OK

ACIAR PROJECT PN 9025

COCONUT IMPROVEMENT

en Papouasie
du 30/10 au 13/11/93

REPORT OF THE REVIEW PANEL

H.C. Harries & G. de Taffin

December 1993

ACIAR
Australian Centre for International Agricultural Research

CONT

GABRIEL

EXECUTIVE SUMMARY

INTRODUCTION

- Background
- Aims & Objectives of the Project
- Terms of Reference for the Review
- Reviewers
- Format of the Review
- Dates of the Review

With the compliments of the Director

Colin Piggin

BUDGET

BENEFITS OF THE PROJECT

- Methodologies
- Coconut Germplasm
- Infrastructures
- Training & Cooperation
- Publications & Scientific Recognition

DISTRIBUTION OF PROJECT BENEFITS

- Papua New Guinea
- Australia
- South Pacific Region
- International Community

PROJECT ADMINISTRATION & COORDINATION

- Leadership
- Reporting & Monitoring
- Finance

REVIEW OF PROJECT OBJECTIVES

1. Coconut Germplasm Identification & Characterisation
- 1.1 Achievements
  - Papua New Guinea
  - South Pacific
  - Molecular Germplasm Characterisation
- 1.2 Research Significance
- 1.3 Scientific Merit & Relevance

1.4 Shortcomings
1.5 Recommendations

2. Coconut Germplasm Collecting
2.1 Achievements
Papua New Guinea
South Pacific
Embryo Culture Development
2.2 Research Significance
2.3 Scientific Merit & Relevance
2.4 Shortcomings
Papua New Guinea Collection
South Pacific Viroid Indexing
2.5 Recommendations
Papua New Guinea Collection
South Pacific Viroid Indexing
Embryo Culture Development

3. Field Germplasm Repository
3.1 Achievements
3.2 Research Significance
3.3 Scientific Merit & Relevance
3.4 Shortcomings
3.5 Recommendations

4. Somatic Embryogenesis
4.1 Achievements
4.2 Research Significance
4.3 Scientific Merit & Relevance
4.4 Shortcomings
4.5 Recommendations

5. Regional Breeding Programme
5.1 Achievements
5.2 Research Significance
5.3 Scientific Merit & Relevance
5.4 Shortcomings
5.5 Recommendations

6. Crop Physiology & Other Studies
6.1 Achievements
6.2 Research Significance
6.3 Scientific Merit & Relevance
6.4 Shortcomings
6.5 Recommendations

RECOMMENDATIONS FOR RENEWAL/EXTENSION/TERMINATION

ACKNOWLEDGEMENTS

APPENDICES

EXECUTIVE SUMMARY

The three year Project PN 9025 between ACIAR and CCRI finishes in December 1993. It has achieved about one and a half of its four initial aims. The main stumbling block was due to a circumstance beyond the Project's control; namely, the identification of viroid-like RNA in most of the collected coconut germplasm, which prevented import of germplasm into Papua New Guinea. Nevertheless, the funding from ACIAR appears to have been adequate and timely.

After a close examination of the Project's achievements, objective by objective, the Reviewers consider that significant results have been obtained.

The Project developed and modified RFLP and RAPD techniques for molecular coconut germplasm characterisation. It improved existing methods for embryo collection to make them more suitable for use on Pacific islands and other remote locations. The potential application of these results goes much further than the Project's limits, and are of importance to COGENT, IBPGR and to coconut breeders everywhere.

The Project undertook a comprehensive survey of Papua New Guinea coconut germplasm. The subsequent collection of seednuts and pollen and the establishment of a repository for a Papua New Guinea coconut germplasm collection is in progress. Land preparation for the repository should be ready by the end of December 1993.

Regional and international cooperation has been developed and strengthened and scientific publications have, and will, extend the results to the international coconut research and development community.

The Reviewers base their positive appreciation on the evidence of the Project scientists' dynamism and team spirit. Unexpected problems caused by change in leadership confronted the Project team and there were delays in setting up the required facilities for *in vitro* culture both in Papua New Guinea and in Australia. Nevertheless, the team reacted positively, redirecting their efforts in the appropriate directions.

In that respect the Reviewers accept that dropping research into somatic embryogenesis became necessary when it proved more complicated than expected. The slow progress of similar teams in other countries with more staff and equipment, confirms that the decision was realistic.

The Reviewers' recommendations aim to fully exploit the results of the Papua New Guinea germplasm survey and to correct some shortcomings.

The Reviewers' major recommendations are:

(a) to extend the duration of the first objective (to characterise and identify coconut

germplasm in Papua New Guinea) by six months from January 1994. This is to allow complete analysis, interpretation and preparation for publication of the Papua New Guinea germplasm survey data. Fingerprinting techniques developed under the third objective should complement the biometric approach based on morphological descriptors.

(b) to use the information obtained to devise a comprehensive and long-term breeding programme for the CCRI. Scientists from other disciplines should be involved and use should be made of recent progress in coconut breeding (e.g. the use of testers).

(c) to take all necessary measures to ensure proper drainage at the site of the new CCRI Coconut Research Centre, Madang, where the repository will be established. These measures should include the completion of the detailed land survey already begun and the involvement of drainage specialists in drawing up the drainage plan.

After full completion of the present project, as recommended above, ACIAR needs to begin a new coconut Project to continue involvement in cooperative coconut research.

The Reviewers consider the following topics as the most relevant for ACIAR's further involvement with coconut research:

(a) Complementary research on viroid-like RNA.
The Reviewers **strongly recommend** that ACIAR give priority to this, to enable coconut germplasm exchange. They consider that proving or disproving pathogenicity of the viroid-like RNA is a key issue that must have priority. The ACIAR Coconut Workshop, Taveuni made a similar recommendation.

(b) Characterisation of coconut germplasm.
Using the DNA fingerprinting methods already developed.

(c) Integrated pest management.
A research programme for *Oryctes*, *Scapanes* and *Rhynchophorus* control (as recommended by the previous Review, Project 8442). Lack of any control is a major limiting factor to replanting in most of the Provinces.

(d) Sustainable coconut-based farming systems.
This topic has also been considered important by the ACIAR Coconut Workshop.

(e) Processing of coconut products at the village level.
To improve the profitability of coconut to farmers (as recommended by the previous Review of Project 8442).

For all the above topics, and especially research on viroid-like RNA and DNA fingerprinting, the Reviewers advocate regional and international cooperation.

The Reviewers' draw the attention of ACIAR to the fact that there are a considerable number of Australian based agriculturalists and research scientists with experience of

coconuts and associated crops and of the Pacific region. These people could be usefully employed on agronomy, farming systems and extension-based projects. Finally, it should not be overlooked by ACIAR that when it supports coconut research in Papua New Guinea, the results are of considerable benefit to other countries of the Pacific region, and also to developing countries in the tropics where coconuts grow.

INTRODUCTION

Background

The objective of this Project (PN 9025) is to develop and distribute better technology for multiplication of improved coconuts by the Cocoa & Coconut Research Institute in Papua New Guinea. The need for replanting is common to all coconut producing countries and in this instance Papua New Guinea is the largest producer in the Pacific region (see Appendix 1).

This Coconut Improvement Project, PN 9025, follows a previous Coconut Improvement Project, PN 8442. The recommendations from the previous appraisal mission are included in Appendix 2 along with comments on how the previous set of recommendations have been carried out.

This Coconut Improvement Project, PN 9025, is complementary to other ACIAR projects on cadang cadang viroid and (earlier) on foliar decay.

Aims & Objectives of the Project

At the outset, the four aims of the collaborative research project between Australia and Papua New Guinea were to use the embryo culture technology developed in Phase 1 of the project (PN 8442) to import coconut germplasm into Papua New Guinea and other South Pacific countries; to establish techniques for coconut propagation by somatic embryogenesis; to assess the implications of the new technology in relation to reducing phytosanitary risk in coconut improvement programmes; and to establish a collection of both local and imported coconut germplasm in Papua New Guinea for use in breeding programmes (see Appendix 3 for a full statement of Aims).

The individual Objectives of these Aims, are identified in the working document entitled "Submission to ACIAR Review Team". That document contains an outline of methodology and statements on problems, alternatives, results and suggestions for future work). Briefly the Objectives are to phenotypically and genotypically characterise and identify the coconut genetic resources of Papua New Guinea and the south Pacific region; to collect the identified coconut populations, using embryo culture techniques evaluated and developed for collection of germplasm from remote areas; to index exotic germplasm for coconut cadang-cadang-like viroid; to establish a national and regional germplasm repository; to investigate somatic embryogenesis for clonal propagation in coconut palms; to participate in the regional coconut breeding project; and to provide initial data on the light interception of hybrid coconuts over time.

Terms of Reference for the Review

The appraisal team were instructed to assess and provide comment on the progress and achievements of the project in relation to its objectives; on the scientific merit of the research, its relevance to the collaborating countries and Australia, and the progress and

constraints with adoption of research results; on the extent to which the project achieved true collaboration and strengthened the research capacity of the participating scientists and the partner countries; on the efficiency of the project management in Australia and Papua New Guinea, particularly its administration, monitoring and support; on whether ACIAR and the partner country have adequately funded the project; on the value and relevance of project outputs and linkages established in relation to international coconut improvement research efforts; on whether further support for research on coconut improvement in the region is warranted from ACIAR, and suggest the priority and scope of any possible proposed research projects.

Reviewers

Hugh Harries is a tropical tree crop breeder with experience of coconut research in the Pacific, Southeast Asia, Africa and the Caribbean. Between 1983 and 1988 he was Chief Agronomist at Dami Oil Palm Research Station in Papua New Guinea. In 1989 he was a member of the three man review team for ACIAR Project PN 8442 and in 1990-91 he led a six month, two-man ADB (Asian Development Bank) appraisal of smallholder oil palm productivity in Papua New Guinea. In 1992 he was consultant to IBPGR (the International Board for Plant Genetic Resources) and set up COGENT (international Coconut Genetic Resources Network), in which the Papua New Guinea Cocoa & Coconut Research Institute participates.

Gabriel de Taffin is a CIRAD agronomist with twenty-three years' experience in coconut and oil palm research and development in the Pacific and Africa. From 1979 to 1990 he was Director of the Marc Delorme Coconut Research Station in Côte d'Ivoire (West Africa). He is the Suva based consultant for the Fiji Coconut Rehabilitation and Development Project since 1991.

Format of the Review

The appraisers met CCRI staff on-site in Papua New Guinea and visited laboratories and field sites at Keravat and field sites at Madang. Discussions were held with scientists and commercial representatives in Port Moresby. Mr de Taffin visited Mr Ashburner's laboratory at Burnley Gardens in Melbourne (which Mr Harries had seen in 1992) and had discussions with Mr Ovasuru and Dr Perkins. After a break (when Mr Harries met with Fijian, and Mr de Taffin with French, coconut scientists), the appraisal continued by participating in an ACIAR coconut workshop in Fiji. During the workshop the Papua New Guinea and Australian participants in this and the complementary viroid-like RNA project had further discussions. Also, there was the opportunity to question other regional research and development personnel.
After the main project appraisal, during the writing up period, Mr Harries and Mr Ashburner attended a coconut research meeting in Mexico. Finally, Mr Harries and Mr de Taffin met in London to finalise this report (for full itinerary details see Appendix 4).

Dates of the Review

In Papua New Guinea	1st-5th November 1993
In Australia (de Taffin)	6th & 8th November 1993
In Fiji	11th & 12th November 1993

Documents Studied

A list of documents studied by the Reviewers in the course of this exercise are given in Appendix 5.

BUDGET

The Table below shows the budget summary. It is based on preliminary budget projections according to documents supplied at the outset. It is complemented by actual revenues and expenditures stated in annual reports 1991 and 1992. These figures concern only the overall ACIAR funding. The total Project cost is about Aus$ 700,000, with about 82% met by ACIAR. For 1991 and 1992, the ACIAR expenditure was slightly below the estimate, leaving a total surplus of about Aus$ 20,000. ACIAR and CCRI staff reported that they considered the Project to be adequately funded.

Table BUDGET SUMMARY - $(A) Value

	YEAR 1 (1991)		YEAR 2 (1992)		YEAR 3 (1993)	
OVERALL ACIAR FUNDING						
Cost item	Budget Provision	Expend. Statemnt	Budget Provision	Expend. Statement	Budget Provision	Expend. Statemnt
Personnel	100,341		99,341		100,341	
Supplies & Services	46,185		16,600		16,700	
Travel	66,200		68,100		65,900	
Other	0					
Total	212,726	202,594	184,041	211,755	182,941	0
Revenue Statement		217,010		218,267		
Surplus		14,416		6,512		
PNG CONTRIBUTION						
Cost item	Budget Provision	Expend. Statemnt	Budget Provision	Expend. Statement	Budget Provision	Expend. Statemnt
Personnel	37,865		37,865		37,865	
Supplies & Services	0		0		0	
Travel	0		0		0	
Other	5,000		5,000		5,000	
Total	42,865		42,865		42,865	
TOTAL PROJECT COST	255,591		226,906		225,806	708,303

BENEFITS OF THE PROJECT

Some of the benefits expected from the Project could not be achieved. No exotic germplasm has been transferred to Papua New Guinea and clonal propagation of coconuts was not achieved. Nevertheless, the Reviewers consider that significant benefits have been obtained or are within reach.

Methodologies

Embryo culture has been improved, especially for collection in remote locations, and also for acclimatization. The proposed improvements for collection have been successfully tested in different environments and on several hundred embryos.

The so-called DNA fingerprinting techniques have been used for coconuts and are now available for complementary screening of coconut populations (variability within population and genetic distance between populations).

Some of the IBPGR descriptors have been used for a large scale coconut survey. Analysis and interpretation of these data will help in validating the descriptor list.

Coconut Germplasm

When analysis of the collected data is completed it will represent a big step forward in characterisation of the Papua New Guinea coconut germplasm.

Complementary and valuable information has been obtained for germplasm of the Pacific Region.

A large repository of Papua New Guinea germplasm is on the verge of being established. It will provide basic material for a comprehensive breeding programme, which has already been initiated.

Infrastructures

Suitable facilities have been set up in Papua New Guinea for coconut pollen processing and coconut embryo culture.

Another facility has been set up at Burnley Gardens for embryo culture and DNA fingerprinting techniques.

Training & Cooperation

Papua New Guinean staff have been trained, both in Australia and in Papua New Guinea.

The Papua New Guinea and Australian staff have also acquired new skills while working in Papua New Guinea, Australia or in the South Pacific region. Cooperative links have been

established with research organisations in other countries (Wye College in the UK, Max Planck Institute in Germany, CIRAD in France and Vanuatu, etc.). An international association has been founded for networking in coconut tissue culture.

Last but not least, through collaborative work, friendship has developed and built up between the Papua New Guinean and Australian teams involved in the Project.

Publications & Scientific Recognition

Through publications, made or in draft, the Project has gained scientific recognition. This can be judged by the invitations extended to Project scientists to attend international conferences and to present communications.

DISTRIBUTION OF PROJECT BENEFITS

Papua New Guinea

Papua New Guinea should undoubtedly benefit from all the Project achievements - germplasm characterisation and repository, research infrastructures, improved methodology, training, etc. Potential benefits to Papua New Guinea staff will depend on the successful resolution of some domestic difficulties within CCRI.

Some benefits can be realised on a short term basis. For instance, when Mr Ovasuru returns to Papua New Guinea he should be given full responsibility for continuing the germplasm survey and characterisation. His knowledge of what is being grown by the farmers will be invaluable when improved planting material is ready for introduction. It is essential to avoid the sort of fiasco that accompanied the introduction of F1 hybrid coconuts in the late 1970s. Mr Ovasuru should not need to become involved in routine breeding operations at Omuru.

Once Mr Ovasuru has returned it would be possible to consider sending Mr Faure for a plant breeding PhD in Australia. There would be no change in CCRI staff numbers and Mr Faure's new experience gained under the Project would be optimised.

Other benefits will appear only on a long term basis. The support given to the Papua New Guinea coconut breeding programme will only eventually increase in production. In the meantime, benefits to the coconut farmers must come from a farming systems approach to agronomy, integrated pest management, improved processing and aggressive/progressive marketing.

Australia

Although Australia has no coconut industry, the country will benefit from anything that improves the agricultural performance of the neighbouring Pacific and Indian Ocean countries. Special mention has to be made for Mr Ashburner, who now has unparalleled experience in applying modern scientific techniques to coconuts. The benefits that have accrued to him are available to ACIAR (and also to international coconut research) as long as he continues this sort of work. ACIAR must give priority to finding continued and suitable employment for Mr Ashburner.

South Pacific Region

All the methodologies will help the entire South Pacific region, (not merely the PDICC), especially if the problem of viroid-like RNA can be resolved and exchanges of germplasm can resume.

Publications made, or in draft, will provide benefits to the scientific research community in Australia, Papua New Guinea and the Pacific region. Some consideration has to be given by ACIAR to this matter in view of all relevant knowledge acquired under the Project to be published.

International Community

The International Community is interested in the improved methodologies. The application of the IBPGR descriptors for a large scale survey are also particularly expected along with the description of germplasm available in Papua New Guinea.

The DNA fingerprinting results are the first of their kind and will be widely emulated.

The project of regional collection in Papua New Guinea under the aegis of COGENT still remains, awaiting a solution to the viroid-like RNA problem. Project staff participated in the establishment of COGENT (Cipanas 1991 and Montpellier 1992). COGENT's activities will include germplasm transfer by embryo culture. It is up to CCRI to make sure that they will continue to be involved and to take the lead regionally.

PROJECT ADMINISTRATION & COORDINATION

Leadership

The Project suffered unnecessary problems arising from changes in Project leadership, both in Australia and in Papua New Guinea.

In Australia, the first Project Leader (Dr Thomson) was in office for only for two months. His replacement (Dr Richard) stayed with the Project till the end of 1992, but had little time to devote to the Project due to many other commitments. The Project was without a leader for most of 1993.

In Papua New Guinea, the same volatility has been observed with the departure of the CCRI Research Director, Dr Kola, in October 1992 without a replacement until October 1993. It has also been note that CCRI has been without a senior plant breeder for months.

The delays in setting up of proper embryo culture facilities in both Melbourne and Keravat, which have hampered the Project implementation are most probably due to that leadership problem.

Nevertheless, when achievements are put into perspective of the chronic crisis of leadership, clearly the other Project scientists bridged the gap. To the Reviewers, this is proof of their dynamism and commitment as well of the excellent team spirit between Papua New Guinea and Australian teams.

The lack of a comprehensive, long-term breeding programme, mentioned by the Reviewers, is also explained by the long vacancy for the position of breeder at Keravat.

Reporting & Monitoring

Annual reports were published on time. Regular meetings were held with minutes properly kept. The Reviewers were also given a very comprehensive document. These efforts support the conclusion that, despite lack of leadership, the Project has been properly managed and coordinated.

Finance

The financial situation in Papua New Guinea has been described as tight especially for 1993. Nevertheless, all expected funding has been found especially for purchase of land for the repository. The funding by ACIAR has been unanimously described as sufficient and timely (see Budget Summary).

REVIEW OF PROJECT OBJECTIVES

The following section contains the Reviewers' comments and recommendations arising from the perceived achievements, research significance, scientific merit, relevance and shortcomings of the project objectives identified in the working paper presented at Kerevat - coconut germplasm identification, characterisation and collecting, field germplasm repository, somatic embryogenesis, regional breeding programme, physiology & other topics.

1. Coconut Germplasm Identification & Characterisation

In Papua New Guinea, Mr Ovasuru carried out the germplasm survey between January 1991 and October 1992. In the South Pacific area Mr Foale and Mr Ashburner did similar work in 1991-92. Complementary studies on molecular germplasm characterisation were also undertaken in Australia (Mr Ashburner).

1.1 Achievements

Papua New Guinea

Altogether, 153 populations were surveyed using fruit component analysis along with vegetative and floral characters. It used 45 of the IBPGR descriptors. The survey sites were New Britain (East and West), New Ireland, North Solomons, Manus, Morobe, Madang, East Sepik, Sandaun, Central, Milne Bay, Oro, Gulf and Western Province.

Information was also collected on the history of the populations along with the local uses of coconut products and its incidence on human selection of coconut types.

Processing of the collected data has commenced at the University of Melbourne, where Mr Ovasuru has enrolled in a postgraduate program in February 1993. He has been advised by Dr Halloran, Reader in Plant Genetics and Dr Ades, Lecturer in Forest Genetics.

To date, the task is far from being completed given the large quantity of data to be processed and the difficulty for Mr Ovasuru to work on it full time. Provisional results from class analysis show seven clusters. A first list of 62 populations with high albumen/nut has also been established.

South Pacific

A further twelve populations were surveyed or re-surveyed using the method of fruit component analysis. The populations were from: Tonga, Vanuatu, Fiji, Kiribati, the Solomon Islands, Rennell Island, Cook Island, the Tuamotu Archipelago, the Society Islands and the Marquesas. Cocos Keeling Island in the Indian Ocean was also surveyed.

Results have been processed and analysed.

Molecular Germplasm Characterisation

Interpretation of the South Pacific survey appeared a difficult exercise as the true level of genetic diversity has to be interpreted in the light of natural selection, domestication and subsequent introgression. Therefore, it was decided to attempt to characterise germplasm on a genotypic basis by using isozymes and DNA analysis.

Collaborative work was undertaken with Dr Rohde, Max Planck Institute, Germany, resulting in protocols being developed for extracting DNA and for generating data using the RAPD and RLFP techniques.

Preliminary analysis suggests little divergence of coconut populations in the Pacific region, except Niu Leka (Fiji), Vanuatu Red Dwarf, Rennell Tall and Marquesas Tall. Greater diversity was recorded within populations. This is in line with earlier survey findings (Whitehead, 1964). In contrast, the coconuts of Cocos Island in the Indian Ocean, appeared quite different from most of those investigated the Pacific area. This is in accordance with well established theory on evolution, dissemination and classification of the coconut.

The conclusion from this research is that DNA fingerprinting techniques which are simple, cheap and precise are applicable for coconuts. Therefore, they are an excellent technique for systematically assessing diversity within populations and genetic distance between populations.

1.2 Research Significance

The Reviewers consider the achievements under the first objective as particularly significant. The number of populations surveyed in Papua New Guinea is impressive, especially considering the number of descriptors used. Adjustment and preliminary use of DNA fingerprinting techniques has also been obtained in a remarkably short time. It is also noted that the South Pacific survey was not limited to easily accessible places but covered also remote islands like the Marquesas.

1.3 Scientific Merit and Relevance

Complementing the Papua New Guinea survey with historical information and observations on the local use of coconut products appears very commendable to the Reviewers.

The Reviewers acknowledge also the decision to undertake some work on DNA fingerprinting to help in interpreting the results of the surveys as particularly relevant. The facility and equipment currently used by the Project at Burnley Gardens are of top level standard.

Furthermore, the collaboration with Dr Rohde in a publication on DNA fingerprinting is an indication of the scientific merit of this research.

1.4 Shortcomings

These objectives will be achieved only when full analysis and interpretation of the Papua New Guinea survey has been completed. The major questions that remain to be answered are:

(a) How many differentiated populations exist in Papua New Guinea?

(b) Which ones are to be planted in the repository and to be used in the Papua New Guinea breeding programme?

1.5 Recommendations

In that respect, the Reviewers recommend that:

(a) the project component is extended by six months for full completion. Mr Ovasuru would work full time on analyses and interpretation of his survey data, with assistance given by specialists on Plant Genetics and Biometrics at Melbourne University. (The proposed duration of six months is based on discussions held with Mr Ovasuru and Mr Ashburner respectively).

(b) Mr Ashburner should help, by carrying out DNA fingerprinting tests on the most interesting Papua New Guinea populations. CCRI would be involved in the collection and dispatching of the necessary samples. This would involve further cooperation with other DNA fingerprinting specialists.

(c) complementary samples could also be received and processed from the South Pacific region. In that respect it is suggested to include samples collected material known for its general combining ability, such as the red and yellow Malayan Dwarf varieties. These could be controls for evaluation of variability within population and of genetic distance between populations.

(d) all information is summarised and used to assess the Papua New Guinea coconut population and advise on the most interesting accessions for the Papua New Guinea breeding programme.

(e) specialists from other disciplines (breeders, agronomists and plant protection), who have good knowledge either of the plant or of the collected sites, should be consulted interactively.

(f) the results are made available to the COGENT database, and to IBPGR for amendment of the coconut descriptor list.

2. Coconut Germplasm Collecting

Seednuts and pollen were collected in Papua New Guinea by Mr Faure from March to December 1993. In the South Pacific embryos were collected by Mr Ashburner and Dr Tomlinson and sent to Australia, as planned. The collection of embryos gave an opportunity to improve the methodology to make it more practical for remote islands. The acclimatisation process has also been studied at Keravat by CCRI staff, including Mr Tade and Mr Pulo.

2.1 Achievements

Papua New Guinea

Based on a list given by Mr Ovasuru, 62 populations were chosen for the germplasm repository (see Appendix 6). They correspond to 19 different areas of Namatanai, Oro, Manus, West and East New Britain. Mr Ovasuru's choice was mostly based on high endosperm content (see Appendix 7).

The number of seednuts to be collected varies according to the assessed interest of the population, from 250 for the standard one up to 750 or 950 for the elite germplasm. The seednuts are sent to Omuru nursery (near Madang), where they are put into seedbeds.

During the Reviewer's visit to Omuru, seednuts from 21 populations were already germinating in the seedbeds. There was a total of 3,927 germinated from a total of 5,909 received (or 66% germination, which is good given the transportation delay). This confirms the satisfactory aspect of the nursery at the time of the visit and its proper management.

Based on 165 germinated seednuts for planting one hectare of the repository, the current planting potential was estimated at 24 hectares.

Collected male flowers are taken or sent to CCRI, Keravat for processing. Pollen is dispatched to Omuru and used for hybridisation work in the seed garden. The mother palms are about 250 of either the red or yellow Malayan Dwarf, or about 150 Papua New Guinea Brown Dwarf. A crossing programme has been devised with a change of pollen every month (see Appendix 8).

The Reviewers learned from Omuru staff that the quantity of pollen received was frequently insufficient, while the lack of proper electricity supply prevented systematic checking of pollen viability.

At Keravat, the Reviewers inspected the pollen laboratory set up within the framework of the Project and found it adequate. It appeared also that Keravat staff is well trained in pollen processing techniques. Reported figures for pollen viability tests were also normal. There are no technical reasons for any shortage of pollen dispatched to Madang.

The Papua New Guinea germplasm collection is expected to be completed by February 1994.

South Pacific

The travelling undertaken for characterising germplasm (see 1.1) gave an opportunity to collect about 3,000 embryos. The embryos were sent to Melbourne to be cultured (first Knoxfield then Burnley Gardens).

Various difficulties were encountered, the major one being inadequate facilities until mid-1993. The overheating of a temporary culture room in 1991 led to substantial loss of embryos. But new germplasm has been successfully collected by remote instructions (e.g. Fiji).

The plantlets[1] issued from these embryos represent germplasm from the following accessions: Tonga Tall, Fiji Tall, Niu Leka, Vanuatu Tall, Vanuatu Red Dwarf, Brazil Green Dwarf, Cameroon Red Dwarf, Catigan Dwarf, Kiribati Tall, Rarotonga Tall, Tahiti Tall, Cocos Island Tall.

Samples of the accessions were tested for viroid-like RNA in Dr Randles' laboratory at the Waite Agricultural Research Institute (WARI, University of Adelaide). Many accessions tested positive, though some differences were observed, depending on the type of equipment or technique used. One round of tests produced 91% positively indexed accessions.

The uncertainty surrounding the viroid-like RNA, which has similarities with the viroids causing the coconut cadang-cadang disease, gave the Papua New Guinea Quarantine authorities no choice but to refuse access to all plantlets. Therefore, no exotic germplasm has been transferred to Papua New Guinea.

Later, the germplasm was offered to other countries (Vanuatu, Solomon Islands and Indonesia) which understandably declined for the same quarantine reasons. Even the source countries refused to receive their own material. Subsequently, the plantlets have been partially used for experimental studies. Some plantlets in good conditions are still kept at Burnley Gardens.

Embryo Culture Development

Shortcomings were found in the methodology developed in West Africa by Assy Bah *et al* under a CIRAD/IBPGR project when used in remote locations. Improvement of collection and transport techniques was then immediately considered. It proved suitable, after testing, and was subsequently used on a large scale for repeated collection of germplasm.

It was also decided to study *in vitro* growth and acclimatisation, to develop a

---

[1] Plantlets cultured from genetic embryos are known as "emblings", in contrast to "ramets" that are cultured from somatic tissues.

comprehensive technology package for embryo culture.

The renovation of the Keravat *in vitro* culture laboratory, when completed in November 1991, made cooperative research work possible between Melbourne and Papua New Guinea. Melbourne concentrated on *in vitro* research with embryos received from Papua New Guinea. Keravat experimented on acclimatisation, using protocols and methodologies drafted in Melbourne. By the end of the Project, it was conservatively estimated that 100 coconut embryos collected in a remote location give 20 to 25 plantable seedlings.

2.2 Research Significance

To the Reviewers, the achievements under the second objective are also very significant. A large quantity of germplasm has been collected in both Papua New Guinea and the South Pacific.

The embryo culture technique developed in West Africa has been tried and improved to make it more suitable to South Pacific islands and other remote locations.

The failure to transfer any exotic coconut germplasm to Papua New Guinea is not the fault of the Project. Indeed, the Project team have developed a workable technique for the safe transfer of germplasm. Once those plantlets that test positive for a dangerous disease are destroyed, the healthy ones can be moved with minimal quarantine hazard.

2.3 Scientific Merit and Relevance

The Reviewers consider the work on embryo culture development as particularly meritorious and relevant. These achievements have to be put into perspective against laboratory problems and long transportation distances or delays for the germplasm.

To the Reviewers, the Project scientists have shown logic in their experimental approach and realism when redirecting their effort towards the only left open direction.

A well defined embryo culture technique is a precious tool in coconut germplasm collection and a prerequisite to safe movement of germplasm

2.4 Shortcomings

Papua New Guinea Collection

Based on the collection programme given in Appendix 4, a total of 27,975 seednuts are to be collected by February 1994. It represents some 100 ha to be planted in the repository, which is quite a high figure when maintenance costs and proper monitoring and evaluation of the germplasm are considered.

On the other hand, the Reviewers are concerned by the fact that all data collected for the characterisation of Papua New Guinea germplasm were not used for choosing the accessions to be collected. In other terms the Reviewers consider that Papua New Guinea collection should make better use of the germplasm characterisation undertaken under the first objective.

The same remark applies for the on-going pollen collection. Its systematic use in a crossing programme appears somewhat premature, as it will need a large area of hybrid tests to be field planted with all the corresponding recurrent costs for maintenance and evaluation.

CCRI has revised its breeding programme. Progeny testing of Dwarf x Tall, Tall x Tall and Dwarf x Dwarf hybrids have been planned, along with multilocation experiments. Such a general framework needs to be preceded by detailed protocols and annual work plans.

For instance, before planting a Dwarf x Tall experiment with five new hybrids in 1995, the following questions need to be answered:

(a) Which planting lay out (statistical design, number of palms per plot, number of replications and total planted area)?

(b) Which control varieties to adopt?

(c) Which parental palms to use, the source and quantity of pollen to be collected, the method of pollination, etc?

(d) Where to plant the trials?

(e) What are the labour requirements and costs?

The Reviewers asked if such documents exist but, in the absence of Mr Ovasuru (in Melbourne), none were available.

South Pacific Viroid Indexing

The Reviewers consider the issue of viroid-like RNA as a critical one. It has prevented the transfer of exotic germplasm to Papua New Guinea. The same way, it is a major obstacle to exchange of germplasm needed for coconut breeding in the South Pacific Region.

The matter was discussed at length in the Taveuni ACIAR Workshop and a communiqué was prepared (see Workshop Proceedings).

Given the current state of knowledge on the issue, the Reviewers are sceptical about the value of systematic indexing for coconut germplasm. For safe movement of embryos, any national Quarantine Service will most probably (and sensibly) react as did Papua New Guinea, refusing entry of all germplasm, even for the plantlets having a negative index.

The basic IBPGR recommendation, not to collect germplasm from an infected area will prevail, as all areas may be infected. With the present state of knowledge, any facility for mass indexation of samples would probably remain idle and prove a costly and unnecessary investment.

2.5 Recommendations

The Reviewer's recommendations are as follows:

Papua New Guinea Collection

(a) Mr Ovasuru to complete analysing and interpreting the germplasm survey data (see 1.4).

(b) To use results for sorting out germplasm already collected and present as plantable seedlings at Omuru.

(c) To field plant in the repository only what is of greatest interest.

(d) To devise a complementary collection programme on a medium or long term basis, to build up the collection progressively while spreading costs over more years.

(e) To use the completed germplasm survey data for devising a comprehensive long-term breeding programme.

(f) To Involve CIRAD, along with the CCRI plant protection scientists and agronomists, with breeding targets such as pest tolerance.

(g) To decide details of multilocation trials (where, how many hectares, etc.).

(h) To devise a time frame along with estimated annual budgets.

(i) To submit the plans to the CCRI senior plant breeder and have them approved by the CCRI Board of Trustees to ensure proper long-term funding.

(j) To reduce the cross-pollination activities, in the mean time, and concentrate on a range of hybrids that may be expected to show distinctive differences.

South Pacific Viroid Indexing

(a) ACIAR to give top priority to the issue of the viroid-like RNA and fund (or help in securing funding) further investigations after completion of the current phase (ending December 1994)

(b) To give priority attention to the question of the exact origin of the viroid-like RNA observed along with disease risks involved.

(c) To resolve the divergent CIRAD interpretation of the WARI results by further research with advice and cooperation from independent experts.

(d) The Reviewers also believe that cooperation between WARI and CIRAD would be of general interest and much appreciated by the Pacific countries.

(e) Should the WARI hypothesis been confirmed, then systematic indexing would appear as the only way to deal with the problem.

(f) As for the remaining plantlets available at Burnley, they could be given to WARI as material for the ongoing research.

Embryo Culture Development

(a) Some verification or complementary observations are needed on acclimatisation. The importance of this was underlined at the ACIAR Workshop. Results can be highly variable and, as such, deserve more attention. For instance, is there a seasonal effect?

(b) Acclimatisation could also be usefully tested after transportation of plantlets. For instance at Omuru, using those received from Keravat.

Once the embryo culture process is under control, introduction of germplasm could commence without delay, if or when the viroid-like RNA obstacle is overcome.

3. Field Germplasm Repository

The repository is aimed at serving both Papua New Guinea and the South Pacific Region breeding requirements, under guidance from COGENT. The CCRI is responsible (Mr Ovasuru till February 1993, Mr Faure from March 1993 onwards). Technical advice has been given by a CIRAD agronomist & breeder, Mr Manciot, who helps manage the CCRI activities in Madang (see Appendix 9).

3.1 Achievements

The site originally selected in Bougainville (Duncan Research Station) was abandoned because of political unrest. Obtaining a new site took time. Suitable land was found and money obtained for its purchase and in early 1993 Kaile and Murnass Plantations near Madang were purchased. The CCRI Coconut Research Centre has been named the Jim Grose Research Station.

It has a total area of 470 hectares with about two-thirds of the area under old coconuts. The other one-third was never developed because it was poorly drained and it was left under forest. A preliminary survey by the Land Use Section of the Department of Agriculture classified 35 ha as seasonal swamp and 110 ha as permanent sago swamp.

The CIRAD agronomist considers the non-planted area suitable for coconut development after proper drainage. His view is supported by a drainage expert of the Coffee Research Institute. Felling of the forest has been commenced along with a detailed land survey.

When the Reviewers visited the site more than 100 ha of forest were already nearly completely cleared by village contractors. Only the bigger and valuable trees remained standing, to be felled later for timber. Burning of fallen trees and undergrowth had also commenced.

Land preparation was progressing very well, following a long spell of dry weather. Permission was expected from Keravat for the digging of a large drain to begin the following week. Funding of the development work is partly met by the copra sale from the coconut plantation and by the sale of timber to a local mill.

A comprehensive development programme was also being drafted with sites proposed for establishment of the nursery and the setting of staff quarters. Electrification and water system (nursery and domestic use) plans were also being drawn up.

It has also been noted that the Madang area is free of Rhinoceros beetles and Scapanes (dangerous pests prevailing for instance in New Britain). This, if correct, is a positive factor regarding the safe establishment of the repository.

3.2 Research Significance

Here, the Reviewers deal with land development, which is not a research activity. But the establishment of a repository aims to provide breeders with the coconut germplasm they need. It is therefore an indispensable component of a breeding programme.

The enthusiasm and dynamism of the local team in charge of the land development appeared to the Reviewers unquestionable. Advantage was rightly taken from the dry weather to go as fast as possible in land preparation.

3.3 Scientific Merit and Relevance

The above remark on land development applies. This objective can be considered as meritorious and relevant when properly completed. It means, field coconut collections properly planted and monitored in a suitable land.

3.4 Shortcomings

The Reviewers understand the difficulty in getting suitable land. Had it been decided to go only for an ideal area, most probably no site would be available to date.

Nevertheless, the selected site for the establishment of the repository is not an easy one. The development of flood-prone or swampy areas requires the skill of many specialists - soil surveyors, soil and drainage specialists, agronomists and public works engineers.

It also makes the investment more expensive and, sometimes, increases the maintenance costs as well.

3.5 Recommendations

(a) To achieve the land survey as soon as possible (topography and soils).

(b) To study drainage possibilities with drainage specialists and eventually to cross check advice (to the reviewers this is a sensible approach not at all offensive for the involved experts).

(c) To map the land according to soil categories (e.g. Class 1 with deeper water table along with fertile land).

(d) To establish a planting plan for the repository, using first the best soils. Involve also agronomists and breeders, since for instance some accessions might grow in nearly swampy conditions. If so, they could be planted on Class 2 soils.

(e) To complete a land use map with reserved areas for the South Pacific Collection, to be ready when and if the quarantine problem can be overcome. Areas should also be reserved for the hybrid experiments.

(f) To coordinate activities between Keravat and Madang by the drawing up of a comprehensive long term breeding programme with estimated annual costs (capital and operating costs see 2.4).

4. Somatic Embryogenesis

An attempt to develop a somatic embryogenesis system for coconut was tried, mostly in Melbourne, from January 1991 to February 1992 (Ashburner, Tomlinson and Faure).

4.1 Achievements

Model systems were studied for zygotic embryogenesis and somatic embryogenesis of immature embryos. There was sporadic success in producing somatic embryos and one plant was regenerated.

Difficulties were encountered in getting adequate material for the experiments and the scientists did not have enough time to work efficiently on that objective. Information received on the state of the research conducted by other teams working on the same topic showed that a breakthrough by the Project was improbable. It was decided to drop that objective of the Project. All the information that had been acquired was passed on by Mr Ashburner to the International Tissue Culture Network.

4.2 Research Significance

The decision to undertake research on coconut somatic embryogenesis has to be seen in the

context of attitudes in 1990. Then optimism prevailed among the different teams who had embarked on that scientific venture. A breakthrough looked close, according to predictions by the CIRAD team. Since then, optimism has been replaced by disappointment among teams working full time on the topic.

4.3 Scientific Merit & Relevance

The coconut has proved a very recalcitrant plant and the Reviewers consider the decision to abandon that objective was correct.

4.4 Shortcomings

From a technical point of view the Reviewers only question the choice of embryos as material for cloning. Even if the mother palm has known performance, clones from embryos offer no guarantee for genetic improvement.

4.5 Recommendations

(a) To monitor the evolution of the research conducted by other teams, especially in the UK, France, Philippines and India

(b) When or if significant progress is achieved, consider taking up that topic again in association with one or several teams.

5. Participation in a Regional Breeding Programme

Papua New Guinea is part of the PDICC Project (PRAP Project number 2), which concerns the eight ACP Pacific countries. The implementing agency is CIRAD in Vanuatu, with funding provided by EEC. The CCRI staff involvement was Mr Ovasuru (until February 1993) and Mr Faure (from March 1993).

5.1 Achievements

Pollen of the Markham Valley was recently sent to Vanuatu, where it will be used for hybridisation. The hybrids will be planted and evaluated in Vanuatu. Performance data will be passed on to Papua New Guinea along with results of all the hybrids tested under the programme.

Project staff have been trained in Vanuatu under the PDICC. The PDICC Coordinator visited also Papua New Guinea.

5.2 Research Significance

This cooperative programme will have significant research results for Papua New Guinea when data is available from PDICC.

5.3 Scientific Merit & Relevance

Pollen received by PDICC from CCRI was excellent quality. Training sessions organised by PDICC for CCRI staff proved of great worth.

5.4 Shortcomings

There are no shortcomings to mention.

5.5 Recommendations

To take more advantage of possibilities offered by the PDICC Project for instance:

(a) to study the general combining ability of some common crosses, to be planted in both Vanuatu and Papua New Guinea for further validation and better use of the PDICC results.

(b) to exchange information on South Pacific germplasm characterisation, since this is also a component of the PDICC Project.

(c) to exchange information or material for DNA fingerprinting tests and afterwards to cooperate in interpretation of results.

(d) To ask the PDICC Coordinator to put CCRI the mailing list for quicker reception of useful documents (e.g. new Programme of Activities to be conducted under Lome IV from 1994 to 1998, annual scientific reports etc.)

6. Crop Physiology & Other Studies

6.1 Achievements

Although not included in the Project aims, observations were made on light interception of hybrid coconuts over time by Mr Foale.

6.2 Research Significance

The Reviewers support the idea that breeding work has to be complemented by a wide range of studies - agronomy, farming systems and plant protection (see Recommendations of previous Review).

6.3 Scientific Merit & Relevance

With tree crops like coconuts, selection and breeding is a long term process, while agronomy or plant protection can bring results more quickly, and sometimes quite profitably. On the other hand, the long term aspect of any coconut breeding work (along with its high cost) has been the major incentive for mobilising aid for the interested countries.

6.4 Shortcomings

The Reviewers also consider that topics as complex as the interaction of light transmission and planting density on yield, require more than a quick survey if sound and significant results want to be obtained.

6.5 Recommendations

(a) If redeployment of the Project is envisaged, to allow for physiology research after giving priority to beetle control and farming systems (as already recommended in the previous Review).

RECOMMENDATIONS FOR RENEWAL/EXTENSION/TERMINATION

This Project terminates when the six month extension for data processing has been completed. The Reviewers do not recommend a renewal of the same project but believe that there is a need for ACIAR's continued involvement in coconut research in Papua New Guinea and the South Pacific region.

Outstanding from the recommendations of Project 8442 and arising form the recommendations of the Taveuni workshop, the Reviewers propose the following topics for ACIAR's consideration. Complementary research on viroid-like RNA is the most important one, as it prevents movement of germplasm and impedes all breeding work. Characterisation of coconut germplasm, since this is an area where ACIAR and CCRI now have some experience. Integrated pest management is important to Papua New Guinea, if improved planting material from the breeding programme are to be used successfully for replanting large areas. As world market prices for coconut products are decreasing, it is important to develop sustainable coconut-based farming systems to complement farm incomes. Likewise, processing of coconuts at the village level, will add value for the producers.

Within the South Pacific region, a number of agencies are involved in coconut research and development as the crop remains a major element in socio-economic and environmentally sound agriculture. Although Australia does not have a coconut industry, as such, it can still help by sharing experience in fundamental research as well as application to agriculture production and processing. The Reviewers' strongly believe that ACIAR has role to play for complementary and cooperative endeavours with COGENT, CIRAD, SPC, EEC, APCC for instance. Experienced Australian scientists are able to greatly contribute to the topics mentioned above. Results from such research will be important in the Pacific region and throughout the developing countries of the tropics where coconuts grow.

ACKNOWLEDGEMENTS

The Reviewers' would like to acknowledge the invaluble help and dedication of Mr Ashburner (project research scientist & leader) of the Institute for Horticultural Development, Victoria, who met them at Rabaul and accompanied them (singly or together) to Madang, Burnley, Taveuni and Merida. The Reviewers' thank the CCRI Research Director Dr Moxon, and his staff at Keravat, Messrs Faure, Pulo, Tade, Prior & Powell and at Madang, Messrs Manciot, Lotto & Wapp; also the project technical officer from Burnley, Mr Tomlinson. The Reviewers' were glad to receive production information from Mr Nohou, Deputy General Manager of the PNG Copra Board. The Reviewers' benefited from the experience of project collaborators Mr Foale, CSIRO Tropical Crops & Dr Randles, Waite ARI, Dr Perkins, Melbourne University, and to the participants of the ACIAR coconut workshop, Taveuni. Special thanks are due to ACIAR staffers, Dr Piggin who accompanied the appraisers, and Mrs Jay who made the travel arrangements.

APPENDIX 1

THE COCONUT INDUSTRY IN PAPUA NEW GUINEA

1. Hecterage.

With about 250,000 ha under coconuts, Papua New Guinea is the main coconut grower of the Pacific area. Coconuts occupy about 6% of the total Papua New Guinea land area. The proportion would be much higher if only areas either suitable for, or under, cultivation were accounted for (see Map 1).

The first commercial plantations were established in the Gazelle Peninsula (East New Britain) in 1880 by German planters. To date, they cover about 100,000 ha. Smallholdings are also market oriented and represent about 150,000 ha, with an average size of 1.5 ha. Coconuts are commonly associated with other crops especially cocoa, betel nut and food crops.

While 50% of commercial plantations are considered nearly senile (Sacket and Williamson, 1973), only an insignificant proportion of Papua New Guinea coconuts derive from selected planted material (Douglas, 1965).

2. Processing and Marketing of Products

The coconuts, which are not used for domestic consumption, are turned into copra. Part of the copra is processed by a private owned mill based in Rabaul or directly exported overseas. Hence, Papua New Guinea exports copra along with coconut oil and copra meal.

The Copra Marketing Board (CMB) has been, since its establishment in 1954, the only buyer and exporter of copra. CMB operates under a stabilisation scheme to minimize price fluctuations to copra producers.

Regarding coconut products and by products diversification, the Reviewers were told that only one fibre project is currently operating.

3. Copra Production and Exports

Papua New was the second exporter of copra and coconut oil for many years (although far behind the Philippines) but it has slipped to third and then fourth position.

Production figures show a declining trend from 1985 on (see Table 1). This is mostly attributed to the low prices on the slump world market and to the Bougainville crisis. The need to replant the senile older stands is also acknowledged as necessary on a medium and long term basis.
Exported coconut products contributed to about 1.28% of the Papua New Guinea exports in 1991 (source APCC). In 1991 , coconut export earnings contributed 8% of the total Papua New Guinea agricultural exports, in contrast to 62% for cocoa, coffee and tea products and

18% for palm oil (Table 2).

4. Research and Development

Coconut research is entrusted to CCRI (Papua New Guinea Cocoa & Coconut Research Institute), based near Rabaul and jointly owned by the cocoa and coconut industries. It conducts research on various aspects of the industry, including:

- breeding
- germplasm collection
- embryo culture
- agronomy
- crop protection

For coconut research, CCRI cooperates with ACIAR and CIRAD. It is also associated with regional or international projects such as PDICC or COGENT.

It is generally recognised that revival of the Papua New Guinea coconut industry requires extensive replanting with drastic improvement of the yielding ability of planting material (Tan *et al*, 1991). To date, there is no ongoing large scale coconut planting or replanting programme.

References

Douglas, L.A. (1965) Some aspects of coconut agronomy in Papua New Guinea. PNG Agric. J. 17 87-91.

Sacket, M.A. and Williamson, P.G. (1973) The copra industry in PNG. Dept Primary Industry, PNG. pp79.

Tan, G.Y., Ovasuru, T. & Bridgeland, L.A. (1991) Selection and utilization of coconut germplasm in the breeding programme. Proceedings ISOCRAD II, Kasaragod, India, November 1991.

Map 1 **COCONUT GROWING AREAS IN PAPUA NEW GUINEA**

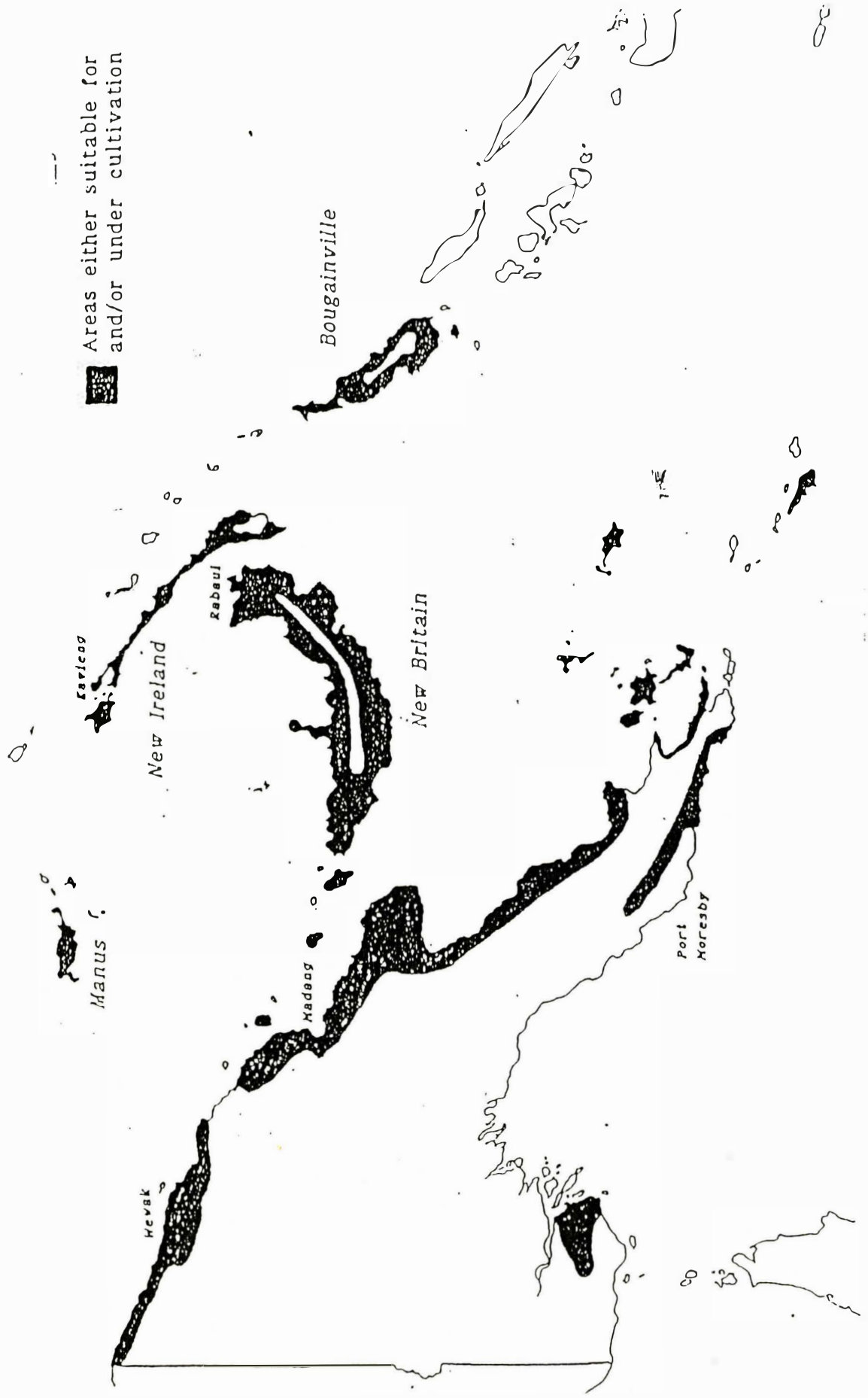

Table 1 PAPUA NEW GUINEA COCONUT INDUSTRY

PRODUCTIONS AND EXPORTS (Tonnes)				
Year	Production	Exports		
	Copra	Copra	Coconut Oil	Meal
1984	158,224	94,453	40,867	21,890
1985	175,834	105,344	38,762	21,900
1986	158,492	92,968	41,109	19,575
1987	149,317	84,138	40,183	20,158
1988	135,852	77,623	36,247	15,158
1989	133,738	71,375	37,044	17,390
1990	116,582	60,762	36,532	15,217
1991	90,824	42,773	30,000	12,500
1992	116,602	44,830	40,405	16,927
1993	77,000	42,552	17,600	7,928

Source: Copra Marketing Board of Papua New Guinea
Note: 1993 figures are 9 months, except meal (6 months)

Table 2 PNG EXPORTS OF MAJOR AGRICULTURAL PRODUCTS (1000 US$)

	1989	1990	1991
Agri. products Total	333,513	219,496	218,196
Coffee/Tea/Cocoa + SP	234,862	149,733	136,750
Cocoa (Beans)	53,744	33,662	36,500
Coffee (Green + Roast)	17,314	10,826	9,400
Oil Palm	44,305	28,445	17,485
Coconut Prod. Total	40,874	22,877	17,485
Copra	19,812	9,242	6,348
Coconut Oil	19,197	12,586	10,342
Meal	1,865	1,049	795

Sources: FAO Yearbook - Trade, 1991
APCC Coconut Statistical Yearbook, 1991

APPENDIX 2

APPRAISAL RECOMMENDATIONS FOR PROJECT PN 8442

1. A one year extension of the embryo culture work at Knoxfield and CCRI is necessary.

2. A new coconut improvement project should be implemented to replace project No. 8442.

In the event that a new project is set up, the following recommendations are appropriate.

(a) A single project leader should be given overall responsibility for the new project.

(b) The vacant post of embryo culture technician at CCRI should be reappointed to carry out embryo culture and some breeding work.

(c) The embryo cultured plants at Knoxfield should be disease screened immediately.

(d) Collect and establish accessions identified in the germplasm survey.

(e) Information arising from the germplasm research should be published.

(f) The agronomist at CCRI should initiate agronomic programmes as soon as the germplasm accessions have been collected.

(g) The breeding work should be modified to incorporate a revised crossing programme.

(h) ACIAR should commission a report to investigate possible collaboration between coconut tissue culture laboratories in Australia, France, the United Kingdom, Philippines and Sri Lanka.

(i) The germplasm survey in Papua New Guinea and the Pacific region should continue.

The following recommendations refer to additional matters that the review team were asked to consider.

3. ACIAR should consider establishing a biological control programme against *Oryctes*, *Scapanes* and Rhynchophorus.

4. ACIAR should investigate locations for disease screening and international quarantine.

5. ACIAR should consider supporting aspects of the coconut processing work.

APPENDIX 3

AIMS & OBJECTIVES OF ACIAR PROJECT PN 9025

Aims

1. Use embryo culture technology developed in Phase 1 of the project (PN 8442) to import coconut germplasm into Papua New Guinea and other South Pacific countries

2. Establish techniques for propagation of coconuts via embryogenesis

3. Assess the implications of new technology in relation to reducing phytosanitary risk and in coconut improvement programmes

4. Establish a collection of both local and imported coconut germplasm in Papua New Guinea for use in breeding programmes

Objectives (from document "Submission to ACIAR Review Team")

1. To characterise the coconut genetic resources of Papua New Guinea and identify representative or unique germplasm for evaluation and conservation in a germplasm repository.

2. To characterise the coconut genetic resources of the south Pacific region and identify representative or unique germplasm for evaluation and conservation in a germplasm repository.

3. To characterise germplasm on a genotypic basis.

4. To collect the coconut populations identified in Papua New Guinea.

5. To collect and index for coconut cadang-cadang-like viroid, exotic germplasm from the south Pacific region using embryo culture techniques.

6. To evaluate and develop embryo culture techniques for collection of germplasm, particularly from remote areas.

7. To establish a national and regional germplasm repository in Papua New Guinea.

8. To investigate somatic embryogenesis for clonal propagation in coconut palms.

9. To participate in the regional coconut breeding project (PDICC) funded by the Pacific Regional Agricultural Project.

10. To provide initial data on the light interception of hybrid coconuts over time.

APPENDIX 4

ITINERARY

Saturday 30th October
Harries arrived Brisbane (from London via Darwin) and had informal meeting with Foale. De Taffin arrive Sydney from Nadi

Sunday 31st October
De Taffin, Piggin and Harries met en route to Port Moresby.

Monday 1st November
Piggin, Harries and de Taffin to Rabaul to meet Ashburner, Faure, Moxon, Prior, Powell, [Pulo, Tade] & Tomlinson

Tuesday 2nd November
Appraisal continued in morning. In afternoon Piggin, Harries, de Taffin, Ashburner and Faure departed for Madang via Port Moresby. Met by Manciot.

Wednesday 3rd November
Group with Manciot and Lotto to Omuru Hybrid Seed Garden to meet Wapp and inspect nursery. Then to Kaile-Murnas, site of CCRI Research Centre.

Thursday 4th November
Discussions, reading documentation, report drafting

Friday 5th November
am to Port Moresby. Informal discussions with Mr Gillbanks (CCRI Research Committee member). Meeting with Mr Nohou, Copra Marketing Board.
pm all to Sydney en route to various destinations; Canberra (Piggin); Melbourne (de Taffin & Ashburner); Fiji (Harries).

Saturday 6th - Wednesday 10th November
Various peripheral activities. de Taffin visited Ashburner's laboratory facilities and had discussions with Ovasuru and Perkins (Coordinator International Agriculture & Forestry programme, Melbourne University). Harries met coconut research workers in Fiji for familiarisation. Participants travelling separately to reunite at Taveuni location of ACIAR workshop.

Thursday 11th & Friday 12th November
ACIAR Coconut workshop

Saturday 13th November
Participants dispersed. Ashburner and Harries to CICY Lethal Yellowing disease meeting, Merida, Mexico.

Tuesday 14th December

Harries and de Taffin had discussions in London to finalise report for submission.

APPENDIX 5

DOCUMENTS STUDIED

The documents marked (*) were included in the overall document "Submission to ACIAR review team: 9025 Coconut improvement. November 1993" and (**) was an extract from the research review document. The Proceedings of the Taveuni workshop are being produced by ACIAR.

APCC (1991) Coconut Statistical Yearbook, 1991

APCC (1993) Country report, Papua New Guinea. Asian & Pacific Coconut Community 30th Session. Honiara, Solomon Islands.

(*) Ashburner, G.R. (draft) Genetic markers for coconut palms.

(*) Ashburner, G.R. (draft) Reproductive biology of coconut palms.

(*) Ashburner, G.R., Faure, M.G., Franz, P.R., Tomlinson, D.R., Pulo, P., Burch, J.M. & Thompson, W.K. (in draft) Coconut embryo culture for remote locations.

(*) Ashburner, G.R. & Rohde, W. (draft) Coconut germplasm characterisation using DNA marker technology.

Bourdeix, R. *et al* (1991) Coconut (*Cocos nucifera* L) selection strategy, II. Improvement of Tall x Tall hybrids. Oléagineux 46(7).

Bourdeix, R. *et al.* (1991) Coconut (*Cocos nucifera* L) selection strategy, III. Improvement of Dwarf x Tall hybrids. Oléagineux 46(10).

CMB (1993) Copra Marketing Board of Papua New Guinea - 50 years - 1943 to 1993.

de Nucé de Lamothe, M., Gordon, G. & Harries, H.C. (1989) ACIAR project 8442: Coconut improvement - report of the review panel.

FAO (1991) Yearbook, Trade Vol. 45.

Hanold, D. & Randles, J.W. (1991) Coconut cadang-cadang disease and its viroid agent. Plant Disease 75(4).

Hanold, D. & Randles, J.W. (1991) Detection of cadang-cadang viroid like sequences in oil and coconut palm and other monocotyledons in the southwest Pacific agent. Ann. app. Biol. 118, 139-151.

Jack, P.L. & Mayes, S. (1993) Use of molecular markers for oil palm breeding, II. Use of DNA markers (RFLPs). Oléagineux 48(1).

.(**) Manciot, R. (1993) Draft of CCRI research review document.

N'Cho, Y.P. *et al* (1993) Assessment of a few coconut ecotypes: a biometric approach. I. Study of Tall populations. Oléagineux 48(3).

Whitehead, R.A. (1964) Sample survey of coconut germplasm in the South Pacific region. HMSO, London.

APPENDIX 6

SEEDNUT COLLECTION PROGRAMME

Dates	Collectors	Materials	Province	Number of nuts
22-31/3/93	G. Kone	GAZELLE Tall	ENBP	
	O. Hataba	ULT		225
		GLT 1		225
		GLT 2		225
		GLT 3		225
		GLT 4		225
19-30/4/93	M. Faure	NAMATANAIT	NEW IRELAND	
	D. Pue	NLT 1		225
		NLT 2		225
		NLT 3		225
19-30/4/93	G. Kone	GAZELLE YFT	ENBP	
	O. Hataba	GYT 1		225
		GYT 2		225
		GYT 3		225
10-21/5/93	P. Pulo	MANUS Tall	MANUS	
	D. Pue	MLT 1		225
		MLT 2		225
		MLT 3		225
		MLT 4		225
10-21/5/93	G. Kone	GAZELLE RFT	ENBP	
	O. Hataba	GRT 1		225
		GRT 2		225
		GRT 3		225
21-30/6/93	M. Faure	WEST NEW BR		
	D. Pue	TALL	WNBP	
		WNT 1		950
		WNT 2		950
		TRT		225
		RLT	Nomundo Pl.	950
		DWARF	WNBP	750
		PYD	Dami	750
		PRD	Dami	750
		RRD	Dami	750
		PBD	Dami	750
		IRD	Dami	
12-23/7/93	O. Hataba	NUGURIA Tall	NUGURIA	225
	D. Pue	FIT 1		225
		FIT 2		225
		FIT 3		
12-23/7/93	G. Kone	GAZEL. MFT	ENBP	225
	M. Faure	GMT 1		225
		GMT 2		225
		GMT 3		225
		GMT 4		225
		GMT 5		225
		GMT 6		
02-13/8/93	E. Tade	CENTRAL Tall	CENTRAL	
	D. Pue	BBT		225
		HLT		225
		PLT		225

APPENDIX 6

SEEDNUT COLLECTION PROGRAMME

23-31/8/93	M. Faure	ORO Tall	ORO	
	D. Pue	OLT 1		225
		OLT 2		225
		OLT 3		225
06-12/9/93	Mr X	MARKHAM T	MOROBE	
	K. Wapp	MVT 1		950
		MVT 2		950
06-17/9/93	E. Tade	MILNE BAY T	MILNE BAY	
	D. Pue	MBT 1		225
		MBT 2		225
		MBT 3		225
		MBT 4		225
		MBT 5		225
04-29/10/93	G. Kone	KIWAI Tall	WESTERN	
	D. Pue	KWT 1		225
		KWT 2		225
04-29/10/93	G. Kone	VAILALA Tall	GULF	
	D. Pue	VLT 1		950
		VLT 2		950
		VLT 3		950
15-26/11/93	K. Wapp	EAST SEPIK T	EAST SEPIK	
	D. Pue	TALL		
		ELT 1		950
		ELT 2		950
		ELT 3		950
		ELT 4		950
		DWARF		
		PGD		750
06-17/12/93	Mr X.	KARKAR Tall	MADANG	
	K. Wapp	KKT 1		950
		KKT 2		950
		BOUGAIN-VILLE Tall		
		BLT		950

APPENDIX 7

FRUIT CHARACTERISTICS OF SELECTED LOCAL TALL VARIETIES

Table 6.1: Fruit and nut characters of selected Local Tall ecotypes in PNG (mean values)

Ecotypes	Fruit weight (g)					Nut weight (g)					Endosperm weight (g)				
	AVG	MAX	MIN	STD	CV	AVG	MAX	MIN	STD	CV	AVG	MAX	MIN	STD	CV
lang Province															
arkar Tall	2276.4	3343.4	1583.8	407.2	17.6	1407.4	2079.8	993.8	246.2	17.8	565.8	548.2	411.0	91.8	16.2
Ireland Province															
ew Ireland Tall	1666.5	2290.5	1090.0	292.0	17.5	1026.5	1418.5	574.0	189.5	18.5	461.5	605.5	265.5	74.0	16.0
obe Province															
larkham Tall	3370.5	4787.5	2325.0	466.5	14.5	2163.0	2900.0	1687.5	283.0	14.0	739.0	973.5	567.5	91.5	12.5
Sepik Province															
ast Sepik Tall	2399.3	3338.3	1736.7	402.7	17.0	1619.0	2280.0	1138.3	282.3	17.7	596.7	792.0	424.0	86.0	14.3
New Britain															
ovince															
azelle Tall	1776.0	2763.0	1235.7	318.0	18.3	1018.6	1753.0	684.0	214.5	21.5	441.5	649.2	322.2	70.7	16.3
New Britain															
ovince															
est New Britain Tall	1827.0	2923.0	1049.5	452.0	25.0	1192.0	2046.5	741.0	315.0	26.5	517.5	849.0	346.0	112.0	17.0
ral Province															
ibara Tall	1805	2746	1189	333	18	964	1371	638	147	15	422	556	281	54	13
Province															
ro Tall	1384	2054	839	271	20	638	1336	415	174	21	356	545	165	71	20
us Province															
anus Tall	1681.0	2342.0	1179.0	269.0	16.0	913.0	1245.5	700.0	126.0	14.5	413.5	541.5	313.0	50.0	12.5
Province															
ilala Tall	1873.5	2797.0	1101.0	397.0	21.0	1108.5	1708.0	735.0	217.5	20.0	471.0	655.0	323.5	70.5	15.5
e Bay Province															
ilne Bay Tall	1703.7	2819.0	1020.0	370.0	21.7	925.7	1566.7	504.0	232.0	25.0	405.7	998.0	254.7	83.0	20.3

= Average; MAX = Maximum; MIN = Minimum; STD = Standard Deviation; CV = Coefficient of Variation.

Table 6.2: Percentage of fruit components from selected Local Talls in PNG (Mean values)

Ecotypes	Husk/fruit (%)					Water/nut (%)					Endosperm/nut (%)				
	AVG	MAX	MIN	STD	CV	AVG	MAX	MIN	STD	CV	AVG	MAX	MIN	STD	CV
g Province															
ar Tall	37.7	54.2	26.1	6.1	16.2	36.3	45.1	28.8	3.6	10.0	40.5	47.4	31.4	3.4	8.4
eland Province															
Ireland Tall	38.0	62.3	20.6	7.1	19.0	30.6	37.5	22.3	3.7	12.2	45.2	54.0	39.5	3.1	7.0
e Province															
cham Tall	35.4	48.8	23.6	6.8	19.2	46.8	54.8	39.6	3.2	6.9	34.5	38.4	31.1	1.9	5.7
pik Province															
Sepik Tall	30.3	41.9	18.5	5.7	18.3	40.9	46.7	32.1	3.1	7.7	37.1	41.8	32.6	2.0	4.8
ew Britain															
ince															
ille Tall	43.0	56.0	31.4	6.8	16.2	31.2	44.5	19.2	5.4	17.4	44.0	51.9	34.3	3.8	8.6
ew Britain															
ince															
New Britain Tall	34.9	52.3	23.8	9.5	26.3	33.4	41.9	21.7	4.6	14.0	44.1	56.2	36.5	4.2	9.4
Province															
ara Tall	46.2	57.0	39.5	4.7	10.2	30.6	37.3	19.0	3.9	12.7	40.0	49.1	39.6	2.4	6.0
ovince															
ila Tall	39.9	53.6	7.9	9.9	24.8	32.8	42.1	25.0	4.4	13.6	43.0	49.1	35.9	3.3	7.7
Bay Province															
e Bay Tall	45.6	58.7	28.1	7.3	16.0	31.0	45.8	15.7	6.9	22.2	44.5	54.4	36.6	4.2	9.5
Province															
us Tall	45.6	57.4	29.4	5.0	10.9	29.5	48.0	12.7	7.2	25.4	46.1	54.5	39.7	3.3	7.1
ovince															
Tall	39.0	57.1	5.4	9.2	23.6	30.3	54.3	11.4	6.7	22.1	42.8	55.4	26.8	4.5	10.5

= Average; MAX = Maximum; MIN = Minimum; STD = Standard Deviation; CV = Coefficient of Variation.

APPENDIX 8

CROSSING PROGRAMME AT OMURU

Month of crossing work		Crossing Programme	Province	Month of collection of pollen to send to MADANG
March	93	MD x ULT PBD x ULT(2)	ENBP	February 93
April	93	MD x GLT 2 PBD x GLT 2(2)	ENBP	March 93
May	93	MD x GLT 1 PBD x GLT 1(2)	ENBP	April 93
June	93	MD x NLT 1 PBD x NLT 1(2)	NEW IRELAND	May 93
July	93	MD x RLT(3) PBD x RLT(2X3)	WNBP	June 93
August	93	MD x NLT 2 PBD x NLT 2(2)	NEW IRELAND	May 93
September	93	MD x NLT 3 PBD x NLT 3(2)	NEW IRELAND	May 93
October	93	MD x ULT PBD x ULT(2)	ENBP	September 93
November	93	MD x MLT 1 PBD x MLT 1(2)	MANUS	October 93
December	93	MD x MLT 2 PBD x MLT 2(2)	MANUS	October 93
January	94	MD x RLT(3) PBD x RLT(2X3)	WNBP	December 93
February	94	MD x GLT 3 PBD x GLT 3(2)	ENBP	January 94
March	94	MD x GLT 4 PBD x GLT 4(2)	ENBP	February 94
April	94	MD x MLT 3 PBD x MLT 3(2)	MANUS	March 94
May	94	MD x MLT 4 PBD x MLT 4(2)	MANUS	March 94
June	94	MD x GRT 1 PBD x GRT 1(2)	ENBP	May 94
July	94	MD x RLT(3) PBD x RLT(2X3)	WNBP	June 94

APPENDIX 8

CROSSING PROGRAMME AT OMURU

August	94	MD x GRT 2 PBD x GRT 2(2)	ENBP	July 94
September	94	MD x GRT 3 PBD x GRT 3(2)	ENBP	August 94
October	94	MD x WNT 1 PBD x WNT 1(2)	WNBP	September 94
November	94	MD x WNT 2 PBD x WNT 2(2)	WNBP	September 94
December	94	MD x FIT 1 PBD x FIT 1(2)	NUGURIA	November 94
January	95	MD x RLT(3) PBD x RLT(2&3)	WNBP	December 94
February	95	MD x FIT 2 PBD x FIT 2(2)	NUGURIA	January 95
March	95	MD x FIT 3 PBD x FIT 3(2)	NUGURIA	January 95
April	95	MD x BBT PBD x BBT(2)	CENTRAL	March 95
May	95	MD x HLT PBD x HLT(2)	CENTRAL	March 95
June	95	MD x PLT PBD x PLT(2)	CENTRAL	March 95
July	95	MD x RLT(3) PBD x RLT(2&3)	WNBP	June 95
August	95	MD x OLT 1 PBD x OLT 1(2)	ORO	July 95
September	95	MD x OLT 2 PBD x OLT 2(2)	ORO	July 95
October	95	MD x OLT 3 PBD x OLT 3(2)	ORO	July 95
November	95	MD x MVT 1 PBD x MVT 1(2)	MOROBE	October 95
December	95	MD x MVT 2 PBD x MVT 2(2)	MOROBE	October 95
January	96	MD x RLT(3) PBD x RLT(2&3)	WNBP	December 95
February	96	MD x MBT 1 PBD x MBT 1(2)	MILNE BAY	January 96

APPENDIX 8

CROSSING PROGRAMME AT OMURU

March	96	MD x MBT 2 PBD x MBT 2(2)	MILNE BAY	January 96
April	96	MD x MBT 3 PBD x MBT 3(2)	MILNE BAY	January 96
May	96	MD x MBT 4 PBD x MBT 4(2)	MILNE BAY	April 96
June	96	MD x MBT 5 PBD x MBT 5(2)	MILNE BAY	April 96
July	96	MD x RLT(3) PBD x RLT(2x3)	WNBP	June 96
August	96	MD x KWT 1 PBD x KWT 1(2)	WESTERN	July 96
September	96	MD x KWT 2 PBD x KWT 2(2)	WESTERN	July 96
October	96	MD x GMT 1 PBD x GMT 1(2)	ENBP	September 96
November	96	MD x GMT 3 PBD x GMT 3(2)	ENBP	October 96
December	96	MD x GMT 5 PBD x GMT 5(2)	ENBP	November 96
January	97	MD x RLT(3) PBD x RLT(2x3)	WNBP	December 96
February	97	MD x KKT 1 PBD x KKT 1(2)	MADANG	January 97
March	97	MD x KKT 2 PBD x KKT 2(2)	MADANG	January 97
April	97	MD x VLT 1 PBD x VLT 1(2)	GULF	March 97
May	97	MD x VLT 2 PBD x VLT 2(2)	GULF	March 97
June	97	MD x VLT 3 PBD x VLT 3(2)	GULF	March 97
July	97	MD x RLT(3) PBD x RLT(2x3)	WNBP	June 97
August	97	MD x GMT 2 PBD x GMT 2(2)	ENBP	July 97
September	97	MD x GMT 4 PBD x GMT 4(2)	ENBP	August 97

APPENDIX 8

CROSSING PROGRAMME AT OMURU

October	97	MD x GMT 6 PBD x GMT 6[2]	ENBP	September 97
November	97	MD x ELT 1 PBD x ELT 1[2]	EAST SEPIK	October 97
December	97	MD x ELT 2 PBD x ELT 2[2]	EAST SEPIK	October 97
January	98	MD x RLT[3] PBD x RLT[2X3]	WNBP	December 97
February	98	MD x ELT 3 PBD x ELT 3[2]	EAST SEPIK	January 98
March	98	MD x ELT 4 PBD x ELT 4[2]	EAST SEPIK	January 98
April	98	MD x TRT PBD x TRT[2]	WNBP	March 98
May	98	MD x RLT[3] PBD x RLT[2X3]	WNBP	March 98
June	98	MD x GFT 1 PBD x GFT 1[2]	ENBP	May 98
July	98	MD x GFT 2 PBD x GFT 2[2]	ENBP	June 98
August	98	MD x GFT 3 PBD x GFT 3[2]	ENBP	July 98

MD = Malayan Red (MRD) and Malayan Yellow Dwarf (MYD).

PBD = Papua new Guinea Brown Dwarf.

[1] = Second half of the month.

[2] = Crossing work done by Keravat on the PBD.

[3] = Pollen from Nomundo Plantation (West New Britain Province).

APPENDIX 9

BILATERAL ASSISTANCE

According to the country report presented to APCC, the governments of France and Papua New Guinea entered into a comprehensive agreement on coconut research and development. The following extract is taken from the APCC document:

> "The CIRAD/CCRI joint project to establish [a] necessary base for coconut breeding and development in PNG began in 1990 with the arrival of a consultant from CIRAD. Under this project, the French and PNG Government[s] entered into a comprehensive agreement that covers all aspects of research and development activities including planning and implementation of joint research, development activities, exchange or assignment of personnel[,] training of personnel, supply or exchange of information, or genetic materials and organisation of conferences or other meetings, as agreed by the two parties."