 3. Effect of different fertilizer regimes on rubber growth (PB 260 clone)- Rubber girth at 38 months

RAS 1.3 Jambi (2 replications)	Fertilizer regime			
	No fertilizer	RP + Urea	SP36+Urea	KCl + Urea
Girth (cm)	26.2	25.2	27.3	26.5
(%)	(100)	(96)	(104)	(101)

Fertilizers did not increase significantly rubber growth after 38 months. Phosphorus seems to have some effect (+4%) in association with urea. Under trial conditions no significant increase of growth was obtained. As jungle rubber accumulates litter on soil surface a significant amount of nutrients is available for young rubber plants. In replanting rubber, only moderate applications of fertilizer are required in most situations. In other words, replanted rubber profits from the "agroforest rent"[3], comparable to the "forest rent", identified by Ruf on cocoa (Ruf, 1994). The fertility status is different if a succession of food crops is cultivated before rubber planting.

The soils in the peneplain of Jambi are rather fertile if compared with soils of West Kalimantan in particular for exchangeable phosphorus and bases. The pH is rather low at 3.7 but, extractable phosphorus in HCl 25% is 55ppm in the topsoil and total exchangeable bases at 0.84 meq are at sufficient level to fulfill rubber requirement (table 4)

Table 4. Soil analysis in trial RAS 3.1 (Jambi province)

Sample depth	pH		Organic matter			in HCl 25%		Ech. bases in meq/100g					
	H2O	KCl	C %	N %	C/N	P2O5	K2O Ppm	Ca	Mg	K	Na	Total	Ecap
0-5 cm	3.7	3.6	2.51	0.22	11	55	8	0.41	0.27	0.15	0.01	0.84	8.40
5-20 cm	3.9	3.8	2.17	0.16	14	47	8	0.31	0.20	0.12	0.01	0.64	9.28

Conclusion

RAS-type 1 trials have indicated that rubber clones can grow in an agroforestry environment where natural vegetation is allowed to grow simultaneously with rubber. If rubber is replanted after a slash-and-burn land clearing and rubber planted in the first year with upland rice intercrop, the risk of infestation by *Imperata* is limited. Most of the natural vegetation re-grow is composed of shrubs and trees, which prevent or control the infestation of *Imperata* and grasses, by shading. A weeded strip of a 1 to 1.5 m wide on rubber planting rows is sufficient to prevent weed competition on rubber. A moderate fertilization during the two or three first years is recommended to ensure tree opening before 6 years.

Farmers should easily adopt RAS type-1 as the system integrates some practices already used in jungle rubber and the productivity is significantly increased (threefold that of jungle rubber. As RAS type-1 needs much less labor, input and investment cost than monoculture rubber, it should be widely promoted by development agencies.

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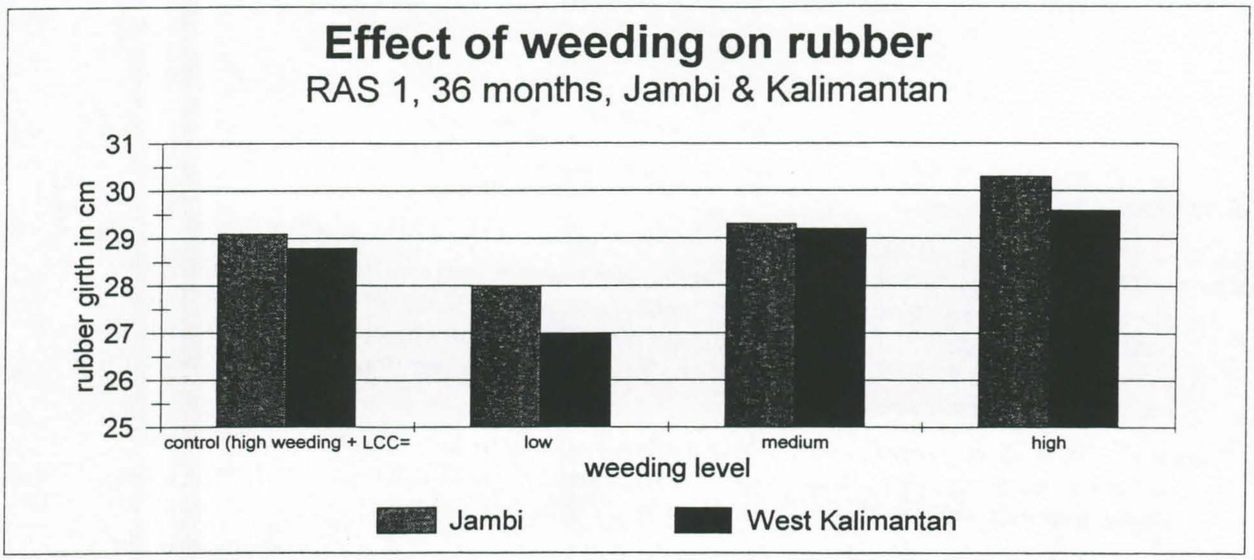
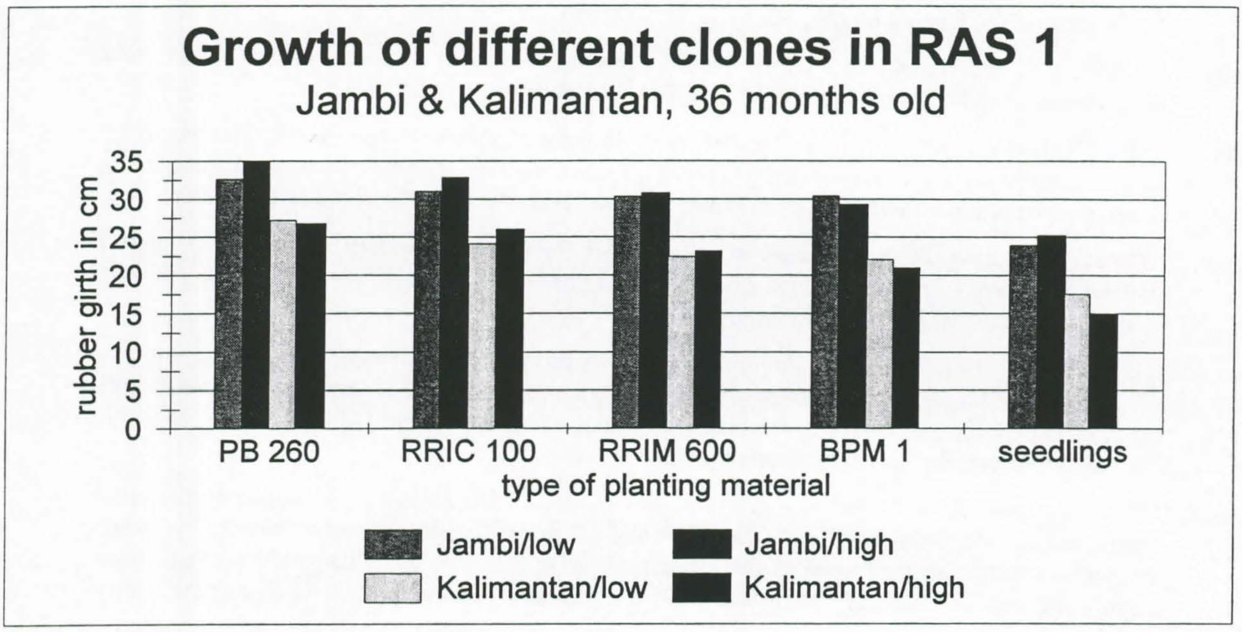
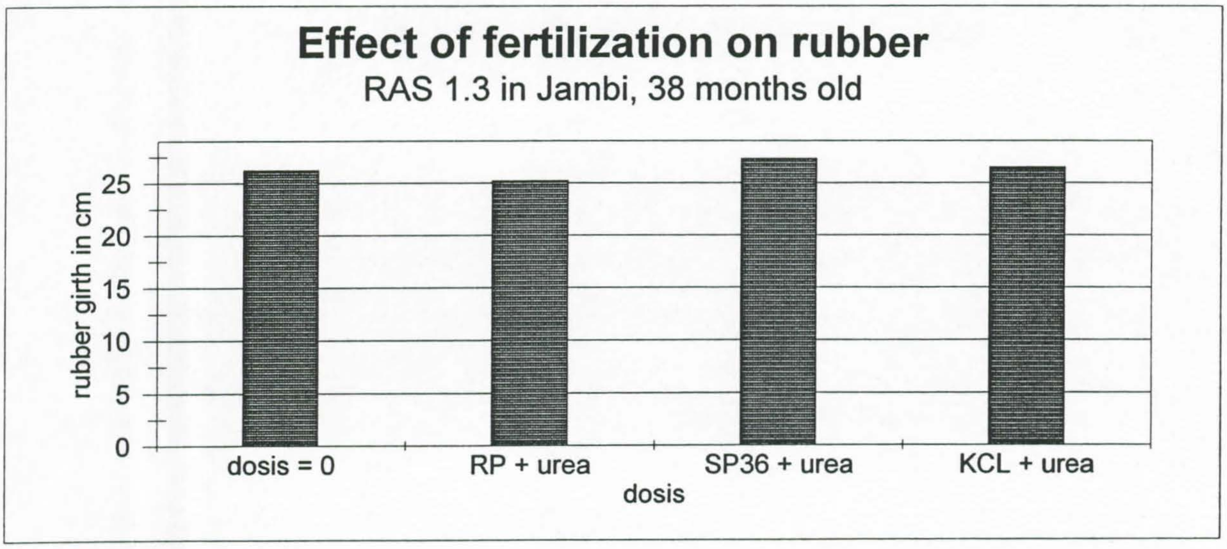
[3] The "agro-forest rent is similar to the "forest-rent": technically speaking, it means that the replanted crop profits from good soils after forest, both chemically and physically, a minimum weed pressure and a very favorable environment for crop establishment


Effect of weeding on rubber
RAS 1, 36 months, Jambi & Kalimantan
rubber girth in cm
31
30
29
28
27
26
25
control (high weeding + LCC=
low
medium
high
weeding level
Jambi
West Kalimantan


Growth of different clones in RAS 1
Jambi & Kalimantan, 36 months old
rubber girth in cm
35
30
25
20
15
10
5
0
PB 260
RRIC 100
RRIM 600
BPM 1
seedlings
type of planting material
Jambi/low
Jambi/high
Kalimantan/low
Kalimantan/high


Effect of fertilization on rubber
RAS 1.3 in Jambi, 38 months old
rubber girth in cm
25
20
15
10
5
0
dosis = 0
RP + urea
SP36 + urea
KCL + urea
dosis

References

Budiman AFS. 1994. *Wanatani karet terpadu untuk masa depan karet rakyat Indonesia (Rubber Agroforestry systems as alternatives for smallholders in Indonesia)*. Presented at the Rubber National Conference, IRRI, Indonesian Rubber Research Institute, Medan, November 1994. In Indonesian and in English. Title in English "Integrated rubber agroforestry for the future of smallholder rubber in Indonesia".

de Foresta H. 1992a. *Botany contribution to the understanding of smallholder rubber plantations in Indonesia: an example from South Sumatra.* Symposium Sumatra Lingkungan dan Pembangunan. Bogor, Indonesia: BIOTROP.

de Foresta H. 1992b. *Complex agroforestry systems and conservation of biological diversity* (II. Proceedings of the International Conference on Tropical Biodiversity 'In Harmony with Nature' 12-16 June, 1990, Kuala Lumpur, Malaysia. pp 488-500.

Gouyon A. 1995. *Paysannerie et hévéaculture: dans les plaines orientales de Sumatra: quel avenir pour les systèmes agroforestiers?* Thése INA-PG. INA-PG, Paris.

Penot E. 1994. *The non-project rubber smallholder sector in Indonesia: rubber agroforestry systems (RAS) as a challenge for the improvement of rubber productivity, rubber-based systems sustainability, biodiversity and environment.* ICRAF Working Paper, Nairobi: ICRAF. 18 pp. plus annexes.

Penot, E. (1994). *Improving the productivity of Smallholder Rubber Agroforestry Systems: sustainable alternatives. Project frame, general proposals and on-farm trial methodology.* Bogor (IDN) :, ICRAF, - 28 p., 4 tabl. ST: Working Paper (IDN).

Penot E and Wibawa G. 1996. *Improved Rubber Agroforestry Systems in Indonesia: an alternative to low productivity of jungle rubber, conserving agroforestry practices and benefits.* First results from on-farm experimentation in West-Kalimantan. Paper presented at the IRRDB Annual Meeting, Colombo/Bentota, Sri Lanka, November 1996.

Ruf, F. (1994). *"La rente forêt, l'arbre et l'instabilité des marchés." In "La parabole du cacao. Quelques enseignements de l'Indonésie sur la durabililité de l'agriculture en régions tropicales humides".* Rapport de recherche sur l'appel d'offre: "l'arbre dans les systèmes de culture sédentaires dans les régions chaudes et humides". Ministère de l'Enseignement Supérieur et de la Recherche. Paris: p32-56.

Rubber Agroforestry Systems-type 3 (RAS 3), a strategy to convert *Imperata* grasslands

By D.Boutin[1], E. Penot[2] and Ilahang[3]

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Abstract

Lalang (Imperata cylindrica) is known to be the most noxious weed in the tropics and a major constraint for food and tree crop development. Estates developed technologies to suppress Imperata using chemical herbicides and promoting the establishment of legume cover crops (LCC). These technologies have been also used in assisted smallholder schemes but such methods are too costly to be widely adopted by farmers in self-help development.

In SRAP (Smallholder Rubber Agroforestry Project) a different approach for the suppression of Imperata was tested. The association of various cover crops, shrubs and fast growing trees (FGT) with rubber is used to control Imperata by shading. The system was called "Rubber Agroforestry System-type 3" (RAS 3). All experiments were conducted in smallholders' fields with participatory approach.

The association of different species with rubber aims to assess the ability of various plants to control Imperata and to evaluate the impact of the association on rubber growth. Legume shrubs like Flemingia congesta were found effective to control Imperata as the rubber growth in RAS type-3 was found similar to growth with conventional technologies using Pueraria phaseoloides after 3 years of experiment. Fast Growing Trees (FGT) like Acacia mangium, Acacia Crassicarpa, Paraserianthes falcataria, Gmelina arborea did not affect rubber growth after a period of 42 months. Before experiment establishment, all the plots were infested by Imperata but during trial implementation, flora composition changed and some plots were invaded by Chromolaena odorata and Melastoma affine reducing Imperata extend.

Acacia mangium was founded as the most effective tree to suppress Imperata by shading. As Acacia trees become competitive to rubber at the age of 42 months, they must be pruned or felled to prevent a depressive effect on rubber growth due to competition for light.

Fast Growing Trees (FGT) associated with rubber can help Imperata control reducing maintenance cost in rubber farms however, the planting pattern of associated trees with rubber must be adapted using wider inter-row if an income from pulpwood sales is expected.

Introduction

Imperata cylindrica is the most noxious weed in the tropics. *Imperata* grasslands develop after food crop cycles or rapid deforestation in transmigration areas for instance. The eradication of the weed is always a costly process, which involves the use of herbicides at large amount (mainly *Glyphosate*) and legume cover crops (LCC). Farmers are reluctant to convert these degraded grasslands because of the high cost in inputs and labor (Van Noordwijk et al., 1995). Some positive results were obtained in tree crop development project where Imperata is rolled down using light wooden rollers (Bourgoing & Boutin, 1987). Less than 5 % of farmers in indonesian rubber projects (SRDP/TCSDP) do establish LCC at planting time (Delabarre, pers. com.). On the other hand, the use of large amount of *Glyphosate* herbicides, very effective against *Imperata* for a period of 4 months after treatment, is very costly and might have an negative environmental impact[1] if used on a very large scale.

A strategy called "Rubber Agroforestry System type-3" (RAS 3) was developed and tested in SRAP[2] (Smallholder Rubber Agroforestry Project) to help the conversion of *Imperata* areas into productive clonal based rubber agroforest.
The presence of *Imperata* is delaying the "opening" of the rubber trees (production) and increase the length of the immature period (from 5 to 8 years) (Wibawa, 1997)

The technologies aim at reducing investment cost and at making *Imperata* grassland conversion an affordable venture to farmers (Penot, 1995). RAS type-3 strategy makes use of legume shrubs or fast growing trees (FGT) to control and suppress *Imperata* by shading from the trees. The use of fast growing trees to suppress *Imperata* was also found promising by other research teams (Bagnall-Oekeley et al., 1997), (Mac Dicken et al., 1997). The selection of species and the planting design took into account possible interaction and competition between associated plants and rubber. Beside the combination of covercrops and shading trees, RAS type-3 is similar in its perennial structure to another system RAS type-2 with clonal rubber (550 trees/ha) with fruit and timber associated trees (275 trees/ha).

In RAS type-3 trials various associations of shrubs and fast growing trees FGT were tested. The objective of the trial was to find the best combination of cover crop and FGT to control *Imperata* at low cost in input and labor. Experiments were established in farmer fields and the experimental protocols were discussed with the farmers to ensure the acceptance of proposed technologies.

Material and methods

Hypothesis:

Several legume shrubs multi purpose trees (MPT) and fast growing trees (FGT) are able to compete with *Imperata* and suppress it by shading. Competition with rubber is limited as far as rubber dominates the vegetation and occupies the upper strata.

Various plants and fast growing trees are tested in association with rubber planted at a standard density 550 trees /ha (planting spacing 6 x 3 m). All selected farmers fields were infested in *Imperata,* some with sheet lalang, others with patches of *Imperata* mixed with shrubs.

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[1] Effectively, a dosis of 5 to 6 liters of herbicide/ha is necessary to get rid of an *Imperata* grass sheet for 4 months, a sufficient period of time for most food crops. For tree crops, and in particular rubber: a dosis of 2 liters/ha , applied on the rubber trees line, 3 to 4 times a year, is necessary. Eventually, at the end of the immature period, a very large amount of *glyphosate* might be used.

[2] Smallholder Rubber Agroforestry Project, a project in Indonesia supported by USAID, Gapkindo, IRubRI, CIRAD and ICRAF SE Asia Regional Research Program

- **Experiments with various cover crops**

- *Trial 3.1*

In 1995, a preliminary observation trial with one replication only was established using various covers: *Mucuna cochinchinensis*, *Pueraria phaseoloides*, *Setaria sp., Chromolaena odorata* and *Flemingia congesta, which* were planted in *Imperata* plots. Most of the treatments failed due to the vigor of *Imperata* but *Mucuna* and *Chromolaena* established successfully. The experiment indicates the need to associate fast growing trees (FGT) to control *Imperata* by shading. Another problem is the quality and availability of some cover crops seeds in Indonesia.

- *Trial RAS 3.2*

A new trial with 5 replications was established in 1996 with *Chromolaena odorata, Flemingia congesta, Crotalaria anagyroides and Mucuna cochinchinensis.* Treatments in randomized blocks are:

A: Control Rubber alone with LCC *Pueraria phaseoloides*
B: Rubber + *Mucuna cochinchinensis*
C: Rubber + *Crotalaria* + *Gliciridia*+ *Gmelina* planted at 6x3 m
D: Rubber + *Flemingia* + *Gliciridia*+ *Gmelina* planted at 6x3 m
E: Rubber + *Chromolaena odorata* + *Gmelina* planted at 6x3 m
F: Rubber with *Imperata*

Gliricidia grew well but it needs frequent prunings therefore this tree is therefore not very interesting for local farmers due to labor requirement. *Gliricidia* trees provide little shade, insufficient to control *Imperata* development. On the other hand, *Gliricidia* might provide firewood and feed animals but, in reality, it has never been valorized in such a way.

Gmelina had a very slow growth and looked stunted; it didn't control *Imperata* under trial conditions.

- **Trial with Fast Growing Trees (FGT)**

- *Trial RAS 3.3*

A new trial was established in 1996 with 2 cover crops only: *Flemingia congesta and Crotalaria anagyroides associated with fast growing trees.* The treatments in randomized blocks are:
A: Control: rubber alone with LCC *Pueraria phaseoloides*
B: Rubber + *Paraserianthes falcataria (Albizia)* planted at 3m in row
C: Rubber + *Acacia mangium* planted at 3m in row
D: Rubber + *Gmelina arborea* planted at 3m in row
E: Rubber + Mixture of three 3 pulp trees planted at 3m in row
Associated trees were planted between lines of rubber at the same density of rubber i.e. 550 trees/ha

Rice was intercropped in the first year at planting time, immediately followed by cover crops in the inter-rows. Non viny cover crop was chosen to limit weeding and only two legume shrubs were sown: *Flemingia congesta and Crotalaria anagyroides*. The concept was that of "plant and forget" for cover crops to minimize labor.

FGT/pulp trees were planted in the inter-row at 6 x 3m in order to provide shade to control *Imperata*). FGT were expected to produce an additional source income at year 7 or 8.

- *Trial RAS 3.4*

The trial was planted in February 1996 with the same design than RAS 3.3 but every two row a pulp trees was replaced by a fruit trees with 460 trees /ha for pulp trees and 92 for fruit trees. Fruit trees were added because farmers considered as fruit trees had potential market in the area.

Results and discussion

- **Experiment with different cover crops (RAS 3.2)**

In RAS 3.2 trial after 36 months, rubber grew satisfactory in legume shrubs plots and rubber performances were similar to those obtained in control LCC plots (Table 1). *Flemingia* was found particularly effective in controlling grasses. The shrub can be easily sown in rows then multiply in spot by seeds or cuttings. *Mucuna cochinchinensis* is an annual legume, which must be sown again every year. *Mucuna* seeds must be dried and be stored for 3 months before to be sown again. *Mucuna* is affective to softening *Imperata* during the first year but an association with other LCC like *Pueraria* or *Centrosema* is needed to obtain an effective control of *Imperata*. Pests often affected *Crotalaria anagyroides* and the shrub regressed during the second year.

Imperata is confirmed to be the most noxious weed for rubber. *Chromolaena* established late in *Imperata* plots and could not control effectively *Imperata* the first year. No rubber growth differences were observed between *Imperata* and *Chromolaena* because of the *Imperata* extend in *Chromolaena* plots. As compared with LCC control with *Pueraria phaseoloides*, *Flemingia congesta* confirmed its potential to suppress *Imperata* in grasslands.

Table 1. Trial RAS 3.2- Effect of various covers on rubber growth.

Treatment (5 replicates)	Rubber girth (cm) at			
	12 mth	24 mth	36 mth	% 36 mth
Control LCC with *Pueraria*	8.7	20.1	30.6 a	100%
Mucuna	8.1	20.5	31.7 a	104%
Crotalaria anagyroides	8.5	19.6	29.0 a	95%
Flemingia congesta	8.0	19.3	29.3 a	96%
Chromolaena odorata	8.1	17.5	25.1 b	82%
Imperata cylindrica	7.8	17.2	25.7 b	84%

- **Experiments with Fast Growing Trees (FGT) and Multi Purpose Trees (MPT) in association with rubber (RAS 3.3 and RAS 3.4).**

Various trees were associated in rubber rows in order to help the control of *Imperata*. Two experiments were settled one with *Flemingia* strips and the other with FGTs alone. Control and treatments differed by trees association only.

After 48 months association of trees at the density of 400 trees/ha did not affected rubber growth (Table 2 and 3). *Acacia mangium* providing a dense shade was found the most effective species to control *Imperata*, the weed being effectively suppressed at the proximity of *Acacia* trees. Albizzia (*Paraserianthes falcataria*) was not successful in controlling *Imperata* because his small leaves provide light shade and its growth is poor in *Imperata* grassland. *Gmelina arborea* was found to have very slow growth and looked unhealthy. Pruning done on some trees increases the density of the canopy then improving weed control.

For a period of 48 months rubber growth was not affected by associated trees but *Acacia mangium* and *Paraserianthes falcataria* grew higher than rubber and needed a top pruning to prevent competition.

Table 2. Trial RAS 3.3- Effect of MPT and FGT on rubber growth – Village of Engkayu

Treatment (3 replications)	Rubber girth (cm) at				
	12 mth	24 mth	36 mth	48 mth	% at 48 m.
Rubber alone	4.9	12.5	23.3	32.5	100%
Paraserianthes falcataria	5.1	11.7	21.3	31.2	96%
Acacia mangium	5.6	13.0	23.3	33.0	102%
Gmelina arborea	5.4	12.3	21.9	30.5	94%
Mixed trees	4.6	10.8	19.5	29.3	90%

Table 3. Trial RAS 3.4 - Effect of MPT and FGT on rubber growth– Village of Trimulia

Treatment (3 replications)	Rubber girth (cm) at				
	12 mth	24 mth	36 mth	48 mth	% at 48m.
Rubber with *Flemingia* rows	4.3	12.3	22.7	31.1	100%
Paraserianthes falcataria	4.0	12.3	23.8	32.5	104%
Acacia mangium	4.0	12.4	23.6	32.0	103%
Gmelina arborea	4.2	12.8	23.6	31.4	101%
Mixed trees	3.9	13.0	23.3	30.9	99%

Discussion

The above results confirmed that other strategies that the conventional LCC technologies can be effective to control *Imperata*. Shrubs like *Flemingia congesta* can effectively control *Imperata* but farmers should use *Flemingia* seeds of good viability. For farmers with limited resources a strategy of selective weeding can be successful where shrubs like *Chromolaena odorata* or *Melastoma affine* are present and vigorous. Top slashing is effective to favor the *Chromolaena* extend and multiplication by cutting can help Melastoma *affine* extend.
Within tested tree associations, *Acacia mangium* was found highly effective to control *Imperata* and has no adverse effect to rubber was observed before 48 months. At that period *Acacia mangium* needs to be felled because it becomes competitive with rubber, as trees become taller than rubber. Therefore, the expected source of income from pulp trees at the year 7 or 8 should be forgotten.

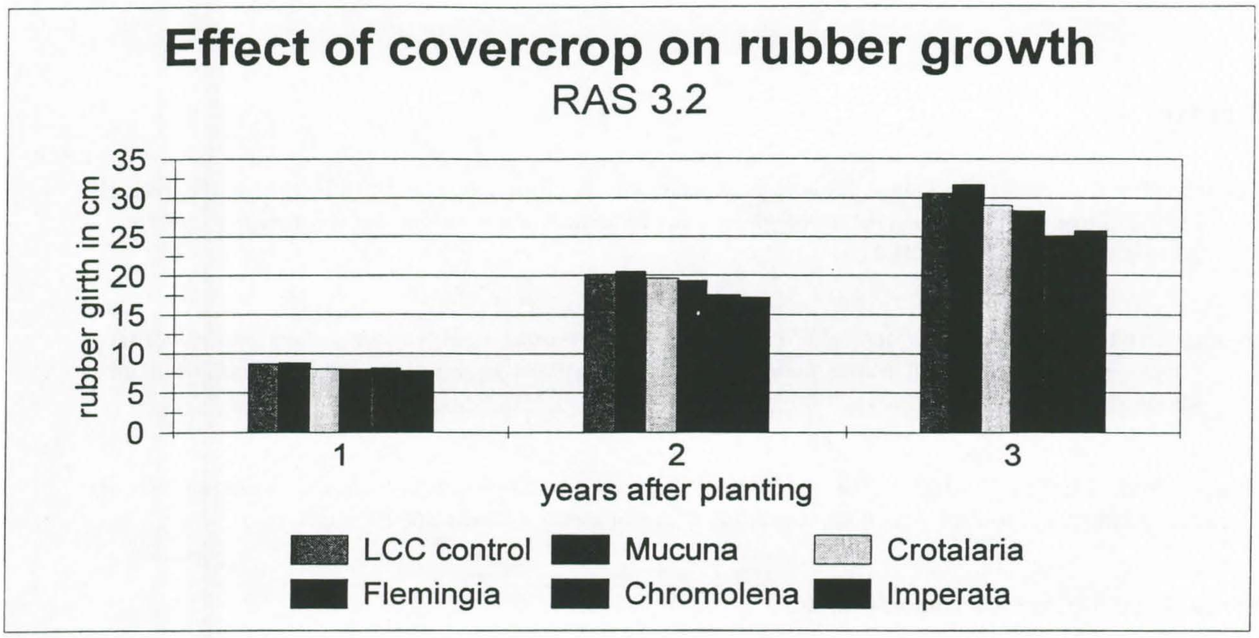
A strategy based on RAS-type 3 approach has been successful in controlling *Imperata* but the cost and availability of shrub and fast growing tree seeds has to be considered before implementation. A gradual establishment of *Flemingia* at proximity of rubber and progressive multiplication of the shrub after could facilitate the implementation of the system.

Conclusion

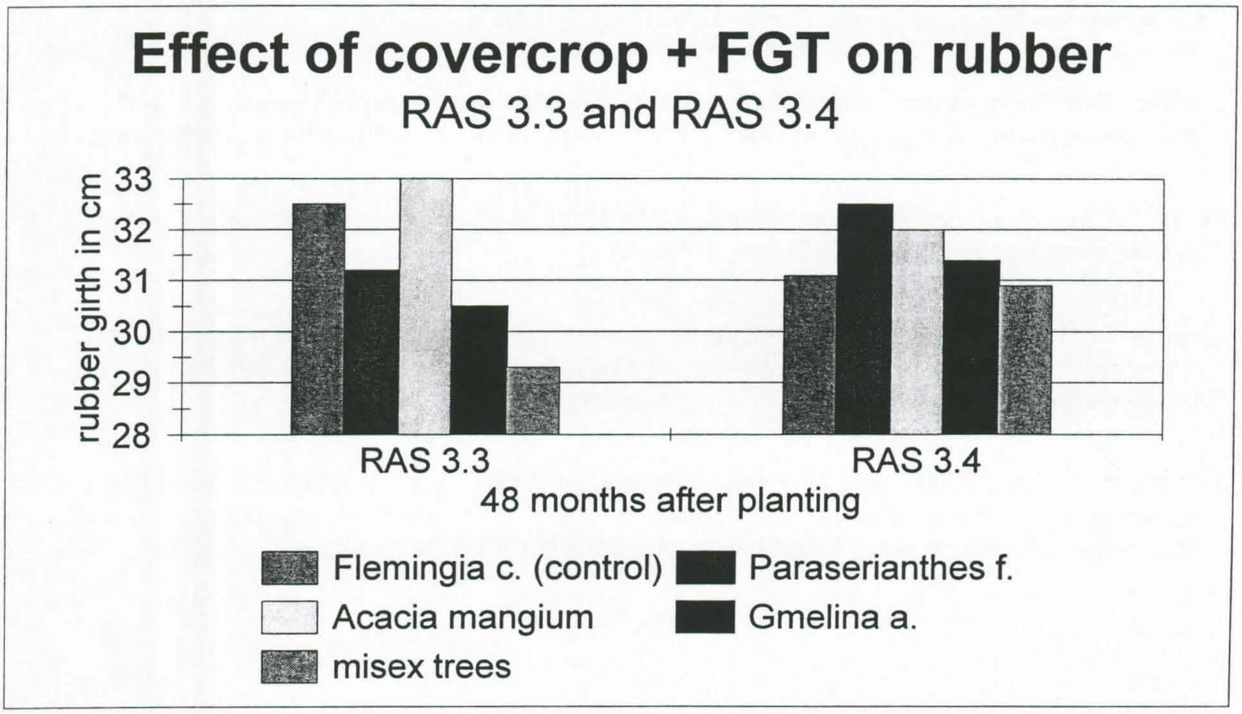
The main purpose of the RAS-type3 strategies was to test different approaches to control effectively *Imperata* at low cost by promoting the development of various shrubs and to generate additional incomes by growing fast growing trees. The first hypothesis is confirmed that legume shrubs like *Flemingia* can help *Imperata* control. Legume shrubs planted in rows can also be effective to control erosion and facilitate the building of contour paths (ProRLK, 1995).

Fast growing trees under the tested design must be felled at 4 years, therefore earlier that the estimated age of 7 years for commercial use. Association rubber with *Acacia mangium* could be found feasible and beneficial with a different planting pattern (wide inter-row with *Acacia mangium)*. The planting of *Acacia mangium* or other fast growing tree has proven an effective method to control Imperata but taking into account the investment cost, this approach can only be recommended if a market for pulp wood exits in the region.

RAS-type 3 has shown positive results in helping rubber to establish in *Imperata* grasslands at limited cost and labor investment but the system needs a reevaluation in terms of investment cost, labor and expected additional income.



Effect of covercrop on rubber growth
RAS 3.2
rubber girth in cm
0
5
10
15
20
25
30
35
1
2
3
years after planting
LCC control
Mucuna
Crotalaria
Flemingia
Chromolena
Imperata



Effect of covercrop + FGT on rubber
RAS 3.3 and RAS 3.4
rubber girth in cm
28
29
30
31
32
33
RAS 3.3
RAS 3.4
48 months after planting
Flemingia c. (control)
Paraserianthes f.
Acacia mangium
Gmelina a.
misex trees

References

Bagnall-Oekeley H, Conroy C, Faiz A, Gunawan A, Gouyon A, Penot E, Liangsutthissagon S, Nguyen HD (1997) *Imperata management strategies used in smallholder rubber-based farming systems* in Agroforestry Systems 36: 83-104

Bourgoing R and Boutin D (1987) *Method of control Imperata by using light wooden rollers and establishing cover crops (Pueraria) in young hybrid coconut plantations in a village environment.* Oléagineux 42:19-23

De Foresta and Michon G (1997) *The agroforest alternative to Imperata grasslands: when smallholder agricukIture and forestry reach sustainability* in Agroforestry systems 36; 105-120

Delabarre M. (1994) Personal communication

MacDicken KG, Hairah K, Otsamo A, Doguma B and Majid NM (1997) *Shade-based control of Imperata cylindrica: tree fallows and cover crops* in Agroforestry Systems 36: 131-149

Penot E. (1995) *Rubber agroforestry systems, RAS, as sustainable alternatives to Imperata grasslands in West-Kalimantan, Indonesia.* Paper presented at the ICRAF Imperata workshop, Banjarmasin, January 1995.

Pro-RLK. (1995) *Input paper for the planning framework for East Rao, East-Pasaman, West Sumatra.* Internal working document. Pro-RLK/GTZ. Padang, Indonesia.

van Noordwijk M, Tomich T, Winahayu R, Murdiyarso D, Suyanto, Partoharjono S and Fagi AM. 1995. *Alternatives to Slash-and-Burn in Indonesia, Summary Report of Phase 1.* ASB Indonesia Report Number 4, 1995, Bogor, Indonesia.

Wibawa G (1997). "*Study of hevea based intercropping system functioning: A. Effect of different intercrops on rubber growth.*" Paper presented on Seminar on Study of hevea based intercropping system functioning, in Sembawa, South Sumatra, Indonesia, 8-9 July 1997. 25pp (in English).

Annexe 3

Textes des 3 posters de la session 4 pre-harvest

- Smallholder rubber research programme in Cambodia : general presentation and preliminary results de Yin song, A. Leconte et J.M.E.Eschbach (IRCC, CIRAD CP).

- The research approach on smallholder rubber development project in central highlands of Vietnam according to the first rural statement de Stephane Boulakia, (CIRAD-TERA).

- Does rubber trigger reforestation after deforestation, E Penot (CIRAD-TERA)

IRRDB Annual Conference, 12-14 September 2000, Bogor, Indonesia

A poster paper :

THE SMALLHOLDER RUBBER RESEARCH PROGRAMME IN CAMBODIA GENERAL PRESENTATION & PRELIMINARY RESULTS

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Abstract

As part of the "Agricultural Productivity Improvement Project" (APIP), funded by the World Bank, the purpose of the Smallholder Rubber Research Component (SRRC) is to produce the technical data needed to confirm Cambodia's suitability for smallholder rubber development through the formulation and implementation of a smallholder research programme and training of national scientists and technicians. If the potential for smallholder rubber is good, it is anticipated that this would lead to a larger national project for smallholder rubber development implemented over a wider area. The programme, carried out by the Rubber Research Institute of Cambodia, has started in 1998 and up to now, a total of 27 trials (clones, fertilization, planting material, intercropping) have been established in 7 different areas. Preliminary results on rubber growth 1 and 2 years after plantings show interesting trends. The experimental network is scheduled to be completed in 2001. A socio-economic survey has been carried out early 2000 in four provinces in the aim to characterize access to land and willingness of the farmers for growing rubber in non-traditional areas.

PROJECT GENERAL DESCRIPTION & OBJECTIVES

The overall objective of the Agricultural Productivity Improvement Project (APIP), funded by the International Development Agency (IDA-World Bank) through ITF (Interim Trust Fund), is the sustainable and broad-based improvement of smallholder agricultural productivity as a means to improved food security and increased rural incomes. The project will help to build the necessary institutional capacity in Ministry of Agriculture, Forestry and Fisheries (MAFF), in part by implementing pilot field programmes as a mean of (i) gaining experience in the planning, organization and management of agricultural development programmes ; (ii) adapting, testing and demonstrating improved agriculture technology under field conditions ; and (iii) more generally developing MAFF's understanding of and responsiveness of the needs of its client base.

In this aim, APIP consists of a coordinated five-year programme to improve the quantity and quality of the technical, human and physical resources of MAFF needed to promote sustainable agricultural development. This will be achieved through carrying out (i) programmes in each of the main agricultural subsectors comprising essential knowledge acquisition, technology testing and adaptation, field development activities, priority rehabilitation investments, and (ii) a major effort in MAFF human resources development. The sum total of these activities should lead by project completion to the building of substantial capacity in MAFF to plan, coordinate and implement successful agricultural development programmes for the benefit of and with the participation of the rural population concerned, and to substantial benefits for farmers in the areas of the pilot field programmes in terms of increased crop and livestock production.

The project comprise five components to be carried out by MAFF technical departments :

- Agronomy, Seeds and Plant Protection
- Animal Health and Production
- Agricultural Hydraulics
- Fisheries
- Smallholder Rubber Research

The Smallholder Rubber Research Component (SRRC) is implemented by the Department of Rubber Production (DGPH) of MAFF through the technical execution support of the Rubber Research Institute of Cambodia (IRCC). The project for smallholder rubber research originated in 1995-1996 with a proposal prepared by the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) funded through the French Ministry of Foreign Affairs.

The work undertaken as part of APIP is intended to obtain the technical data needed to confirm the country's suitability for smallholder rubber development, through formulation and implementation of a smallholder rubber research programme and training of national research scientists and technicians. If the potential for smallholder rubber is good, it is anticipated that this would lead to a larger national development project implemented over a wider area (20,000 ha or more) with co-funding from France (Agence Française de Développement) and the World Bank.

Fench aid is assisting the APIP/SRRC with the placement of a senior rubber research specialist from CIRAD for five years acting as Technical Adviser.

The long-term goal of APIP/SRRC is smallholder rubber production contributing significantly and sustainably to rural incomes and to foreign exchange earnings. Research results (main outputs) would provide key data necessary to target resources to the sub-sector most efficiently and cost effectively. The research would identify:

i. The geographical areas (soils and climate) which are especially suitable, and the strains (clones) that are likely to be the most productive given cambodian agro-ecological conditions

ii. Enterprise combinations (rubber and temporary or permanent inter-cropping) that would promote successful establishment of the young trees as well as generate an adequate interim cash flow for the farmer.

In addition, data would be gathered on existing cultural practices and on farmers responses to new technologies.

The main research outputs of APIP/SRRC are as follows:

⇒ Identification of the most suitable areas for growing rubber through the development of an information bank including both technical and socio-economic data such as soil characterics, climatology, rubber behaviour, farming practices, farmers response to new technologies.

⇒ Implementation of a network of field demonstration plots.

⇒ Establishment of adaptated recommendations (clones, fertilization, planting material, intercropping...) so as to optimize agronomical as well as financial returns, especially during the immature period of rubber trees.

⇒ Creation of local sources of planting material for the future national project : establishment of certified budwood gardens (checked through electrophoresis clone conformity testing) and promotion of smallholder private nurseries.

IMPLEMENTATION & PRELIMINARY RESULTS

The APIP/SRRC has started in 1998 and up to now, a total of 27 trials (clones, fertilization, planting material, intercropping) have been established in 7 different areas. At the end of the project, a total of 74 trials is planned to be established in 8 different areas (Tables 1 & 2 and Fig. 1).

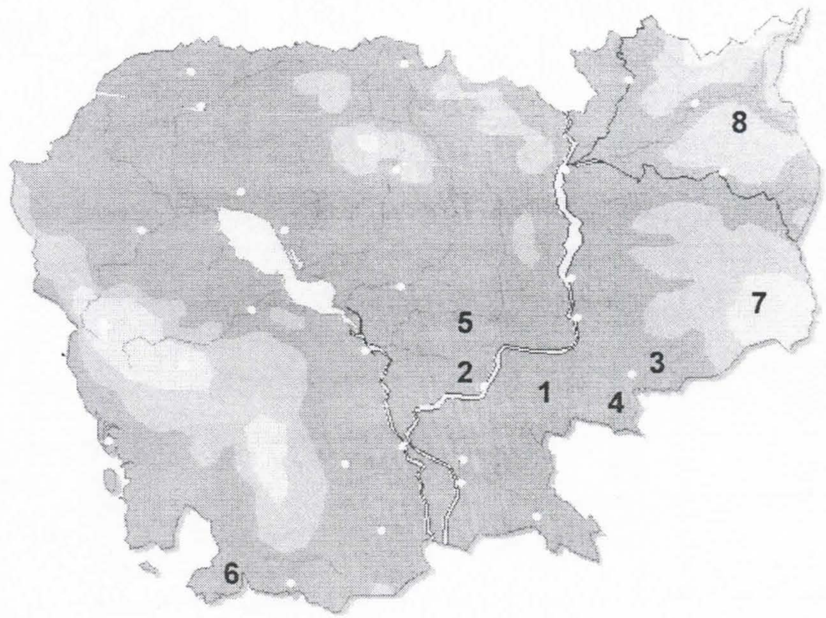
Table 1 : Schedule for the establishment of field trials per year and per location

Area	1998	1999	2000	2001	2002	Total
1. Chup	4		4	2		10
2. Chamcar Andong	4			3		7
3. Snuol		3	3	4		10
4. Memot			3	7		10
5. Kompong Thom			3	4		7
6. Kompong Som			3	4		7
7. Mondolkiri			3	5	4	12
8. Ratanakiri				5	6	11
Total (number)	**8**	**3**	**19**	**34**	**10**	**74**
Total area (ha)	**8.4**	**3.3**	**19.4**	**35.1**	**10.0**	**76.2**

Table 2 : Types of trials and budwood gardens to be planted per location

Area	Clone	Fertilization	Planting Material	Intercropping	Budwood Gardens (ha)
1. Chup	2	2		6	
2. Chamcar Andong	3	3	1		0.4
3. Snuol	4	3	2	1	0.4
4. Memot	3	3	2	2	0.4
5. Kompong Thom	3	2	1	1	
6. Kompong Som	3	2	1	1	0.1
7. Mondolkiri	4	4	1	3	0.4
8. Ratanakiri	4	4		3	0.3
Total (number)	**26**	**23**	**8**	**17**	**2.0**

Fig. 1 : Location of Field Activities

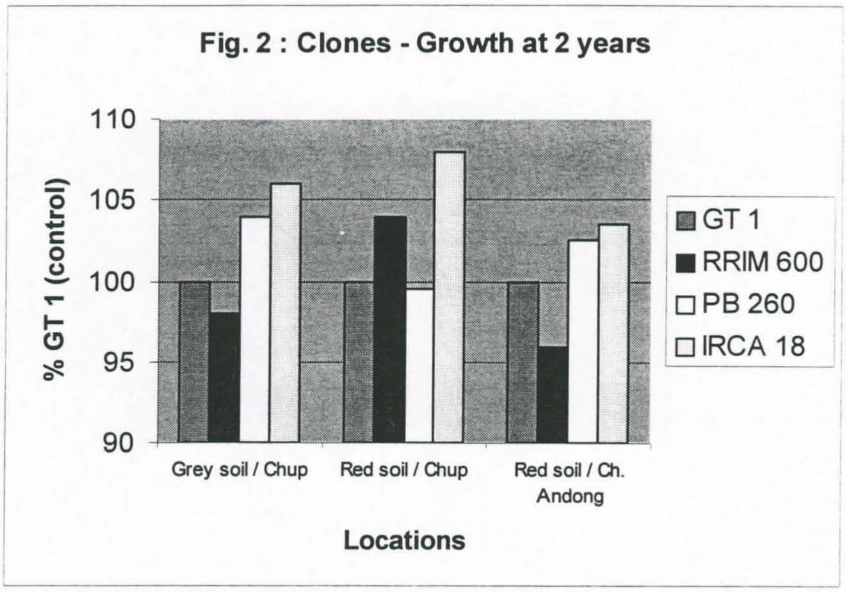


1. Chup - **2.** Chamcar Andong - **3.** Snuol - **4.** Memot - **5.** Kompong Thom
6. Kompong Som - **7.** Mondolkiri - **8.** Ratanakiri

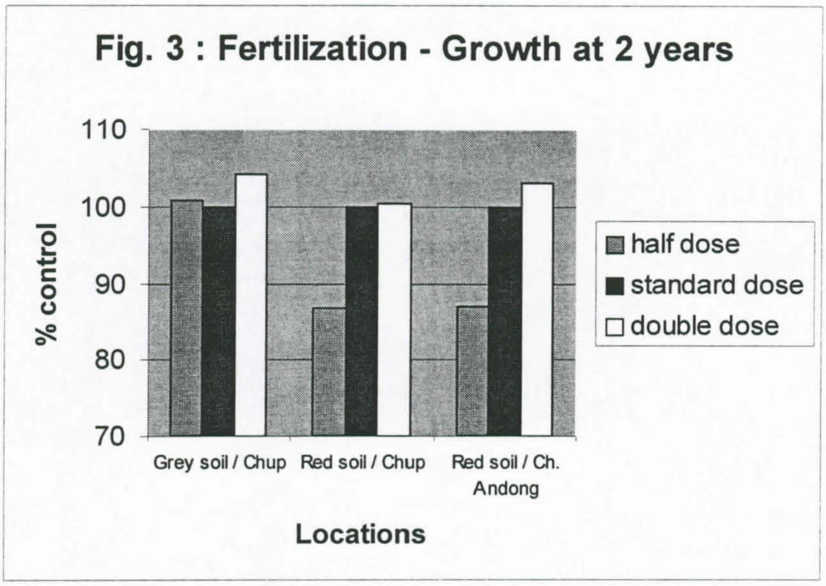
A socio-economic survey has been carried out early 2000 by CEDAC (Centre d'Etudes pour le Développement de l'Agriculture au Cambodge) in four areas (n° 3 - 5 - 7 & 8, see Fig. 1) in the aim to characterize access to land and willingness of the farmers for growing rubber in non-traditional areas.

Preliminary results on rubber growth 2 years after planting (trials planted in 1998) show the following trends:

- Clones: Better growth of IRCA 18 in most locations (Fig. 2).



- Fertilization: On grey soils with a low level of fertility, the standard dose of fertilizer does not seem to be sufficient, while on red soils, the standard dose is sufficient, no significant difference is registered with double dose (Fig. 3).



APIP/SRRC PARTNERSHIP

Ministry of Agriculture, Forestry and Fisheries (MAFF)
General Directorate of Rubber Plantations (DGPH)
Rubber Research Institute of Cambodia (IRCC)
Centre d'Etudes pour le Développement de l'Agriculture au Cambodge (CEDAC)
International Development Agency (IDA-World Bank)
Agence Française de Développement (AFD)
CIRAD (Technical Assistance)

THE RESEARCH APPROACHES ON SMALLHOLDER RUBBER DEVELOPMENT PROJECT IN CENTRAL HIGHLANDS OF VIETNAM ACCORDING TO THE FIRST RURAL STATEMENT

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1. Introduction

The Vietnamese government intends to develop natural rubber sector. The Rubber area should be extended from 390 000 hectares in 1998 to 700 000 hectares at the end of the decade 2000-2010. This increase will be carried out through an extension of the smallholder part (**Table I**).

Table I : evolution of natural rubber production sector.

	1998		Prospects 2005 – 2010	
Estate companies	324 000 ha	83 %	400 000 ha	57 %
Smallholder	66 000 ha	17 %	300 000 ha	43 %
Total	390 000 ha		700 000 ha	

The Agricultural Diversification Project (ADP), started in 1999, aims to increase and stabilise incomes of the poorest farmers in central Vietnam (3 Highland and 8 coastal provinces). This aim can be reached by a diversification of the existing farming systems, in which rubber can occupied a central part as a way to get long term regular incomes and to protect land. ADP works with three main tools : (i) loans for smallholders including long term credit for perennial crops, (ii) land use certificate attribution and (iii) technical support to farmers by institutional strengthening.

Research program, linked to ADP and carried out by Rubber Research Institute of Vietnam (RRIV) in partnership with International Centre for Agricultural Research and Development (CIRAD), has to create diversified rubber cropping technologies, fitted to a large range of socio-economical and ecological conditions.

National authorities often consider Highlands in Central Vietnam as the most promising area for Rubber development. This region constitutes also one of the most important land reserve of the country which would have the biggest new planting in the period 2000-2010. Following this logic, Highlands are the first priority area of the project and research component.

This paper presents first the main characteristics of rural socio-economical conditions and current dynamics in Gia Lai province, the research approaches and the trials already established. This statement enables to precise opportunities, constraints and means to farming systems diversification and rubber smallholding development with the poorest farmers, who mostly belong to ethnic minority groups.

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2. Agro-socio-economical conditions and dynamics in Gia Lai province.

This analysis principally concerns red soils area (ferralitic soils on old volcanic materials) which cover west and central parts of the province. The districts chosen for ADP implementation belong to this pedological unit. These lands concentrate also most of the rural migrants and all Rubber companies of the province.

This area shows a pronounced contrast between traditional ethnic minority farming systems and the recently introduced ones by estate companies and Kinh migrants (the most important ethnic group in Vietnam), based on perennial cash crops (Rubber, Coffee, Pepper, ...).

2.1. Traditional farming systems.

The farming systems of ethnic minority groups, which can be observed at present, result from recent changes, occurred in the 40-50 last years. Progressive settlement of the villages by the authorities, almost complete disappearance of previous monsoon forest have already pushed farmers and communities into less extensive techniques than former ones.

The both main ethnic groups of Gia Lai province, Jarai and Bahnar belong to two different linguistic groups (respectively Malayo-polynesian and Mon-Khmer) but still have the same shifting agriculture. This agricultural practise called "Ray" technique consists on slash and burn clearing with 2 to 3 years of cultivation and then followed by a long as possible fallow period. The fields are mainly cropped with upland Rice varieties mixed with various secondary crops as Corn, Squash, Banana, ... On an apart field, Jarai people cultivate also *Eleusine coracana*, for traditional alcohol production. Gardens, nearby houses, are cropped with Tobacco (own consumption), various species of Cucurbitaceae, vegetable and trees (Papaya, Jack fruit, Kapok tree, ...).

Jarai and Bahnar communities raise buffaloes, oxen and cows, pigs and poultry. Cattle graze on extend pasture land, mainly covered by *Pennisetum polystachyum* and *Imperata cylindrica*. Traditionally, animals are principally raised for religious sacrifices but constitute also now a safety reserve in case of rice shortages.

2.2. Migrations and settlements

2.2.1 The main stages of settlement in Highlands.

Before 1954, Kinh immigration in Highlands was restricted. Kinh people moved to the area and began to be workers in the plantations or small traders. During the years 1954-1955, massive population movements occurred from the north to the south Vietnam. Between 1962 and 1975, Kinh immigration continued during the war with a reduced rate. From 1975 to 1986, migrations on Highlands are carried out in the scope of transmigration policy which conducted to transfer populations from most populated plain areas to the new economic zones. Migrants received help to settle (credits and rice during the first year) and are mostly employed in collective sector as rubber plantations establishment. Since 1986, spontaneous migrations increased with agrarian reform (Doi Moi policy) and rapidly raised over official and organised migrations. After 1994 and until 1998, these movements were probably enhanced by a pronounced increase of coffee prices.

2.2.2 Actual situation : the Pioneer front's.

These increasing population movements are coupled with important land reclaims and cash crop settlements. During the collectivisation period, industrial plantations – mostly Rubber – were predominating. Then, since the Doi Moi policy (de-collectivisation), the cash crops development in Highlands is also due to small private sector. Coffee is the origin of pioneer front running from South (Lam Dong, Dong Nai provinces) to North (Dak Lak and then Gia Lai and Kon Tum provinces).

This movement is intense and some fragmentary information can give an idea:

- Between 1995 and 1998, period of high coffee price, 82 500 hectares were planted in Dak Lak and 184 000 in the country ;
- the national production raised from 400 000 tons in 1998-99 to 450 000 tons for the 1999-2000's harvest, mainly due to new productive areas in Highlands ;
- in 2000, Rubber companies, in Gia Lai province, can not realise their planting programs because of the impossibility to find anymore large plots.

Land availability seems to become an important constraint in this area.

2.3. Coffee plantations as the main component of migrants farming system

Different kinds of Kinh farmers grow coffee : There are the prime migrant, mostly from Northern or Coastal provinces with a limited capital (often from broad family), and also migrants who already own productive Coffee plantation in southern provinces (Lam Dông, Dong Nai, and especially Dak Lak).

In spite of this diversity of the migrants, the Coffee's cropping system is quite uniform and very intensive. This systems requests important investments, mainly for irrigation (well, pump and pipes) and fertilisers. Even with high yields, between 2,5 to 4,0 tons per hectare, the economic results are strongly dependent on international prices. During 1994-1998 period, coffee prices raise to 40 000 Dông/kg and provide "miraculous" profit margins. But since 1999, the price is under 15 000 Dông per kilogram (9 000 Dông in 07/2000), bordering production costs.

2.4. Social and Agronomic consequences

For minority ethnic groups, the fast and inescapable closing of space challenges the sustainability of the traditional farming systems based on fallow and extensive cattle grazing. Different adaptive attempts can be observed :

- <u>short term ones</u>, when land pressure start to increase around the village, aim to preserve some land resources. Farmers often enclose ray fields (as a protection against cattle and a way to mark the land) and try to prolong cropping duration; they extend gardens around the house when it is possible ; sometimes they plant coffee with extensive techniques after 2 or 3 years of food crops production, mainly to fix the property of the fallow. But in the same time, natural pasture land availability are steadily reducing and cattle exert an increasing pressure on land, in the first place around the village. Most of indigenous villages are belt by an overgrazed area which offers no more fodder resources; the last degradation stage is characterised by a complete moss cover. This land, considered as sterile by farmers, is often sold to migrants. A part of this money can be invested in new coffee plantation, set up through similar techniques than migrants.
- <u>medium and long term evolutions</u> which can be already observed in minority villages, early surrounded by estate companies (end of the 70's). The cattle has almost disappeared, food crops productions are concentrated on extended gardens and farmers try to adopt on reduced areas (compared with migrants) cash crop productions (Coffee and Pepper). Due to lack of money to invest in fertilisers and irrigation, technical and economic results are much more below than those obtained by Kinh migrants. Minority composed most of the workers staffs of the companies and are employed for seasonal tasks in coffee plantations.

The extension of the present coffee cropping system questions the future of water resources and then the sustainability of such system. Some problems start to appear in Dak Lak province where the groundwater level decreases in a catchment basin cropped only with coffee.

<u>3. Rationale for a research problematic and an experimentation system.</u>

3.1. Strategic aims.

Based on this statement, Research has to face two main aims :

- propose to farmers alternative imposed by the severe decrease of land availability ; it requests to shift extensive traditional food crops system into fixed ones and, in the same time, to increase fodder resources for cattle.
- set up the basis of perennial crop diversification which do not need irrigation because :
  - o irrigation induces high investments, not available or accessible for poorest farmers, even with micro-credit access ;
  - o research has to forestall probable water resources shortage in the future and prepare the change and diversification of coffee farms in fruits production (trajectory already observed in southern provinces).

Table II : Rural populations and current dynamics in Vietnamese Central Highlands

Population	Main components of the farming systems	Aims of the farmers	Assets	Constrains	Current adjustments
Ethnic minorities	- Upland food crops on slash and burn soil's management - Extensive cattle breeding on natural pasture lands - Cash crops with low level of intensification (Coffee, Pepper, Kapok tree, …) - + Lowland rice (sometimes)	- Insure family's food supplies - Develop family's incomes - Warrant long term access to Land	- Good knowledge of the environment - Already diversified farming system	- Extensive farming system based on a large Land reserve - **Reduction of Land reserve due to demography and pionner front** - Extensive system incompatible with Vietnamese Landuse law - Limited incomes and access to credit	- **Increase cropping period before fallow** - Cash crops development through technologies inspired from migrants ones, but less intensive
Migrants	- Highly intensive (fertilizers, irrigation, pesticides) cash crops (coffee, pepper, …) - sometimes, upland foodcrops during immature period	- development of cash crops with high profitability	- starting capital - credits access - legal Land access easier with perennial crops	- very intensive system, profit margins highly dependant from international market prices - the large development of such a system questions the medium term future of water ressources	- rapid response / prices fluctuations → change of cash crops → diversification based on perennial crops (fruit trees)
Rubber estate companies	- Rubber trees monocropping → total area on 3 Highlands provinces : 77 000 ha (40 000 ha tapped)	- development of planted area - improvement of technical and economical results	- state supported sector - credit access - low labour cost	- low current natural rubber prices - decrease of available land for large planting blocks	- research on productivity's improvements

Table III : Rationale for a research problematic and an experimentation system

Questions	Topics	Systems and technologies	Populations and fields of applications	Trial in controlled area
Land Réduction → question the sustainability of traditionnal farming systems (etnic minorities) → What kind of systems, other than coffee monocropping, compatible with vietnamese law, for upland cultivation ?	**Sustainable soils management** - fixation of upland food crops systems - improved pastures - crops-grazing rotation - soil's protection and perennial crops growth and productivity	**Agrobiological soils management by direct seeding on cover crops technologies**	**Principally ethnic minorities** - food crops fields - rehabilitation of degraded natural pastures - intercropping systems between perennial species	- Cover crops and forage crops collections - Food crops collections **- Experimentation to set up and compare cropping systems** - Experimentation on interrow management on rubber trees developpement
Fragility of a development based coffee monocropping → / changes in international market prices → strong social selection (out-of-way system for poor farmers, integration of the production during low prices period, …) → high pressure on natural ressources (irrigation, massive doses of fertilizers, soils degradation, …)	**Perennial species based diversification** - stabilization of profit margins by * reduction of production costs (suppression of irrigation, reduction of fertilizers applications, …) * diversification of the species (fruitiers, …) * Improved qualities, post-harvest processing, …	**Rubber agroforestry based systems** **- association with food crops** - association with cattle breeding - association with medium and long term cash crops (pineapple, sugarcane, coffee, fruit trees, …)	**Migrants et minorités ethniques**	- Intercropping systems between Rubber simple row and hedge-row planting patterns - cropping systems corresponding to different aims and contrasted levels of production factors (food crops, cattle breeding, cash crops, more or less intensified in labour and capital)

3.2. Tactics involved.

Research works towards these general ends at two levels :

- at plot level, by focusing fertility management on agrobiology through direct sowing and soil coverage techniques ;
- at farm level, by proposing agroforestry systems according to contrasted levels of production factors (labour and capital) and to different terms of on investments to allow farmers to stagger the different loans.

The experimentation system is dealing with different kinds of trials, aiming to get a permanent fit between technology innovation process and farmers needs and constraints :

- trials in controlled area, to set up the technical references of cropping systems;
- adaptive trials, to test technical proposals in different agro-ecological conditions ;
- participatory research, to define farmers appropriation through a farm network, representative of socio-economical and agro-ecological diversity, come upon project's area.

4. Trials in controlled area : basis of the technical references.

After having defined the strategies and aims for the research program based on the first assessment of land constraints, the first step to design the detailed protocols was to characterise the red soils main properties. This characterisation was carried out on uncropped areas, under two kind of vegetable covers. These vegetable covers, a high grass weeds savannah and natural over-grazed pasture, represent most of the land reserve in Gia Lai Province.

4.1. Red soils main properties.

Red soils in Gia Lai province are ferralitic soils developed on old volcanic substratum (end of Third beginning of Fourth era) made of basalt covered in some place by a strong layer of ashes.

4.1.1. Chemical parameters.

The pH water ranges from 4,8 to 5,4 according to the different studied profiles, but is constant from 0-10 cm to 30-50 cm depth. The pH_{KCl} ranges from 4,1 to 4,5. The organic matter contains are high, around 7,5% in 0-10 cm layer and still 4% in 30-50 cm depth. This organic matter is a little evolved as shown by high C/N ratios, ranging from 17 on 0-10 cm to 16 on 30-50 cm depth. Correlatively, Nitrogen contained are high, 2,5‰ on 0-10 cm to 1,5‰ on 30-50 cm. The exchangeable basic cations are very low : (Ca^{2+} + Mg^{2+} + K^{+}) range from 0,4 to 0,7 meq/100 g. The basis saturation rate of the Exchangeable Cationic Capacity is inferior to 7%.

These chemical parameters are similar under savannah and over-grazed pasture. They reveal the character acid, extremely desaturated and the apparently low microbiological activity of these soils. Aluminium may be important and contribute to organic matter stabilisation and phosphorus insolubilization.

These soils show pronounced chemical constraints but in the same time offer important fertility potential according to the high organic matter contains due to its low level of activity.

4.1.2. Physical parameters.

Granulometric studies show out sand-silty texture on 0-10 cm and silt texture under. Silts form extremely stable aggregates which can be measured as granulometric sand if any precautions are not taken during samples preparation. The soil structure was study through three parameters :

- (i) bulk density and total porosity are similar - respectively around 0,8 and 70% - between savannah and pasture and quite stable from the top horizon to the deepest one.
- (ii) water infiltration speeds, measured in situ, are opposed : water infiltration amounts 65 cm/h in Savannah and is inferior to 5 cm/h on pasture.
- (iii) water-air exchanges confirm the duality of porosity structure under the two vegetable covers : Savannah shows macroporosity and microporosity is prevailing under Pasture.

The very good physical conditions under savannah are due to a strong action of *Pennisetum* roots system, which represents 3,2 t/ha of dry matter (compare with 0,6 t/ha on pasture), and a nearly permanent cover of the soil during rainy season : after dry season and land fires, *Pennisetum* *polystachium* restarts both from seeds and roots stocks, reproducing early in the rainy season a soil cover. Pasture restarts from seeds, much more slowly ; during first months of the rainy season, soil is submitted to baking and strong surface run off which, combined with cattle's trampling, contribute to accelerate physical degradation.

4.2. Trials description.

So, some trials have been established to fit most of the social and technical constraints described previously. On a 4-hectare plot, traditional cropping systems are compared with introduced ones, based on direct sowing techniques. The comparisons turn on technical, economic results and agronomic aspects.

In this experiment, cropping systems are defined as a combination of 3 factors :

- crops successions involving traditional food crops species and varieties (long cycle upland Rice, Corn, Mungbean, Cowpea, *Eleusine coracana*), introduced ones (short and medium cycle upland Rice, Sorghum, soybean), cover and fodder crops (*Brachiaria ruziziensis*, *Pennisetum clandestinum*, *Mucuna cochinchinensis*, *Stylosanthes guyanensis*, *Chamaecrista rotondifolia*, *Arachis pintoi*).
- Intensification levels, based on 3 contrasted mineral dressing (from no fertiliser to high level including basal amendment and phosphate application), practise of "ecobuage" (partial and controlled combustion of organic matter on sowing lines). The "ecobuage" technique is practised only on direct seeding systems and only on the lowest two levels of fertilisers.
- Soil management techniques, slash and burn (annual), slash and burn first year followed by hoe light tillage during the following year, disc ploughing and direct sowing (no tillage)

Table IV : tested crops successions and soil management sequences.

system	soil preparation	1st cycle : # 05 – 08	soil preparation	2nd cycle : # 08 - 11
systems as reference on "traditionnal practises"				
1-	burn	Rice$_{lc}$	→	→
2-	burn	Vigna r.	direct seeding	Rice$_{mc}$
3-	disc ploughing	Vigna r.	direct seeding	Rice$_{mc}$
systems based on direct seeding on vegetable cover technics				
4-	direct seeding	Maize + Brach.		Brach.
5-	direct seeding	Maize + Mucu.		Mucu.
6-	direct seeding	Maize + Cassia r.		Cassia r.
7-	direct seeding	Maize + Stylo.		Stylo.
8-	direct seeding	Rice$_{sc}$	direct seeding	Maize + Brach.
9-	direct seeding	Rice$_{mc}$	direct seeding	Vigna u.
10-	direct seeding	Rice$_{sc}$	direct seeding	Maize + Vigna u.
11-	direct seeding	Rice$_{mc}$	direct seeding	Sorg. + Vigna u.
12-	direct seeding	Rice$_{mc}$	direct seeding	Eleusine c.
13-	direct seeding	Cassava + Cassia r.	→	→
14-	direct seeding	Soybean + kiku.		kiku.

Rice$_{lc}$	Rice long cycle (traditionnal var. 150-160 days)	Mucu.	Mucuna cochinchinensis
Rice$_{mc}$	Rice medium cycle (110-120 days)	Stylo.	Stylosanthes guyanensis
Rice$_{sc}$	Rice short cycle (90-100 days)	Sorg.	Sorghum
Vigna r.	Vigna radiata	Eleusine c.	Eleusine coracana
Vigna u.	Vigna unguiculata	Cassia r.	Chamaecrista rotondifolia
Brach.	Brachiaria ruziziensis	Kiku.	Kikuyu grass (Pennisetum clandestinum)

Each sequence is established on the different levels of inputs.

All the plots are at least 400 m², which is the minimal size requested to appraise labour time of each system. Those managed with direct seeding techniques, are mulched at the beginning of the first cycle. This initial soil cover is relayed by the development of the cover crops in second cycle for the successions 4, 5, 6, 7, 14 or by crops residues for the successions 8, 9, 10, 11, 12. All the cover crops species, except

Mucuna, can cross the five months dry season; they are chosen for their ability to grow on poor soils. *Brachiaria ruziziensis* (grass weed) and *Stylosanthes guyanensis* (legume species) are highly palatable for cattle. Farmers can then insert period of grazing (6 months, one year or more), before restart a cycle of food crops production.

4.3. Assiociations with rubber trees.

Vietnam has traditional intercropping systems in young state rubber plantations with annual crops such as upland rice, groundnut, corn, bean, sweet potato ... Since 1985, the Rubber Research Institute of Vietnam started to test intercropping systems in the hedge rows (16 + 4) x 2 m with perennial crops such as coffee tree and fruit tree. Recently, various short term and medium term crops have been introduced in smallholder rubber plantations (cassava, yam, taro, pineapple, banana, fruit tree...). But, Vietnam has a little experience on agroforestry systems involving Rubber trees and forestry trees.

This 11-hectare experimentation intends to test different kind of associations with Rubber trees. In order to provide "answers" to different socio-economical conditions, these associations were chosen to resort to a large range of production factors - capital and labour – requests. Some of these associations are temporary, others permanent.

- Associations based on food crops – 3 modules .

- 1st module : one cycle of upland Rice (120 day variety) per year implanted through direct sowing techniques, on *Chamaecrista rotondifolia* cover ; between a 6 m x 3 m rubber planting ; medium labour request, low investment (two moderate level of intensification are tested), short term association (about 3 years).
- 2nd module : similar cropping system ; between a hedge rows rubber planting (13 m + 3 m) x 3 m ; medium term association (6 or 7 years).
- 3rd module : two cycles a year, one cycle of upland Rice (100 days variety) followed by a Corn crop implanted with *Brachiaria ruziziensis* ; between a 7 m x 2,5 m rubber planting, high labour request, low investment, short term association (about 3 years).

- Associations based on fodder crop – 1 module .

- Installation of *Brachiaria rurziziensis* pasture for Cattle. Rotation grazing on 6 plots - one week grazing, 5 weeks regrowth -, 4 yearling bulls per ha during one year (to avoid damage on rubber trees, animals are introduced twice a day in the plot, for two 3 hours periods of grazing) ; between equidistant (4 m x 4,5 m) rubber planting ; low labour request, low investment (farmers own already animals) ; short term association (about 3 years).

- Associations based on short term cash crops – 1 module .

- Inter cropping with Pineapple combined with Sugarcane, soil cover with *Arachis pintoï* ; between a hedge rows rubber planting (13 m + 3 m) x 3 m ; low labour request, high investment and rapid return on investment (18 months) ; medium term association (about 6 or 7 years).

- Associations based on medium term cash crops – 1 module .

- Inter cropping with Coffee arabica (Catimor Hybrid), no watering during dry season, soil cover with *Stylosanthes guyanensis*, winbreaks with *Crotalaria sp.* ; between a hedge rows rubber planting (13 m + 3 m) x 3 m ; high labour request, high investment and medium term return on investment (4 to 5 years) ; long term association (about 8 to 10 years).

- Associations based on long term cash crops – 2 modules .

- 1st module : inter cropping with Durian (*Durio Zibethinus*) and Mango (*Mangifera indica*), soil cover with *Stylosanthes guyanensis* ; between a hedge rows rubber planting (13 m + 3 m) x 3 m ; low labour request, high investment and long return on investment ; long term to permanent association.
- 2nd module : inter cropping with Durian combined with Guava (*Psidium guajava*) or Papaya (*Carica papaya*), soil cover with *Stylosanthes guyanensis* ; between a 7,5 m x 2,4 m rubber planting ; low labour request, high investment and long return on investment ; association, medium term for Guava and Papaya and permanent for Durian.

In the same time, a fruit trees collection (*Citrus sp.*, *Nephelium sp.*, etc) is introduced to enlarge in the future the choice of the species.

On the fringe of the main aim of this experiment, focused on smallholding, another association with forest trees was planted to check the possibility of using Rubber trees in reforestation programs (several millions hectares in Vietnam). On hedge rows planting pattern, Rubber is associated with fast growing trees (*Acacia* hybrid) and dipterocarpaceae species (*Hopea sp.*, *Shorea sp.*) ; Acacia will be cut soon, in two times (at 3-4 years and 5-6 years old) and partly replaced by Cinnamom (*Cinnamonum cassia*). This kind of association, provide staggered and then regular incomes after the beginning of the tapping of rubber trees (wood, latex, resin, …) and could be a way to involve neighbouring populations in reforestation programs.

These associations should not be considered as models. They constitute a demonstrative experiment to show the field of possibilities. They propose to farmers different ways, adapted to contrasted financial and work force availability, to get uninterrupted incomes during immature period and to raise land productivity in sustainable practises.

5. Conclusion.

A first rural appraisal has enabled to understand general conditions for a balanced and sustainable rural development in Highlands of Vietnam. For poorest farmers, the current dynamics linked to pioneer front enforce radical changes of the traditional agricultural practises. Concurrently, the large development of watered cash crop challenges the future water resources and then the present smallholder cash crop systems.

Based on this statement, research works on technical proposal aiming the fixation of agricultural practises. This fixation recover (i) technical and agronomical aspects linked to fertility management at plot level and (ii) economical aspects at farm level.

This technical creating takes into account in its conception, the farmers' wills and possibilities. Global experimental system will permanently watch over the fit between farmers conditions and technical proposals by complementary approaches involving controlled, multi-located experiments and participatory research through farms network monitoring.

Smallholder Rubber research in Vietnam can take benefits from numerous experiences of others south-east Asia countries, mainly on agroforestry systems. The adaptation of these important technical references will have to care soon on land productivity. Land is being the most important limiting factor in a next future for Vietnam.

IRRDB Annual Meetings, Bogor, Indonesia

Conference September 12-14, 2000

DOES RUBBER TRIGGER REFORESTATION AFTER DEFORESTATION in INDONESIA?

Poster paper

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Does Rubber Trigger Reforestation after Deforestation?

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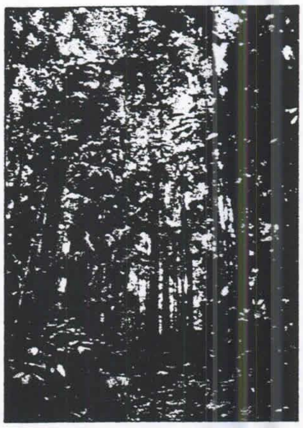
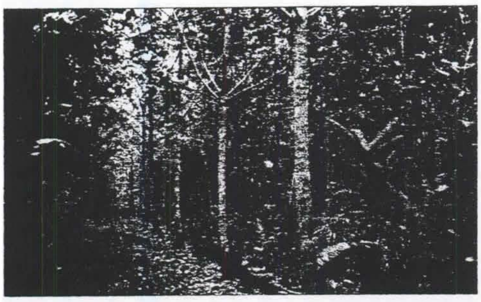
From Deforestation to Reforestation: the Role of Jungle Rubber

As soon as it has been introduced, at the turn of the century in Sumatra and West Kalimantan in Indonesia, rubber has been a major deforestation agent (3.5 millions hectares in 1998), mostly with smallholdings (83% of the total rubber area, 73% of the production). Meanwhile the monoculture system was adopted by both governemental ad private estates, smallholders developed their own "low input" complex agroforestry system: the "jungle rubber". Jungle rubber is based on the use of unselected rubber seedlings in association with the forest regrowth. There are fully considered as "plantations" or rubber based cropping systems. Jungle rubber are low cost and input, easy to implement with no major risk of crop failure but they do have as well a low productivity.
However, these jungle rubber may be considered as agents of reforestation as there are currently the main reservoir of biodiversity in regions where forest has almost disappeared. The "jungle rubber" helped reversing the idea of a tree-crop being a pure deforestation agent.

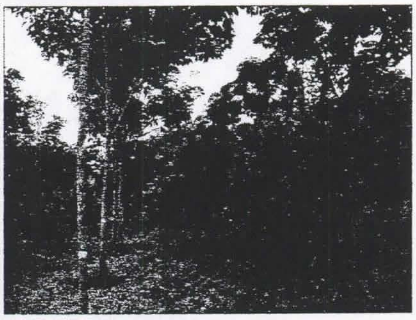


Photos : E. Penot

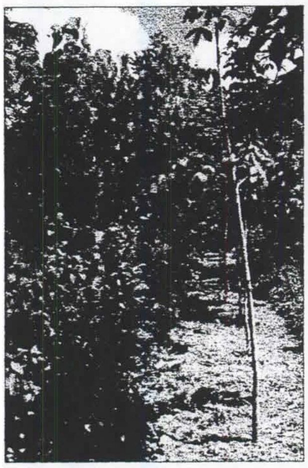
Jungle rubber: unselected rubber trees with forest regrowth, West Kalimantan.



RAS 1 type: clonal rubber + forest regrowth in the inter-rows. SRAP plot in Embaong, West Kalimantan (Smallholder Rubber Agroforestry Project).



RAS 2 type: clonal rubber + intercrops in the first 2 years + associated fruit and timber trees in the interrows. SRAP plot in Kopar, West Kalimantan.



RAS 3 type: clonal rubber + a combination of covercrop (*Flemingia congesta*) and shading trees (*Gmelina Arborea*) + associated fruit and timber trees in the interrows. SRAP plot in Tomula, West Kalimantan. RAS 3 is aimed for *Imperata* grassland rehabilitation.

From Jungle Rubber to Rubber Agroforestry Systems (RAS): Clonal Rubber in Agroforestry Environment

One major technological progress is the recent use of herbicides to control *Imperata cylindrica* on degraded lands. Many rubber farmers reintroduce also agroforestry practices in former monoculture plots or develop their own systems when not under influence of extension. In that case, technological progress clearly seems to encourage reforestation through the development of agroforestry systems. CIRAD/ICRAF/IRRI-Sembawa research with on farm trials with real participatory approach is based on the idea to merge two technical progresses: clonal material (and its bunch of associate technologies: fertilization, crop protection...) and agroforestry techniques (annual intercropings, combination with other perenials, reduction of inputs and labour during immature period...) into "Rubber Agroforestry Systems" (RAS). Replantation of ageing jungle rubber into R.A.S. should have in the future a significative impact on the deforestation/reforestation process and its environmental contribution to agriculture and forest sustainability.

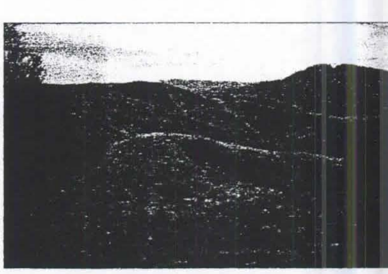
Clonal Rubber Monoculture as a Potential Intensification Factor: the Constraints of Development

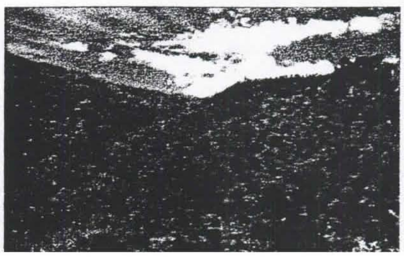
Since the 1980s, governemental projects have introduced technical change and "modern agriculture" based on clonal material through monocropping systems. Although the main target was to increase the Indonesian supply of rubber, the theory claiming that technological progress in agriculture reduced pressure on forests may have helped to promote these monoculture systems. However, some contraints limit the development of the monoculture system: shortage of labour, lack of information, non-availability of improved planting material as well as lack of credit, in particular when projects stop their activities due to governemental disengagement.

Rubber as a Reforestation Agent

If the conditions of a pioneer phase are gathered (abundance of land, reservoir of labour, a crop opportunity and an attractive sustainable market), it is true that technological progress is likely to increase deforestation and traditionnal land-use. Technological progress may reduce the pressure on forest only when the pioneering effect is already slowing down. The rubber showcase helps to demonstrate it. RAS technologies aim to alleviate poverty in rural areas, increase and diversify farmers'incomes as well as contribute to sustainable agricultural production and environment conservation.

A typicaly deforested and degraded area: Kabupaten East Pasaman in the province of West Sumatra; *Imperata* grassland with steep slopes on poor leached soils.





The same area rehabilitated with RAS 2 technology 4 years later in SRAP plots in the village of [illegible] Pasaman, West Sumatra.

CIRAD
Centre de coopération internationale en recherche agronomique pour le développement

DOES RUBBER TRIGGER REFORESTATION AFTER DEFORESTATION in INDONESIA?

Summary

As soon as it has been introduced, at the turn of the century in Sumatra and West Kalimantan (Indonesia), rubber has been a major deforestation agent (2.5 millions hectares in 1998), mostly smallholdings (83% of the total rubber area). However, these rubber low input complex agroforestry systems, " jungle rubber ", may be considered as agents of reforestation as there are currently the main reservoir of biodiversity in regions where forest has almost disappeared, The 'jungle rubber' helped reversing the idea of a tree-crop being a pure deforestation agent.

Since the 1980s, governemental projects have introduced technical change and 'modern agriculture' based on clonal material through monocropping systems. Although the main target was to increase the Indonesian supply of rubber, the theory claiming that technological progress in agriculture reduced pressure on forests may have helped to promote these monoculture systems. However, some contraints limit the development of the monoculture system : shortage of labour, lack of information, non-availability of improved planting material as well as lack of credit, in particular when projects stop their activities due to governemental disengagement.

If the conditions of a pioneer phase are gathered (abundance of land, reservoir of labour, a crop opportunity and an attractive sustainable market), it is true that technological progress is likely to increase deforestation and traditionnal land-use. Technological progress may reduce the pressure on forest only when the pioneering effect is already slowing down. The rubber showcase helps to demonstrate it.

One major technological progress is the recent use of herbicides to control *Imperata cylindrica* on degraded lands. Many rubber farmers reintroduce also agroforestry practices in former monoculture plots or develop their own systems when not under influence of extension. In that case, technological progress clearly seems to encourage reforestation through the development of agroforestry systems. The paper will mention recent CIRAD/ICRAF research with on-farm trials based on the idea to merge two technical progresses : clonal material and Agroforestry techniques. Its impact on the deforestation/reforestation process and its environmental contribution is also explored.

DOES RUBBER TRIGGER REFORESTATION AFTER DEFORESTATION in INDONESIA?

Introduction

Since its introduction to Sumatra and West Kalimantan in Indonesia at the turn of the century, rubber has been a major cause of deforestation. Rubber planting triggered deforestation on a large scale (more than 2.5 million hectares in Sumatra and 0.9 million hectares in Kalimantan), and this was mostly due to smallholdings (83% of the total rubber area, see Figures 1, 2 & 3). Rubber was mainly planted as a complex agroforestry system (CAF), with a level of biodiversity close to that of a secondary forest (de Foresta, 1997). In such a system, rubber has also helped to re-green the deforested land, and moreover, can be considered as a real agent of reforestation, as the level of biodiversity in the system is far higher than that of monoculture. This system is called 'jungle rubber' ('hutan karet' in Indonesian), and its agroforestry properties have helped to reverse the idea of a tree-crop being purely an agent of deforestation. Jungle rubber is now effectively the main reservoir of biodiversity in regions where forest has almost disappeared (there are less than 1.5 million ha of lowland forest in Sumatra (excepting mangroves), in contrast to 2.5 million ha of jungle rubber).

The general aim of this paper is to identify how different types of technological change in various situations with rubber based farming systems have affected agricultural expansion in Indonesia, and how this again has affected deforestation.

After defining the type of innovations and the major technological changes in the history of the "rubber boom" in Indonesia(Section 1), we will consider the particular conditions in which innovations have emerged, with reference to a typology of villages representing a range of situations (Section 2). Special attention will be paid to herbicides (Section 3), and then we explore the effect of these changes on the "forest dynamics" (Section 4). In conclusion, we see how rubber adoption and technological changes in rubber farming systems can be simultaneously considered as factors contributing to deforestation and reforestation. This will also depend on the exact definitions of deforestation and reforestation.

Our study area is composed of two of the main rubber producing provinces in Indonesia: Jambi in Sumatra and West Kalimantan in Borneo. The West Kalimantan hinterland is populated with Dayak people who were collectors of forest products a century ago, and are still very keen to preserve forest and forest products. The plains of Jambi are populated with Malayu people, partly mixed with Javanese and Minangkabau people from Java and West Sumatra respectively (two areas with a very high density of population), as immigration has always been very important and facilitated the colonisation of the province. The Malayu have also developed jungle rubber, but do not rate the importance of forests as highly as the Dayaks. They did not develop long term and sustainable fruit/timber based agroforestry systems such as "tembawang"[1] as the Dayaks did. Finally, the last ethnic group taken into account in this study are poor Javanese in transmigration areas (either in food-crop or tree-crop based schemes).

[1] A « tembawang » is a fruit and timber based complex agroforest, generally based on the « tengkawang tree » in West Kalimantan (Illipe-nut tree or Shorea spp). Very old jungle rubber evoluate into Tembawang when rubber trees disappear.

1 Technological changes and types of innovations

1.1 "Technologies and innovation process"

Many studies have been carried out on the impacts of technology, on the effects of certain types of technological change on land-use and how this might have affected forest use. But what do the terms 'technology', or the 'adoption and diffusion of technical innovations' mean in this context?

"Technology adoption" is a very reductive concept, as many "innovations" are the result of a long process of "elaboration of innovation" rather than a simple adoption/diffusion of technologies. Innovation in itself is the fact that a "technology", or a "technique of production", has been created, either by local people using indigenous knowledge (such as jungle rubber), or by organisations (projects, estates, etc.). This is then redefined through use, and improved according to farmers strategies or requirements. So whatever the technology, the result is that technological change integrates the expertise of farmers, and their ability to transform, adapt or improve a particular technology. Such adaptation aims to provide a better solution to production constraints, or one more appropriate to local conditions.

In other words, innovations, as technical objects, are not only simply "adopted", they are re-created, transformed, integrated, improved, and evolve into an output completely reviewed and adapted by farmers. Indigenous knowledge, expertise and external technical innovations are integrated into this process of elaboration. The various technologies might have different histories and evolution processes. Therefore, assessing if technology changes directly affect deforestation or reforestation is not easy. There are a wide range of "technologies" according to the way they have been "re-appropriated" and "elaborated upon" by local populations. Technologies and innovations occur differently in different contexts at different levels: national (agricultural policies) and regional, as well as at the farm level. We will consider two different situations with the rubber sector: planting in pioneer zones, and replanting in former pioneer areas where land-use change has now relatively stabilised[2].

1.2 Jungle rubber and monoculture

Up until the 1960s and early 1970s, jungle rubber was the only way of producing rubber by smallholders without any help in terms of technical information and inputs from governmental agencies[3]. Jungle rubber is an efficient agroforestry system which saves labour and does not require any capital, but which however delays the immature unproductive phase of rubber up to 10-15 years, and which is extensive, land consuming and with low productivity. It has been the main tool of the Indonesian rubber boom since the turn of the century. It clearly contributed to the original deforestation

[2] However, the introduction of oil palm and the policy of concessions to private companies in the late 1990's deeply modified the land-use of traditional rubber areas.
[3] Extension agencies or projects have a very limited impact before the end of the 1970's and quasi nul in the 1950's and 1960's, see Penot, 1997 or Gouyon, 1995.

process in Sumatra and Kalimantan, replacing partly and progressively shifting agriculture.

One, two, or even three generations after the adoption of jungle rubber, land is becoming less abundant and jungle rubber farmers face difficulties. They might not have enough land to keep the system profitable. The necessity of shortening the investment phase, increasing yields and labour productivity of traditional jungle rubber while reducing risks (crop failure) is becoming critical, in particular since the 1990's.

At this point, farmers are, or should be, ready to adopt clones (improved planting material) and replant clones in old traditional rubber areas or move partly to oil palm. Rubber clones came at the right time to enable a significant increase of productivity in a changing economic environment. In the 1970s and 1980s, the government, helped by International Agencies[4] set up a large number of clonal rubber-based projects at a high cost, however a very low percentage of rubber farmers in Indonesia actually benefited from these projects (estimated at 10% in 1999[5]). Despite this, the government effort was sustained, and it is currently estimated that development projects between 1970 and 1998 reached an area of 450 000 ha from which 300 000 ha can be considered as effective plantations[6].

More importantly, the strength and the potential of 'copying effects' (emulation of the project model by farmers establishing their own independent plantations) were probably underestimated. In the late 1990s, the fantastic 'demo effect' of the rubber projects has had two main impacts. The first one is the demonstration of rubber monoculture as an expensive but efficient and highly productive rubber system, mainly through the use of clones. The second one is the use of herbicide as a labour saving method and technically efficient way of controlling *Imperata cylindrica*.

After this huge "demo effect" of projects, herbicides and other inputs such as fertilisers and pesticides became available even in remote areas. This was facilitated by networks of private traders, in particular those involving collection of rubber in weekly markets, as well as the village co-operatives (KUD).

A network of private nurseries providing improved planting material expanded rapidly at least in two provinces: South and North Sumatra and to a lesser extent in Jambi. Unfortunately, the quality and purity of this planting material varies widely[7] and does not match generally the required standard to guaranty a maximum potential of production. .

[4] In particular the World Bank (NES and SRDP/TCSDP projetcts) and the Asian Development Bank (TCSSP project).

[5] Although 15 % of the area has been replanted with clones, part of this area never developed into fully productive plantations due to poor management. We can roughly assess that around 70 % of plantations have been fully productive.

[6] It means that 1/3 of the plantations did not reach the stage of production or did not produce sufficiently to be considered as a clonal « normal » plantation.

[7] In 1993, more than 500 private nurseries were identified in South-Sumatra, and more than 100 in Jambi in 1998.

The development of this small private sector, outside official projects, has helped to improve the availability of clonal plants for farmers in some areas. Such private nurseries flourished on a small scale around Sanggau and Bodok in West Kalimantan (Schueller *et al.*, 1997), and in 3 specific areas in Jambi (Sungei Tiga in Batang Hari district, Sabir in Sarko district and NES Rimbo Bujang in Bungo Tebo district (Penot *et al.*, 1998), considering our two study provinces.

1.3 Innovations and rubber farming systems

The technical innovations involved in rubber cropping systems are linked with the two main rubber cropping systems: complex agroforestry (CAF) and monoculture, generally based on clones. However, some farmers have spontaneously started to combine some jungle rubber techniques with clones in the mid 1980's in former SRDP plots[8]. Some projects are now moving the same way[9].

CAF: The main features are the combinations of crops; both perennial and annual, both food and cash crops (fruits, foodcrops, timber and rubber), integration of secondary forest into rubber (in the case of jungle rubber), and low input/low labour technologies. In addition to the agroforestry practices that constitute the heart of the jungle rubber system, technical improvments have been the use of high stump seedlings for planting, planting in lines, limited weeding once a year in the rubber rows to decrease the immature period, selection of associated trees amongst the natural vegetation and the use of herbicide to control *Imperata cylindrica* in the first year of planting in order to favour secondary forest regrowth. CAFs are generally established after clearing forest or old CAFs, as they need a stock of seeds for the regrowth of woody vegetation.

Monoculture: The technology is based on improved planting material (mainly clones) and the use of inputs (fertilisers during immature period, pesticides against leaf and root diseases, herbicides, cover-crops to control vegetation regrowth in the inter-row, tapping techniques and stimulation, etc.). Monoculture is very labour-intensive. Immature period is reduced to its minimum (5 to 6 years). Rubber monoculture can be established either after clearing forest or in *Imperata* grassland (requiring more inputs in that case).

Composite systems: Some techniques from monoculture have already been integrated by some innovative farmers into "composite systems"; CAF with clones, or clones with CAF. Some of these non-project CAF experiences have been documented in Indonesia (Schueller *et al.,* 1997) and Thailand (Buranatham *et al.*, 1997. The very first tentative has been called the "jungle weeding" in the 1930"s, cited by Dijkman (1951), (basically improved planting material with secondary forest in the inter-rows).

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[8] Personal observation from the first author in West Kalimantan (documented in Shueller et al, 1997), in North and South Sumatra.

[9] TCSDP is providing rattan seedlings, to be planted in association with rubber. This a good idea only if rattan is established towards the end of the productive life of the rubber trees. Rattan harvest, 5 to 8 years after planting, almost entirely destroys the rubber trees.

This endogenous experimentation with "composite systems" initiated by farmers themselves have been used as a methodological base for RAS (Rubber Agroforestry Systems) experimentation by CIRAD and ICRAF[10] since 1994 in Sumatra and Kalimantan. Such CAFs based on the use of clones in order to improve both yield and labour productivity are now 5 years old. Several RAS were designed with different levels of intensification for various situations. Some RAS are also designed for *Imperata* grassland rehabilitation, with a limited but valuable rebuilding of "economically interesting" or "productive" biodiversity (fruit and timber, rattan, etc.).

The use of a participatory approach with large contributions from local farmers in RAS design, conception and evolution, as well as field implementation of on-farm-trials led to the identification of improved rubber CAFs adapted to farmers' requirements in terms of labour and capital. Preliminary results concerning the RAS systems establishment phase are very promising (Penot *et al.*, 1999).
The analysis presented in Section 2 is based on surveys implemented with a sample of SRAP and non-SRAP farmers in Sumatra (34 farmers in Jambi) and in West Kalimantan (91 farmers) (Courbet *et al.*, 1997) (Kelfoun *et al.*, 1997).

We will focus our analysis on three main technical innovations: clones, fertilisers and herbicides (Round Up used against *Imperata cylindrica*) and consider for various situations what the farmers' strategies and technical choices are. We will also discuss the problem of replanting, as planting in pioneer zones with the jungle rubber system has already been described in detail by Dove (1993), Barlow (1987), Gouyon (1995) and Levang & Michon (1990).

2 A typology of situations : the context

2.1 Planting and replanting: two different dynamics.

Planting occurs in pioneer zones. Pioneer zones are still important in terms of area and dynamics, as there are always new families of local or spontaneous migrants from Java searching for land for food production or cash generation. These pioneer zones are now located at the borders of central plains, in the piedmont zones where land and primary or, more often, logged forests are still plentiful. Whatever technology farmers use to increase the value of land, the result is always deforestation with jungle rubber establishment and some shifting agriculture. Planting rubber in this case, is therefore always synonymous with deforestation. But generally, smallholders do profit for the establishment of their plantation of a "forest rent" (Ruf, 1987) except for those who are planting in very young "belukar (young forest < 10 years old) or *in Imperata* grassland.

[10] By the SRAP, Smallhoder Rubber Agroforestry project (CIRAD/ICRAF/GAPKINDO/IRRI)

Replanting is a totally different process. After the first cycle of jungle rubber, farmers who are ready to replant may have several options, according to their resources, skills and knowledge. These include the following patterns:

- ☛ jungle rubber again (the most common up until very recently),
- ☛ monoculture with or without clones, according to capital and clone availability
- ☛ another tree crop (generally oil palm in our selected areas)
- ☛ semi-perennial cash crops (e.g. pepper in the Putussibau district in West Kalimantan), in areas where rainfall may become a constraint to rubber production (rainfall > 4000 mm/year).

The determinants of replanting may be shortage of land, access to labour and capital, the presence of a project in the area, land status, know-how, technological packages and access to roads and markets. For official transmigrants, land shortage is a serious constraint right from the beginning. Most smallholder, in the replanting process after an old jungle rubber, profit very often from a similar rent[11] as the forest rent : the "agroforest rent", as an old jungle rubber has a biomass and a root system comparable to that of an old secondary forest of the same age (generally between 35 and 50 years).

Technology in itself is far from being the main factor that triggers replanting. However, the existence of a particular technology (monoculture vs CAF for instance), know-how and capital can trigger the choice and type of the new plantation, and potentially trigger a process of elaboration of innovations if specific constraints are present (e.g. land shortage). If the available technology is not intensive in terms of capital and labour (such as jungle rubber, or ; to a less instance , RAS), deforestation will occur in relation to population increase. If technologies are more capital-intensive, they lead to intensification (e.g. rubber and oil palm monoculture, some RAS) and if they are accessible to farmers, they help each farmer to reduce his cropped areas and to adapt the new system to their available labour force. Generally, shifting cultivation is rapidly reduced or even abandoned.

Planting trees is also part of a land acquisition process recognised by "adat" (the local law). However it is only officially recognised by the government if the plantation is planted with clones.
Around Palembang in South-Sumatra for instance, farmers now have 2 to 4 hectares of clonal rubber and sometimes another 2 to 4 ha of jungle rubber (that are not all tapped), as a land reserve for themselves and for their children. Their total land holdings are now 5 to 8 hectares per family, compared to 15 ha, 25 years ago, and 30 ha (with shifting cultivation) 50 years ago.
However, natural population increase, at 2.5 % per year will "consume" this available land in less than two generations.

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[11] As noted by F Ruf, the rent is considered in its Ricardien definition.

The hypothesis that "improved cropping systems" will conserve land is true at a given time in non-pioneer zones. However, due to continuous increasing demographic pressure, and without out-migration to industrial or urban employment, in the long term this is no longer true. It does enable a higher population density per unit of land.

Adoption of new rubber technologies is more the consequence of the constraints of decreasing land (and forest) availability, rather than a concious effort to conserve land and forest resources "(and old jungle rubber which can be considered as a valuable secondary forest).

However, if decisions are made in time (when land is still available), in accordance with the wishes and willingness of the local people, improved technologies could pave the way for a redefinition of land use at the village level, and the creation of protected forested or reforested areas, as is already the case with "tembawang"[12] areas in Dayak villages in West Kalimantan (Momberg, 1992).

Institutional creativeness is necessary to optimise some positive impacts of the technological progress with regard to forest protection. Such institutional arrangements should be designed to hamper or block migration, as this is clearly a major cause of deforestation.

[12] Tembawang are fuit and timber based CAF, generally managed by the communities in order to provide fruits and other products such as medicinal plants or vegetables, timber for housing, etc

Description of selected surveyed villages

Table 1 display the typology of situations :

Table 1 : Typology of situations : main characteristics of the villages

Province	JAMBI		WEST KALIMANTAN						
Village name	Sepung-gur	Rimbo Bujang	Kopar	Engkayu	Sanjan	Embaong	Trimulia	Sukamulia	Pariban-Baru
Villaget type/ Project	Traditional	Trans-migration	Traditional	Traditional	Traditional/SRDP	Traditional/SRDP	Trans-migration	Trans-migration	Trans-migration
Ethnic group	Malayu	Javanese	Dayak	Dayak	Dayak	Dayak	Javanese	Javanese	Dayak
Religion	Muslim	Muslim	Catholic	Catholic	Catholic	Catholic	Muslim	Muslim	Catholic
Population density Inhabitants per km²	28	90	10-30	10-30	30	10-30	50	50	10-30
Access to roads	+	+	-	+	+	++	-	+	-
Access to land	+	- -	+	+	-	-	- -	- -	+
Land to sell	-	-	+	+	-	-	+	+	+
Land title	no	yes	no	No	Yes Partly	yes partly	Yes	Yes	yes
Environment	forest	deforest-ed	AF	AF	AF	AF	Imperata	Imperata	Imperata
Jungle rubber	yes	no	yes	Yes	Yes	yes	No	No	yes
Clonal rubber	no	yes	no	No	Yes	yes	No	Yes	yes
2nd Forest/fallow	yes	no	yes	Yes	Yes	yes	No	No	yes
Irrigated rice (sawah)	no	yes	no	No	No	no	Yes	No	no
Main project	SRAP	NES	SRAP	SRAP	SRDP	SRDP	SRAP	DISBUN	PKR-GK/SRAP
No. of projects	1	2		2	7	4		2	2
New projects since 1997	no	TCSDP	Oil palm	Oil palm	No	Oil palm	Oil palm 1999	No	no
Main cropping system	Jungle rubber = JR	mono-culture	JR	JR	JR/mono	JR/mono	Sawah, off farm	Sawah, nurseries, off farm	JR/monoculture

Source:Courbet *et al.*, (1997), Kelfoun *et al.* (1997) and various BPS sources (Statistik didalam angka per province).

SRDP : Smallholder Rubber Development Project (World Bank/DGE)
TCSDP : Tree Crop Smallholder Development Project (WB/DGE)
NES : Nucleus Estate Scheme (WB/PTP/DGE)
SRAP : Smallholder Rubber Agroforestry project (Research)
DGE : Directorate General of Estate (Ministry of Agriculture, now of Forestry)
PTP : Governmental estate sector

2.3 A typology of situations concerning replanting

Four main situations have been observed, and can be summarised in Table 2.

Table 2 : Typology of situations: Replanting

Situations	**Main cropping system**	**Ethnic groups**	**Ecological environment**	**Villages surveyed**
1 Traditional area with jungle rubber **REPLANTING BY INITIATING A NEW CYCLE OF JUNGLE RUBBER**	Jungle rubber and upland rice in shifting cultivation	Dayaks in Kalimantan Malayu or Minang in Sumatra	Forests, agroforests. Jungle rubber and tembawang in plains.	*Sumatra* : Sepunggur
2 Traditional area with jungle rubber **SUBSTITUTION OF OLD JUNGLE RUBBER BY OIL PALM + YOUNG JUNGLE RUBBER**	Young jungle rubber and , since 1998/99, oil palm	Dayak	Old jungle rubber + Imperata grassland	*Kalimantan :* Kopar and Engkayu
3 Traditional area with clonal rubber from projects (SRDP/TCSDP) **REPLANTING WITH CLONAL MATERIAL**	Jungle rubber, paddy shifting cultivation and clonal rubber plots	Same	Same	*Kalimantan:* Sanjan Embaong
4 Transmigration areas **-food-crop oriented** **REPLANTING AFTER GRASSLAND FALLOW with RUBBER** **OR OIL PALM** **-tree-crop oriented (NES)**	NES clonal rubber plots, Irrigated rice (sawah)	Javanese or Madurese	Imperata grasslands in plains endemic or after deforestation	*Kalimantan* : Rubber only Pariban-Baru, Rubber and oil palm Trimulia, Nursery : Sukamulia *Sumatra NES* Saptamulia, Sukadamai

2.3.1 Traditional areas with farming systems based on jungle rubber

This situation can be summarised by the following three main points:

- *No replanting, or only slow replanting of jungle rubber.(situation 1)*
- *Relatively low pressure on land because of few migrants.*
- *Possibility of radical change with the arrival of oil palm projects. (situation 2)*

Situation 1 is that of old rubber villages that are stable in terms of land and population, with a potential problem of replanting of old jungle rubber. Land can be classified into four main types:

1) Communal land for annual food-crop shifting cultivation (still existing in Kopar/Engkayu in Kalimantan, but not any more in Sepunggur in Jambi), or for fruit/timber CAF (such as "tembawang" in Kalimantan)

2) Land planted with tree crops, such as jungle rubber or clonal rubber plots that can be considered as private land, although this land is still technically communal land with long term use rights, for the duration of tree life-span

3) Protected areas with no private use (generally primary of old secondary forests)

4) "Regrouping land" for project areas, that can be formerly communal land and intended to be privatised (for rubber or oil palm projects for instance). This traditional land tenure, according to "adat" (custom law), is officially recognised by the government by default as long as the government does not claim the land[13].

In 'traditional' villages, the fourth type of land might not exist. The two main cropping systems are jungle rubber and upland rice. The more jungle rubber area or transition to clonal rubber, the less shifting cultivation. In this situation, some villages may previously have been approached by rubber projects, but had declined to participate. In our example, the 3 villages eventually agreed to participate in the SRAP with RAS systems in 1994. Very recently, in 1997/98, the 2 villages in West Kalimantan agreed to join an oil palm project. The main reason for this latest decision was to avoid missing out on this opportunity for development, in light of the fact that they had rejected several similar opportunities in the past. However strong disagreements have occurred between community members and farmers groups ("Kelompok petani"), regarding the type of alternatives that should be developed.

In West Kalimantan, jungle rubber plots are declining in yield, as they are getting old[14] (see rubber yields in Figure 4). This is purely a problem of replanting; the main constraint being limited capital for investment in inputs and improved planting material (see Figure 5). In Jambi, jungle rubber produces higher yields per unit area, off farm employment is relatively limited, and farmers' strategies are based on exploitation of the maximum area of jungle rubber available. Net farm income is even better than farmers

[13] 74 % of the Indonesian territory is officially covered by "forest" and therefore can be claimed for any purposes by the government for projects.

[14] Soils and climate are not also as favourable as in Sumatra.

with clonal rubber in West Kalimantan (but this is partly due to low clonal rubber yields resulting from leaf disease in that province).

2.3.2 Traditional areas with access to clonal rubber through development projects (SRDP/TCSDP) in West Kalimantan.

Partial replanting of old jungle rubber with clones

Situation 3 is that of villages that had access to a project, either with a "full approach project" including a complete technological package, credit and extension (SRDP/TCSDP) or with a "partial approach project" where inputs are provided only for the first year (PKG-GK, APBN, PKT, P2WR). In our case, the 2 villages participated in the SRDP programme (Smallholder Rubber Development Project), a World Bank tree crop programme oriented towards local farmers. Farmers decided to re-organise their land tenure in order to provide a block of 25 hectares to be planted with clonal rubber through projects (SRDP and TCSDP). For partial approach projects, farmers are free to use their existing plots of land[15].

These villages are innovative firstly because they accepted the official projects, and secondly, due to farmers' ability to adapt the monoculture concept to fulfil their own needs. For example, monoculture was turned into CAF in the village of Sanjan, and in Embaong, farmers developed their own new clonal rubber plantations, completely independently of the original project. Embaong has also developed its own oil palm small scale project.

Incomes are far better than for farmers still relying on ageing jungle rubber (Figure 5). Total income from rubber is lower in West Kalimantan than in Jambi, due to the unsuitability of the selected clone (GT1), which is susceptible to *Colletotrichum* leaf disease, which seriously decreases yield. This may limit the effectiveness of external technological progress in the long run.

Clonal rubber yield in West Kalimantan is around 1000 kg/ha/year compared to 1300 in Jambi (NES project with poor tapping skills). The new clones introduced in the 1990's in TCSDP projects, in particular PB 260, have a better potential yield around 1600-1800 kg/ha/year[16] (as observed in TCSDP plots in South Sumatra). In the long term, new plots with such clones will provide farmers with higher capital availability for investment in replanting. Farmers are already investing in clonal rubber replanting with PB 260 in Embaong and Sanjan villages through the purchase of plants (Embaong) or the development of their own budwood garden (in Sanjan) and self-production of clonal planting material by communities.

[15] In all cases, there is no land title provided to farmers but clonal rubber plots are officially recognized as "private land".
[16] TCSDP, D. Boutin, Comm pers.

2.3.3 The transmigration areas

Replanting after grassland fallow: a form of reforestation

Situation 4 is peculiar to transmigration villages. Two cases can be observed: food-crop oriented transmigration villages where it was forbidden to plant tree crops until 1992, and tree-crop transmigration villages where rubber or oil palm plantations were provided through the NES programme. NES 'Nucleus Estate Scheme" is a World Bank funded tree-crop development programme specifically designed for transmigrants.

In both cases, migrants received 2.5 hectares and a small house. Our selection of villages is representative of both cases: former food-crop oriented transmigration villages where upland food-crop systems have generally been a complete failure and a real disaster. In some places in West Kalimantan (in the Sintang area with Pariban Baru village with local Dayaks, and in the Sanggau area with Trimulia and Sukamulia villages), up to 80 % of the Javanese migrants left the project. Those who stayed had access to low-lying land that enabled them to grow some irrigated rice. Since 1992, they have tried to increase the value of their small plot of land, (which was often invaded by Imperata), by planting tree crops, in particular rubber. They used unselected seedlings or grafted clones if available, or if they had sufficient capital). In this case, clonal rubber is generally not yet productive. Farm income levels are comparable with those of traditional areas based on jungle rubber (Figure 5). However the sources of income are different (Figure 6), mainly derived from rice production in sawah (irrigated rice) and off-farm activities (generally employment in surrounding oil palm or *Acacia mangium* plantations as workers). De facto, these transmigrants constitute a captive labour force for these estates. Farmers have very recently invested in clonal rubber plantations, in order to develop capital for further investment, as is the case in Trimulia and Pariban Baru village. In Pariban Baru, local Dayak farmers have joined the transmigration project to be closer to the road[17]. Part of their income (40 %), is provided by their old jungle rubber (Figure 6).

In Sukamulia, some farmers have developed private nurseries and specialised their farming activity for production of clonal planting material for sale.

In Jambi, two villages were selected in the rubber-oriented NES of Rimbo Bujang (Saptamulia and Sukadamai villages with Javanese migrants). In this case, although the clonal rubber is not always well maintained and correctly tapped, the project can be considered a success in terms of population establishment and income generation (see Figure 5).

[17] In almost all transmigration projects, initially aimed at poor Javanese farmers, a small part of the land and plantations, if any, is allocated to local farmers through a "trans-lokal programe ".

2.4 *Inputs, farm income and capital*

2.4.1 Farm incomes and investment problems

Figure 5 displays gross incomes and inputs costs. Income distribution is displayed in figure 6. Some expenses for basic needs (food and education costs for children for instance) are presented in figure 7. It is clear that the capital available for investment in tree-crop replantation with improved varieties, is clearly insufficient for traditional farmers in West Kalimantan who still rely only on ageing jungle rubber. In the past, jungle rubber has enabled a subsistence income that covered basic needs, housing and education costs for children. However it is clearly insufficient to allow investment in improved cropping patterns. Jungle rubber maintains a basic income but does not allow any investment, at least in West Kalimantan. These farmers also try to cover their rice requirement by cropping rice in sawah and ladang (upland rice). This reduces rice purchases, which can be 30 to 50 % of all expenses in transmigration villages, or in traditional villages with clonal plantations. The trend is to buy rice rather than to produce it, as soon as farmers have productive clonal plantations. Effectively the labour productivity of clonal rubber is far higher than that of rice production even in sawah (irrigated rice fields).

The situation is not the same in Jambi, where traditional local farmers crop more productive jungle rubber areas, and also profit from share cropping. Income from these jungle rubber plantations *does* enable farmers to invest in new plantations, and they generally do so on a step by step basis.

In short, what must be learnt from this rapid revenue analysis is the potential indirect effect of clonal rubber adoption on 'deforestation' or more probably on 'reforestation'. By increasing revenues, clones encourage farmers to reduce or even stop shifting cultivation for rice production. It might be not good news for the national campaign for self-sufficiency in rice, but it may help fallows to regenerate in secondary forests.

2.4.2 Input cost distribution

Figure 8 displays the distribution of input costs for rubber for each village. Use of inputs is higher in transmigration areas with clonal rubber, mostly due to investment in new plantations, in particular Round-up and fertilisers during the immature period. Inputs are still important in traditional areas with clonal plantations. Costs of the planting material are not presented in these figures as plantations are already established. Input costs for upland rice are presented in Figure 9.

An initial hypothesis was that "local farmers rely more jungle rubber and are less keen than Javanese transmigrants to use inputs in order to improve cropping systems productivity". This is no longer true as local farmers, as well as the Javanese, use inputs for tree-crops as soon as they can afford them or have access to them. Intensification for tree-crops is not directly linked with ethnicity.

Javanese transmigrants do not have any choice other than intensification due to their degraded land (generally covered with *Imperata cylindrica*) and the very limited land area (around 2.5 ha), particularly if they have no access to sawah. This explains why input costs are important in Trimulia for instance (Figure 10) as they do not have any other opportunities such as clonal planting material production (Sukamulia) or old jungle rubber (Pariban Baru). On the other hand, intensification with annual crops, including the use of draught power, is more common with Javanese transmigrants. Input costs for rice are more important in Trimulia and Sukamulia than in other areas (Figure 9)

In short, it is not technological progress which influences deforestation rates, but more in line with Boserup's theory, (E. Boserup, 1970) land scarcity and deforestation which trigger innovations.

3. Herbicide replaces Gotong Royong

A key labour saving technology

The largest proportion of input costs is the labour cost (Figures 9 & 10) explaining clearly why farmers replace manual labour for weeding by chemical methods. In particular, Round-Up used against *Imperata cylindrica*, is far more effective in the short term (4 months), than manual weeding. Labour costs are relatively high and enhanced by the nature of "Gotong Royong" (mutual help[18]) for annual crops. The use of herbicide can cut labour costs by a factor of 2 or 3. It can also guarantee a certain level of maintenance for tree-crops, and ensure successful establishment of new clonal plantations if labour is scarce.

Gotong Royong is traditionally used for annual crops, in particular for upland rice, but its cost is becoming too prohibitive. The move from annual crops to tree crops also decreases interest in, and the use of Gotong Royong. Farmers develop a more individual strategy where herbicide replaces mutual help. Besides these economic reasons, there is also a strategic reason, as there is greater flexibility and freedom in the decision making process when using herbicide rather than complex forms of labour such as Gotong Royong. "Upah" or local use of wage labour on a daily basis seems to be more developed than some years ago. Beside these different labour use possibilities, share-cropping ('bagi-dua' with 50 % of net income to each) is still very important, particularly in Jambi. With limited family labour and the presence of spontaneous Javanese migrants searching for land and employment opportunities, part of the farm's jungle rubber area is commonly exploited on a share-cropping basis, providing an extra source of income from rubber. In the long run, it also enables the integration of the Javanese population with the local Malayu, as long as land is not a constraint.

The very large scale development of oil palm and *Acacia mangium* plantations in Jambi and West-Kalimantan has largely contributed to the trend of land becoming scarce, and

[18] We use here the Javanese word for mutual help, "gotong royong" but similar patterns with local names do exist for local people.

a major constraint. Due to this, and in light of the demand from Javanese migrants in NES programmes, the land market is emerging, and land prices increasing (Figure 11). Prices in Jambi are twice those in West Kalimantan where land is still relatively plentiful.

In transmigration areas, income from off-farm activities is invested in new clonal plantations which are still in their immature period, in particular for fertilisers and herbicide for clonal rubber (Figure 10).

In conclusion, the use of herbicide decreases replanting costs by reducing labour costs as a whole (for both trees and intercrops) and by increasing efficiency[19] (4 months for Round-up, compared with one month for manual weeding). Herbicide is probably the most powerful labour saving tool, in particular for rubber and rice crops.

4 Forest dynamics

4.1 Biodiversity integration and productivity

Jungle rubber has been a very important opportunity for both income generation (it is economically more interesting than shifting cultivation as labour productivity is four times higher, Penot, 1997), and also as a refugium for biodiversity (Werner 1997). It is probably one of the most relevant examples of integration of this biodiversity into a productive tree-crop system. However jungle rubber has lived its best years. It is now not able to compete with more productive systems, most of them based on monoculture (oil palm/rubber), or simple agroforestry systems (coffee or cocoa).

Some hopes for integration of clones in Rubber Agroforestry Systems (RAS) in the future

Rubber is a very "flexible" plant in terms of light competition, and can be integrated into complex agroforestry systems (such as jungle rubber with unselected seedlings). Besides the optimisation of jungle rubber with clones, one of the objectives of the RAS experiments is to see if clones can maintain the same production potential in an agroforestry environment as in monoculture. If this is the case (and the preliminary results are very promising in that respect), then the replacement of jungle rubber by RAS in the long run will maintain this level of biodiversity integration in cropping systems, at least for the 3 million ha of jungle rubber that need replanting. If not, then there are few alternatives in these humid tropical areas, other than reducing farm land requirement by very highly productive systems such as oil palm. It is hoped that this trend will enable farmers to spatially re-organise their territories, and redefine land use to include some forest or "forest-like" areas.

The solution probably lies between these alternatives, with the development at the farm level of both tree-crops, RAS and oil palm, to counter the decrease in productivity of

[19] This efficiency can be furthermore improved if combined with a selection of adapted cover-crops but farmers are reluctant to establish a crop that does not provide an immediate output.

jungle rubber and provide farmers with more than the basic subsistence needs they have had until now.

4.2 Technical change and forest dynamics

Technological progress may reduce the pressure on forest only when the pioneering effect is already slowing down. The rubber case study helps to demonstrate this.

The answer therefore depends on the degree of deforestation already achieved:

- "Yes" for replanting, rehabilitation or renewal of plantations in areas which are already populated and deforested, where land has been 'appropriated' (which may also mean that land conflicts have been resolved). Yes...... at least for a certain period of time.
- "No" when technological advances trigger the process of planting in pioneer zones, under the influence of other factors (prices, patrimony, etc)

After a second, or a third generation (20 to 40 years), with the natural population increase, the reduction of land requirements per farm will be compensated for by the demand for land from the newcomers, and the same problem will occur again. If natural population increase is a key factor, then immigration, (whether spontaneous or organised), can also be considered as a "multiplication factor".

Finally, the only way for already established communities to maintain a certain level of forested area is firstly to secure part of their territory in the form of protected forest areas and to have a say in controlling these areas. The best time to adopt such a strategy at the community level is when the majority of farmers adopt or develop improved technologies at the same time, creating an opportunity for a new land use system in the village.

In short, technological change may have some impact on deforestation only if consolidated by creative and sensitive institutional arrangements.
Secondly, one option for technological change may be to integrate or re-integrate biodiversity into improved cropping systems such as RAS or improved jungle rubber and recreate 'agroforests'.

In the long run, it seems that the most effective way to conserve forest is to set aside areas of forest land, and maintain them as such, with no agricultural use first within a particular village based land-use policy. This designation of land-use type must be implemented not only at the village level, but also at the regional level. Another alternative would be to integrate forest species into cropping systems where this is technically feasible, such as in complex rubber agroforestry systems. However, it is vital that both the community and the government recognise the importance and value of these new land-use designations and strategies, and can define suitable and comprehensive policies to ensure their success. Technological progress could have a significant impact on reforestation, or in slowing deforestation, if it is linked directly with land-use policy at both community and regional levels. Introduction of new technologies such as block planting of rubber or oil palm in large projects often force a reappraisal of land use in a community, and this could be an important opportunity for setting aside land to conserve forest resources.

Conclusion

Technological progress will increase the expansion of agricultural land in pioneer zones, and even if already deforested land is used, it will still probably act to "boost" deforestation in the mid-term, as has been seen in the Sulawesi cocoa booms (Ruf & Siswoputranto, 1995).

In the case of replanting, technological progress may decrease deforestation for a limited period. However a 2.5 % annual population increase will alter this situation. Therefore the "Borlaug hypothesis" "Technological progress in sedentary or intensive agriculture will reduce the pressure at the frontier " may not necessarily apply to jungle rubber because it remains to be proven that jungle rubber is sedentary and/or intensive. But if we admit that it is, the hypothesis does not work in the long run.

Considering these points, *"Labour-intensive technological change is **not** more likely to reduce deforestation than capital-intensive technological change*", at least in the long run. Even if capital and labour are reduced, it will not change the main trend in the long term, as long as the demographic increase is not absorbed by industry or tertiary activity in urban areas.

Considering any technological change without considering its global economic and demographic environment over a longer time scale might lead to contradictory answers in the short and long term.

Finally, as for cocoa, technological change has had little impact in preventing deforestation, but may have much more influence on 'reforestation'. The use of tree crops, either in monoculture or agroforestry systems (hopefully the latter, but not necessarily), will achieve the supposed 'main goal': generation of family incomes, while in addition will recolonize degraded fallow and thus help in 're-greening', and will re-establish tree cover (and thus aid carbon sequestration).

Therefore, efforts should be maintained in current development-oriented research such as RAS experimentation, in order to release optimised cropping patterns acceptable to farmers.

Acknowledgements

The authors would like to thank Sandy Williams for editing and correcting the grammar of this paper as well as for her comments.

References

Barlow, C. (1987). "Smallholder rubber in South Sumatra." Balai Penelitian Perkebunan Bogor and Australian National University: 32 pp.

Boserup E. Evolution agraire et pression démographique. Ed Flamarion, Paris .

Buranatham, W., S. Chugamnerd, et al. (1997). Agroforestry under rubber plantations in Thailand. Thailand/Malaysia Technical Seminar on Rubber, Phuket, Thailand.

Courbet, P., E. Penot, et al. (1997). Farming systems characterisation and innovations adoption process in West Kalimantan. ICRAF/SRAP workshop on RAS (Rubber Agroforestry Systems), Bogor.

de Foresta, H. (1997). Smallholder rubber plantations viewed through forest ecologist glasses. An example from South Sumatra. ICRAF/SRAP workshop on RAS (Rubber Agroforestry Systems), Bogor.

Dove, M. (1993). "Smallholder rubber and swidden agriculture in Borneo: a sustainable adaptation to the ecology and economy of tropical forest." Economic Botany **47**(2).

E. Penot, I. Komardiwan. (1998). "Improved rubber planting material in the Jambi province." World Bank report for the JRDP (Jambi Regional Development Project), Jakarta, Indonesia, March 1998.

Gouyon, A. (1995). Paysannerie et heveaculture: dans les plaines orientales de Sumatra: quel avenir pour les systemes agroforestiers? INA-PG. Paris, France, INA-PG.

Kelfoun, A., E. Penot, et al. (1997). Farming systems characterisation and innovations adoption process in Jambi. ICRAF/SRAP workshop on RAS (Rubber Agroforestry Systems), Bogor.

Levang, P., G. Michon, et al. (1990). De la jachere arboree aux agroforests, des strategies paysannes adaptees a des milieux de fertilite mediocre, ORSTOM/ICRAF.

Momberg, F. (1973). Indigenous knowledge systems: Resource management of land-Dayaks in West Kalimantan. Technical University of Berlin, Germany.

Penot, E. (1997). From shifting agriculture to sustainable jungle rubber in Indonesia: a history of integration of innovations for smallholders in peneplains of Sumatra and Kalimatan since the turn of the century. Workshop on "Indigenous strategies for intensification of shifting cultivation in Southeast Asia, Bogor, Indonesia.

Penot E, Wibawa G. and Williams S. (1999). "Rubber Agroforestry Systems." Proceedings of the SRAP workshop" (CIRAD/ICRAF/GAPKINDO/USAID), Bogor, 1997, Indonesia: 550 pp.

Ruf, F and P.S. Siswoputranto (1995). Cocoa Cycles. The economics of cocoa supply. Woodhead Publishing, Cambridge, UK, 384 pp.

Schueller, W., E. Penot, et al. (1997). Improved Rubber Genetic Planting Material (IGPM) availability and use by smallholders in West-Kalimantan Province. ICRAF/SRAP workshop on RAS (Rubber Agroforestry Systems).

Werner, S. (1997). Biodiversity of jungle rubber in West-Kalimantan. ICRAF/SRAP workshop on RAS (Rubber Agroforestry Systems), Bogor.

Figure 1

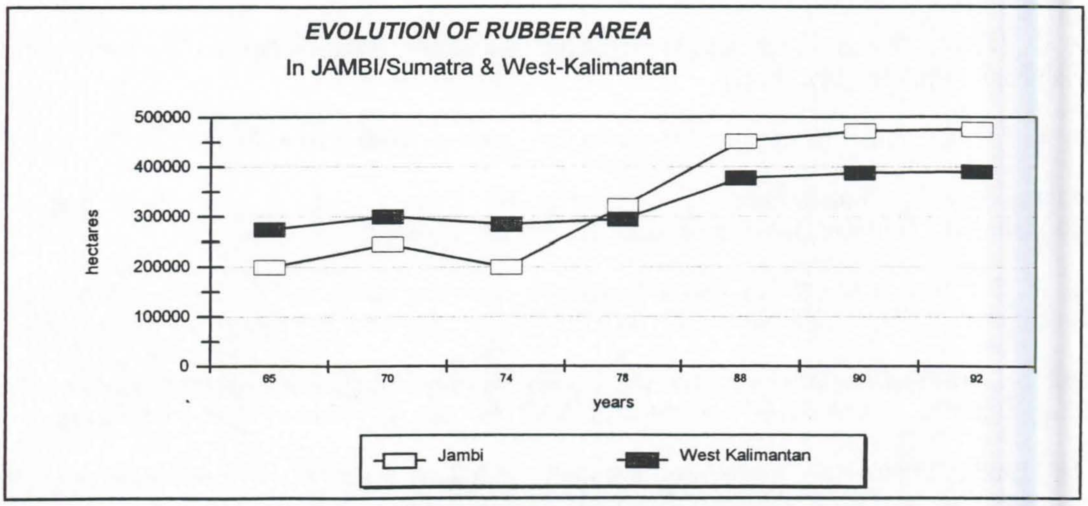
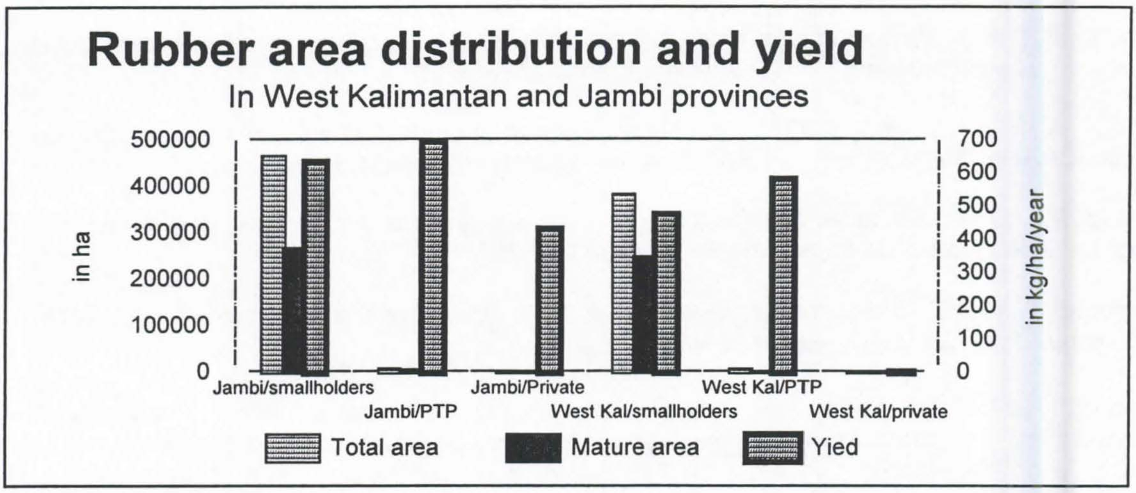


Figure 2



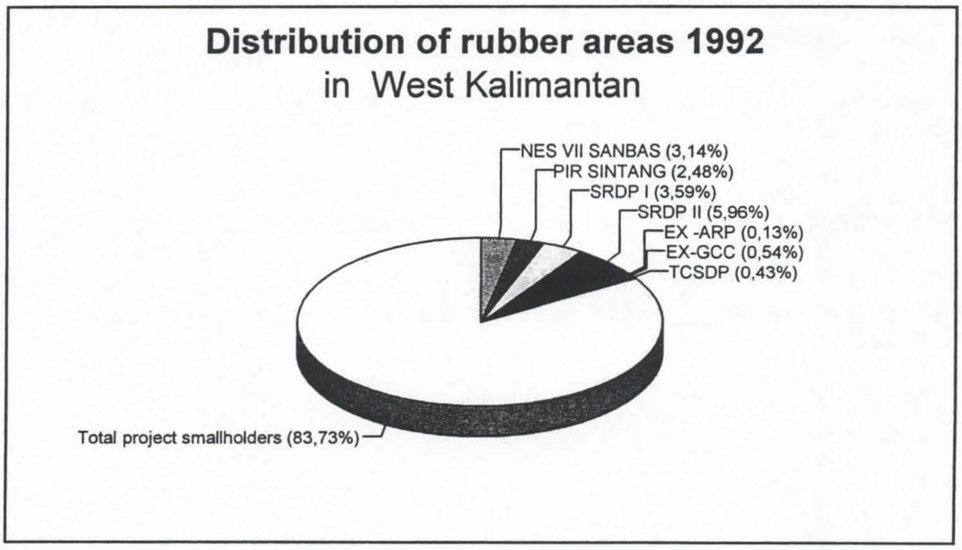
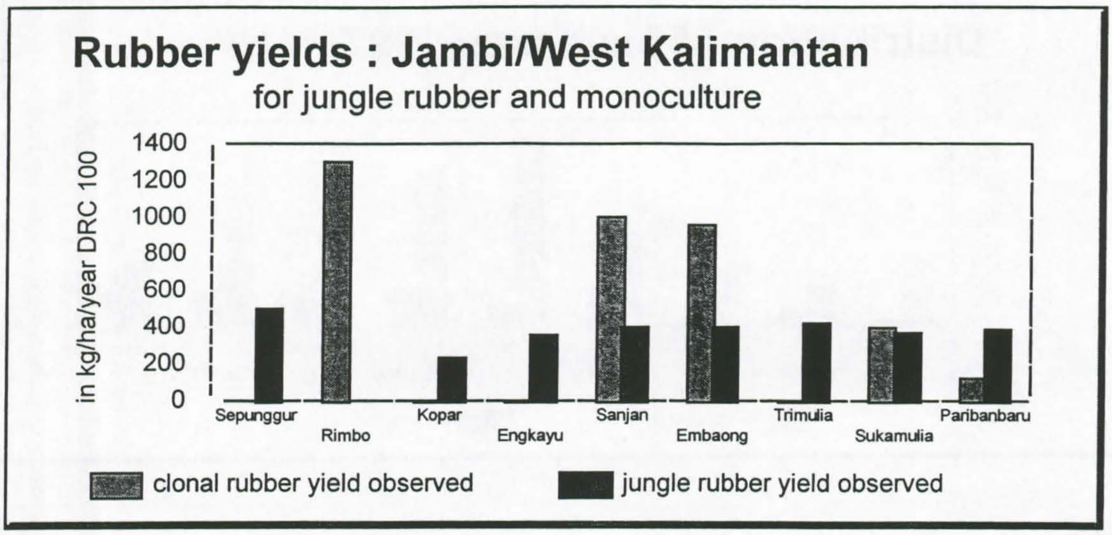


figure3*

figure 4



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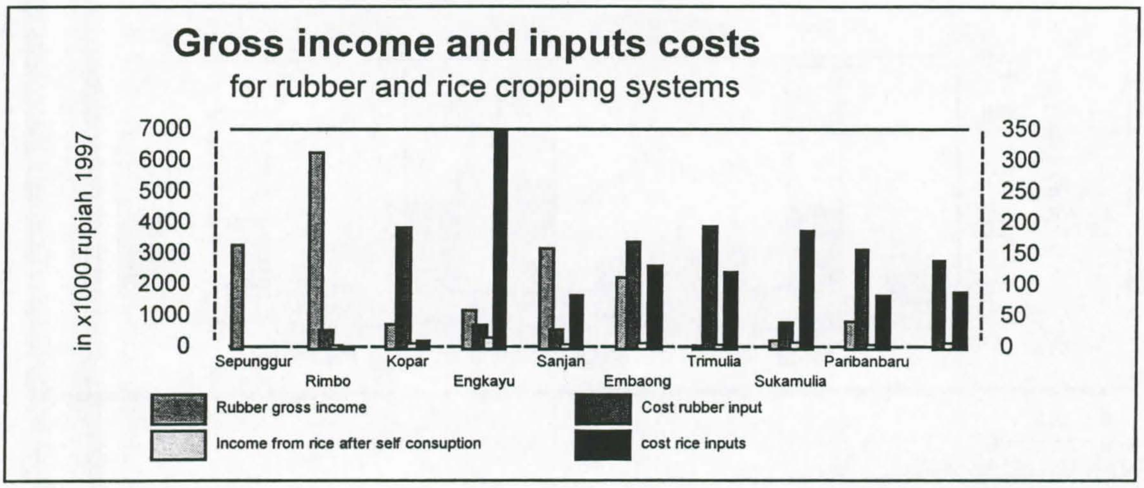

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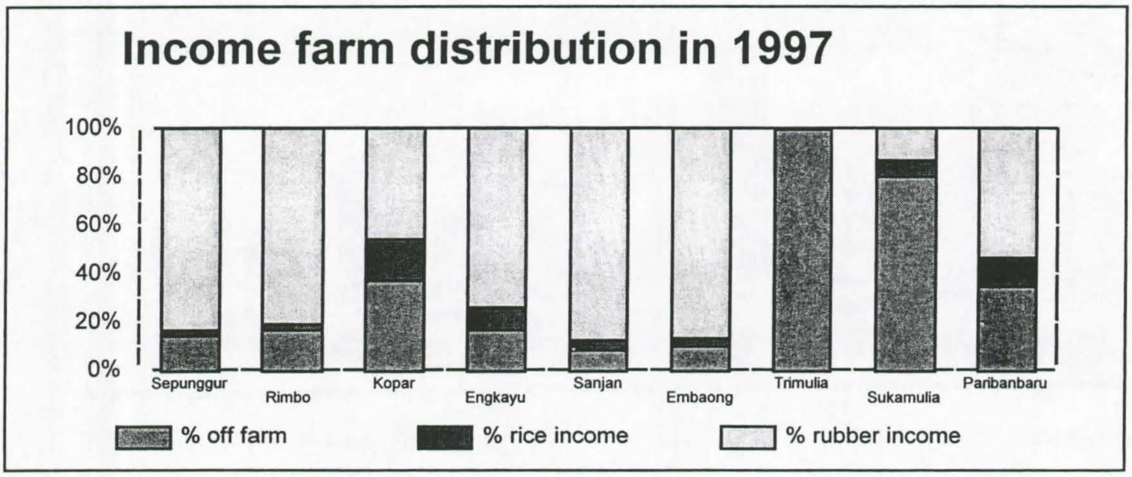

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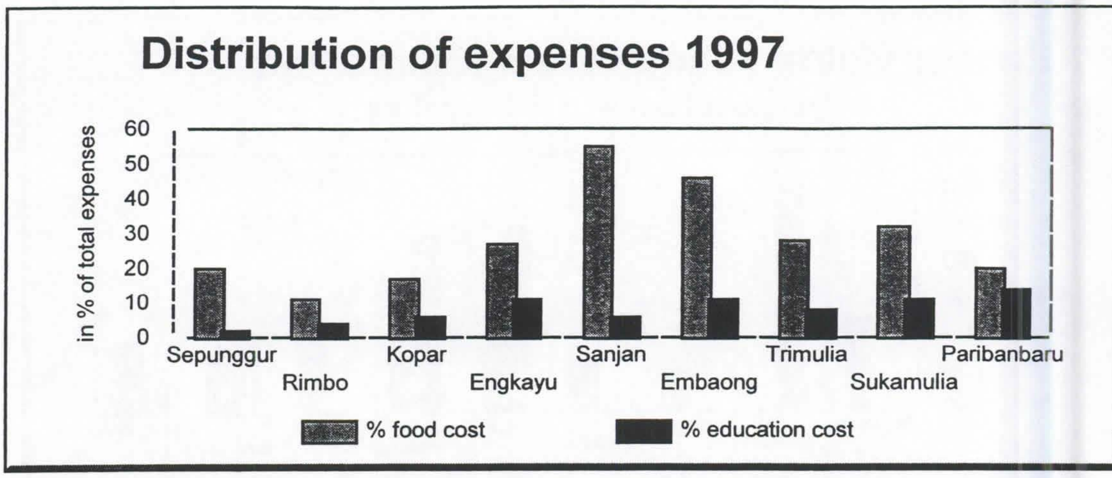


Figure8

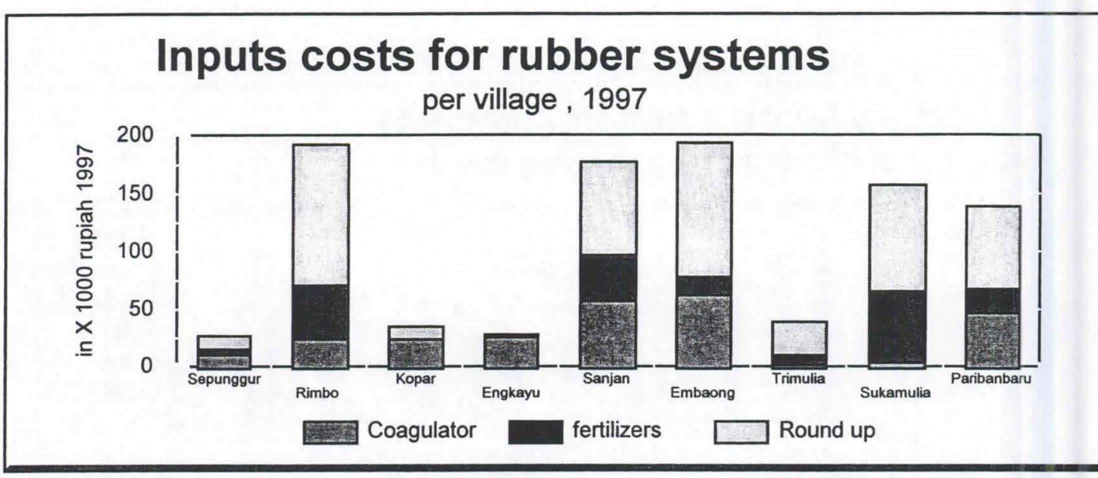


Figure 9

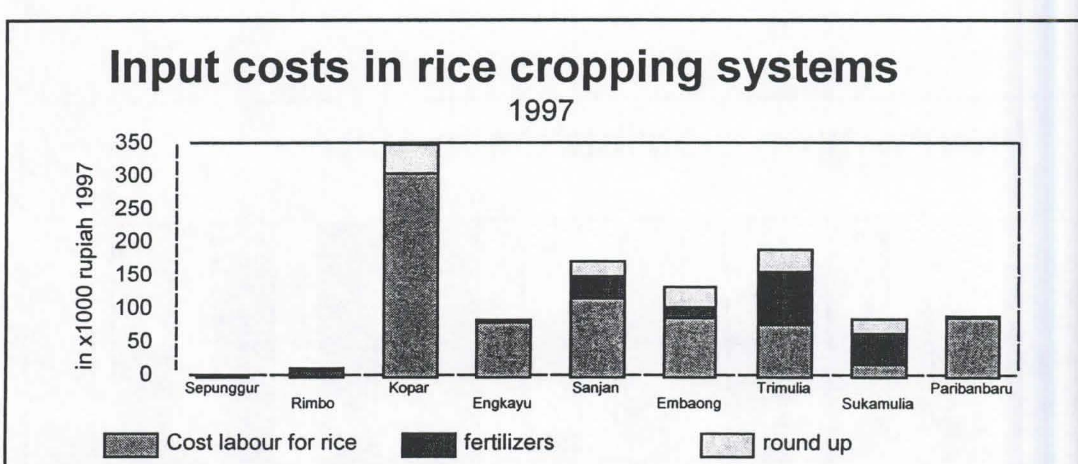
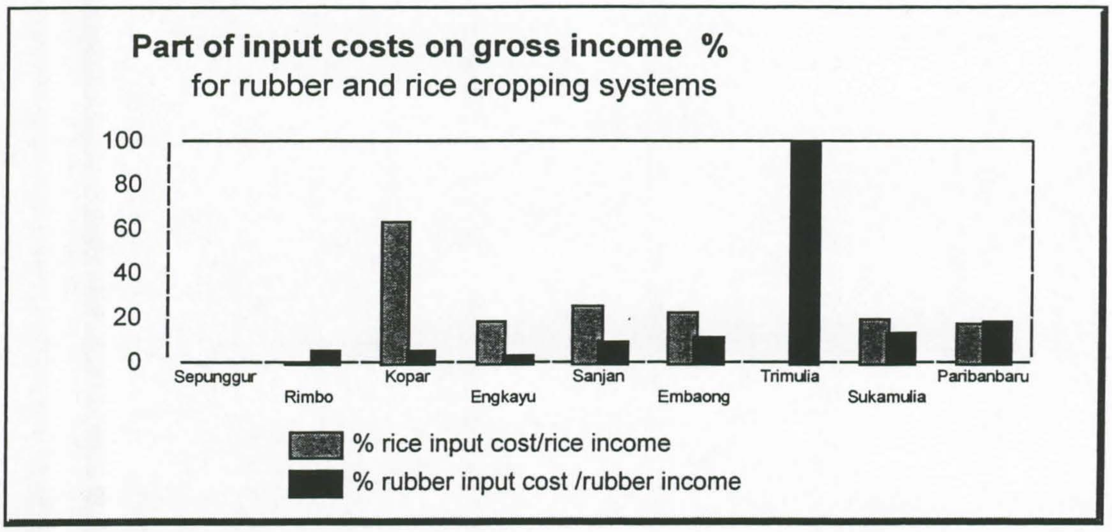


Figure 10



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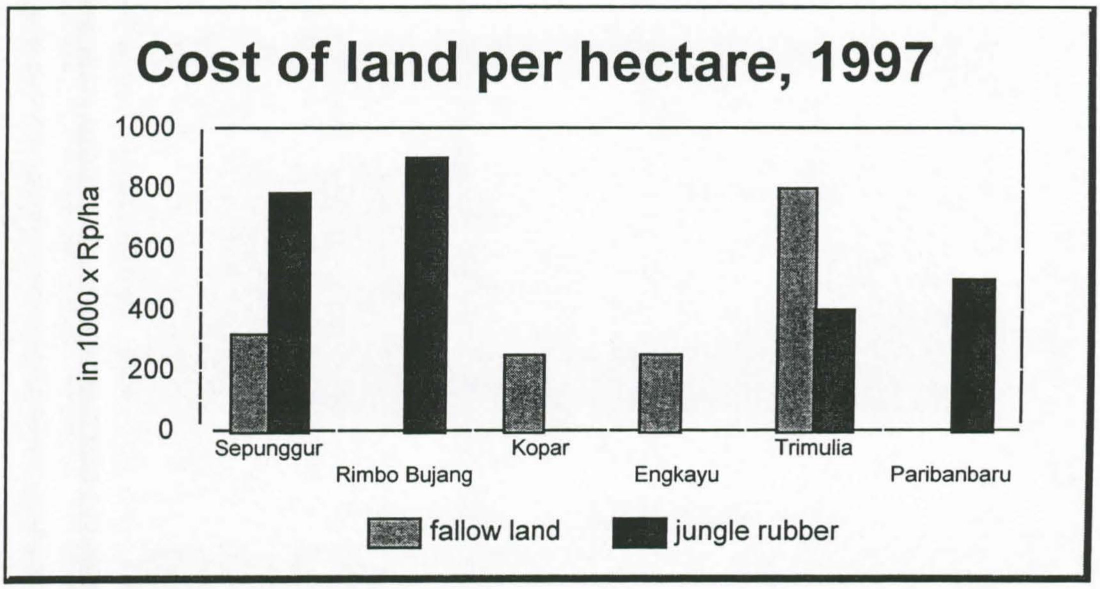

Annexe 4

PRESSE RELEASE : International Rubber Research and Development Boar, 26 September 2000

Indonesian Rubber Conference & IRRDB Symposium 2000, Bogor September 12-16

The Indonesian Rubber Research Institute together with the International Rubber Research and Development Board organized the Indonesian Rubber Conference in Bogor, Indonesia. The highly successful Conference was followed by the Board Meetings of the IRRDB at which a number of significant decisions were made. Some of the major contributions to the Conference are outlined below. It is intended that the Proceedings should be available within the next month.

Rubber plantation development policy in Indonesia

The opening paper was presented by Mr Agus Pakpahan, Director General of Estate Crops. This examined future policies for natural rubber development in Indonesia in terms not only of achieving higher welfare for the rubber smallholders, but also for enhancing benefits for the rubber industry in terms of its economic, social, and environmental aspects. Problems faced by the Indonesian rubber industry include the low average yield per hectare, the weakness of farmers' institutions, inadequate skill and knowledge, and a lack of technological input. In the downstream sector, there has been a lack of industrial development. Policies being instigated include measures to enable smallholders to be able to capture benefits from the market; technology generation and utilization to increase production and productivity; incentives to reduce transaction costs; deregulation, the elimination of bureaucracy, decentralization; investment for improved infrastructure; and elimination of social conflict.

Smallholder rubber in Thailand

Mr Sunthom Nikomrat, President of the Rubber Holder Co-operatives Federation of Thailand, spoke on behalf of the largest single national group of rubber smallholders. In 1960 the Thai Government established the Office of Rubber Replanting Aid Fund (ORRAF) to replant old and low yielding trees with high yielding trees. From 1987 onwards, the Government introduced rubber to a new area in the Northeast. Through the replanting activity, rubber production of Thailand, as well as smallholder income, has increased, and Thailand has become the world's largest producer and exporter since 1991.
Rubber prices on the world market fluctuate. The rubber price, in general, is quite low and this affects the standard of living of smallholders. To increase their bargaining power, as well as to improve the quality of rubber, several organizations have been developed with the assistance of the Government. Such organizations include group processing, group marketing, smallholder co-operatives and provincial smallholder associations.
The Government has also developed the marketing system in Thailand to assist rubber smallholders by introducing auction markets, a central rubber market and direct trading.

Overall position of natural and synthetic rubber

Dr Budiman, Secretary General of the International Rubber Study Group reminded delegates that as daily users of rubber products, we tend not to bother from whence the bouncy and springy material is sourced, whether from trees or petroleum. In actuality the overall breakdown is 39% natural and 61% synthetic. Natural rubber has a unique position amongst agricultural commodities as it is essentially an industrial raw material. The largest consumers of natural (and also synthetic) rubber is the pneumatic tyre.

Tyre manufacturers call for enhanced quality and uniformity

Representatives from two of the leading tyre manufacturers, Bridgestone and Goodyear, were present. This was a significant development as the IRRDB has tended to be isolated from what Dr Peter Allen, a former Secretary, succinctly termed "consumer-pull". Both corporations considered that natural rubber has a considerable amount to offer in reducing rolling resistance and thus reducing the environmental impact of tyre use. According to Mr Itsuo Miyake, General Manager Tire Material Development, Bridgestone Corporation, more than 85% of the carbon dioxide emitted during a tyre life cycle comes from its use stage. Therefore, the most important aim is to reduce vehicle fuel consumption. Silica compounds improve both wet traction and rolling resistance. Silica dispersing agents and polymers designed for silica have been introduced to obtain better silica compounds, and to attain further reductions in rolling resistance. Clearly, there is an immediate to improve the incorporation of silica reinforcement into natural rubber. The "battle" between ribbed smoked sheet (RSS) and Technically Specified (TSR) "crumb" rubbers still persists: RSS has a higher molecular weight compared to TSR, which leads to excellent performance of tensile strength and abrasion resistance. In addition, RSS shows better ageing properties due to the higher amount of non-rubber constituents.

Quality and consistency

Dr Richard J Steichen, Vice President, Corporate Research, Goodyear Ltd, called for improved quality and higher consistency in natural rubber. Quality is the simpler of the two objectives and can be achieved by selecting higher crade materials, as quality is measurable mainly in terms of dirt contents. To an extent, consistency can be achieved through selective buying, but the tyre industry which is the bed-rock of natural rubber consumption cannot be faulted in seeking to enhance its overall productivity and product consistency bv pursuing higher uniformity in its input materials. This is a factor which will need to be addressed collectively by the natural rubber producers, possibly via breeding and possibly by improvements to the processing of smallholder rubber. The latter is partly dependent on factors, such as the improvement of infrastructure, which lie outside the industry as such.

Green issues

The Secretary, Kevin Jones, examined some of the factors, such as global warming and the decline in fuel reserves which may influence all sectors of the industry over the next fifty years. A Malaysian Rubber Board paper, presented by Dr Ismail Hashim, examined the implications of *Hevea's* excellent ability to sequester carbon from the atmosphere. This would appear to be a key issue at a time when the world appears to be slidin. towards an energy crisis prompted by excessive fuel consumption rather than by limits to production.

Other papers

It is impossible to list all of the papers which were presented orally or as poster sessions. Nevertheless, one session did encompass rubber agroforestry, or jungle rubber, which may be regarded as an Indonesian speciality, althou-h the same cultivation practices are still to be found in the Amazonas region of Brazil. The essential nature of rubber agroforestry is that *Hevea* cultivation, based on unselected seeds rather than selected seedlings, is associated with subsistence farming, including livestock husbandry, within a jungle setting. The ecological benefits, such as biodiversity, of such systems are hich, but the productivity is low. Systems are being devised to increase productivity and to raise overall incomes and livelihoods by the careful selection of intercrops during the immature period.

Seismic isolation

The Board and delegates to the Conference visited the UNIDO-funded earthquake resistant building in Pelabuhan Ratu which is about 80 km from Bogor and is deliberately located in a highly seismic area. The building had recently experienced a relatively severe earthquake (its epicentre was in Southern Sumatra) and had behaved as predicted: that is the bearings saved the building and its contents from the oscillations which would have been experienced in traditional buildings in the surrounding area. The building had been constructed to demonstrate the feasibility of employing natural rubber bearings in relatively low cost buildings. The same programme had seen a similar demonstration building constructed in the People's Republic of China. The intension of the programme had been not only to promulgate a technique which should be capable of saving lives and reducing suffering imposed by one of the most devastating of all natural phenomena, but as a means of increasing the market for natural rubber, and thereby increasing its price and ultimately the income of the poor smallholders who produce it.

Diseases and plant breeding

The Board considered that disease is one of the major threats to enhancing productivity. In June the Board had organized workshops in Malaysia and Indonesia to enable pathologists to be more aware of the symptoms associated with Corynespora leaf fall disease (CLFD). This is a major threat in many countries and has led to the withdrawal of some promising clones, notably RRIC 105 in Sri Lanka. The Common Fund for Commodities has agreed to finance a programme of Integrated Pest Management to combat the disease, but progress has been inhibited by the failure to find an organization willing to co-finance the effort which is already being put in place by many of the Member Institutes.

Looking to the future, there is a need to incorporate disease resistance within plant breeding programmes:in the past, breeding has concentrated on yield, initially of rubber, but more recently, of timber. It was also proposed that as South American leaf blight (SALB) shares many of the characteristics of CLFD (both are fungal diseases) there is a case for evolving a Global Rubber Plant Disease Programme, possibly under the auspices of CGIAR, with the aim of attracting a major level of funding. It would be hoped that such a programme might enjoy a broader financial base. SALB remains a major potential threat: the FAO has agreed to provide funds for a workshop on this serious threat in 2001. It is hoped that it may be possible to move the location for a this proposed workshop from Kuala Lumpur to a location in Brazil, and that such a move might be accompanied by an IRRDB Meeting.

The Board also considered taking the first steps towards developing an IRRDB series of clones, by encouraging exchanges prior to the trials stage - the most expensive part of any breeding programme.

Cultivation in marginal areas

The Member Institutes in China and India are in the final stages of preparing a proposal for an international research programme which had previously been entitled rubber cultivation in marginal areas. The programme has changed its emphasis and this is reflected in a new title: Restoration of degraded and marginal ecosystems using natural rubber. In most cases, such degraded ecosystems (typically those affected by slash-and-bum cultivation) are beyond the normal limits for rubber cultivation. Nevertheless, rubber cultivation offers an excellent medium for restoring degraded lands and thereby providing a regular source of income for the residents of such areas.

Engineering information data sheet

An Engineering Information Data Sheet had been prepared by the Secretariat and a draft was circulated to the Board. It was agreed the present information, with some modifications, should be placed on the IRRDB web site. The final version would be sent to Member Institutes electronically to enable them to prepare translations and publish it on behalf of the IRRDB. The overall aim is to encourage the use of natural rubber in applications where synthetics are needlessly specified.

IRRDB Gold Medal

The Board decided to award its Gold Medal to the internationally-renowned Indonesian plant breeder, Dr Abdul Madjid bin Umar, who was born in Sentolo, Yogyakarta, on May 25, 1934. Dr Abdul Madjid retired from the Department of Agriculture in Indonesiain 1993, but has since been a consultant to the Government on several major projects. From 1989 to 1992 he was Secretary General of the Association of Natural Rubber Producing Countries. Between 1981and 1989 he was Rubber breeder and Director of the Sungei Putih Research Institute for Estate Crops in North Sumatra.

The award was made on the basis of Dr Abdul Madjid's outstanding record as a plant breeder, especially his work relating to rubber, although prior to his association with rubber he had worked on breeding other crops. including tea, chichona and groundnuts. He represented Indonesia at several meetings of the IRRDB Plant Breeders and had for a time been IRRDB Liaison Officer for PlantBreeding. He was amongst the original proposers for a new expedition to widen the genetic base of rubber and participated in drafting the arrangements for the IRRDB 1981 Germplasm Expedition to Brazil, and in the post-expedition arrangements for the plant materials.
This is the third award of the IRRDB Gold Medal: previous recipients have been Dr Ong Seng Huat and Dr Jean-Louis Jacob. The former also received his Medal for work on plant breeding, especially for his contribution to Germplasm collection; whilst the latter was a respected research
worker on the physiology and biochemistry of *Hevea* latex.

The Secretary was requested to make a call for fresh nominations from its Member Institutes before the end of the current year. The presentation to Dr Abdul Madjid will be made at a future appropriate date and venue.

Changes in Board and location of Secretariat

The new arrangements for Chairmanship are for a period of two years and Datuk Dr Abdul Aziz b S A Kadir retired from this position at the end of his term of office. The new Chairman is Dr Soekirman Pawirosoemrdjo, Director of the Indonesian Rubber Research Institute in Sungei Putih, near Medan. As Dr Asril Darussamin has now retired from the position now occupied by Dr Soekirman, the vacancy for one of the two Vice-Chairmen was filled by Mr. Prasat Kesawapitak Director of the Rubber Research Institute of Thailand. M Omont, who has been seconded to CGIAR from CIRADCP, remains the other Vice Chairman and Chairman of the Finance Committee. At the previous Board Meeting it had been decided that the Secretariat Office should move to the Malaysian Rubber Board's headquarters in Kuala Lumpur. This had the obvious advantage that the Secretariat would remain within the same organization as TARRC is a unit of the MRB. The new Secretary will be the former IRRDB Chairman: Datuk Dr Aziz. The present Secretary will retire at the end of the present year.

Liaison Officers

The Board's Liaison Officers play an important role in ensuring lateral communication within the organization and by keeping the Board informed of new and pressin. issues. Several of the existing Officers have had to resign and several new appointments have been made. These new appointees are Mrs Varapom Kajornchaiyakul, Director, Rubber Technology Division, Rubber Research Institute of Thailand. Mrs Varapom was requested to be diligent in her examination of the serious issue of latex protein allergy and in the quest for greater consistency in raw rubber which is being sought by the tyre industry. Dr James Jacob of the Rubber Research Institute of India has been appointed to be Liaison Officer for the Plant Physiology Group in succession to Dr Sivakumaran who has retired. Dr M. Supriadi, of the Sembawa Research Station of the Indonesian Rubber Research Institute, is the new Liaison Officer for the Socio-Economic Group. Mr Sagay of the Rubber Research Institute of Nigeria is the new Liaison Officer for the Agronomy Group, the remit for which has been extended to include agroforestry. It was considered premature to create a Biotechnology Group, but the Board would seek specialist expertise in this area.

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IRRDB Symposium and Indonesian Rubber Conference 2000
Notes et communications

Résumé

La conférence annuelle de l'IRRDB (International Rubber Research and Development Board) est un lieu de présentation de l'état de la filière caoutchouc naturel et des principales recherches en cours dans le monde. Cette année elle a été couplée à un séminaire scientifique (IRC) organisée pat l'Institut de Recherche Indonésien (IRRI). La première journée a été consacrée à des présentations générales sur la filière hévéa en Malaisie, Thaïlande et Indonésie (les trois premiers producteurs mondiaux) et sur les perspectives de la filière pour la prochaine décade.
Le CIRAD a présenté dans la quatrième session de la seconde journée, centrée sur l'hévéa et l'agroforesterie, 2 communications sur les systèmes agroforestiers à base d'hévéa : résultats des essais sur les RAS 1 et 3 (Rubber Agroforestry Systems), respectivement présentés par D. Boutin et E. Penot. Une troisième communication générale sur l'agroforesterie a été faite par G Wibawa (IRRI/Sembawa).
Trois posters ont également été présentés sur le Cambodge (IRCC), le Vietnam (IRCV et l'Indonésie (CIRAD/SRAP/ICRAF).
On remarquera qu'il y a peu de vraies innovations ou nouveautés dans les communications et posters et pratiquement pas de prise en compte réelle des problèmes de production que rencontrent les petits planteurs. La recherche, de façon globale, semble déconnectée du monde de la production (plus de 80 % par les petits planteurs), ses contraintes mais aussi ses opportunités. Nous n'avons vu que trois communications et deux posters (Vietnam et Cambodge) à caractère socio-économique sur la problématique des petits planteurs. La majorité des autres communications est restée dans le vague, avec une approche très générale et sans apport d'alternatives ou de propositions de solutions.

Mots clés : IRRDB, hévéa, Indonésie, Vietnam, Cambodge, Agroforesterie.