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MAINTIEN DE L'ENVIRONNEMENT ET PRODUCTION DE BOIS DANS LE PACIFIQUE SUD

CIRAD

Centre
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pour le
développement

Département
Forêt

Rapport de mission aux Iles COOK

RAROTONGA, février 1996

Yves EHRHART
Nouméa
Nouvelle-Calédonie

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Photo de la page de couverture:

Pokoinu, Rarotonga :

La colline centrale de la photo a été reboisée en 1990. Auparavant elle n'était couverte que de fougères et de *Casuarina equisetifolia* dans le haut.

Essai 17 en haut à gauche est une plantation d'*Acacia auriculiformis* en courbes de niveau. Dans la parti à l'extrême gauche, très exposée aux vent et sur un sol très superficiel la croissance des arbres est faible et les lignes sont encore bien visibles.

Essai 12 à droite de cette colline il est constitué de parcelles mixtes de *Pinus caribaea hondurensis* et d'*Acacia auriculiformis* ainsi que de parcelle pures de chacune de ces espèces. L'aspect de plantation de pins ne ressort pas du tout de ce dispositif alors que c'est l'essence objectif. .
Ce système peut permettre une modification importante de l'aspect des peuplements dans le cas de plantations de pins d'un aspect toujours assez monotone.

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RAPPORT DE MISSION AUX ILES COOK
du 10 février 1996 au 4 mars 1996.

Introduction

La convention du 9 décembre 1993 entre la Caisse Française de Développement et le CIRAD-Forêt prévoit une série de trois missions annuelles de suivi des essais installés par le CIRAD-Forêt lors du projet "Maintien de l'Environnement et Production de bois dans le Pacifique Sud" (Convention du 27 septembre 1989).

Le présent rapport décrit la mission réalisée en février 1996, dernière des 3 missions. Elle correspond à la mission prévue pour 1995.

Cette mission s'est déroulée en quatre phases :

- préparation des stages de formation à Nouméa;
- visite des essais et commentaires des résultats communiqués par le Service Forestier des Iles Cook;
- stage de formation concernant la sylviculture du pin;
- missions sur les îles de Mauke et Mangaia pour les mesures et analyses des essais et soutien du Service Forestier.
- rencontres avec le ministre de l'agriculture, le directeur des finances et du planning économique pour présenter les résultats de nos missions et préparer une suite à celle-ci en ce qui concerne la mission "Aménagement" prévue par la présente convention et envisager d'autres développements forestiers ultérieurs.

I. Calendrier

Départ de Nouméa : 10 février 1996.
Arrivée à Rarotonga : 12 février 1996.

13 février 1996,

Rencontres avec :

Hon. Vaine TAIREA,	Ministre de l'agriculture.
M. William HOSKING	Secrétaire général du ministère pour 10 jours encore.
M. Otheniel TANGIANAU,	Chef de service forestier.
M. Sabati SALOMONA,	Chef du service de vulgarisation pour les îles du Groupe Nord.

Organisation générale de la mission, mise au point de la session de formation et calendrier des mission dans les îles

Visite de l'essais 24 à la station de recherche de Totokoitu

14 février 1996

Organisation pratique des déplacements vers et en provenance des îles.

Rencontre avec Mme Diane McKegg ancien Consul Honoraire de France.

Visite des essais 12, 17, 8, 9, 2, 20

15 février 1996

Visite des essais 11, 13, 1, 16, 18, 21

16 février 1996

Visite des essais 5, 19

Préparation de la session de formation des agents forestiers

19 -21 février 1996

Ile de Mauke et rencontre avec le responsable forestier de Mitiaro lors de l'escale de l'avion sur cette île

- visite des essais de santal
- visites des plantations du service forestier : pins et "maire" (prononcer: maïre), *Alyxia stellata*.

22 février 1996

Rencontre avec

M. Llyod POWELL: directeur des finances et du planning pour discuter de l'aspect économique des plantations forestières des Iles Cook et des priorités à mettre en oeuvre dans l'optique d'une exploitation de cette importante ressource de l'avenir. Dans ce cadre nous avons abordé la réalisation de la prochaine mission d'aménagement prévue dans la convention.

Ile de Mangaia: visite des plantations de pin des Caraïbes (680 ha soit la quasi-totalité de l'intérieur montagneux de l'île

23 février 1996

Ile de Mangaia :

- visite de l'essai 15 et mesures;
- inspection des terrains préconisés pour les essais de santal
- visite de la pépinière: germination du santal

26 au 29 février 1996

Rarotonga :

Rencontre avec:

Dr. Matarangi PUREA, directeur de la station de recherche agronomique de Totokoitu (essai santal et divers autres sujets)

Session de formation pour les agents du service forestier:

+ feux de forêts, dégâts et impact, aménagement forestier et sylviculture de prévention, infrastructures et techniques de lutte contre l'incendie de forêt

28 février 1996

Rarotonga

- ouverture officielle de la conférence des chefs des services ruraux du Pacifique organisée par la Conférence du Pacifique Sud (CPS).

Rencontres avec:

Son Excellence le représentant de la Reine, M. Apenera SHORT
Pa Ariki présidente de la Chambre des Ariki
M. Hon Tat TANG directeur du Programme de développement forestier du Pacifique sud de l'OAA/PNUD (SPFDP).
M. Olivier TROCME conseiller technique en matière de coopération agronomique et forestière de l'Ambassade de France à Suva en charge de la coopération régionale.
M. Malcolm HAZELMANN: directeur du programme agricole de la CPS
M. Robert DUN secrétaire général de la CPS
M. Patrice COURTY spécialiste des technologies appliquées à la CPS

différents secrétaires généraux de l'agriculture des pays du Pacifique et des Territoires Français d'Outre-Mer

1er mars 1996

Rencontre avec:

Hon. Vaine TAIREA ministre de l'agriculture

+ tirer le bilan de notre mission
+ présenter la future mission d'aménagement encore à réaliser par cette convention
+ mise au point d'un futur programme de coopération forestière

Rédaction du projet santal pour les Iles COOK.

2 mars au 4 mars 1996

Voyage Rarotonga - Auckland - La Tontouta

II. Evaluation du projet depuis la dernière mission en décembre 1996.

1. Essais

La liste des travaux à effectuer avait été laissée après discussions à Otheniel TANGIANAU, chef du service forestier, qui se chargeait de les faire réaliser par ses ouvriers.

Les principaux travaux ont été réalisés tant sur les îles qu'à Rarotonga et la campagne de mesure 1995 a été réalisée avec soin et à temps sauf sur une des îles d'où les résultats ne sont arrivés à Rarotonga qu'en début 1996. En raison de cet unique retard, l'ensemble des résultats ne nous est parvenu à Nouméa que fin janvier. Une fois encore nous n'avons pas pu présenter les résultats de façon définitive lors de la mission.

Les travaux d'entretien qui concernaient essentiellement les essais en zones fertiles (Essai 18: *Hymenaea courbaril*) n'ont pas été suffisamment surveillés et comme l'année dernière l'équipe d'ouvriers les a bâclés. Ceci a occasionné, une fois de plus, des dégâts importants et des retards de croissance très marqués sur les plants. Seul *Hymenaea courbaril*, espèce à croissance initiale lente en a réellement souffert. Ceci est très regrettable car ces plants qui avaient déjà fortement souffert entre 1992 et 1994 étaient repartis et commençaient à grandir de façon marquée. Par contre tous les travaux d'entretien réalisés sur les essais des îles ont été bien menés et les résultats obtenus sont très prometteurs (essais santal).

Le passage accidentel de feux dans les essais 11 à Rarotonga en juin 1994 et 15 à Mangaia en janvier 1993 a permis de mettre en évidence les comportements respectifs des espèces face au feu et de préconiser des opérations de rattrapage des peuplements après incendie. En outre les parcelles détruites nous ont servi d'illustration pour notre cours sur les dégâts d'incendies et leur impact sur le milieu (arbres, sol, faune...).

Les données rassemblées grâce aux mesures effectuées sur les arbres des essais permettent d'avoir déjà une idée assez claire sur le comportement des espèces à plus long terme et d'envisager leur sylviculture lorsque que leur utilisation s'avère intéressante pour les objectifs envisagés.

2. Projet Santal

Suite au stage de formation sur le Santal que nous avions réalisé en juin 1994 et à la participation d'un agent forestier des Iles Cook à l'"atelier santal" de Nouméa, nous avions demandé à chaque participant de monter un projet sur son île. Sous l'impulsion du participant à l'"Atelier santal", des essais de germination avaient été commencés lors de notre dernier passage en décembre 1994. Les plants obtenus ont permis la mise en place de deux essais à Mauke ou ils ont été distribués à la population pour être plantés dans les jardins et autours des maisons. Ces essais viennent s'ajouter à ceux de Mitiaro et de Rarotonga. Deux autres essais sont aussi envisagés sur l'île de Mangaia à très court terme puisque les terrains sont identifiés et les plants en court de production à la pépinière de cette île. Sur Atiu, 700 plants ont été produits et sont en cours d'élevage en pépinière. Là aussi ils seront installés dans une plantation pilote et l'excédant sera distribué à la population avec des règles strictes de distribution.

Les résultats des essais de Mitiaro et de Mauke mettent en évidence une adaptation remarquable de cette espèce aux sols coralliens ("makatea") les plus pauvres. C'est donc une production de tout premier plan pour ces milieux qui n'ont aucune valorisation possible jusqu'à présent. Le service forestier et le ministre de l'agriculture (qui est originaire de Mauke et est donc en permanence à la recherche de revenus supplémentaires pour ces îles coralliennes) sont très conscients de ce fait et poussent ce projet car ils voient là une valorisation exceptionnelle de certaines îles totalement dépourvues de revenus en raison de la pauvreté de leur sol (Mitiaro) ou dont le "makatea" recouvre une proportion importante de la surface (Mauke, Atiu, Mangaia).

- à Mitiaro, où le projet a débuté il y a 3 ans, une parcelle de 200 arbres a été plantée et son évolution est remarquable;

- à Mauke, deux parcelles ont été plantées dans deux milieux très différents.
  - Celle située sur "makatea" a une croissance remarquable quoi qu'un peu inférieure à celle de Mitiaro semble-t-il. En outre, une des autres productions de cette île est le "maire" : *Alyxia stellata,* petits buissons dont le latex est très odoriférant et dont les rameaux débarrassés de leur partie interne rigide sont utilisés pour faire des guirlandes parfumées très prisées à Hawaï vers où elles sont exportées. Cette espèce a été plantée dans le "makatea" et elle pourrait très bien être conduite en association avec le santal et permettre ainsi de mieux rentabiliser le coût de préparation et d'entretien des plantations en le divisant de moitié par espèce et en donnant un revenu faible mais régulier dès la cinquième année après la plantation.
  - La parcelle installée sur lande à fougères montre que le santal n'est pas adapté à ce milieu en raison de l'acidité très importante du sol et de l'absence (ou le très mauvais état physiologique) de plante à parasiter. A cet endroit, même les *Acacia crassicarpa* poussent très mal.

  Plusieurs centaines de plants ont été distribués à la population pour des plantations décoratives autour des maisons et dans les jardins afin qu'elle s'habitue avec cet arbre et qu'un nombre conséquent d'entre eux se trouve dans des conditions d'entretien assuré. C'est aussi un moyen très simple de constituer une réserve importante de bois à statut foncier assuré et sans investissement financier visible pour le propriétaire.

- à Mangaia, la production de plants a pris du retard en raison d'un taux de germination faible (sûrement dû à un problème de conservation des graines). Les plants ne seront disponibles que dans quelques mois. Deux parcelles d'essai ont été identifiées. Toutes deux situées sur "makatea" elle représentent néanmoins deux milieux très différents.
  - L'une est située sur la zone basse côtière avec un sol très rocailleux et pauvre à l'image de celui de l'essai de Mauke.
  - La seconde se trouve sur le "makatea haut" qui est beaucoup plus fertile avec un sol plus profond mais d'accès difficile en raison des blocs de corail qui le hérissent. C'est la zone traditionnelle de jardins. C'est à notre avis la zone privilégiée pour cette espèce à condition que le suivi des entretiens soit bien fait car la végétation herbacée et arbustive y est vigoureuse, par contre elle se caractérise par une absence de plante grimpante ce qui fait que, dès que le santal est assez haut pour sortir des buissons environnants, il est quasiment sauvé.

III. Stage de formation sur les feux, l'aménagement forestier de prévention des feux et la lutte contre l'incendie

Depuis les incendies catastrophiques de juillet 1993 et janvier 1993 qui avaient détruit près des trois quarts des plantations de Mangaia (450 ha au moins) le service forestier est extrêmement sensible à la protection des forêts contre le feu. Le chef du service forestier nous a donc demandé de réaliser une session de formation de ses agents consacrée à ce fléau.

Comme une partie importante des mesures de prévention contre le feu est une sensibilisation poussée des populations locales, cette session ne s'est pas contentée de d'aborder les aspects techniques de protection des peuplements contre le feu, mais elle a développé également l'aspect théorique du feu, des facteurs intervenants dans sa propagation et les dégâts qu'il provoque sur les végétaux, la faune et le sol afin que lors les réunions de sensibilisation et des interventions en milieu scolaire, les agents du service forestier soient capables de bien faire

comprendre aux participants l'impact énorme du feu sur le milieu à court, moyen et long terme. Pour le villageois, la notion de protection contre le feu ne doit pas venir uniquement d'un slogan appris par coeur mais aussi d'une réflection personnelle sur l'impact d'un tel phénomène sur sa vie de tous les jours.

La session s'est composée de plusieurs modules

- le feu, les composantes du feu et son impact sur le milieu

  une visite de l'essai 11 détruit partiellement par le feu de juin 1994 a parfaitement illustré:
  - *l'impact du feu sur les arbres et le sol,*
  - *les opérations à réaliser pour "récupérer" un peuplement dévasté par le feu en fonction de l'espèce plantée,*
  - *les opérations sylvicoles de protection du peuplement*;

- l'aménagement des forêts et le plan de gestion sylvicole pour les rendre le moins combustible possible. Les opérations sylvicoles associées;

  A partir de l'expérience de Mangaia et des opérations sylvicoles réalisées après les incendies de 92 et 93, nous avons développé les différents types de plantations, leurs conduites sylvicoles et les avantages/inconvénients qu'ils présentent vis à vis de la prévention des feux et de la protection des sols.

- la conception et l'entretien d'un réseau de défense contre l'incendie;

  Après la partie théorique, un exercice de création d'un réseau de défense contre l'incendie a été fait sur carte pour Mangaia avec:
  - *l'identification points d'initiation possible d'un feu, les facteurs de risques, les points d'appui naturels pour la lutte, les infrastructures existantes et leur état actuel.*
  - *à partir de ce diagnostique, les infrastructures nouvelles à créer, les travaux de remise en état de ce qui existe et les entretiens à prévoir par la suite.*
  - *mise sur pied d'un programme de sensibilisation de la population, de formation et d'entraînement des équipes de lutte contre l'incendie.*

Cette session a duré trois jours complets. Cinq forestiers y ont participé dont un pour chacune des îles concernées (Mauke, Mangaia, Atiu).

IV. Résultats et commentaire des essais

Remarque: La description des résultats des essais est donnée en annexe ainsi que le compte rendu des missions aux îles.

L'évolution depuis le mois de décembre 1994 est sensible mais elle ne marque pas de modification dans la tendance qui ressortait à ce moment. L'élément le plus intéressant quant à l'évolution est la réaction à l'éclaircie des pins réalisées en décembre 1994 qui illustre bien le rythme de croissance des arbres. C'est un des points que nous avons abordé hors session "feu" avec les agents du service forestier.

Le démarrage de la croissance en hauteur auquel nous nous attendions sur *Hymenaea courbaril* ne s'est pas concrétisé en raison du manque d'entretien que nous avons déjà évoqué précédemment.

L'analyse des dégâts causés par les feux qui ont parcouru les essais 11 et 15 ainsi que les plantations de pins de Mangaia permet d'édicter des règles de rattrapage de peuplements ravagés par les flammes. Si les espèces ont des réactions différentes face au feu, les résultats à long terme montrent que le traitement post-incendie est le même pour les trois acacias utilisés: un recépage complet à ras de terre pour tous les peuplements parcourus par les flammes (lorsque celles-ci ont brûlé une partie du houppier), puis, six mois à un ans après, une sélection du meilleur rejet et l'élimination des autres.

- *A. crassicarpa* : semble bien rejeter, la mortalité est faible et les rejets, peu nombreux, sont vigoureux et de croissance en hauteur rapide. Le tronc brûlé subsiste jusqu'à pourrissement et provoque des déformations à la base des rejets et empêche une bonne individualisation du rejet par rapport à la souche car ils partent souvent de trop haut.

- *A. mangium* : mortalité faible à forte en fonction de l'intensité des flammes et de l'age de l'arbre (épaisseur d'écorce). Il rejette assez bien en donnant beaucoup de rejets par souche. Le rejets partent souvent sur des hauteur variables du tronc qui peut parfois sembler indemne. En fait, la partie exposée aux flammes a son cambium détruit et le tronc pourri, ce qui ne ressort que deux à trois ans plus tard. L'arbre va casser au niveau des branches ou du tronc, complètement pourri. Le recépage ras de terre est donc nécessaire pour essayer de sauver le peuplement autant que faire se peut.
  Pour *A. mangium*, la provenance semble jouer un rôle dans la résistance au feu par contre cela ne doit rien changer au traitement post-incendie. Il faut tout de même éviter les provenances les plus sujette à mortalité.

- *A. auriculiformis* : son écorce fine ne le protège pas et la partie aérienne est totalement détruite. Par contre la mortalité est assez faible. Les rejets sont nombreux à partir de la souche ou des racines (drageons). La remarque est la même que pour *A.crassicarpa*.

Pinus caribaea hondurensis est par contre très résistant au feu, dès que sa taille permet au bourgeon terminal d'être protégé des flammes (4 à 5 mètres). Des arbres au houppier quasiment détruit reverdissent et si leur croissance en est fortement affectée, les dommages au tronc sont peu importants et ne remettent pas en cause le peuplement.

V. Rencontre avec le directeur des finances, du budget et du développement économique

La rencontre avec M. Lloyd POWELL s'est déroulée dans un contexte politique et financier très grave pour les Iles Cook. Le gouvernement est en rupture de paiement chronique et les bailleurs de fond (la Nouvelle-Zélande en tête) exigent une remise en ordre de l'économie du pays. M. POWELL a donc été commissionné pour faire ce travail de remise en ordre.

Lors de notre séjour à Rarotonga le salaire de toutes les personnes travaillant pour le Gouvernement a été réduit de 15% et les informations ultérieures que nous avons reçues depuis font état d'un projet de licenciement massif parmi les employés du Gouvernement. Ces événements sont fortement ressortis de cet entretien qui s'est axé surtout sur l'aspect économique des plantations de pin et l'activité économique qui doit en ressortir.

Monsieur POWELL est très intéressé par la filière bois dans les Iles Cook car il y voit les moyen d'une production locale permettant une activité économique importante à l'échelle de l'île de Mangaia et une économie substantielle en devise pour le pays.

En outre, dans la crise actuelle de sureffectifs flagrants des services publics il y voit aussi une activité demandeuse de main d'oeuvre et il n'hésite pas à envisager d'y affecter d'office une partie des sureffectifs qui encombrent tous les ministères !

Etant propriétaire forestier lui même, il appréhende bien ces problèmes et nous a surtout demandé de lui donner des éléments de croissance, de production et de ressource disponible ainsi que des renseignements techniques sur les qualités technologiques de ce bois de pin et les traitements nécessaires pour arriver à une préservation sérieuse tout en prenant en compte les risques de pollution inhérents à une petite unité de traitement dans des conditions insulaires (traitement suffisant et si possible avec un produit faiblement toxique).

Nous avons abordé la quatrième mission de la convention concernant un plan d'aménagement forestier des forêts des Iles Cook. Il nous demande d'appuyer ce projet de notre mieux. C'est une opportunité à ne pas manquer pour les Iles Cook et il va la soutenir de son côté.

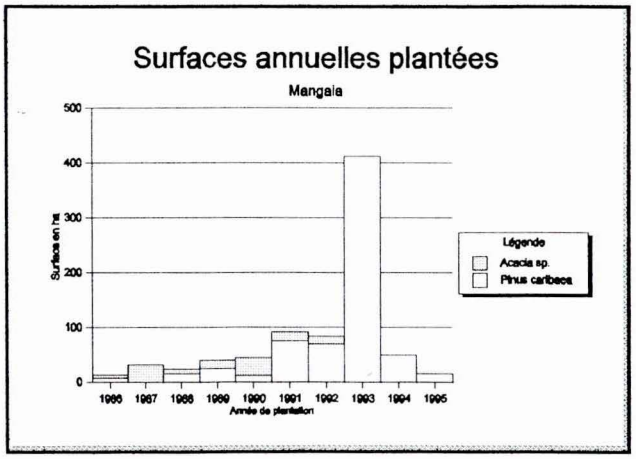
Nous avons pu lui fournir les éléments demandés selon nos connaissances actuelles de la croissance des pins et par comparaison avec les données actuellement en notre possession concernant les qualités technologiques du pin:

Surfaces actuellement plantées en pin:

Mangaia:	685 ha (plus les plantations de fin 1995 non répertoriées lors de mon enquête)
Atiu:	120 ha approximative-ment
Mauke:	15 à 20 ha approxima-tivement

Distribution annuelle des surfaces plantées sur Mangaia :

voir Figure ci-contre:



La répartition des surfaces est extrêmement déséquilibrée en raison du passage des incendies de 1992 et 1993 qui ont détruit une grande partie de la zone plantée et qui ont été suivis d'un effort de replantation très important et systématique en 1993. Ce déséquilibre va rendre très problématique la gestion de la filière en raison de surfaces énormes à traiter en même temps, sans

répartition dans le temps. Le bois arrivera en volumes importants pendant de courtes périodes. Un plan de gestion sylvicole très fin est donc nécessaire en tenant compte des croissances plus ou moins importantes selon la station afin de répartir la récolte de la façon la plus étalée possible dans le temps en ajoutant des éclaircies supplémentaires au régime à une éclaircie forte unique qui est préconisé actuellement. Ceci est favorisé par le fait que la densité de plantation d'avant1993 est de 1100 tiges à l'hectare au lieu des 625 tiges à l'hectare actuelles. Leur surface est néanmoins restreinte et leur étendue dans le temps n'est que de cinq ans.

Production des peuplements:

Selon nos comparaison avec les production calédoniennes, bien inférieures à celles observées aux Iles Cook, il est possible de tabler sur une production moyenne de 20 à 25 m^3/ha/an de bois fort pour une rotation de 20 ans avec une croissance moyenne en diamètre de 2,5 cm/an. Comme la densité de plantation est très faible (625 tiges/ha) la concurrence ne se fera sentir que très tard et dès la première éclaircie les bois d'éclaircie vont fournir des poteaux et des petits sciages. Cette faible densité fait nettement chuter la production annuelle jusqu'à ce que la canopée soit fermée. Quoi qu'il en soit la production globale sur vingt ans devrait dépasser les 300 000 m^3 de bois fort sur écorce pour les Iles Cook et couvrir largement les besoins locaux d'avivés.

Qualité technologique du bois et commercialisation

Les recherches que nous menons sur les bois de pin de Wallis devraient bien cadrer avec cette demande et nous permettre de donner une réponse assez précise. Les données calédoniennes nous permettent d'affirmer que ce bois a des caractéristiques technologiques supérieures ou égales à celles du bois de *Pinus radiata* actuellement importé de Nouvelle-Zélande et un aspect visuel bien meilleur permettant une utilisation en menuiserie.

Son utilisation en bois de structure (marché principal) et de menuiserie est donc assuré pour la consommation locale. Par contre, il est illusoire penser à exporter ces bois en dehors des Iles Cook car le coût de revient ne pourrait pas concurrencer ceux de Fidji ou de Nouvelle-Zélande.

Exploitation des peuplements

Au départ, les plantations de Mangaia ont été financées par la Nouvelle-Zélande dans le but de réhabiliter les sols. Ce projet a été détourné par la suite en plantations de production de bois. Malgré cela, l'aspect environnemental est donc encore très marqué et une étude de faisabilité de différents types d'exploitation devrait être menée pour mettre au points les règles d'exploitations tout en tenant compte de ce qui existe déjà comme desserte routière.

Sciage des bois

Une étude de faisabilité d'une scierie devrait être entreprise assez rapidement afin de définir la politique en la matière. Quelle doit être la taille de cette scierie, où la construire, avec quel matériel ? Comment prendre en compte la dispersion des peuplements sur plusieurs îles. Cette demière question est particulièrement pertinente en ce qui concerne le traitement des bois qui met en jeu, outre des éléments économiques, des contraintes de protection du milieu et des ouvriers, en raison des matière toxiques qu'il nécessite.

Traitement des bois

Comme déjà évoqué, il est nécessaire mais les contraintes humaines et du milieu imposées par l'état insulaire sont très fortes. Une étude est nécessaire pour identifier exactement les traitements idoines pour les conditions des Iles Cook, suffisants en protection mais le moins dangereux possible pour le milieu (et l'élimination des résidus). A partir de là, quelle installation doit être prévue, comment résoudre le cas des îles plus petites (Atiu :120 ha, Mauke: 15 à 20 ha) ?

VI. Rencontre avec le Ministre de l'agriculture

Hon. Vaine TAIREA nous a reçu en début de mission le mardi 13 février 1996 puis nous avons eu un long entretien avec lui en fin de séjour le vendredi 1er mars 1996 pour faire le point sur cette mission et surtout envisager l'avenir maintenant que cette convention arrive à sa fin.

Il nous a félicité pour le travail qui avait été fait par la France en soutien du service forestier des Iles Cook ces six dernières années, en actions de formation des agents forestiers et pour lui la vision constante de plantations qui remplacent désormais une bonne partie des landes à fougère est à l'actif de ce projet. L'autre point de satisfaction est le développement du programme santal qui donne un espoir important de source de revenu à un milieu pour l'instant sans intérêt économique: le "makatea". En tant qu'originaire d'une de ces îles à "makatea" il est doublement concerné et il nous appuie fortement pour la mise au point d'un projet plus poussé de développement de cet arbre sur ces îles. (Nous reviendrons sur ce sujet par la suite dans un chapitre particulier).

La première partie de cet entretien s'est déroulée en présence de M. HonTat TANG, coordonnateur OAA du Projet de développement forestier du Pacifique Sud (SPFDP) financé par le PNUD. Nous avions d'abord abordé les aspects de coopération régionale que nous entretenons avec le SPFDP et pour lesquels les Iles Cook sont concernés et plus particulièrement l'articulation du projet santal aux Iles Cook avec le programme de développement régional de cette essence qui prend forme et qui est piloté par le CIRAD-Forêt/Nouvelle-Calédonie.

Projet forestier sur Puka-Puka:

Comme nous n'avons pas pu nous déplacer sur l'île de Puka-Puka comme nous le souhaitions, en raison de l'absence de vols réguliers vers cette île, nous avons évoqué les actions forestières possibles à partir d'un rapport du chef du service forestier qui s'y était rendu deux mois auparavant. Il y décrit un peuplement remarquable d'espèces locales (*Calophyllum inophyllum, Cordia subcordata, Guetarda speciosa, Pisonia grandis*...). Il y aborde l'exploitation de ces arbres pour produire du bois d'une manière trop détachée qui n'appuie pas assez sur les conséquences d'une telle exploitation qu'il rejette sur la fin en proposant certaines actions de protection. Nous en avons discuté avec lui pour préciser ses conclusions.

Nous avons souligné le danger de laisser croire au gens de Puka-Puka (par une mauvaise interprétation de dires ou de rapports) qu'il est possible de tirer un revenu substantiel de leurs arbres. Ce milieu est trop fragile pour que l'on se permette de jouer à l'apprenti sorcier. Si action forestière il doit y avoir, c'est en direction d'un développements des actions de plantation en zones dégradées ou de cultures (opérations agroforestières essentiellement) ou peut être de développement du santal (mais nous n'y croyons pas trop sur ce type d'atoll) mais pas en direction d'une destruction même partielle de la forêt naturelle, ce qui n'empêche pas des récoltes ponctuelles d'arbres pour des besoins locaux.

Projet de plan d'aménagement forestier pour les Iles Cook

Nous avons aussi évoqué la quatrième mission de la présente convention qui consiste à réaliser un plan d'aménagement forestier d'un pays du Pacifique Sud. Cette idée lui plaît beaucoup et il a insisté pour que cela se fasse aux Iles Cook le plus rapidement possible. Cette réponse cadre bien avec celle que nous avait fait le chef du service forestier qui avait également été très intéressé par cette proposition. Cet aménagement devra prendre en compte tous les aspects forestiers des Iles Cook avec des forêts de productions de bois (pins) des peuplements de protection, des productions forestières non ligneuses (santal, "maire") et des aspects d'impact visuel avec un tourisme très présent sur Rarotonga. Il nous donne son entier soutien et nous assure de la collaboration de ses services pour ce projet (voir Rapport de synthèse : §4.2 : "Proposition de termes de référence pour une mission aménagement aux Iles Cook")

Projet de développement du santal dans les îles à "makatea": suite à donner à la coopération forestière entre la France et les Iles Cook

La convention présente arrivant à sa fin après le projet d'aménagement encore à réaliser, le ministre de l'agriculture a évoqué la suite à donner à la coopération forestière entre la France et les Iles Cook. Il tient beaucoup à ce qu'elle continue et se renforce même - son grand regret ayant été l'absence d'un forestier français en poste fixe aux Iles Cook durant ces trois dernières années-.

A notre avis, la plus intéressante voie de développement actuelle en matière forestière dans les Iles Cook est la mise en place d'un programme d'extension du santal. En effet, les terrains "classiques" pour une mise en valeur forestière par plantation sont pratiquement tous reboisés. L'effort dans ce domaine doit maintenant concerner leur aménagement, leur gestion et leur mise en valeur par une filière de transformation des produits. Le santal, par contre, qui est bien adapté aux conditions de milieu des îles à "makatea", va permettre une mise en valeur d'un milieu jusqu'alors quasiment improductif. Les techniques de plantation préconisées ont un impact visuel faible sur le milieu et ne nécessitent pas un suivi très long en raison de la faible dynamique de la végétation encaissante. En outre, cette voie a la grande particularité d'être toute nouvelle et d'ouvrir un champ de recherche très prometteur ainsi que l'assurance d'une image de marque réelle tant pour les Iles Cook que pour la France qui a déjà soutenu les prémices de ce projet. Le CIRAD-Forêt / Nouvelle-Calédonie détient la connaissance des techniques nécessaires à ce développement et il est important de ne pas laisser échapper les avancées en ce domaine très prometteur. La recherche australienne, elle aussi en pointe dans ce domaine pour les espèce de santal australien n'attend que notre retrait pour se lancer dans la brèche.

Nous avons donc exposé au ministre le projet de développement des plantations de santal sur les îles à "makatea" du Groupe Sud que nous avions mis au point avec le chef du service forestier.(voir Rapport de synthèse : § 6 : "Proposition de projet de développement du Santal dans les îles du Groupe Sud"). Il consiste en la mise en place sur chacune des îles de plusieurs parcelles de santal de taille suffisante pour que les aspects économiques de cette plantation puissent être évalués et la sylviculture affinée en fonction du type de terrain sur lequel elles sont réalisées.

Le ministre a demandé que ce projet soit présenté à la France pour en obtenir le financement car en l'état actuel le gouvernement des Iles Cook n'est pas en mesure d'assurer la totalité du coût de ce projet. Il tient absolument à une continuité de la coopération forestière avec la France et la poursuite des liens étroits tissés avec le CIRAD-Forêt particulièrement dans le domaine du développement du santal qui est l'espoir d'une production rémunératrice pour les îles à "makatea".

Autre domaines d'interventions évoqués

Le ministre a, lui aussi, évoqué le grand besoin du développement à relativement court terme maintenant, d'unité(s) de sciage et de traitement qui soi(en)t en mesure de transformer la ressource de bois de pin qui va bientôt être disponible sur Mangaia et Atiu. Il nous a demandé aussi de proposer un projet d'étude (technique et économique) d'une telle unité afin que la mise en place de cette unité puisse se faire dans les meilleures conditions et dès que le besoin s'en fera sentir.

Ce sujet entre parfaitement dans le cadre du plan d'aménagement qui devrait mettre en évidence les besoins en études de faisabilités (exploitation, sciage, traitement) pour la filière bois dans les Iles Cook. C'est un domaine commercial ce qui devrait permettre, une fois les études réalisées, de trouver un bailleur de fond pour soutenir des investissements - qui se devront privés - en la matière.

L'autre domaine de la transformation de la ressource ligneuse qu'il aborde à chacun de nos entretien est le sciage et la transformation du bois de cocotier. Les îles du Groupe nord ont une ressource très importante en cocotiers surannés. Ils ne veulent pas commencer le remplacement de ces arbres (par des jeunes cocotiers) avant la mise en place d'une filière de sciage/ transformation des stipes. Les démonstrations et stages de formations qui avaient été réalisés en

1991 et 1992 ont fortement marqué les esprits et leur concrétisation pratique est une idée constante du ministre.

Ce sujet est très important pour les atolls du Nord mais il devrait être envisagé dans un système intégré de développement de toute la filière cocotier sur ces îles avec la fabrication d'huile, la production d'énergie à partir d'une partie de cette huile (la technique de l'utilisation de l'huile de coco pour faire tourner des moteurs diesel est bien maîtrisée par le CIRAD-SAR) pour permettre des activités annexes rémunératrices: par exemple sciage et menuiserie dans le domaine du bois. Cette idée de chaîne intégrée de développement du cocotier avait déjà été fortement appuyée par Monsieur Gabriel DE TAFFIN, ancien conseiller technique de l'ambassade de France de Suva pour la coopération technique agricole et ancien responsable du centre de recherche sur le cocotier de Taveuni, Fidji, lors de sa mission aux Iles Cook en 1993.

VII. Rencontre régionale des chefs des services ruraux des pays de la région

Lors de notre séjour rarotongien, nous avons eu l'occasion de participer à la session d'ouverture de cette réunion à laquelle le ministre de l'agriculture nous avait convoqué. Elle est financée et organisée par la Commission du Pacifique Sud (CPS). Ce fut l'occasion de la rencontre de nombreux chefs des services ruraux du Pacifique ainsi que de nombreux experts de différentes origines et domaines d'intervention.

Lors des discours d'ouverture, le ministre de l'agriculture, Hon. Vaine TAIREA nous a nommément félicité en tant que représentant de l'action de la France dans son pays pour l'efficacité de notre travail et en exemple d'action de coopération réussie et parfaitement intégrée au pays.

Les discussions les plus poussées que nous avons eu par la suite avec les participants concernèrent soit des actions aux Iles Cook - en particulier avec M. Patrice COURTY, spécialiste de la Technologie à la CPS, pour un projet intégré de développement du cocotier -, soit nos interventions de coopération régionale particulièrement dans le domaine du santal avec M. Hon Tat TANG, coordonnateur du SPFDP et M. Olivier TROCME, conseiller technique en matière de coopération agronomique et forestière de l'ambassade de France à Suva en charge de la coopération régionale.

Les autres rencontres furent plus protocolaires avec M. Malcolm HAZELMANN: directeur du programme agricole de la CPS, M. Robert DUN, secrétaire général de la CPS ainsi qu'avec les représentants politiques et coutumiers des Iles Cook: Son Excellence le représentant de la Reine, M. Apenera SHORT, toujours très intéressé par notre projet forestier et à qui nous avons présenté notre mission et les propositions de projets ultérieures; Pa Ariki, présidente de la Chambre des Ariki (chefs coutumiers).

ANNEXE 1

RÉSULTATS ET COMMENTAIRES DES ESSAIS

REVIEW OF THE TRIALS

MISSION IN THE COOK ISLANDS

REVIEW OF THE TRIALS

Yves EHRHART

CIRAD-Forêt/Nouvelle-Calédonie

February - march 1996

RESULTS AND COMMENTS

Trial 1 : planted in 1985 - Rutaki

This trial was an elimination trial. It shown what it had to show. Located on fertile soil the major part of the species have quite well grown particularly *Samanea saman*, *Cassia siamea, Cedrela odorata.*
Eucalyptus camaldulensis is now growing quite fast although its initial growth was low.
Leucaena leucocephala was severely affected by *Heteropsylla cubana* but is now quite vigourous and healthy.
Gliricidia sepium grows strongly too, but its shape is always very bushy. This characteristic discards this species to be planted for a wood production target, even if it is only for biomass purpose.
Acacia mearnsii started to grow very fast in height as well as in girth but it was rapidly affected by insect attacks that killed all the trees.

Conclusion : in this fertile soil

Samanea saman, Cassia siamea and *Cedrela odorata* can be grown easily although *Samanea saman* has a bad shape and the stand is very heterogeneous. Its use in extended plantation is not recommended for that reason. *Cedrela odorata* begins now to develop a crown and is the most interesting tree of this trial.
The other species are not recommended for forestry production due to their low initial growth, their bad shape or their important insect damages.

Remark : due to the lack of a statistical layout, no information on production is available for this trial.

Trial 2 : planted in 1985 - Hospitall Hill

Acacia mangium and *Acacia auriculiformis* have grown quite well in spite of the very exposed location on the top of the hill. *A. auriculiformis* was fast growing at the beginning then *A. mangium* grew faster. This behaviour is the same on all the trials. An other explanation of the fast initial growth of *A. auriculiformis* is the location of this species on an old pineapple plot that was fertilised. The vegetation was mainly grasses under the *A. auriculiformis* (fertilised area) whereas it is ferns (*Dicranopteris linearis*) under the others species. Both species where quite heavily damaged by the winds.

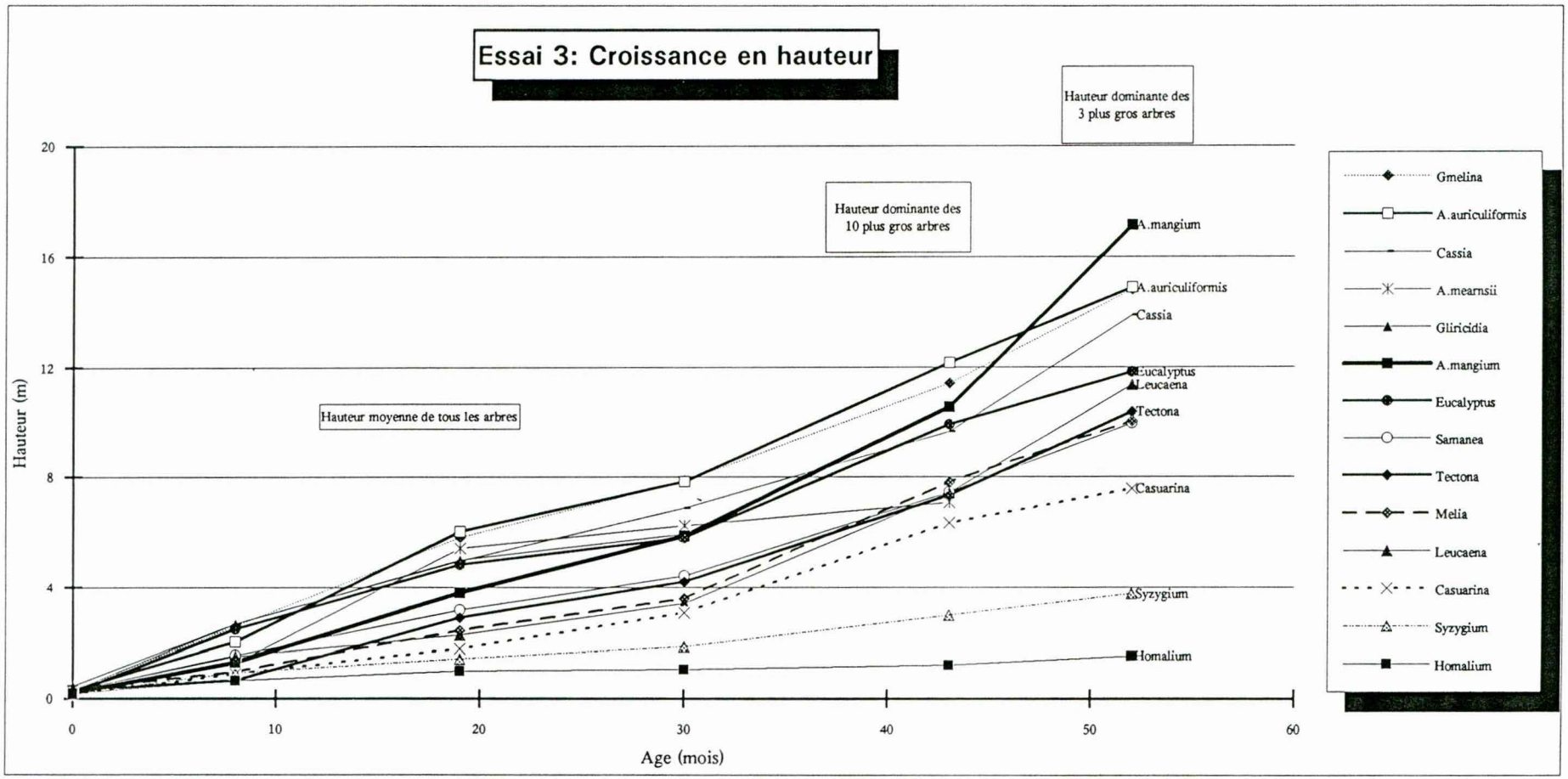
Eucalyptus camaldulensis have not grown properly.

Conclusion

A. mangium and *A. auriculiformis* are interesting species to be planted on fernlands for soil rehabilitation but they would need an initial fertilisation and the wind damages can be important, discarding their trees to give any forestry products other than fire wood.

Although *A. auriculiformis* grows faster, more homogeneously and demands less care than *A. mangium* at the first stage, after few years this latter has a better growth and the biomass production should be better, provided that the stand was carefully maintained during the two first years.

Remark : The same than for Trial 1. The lack of statistical layout hinders us to extract any information on production in this trial.


Essai 3: Croissance en hauteur
Hauteur dominante des 3 plus gros arbres
Hauteur dominante des 10 plus gros arbres
Hauteur moyenne de tous les arbres
Hauteur (m)
Age (mois)
0
4
8
12
16
20
0
10
20
30
40
50
60
A.mangium
A.auriculiformis
Cassia
Eucalyptus
Leucaena
Tectona
Casuarina
Syzygium
Homalium
Gmelina
A.auriculiformis
Cassia
A.mearnsii
Gliricidia
A.mangium
Eucalyptus
Samanea
Tectona
Melia
Leucaena
Casuarina
Syzygium
Homalium

Trial 3 : planted in march 1988 - Turoa

This trial is located in a native forest area on very steep slope, excepted the bottom of the trial where the slope is more gentle and the soil quite deep. In some part of the trial, the soil is very shallow and the weathered rock emerges from the ground level.

13 species were tried, ranging from local species to exotic fast growing species. They can be gathered in three groups depending on their growth ability.

Very low growing species :

Their height growth is very slow at the beginning. Such a plantation needs very frequent weeding for a long period before to begin to grow properly.

The local species *Homalium acuminatum* (MATO) and *Casuarina equisetifolia* (TOA), the long time adopted species *Syzygium cuminii* (PISTACH), and *Melia azedarach* (TIRA) or the recently introduced *Eucalyptus camaldulensis* belong to this group. They cannot be considered for wood production due to their very low growth rate. However, *Melia azedarach* can be used for other purpose than forestry particularly in agroforestry.

Fast growing species

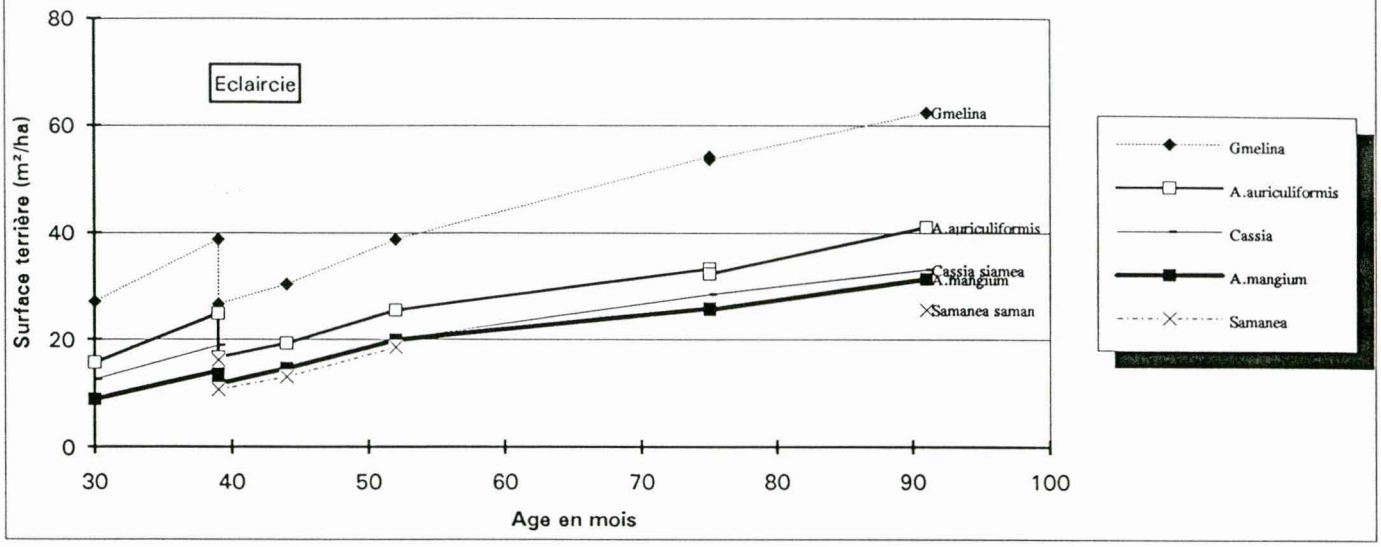
Out of the four species that can be considered as fast growing, the best one in term of wood production is *Gmelina arborea*. Its mean girth is slightly bigger than *A. auriculiformis* and *A. mangium* but its basal area (64 m²/ha) is 50 % higher than the first following species : *A. auriculiformis* (41 m²/ha). This apparent contradiction between the mean diameter and the basal area is due to a very high heterogeneity in the stand of *Gmelina*. The competition between the trees is very high and the segregation between them is strong and occurs very early. The very high initial stocking (4444 t/ha) and a late and low intensity thinning are the reasons of this contradiction. The biggest tree of the trial is from this species : 50 cm in diameter.

A. auriculiformis has a mean basal area of 41 m²/ha significantly higher than the one of *A. mangium* (31 m²/ha) but this latter had a high early mortality due to the lack of maintenance during the first years. If we compare the two plots of the block 1 that were not damaged, the difference between the two species is only of 6 m² (54 m² and 48 m²) that is not statistically significant.
A. auriculiformis was damaged by the strong winds and it seems that it did not recover properly of the thinning. The canopy did not close itself and the crowns seemed to weaken instead of taking profit of the thinning. *A. mangium* plots are heterogeneous due to the competition between trees. The segregation came early and is quite strong. *A. auriculiformis* is more homogeneous but it is always crooked and presents lots of forks (linked to wind damages).

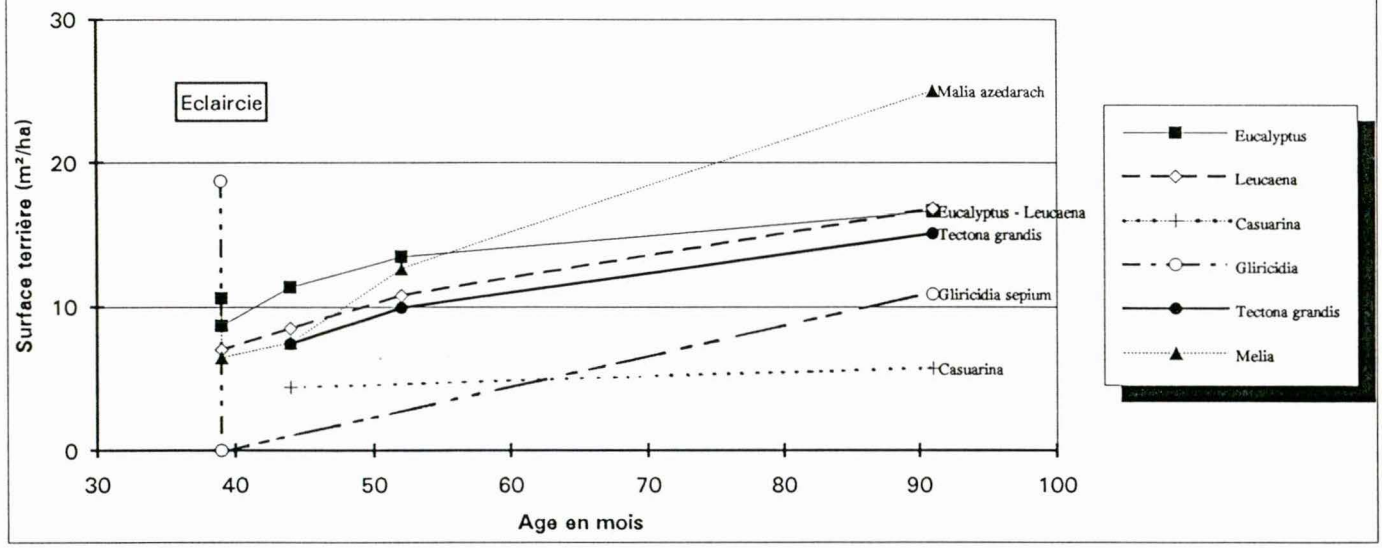
Cassia siamea plots are homogeneous. The shape is beautiful with a quite straight bole and small branches. It reacted strongly to the thinning and the stand closed again rapidly. Its basal area is only of 27 m². Its production is significantly lower than the one of the other three species.

Other species : their growths vary strongly from one of the other but we have discarded them from interesting wood production species due to the special features they present.

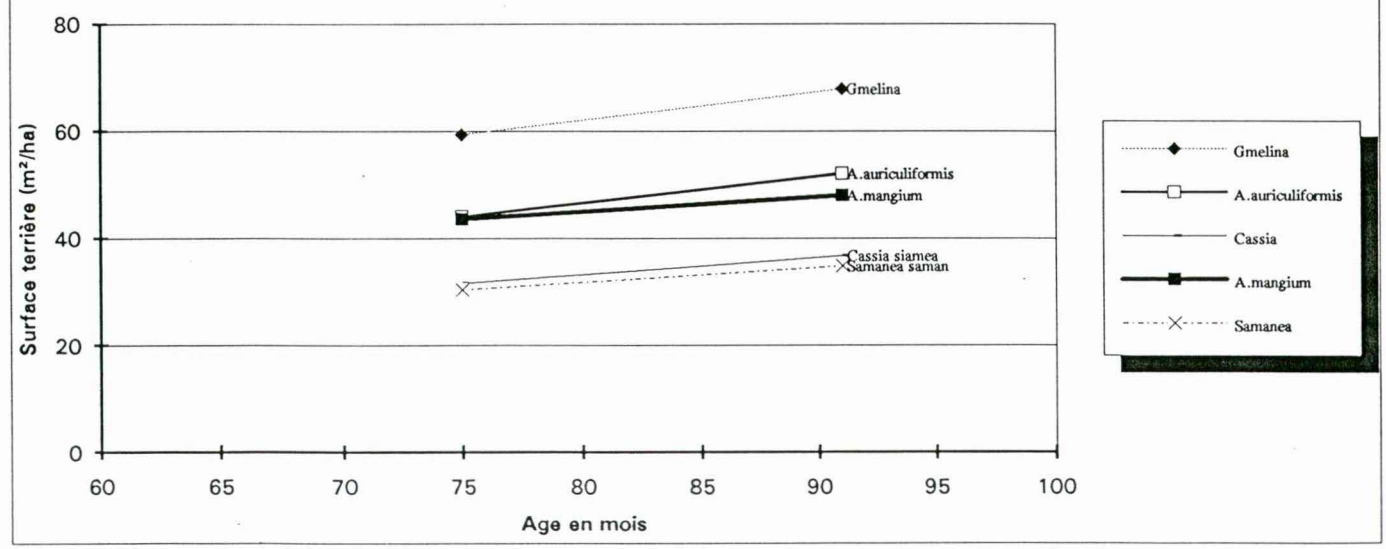
Essai 3: Evolution de la surface terrière



Essai 3: Evolution de la surface terrière



Essai 3: Evolution de la surface terrière: bloc I



Samanea saman : its growth is quite fast, not far from *Cassia siamea* with 25 m²/ha but the stands are very heterogeneous with only few trees dominating many very small trees. An other characteristic is its very bad shape. The bole is leaning strongly and is very short and crooked. Very few of the biggest trees will give a harvestable bole. Otherwise, it is a well adapted species to the Cook Islands on fertile soils.

Melia azedarach (TIRA) (25 m²/ha), the plots are heterogeneous and the initial growth was low. The boles are straight.It needs a strong attention during the first years (weedings). It is mainly interesting for agroforestry and alley cropping due to its special phytosanitary characteristics.

Leucaena leucocephala (NITO) : took a long time to grow due to severe attacks of *Heteropsylla cubana*. But, among the plots, some of the trees reach a diameter of 30 cm and the basal area of the plot 2 (Block 1) is 20 m²/ha with five trees over 20 cm of diameter.
This species cannot be recommended for wood production due tot these attacks but its potentiality would be high. Since the differences are high between trees, a selection would be needed for wood production.

Acacia mearnsii : seems to be a very fast growing tree but it is highly prone to insect attacks that destroyed everything excepted 3 trees that have been able to survive in spite of the attacks but they have dried by now. It must be completely banned of any forestry use.

Gliricidia sepium : grows well in the conditions of this trial but its shape is always very branchy and bushy, even after a strong form pruning. Its use as an agroforestry tree should be promoted but it grows reasonably well on rather good soils only. It is highly prone to rat damages : the young branches are eaten.

Tectona grandis (TEAK) : two of them are straight. It is enough due to the size of the plot. They are tall (12 - 13 m) without branch. This high value timber species is well adapted to Rarotonga in fertile soils.

<u>The uses of these trees for soil protection purpose</u> :

The main factor to be considered for soil protection and rehabilitation is the cover of the ground. This cover is made out of green vegetation or a litter of leaves and branchlets. The fertile areas are characterized by a very fast invasion and growth of weeds or vines, very detrimental to the tree growth. One of the factor of success of a plantation will be its ability to close the canopy and suppress the herbaceous vegetation by its shade :

- if it is not the case, the cost of the plantation maintaining would be far too high ;
- if the shade is too dense,an early thinning should be done in order to open the canopy. It will give light to the ground.

This problem can be controlled when the trees produce an important litter of dead leaves that cover the soil and protect it from the erosion. This abundant litter is linked to the decay speed of the litter too. With a low decay rate, the litter can be thick whereas with a fast decay rate the litter will be very thin. For that reason, a species with a fast turnover that would improve the soil in a flat area would facilitate the erosion in slopes not protected by a thick litter of leave. Among the

tried species, we have several cases :

Syzygium cuminii : once the canopy closed (it is quite long), the very dense shade eliminate all the vegetation. There is no litter under it. The soil is highly prone to erosion.

Gliricidia sepium : it gives a dense shade that eliminate all the vegetation under it. The leaf fall is periodic and abundant but they decay very quickly leaving a bare soil. Thinnings help only for a short spell due to the coppicing ability and the bushy shape of the tree. This tree is very good for soil improvement in agroforestry, alley cropping but must be discarded for large planting on areas prone to erosion.

Gmelina arborea : it gives a dense shade and the leaves decay quickly. It can be dangerous to use it in areas prone to erosion. In the other hand, it demands a very strong silviculture with early thinning. That should be sufficient to provide enough sunlight to soil and have a living vegetation on it.

Acacia mangium gives a thick litter that decays slowly and protects efficiently the soil to prevent erosion once the ground vegetation is controlled or suppressed.

Acacia auriculiformis : control the ground vegetation faster than *Acacia mangium*. The litter is quite thick and protects efficiently the soil if it is undisturbed (men or animals).

Eucalyptus, Casuarina, Homalium, Melia, Leucaena : their very low growth or their light foliage has not controlled at all the ground vegetation. However, if not attacked by *Heteropsylla cubana, Leucaena* could form a dense stand with a very fast decay of the litter. The canopy is not dense enough to eliminate all the ground vegetation.

Once the height of the stand is tall enough (more than 10 m), the canopy is far from the ground and the light is strong enough to allow a shade vegetation to grow (mainly ferns found in native forest). Out of all the trees tried, only *Syzygium* has presently a bare soil under it.

Conclusion :

Among all the species tried, in this trial, several of them are well adapted to this station with high wood productions.

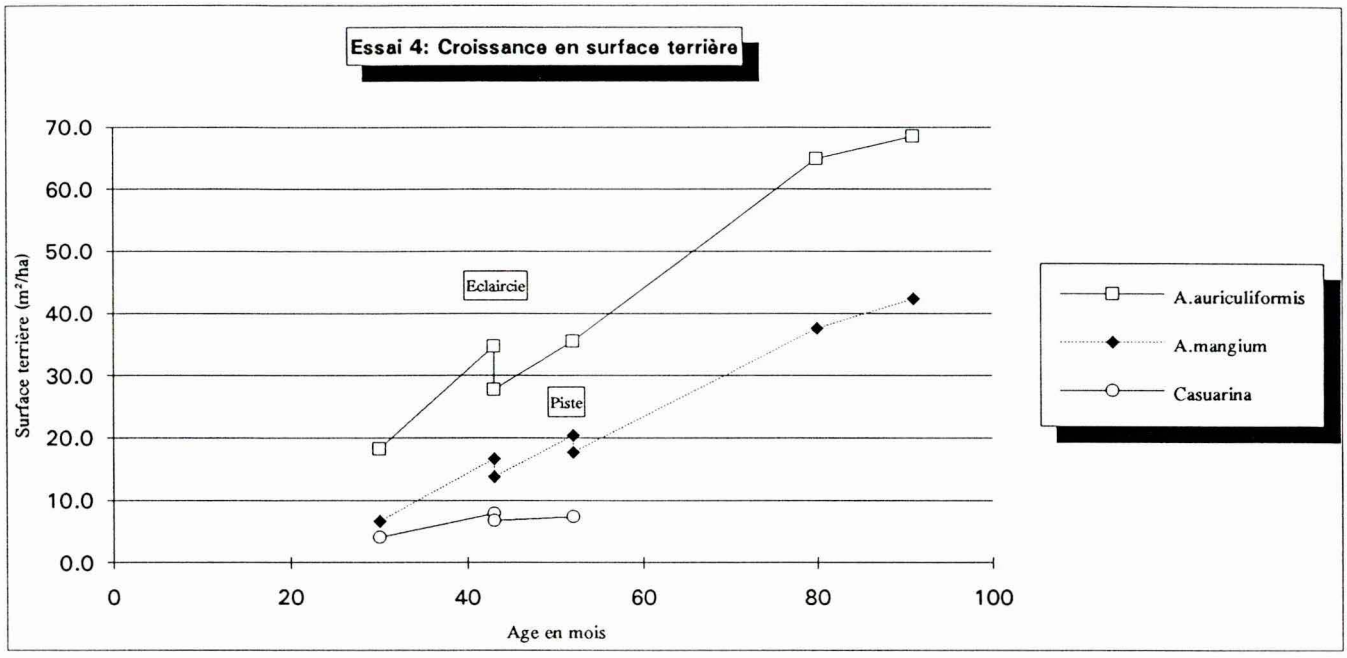
- *Gmelina arborea* : the best growing species with a basal area of 64 m²/ha and an average height of 18 metres at 8 years. The shape is rather good. It could easily be used for timber production on fertile soils. The silviculture must be strong with early thinnings. The soil under its stands is quite prone to erosion the first years.

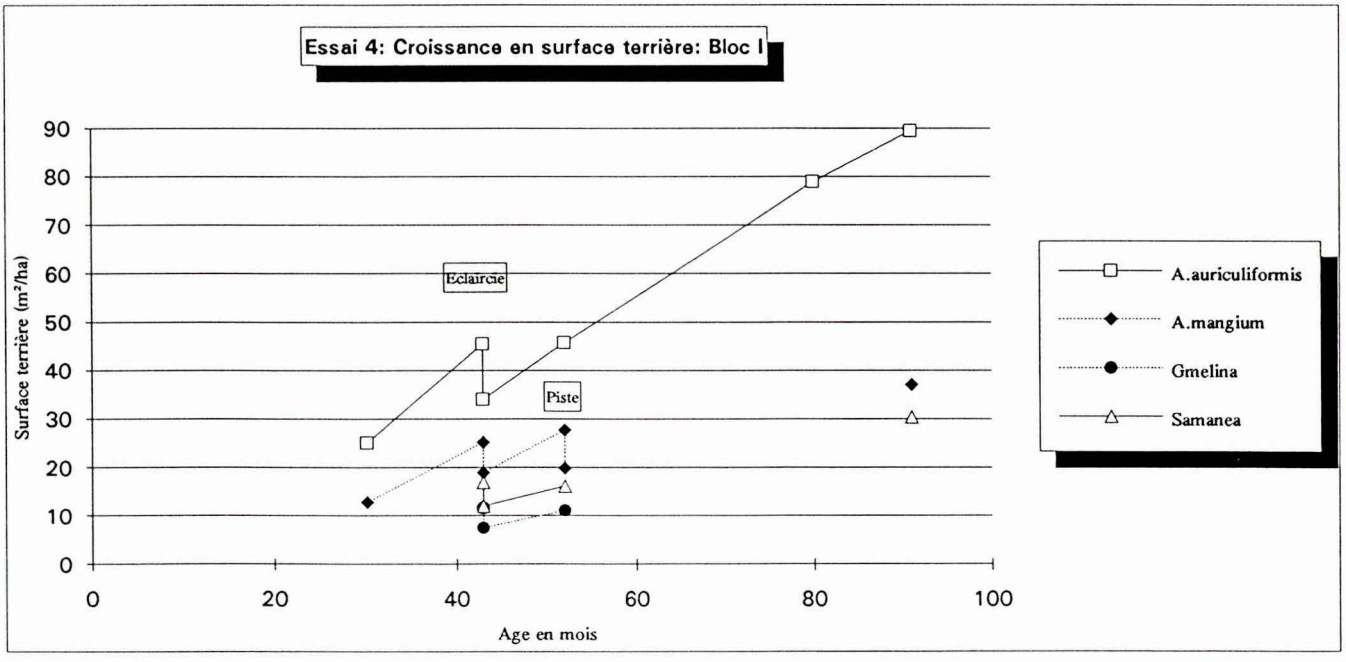
- *Acacia auriculiformis :* fast growing at the early stages, it gives mainly crooked boles with forks. It is prone to wind damages. Its production is high with a basal area of 41 m²/ha at 8 years and a height of 16 to 18 metres. It has not properly recovered of the thinning done at 3 years old. Its rather bad shape and the damages due to the wind allow to expect only the use of this species for fire wood or pulpwood, if wood production is the target. It can be used in an other way for protection, beautification or soil improvement.

- *Acacia mangium* : badly disturbed by the lack of maintenance, this species shows a good growth in the only complete plot. The shape is rather good and the basal area is slightly

less than the one of *Acacia auriculiformis* : 31 m² in average but 48 m²/ha in the plot 1. The trees are prone to wind damages. It has well reacted to the thinning. It needs a strong early silviculture too. Its main wood production uses are fire or pulp wood and if the stand has not been affected by wind damages, few timber logs can be expected. Protection and soil improvement are the main uses of this species.

Among the other species, few of them can be used for agroforestry (*Gliricidia sepium, Melia azedarach*) or for high value timber production as *Tectona grandis*. The other ones give few opportunities for forestry either due to their low growth rate, or to their bad form (*Samanea saman*), or their low resistance against insect attacks.


Essai 4: Croissance en surface terrière
Surface terrière (m²/ha)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
20
40
60
80
100
Age en mois
Eclaircie
Piste
A.auriculiformis
A.mangium
Casuarina


Essai 4: Croissance en surface terrière: Bloc I
Surface terrière (m²/ha)
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
Age en mois
Eclaircie
Piste
A.auriculiformis
A.mangium
Gmelina
Samanea

Trial 4 : planted in march 1988 Nikao

This trial is a replication of the Trial 3, but the layout is unbalanced. Only the first plot, located on rather fertile soil and the block 2 located on slightly degraded soil are complete. The block 3 contains only 8 species.

In the same time, the high level of soil fertility variation inside the blocks do not allow a very accurate comparison between the species. The main results are that only few of the trees tried are suited for depleted soils. The only species that growth fairly well are *Acacia mangium* and *Acacia auriculiformis* all the other one are out of interest in fernland.

After eight years, the protection given by the tallest species allow some other species to grow slowly like *Melia azedarach* and *Cassia siamea*.

Acacia auriculiformis is the best species considering the basal area in all the three blocks with a mean of 70 m²/ha. The maximum reaches 90 m²/ha for a dominant height of 22 meters in the block 1. The shape is crooked with many branches. Wind damages are important. (One of the trees is beautiful, straight with small perpendicular branches).

Acacia mangium took a long time to start to grow properly. Presently, they have the same growth rate than *Acacia auriculiformis*. Their total production is far less important with a basal area of 42 m²/ha compared to the 70 m²/ha of *Acacia auriculiformis*. It is also strongly damaged by the winds and the stem is often badly rotten due to these damages. The trees damaged by the winds will rot quickly and be out of any use. Like in the Trial 3, the initial growth of *Acacia mangium* was slow then it increased. The first two years after planting are very important and the weedings must be regularly and perfectly done. During these two years, *Acacia mangium* is highly prone to competition from the ground vegetation. The plots are very heterogeneous due to the lack of a sufficiently strong thinning.

Other species : as mentioned above none of them match the two *Acacia*, even on the most fertile soils.

Cassia siamea : the trees are quite tall and straight in the block 1 and compared to the shape and the damages of the two *Acacia* species, it would give a good substitution species in quite fertile soils. In the two other blocks, it grows very slowly but, under the protection of the neighbouring *Acacia*, their height growth has much increased these last two years. (It is still small and thin).

Melia azedarach : heterogeneous and small. Few interest in this soil, even in the best block. However, the same remark than for *Cassia* can be made about a far better growth under the protection of the neighbouring *Acacia auriculiformis*.

Samanea saman : the growth is not too bad with a basal area of 30 m²/ha on fertile soils, but the plot is very heterogeneous and the shape of the trees is horrible, crooked with many big branches.

Tectona grandis : the height growth is regular. They reach 9 to 10 metres. The trees have no branch yet and the mean diameter remains small. It will really increase once the crown will begin to take shape.

Gmelina arborea : they are badly shaped, branchy and the growth is poor. This trial, compared with the Trial 3 shows obviously the high level of fertility that this species demands.

Gliricidia sepium : grows rather rapidly in fertile areas but its shape is always very bushy even after a severe form pruning.

Casuarina equisetifolia : grows slowly even if its is quite well adapted to this kind of soil. It is very windfirm but its wood production is very low. The species must be used as windbreak particularly along the exposed areas like ridges.

Eucalyptus camaldulensis : few trees have begun to grow in height but they are still thin. This species, as well as the other species of *Eucalyptus* tried on Rarotonga, is not recommended at all for wood production.

Conclusion :

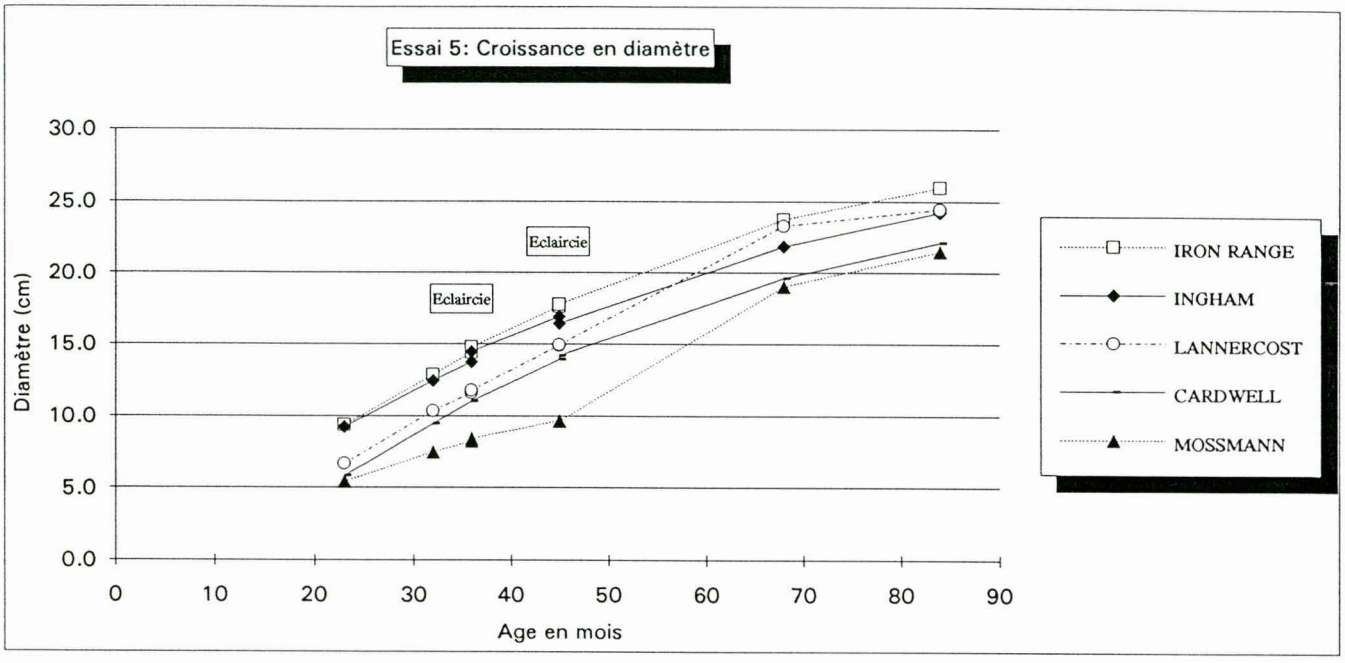
Among the 13 species tried, only two seem to grow properly in this moderately fertile fernland soils.

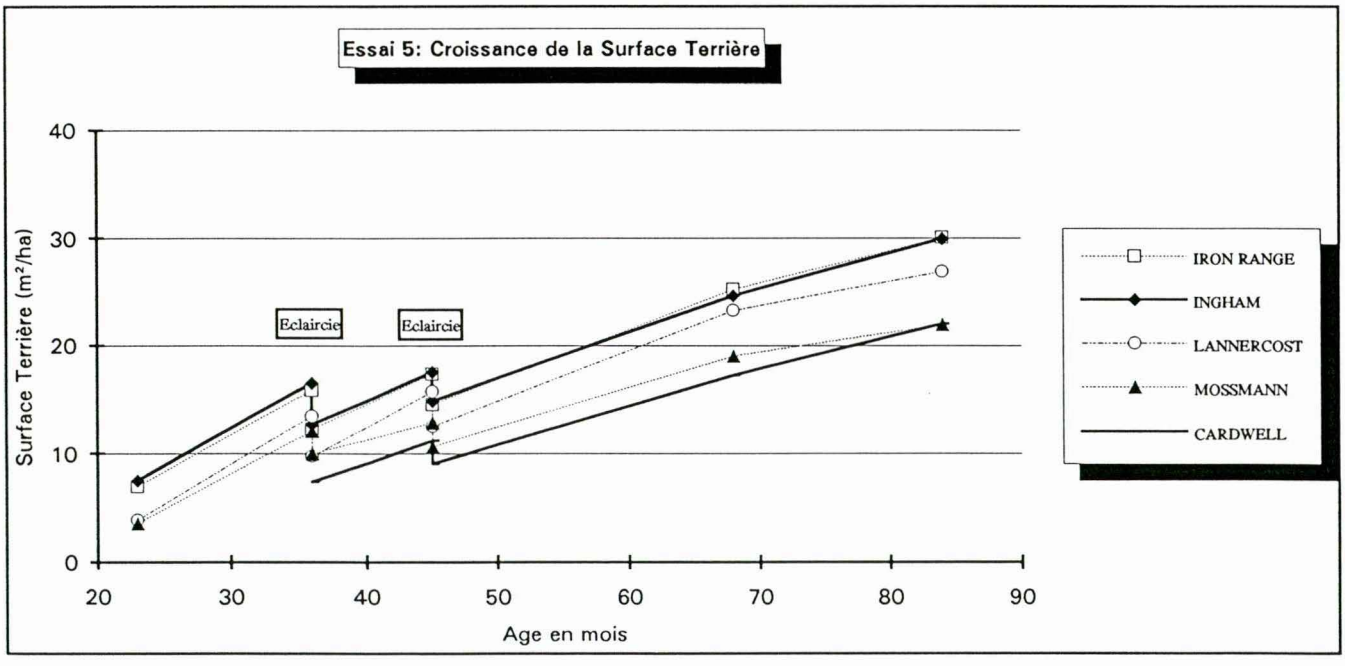
Acacia auriculiformis : it seems to grow far better than *Acacia mangium* but its location in all the blocks is always better than the one of *Acacia mangium.* That explains such a high difference. The production of *Acacia auriculiformis* is very high reaching a basal area of 70 m^2/ha [the plots are small and the border effect is high due to the huge difference in size between species].
Both *Acacia* species were badly damaged by the wind and the bole are badly rotten. Few uses of this wood can be envisaged excepted for fire wood.

Cassia siamea could be a substitution species that has a straight bole and, even if the growth rate is lower, the utilisable wood is higher due to the bole shape. However, it must be restricted in fertile areas. The other species have no interest for wood production in this kind of soil.

Acacia auriculiformis has suppressed the fern *Dicranopteris linearis* and the ground vegetation is presently composed of ferns like *Asplenium sp.* and few *Lantana camara*. Good decay of the litter that is not very thick.

Acacia mangium : *Dicranopteris linearis* is controlled but it is still far to be eliminated. The decomposition of the litter is low.


Essai 5: Croissance en diamètre
Diamètre (cm)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
10
20
30
40
50
60
70
80
90
Age en mois
Eclaircie
Eclaircie
IRON RANGE
INGHAM
LANNERCOST
CARDWELL
MOSSMANN


Essai 5: Croissance de la Surface Terrière
Surface Terrière (m²/ha)
40
30
20
10
0
20
30
40
50
60
70
80
90
Age en mois
Eclaircie
Eclaircie
IRON RANGE
INGHAM
LANNERCOST
MOSSMANN
CARDWELL

Trial 5 : planted 29 October 1988 - Matavera

Provenance trial of *Acacia mangium*, it experienced several cyclones during its early life that have affected quite strongly the stand. Damages are different than the one occurring on *Acacia auriculiformis*. Top branches are quite big (as big as the main axe) and are very prone to break at the insertion point. After the damage, the trees recover quite well and make several coppices but it is now a weak point that would be easily broken again during strong winds. These damages will badly affect the bole by allowing it to rot, starting from that point. Later on, even if the stem is straight and well pruned, the rot is already inside, consequently, no timber production is available. It can only be used for fire wood (if the wood production is the target). It is very difficult to expect a forest revenue of *Acacia mangium* stand in a country where hurricanes and strong winds are frequent or, only on very protected areas.

Acacia mangium growth is fast and the characteristics of the best provenances of this trial are noteworthy : 20 m high stand, with a basal area of 30 m²/ha in fertile areas ; 16 - 17 m high stand and a average diameter of 22 cm in the less fertile plots (small ridges).

The present stand is good enough to be harvested since it is supposed to give only fire wood. To leave it like now, will allow the wood to decay even more in the stem and to lower the utilisable wood in spite of the total volume increment. An other thinning would only create holes in the canopy, that would get the remaining trees more prone to wind damages.

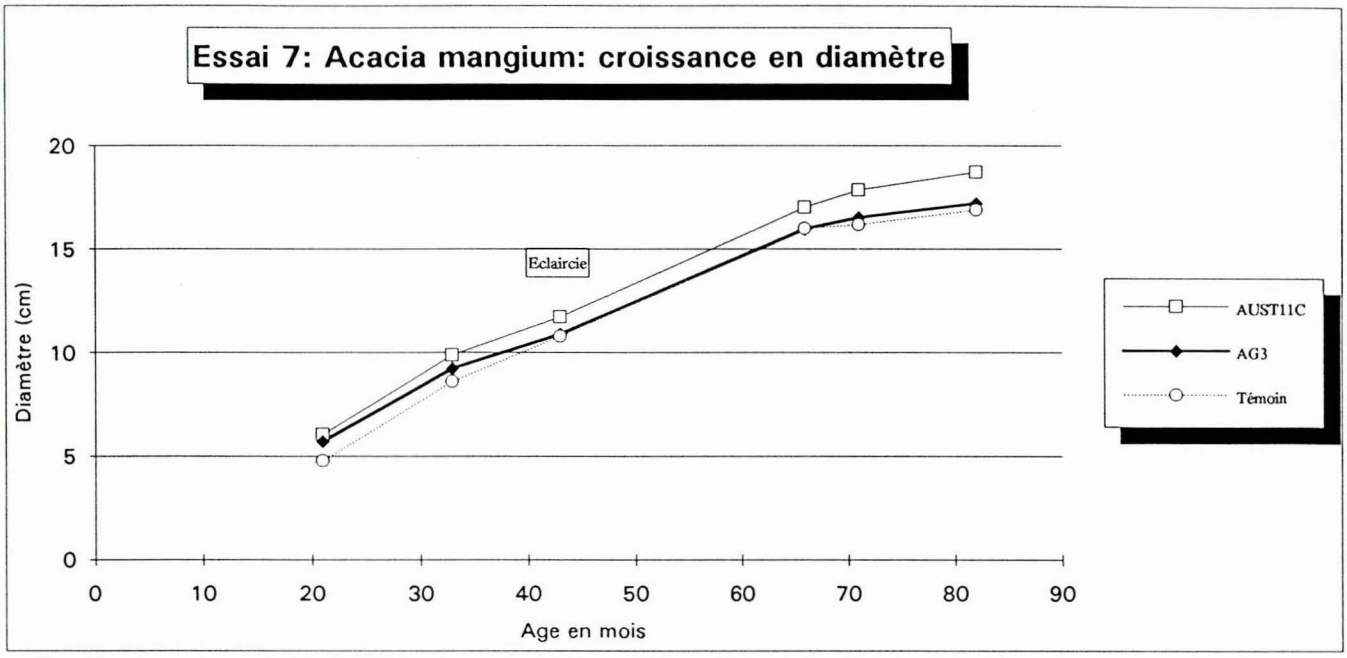
The ground vegetation is well controlled although it is covered with grasses and vines (*Mikena sp.*, few *Momordica sp.* near the borders). Any strong opening or clear felling would burst the growth of it. The diagrammes show that increment in girth is quite regular between the provenances (excepted KURANDA). The initial ranking is almost the same at 8 years as well as the differences between the provenances. This behaviour is quite the same for the basal area. The very early growth of *Acacia mangium* (provenance characteristics, or quality of weedings) is the major determinant for the future growth. It is during the two first years that the final result was settle.

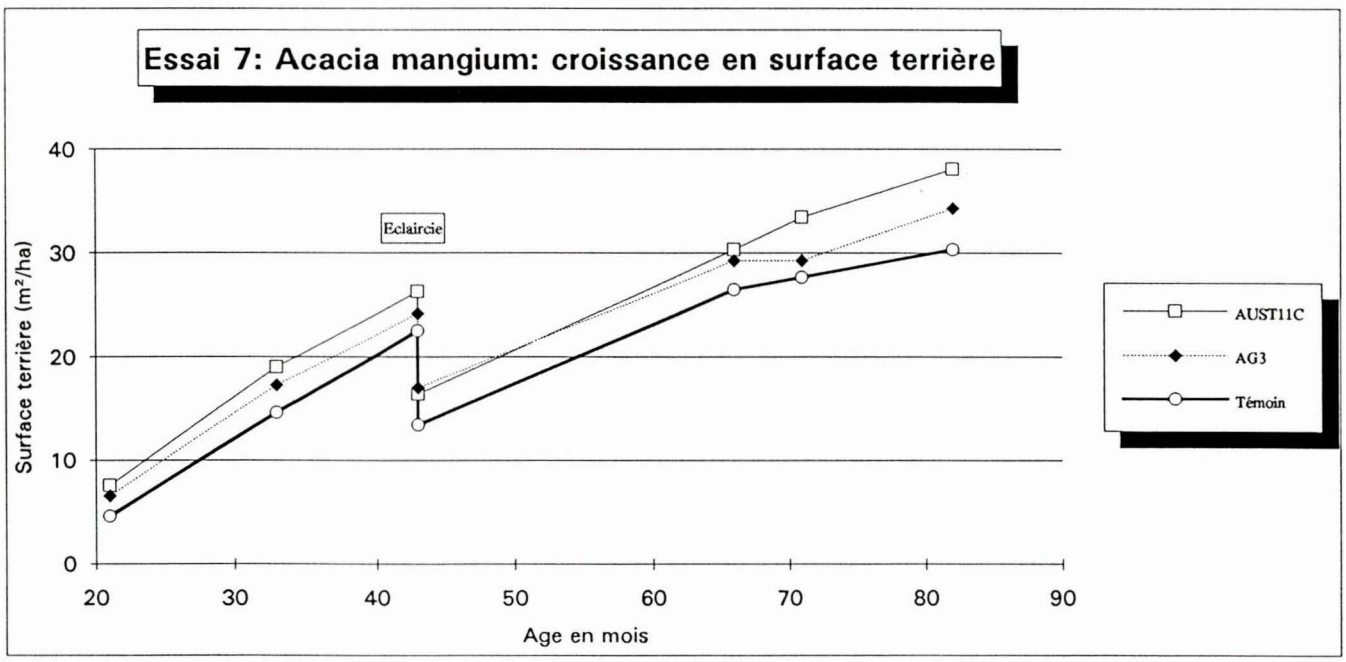
The general decrease in the girth growth rate shows that the stand is too dense. It is the most obvious for INGHAM and LANNERCOST that are the provenances the plots of which are the most dense and regular. For the other provenances, the plots are quite open due to early mortality (MOSSMAN, CARDWELL) or to wind damages (IRON RANGE).

Conclusion :

A. mangium grows fast in fertile soils but its wind weakness does not allow to use it for wood production in the areas that are prone to strong winds and hurricanes. The provenances (all of them are Australian) have shown differences in growth but they are quite stable since the age of two years.

The two first years of growth are essential for the future growth and a perfect stand maintenance must be followed.


Essai 7: Acacia mangium: croissance en diamètre
Diamètre (cm)
Age en mois
Eclaircie
AUST11C
AG3
Témoin
0
5
10
15
20
0
10
20
30
40
50
60
70
80
90


Essai 7: Acacia mangium: croissance en surface terrière
Surface terrière (m²/ha)
Age en mois
Eclaircie
AUST11C
AG3
Témoin
0
10
20
30
40
20
30
40
50
60
70
80
90

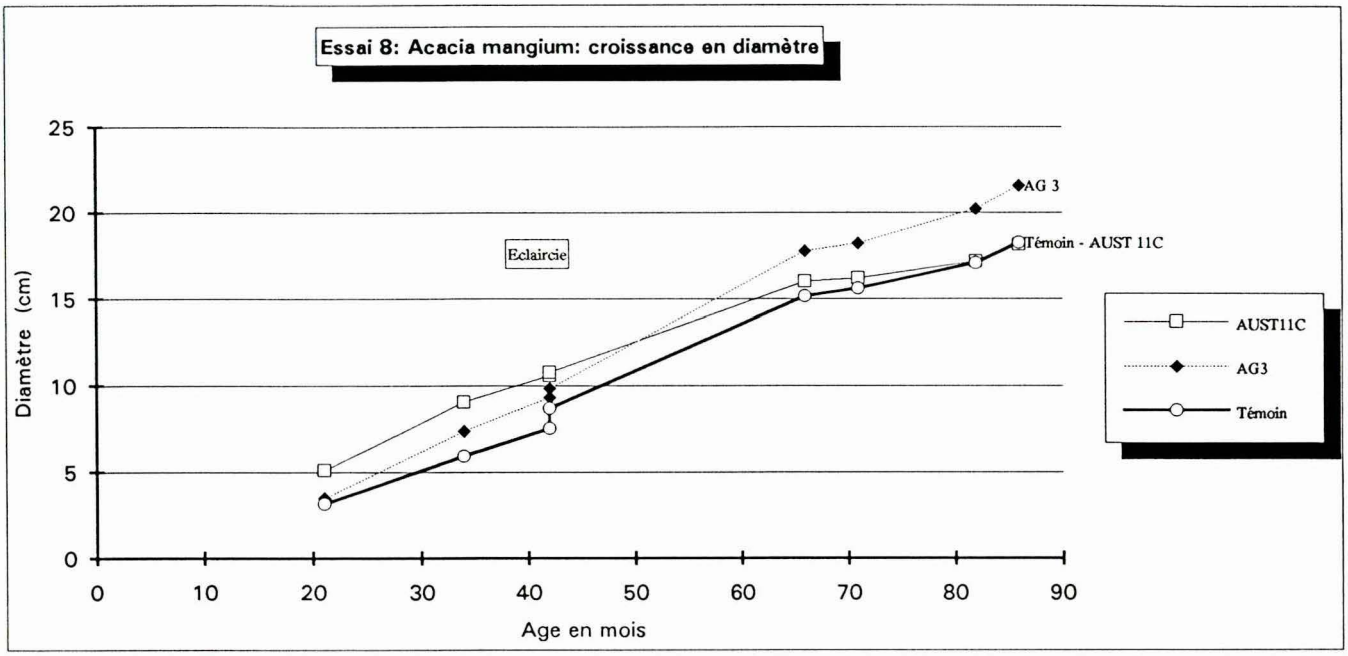
Trial 7 : planting in September 1988 - Turoa

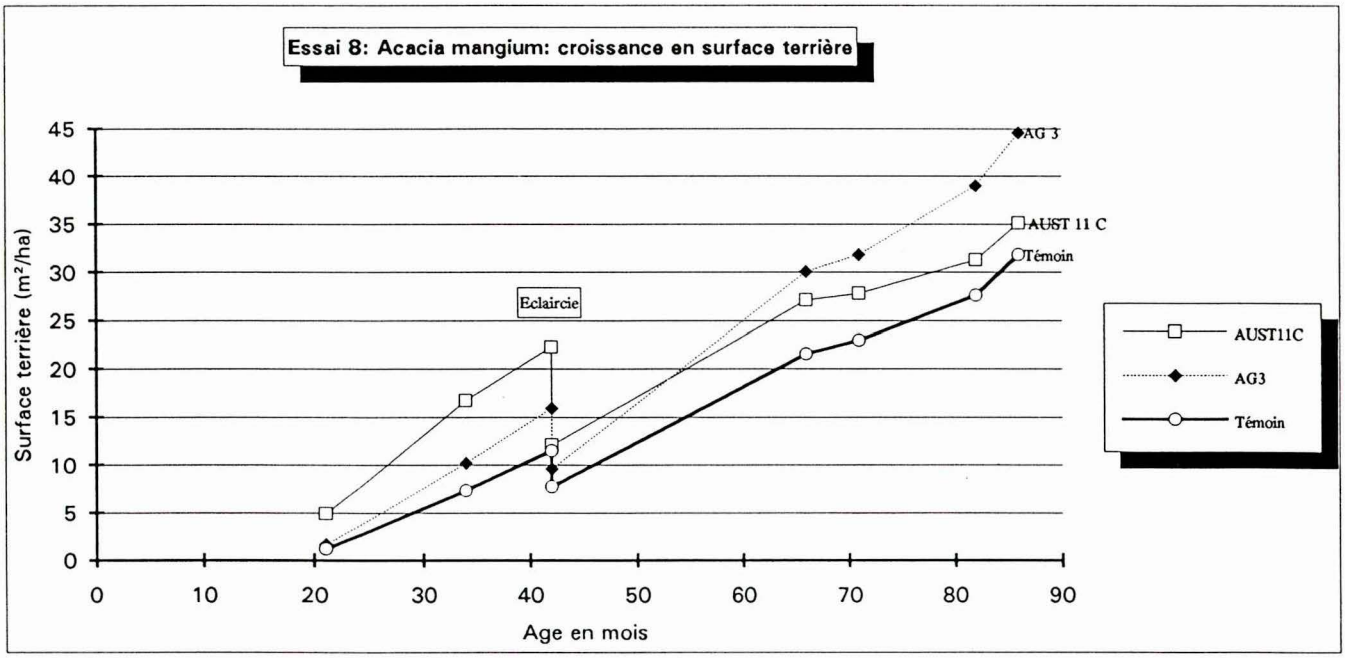
Inoculation trial of two strains of *Rhizobium* on *Acacia mangium*.

The growth of the plots is homogeneous. The difference between the strains is no more statistically significant. The canopy is closed and the ground vegetation is well controlled. This latter has grown a little bit since the thinning, due to the opening of the canopy followed by its elevation that provides more sunlight to the ground. Some native forest tree species are growing under the acacias (*Homalium acuminatum*).

Conclusion :

The inoculation was an important factor in the early growth of the stand. It has given a faster growth and a better homogeneity that influence much on the number and cost of weeding and on the initial silviculture. Once the stand closed after 3 or 4 years, the characteristics of the soil (topography, exposition to the sun...) become more influent than the inoculum.
Both inocula : AUST 11 C and AG 3 ; were efficient, AUST 11 C being slightly better than AG3.


Essai 8: Acacia mangium: croissance en diamètre
Diamètre (cm)
Age en mois
Eclaircie
AG 3
Témoin - AUST 11C
AUST11C
AG3
Témoin


Essai 8: Acacia mangium: croissance en surface terrière
Surface terrière (m²/ha)
Age en mois
Eclaircie
AG 3
AUST 11 C
Témoin
AUST11C
AG3
Témoin

Trial 8 : planting September 1988 - Hospital

The comments are the same than for Trial 7, but since the soil was less fertile, the influence of the strains was higher and a significant difference was obvious between the two strains.

AUST 11C was the best before AG3 and Control. The late evolution of this plot is interesting. Since the thinning, the growth rate has changed and AG3 that used to be the second is now widely ahead of AUST 11C and Control is getting closer of the latter.

This is explained by the exposition to the prevailing winds and the recent enlargement of the road along the plot AUST 11C. It has exposed the trees to the prevailing winds by destroying the bushes along the plot and disturbing the root system of the trees of the first row along the road. In the same time, the 50 % intensity thinning has systematically opened this very homogeneous plot. It has disturbed the stand more than in the other plots were the thinning was more selective. The other plots being more irregular, the weakest trees were cut. The change for the remaining trees was less important than for those of the AUST 11C plot. The best plot is now AG3 which is protected from the wind by the other plots and that has two sides exposed to the sun.

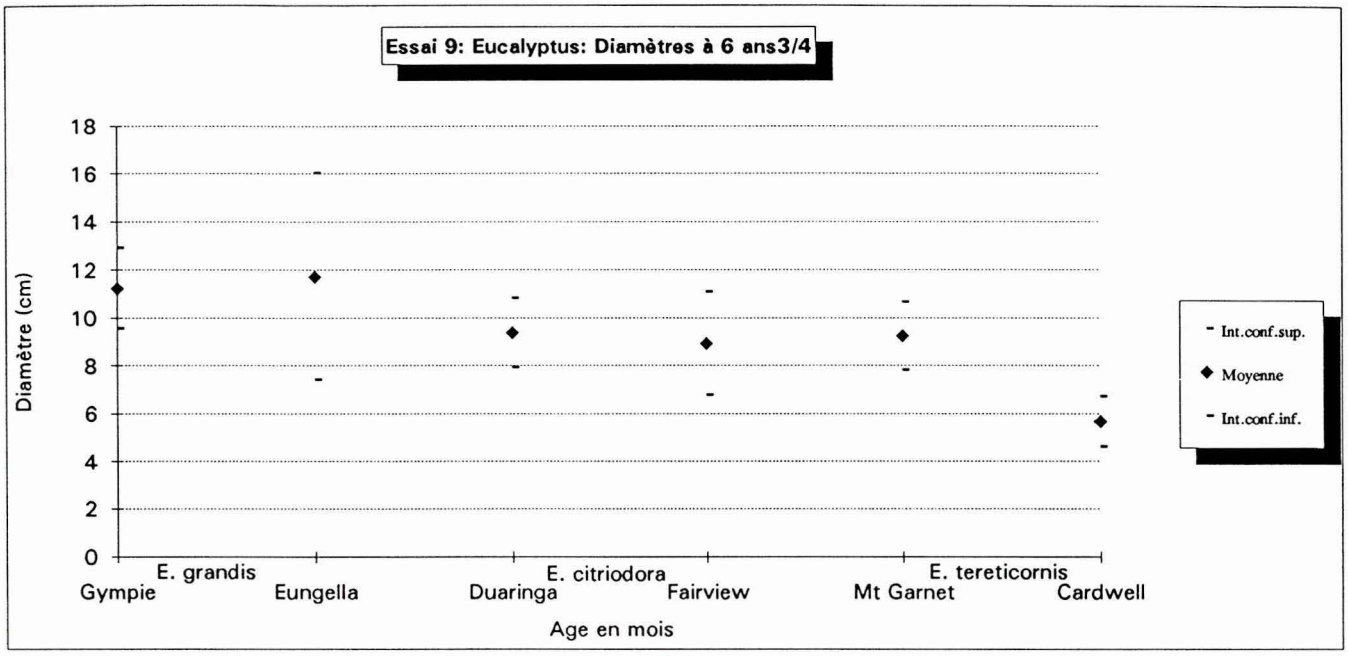
Measurement taken in September 1995 and during the mission in February 1996 shows that the growth during the summer period is higher than the year average growth. The average height of the trees is of 12 m - the tallest reach 14 m in plot 9 - and the basal area is 35 to 45 m^2/ha, depending on the strain.

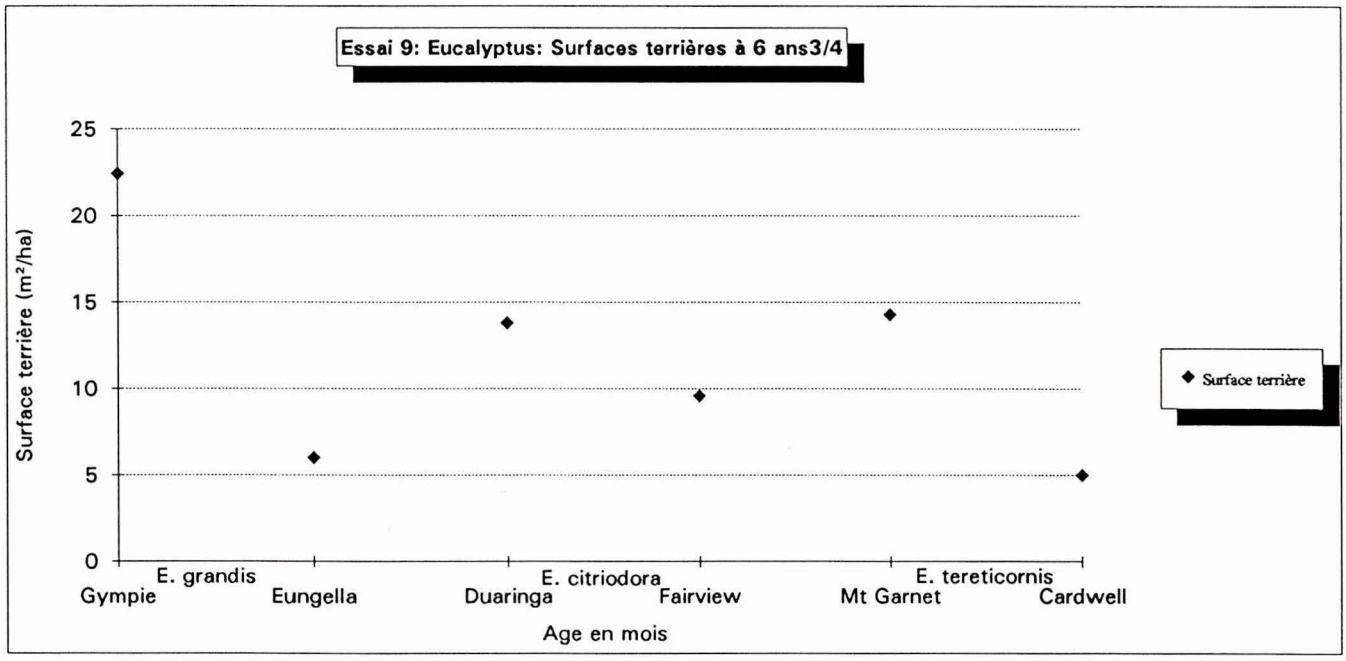
The ground vegetation is well controlled although some *Lantana* are growing again but in limited size. The vertical structure is interesting. Under the canopy, the coppices from the last thinning stumps make an understorey that gives shade and litter. They control the ground vegetation and make up a thick litter protecting the soil.

Conclusion

As for Trial 7, and even more obviously, the inoculation plays a major role in the early growth (and subsequently in the cost of plantation establishment) as well as on the homogeneity between trees that facilitate greatly the silviculture. After 3 to 4 years, when the stand is closed, the growth is then more influenced by the soil characteristics and the silviculture than the inoculum strains.

Strong and early thinnings are needed. If the thinning comes too late, the stand is quite disturbed in its growth and it takes time to recover properly.


Essai 9: Eucalyptus: Diamètres à 6 ans3/4
Diamètre (cm)
18
16
14
12
10
8
6
4
2
0
E. grandis
E. citriodora
E. tereticornis
Gympie
Eungella
Duaringa
Fairview
Mt Garnet
Cardwell
Age en mois
Int.conf.sup.
Moyenne
Int.conf.inf.


Essai 9: Eucalyptus: Surfaces terrières à 6 ans3/4
Surface terrière (m²/ha)
25
20
15
10
5
0
E. grandis
E. citriodora
E. tereticornis
Gympie
Eungella
Duaringa
Fairview
Mt Garnet
Cardwell
Age en mois
Surface terrière

Trial 9 : planting in September 1988 - Hospital Hill

The *Eucalyptus* are now growing quite well in height, but their still low basal area after 7 years of growth eliminate them from any interesting wood production in the Cook Islands. Species and provenances have different behaviour.

Eucalyptus citriodora : both provenances are quite similar. The trees are tall and straight but the diameter is still low. Presently, it seems to increase much. Many of the trees present gum emissions on the trunk that show a sanitary problem.

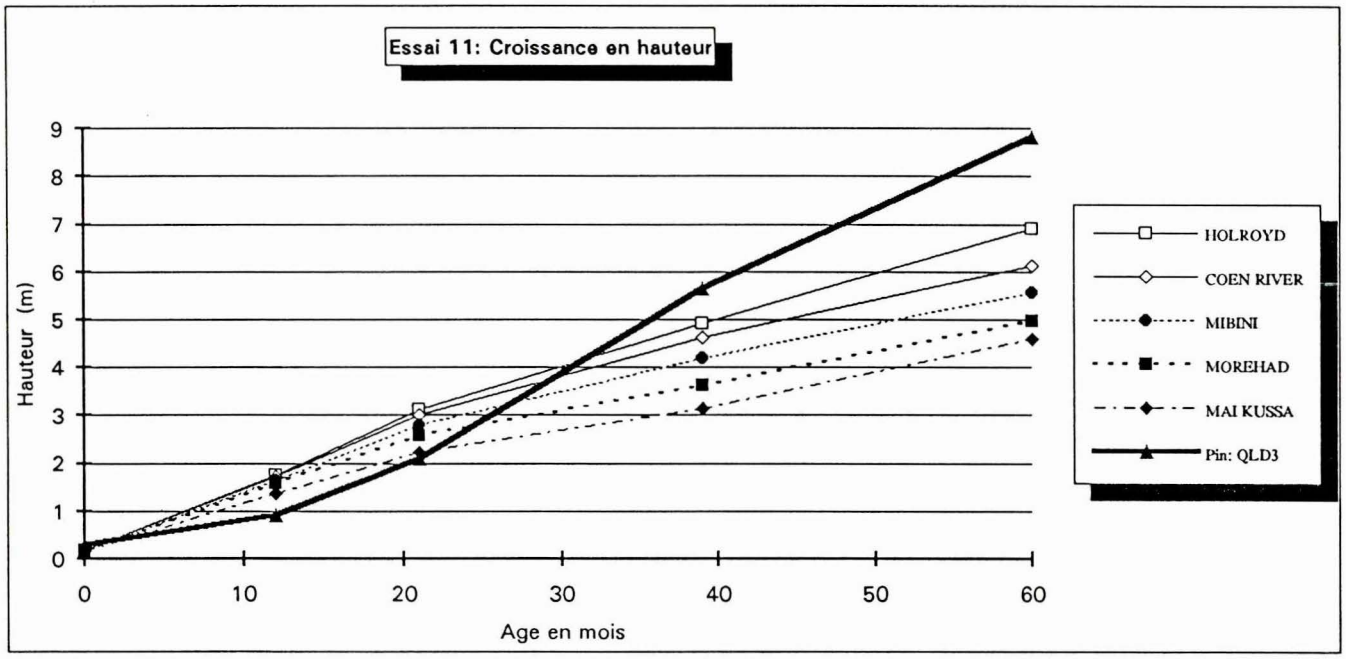
Eucalyptus grandis : the GYMPIE provenance seems better acclimated than the EUNGELLA one. The height is presently of 10 to 12 metres for the tallest trees. The bark is now the one of adult trees and the very intense gum emissions that occurred two years ago seem to have vanished although the bark seems still black coloured. The trees are branchy, particularly in the lowest part of the trunk. The taper of the stem is important.

Eucalyptus tereticornis :
CARDWELL : only thin and small trees.
MOUNT GARNET : few big trees (⌀ 15 cm) but crooked.

Conclusion

Eucalyptus need a very strong maintenance the two first years with a total elimination of the herbaceous competition in order to have a fast early growth. This need can explain - but not completely - the poor initial growth of the stand.

Of all the species of *Eucalyptus* tried in the Cook, among the CTFT trials as well as in the forestry service trials (Mangaia), none of them are really growing satisfactorily in the Cook Islands. The species must be discarded from any wood production plantation in the Cook Islands.


Essai 11: Croissance en hauteur
Hauteur (m)
0
1
2
3
4
5
6
7
8
9
0
10
20
30
40
50
60
Age en mois
HOLROYD
COEN RIVER
MIBINI
MOREHAD
MAI KUSSA
Pin: QLD3

Trial 11 : planting in October 1990 - Raemaru

This trial was severely damaged by fire in June 1994 and the plots of the block I were almost destroyed. However, this fire gave us information on fire firmness of the species and on what must be done following a strong fire that destroyed the major part of the foliage.

Three species are present in the trial.

Pinus caribaea hondurensis : the average height was 6.5 m when the fire occurred. The foliage was destroyed from half to four fifth of the crown. The bark was black but not deeply damaged. None of the tree was killed or too much damaged and their crowns are now healthy. The bark does not show any visible damage.

Pinus caribaea is strongly fire resistant provided that it reaches a height of 4 to 5 metres in order to have its terminal bud out of reach of the flames.

Acacia mangium : depending on the importance of the fire and the size of the trees, the damages are of several types :

- small trees with thin bark : the trees are definitively killed by the fire.
- tall trees with thick bark : depending of the fire intensity the foliage is more or less destroyed and the bark damaged. Excepted for trees that were not damaged at all, the cambium is, at least, destroyed on the windward side(the side where the fire come from) of the trunk. The trees will coppice along the trunk or from the stump. After two years, the trees seem tall and green again but they are completely rotten inside. They will be rapidly broken by winds. Their trunks have no use at all.

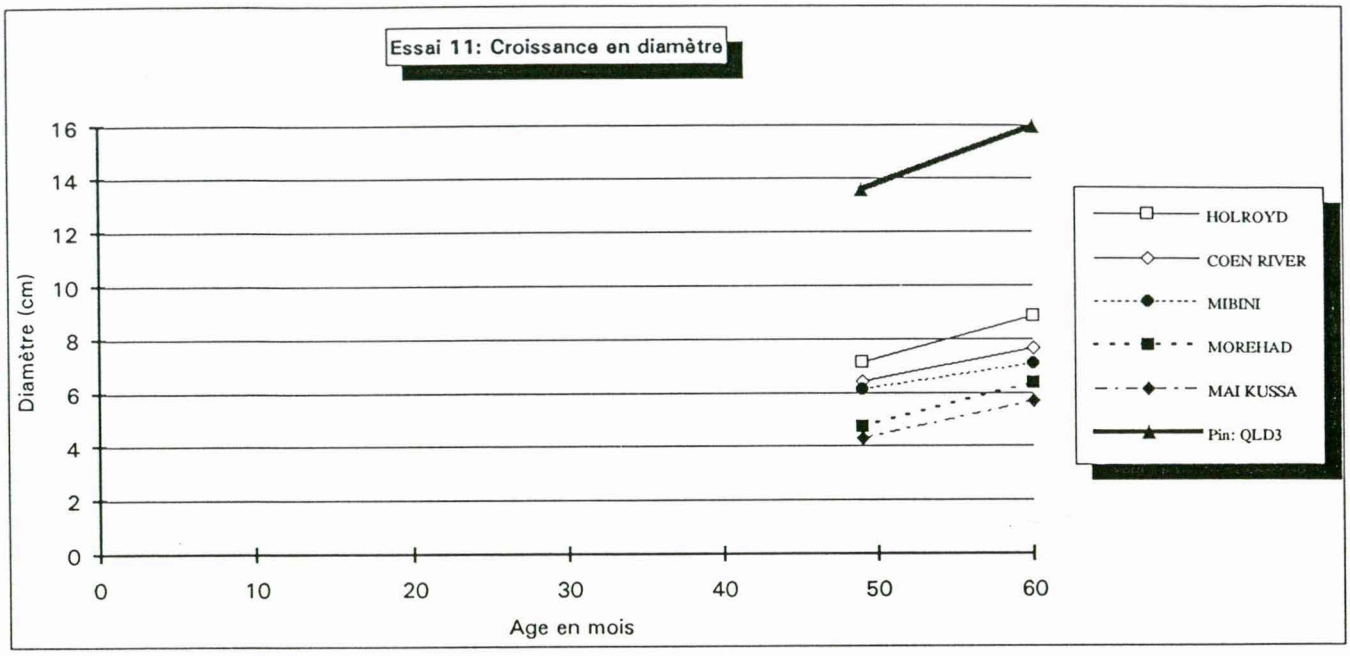
Acacia mangium is highly damaged by fire. The mortality is high and the surviving plants are definitively damaged even when their crowns seem to be only lightly burned. The best operation to be done in a fire damaged stand is to fell down all the trees whatever are the external damages. If they coppice, they will start from the stump and the new trees will be sound. After 6 months, the best shoot will be selected on each stump and the others cut.

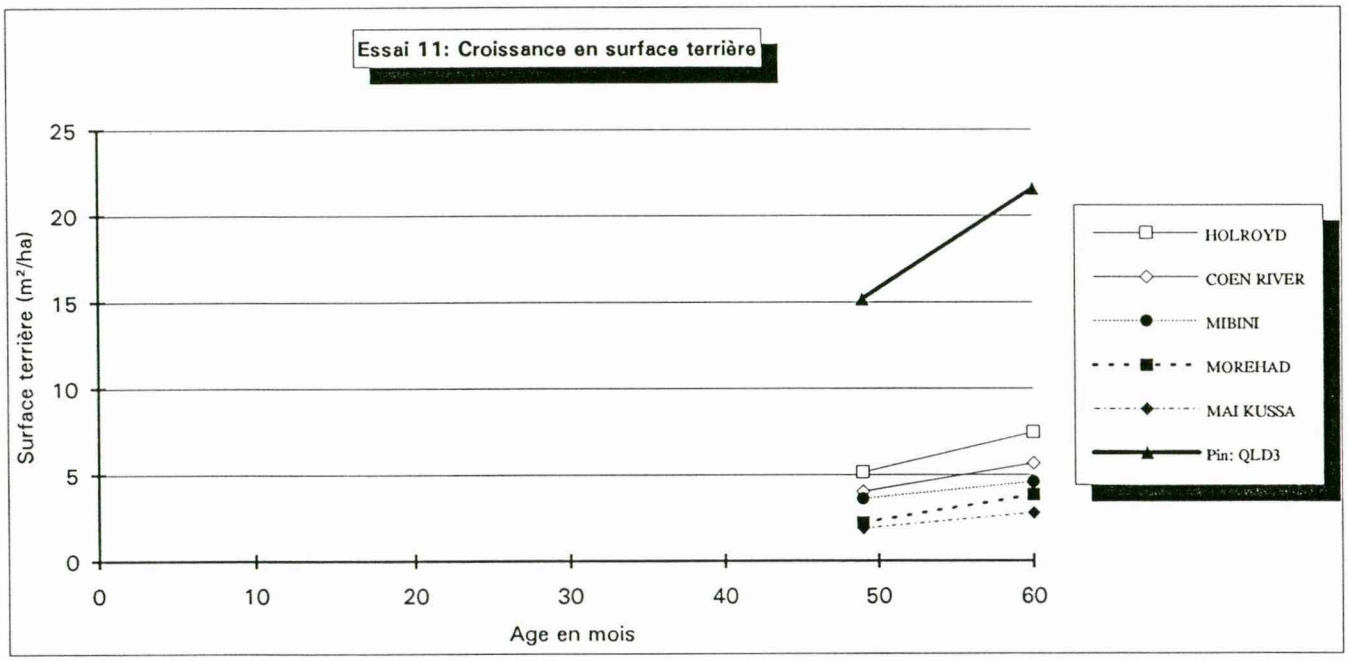
Acacia auriculiformis : the aerial parts of the trees are completely destroyed. However they coppice from the stump or emit suckers. Very few of them coppice from the trunk. The thin bark of this tree does not protect the cambium from the fire. It is destroyed. The mortality rate is low and after 6 months almost all of the stump have coppiced or have emit suckers.

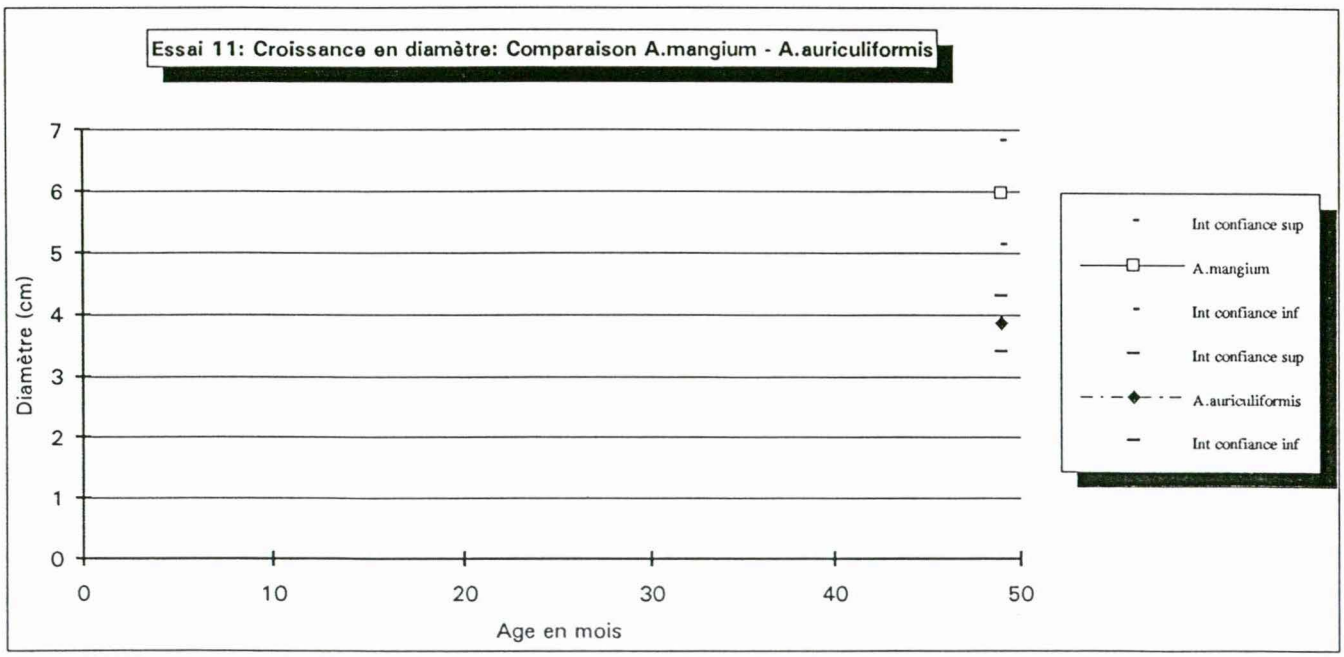
Like *Acacia mangium*, the burned trees must be felled down as soon as possible after the fire. The stumps must be as short as possible. After one year, the best shoot on each stump is selected and the others eliminated.

Due to the destruction of the block I by the June 1994 fire, the two ways analysis of variance is not accurate enough to allow to identify significant differences between the provenances. However, the last analysis of variance with the complete three blocks was highly significant and since it, the ranking of the mean has not changed. The Australian provenances have a better growth than the Papuan provenances although the provenance MIBINI is quite close of them. The shape of the stem and the branching is usually better among the Australian provenances.

The global growth rate is quite low now and the canopy is not closed among the major part of the plots excepted in the rows along the pine plots that were fertilised after planting. This strong


Essai 11: Croissance en diamètre
Diamètre (cm)
0
2
4
6
8
10
12
14
16
0
10
20
30
40
50
60
Age en mois
HOLROYD
COEN RIVER
MIBINI
MOREHAD
MAI KUSSA
Pin: QLD3


Essai 11: Croissance en surface terrière
Surface terrière (m²/ha)
0
5
10
15
20
25
0
10
20
30
40
50
60
Age en mois
HOLROYD
COEN RIVER
MIBINI
MOREHAD
MAI KUSSA
Pin: QLD3


Essai 11: Croissance en diamètre: Comparaison A.mangium - A.auriculiformis
Diamètre (cm)
0
1
2
3
4
5
6
7
0
10
20
30
40
50
Age en mois
Int confiance sup
A.mangium
Int confiance inf
Int confiance sup
A.auriculiformis
Int confiance inf

positive reaction to fertiliser seems to be also linked to the association with pines. The rows located along pine plots that have not grown does not show such a strong positive reaction whereas the quantity of the fertiliser was the same. The location near a healthy and dense plot of *Pinus caribaea* influences strongly the growth of *Acacia auriculiformis*.

The last characteristic interferes with the ranking of the provenances since some of them are close to complete pine plots and other close to nearly empty ones.

The pine provenances are quite poorly shaped but the growth in hight and diameter is strong with an average diameter of 16 cm at five years old for the provenance QLD3 (the only complete plots) and a basal area of 22 m^2/ha. This latter characteristic is three time better than the best *Acacia auriculiformis* provenance.

Conclusion

The Australian provenances of *Acacia auriculiformis* are more adapted than the Papuan ones in the Cook Islands (growth, shape).

Although the initial growth of *Acacia auriculiformis* is rather strong, as soon as the second and later years, it weakens significantly in less fertile soils.

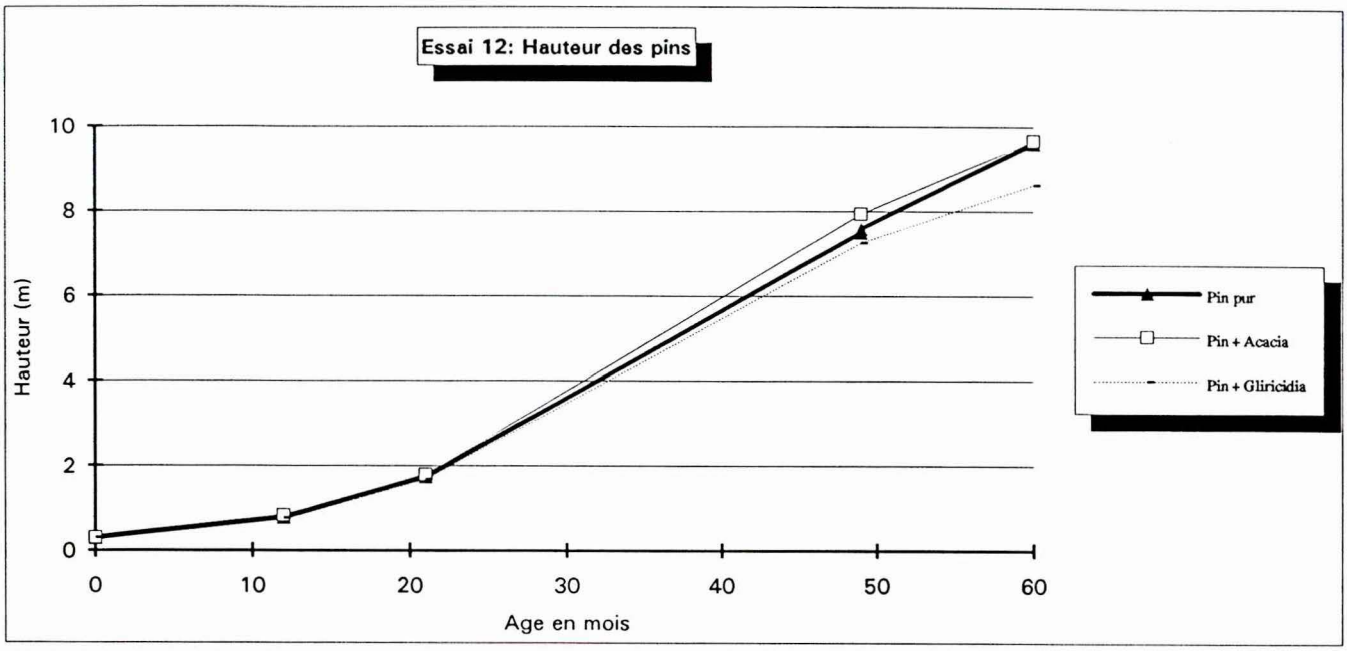
Acacia mangium that grows far slower during the first and second year shows a better growth after 3-4 years (see the compared growth of these two species before the fire) and is able to close the canopy whereas *Acacia auriculiformis* keeps a light canopy. However, in poor soils, fertilisation is strongly beneficial to *Acacia auriculiformis*. It makes then a dense canopy that allows a ground vegetation substitution.

For soil rehabilitation purpose, fertilisation is highly recommended with *Acacia auriculiformis*.

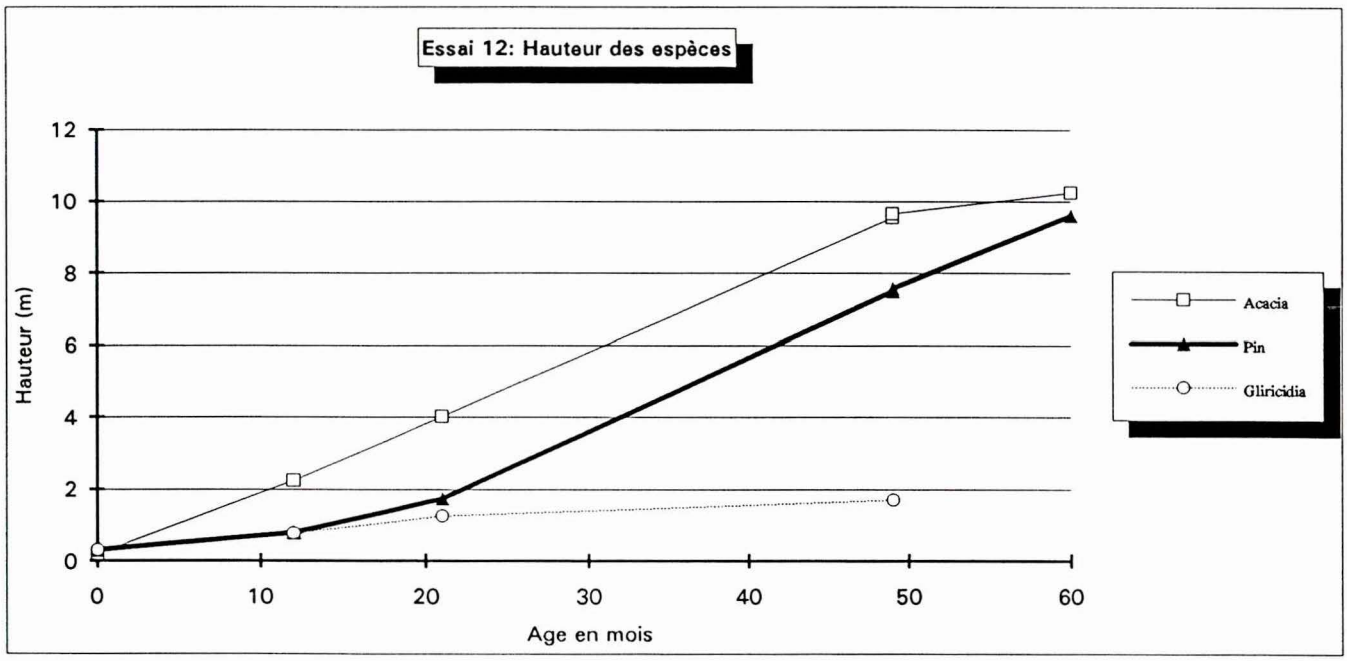
Fire are very detrimental to both *Acacia mangium* and *Acacia auriculiformis*. Any stand affected by such a disaster must be immediately felled down, in order to allow a sound coppicing from the stump.

Casuarina equisetifolia is completely killed by fire.

Pinus caribaea hondurensis is fire resistant provided that the trees are tall enough and that the terminal bud is not affected. In this case, even if the major part of the foliage is burned, it will recover quickly.



Essai 12: résultats à 4 ans et 5 ans									
Caractéristiques des pins des parcelles									
Moyenne	Diamètre (cm)			Hauteur (m)			H/D (%)		
Moyenne	Déc-94	Oct-95	Acc	Déc-94	Oct-95	Acc	Déc-94	Oct-95	Acc
Pin Pure	11.45	**13.84**	20.9%	7.5	**9.61**	28.1%	65	**71**	9.2%
Pin & Acacia	11.78	**13.79**	17.1%	7.94	**9.67**	21.8%	69	**72**	4.3%
Pin & Gliric.	13.53	**16.41**	21.3%	7.25	**8.62**	18.9%	54	**53**	-1.9%



Trial 12 : planted in end November 1990 - Pokoinu

This trial is designed in order to evaluate the possibility of the silviculture of mixte plantation : *Pinus caribaea* - nitrogen fixing trees.

1 Pure plots

The comparison of the pure plots shows that the height of *Pinus caribaea hondurensis* is close to reach the one of *Acacia auriculiformis* the height growth of which is presently lower than few years ago. *Gliricidia sepium*, destroyed by rats has never recover of this hazard. For the diameter, *Pinus caribaea* has an average diameter higher than *Acacia auriculiformis*. It seems that the December 1994 thinning was quickly efficient for *Acacia auriculiformis* whereas *Pinus caribaea* took a long time to profit of it. Now, the diameter growth rate of this latter is high and between October 1995 and February 1996, the average diameter increased from 13,8 cm to 15,3 cm (1,5 cm for 4 months).

2 Mixed plots

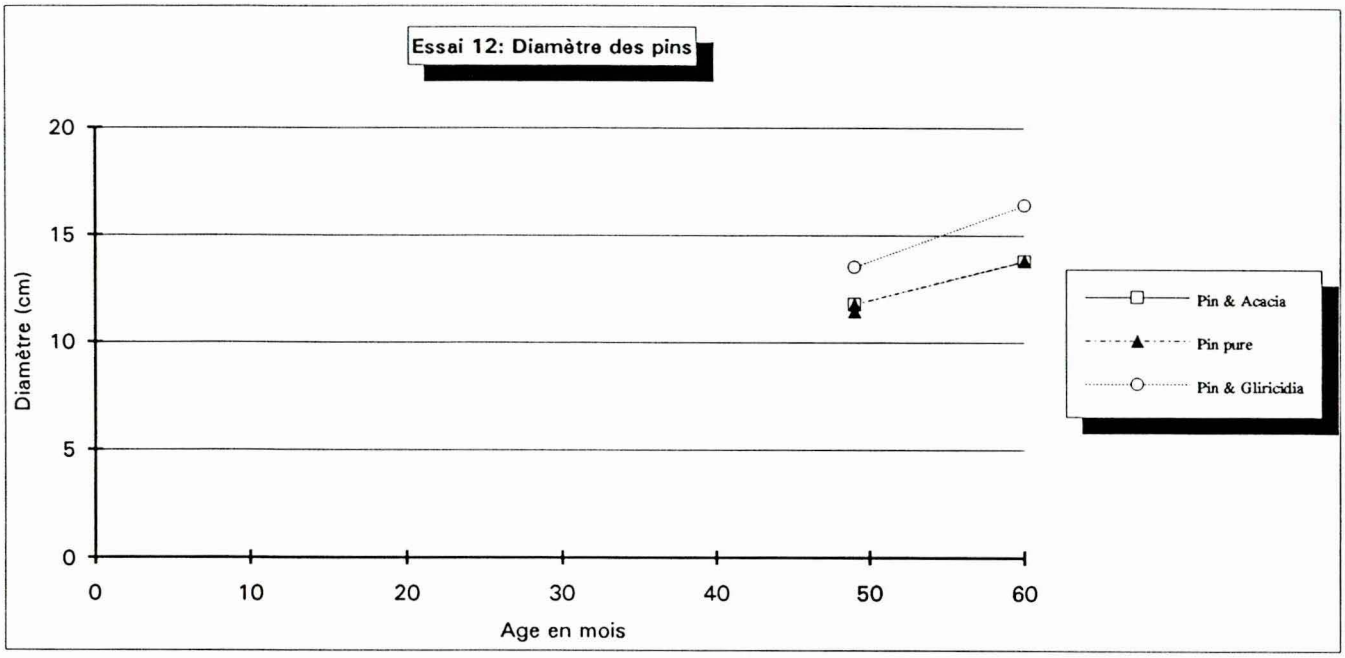
Height : the height is significantly different between the pine mixed with *Gliricidia* and the pines with *Acacia auriculiformis* or the pure stand of pine. The difference between the mixed plot : pine + *Acacia auriculiformis* ; and the pure pine plot has vanished.

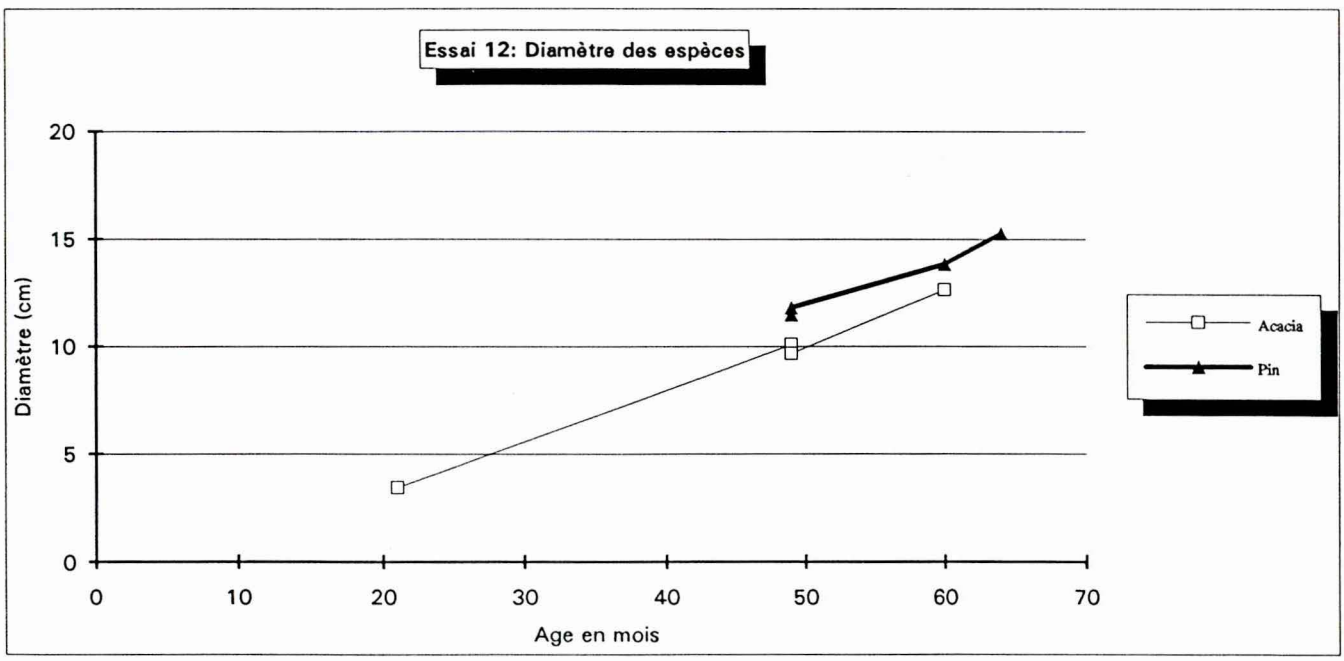
Since *Gliricidia sepium* has not grown, the pines were more exposed to wind than the other plots. The pines mixed with *Acacia auriculiformis* were the best protected and took advantage of that. The trees of the pure plot were initially more exposed but, since their density is the double of the one of mixed plots, the trees protect themselves as soon as they are tall enough and there is no more difference between the plots.

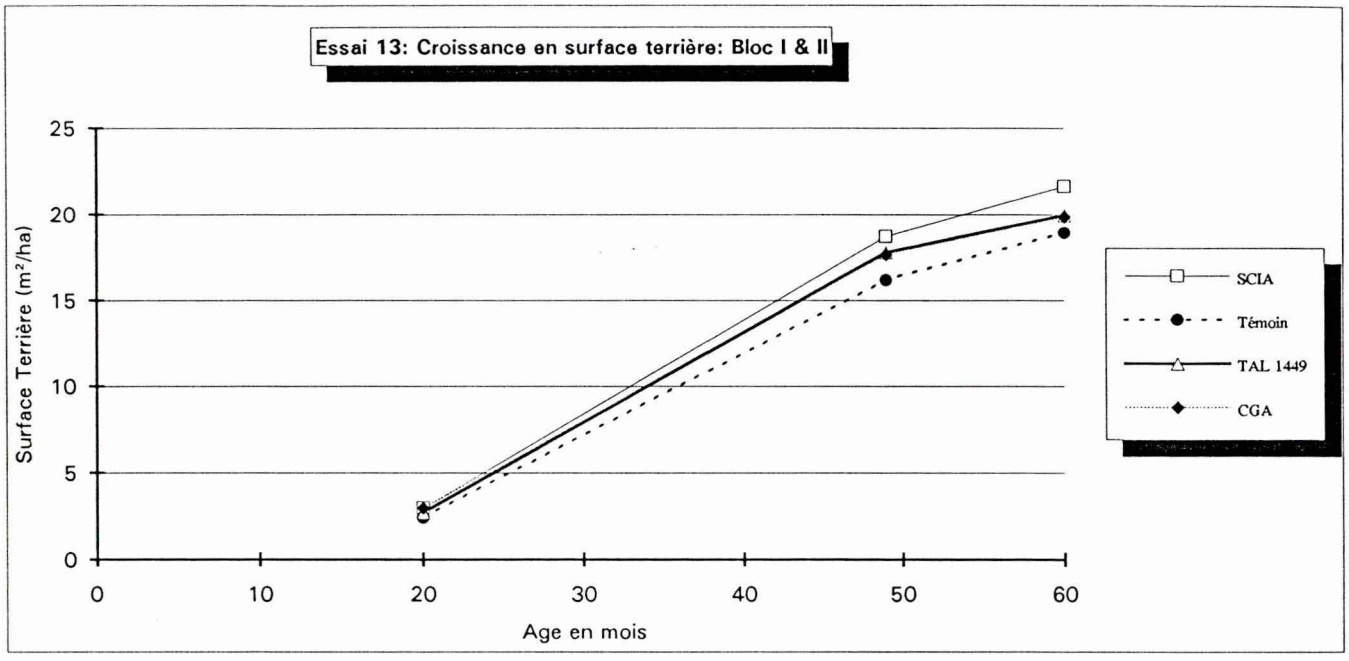
The shape of the pines is good but the rows of *Acacia auriculiformis* are too close to the ones of pines and the shape of these latters were strongly influenced by acacias with all the branches on the same side of the tree and the top often bent or killed by the competition of the taller acacia crown.

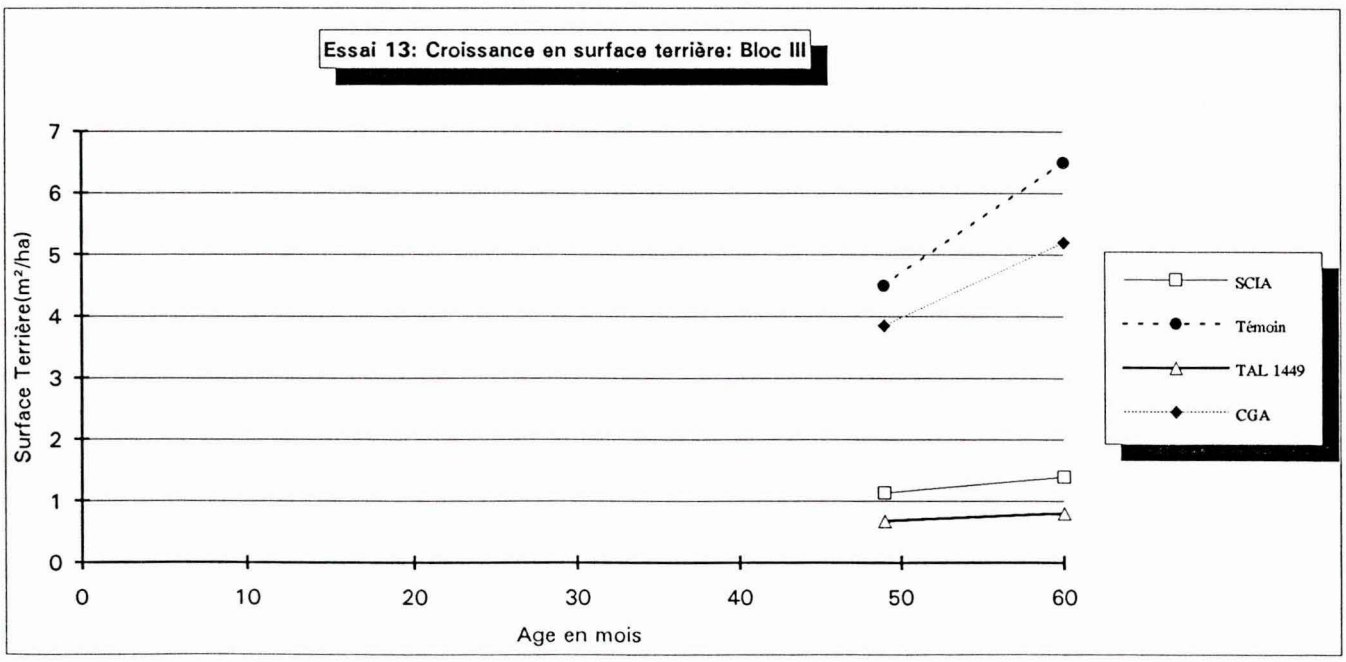
Diameter : We have exactly the same figure than for the height. The pure stand and the mixed acacias and pines stand have exactly the same average diameter and the same diameter increment whereas the *Gliricidia* + pine stand (in fact, the pure pine stand with very large spacing) has a significantly higher average diameter that increases faster than the one of the other plots. The competition is still lower in this plot than in the two other ones.

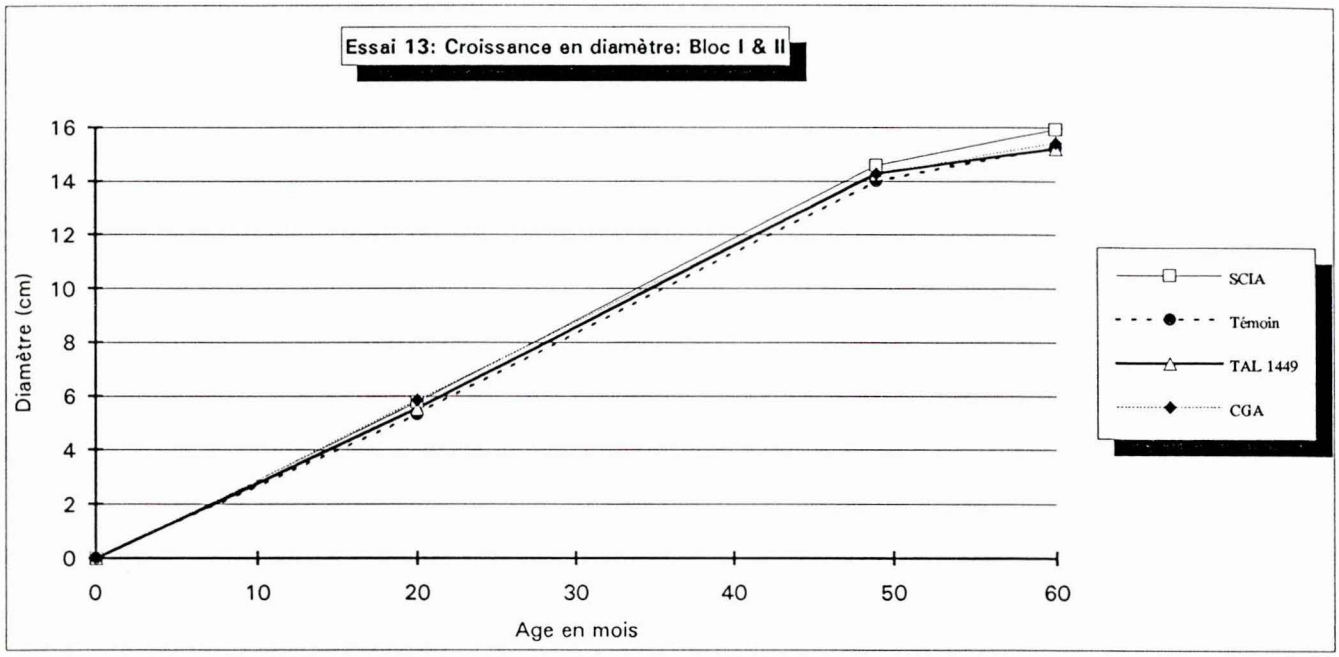
H/D : The ration H/D is 53 for the pine in the Pines + *Gliricidia* plot, and 71-72 in the two other plots. The evolution shows that this ratio is stable since last year in the pines + *Gliricidia* plot (54 → 53). The trees have no significant competition between them and they are still in almost free growth. In the other plots, H/D has increased since last year. If it is normal for the pines + acacias with an increase of the competition inside the plot, it seems to be more curious in the pure plot that was thinned last year. In fact, since the thinning was done during the growing period the tree diameter did not profit of the thinning and the 1995 measurements were done just at the beginning of the growing period. In the same time, the height growth is not affected by the thinning and the height kept a regular growth. The effect of the thinning in the pure plot should be visible on the ration H/D next year with a diminution of this ratio.

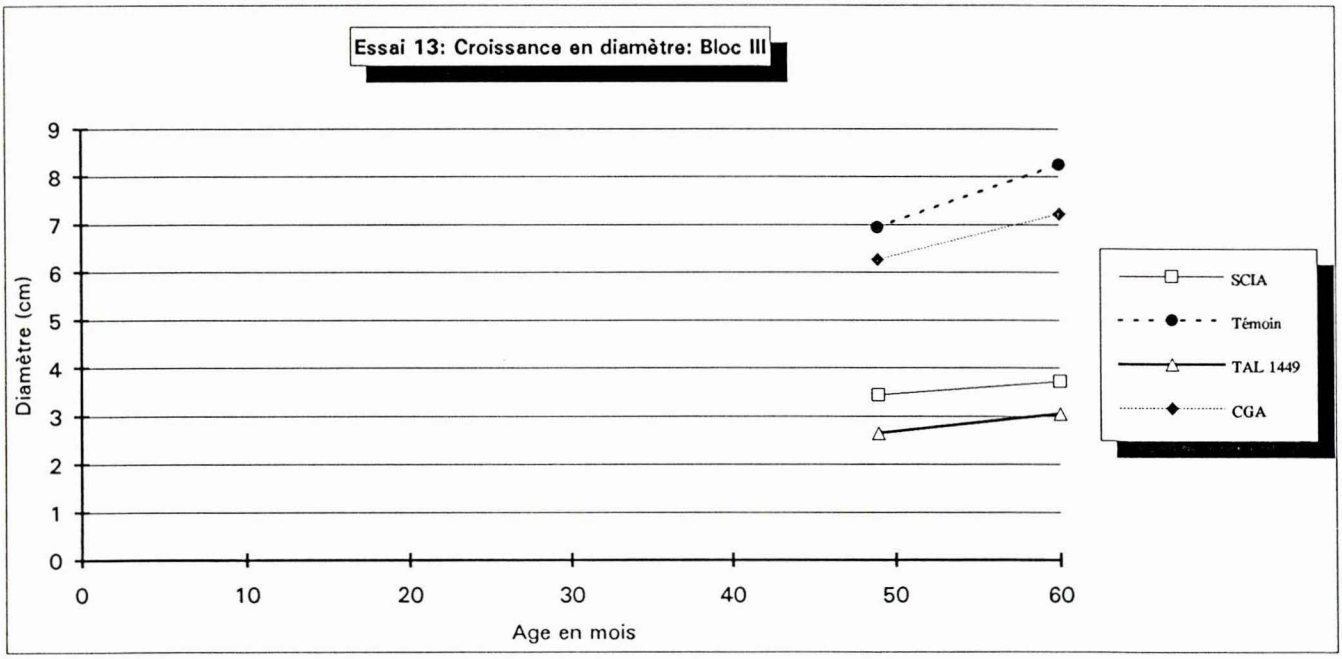

Essai 12: Diamètre des pins
Diamètre (cm)
20
15
10
5
0
0
10
20
30
40
50
60
Age en mois
Pin & Acacia
Pin pure
Pin & Gliricidia

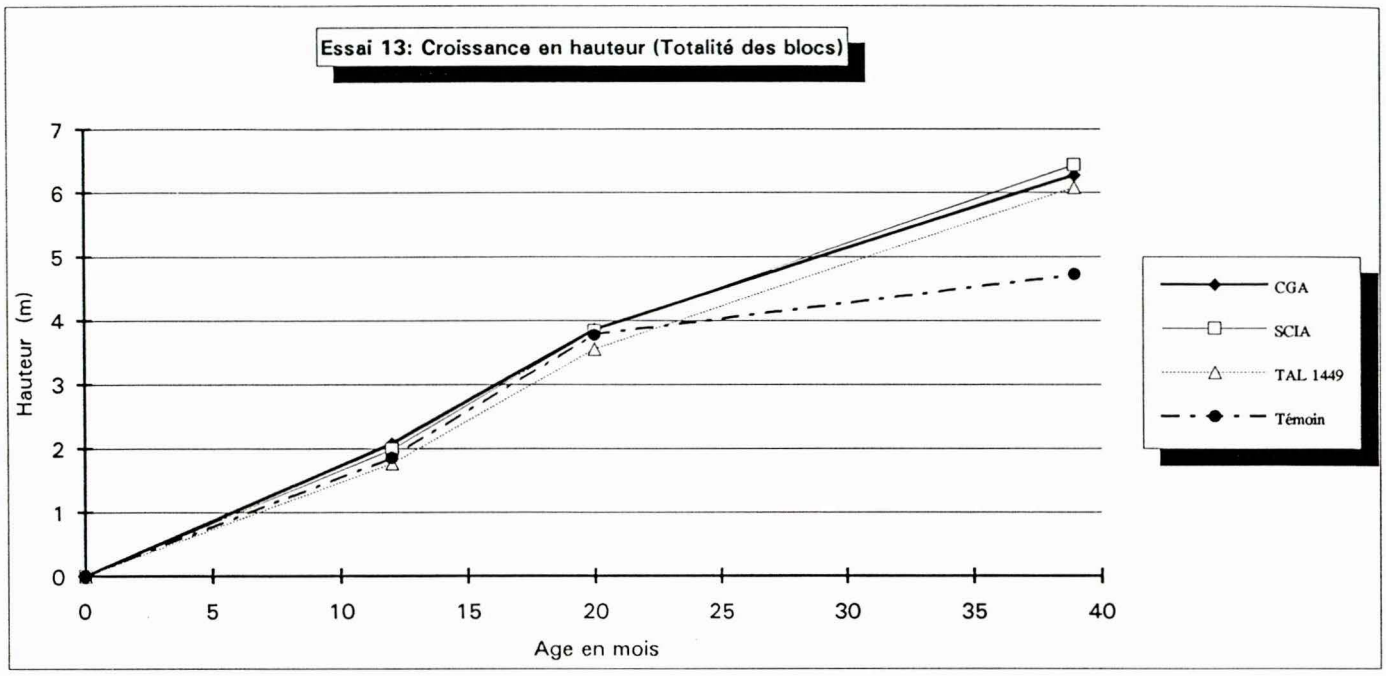

Essai 12: Diamètre des espèces
Diamètre (cm)
20
15
10
5
0
0
10
20
30
40
50
60
70
Age en mois
Acacia
Pin

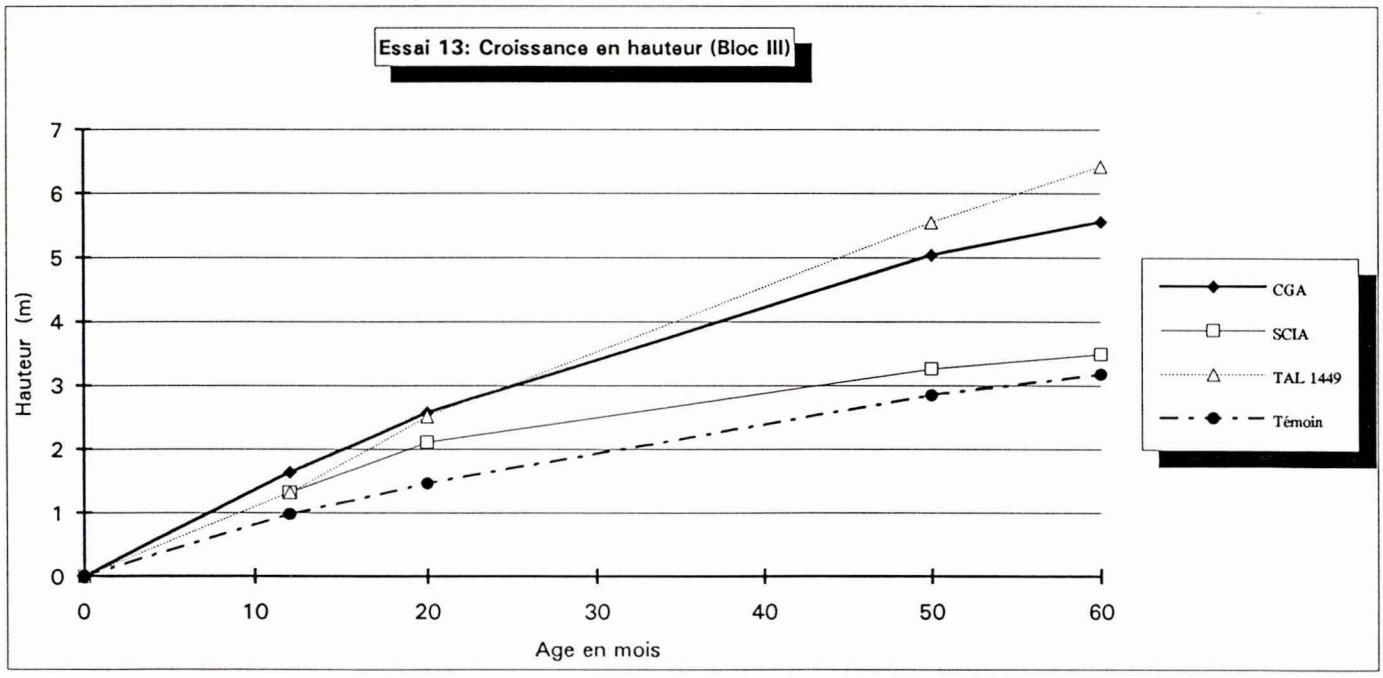

Essai 13: Croissance en surface terrière: Bloc I & II
Surface Terrière (m²/ha)
25
20
15
10
5
0
0
10
20
30
40
50
60
Age en mois
SCIA
Témoin
TAL 1449
CGA


Essai 13: Croissance en surface terrière: Bloc III
Surface Terrière(m²/ha)
7
6
5
4
3
2
1
0
0
10
20
30
40
50
60
Age en mois
SCIA
Témoin
TAL 1449
CGA


Essai 13: Croissance en diamètre: Bloc I & II
Diamètre (cm)
0
2
4
6
8
10
12
14
16
0
10
20
30
40
50
60
Age en mois
SCIA
Témoin
TAL 1449
CGA


Essai 13: Croissance en diamètre: Bloc III
Diamètre (cm)
0
1
2
3
4
5
6
7
8
9
0
10
20
30
40
50
60
Age en mois
SCIA
Témoin
TAL 1449
CGA


Essai 13: Croissance en hauteur (Totalité des blocs)
Hauteur (m)
0
1
2
3
4
5
6
7
0
5
10
15
20
25
30
35
40
Age en mois
CGA
SCIA
TAL 1449
Témoin


Essai 13: Croissance en hauteur (Bloc III)
Hauteur (m)
0
1
2
3
4
5
6
7
0
10
20
30
40
50
60
Age en mois
CGA
SCIA
TAL 1449
Témoin

Trial 13 : planting October 1990 - Raemaru

This inoculation trial does not show any significant difference between the treatments. The blocks I and II are similar and, in this quite fertile and deep soil, the treatments are homogeneous with an average diameter of 15 cm at 5 years and a basal area of 20 m²/ha. Inside the block III (poor and shallow soil) the soil heterogeneity is far more important in terms of tree growth than the treatment. The inoculation with a selected Rhizobium strain does not seem to be significantly beneficial to *Acacia auriculiformis* contrarily to what is shown in the Trial 7 and Trial 8 for *Acacia mangium*.

Under the closed canopy of the blocks I and II, the previous thick fern has been completely suppressed and now, other shade species of fern colonise the ground. Near the borders, the climber *Mikena sp.* covers the ground.

The trees have been strongly and regularly damaged by winds and many of them are broken (main branches broken). The only utilisation of such trees is biomass production.

Acacia auriculiformis is highly prone to wind damages due to its often bad shape. In fertile soils, this characteristic is accentuated and in wind exposed areas, the result can be awful. In the block III the shape of the trees is quite better and few of them are really straight with regular and thin branches.

Acacia auriculiformis shows a strong negative interaction between soil fertility and shape.

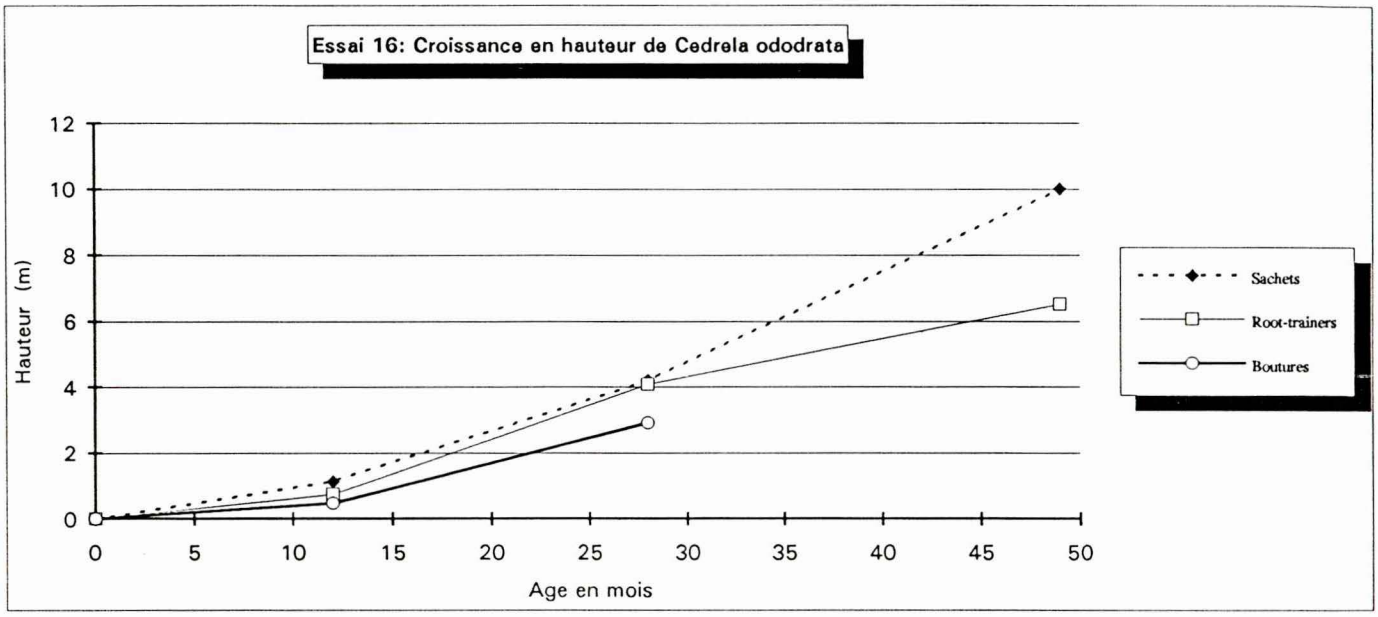
Conclusion

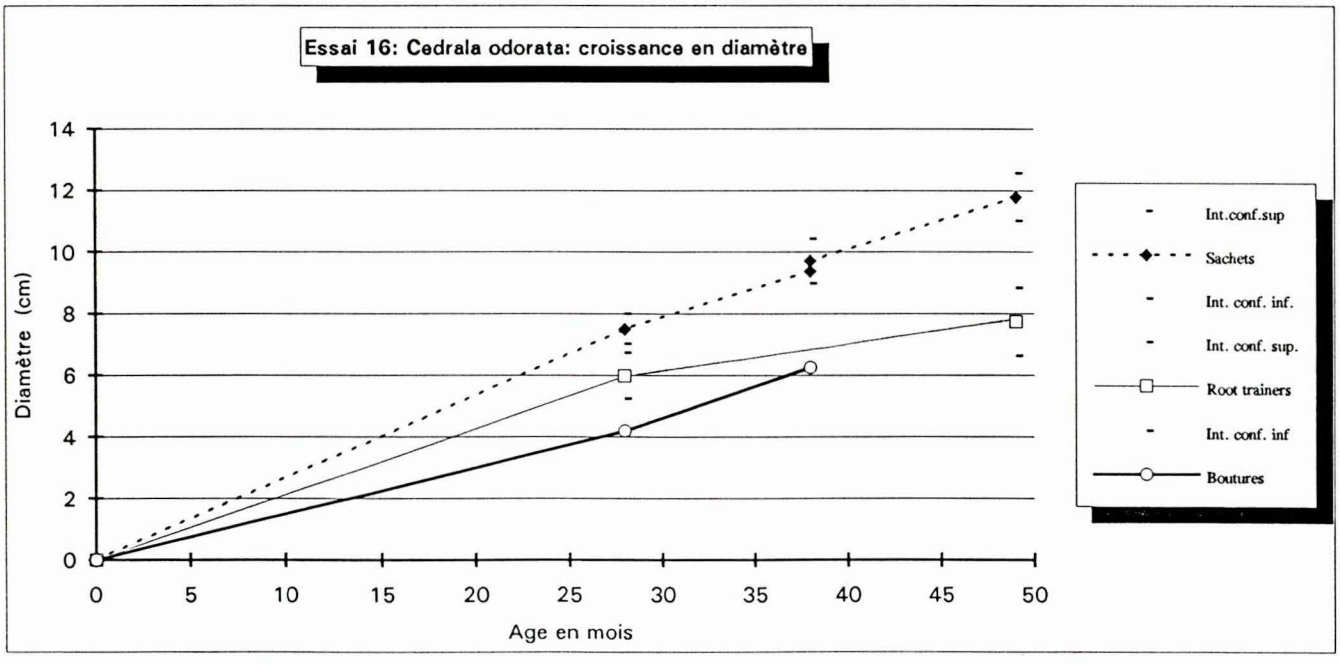
Even if *Acacia auriculiformis* grows fast on fertile soils, its shape is usually poor with a crooked stem and many big branches that expose the tree to wind damages. *Acacia auriculiformis* cannot be used as a wood production tree in areas prone to strong winds.

On poor soils, for rehabilitation purposes, or in silvicultural association with pines, an initial fertilisation is needed in order to boost the growth and allow the stand to close the canopy.

Inoculation was not beneficial in this trial

Trial 15 : see Report of Mangaia trip


Essai 16: Croissance en hauteur de Cedrela ododrata
Hauteur (m)
0
2
4
6
8
10
12
0
5
10
15
20
25
30
35
40
45
50
Age en mois
Sachets
Root-trainers
Boutures


Essai 16: Cedrala odorata: croissance en diamètre
Diamètre (cm)
0
2
4
6
8
10
12
14
0
5
10
15
20
25
30
35
40
45
50
Age en mois
Int.conf.sup
Sachets
Int. conf. inf.
Int. conf. sup.
Root trainers
Int. conf. inf
Boutures

Trial 16 : planting in end September 1991 - Rutaki

This trial is composed of two main species : *Cedrela odorata* and *Hymenaea courbaril.*

Cedrela odorata :

This species is still in its height growth phase. The stems are quite straight, without branch. The average height of the trees grown in nursery in plastic bag (and not in small root trainers) is 10 m and the tallest tree reach 16,25 m high with a diameter of 15,5 cm at 4 years. The crowns have not yet begun to develop themselves.

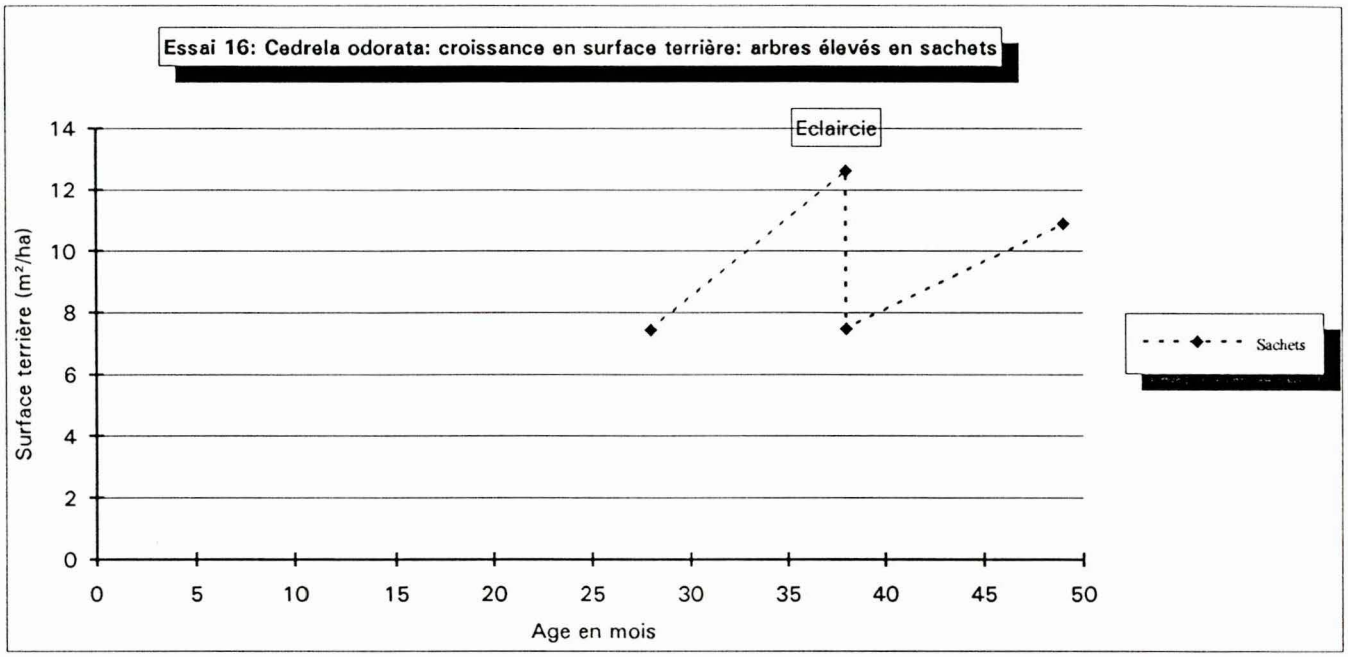
This species is easily managed the first years, due to its very fast growth. However, it needs big containers in nursery and a very strict timing in order to produce the most suited seedlings to be planted : tall but not yet disturbed by the size of the container. Once the container became too small, it is very difficult for the tree to recover after planting in the field. The difference in height growth between the seedlings grown in bags and in root-trainers is huge and keep increasing. The diameter shows exactly the same figure than the height and the average diameter is 12 cm for the bag raised trees and 8 cm for the root-trainers raised trees. The average diameter increment is very regular showing that the competition between trees is low and that the last thinning, in December 1995, arrived in time : the diameter growth that begun to decrease in December 1994 is again at its initial rate.

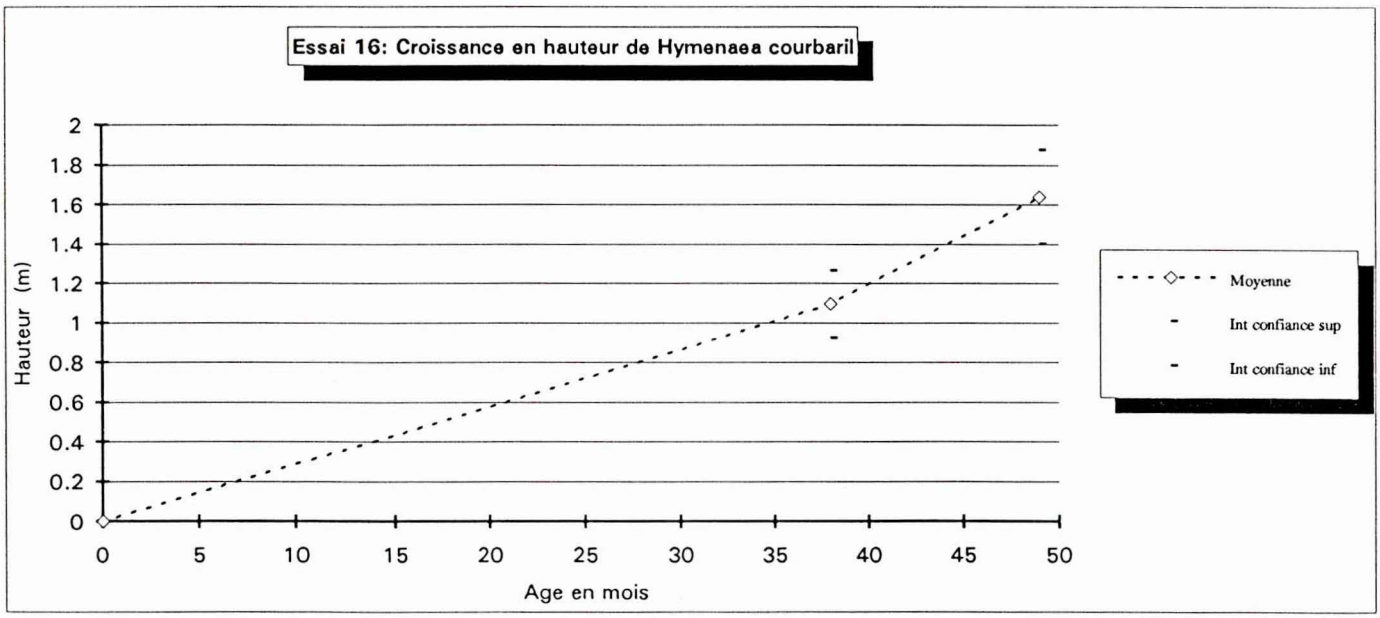
The basal area is still low (10 m^2/ha). The present growth is lower than the one before the thinning (the competition was low) and since this latter removed 40 % of the stems, the new slightly higher diameter growth cannot compensate the loss of stems.

After this thinning, the quality of the stand in terms of shape is rather good with very few branches. Many of the trees have still no branch at all that explains the low competition between these very tall trees. The next silvicultural operation should be done once the trees begin to shape their crown. The thinning must be quite strong in order to allow the trees to develop a regular crown.

Hymenaea courbaril :

The trees are still in a strong competition with the climbers. However, *Acacia auriculiformis* are now dense and begin to control quite well the ground vegetation. *Hymenaea courbaril* has significantly increased its height growth that is still quite low. We can expect now that with the elimination of the climber problem, the height growth will boost. Once the *Hymenaea courbaril* will be out of danger (in one to two years time) a strong thinning will have to be done among the *Acacia auriculiformis* in order to give more light to *Hymenaea courbaril* and to lower significantly the vertical competition of the acacias. At the same time, a shape pruning must be conducted in order to give to the trees a unique vertical axe.


Essai 16: Cedrela odorata: croissance en surface terrière: arbres élevés en sachets
Eclaircie
Surface terrière (m²/ha)
14
12
10
8
6
4
2
0
0
5
10
15
20
25
30
35
40
45
50
Age en mois
Sachets

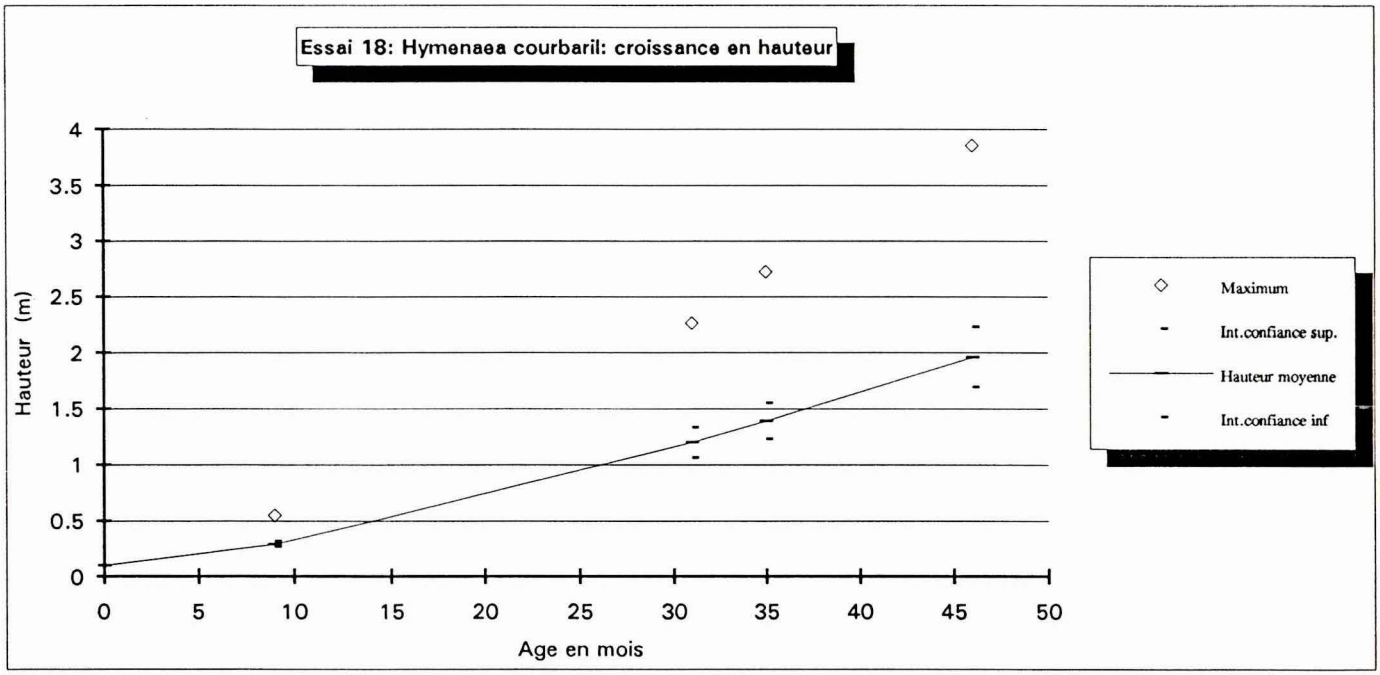

Essai 16: Croissance en hauteur de Hymenaea courbaril
Hauteur (m)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
5
10
15
20
25
30
35
40
45
50
Age en mois
Moyenne
Int confiance sup
Int confiance inf

Trial 17 : planting in December 1990 - Pokoinu

Contour planting of *Acacia auriculiformis*. Three spacings in the row : 1 m - 1,5 m - 2 m. The spacing between the rows is 5 m on the line that make the separation between the 1 m and 1,5 m spacing. Elsewhere, depending on the slope, the spacing varies between 4,5 m on steeper slope and 7 m on more gentle slope. The impact on the ground vegetation is not yet visible. However, the visual aspect of the stand from the road is beautiful. The area seems to be covered with forest. There is no visible continuity. The continuity on the contour cannot be seen from the bottom and since the topography is not regular, no line are visible across the contours.

The advantages of this planting design are interesting in steep slopes covered with high ground vegetation. The initial preparation (land clearing) is easier and does not initiate water path like in line planting where the rows are usually done along the main slope. Later, the stand does not seem to be artificial due to the lack of continuity when it is seen from the bottom (it is not the case if the stand is seen from a higher point of view).

In the case of this trial, all the area previously only covered with ferns seems now to be covered with forest that does not seem human planted. In the other hand, the impact on soil of the contour planting for ground vegetation substitution and erosion control should be less efficient than a regular design at the same global density. This latter will better cover the soil, will provide more shade and will spread more homogeneously the leaf litter on the soil.


Essai 18: Hymenaea courbaril: croissance en hauteur
Hauteur (m)
4
3.5
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
30
35
40
45
50
Age en mois
Maximum
Int.confiance sup.
Hauteur moyenne
Int.confiance inf

Trial 18 : planting in December 1991 - Turangi

Hymenaea courbaril in this trial have been badly damaged by the weeds due to a lack of maintenance. However, this species has survived, even completely covered with a thick layer of vines for months. It has started to grow again as soon as weeded.

The absence of initial shade trees has not allowed a natural weed control and *Hymenaea courbaril* still depends completely on weeding. The few trees that are now tall enough, show a good height growth.

Hymenaea courbaril is well adapted to the fertile soils of Rarotonga, but it needs an initial shade to grow as fast as possible in height (and to control the weeds) and very regular weedings due to a high climber competition in fertile soils. Since the initial growth is low, such maintenance must be planned for a long period.

In the case of a general bad shape following a bad maintenance or an other problem, all the trees can be cut at ground level. They will strongly coppice and, after six to height months the selection of the best shoot will be done.

Trial 21 : planting in July 1992 - Turangi

Tectona grandis is a light demanding species and, in this trial too, the lack of maintenance between 1992 and 1994 was highly detrimental to the trees. However, a strong clearing of the stand in 1994 and in 1995 has allowed a reasonable part of the trees to develop quickly and to reach a height of 4 to 5 metres protecting them from the bushes. Since the recommendations of 1994 - asking that all the trees must be cut to ground level in order to regularise the stand - were not followed, the shape of the trees is not as straight as they should be. However, this trial should become a consistent stand of teak, the only one available in the Cook Islands.

Tectona grandis is well adapted to the fertile soils of Rarotonga. It is a light demanding species that need to be planted in full light. After the first year needed to establish itself, teak grows quickly.

In case of a stand with a high proportion of badly shaped trees, (following meteorological disturbances...) or with a high heterogeneity, all the trees must be cut to ground level in order to foster fast growing shoots that will be straight. The stand will be then more regular with straight trees.

MANGAIA : 22th february 1996 - Visit of the trial and a review of the plantation

The whole burned area was planted in *Pinus caribaea* after the fire. Since *Acacia mangium* or *Acacia crassicarpa* has coppiced, both have grown together and the stands are usually well growing with pine coming out of *Acacia mangium* coppices. Only on few fertile areas where it was not to much damaged, *Acacia mangium* induces a severe competition to pines. Elsewhere, it will give an interesting mixed stand of *Pinus caribaea* with an understorey of *Acacia mangium*. This association will be fruitful for both soil protection or rehabilitation, and pine silviculture. *Acacia mangium* gives a complement to the pines to close the canopy early.

The present spacing for pine is for 4m x 4m.

Pines are healthy and the shape is good with a straight bole and thin branches. Following the comments of the foresters, many of the bare areas before planting bear now a thick staghornfern (*Dicranopteris linearis*) vegetation under pines and *Acacia sp.*. When it has not yet happened, under close stand of pines or *Acacia sp.*, the soil is covered by leaf (needles) litter that protects it efficiently from the sheet erosion. In the still open stands, the bare soil areas are sometime important but the dead leaves are packed in the gullies where they retain much part of the soil going away. It makes thick layers of soft "soil" that are fastly colonised by the staghornfern. It is the first stage of the soil rehabilitation. Once, the stand canopy closed, the leaf litter is more abundant and it is not disturbed any more by wind. Since the micro topography (gully - microridge - gully...) has been softened by the process described here above, the litter accumulates on the soil and will form soon a continuous layer that will protect the soil against sheet erosion.

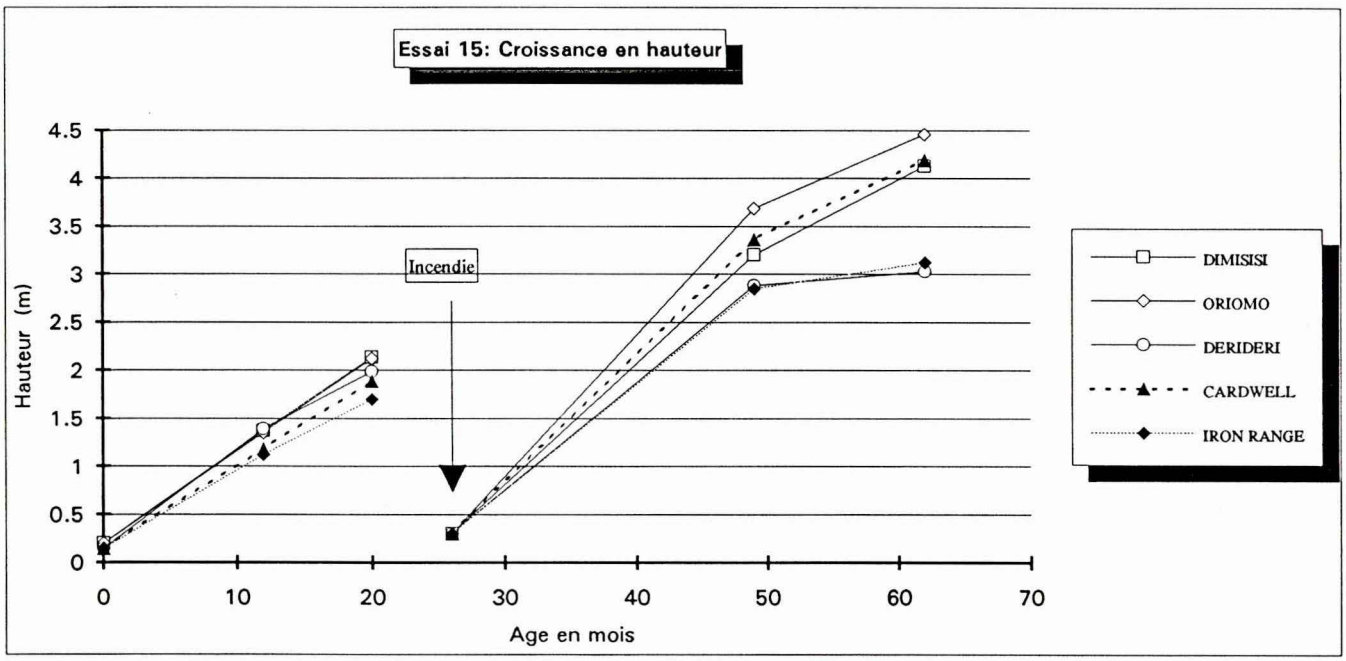
Protection versus production :

Since the 1993 fire, all the destroyed areas were planted exclusively with pine (spacing 4m x 4m) without consideration of the previous trees (acacias or pines) or the main objectif assigned (protection-production).

By this fact, to make a difference between these two objectives is now only a matter of silviculture. Protection does not mean planting then nothing else. Any plantation is a human made stand that is not a native forest. All the trees have the same age, they will die at the same moment or have pests... They need a management. The difference is that for protection the silvicultural action will be done in order to minimise the impact on the environment [but the thinning must be done, the final cutting as well] whereas in the production area silviculture and timber harvesting are done in order to get the best economic return.

The best protection for a land is to give valuable products that can match the cost of the silviculture, provided that the fragility of the environment is always in mind ot the manager.

In the case of other species (*Acacia sp.*) that will not give any timber production (due to the bad shape, bad growth, wind damages...) an other silviculture must be carried out in order to try to keep a permanent cover of the soil. That needs : felling operation, new planting... It is costly without any direct return. In countries with financial problems, this type of plantation is easily set aside. In that way, a plantation that give an economic return will have some cares, and protection minded operations will be far easier to implement.


Essai 15: Croissance en hauteur
Hauteur (m)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Incendie
0
10
20
30
40
50
60
70
Age en mois
DIMISISI
ORIOMO
DERIDERI
CARDWELL
IRON RANGE

Trial 15 : planting in november 1990 - Rangimotia - Mangaia

The major part of the trees was badly damanged by the 1993 fire, but they coppiced quite rapidly from the stump or from the stem. For that reason, only height measurements were done due to the bushy aspect of the trees 2 years after the fire. In end 1995, along with the height measurement, the forestry service has cut all the coppices excepted the best of them and this plantation look again like a forest plantation. The canopy that was nearly close is now very open but the stand should react positively to this operation and create again a well closed stand. This operation allows also to monitor the diameter growth (and the basal area) that was not possible with multi stem bushes. Due to the elimination of a variable number of stem per "tree", this first measurement cannot be properly analysed. The height growth confirm the 1994 results with ORIOMO as being the best provenance for the height (after fire) but not significantly better than DIMISSI and CARDWELL. DERI DERI and IRON RANGE are significantly less tall than the other provenances and the difference has much increased this last year.

The constatation that the earlier growth of the Papuan provenances was better than the one of the Australian provenances is no more true.

Acacia mangium has shown that in the Cook Islands, it does not give any timber excepted fire wood that is not really demanded in the Cook Islands. It is more an accompanying species for pine or for special silviculture management (protection area...). A small difference in the growth is not important in this case, but the provenance has shown a high variation for fire impact from 14 % and 19 % of mortality for CARDWELL and DIMISSI to 42 % and 47 % for ORIOMO and DERI DERI. The frequency of fires on Mangaia demands that this characteristic should be taken in consideration. Futur results should show if there is a significant difference between the best provenance, particularly between the Australian one : CARDWELL ; and the Papuan ones DIMISSI and ORIOMO. Due to the fire, no result is presently available about shape.

Pine plantation : Growth

The growth of the pines is fast with few differences regarding the location. The average height growth is close to the one observed in Rarotonga (1,5m to 1,8 m per year at 5 years and a minimum of 2 cm per year for the mean diameter). The major differences are observed on the top of the hills and on the flat area located on the top of the Rangimotia, highest point of the island. The height growth is only (!) of 1m/year during the first years. The pines located on the foothill should grow better (2m / year) as we estimate from the few plots we have seen during the short stay. The other plots where the height growth was significantly less are the one where the seedlings were planted bare roots. The growth is roughly like the one of the most exposed areas.

Stocking

The quality of the trees is fairly good with a high proportion of straight bole with thin regular branches. However, some areas seem to bear a higher proportion of fox-tailed trees that should be linked to the seed batches. In all the cases, a first thinning will leave a stand composed almost only of well shaped trees.

Spacing

The first plantations have a spacing of 3m x 3m but since 1993, with the replanting operation following the fires of june 1992 and january 1993, this spacing is 4m x 4m (625 trees/ha). This large spacing is not detrimental to the stand due to the high quality of the stock whereas it could

be too low in case of wind damages. It will allow to delay significantly the first (and only) thinning that will already give logs for timber.

Pruning

With such a high spacing, pruning is recommended even if *Pinus caribaea* does not make big branches but, in order to obtain knot free timber, this operation is compulsary. A first complete 2m high pruning must be done at the age of 3/4 years followed by a 6m pruning carried out on the best trees (straight and vigourous) at the age of 7/8 years.

Remark

The plantation done from the beginning to 1992 where fertilised at planting whereas the present one are not. That could affect the initial growth.

Other species plantation

Acacia crassicarpa does not seem to grow properly. The trees are short and the leaves often yellowish. The interesting initial growth that this species displayed seems to be linked with the "starter" fertilisation the effect of which vanish after 2 or 3 years. However, the stems are single and not to badly shaped. The leaves and the high quantity of pods they produce after 6-7 years cover and protect well the soil. The shade is light under them.

Acacia auriculiformis : very crooked and since it has mainly been planted on the ridges along the main road, its height is short and the diameter growth quite slowly.

Acacia mangium : the results are very heterogeneous. The shape is often crooked with many big branches. It has be badly damaged by the fires (92 and 93) and all the plantations were interplanted with pines. Many of the trees were coppicing from the stump and now the stand is an interesting mixture of pine and bushes of *Acacia mangium*. Since Pine is growing fast, it is not a problem excepted in the most fertile areas where *Acacia mangium* grows faster and will have to be controled (trimmed) as soon as it will compete to much with the pine.

Eucalyptus species : not adapted to Mangaia

First Sandalwood plots

Like the other outer islands of the Southern Group, Mangaia is surrounded by an important area of "makatea" (raised coral). In the area where the soil is deep enough it is a shifting garden area, elsewhere it is covered by forest (on the high "makatea") or bushes and low forest on the low coastal "makatea".

Sandalwood is an opportunity to give some value to this "makatea".

Since the high "makatea" is mainly covered with tall and dense trees like *Baringtonia sp* (Utu), land preparation would be to costly (the trees must be removed). A better possibility would be to prepare lands in abandoned gardens. Such a plantation would need a very strong maintenance due to the important weed growth. Only very motivated owners or a strong commitment of the forestry service would allow a success. But, in this case, the growth should be very good.

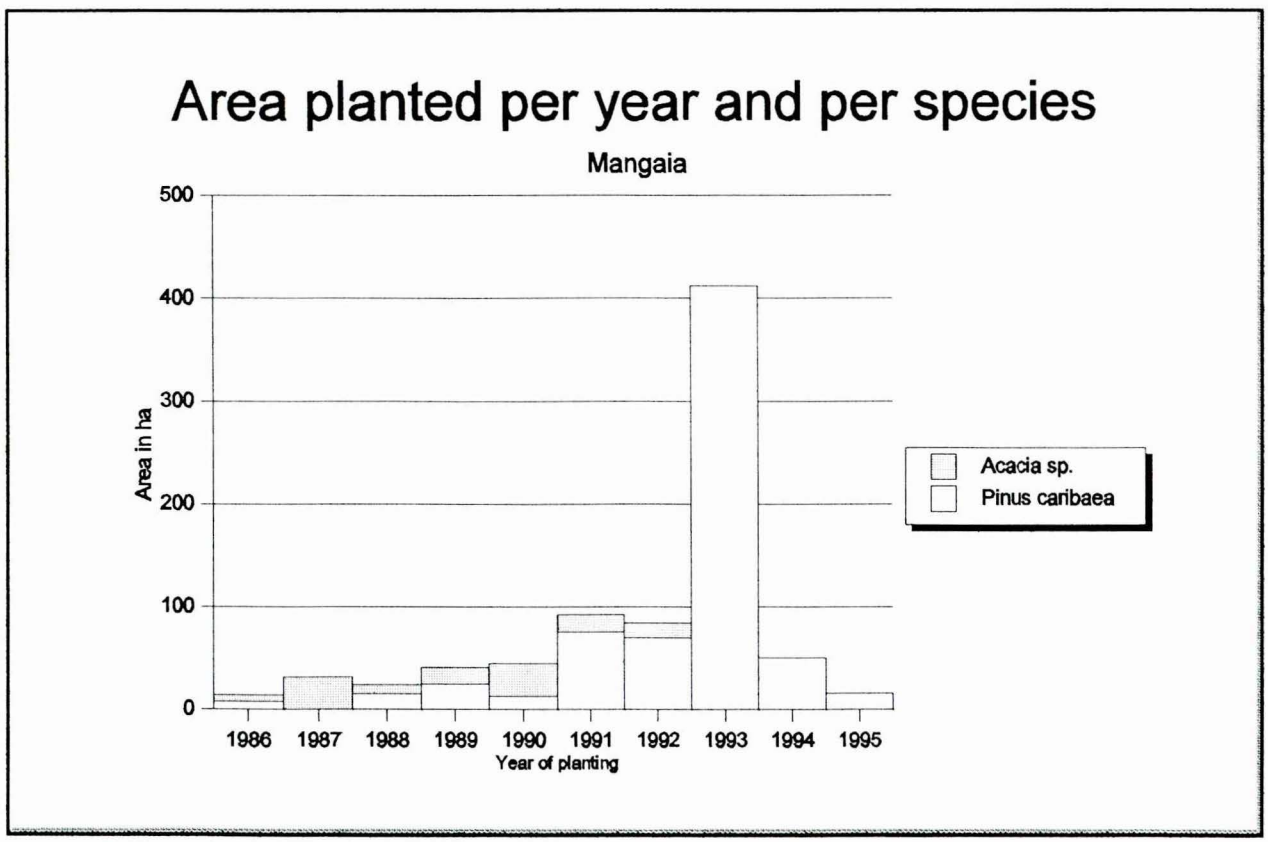
The coastal "makatea" is harsher and look more like the one of Mitiaro or Mauke. The

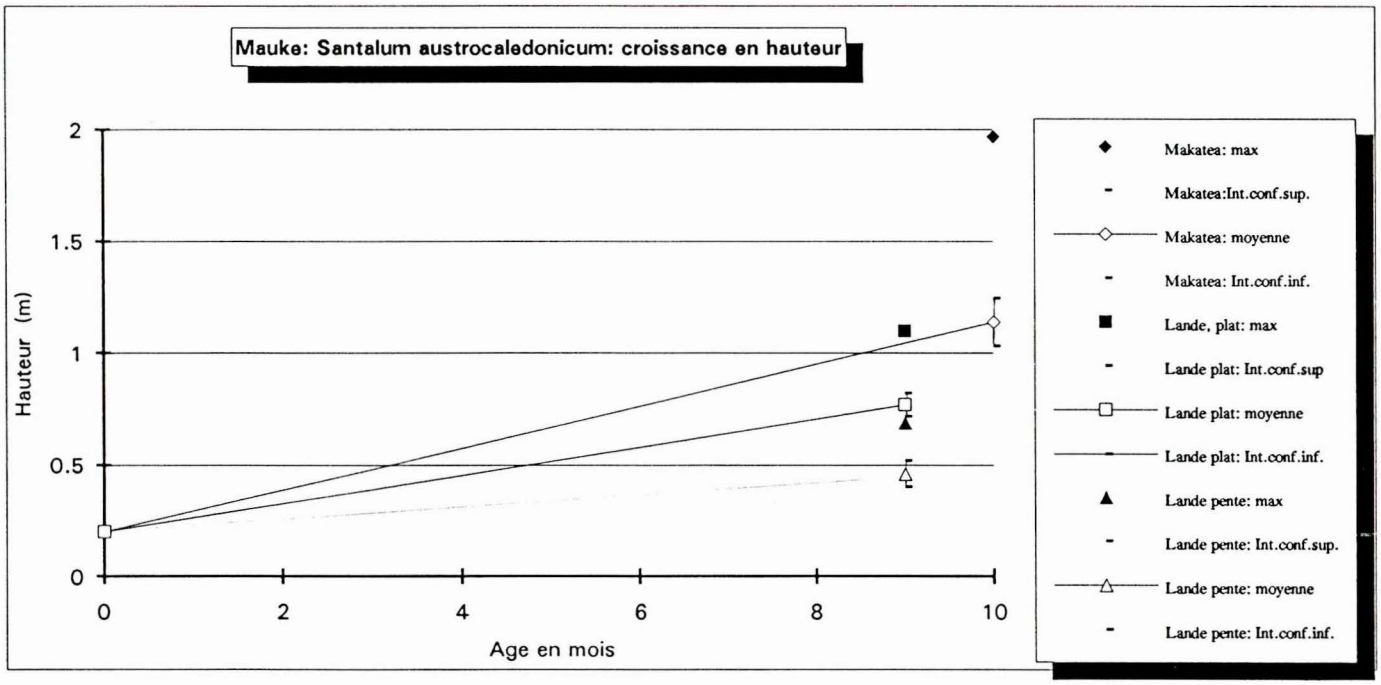
maintenance of a plantation would be easier, but the area must be sufficiently protected from the wind and the sea sprays.

Presently, the Forest Officer in Mangaia will provide two of this family land : one being an old garden area on the upper "makatea", and the second, a land located on the coastal "makatea". The high motivation and the commitment of the owner gathered with the location of the land near the houses of the family give to this project very high chances of success and should be a good incentive for the other Magaian.

MANGAIA : AREA PLANTED PER YEAR AND PER SPECIES

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Total
Pine	8		15,5	24,5	12,5	75	70	412	50	16	684
Other	6	32	8,5	16	32	17	14				126
Total	14	32	24	40,5	44,5	92	84	412	50	16	809




Mauke: Santalum austrocaledonicum: croissance en hauteur
Hauteur (m)
2
1.5
1
0.5
0
0
2
4
6
8
10
Age en mois
Makatea: max
Makatea:Int.conf.sup.
Makatea: moyenne
Makatea: Int.conf.inf.
Lande, plat: max
Lande plat: Int.conf.sup
Lande plat: moyenne
Lande plat: Int.conf.inf.
Lande pente: max
Lande pente: Int.conf.sup.
Lande pente: moyenne
Lande pente: Int.conf.inf.

MAUKE

The plantations that were visited are : the first pines planted on the island, the two sandalwood trials and the "maire" plantation. We saw few other tree species growing in gardens and around houses : *Swietenia macrophylla* (mahogany), sandalwood.

Pines

We shall not describe this plantation. It grows quite similarly than the pines in the other islands of the Southern Group of the Cook Islands. The shape of the stems is not as good as it is on the other islands. This characteristic seems to be linked to the seed batches. It has been observed too in some plantations on Mangaia and Rarotonga.

Sandalwood

Two trials were established on three different soil configurations :

"makatea" soil : it is located on the coastal "makatea" inside a coconut plantation on the east side of the island. The ocean is quite close and sea sprays should occur during strong easterly wind. The low vegetation (*Schleinitzia insulare, Guettarda speciosa...*) has been completely slashed down and no bush protects the sandalwood plants. The soil is rocky and very few soil is visible. The trees have been planted the 11 april 1995. After 10 months, they reach an average of 1,14 m ± 10 cm and a maximum of 1,97 m. The leaves are long and thin, and the colour is quite dark green. The low ground vegetation is dominated by a Commelinaceae that cover completely one third of the plot : *Rhaeo discolor*. The bushes, particularly *Schleinitzia insulare* (Toroire), but Ano (*Guettarda speciosa)* and Nono (*Morinda citrifolia*) too, must be kept between the rows. They will become the hosts for the sandalwood and protect it from winds and sea sprays. Next weeding must be concentrated on a 1m wide row on the planting line.

- fernland soil : This plot is located on two different types of soil and vegetation :

  - one half : on a flat area, covered with *Acacia crassicarpa* in a quite healthy condition. The soil is covered with fern and grasses. These latters show that the soil was fertilised years ago.

  - the second half : on a slope planted with *Acacia crassicarpa* of very poor growth and health conditons. Their top is always dead and the trees short and tiny. The ground vegetation is only staghorn fern.

The behaviour of sandalwood is very different depending the location. On the flat area its average height is 0,77 m ± 0,05 and the maxiumum 1,10 m with a low mortality 11 % whereas on the sloppy area the average height reach only 0,46 m ± 0,05 with a maximum of 0,69 m. The mortality is high : 42 %. Several factors can explain this behaviour :

- acide soils are not suited for *Santalum austrocaledonicum*
- on the flat area, the soil is thicker than on the slope and was fertilised. *Acacia crassicarpa* was able to grow tall enough to close the canopy.

Sandalwood finds a light shade (*Acacia crassicarpa*), host plants (*Acacia crassicarpa,* grasses), a more fertile soil and less root competition with ferns.

On slopes, the seedlings are exposed to wind. They can hardly find any host or to find only very weak ones. It seems too that they have been damaged by snails. Only fertilisation would allow the sandalwood and the acacias to develop. The result is obvious. Sandalwood must be banned from badly depleted fernland.

"Maire" : *Alyxia stellata*

This small creeping shrubs has been widely planted two years ago in the "makatea" area in order to produce shoots easily harvestable and therefore to increase the local production. After 2 years, the plants reach only an average height of 30 to 40 cm and very few shoots have a harvestable size.

The harvest could not be envisaged before 5 to 6 years old and we recommend that a special treatment should be given to the plants in order to induce a vigourous shooting. This should be investigated as soon as possible (trimming, bend the branches...)

Since this plantation is well weeded the first years, it could be easily envisaged to associate Sandalwood with "Maire". The cost of the planting would not change (same preparation) and Sandalwood would profit of the weeding of "Maire". It should be a very promising field of investigation too.

The two main recommandation coming out of this trip is :

- extention of the Sandalwood plantation on the "makatea" areas. The bushes must be kept between the rows particularly the local nitrogen fixing tree : "Toroire" ;

- trial of associated plantation : Sandalwood - "Maire". Before extended mixed plantations, it must be checked if Sandalwood does not parasitise to strongly "Maire" and therefore would significantly affect its production.

ANNEXE 2

RAPPORT DE PRESENTATION DES PLANTATIONS DE MANGAIA

A M. Lloyd POWELL

Report of my mission on Mangaia (22-23 February 1996)

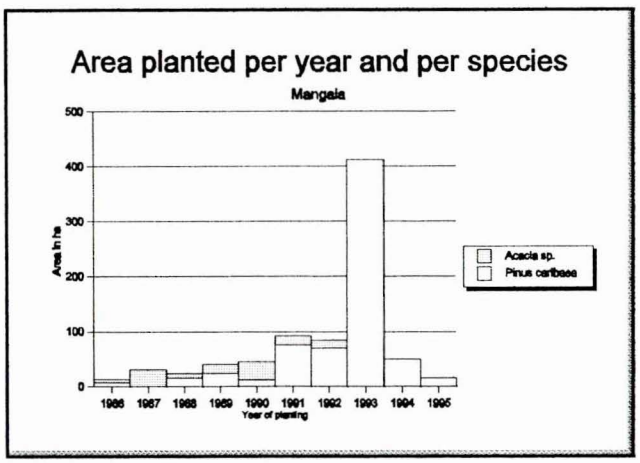
The visit was conducted by Nuku KOROA, forest officer on Mangaia. We have successively seen the pines and acacia plantations, the *Acacia mangium* trial on the Rangimotia, the nursery for the sandalwood seedlings and the expected lands to be planted with sandalwood both on the upper and the lower makatea. We have also collected the data concerning the areas planted on Mangaia since the beginning of the Cook Islands - New Zealand forestry project on this island.

Areas presently planted with *Pinus caribaea hondurensis*:

Mangaia:	685 ha (the last 1995 plantations have not been recorded due to the lack of information)
Atiu:	120 ha approximately
Mauke:	15 to 20 ha approximately

Yearly distribution of the planted areas on Mangaia :

see diagram :



As shown by this diagram, there is a huge lack of balance between the areas planted each year. The 1993 pine plantations count for more than two third of the total planted area and the areas planted between 1991 and 1995 reach 90% of the total pine plantations. Now, the major part of the island is planted and the extension of the pine plantations should stop at the end of this year or during next year.

If dispatched per species and year we have the following figure:

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Total
Pine	8		15,5	24,5	12,5	75	70	412	50	16	684
Other	6	32	8,5	16	32	17	14				126
Total	14	32	24	40,5	44,5	92	84	412	50	16	809

The huge area planted in 1993 follows the fires of July 1992 and January 1993 that destroyed an important part of the existing plantations. Such a big target was possible due to several factors:

- the soil was perfectly clean after the fires and the worker team had only to plant the seedlings without preparation ;
- the density was cut to nearly half, from 1111 trees/ha to 625 trees/ha (spacing of 4 m x 4 m). That allowed to plant almost the double area with the same number of seedlings ;

- fertilisation was abandoned ;
- only pines were planted both in destroyed acacia areas, destroyed pine areas and in still virgin areas and since 1993 only this species has been planted in Mangaia.

These factors will influence a lot the management and the evolution of the forest.

Stocking :

The genetic quality of the pines is mainly high though some plots(few) are prone to some shape defects like fox-tails or crooked stems. This behaviour seems to be linked to some seed batches purchased in 1990-1991. The same phenomenon is visible on Rarotonga and the other Outer Islands. In the major part of the plots the boles are straight and the branches are thin and well balanced on the stem.

This latter characteristic allows the option of a large spacing that aims to manage the stand with a single strong thinning that will already give poles and sawing logs. Even if such a low density is detrimental to the global production, the low cost of establishment and the expected return for the first thinning should easily balance the loss of total production. Caribic pine does not develop to thick branches and after a general pruning to 2 m at 3 to 4 years old, a further higher one to 6 m should not be necessary if the target is structure timber.

If the pruning option is envisaged, only the most straight and beautiful trees will have to be pruned (no more than hundred trees per ha).

Silviculture :

As mentionned here above, pine was planted in all the burned areas what ever was the previous species planted. The result is that we have now a regrowth of the burned acacia in the new pine plantations. This result is very interesting in term of soil conservation and improvement. The pines are growing fastly enough to be taller than the acacias. We shall have a pine stand with a thick under storey of acacias that will provide a lateral competition to the pines. The advantages of this design is a strong control of the fern under the stand, a thick litter of leaves and needles that is far better for humus building than needles alone and an expected better form particularly in term of low branch thickness. However, some care are needed particularly in the fertile areas were the acacias are growing as fast or even faster than the pine in order to keep the acaciasunder the pine canopy. This situation exists but is quite restricted to some bottom of slopes. It needs a strong trimming of the acacias as soon as possible. After that, the difference between pines and acacias should be large enough to ensure a permanent dominance of pine.

This particularity should be used in order to balance as well as possible the logging. Since the pines in these plots have a lateral competition the diameter growth will be slower than in a pure plantation (particularly in the fertile areas where the acacias are vigourous). Therefore, the first thinning will be delayed and the final logging too.

Growth and health condition :

The growth of the pine on Mangaia as well as in the other Outer Islands is surprisingly good, even on very depleted soils. The height growth is of 1,5 m/ year in average but can reach 2 m/year in the best locations. The diameter growth should reach 2.5 cm/year for 20 years. Compared to the Caribic pine plantations in New-Caledonia, the growth is significantly better and we can estimate

that the average production of the stands should easily match 20 to 25 m^3/ha/year even if the low initial density will keep this production at a low level during the first years.

The global health condition is quite satisfactorily. For the moment, no particular problem has been identified in the plantations.

With such a production level, the wood production over a period of 20 years, that seems an ideal rotation length, would be at least 300 000 m^3. At an average recovery rate of 40 % from the total volume to the sawn timber and poles that would give 120000 m^3 of sawn timber. This figure is really rough but will give a global idea.

Management plan for the Mangaian forest :

The previous diagram is clear. If the objectif rotation of the pine stands is 20 years, since all the areas were planted in five years and the half planted during one year, the wood production will be very unbalanced. In three to height years the thinnings will gives few timber then in 15 years the major part of the production will be mature. It is really a major issue for the management of the forest and the economic development linked to this production.

Some silvicultural options can be implemented in order to scatter the production on the larger period possible. It will lead to a loss of production but the regularisation of the wood production over the years must be addressed. Anyway, the problem will always exist.

- several thinnings instead of one or two in the plantations planted before 1993 (1110 stem/ha)
- identification of the most fertile areas where a very strong silviculture will be carried out and the rotation will be shortened (15 to 17 years)
- identification of the less fertile areas where the silviculture will be light and the rotation extended to 25 years and more...

An other possibility could be evaluated too : a large logging operation that would collect a substantial part of the stand. The wood would be sold (chips) to some foreign companies. Such a system would demand a large amount of wood, with logging machinery in order to cut the cost as low as possible to match the international market. The cost of logging machinery need a big operation as well as the size of the vessel. I have presently not the knowledge to analyse the technical and economic feasibility of such project but, in my mind, it is the worse solution due to he fact that the forest will stay as unbalanced as before, the population will hardly support such an operation that will bring some activities for a short time then leave the island to itself with no more forest. Furthermore, the loading at this scale of a ship in the Mangaian conditions seems very difficult since there is no landing available.

This issue of management plan for the Cook Island forest should be addressed by the next mission of the French Forestry Project. Even if the main objective of this mission, on the paper at least, is the management of the forest in a soil conservation point of view, the best protection that can be given to a land, once it has been already degraded, is that the stand it bears would have the most value possible. For that target, the forest management plan for the Cook Islands exercise will have to address the logging and the utilisation of the wood issues. Although they won't have the time to investigate these issues, they should recommend further studies on them and draft their terms of references.

Forest management plant for the Cook islands mission

According to the present French Forestry Project, a last mission will have "to elaborate a management plan for a Pacific country if possible the Cook Islands". Since the idea of this mission has been warmly welcomed by the Minister of Agriculture and the Forestry Service, I shall propose in my report that the Cook Island will be the country selected for this exercise.

The main ideas for the terms of reference are the following:

Concerned islands : Mangaia, Atiu, Mauke, Mitiaro, (Rarotonga : where the tenure system would lead to problems)

Areas that should be considered:
- already planted areas where the land tenure allows a certain management level;
- available lands for forestry related activities where the land is secured;
- land that are prone to soil erosion risks.

Objectives:
- production (wood and non wood forest products)
- protection (soils, fragile areas, endangered species if the forestry operations would disturb their environment)
- landscaping

Means
- plantations
  - -choice of species
    - pine
    - high value exotic broad leaf trees
    - local species
    - local or exotic nitrogen fixing trees
  - -techniques of plantation
    - pure / mixte
    - contour planting / line planting
- forest enrichment on makatea areas (sandalwood, maire...)
- silviculture and logging techniques

Needs of infrastructure

- roads and other exploitation systems
  - for planting and silviculture
  - for logging
- wood processing
  - sawmill
  - treatment plant / wood conditioning

Remark : these two last points need economic and technical feasibility studies :

+ logging and extraction technique to comply with the protection objectif in some areas
+ sawmill plant for pine: location, size, type of sawmill, what to do on islands with small areas of pine
+ technological qualities of timber from young pine (first thinning)

+ wood treatment:
- treatment process
- chemical to be used in environmentally exposed islands
- drying kiln ? or air seasoning
- infrastructure, size, location,

Human and financial resources

Such a mission will need, before it begins, a very strong commitment and support of the Forestry Service in terms of :

- identification for each island of lands to be considered in this management plan. These lands must be secured for forestry related activities ;
- mapping of the present reforested areas with table of ages, species, areas, densities, previous silvicultural operations... (for each concerned island) ;
- mapping of the erosion risk (slope, existing erosion with intensity and type) that will give the protection zones ;
- mapping of the risks that can affect forest plantation (goats, ...) ;
- available lands for forest enrichment (makatea) areas, type of vegetation,.. for each island.

Wood technological qualities of young pines

As soon as I shall have the results of the experimentation that CIRAD-Forêt is doing on Wallis Island, I shall analyse them and I shall send a abstract of these characteristics to you.

In New Caledonian this wood have better technological characteristics than *Pinus radiata*. Its visual aspect is far better and allows uses in furniture making. In the Cook Islands it should be the same. This wood can be used in structure (that is the main market) and furniture making for the local market but I think that there is few to no possibility to target exportation due to the production cost that would never match the one from Fiji or New Zealand.

Wood sawmilling

A feasibility study should be done as fast as possible in order to draft a policy on the subject. What would be the size of the plant, where to built it and what type of sawmill ? How to consider the dispersion of the resource on several islands. This last question is particularly accurate concerning the wood processing that add environmental and human protection to the economic constraints due to the use of toxic chemicals.

Wood treatment

As quoted here above, the treatment is compulsory but the human and environmental

constraints are very high. A feasibility study would be needed in order to identify the most adapted treatment for the Cook Islands, sufficient for the protection and as armless as possible for the environment (including the waste disposal). What plant to built, what will be its location and how to solve the case of the small islands like Atiu (120 ha) or Mauke (20 ha) ?

Sandalwood plantation on Mangaia :

Sandalwood would grow on Mangaia as well as on the other islands provided that it is planted in the right location. On Mangaia two type of areas have been identified, both of them on makatea.

The first one on the lower makatea that look quite like the planted areas on Mauke and Mitiaro. The soil conditions are harsh and the natural vegetation is quite low. Rows are opened every 5 to 6 m in this vegetation (perpendicularly to the prevailing winds if possible) and the sandalwood planted in this row every 3 to 4 metres. If the natural vegetation is poor in nitrogen fixing trees, some of them should be planted between the sandalwood on the row (spacing : 3 m between plants). The native species : Toromiro (*Schleinetzia insulare)*, common on Mauke and Mitiaro should be planted if it is not present in the area. It is perfectly adapted to this type of soil.

The second one is located on the upper makatea that is far more fertile than the lower one. The design is the same but the maintenance of the stand must be carefully followed due to the high competition expected from the natural vegetation that is vigourous on this soil.

Nouméa, the 4 april 1996

Yves EHRHART
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New-Caledonia

ANNEXE 3

ORDRE DE MISSION N°07/96-OM

DU 10/02 au 05/03/96 de M. Yves EHRHART

CIRAD - Forêt
45 bis, Avenue de la Belle Gabrielle
94736 NOGENT-SUR-MARNE CEDEX

Département Forestier du
Centre de Coopération Internationale
en Recherche Agronomique pour le Développement

ORDRE DE MISSION N° 07 /96-OM

— NOM et PRÉNOM : EHRHART Yves

— FONCTION : Ingénieur

— SE RENDRA A : Iles Cook

— OBJET DE LA MISSION : Mission d'étude :
Conservation des sols et aménagement forestier dans le Pacifique Sud

— ITINÉRAIRE : Nouméa - Auckland - Iles Cook - Auckland - Nouméa

— MOYEN DE TRANSPORT : avion

— DATE DE DÉPART : LE 10.02.1996 A — DATE DE RETOUR : LE 5.03.1996 A

— SERA REMPLACÉ PAR :

— IMPUTATION : 4 /Pacifique Sud

~~A NOGENT-SUR-MARNE~~, LE 7 Février 1996
Montpellier,

Le Directeur Administratif et Financier,

Copies :
Chrono
Gestion
CTE
DS

PLANCHES PHOTOGRAPHIQUES

ESSAI 24: RAROTONGA

Santalum austrocaledonicum.

au premier plan, *A. auriculiformis* qui sert de plante hôte n'a pas supporté l'élagage qu'il a subi.

Il lui sera préféré d'autres espèces plus plastiques ou plus buissonnantes (*Calliandra calothyrsus*).

MANGAIA

Plantation d'*Acacia crassicarpa* de 8 ans.

Notez le couvert très clair de cette espèce

Bordure de l'essai avec : au premier plan : *Acacia mangium* (essai)
au deuxième plan *A. crassicarpa*, et *Pinus caribaea hondurensis* (bordure et hors essai)

ESSAI 15: MANGAIA: 3 ans après l'incendie qui avait détruit la totalité de l'essai

La plantation vient d'être élaguée et les rejets multiples éliminés.