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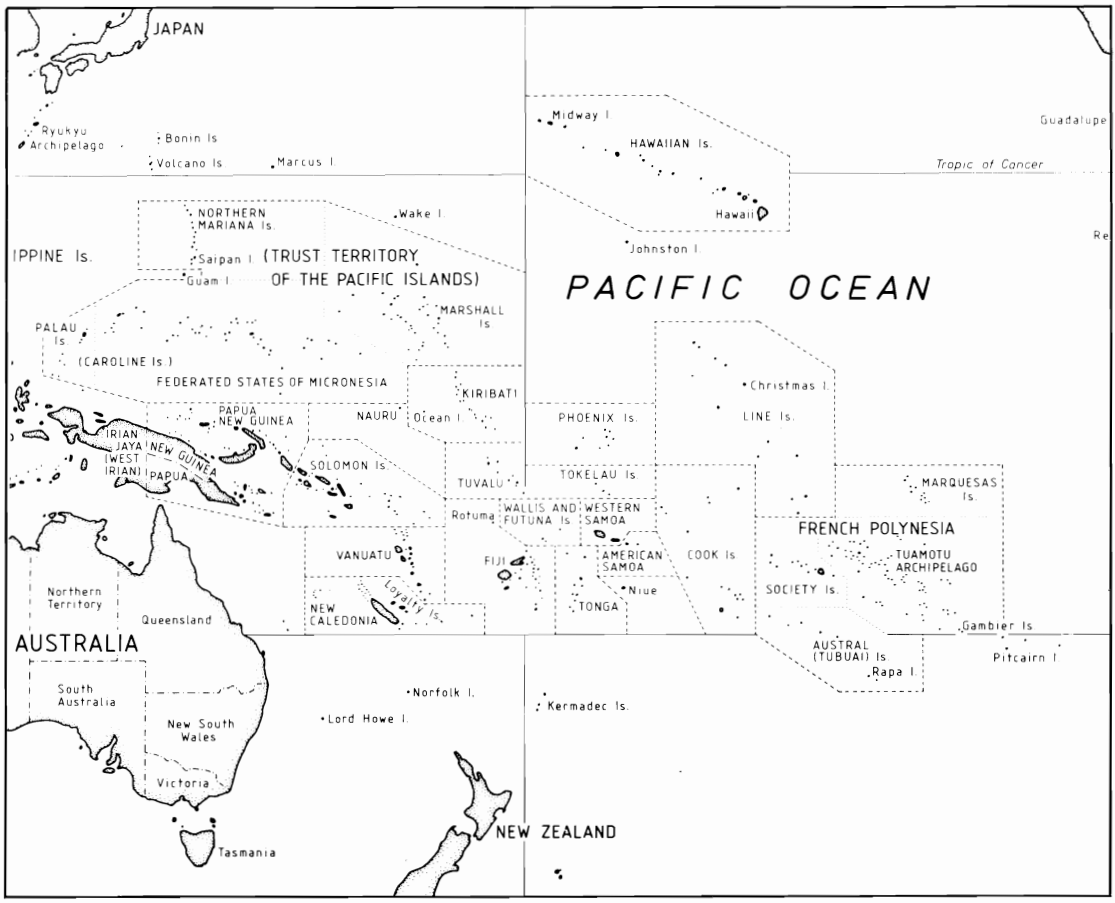
South Pacific Agriculture:

Challenges and Opportunities for ACIAR and its Research Partners

Edited by: Gabrielle J. Persley and Paul Ferrar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Foreword

The Policy Advisory Council of ACIAR met in Apia, Western Samoa, on 17–21 June 1985. As part of the week-long discussions, ACIAR organised a one-day seminar on South Pacific agriculture with the aims of: describing the agricultural sector in the South Pacific to those members of the Council not familiar with the region; outlining ACIAR's activities in the region; seeking the views of other agencies working in the Pacific on agricultural research needs and possible areas of collaboration; raising policy issues related to ACIAR's activities in the Pacific for the Council's consideration; obtaining from the Council members their views on the future direction of ACIAR's program in the South Pacific.

In addition to reporting on the Apia Seminar, this volume also contains a description of ACIAR's activities in the South Pacific, and reports on progress of the 18 projects ACIAR is currently supporting in Papua New Guinea and the Pacific Islands.

ACIAR wishes to thank the Hon. Toi Aukuso, Minister of Agriculture, Forests and Fisheries, Western Samoa for hosting the seminar. We thank also the Director of Agriculture and the staff of the Department of Agriculture for their assistance in the organisation and their participation in the seminar. Particular thanks are due to Mr Sofara Aveau and his colleagues in the Department of Agriculture for organising the field trip which set the stage for the seminar. Professor Dennis Osbourn and his staff at the University of the South Pacific also cooperated in the field trip, for which we are grateful. We are also most grateful to the Australian High Commissioner, Mr A. Godfrey-Smith, and Mr B. Wall, First Secretary (Development Assistance), for their assistance in organising the Council meeting. ACIAR's Council Member from the South Pacific, Tau'ili'ili Uili Meredith from Western Samoa, also contributed greatly to the success of the meeting.

We are grateful to the members of the Policy Advisory Council and the representatives from other national and international agencies for their participation in the Seminar. Three ACIAR project researchers (Drs Flemming, Raff and Waterhouse) were also travelling in the region at the time in relation to their project work and we are pleased that they were able to participate in the seminar.

We hope this publication will prove valuable in fostering further interest and cooperation in agricultural research and development in the South Pacific.

May 1987

J. R. McWilliam
Director
Australian Centre for International
Agricultural Research

Summary and Recommendations

The purposes of the seminar were:

1. to describe the characteristics of agriculture in the South Pacific;
2. to outline ACIAR's current projects in Papua New Guinea and other Pacific Islands;
3. to consider research opportunities in important areas such as farming systems, crop improvement, biological control of pests and weeds, fisheries, animal production and animal health;
4. to discuss ways in which ACIAR's program might complement and interact with the activities of other agencies, such as the Australian Development Assistance Bureau (ADAB), the New Zealand Ministry for Foreign Affairs, the South Pacific Commission (SPC), the International Service for National Agricultural Research (ISNAR) and the University of the South Pacific (USP); and
5. to consider policy issues for ACIAR in the future development of its Pacific program.

The policy issues considered at the seminar were: (a) style of ACIAR's projects; (b) bilateral and/or regional approach to research; (c) relationship between research and development; (d) economic rationale of projects; (e) training; and (f) cooperation with other agencies.

The need for a difference in the style of ACIAR's projects in the South Pacific was recognised, because of the smallness of the departments of agriculture, the limited number of staff engaged in agricultural research and the lack of suitably trained people and infrastructure in some countries. Several conclusions were drawn from the seminar which need to be taken into account by ACIAR when preparing collaborative research projects in the Pacific Islands. These are summarised below.

Geographic Distribution of Research Activities

ACIAR needs to strike an appropriate balance between bilateral and regional activities. While it may appear superficially more efficient to support regional research activities, this approach is not always likely to be successful, due to the diversity of the countries and their different priorities in agricultural research. It is therefore important for ACIAR to adopt a flexible approach and be able to support research projects either bilaterally or regionally.

In deciding which research areas require support, it is important to take account of the development priorities of individual countries, which often differ. In terms of the perceived priorities of the departments of agriculture in the Pacific Islands, there are surprisingly few areas of common interest.

ACIAR is developing its South Pacific program primarily on a bilateral basis, but is identifying some areas of common interest where a number of bilateral projects can be linked. These areas include farming systems, coconuts, root crops, biological control of pests and weeds, fisheries and animal health.

Mode of Operation

There is a need to modify ACIAR's usual mode of operation developed for its collaborative research projects in Asia, where there is a much larger national research infrastructure. In the case of the Pacific Islands, ACIAR will need to give more emphasis to:

1. the training of national staff in agricultural research either in the region or in Australia;
2. the provision of staff from Australia for short or long periods in situ. This will be a new feature of ACIAR's mode of operation, and will be mainly restricted to the Pacific region; and
3. the provision of essential scientific infrastructure, such as equipment and publications.

Research Priorities

The determination of priority areas for research is a key factor for many countries. Commodities which are important in several countries include coconuts, root crops, bananas and fish. Socioeconomic studies such as market and price studies are also considered critical. Research management is an area which requires strengthening in several countries.

Research and Development

The economic rationale of research activities in the South Pacific is particularly critical. Research needs to be closely linked to agricultural development. Several agricultural development activities have been undertaken in the South Pacific with an inadequate research base. ACIAR will be looking to link closely with ADAB in some of the latter's development activities to facilitate the link between research and development and maximise the likelihood of adoption of results.

Cooperation with Other Agencies

There are many research activities in the South Pacific supported by national governments, regional and international agencies and bilateral donors. There is a need to tailor ACIAR's program to complement the activities of other bodies. The participation of representatives of several other agencies in this seminar is a recognition of the importance of these interactions.

Staff Development

There is an urgent need to build research capacity throughout the Pacific Islands, by providing technical training and postgraduate opportunities in all fields of agricultural research. Again, links with ADAB will be important since ADAB supports an extensive training program in the South Pacific.

Conclusion

The Pacific Islands are presently at a critical stage in their development. On the one hand they face the problems of urban drift, unemployment, overseas migration and the aspirations of many people to join the modern cash economy. On the other, some governments wish to decrease their countries' reliance on foreign aid, and become independent countries economically as well as politically.

Agriculture is the dominant sector of the economy in the South Pacific countries. All the national development plans list the development of the agricultural sector as one of the major priorities. Agriculture is the sector which is being asked to provide food for increasing populations, provide substitutes for imported food, earn foreign exchange, provide increased cash incomes for farmers, and generate increased employment.

Attempts to develop the agricultural sector in many Pacific countries have been disappointing. Productivity has been low; cash incomes have not increased; export volumes have not expanded rapidly; and increased employment opportunities have not matched population increases. Various biological, social, economic and political factors have been identified as limiting increased agricultural production. The biological factors, at least, may lend themselves to research-based solutions.

Well planned agricultural research may assist in increasing the productivity of the agricultural sector. New technologies will, however, need to be carefully tested before their widespread introduction, since they will have to operate in the often fragile ecosystems for which the present farming systems are peculiarly well adapted.

It is a political and strategic reality that ACIAR must have a program in the South Pacific. The Pacific Islands will continue to have an agricultural sector, irrespective of how successful some countries may be in diversifying their economies. The challenge to ACIAR is to identify agricultural research activities which will contribute to agricultural development in the Pacific Islands, and which can be undertaken efficiently and successfully by partnerships between scientists in Australian research institutions and those in national departments of agriculture and regional institutions in the South Pacific.

ACIAR's Policy Advisory Council endorsed these general characteristics of ACIAR's mode of operation in the Pacific Islands. The Council noted the need for ACIAR to adopt a flexible but careful approach to assessing priorities and undertaking its research projects in the South Pacific. It noted the need to work closely with partners in the South Pacific. The Council also reiterated the need to rate training as a key issue in the South Pacific. Finally, there is clearly an enormous potential for agricultural development in the South Pacific and the Council recommended that the Pacific countries continue to receive high priority within ACIAR's research program.

Opening Address of the Minister of Agriculture, Forests and Fisheries, Western Samoa

Hon. Toi Aukuso

I am pleased to have been invited, through the good offices of the Australian High Commission, to open this Seminar on South Pacific Agricultural Research, with special reference to a role for the Australian Centre for International Agricultural Research—ACIAR.

I would like to add to the official welcome extended by our Prime Minister to Councillors and members of the Centre staff of ACIAR, as I understand that for this Seminar there are additional guests, speakers, and other invited participants. On my own behalf, and on behalf of the Director, the staff of the Department of Agriculture, Forests and Fisheries, and the primary producers of Samoa, I bid you a warm and sincere welcome.

Agriculture is everybody's business. It is the most important sector of our economy, and I feel this responsibility in my portfolio. In Samoa, and for most if not all of the South Pacific, agriculture is part of our traditional way of life.

Agricultural research, on the other hand, has not been a traditional part of the Department of Agriculture, Forests and Fisheries. There have been publications on our brief history of endeavours to establish an appropriate agricultural research division for the Department, including the recent studies by ISNAR, so I need not duplicate the details here. However, I would like to acknowledge that the infrastructure for our research in agriculture, stock, forests and fisheries has been possible through the aid programs of Australia, New Zealand, West Germany, and UNDP/FAO, to mention a few.

Agricultural research requires highly trained personnel. Because of other pressing priorities, posts in research are usually the last to be localised. The equipment and the laboratories are costly in the face of our own difficulties of distributing budgetted provisions for maintenance and capital works. I am not contributing any new knowledge here, as distinguished agricultural scientists of ACIAR and participants of this seminar are aware of and are more experienced with these problems and difficulties, and ways of overcoming them. I wanted, however, to draw your attendion to the scale and status of agricultural development appropriate to the size and work program of an efficient and viable national research unit.

I do not think that these are problems peculiar to Samoa, but rather I consider that they are regional, and are intensified as national scale of size diminishes. Strengthening of national agricultural research systems, rather than developing a regional research facility, appears now to be the trend, following the ADB South Pacific Agricultural Survey and the ISNAR missions in the region.

Within our limited crop range, the coconut palm occupies a core role, with research required in genetics, breeding and agronomy, including crop protection measures. Taro and other root crops are staples of Samoa and other parts of our region—again with increasing importance as national sizes of islands and island groups become smaller. I would like to draw attention to some crops which in our opinion have potential for further exploitation, such as the breadfruit, other tropical fruit and vegetables, and floriculture.

Production units are small in Samoa. Small-scale farms are the rule rather than the exception. The small size and the shifting cultivation system requires a basic research approach to management of soil and cropping patterns, to sustain or even improve the soil, and increase crop yields.

I have been impressed with the list of ACIAR projects based in the South Pacific, and I need not dwell on the research requirements to develop more fully our forests and fisheries.

You have visited some of our Department's research units in coconut hybridisation, the Crop Development Centre, our Livestock Division, and other agricultural sites. Scientists' eyes are very perceptive, and I hope the visits were worthwhile. I would like to emphasise that we are still establishing our own agricultural research in terms of human and other resources to include also fisheries and forestry. There have been many difficulties encountered.

I am sure that an appropriate role will be found for ACIAR to help develop our regional agriculture further. I wish you well in the execution of your duties, Mr Chairman, and through you I wish all participants a very fruitful seminar.

And now, it is my privilege to declare the seminar officially opened.

An Introduction to Agriculture in the South Pacific

Tau'ili'ili Uili Meredith*

By way of introducing agriculture in the South Pacific, I would like to discuss briefly the geography of our region, the people, and their perspective of the world at large.

The Pacific area may be defined by the boundaries of the Pacific Ocean itself, which comprises one-third of the earth's surface, an area larger than all the land in the world. However, for most practical purposes, the Pacific area may be considered to be bounded by a line drawn from Easter Island, round the Tuamotus and Marquesas to the east, Hawaii and the Marianas to the north, the Palaus, Papua New Guinea and New Caledonia to the west, and finally round Norfolk Island, the Tonga Group and Rapa to the south.

This is the region divided by Dumont D'Urville in 1830 into Polynesia, Micronesia and Melanesia, and contains some 100 million km^2, including several thousand islands and over 300 atolls, more than three times the number in all the other oceans combined.

The South Pacific region is a well-defined geographical area, mostly sea. If the 462 000 km^2 of land in Papua New Guinea are excluded, there remains only 110 000 km^2 for all the other islands, or an aggregate area about equal to that of Cuba or one that could be comfortably accommodated in one corner of Papua New Guinea. The population of approximately 5 million people is rather more evenly divided, with some 3 million in Papua New Guinea, and 2 million in the other islands.

Lest it be thought that a region so small in area and population can scarcely warrant the attention which is being given to it by international organisations including ACIAR, I would add that its importance is an antithesis to these factors. To quote from Professor H. E. Maude (1971): 'fragmentation, geographical in Polynesia and Micronesia and cultural in Melanesia, has provided as near a reproduction as one can find anywhere of a natural laboratory for the social scientist: a multiplicity of societies which, in varying degrees of isolation from one another through barriers of ocean, mountain or mutual distrust, have developed a heterogeneous assemblage of social, economic and political systems, of culture traits and complexes, beliefs, values and attitudes, which can be observed in detail and in time-depth owing to the smallness of the groups and the relatively brief length of their occupancy.'

In addition, the ocean itself, the largest single geographic feature in the world, provides an increasing proportion of our research documentation in the form of oceanographic data, which includes the work being done in marine biology and geology, the many aspects of marine geophysical research, and meteorological observations. As we exhaust the resources of the terrestrial globe, the oceans become ever more important to the researcher.

The South Pacific region is still a 'natural laboratory,' not only for social scientists but for agricultural scientists. It also suggests the potential value to be realised in a joint approach of both categories of scientists as is occurring in the ACIAR-supported farming systems project in Tonga and Solomon Islands. The results might also unravel the close ties of agricultural and social practices in traditional living, and add value to their respective influences be they constraints or advantages.

The other purpose of this introduction is to convey to you that the 'multiplicity of societies . . . in varying degrees of isolation' have developed a mixture of national units which are proportional to the number of agricultural systems in our region. The number of agricultural systems may be even more numerous, since they are compounded by environmental factors.

Natural Resources

Soil, the main base of natural resources in the region, ranges from low fertility to infertile. For instance, none of the islands of Kiribati nor the northern Cook Islands has any land which can be classified as being other than of low fertility. For Western Samoan soils, 51% of the land area is described as of low to very low natural fertility, with a further 35% too stony for mechanised agriculture (Wright 1963). The fertility status of most of the region's soils is not reflected in the lush natural vegetation, which is a result of high rainfall and rapid cycling of nutrients from the temporary rich organic forest litter. Changes occur when these soils

* National University of Western Samoa, Apia, Western Samoa.

are put into more permanent agricultural use, such as for growing tree crops. These changes, whilst they may allow for short-term traditional food cropping, are the basis for shifting cultivation in the region and are one of the constraints against the move from subsistence to plantation or commercial production.

Although soils have been surveyed and classified in varying degrees at the national level, little work has been done on the intercountry relationship except for Wright's work in Western Samoa, Fiji, the Cook Islands, and Niue. There is also evidence that certain groupings at the subregional level are interrelated. Most soils research has been done by the New Zealand Soils Bureau in the Cook Islands, Tonga and Fiji; ORSTOM in the French Territories; the US-based International Benchmark Survey and Network; CSIRO's work in Papua New Guinea; and FAO and UNESCO on an international scale.

The valuable pioneering work of scientists in the evaluation of resources in our region could be used to further develop agriculture on the national and regional level, with links to extend it internationally, with expected benefits. The transfer of agricultural technology could be facilitated from one setting to another with similar resources, by the use of common systems for classifying the resources of the region.

In the South Pacific Agricultural Survey, Ward and Proctor (1980) wrote on the evaluation of resources of the region: "It is clear that the existing surveys of land potential for agricultural development are far from satisfactory and that further research on methods of classification, as well as basic data collection at larger scales, are needed if adequate assessments are to be made. At present, it appears that the existing surveys are generally not used in project planning because of their inappropriateness. This situation also applies to other environmental data. It is clear that climate imposes significant constraints on agriculture in this region, yet the types and detail of data available rarely match the real needs of those planning agricultural enterprises. It is to be hoped that some of the methodological problems involved may be clarified by a study being undertaken by Dr R. Hills (Development Studies Centre, Australian National University, Canberra). Meanwhile, one can give wider application to Brookfield's statement that 'the scientific sieve may . . . let pass some attribute or attributes that are significant in full land evaluation'."

Agriculture in the Pacific Island Economies

With the exception of the mineral-rich island nations such as Nauru and New Caledonia and those heavily dependent on outside sources such as some of the US Territories, the main base of the Pacific Island economies is agriculture. Agriculture, including forests and fisheries, is of paramount importance to the region, providing food, fuel, raw materials for processing, building and other domestic uses.

Agriculture contributes 51% to the gross domestic product (GDP) of Tonga, 33% for Papua New Guinea and 11% for Kiribati. For domestic exports, agriculture contributes 99% for Western Samoa, 98% for Solomon Islands and Tonga, and 13% for Kiribati.

According to the economic authorities of the Pacific Islands Studies Program based at the University of Hawaii (Anon. 1984), there are six constraints that contribute significantly to the economic dependence and vulnerability of Pacific Island nations: (1) the need for some states, still not fully independent, to gear their economies to the needs of a colonial power rather than their own needs; (2) the strain of trying to finance extensive government programs internally; (3) the high cost of energy coupled with the region's almost complete dependence on imported fuels; (4) an over-reliance on imported food supplies; (5) a lack of diversity in exports; and (6) an over-dependence on foreign aid. Most of these constraints are related to the agricultural-based economies. Let us consider the two that are directly related to agriculture: dependence on imported food and diversity of exports.

The dimension of imported food dependency is perhaps more critical. The populations of some island countries and territories may have outgrown their resource bases. At the subnational level, one can find single islands like Majuro in the Marshall Islands with populations that could not be supported from existing land and sea resources on the atoll. If the supply of imported food were cut off, people would starve.

Among Pacific Islands, Solomon Islands appear to be the best equipped to substitute local food supply for imported food. At the other end of the spectrum, we find in American Samoa and Guam people who have acquired a marked preference for imported foods, encouraged by the absence of tariff barriers to food imported from the United States.

Some Pacific governments have adjusted their import tariffs to make locally grown food more attractive to buyers and sellers, in order to reduce food imports and encourage local agriculture. Papua New Guinea and Fiji have been leaders in this area. Fiji now supplies most of its own beef, whereas in the past much of the beef was imported from Australia and New Zealand.

Analysis of the export patterns of some Pacific Islands indicates that Solomon Islands is the least vulnerable to fluctuations in world demand for their exports, while the territory of Tokelau is most vulnerable to export disruptions, being almost totally dependent on copra exports.

Countries which rely on a single export are especially vulnerable if their export is a non-renewable resource. This is true for the heavy mineral-producing countries and territories including Papua New Guinea, Kiribati, Nauru, and New Caledonia. In 1979, copper constituted 42% of Papua New Guinea's exports.

Overall, Melanesia, with its larger continental islands, has greater export diversity than Micronesia or Polynesia, both of which include many small, resource-poor atolls. However, even where the economic potential of a country is limited, vulnerability can be decreased through diversification. Many countries in the region have consciously begun to diversify their exports.

When all six major constraints discussed above (degree of reliance on foreign aid, range of exports, dependence on imported food, fuel imports, fiscal integrity, and political status) are combined, it is possible to produce a composite index of economic vulnerability (Table 1).

Table 1. Composite index of economic vulnerability.*

	Composite rank**
Tonga	17
Solomon Islands	18
Papua New Guinea	22
Fiji	27
Western Samoa	27
Vanuatu	28
Kiribati	39
Cook Islands	40
Tuvalu	41
New Caledonia	45
Niue	48
French Polynesia	49
Trust Territories of the Pacific Islands	50
Guam	52
American Samoa	60

* From Ward and Proctor (1980).
** Least to most vulnerable.

Production Modes

The fragmentation of the region's land area continues down to the level of production units. Smallholdings are the rule in the Pacific Islands. The smallholder sector operates at a subsistence level, is tradition-based, conservative in land and agricultural practices, and constraint-filled with mostly social pressures.

For Western Samoa the smallholder sector contributes 85–90% of the principal export products of copra and cocoa. In the Solomon Islands, which is among the few Pacific countries with trade surpluses, the contribution to exports of the smallholder sector compared to the plantation sector is considerably less. The transitional model of production is between subsistence cropping and plantation cropping. The latter is the commercial mode associated with organised factors of production (land, labour and capital), good management, and profits (Ward and Proctor 1980).

The plantation mode refers to the commercialised level of production rather than the scale. Following this, it can be assumed that there is potential in the desirable progression for smallholders to move into the plantation (cash-cropping) mode given identified and removable constraints.

Range of Crops

Crops are more important than livestock in the South Pacific. The staple food crops are root crops such as taro, yams, cassava, sweet potatoes and swamp taro. Sago palm and breadfruit are also important staples. Vegetables and fruit species important for export and processing are listed in Table 2.

Table 2. Vegetable and fruit species for export and processing.*

Product	Exports[a]	Current processing; location and type	Processing possibilities
Banana	U	Cook Islands, drying (experimental stage)	
Breadfruit	U	none, or only occasional traditional fermentation	stock and human storage food
Avocado	U	none	various preparations
Orange	P	Cook Islands, canned juice	
Mandarin	U	none	canned fruit
Mango	U	none	canned fruit and juice
Pineapple	U, P	Cook Islands, canned fruit and juice	

(Continued on next page)

Table 2. *(Continued)*

Product	Exports[a]	Current processing; location and type	Processing possibilities
Coconut	U, P	Western Samoa, canned cream	
Passionfruit	U, P	Western Samoa, frozen pulp	
Papaya	U	Cook Islands, drying (experimental stage)	
Bean	U	none	canning, freezing, limited potential
Capsicum	U	none	canning, freezing, limited potential
Egg plant	U	none	canning, freezing, limited potential
Zucchini	U	none	canning, freezing, limited potential
Cucumber	U	none	pickling
Onion		none	drying
Green onion		none	drying
Lettuce		none	
Chinese cabbage		none	
Cabbage		none	pickling
Cauliflower		none	pickling, freezing
Radish		none	
Carrot		none	limited potential
Tomato	U	none	pulping, canning
Taro	U		
Alocasia	U		
Xanthosoma Cyrtosperma Sweet potato	U	traditionally fermented for stock or human food	potential for starch extraction and drying for food
Cassava Yams	U		

Notes: (a) 'U' indicates that the product is exported in an unprocessed form.
'P' indicates that the product is exported in a processed form.

* Source: Ward and Proctor (1980).

Coconut is the most important single crop and is the 'tree of life' to the region, not only in terms of export earnings from copra and as raw material for processing, but for various local uses. For the smaller islands the coconut is more important for local consumption than for its export value.

Livestock, Fisheries and Forests

There is a lack of information on livestock and fisheries in the region. Recent trade statistics suggest that fish is becoming an increasingly important commodity for export, following recent fishing agreements which define Exclusive Economic Zones (EEZ). Livestock and fish products are also important imports, giving the impression of some potential for import substitution with these commodities. However, the beef and dairy industries have limited potential, being restricted to the bigger islands, with the cutoff point at about the scale of Solomon Islands (Ward and Proctor 1980). Pigs are also important, having high social values in Papua New Guinea, Western Samoa, Tonga, and other islands. Poultry and goats are also important. Sheep have some potential in Fiji and in the Papua New Guinea highlands.

There is an increasing need for fuelwood and for other forest products for domestic uses. Social forestry and agroforestry are planned in various parts of the region. This is part of the increasing awareness in the region of the rapidly disappearing natural forests, and the need to replant trees to restore the economic, social, aesthetic, and conservation worth of forests.

Agricultural Research

I wish to make two points regarding agricultural research in the region. One is that trained staff is required for research in the face of other competing staff needs in agriculture. The second is that assistance in project identification and formulation may be required in some countries. On both points, some flexibility and special consideration might be given by ACIAR when developing its research program.

I think that this introduction, however incomplete, would be inadequate without my mentioning a deficiency in publications on the region's agriculture, including publications on research. This has been pointed out in the South Pacific Agricultural Survey by Ward and Proctor (1980), but I fear that there has been little collective action to make up for this deficiency. There should be a useful and flexible sharing of results and experience in agriculture amongst the member countries of the South Pacific, with greater accessibility to published material.

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South Pacific Agricultural Research: A Review

Gabrielle J. Persley*

THE Jackson Review of the Australian aid program recommended four geographic areas of priority for future Australian assistance (Anon. 1984a). The geographic areas, in order of priority, are: (i) Papua New Guinea and the small island states of the Pacific and Indian Oceans; (ii) Southeast Asia and the smaller states of South Asia (Bhutan, Nepal and Sri Lanka); (iii) China, India, Pakistan and Bangladesh; and (iv) other developing countries.

The South Pacific (encompassing Papua New Guinea and the small Pacific Island states) is an area of high priority for ACIAR. The purpose of this paper is to provide some information on the Pacific Islands and their agricultural sectors; outline current agricultural research and development activities in different countries; describe ACIAR's current program in the South Pacific; and raise some policy issues.

Geographic and Economic Characteristics of the Pacific Islands

The Pacific Islands lie between 141 °E and 157 °W and 5 °N and 23 °S. There are 22 countries within the area of the South Pacific Commission, with a total population of 5 million. They comprise 1200 islands with a total land area of 550 000 km^2 set in 30.6 million km^2 of sea. Excluding Papua New Guinea, the remaining South Pacific countries have a population of 2 million, a land area of 88 000 km^2 and a sea area of 27 million km^2. Some of the key statistical features of the countries are given in Tables 1–5. More detailed information is available in the statistical summaries produced by the South Pacific Commission (Anon. 1984b).

The common features of the South Pacific countries are: their small size; fragmentation of land areas; the scattered nature of island communities; and their remoteness from major markets. The countries share common problems associated with their smallness and remoteness. However, their common features should not obscure the fact that there are major differences amongst the countries in culture, natural resources, topography, climate and stage of development.

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Culturally, the major ethnic groups are Micronesians, Melanesians and Polynesians, with Fiji also having a substantial Indian population. Melanesians are the dominant group in the Southwest Pacific, in countries such as Papua New Guinea, Solomon Islands, and Vanuatu. Polynesians are the main ethnic group in the Southeast Pacific (Tonga, Western Samoa, Cook Islands, Tahiti). Micronesians predominate in the islands north of the equator.

In the agricultural sector, differences amongst the countries are a reflection of differences in topography, climate, land capability and natural resources, as well as the differences in the agricultural development plans and priorities of the various governments.

Topography

There is considerable variability in topography within the Pacific Islands. At one extreme lie the coral atolls, such as in Kiribati, Tuvalu and the northern Cook Islands. The atolls are deposits of rubble and sand with some rock and hard pan. Soil development is poor and agricultural potential is limited. Copra and fish are the only agricultural exports. Root crops and coconut palms are the major subsistence crops.

At the other extreme are the high islands, which are composed of volcanic hills, rising up to 2300 m in Papua New Guinea, and up to 1000 m in other island countries. The soils on the high islands are more fertile than those on the atolls and support a greater diversity of crops. Some land is suitable for commercial cropping (such as for sugarcane in Fiji), while other areas are suitable for tree crops such as cocoa and coffee (e.g. Western Samoa) or pastures (e.g. Vanuatu).

Rainfall

Another important variable is rainfall. Land use is closely related to rainfall. Kiribati and Tuvalu lie in a low rainfall area (1578 mm/annum on Tarawa Atoll in Kiribati; 700 mm/annum on Tuvalu). Western Samoa (3500 mm/annum), and Fiji (2940–3640 mm/annum) lie in high rainfall zones. Tonga receives moderate rainfall (1680–1990 mm/annum). Most South Pacific countries lie within the cyclone

Table 1. Some regional characteristics of small island countries.

Regional group	Number of countries in group	Population[1] ('000s)	Land (km^2)	GNP per cap. ($A, 1978)	ODA per cap. ($A, 1979)	Exports per cap. ($A, 1979)	Distance to large market (km)
Pacific	19	1 857	88 790	1 543	296	396	2 900
Caribbean	14	2 040	21 970	1 942	277	4 540	700
West Indian Ocean	5	2 017	7 304	1 217	215	282	800

Source: South Pacific Economics 1981: Statistical Summary. South Pacific Commission, Noumea, New Caledonia, 1984.
1. 1979 mid-year estimates.

Table 2. South Pacific population, land and sea areas.

Country	Estimated population (mid-1981)	Land area (km^2)	Sea area ('000 km^2)	Population density (persons/km^2)
American Samoa	33 200	197	390	169
Cook Islands	17 400	240	1 830	74
Federated States of Micronesia	79 500	701	2 978	113
Fiji	646 500	18 272	1 290	35
French Polynesia	149 800	3 265	5 030	46
Guam	107 000	541	218	197
Kiribati	59 900	690	3 550	85
Marshall Islands	31 800	181	2 131	176
Nauru	8 100	21	320	348
New Caledonia	142 500	19 103	1 740	7
Niue	3 200	259	390	13
Northern Mariana Is.	17 600	471	1 823	37
Palau	12 400	494	629	25
Papua New Guinea	3 060 600	462 243	3 120	7
Pitcairn	100	5	800	20
Solomon Islands	235 000	27 556	1 340	9
Tokelau	1 600	10	290	160
Tonga	98 400	699	700	141
Tuvalu	7 600	26	900	292
Vanuatu	119 900	11 880	680	10
Wallis and Futuna	11 200	255	300	44
Western Samoa	156 000	2 935	120	54

Source: South Pacific Economics 1981: Statistical Summary. South Pacific Commission, Noumea, New Caledonia, 1984.

belt and damaging cyclones are common. In 1985, Fiji experienced three serious cyclones, and Vanuatu two. Droughts are unusual but not unknown. In 1983–84, the most severe drought in 30 years affected many Pacific countries, including the Cook Islands, Fiji and Tonga.

Agriculture in the South Pacific

Production Systems

Three basic production systems in the South Pacific have been described by Yen (1980a). These are: (1) integral subsistence systems; (2) mixed subsistence/cash systems; and (3) plantation systems.

Integral subsistence systems: These are the traditional, self-contained production systems which incorporate a variety of food crops, particularly the starchy staple crops, tree and fruit crops (notably coconut), animal husbandry (particularly pigs and chickens), and fish.

Mixed subsistence/cash cropping systems: These systems combine the production of traditional food crops, fish and small animals with the production of cash commodities. Cash commodities may be either those produced solely for sale (such as

Table 3. Total South Pacific trade.

Country	Trade total ($A'000, 1981)		
	Exports	Imports	Balance of trade
American Samoa	173 110	100 034	+ 73 076
Cook Islands	3 858	20 474	- 16 616
Fiji	280 175	562 403	-282 228
French Polynesia	25 321	485 337	-460 016
New Caledonia	286 938	357 827	- 70 889
Niue	454	2 952	- 2 498
Papua New Guinea	733 645	965 284	-231 639
Solomon Islands	58 136	66 636	- 8 500
Tokelau	64	342	- 278
Tonga	7 707	34 999	- 27 292
Tuvalu	36	2 592	- 2 556
Vanuatu	25 067	45 270	- 20 203
Wallis and Futuna	0	5 540	- 5 540
Western Samoa	9 612	59 910	- 50 298
South Pacific Regional Total 1981	1 604 000	2 710 000	-1 106 000

Source: South Pacific Economics 1981: Statistical Summary. South Pacific Commission, Noumea, New Caledonia, 1984.

vanilla, coffee and cocoa), or those produced both for domestic consumption and sale (such as coconut, fish and pigs).

The proportion of land devoted to cash cropping varies from year to year, depending on several factors, including the need for cash and the price of various commodities. These are now the most common systems in the Pacific Islands. The major change has been the reduced production of food crops, and the consequent increased purchase of food, particularly imported tinned food.

Plantation systems: These are large-scale production systems characterised by monocropping, capital input, centralised management, wage employment of labour and export of almost all production. Plantation systems were first used in the South Pacific for coconut and sugar cane. They were later extended to other commodities such as coffee and cocoa. Crops such as rice and oil palm are now also being produced in plantation systems in various countries. There is also increasing production of traditional staple crops such as bananas and root crops in small-scale plantations, for export. Cattle production and fisheries are also being conducted on a larger scale.

The traditional production systems were characterised by their small-scale nature, subsistence base and social orientation (Sevele 1980). These characteristics are retained in the mixed subsistence/cash cropping systems since certain cash crops fit easily into the traditional system of bush fallowing.

The traditional systems are well adapted to their environment, stable and productive (Fisk 1976). They involve some intricate methods of production of traditional crops, particularly root crops which are also important in fulfilling social obligations (Yen 1980b). They have led to the situation of subsistence affluence described by Fisk (1976). Food shortages are rare in the South Pacific.

The change from the traditional subsistence systems to the mixed subsistence-cash cropping systems reflects the social changes which have occurred in the South Pacific over the past century. An abundance of subsistence products will no longer satisfy the aspirations of Pacific Islanders. They also wish to have money and the products it can buy. The desire of Pacific Islanders to join the cash economy is demonstrated by increasing rural to urban migration, overseas migration, involvement in cash-generating activities, and consumption of imported goods, including imported food.

Food Crops

The staple food crops in the South Pacific are given in Table 6. The most important carbohydrate sources are the root and tuber crops, and certain trees such as sago palm and breadfruit. Coconut is an important subsistence crop as well as the dominant cash crop. The traditional food crops are

Table 4. South Pacific exports by principal products ($A'000, 1981).

Products	American Samoa	Cook Islands	Fiji	French Polynesia	New Caledonia	Niue	Papua New Guinea	Solomon Islands	Tokelau	Tonga	Tuvalu	Vanuatu	Western Samoa
Fish and seafoods[a]	166 170		17 515	22	33		34 838	22 187		15			
Bananas		526								408			207
Fruit and vegetables		1 161	1 865	50	132	111[b]				540[c]			1 842[c]
Sugar			137 043										
Coffee, tea, cocoa and spices			2 696[d]	47[e]	371[f]		150 400[g]	902[h]		277[i]		1 108[k]	1 238[l]
Other crops			10 021[m]			26[n]		910[o]		827[p]			
Animal feed	5 552		866										
Copra		268			13	15	26 187	8 131	61	2 565	29	9 473	3 382
Coconut oil			6 620	4 591			16 244			1 172			
Palm oil							18 471	7 166					
Wood and by-products			2 063				57 380	16 232		88[q]		189	249
Minerals			12 376[r]		222 371[s]		388 898[t]	525[u]					
Shells, coral, etc.		248		3,689[v]	739		465	407					
Other[x]	1 388	1 655	89 110	16 922	63 279	302	40 763	1 676	3	1 815	5	14 297	2 694
Total	173 110	3 858	280 175	25 321	286 938	454	733 646	58 136	64	7 707	34	25 067	9 612

Source: South Pacific Economics 1981: Statistical Summary. South Pacific Commission, Noumea, New Caledonia (1984).

Notes:
(a) mainly tuna
(b) mainly passionfruit
(c) mainly taro
(d) mainly ginger
(e) vanilla
(f) coffee
(g) 64% coffee, 30% cocoa, 6% tea
(h) cocoa
(i) vanilla
(k) 93% cocoa, 7% coffee
(l) cocoa
(m) molasses
(n) honey and beeswax
(o) mainly rice
(p) desiccated coconut
(q) wood products
(r) gold
(s) nickel
(t) 98% copper, ore & concentrate, and 2% gold
(u) gold
(v) mainly cultured pearls
(x) includes re-exports

Table 5. South Pacific imports by major commodity groups ($A'000, 1981).

Group	American Samoa	Cook Islands	Fiji	French Polynesia	New Caledonia	Niue	Papua New Guinea	Solomon Islands	Tonga	Tuvalu	Vanuatu	Wallis and Futuna	Western Samoa
0 Food	15 395	4 622	79 781	80 412	60 089	698	177 010	7 118	8 638	785	14 950	1 416	11 410
1 Beverages and tobacco	3 286	1 089	4 710	9 866	11 515	209	10 864	2 424	1 929	118	2 155		1 097
2 Crude materials	1 753	487	4 623	10 074	5 155	73	4 683	600	1 797	68	527		542
3 Mineral fuels etc.	45 057	4 160	144 271	61 752	100 542	563	205 205	15 376	5 745	421	8 012	1 000	10 841
4 Animal and vegetable oils and fats	1 626	108	6 145	2 240	1 500	5	2 434	337	38	6	260		341
5 Chemicals	3 012	1 250	38 883	24 617	19 841	146	58 492	3 855	1 888	114	2 858	1 442	2 653
6 Manufactured goods	10 453	4 110	92 748	78 809	45 777	411	136 377	12 249	6 590	405	5 116	248	10 747
7 Machinery and transport equipment	9 119	2 838	122 846	159 494	70 257	599	286 221	19 342	5 503	353	6 539	903	19 687
8 Miscellaneous manufactured goods	2 847	3 378	49 631	54 069	42 510	248	70 817	5 080	2 802	276	4 385		2 684
9 Miscellaneous transactions	7 485	61	18 764	4 007	642	—	13 183	255	68	46	470	531	48
Total[(d)]	100 034	22 103	562 403	485 341	357 827	2 952	965 284	66 636	34 999	2 592	45 270	5 540	60 051

Source: South Pacific Economics 1981: Statistical Summary. South Pacific Commission, Noumea, New Caledonia, 1984.

Table 6. The staple food plants of the South Pacific.

Species	Common name	Centre of origin	Adaptation	Distribution[a]
Cocos nucifera	coconut palm	Oceania (?)	Coastal plain, extending inland, low altitudes usually below 200 m	All
Metroxylon sagu	sago palm	Oceania	Lowland and swamps, with tolerance to brackish conditions	PNG
Metroxylon salomonense	sago palm	Oceania	Similar to *M. sagu*, but has greater adaptability, growing on slopes up to 250 m, in high to medium rainfall areas	SI
Artocarpus altilis	breadfruit tree	SE Asia	Coastal, low altitude hills up to 300 m	All, but dominant in eastern SI, T, WS, CI, K
Musa spp. (2 forms) *Emusa*, and *Australimusa*	banana (*Emusa*) fe'i banana (*Australimusa*)	SE Asia	Coastal to 2000 m	*Emusa* All *Australimusa* PNG, F, SI, WS
Dioscorea alata	yam, greater yam	SE Asia	Dryland, lowland to 1500 m	PNG, SI, F, T, WS
Dioscorea esculenta	yam, potato yam	SE Asia	Dryland, lowland to 500 m	PNG, SI, F, T, WS
Colocasia esculenta	taro	SE Asia	Varieties differentiated into adaptation to either high water table conditions (e.g. drained swamps) or dryland conditions in high rainfall areas up to 600 m	All (rare in K)
Alocasia macrorrhiza	giant taro	SE Asia	Widely adapted, coralline soils, tolerant to dry conditions but also grows in rain forest up to 1000 m	All but prominent in WS, CI, T
Cyrtosperma chamissonis	swamp taro	SE Asia	Adapted to swamps and high water table, brackish conditions; some forms thrive in volcanic mountain soils under managed forest. Used in atolls as one of few annual crops.	SI, K, unimportant in PNG, F, CI
Xanthosoma sagittifolium	Fiji taro, kongtaro, (many names)	America	Wide adaptation, lowland coastal to 1000 m	All but K; important in T, WS
Manihot esculenta	cassava, manioc	America	Wide adaptation, sandy to heavy soils, but prefers light alluvial. Best at less than 1000 m	All except K
Ipomoea batatas	sweet potato	America	Wide adaptation to 2500 m, sandy to heavy soils. Some tolerance to drought and cold, but killed by frosts	PNG, F, SI, CI, K

Source: Adapted from Yen (1980b)

Notes: (a) PNG – Papua New Guinea
F – Fiji
SI – Solomon Islands
T – Tonga
WS – Western Samoa
CI – Cook Islands
K – Kiribati

grown primarily for domestic consumption, with surplus being sold for cash. Most are grown in the mixed subsistence/cash cropping systems which have become dominant in the Pacific this century.

Cash Crops

The major cash crops in the South Pacific are coconut, cocoa, coffee, oil palm, and sugar cane. Other cash crops include rice (Papua New Guinea, Solomon Islands), vanilla (Tonga), chillies (Papua New Guinea, Solomon Islands), citrus (Cook Islands), bananas (Tonga, Cook Islands), and ginger (Fiji). The relative importance of the cash crops for export from various countries is shown in Table 4. Coconut is the only crop which is significant in all Pacific countries.

Livestock and Fisheries

Farmers in the South Pacific have traditional, subsistence animal production systems based mainly on domesticated pigs and chickens (Quartermain 1980). There is some commercialisation of pigs and poultry in Fiji and poultry in Papua New Guinea. Pig production is particularly important in the social and agricultural systems of most countries.

Government goals for livestock production include import substitution, reduction of prices for consumers, increase of rural incomes, improvement of animal nutrition, and development of species with export potential. Most emphasis is being given to the goal of reducing imports by increasing local livestock production.

Fishing is a major commercial and subsistence enterprise in the South Pacific since all the countries have a sea area many times greater than their land area. The utilisation of fisheries resources is becoming of increasing political interest in the region (see Copland, this volume).

Agricultural Research in the South Pacific

The differences amongst the South Pacific countries are reflected in their different approaches to agricultural development and their different priorities in agricultural research. The Pacific countries are facing common problems in agricultural development but they are seeking different solutions.

Agricultural research is conducted on a national basis by most South Pacific countries and on a regional basis by the University of the South Pacific, particularly the Institute for Research, Education and Training in Agriculture (IRETA) in Western Samoa, and the South Pacific Commission (SPC). There are also several international projects, mainly of regional ambit.

The status of agricultural research in the South Pacific has been described by the International Service for National Agricultural Research (ISNAR 1981). ISNAR has subsequently undertaken more detailed surveys of agricultural research in Papua New Guinea (ISNAR 1982a), Fiji (ISNAR 1982b), Solomon Islands (ISNAR 1982c) and Western Samoa (ISNAR 1983). ISNAR has also assisted Fiji and Western Samoa in the preparation of 5-year research plans, which identify priorities in agricultural research and personnel requirements.

The major constraints to agricultural research identified by an ISNAR team in 1981 are listed below. Although the ISNAR report was completed several years ago, the overall situation has changed little in the intervening period: (1) *Staff constraints*, specifically the lack of an adequate number of appropriately trained staff to conduct agricultural research; (2) *Biological constraints*, particularly the lack of suitable quarantine arrangements to allow the safe introduction of crop germplasm from outside the region and the interchange of crop germplasm within the region; (3) *Policy and planning constraints*, relating not only to agricultural research but to agricultural development policies, such as pricing and distribution of inputs; (4) *Infrastructure constraints*, such as inadequate facilities, equipment and transport; and (5) *Organisational constraints*, particularly the need to design appropriate research organisations for small countries; to reduce the isolation of individual scientists working in remote locations; and to provide adequate financial support for agricultural research.

Another important constraint is the lack of a close relationship between agricultural research and development in many Pacific countries. Many agricultural development projects have commenced with an inadequate research base, and have subsequently not been as successful as envisaged.

Agricultural research is generally not well supported and funded by governments. In times of financial stringency, agricultural research in the South Pacific (as elsewhere), is one of the early casualties.

The continual turn-over of staff in many countries affects the continuity of research. There are insufficient trained local scientists to meet the staffing requirements of the departments of agriculture. Consequently, many positions are filled by expatriate staff, often on short-term contracts. The

common term of 2–3 years is seldom sufficient time to complete a substantial piece of research, translate it into an improved agricultural technology, and write up the work in a permanent, available form.

In addition, research is only a small part of the brief of the departments of agriculture, whose staff are also responsible for agricultural development activities, quarantine, and other regulatory activities and extension. Thus the time and personnel available for longer-term research activities are limited.

Policy Issues

There are several policy issues which are being considered in the development of ACIAR's program in the South Pacific. These are described below.

Bilateral or Regional Approach

ACIAR needs to strike an appropriate balance of bilateral and regional activities. Under ideal conditions, one may favour regional activities in preference to bilateral. However, it is important to take account of the developmental priorities of individual countries, which often differ. In terms of the perceived priorities of the departments of agriculture in the South Pacific, there are surprisingly few areas of common interest. One approach which is being developed by ACIAR is to identify common themes, and to develop a series of bilateral projects around a single theme. Common themes include coconuts, biological control of insect pests and weeds, and farming systems.

Economic Rationale

The economic rationale of ACIAR activities in the South Pacific is particularly important. Research in the South Pacific needs to be closely linked to agricultural development. There are many interesting problems on which to work but few which are likely to contribute to agricultural development.

Style of ACIAR Projects

The style of ACIAR projects in the South Pacific needs to be different from projects in other countries. This is a reflection of the small size of the countries and their departments of agriculture; the few staff engaged in agricultural research (as distinct from development) activities; the lack of essential infrastructure and adequate research facilities in many countries; and the shortage of trained people available for research activities. ACIAR may need to place more research staff in-country on a short- or long-term basis, to work alongside the staff of the departments of agriculture.

Training

There are few local staff and a limited number of expatriate staff engaged in research. ACIAR will need to take a more active role in short- and long-term training, possibly in conjunction with the Australian Development Assistance Bureau (ADAB).

ADAB/ACIAR Collaboration

There are prospects for ACIAR to work with ADAB in some areas, where ADAB is interested in providing assistance to part of the agricultural sector, and ACIAR is able to contribute to the research relevant to development. ADAB has established a Pacific Regional Team who are responsible for the identification of development projects for ADAB. There would be advantages in ADAB and ACIAR working together when developing activities which have both research and development components.

Relative Importance of Agricultural Commodities

There needs to be an appropriate balance of activities in the various subsectors of agriculture, related to the importance of the commodities in the agricultural sector in the Pacific countries and their potential contribution to development. Crops are likely to remain significantly more important than livestock, both for domestic consumption and export.

Conclusion

The challenge to ACIAR is to identify agricultural research activities which will contribute to agricultural development in the Pacific Islands and which can be undertaken efficiently and successfully.

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Coconut Replanting in the Pacific Islands

John Raff*

THE coconut (*Cocos nucifera*) is one of the world's most important and versatile trees and fully deserves the title 'tree of life.' There are approximately 8 million ha of coconuts grown in the tropical regions of the world, of which 600 000 ha are in the Pacific Islands. The coconut is an important crop in both the social and economic development of the South Pacific countries. At the national level, coconuts provide an important source of foreign exchange. At the village level the coconut is an integral part of people's lives, providing food, shelter and cash. Coconuts are predominantly a smallholder crop. Seventy per cent of production is derived from properties of less than 2 ha.

There has been little research on coconut palms in the Asia/Pacific region relative to the importance of the crop. This has been recognised by the Technical Advisory Committee of the Consultative Group for International Agricultural Research (CGIAR), which in a recent review on priorities in international agricultural research recognised coconut as being the oilseed crop most in need of international research support (Anon. 1985). International research on the crop is currently underfunded and has the potential for high payoff. Furthermore, coconut is a smallholder crop that fits a unique ecological niche and offers a broad range of dietary, income and employment opportunities.

There are several major problems facing the coconut industry. On international markets coconut is facing increasing competition from alternative crops such as oil palm and soybean. The productivity of many coconut plantations is declining. A major factor affecting the decline is the age structure of plantings, with well over 50% of plantings being beyond their normal commercial life.

The need for extensive coconut replanting has been recognised by both national governments and international agencies and a number of replanting schemes have been initiated. Generally the replanting schemes have had little impact on the smallholder sector of the industry. It has proved particularly difficult to encourage smallholders to replant using currently recommended practices and improved planting material.

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The factors which motivate the smallholder to replant involve complex interactions between social, economic, and, in some countries, political factors. Part of the reluctance of smallholders to be involved in replanting schemes may be because some of the schemes impose specified replanting systems on the farmer. Much of the 'state of the art' technology for replanting is not relevant to the limited-resource situation of the smallholder. Many of the currently recommended practices are oriented more towards large-scale plantation farming rather than the limited-resource, smallholder sector of the industry.

Smallholders are an important but diverse section of the industry. The major questions involved in replanting are: (1) What is the best available planting material? (2) What nursery practice and replanting system is most appropriate to the needs of the smallholder? and (3) What supplementary sources of income are available during the non-productive period? Specific answers to these questions will vary in different locations. Hence there is a need to develop appropriate packages to assist the smallholders in each region.

Sources of Improved Planting Material

Research on genetic improvement of coconut has been dominated by the production and evaluation of coconut hybrids. Hybrids may be produced by crosses between dwarf × dwarf, tall × tall and, most commonly, dwarf × tall. The dwarf × tall hybrids have been of particular interest as they display both the early bearing characteristics of the dwarf types with the greater vigour and large nut size of the tall.

Much of the valuable work on hybrids has been conducted at the Institut de recherches pour les huiles et oléagineux (IRHO) research stations, particularly in the Ivory Coast, where there are large-scale, long-term, hybridisation programs. The hybrid produced by the cross between Malayan Yellow Dwarf and West African Tall (MAWA) has been widely distributed in Malaysia, Indonesia and the Philippines. Papua New Guinea is also producing coconut hybrids, mainly from the cross between Malayan Red Dwarf and Rennell Tall, but also by

crosses between a range of other local and introduced varieties.

The scientific evaluation of the field performance of hybrids is still in its infancy. However, sufficient information is available to be cautious about the widespread planting of the present limited range of hybrids. Some of the difficulties identified to date include: (1) susceptibility to drought; (2) susceptibility to typhoon damage; (3) susceptibility to pests and diseases; (4) lack of local information on the performance of both exotic hybrids and hybrids between local tall and dwarf varieties; and (5) limited availability of hybrid seed nuts.

Hybrids have not been a significant seed source for voluntary replanting on smallholder properties in the Pacific Islands. Most smallholders replant with seed nuts from local high-yielding tall varieties, i.e. mother palm selection. There have been conflicting reports on the genetic gains derived from mother palm selection. Since this is such a commonly used system by the small farmer, it is an important area in which to conduct research to optimise the potential genetic gains.

Hybrids have not been grown in many Pacific Islands because they have not been available. In the past there has been considerable movement of seed nuts between countries. However over the last decade there has been increasing awareness of the serious diseases that may be transferred through seed nuts. Quarantine regulations now restrict the large scale introduction of material. In the future it may be possible to reduce the risk of the introduction of exotic diseases by transporting zygotic coconut embryos stored in vitro.

Tissue Culture of Coconuts

The technique of embryo culture has already been established for several coconut varieties by IRHO scientists. With further development and when used in conjunction with disease indexing techniques, embryo culture will allow the safe exchange of coconut germplasm between countries. ACIAR is presently supporting the development of embryo culture techniques for use in PNG and other Pacific countries. ACIAR is also supporting the development of improved indexing techniques for the cadang-cadang viroid, and the causal agent of Foliar Decay induced by *Myndus taffini* (FDMT) in Vanuatu (thought to be a virus), by Dr John Randles of the Waite Institute in South Australia, in collaboration with scientists at the IRHO Station in Saraoutou, Vanuatu and the Albay Research Centre of the Philippines Coconut Authority (Randles et al. 1987).

Another area of tissue culture which is likely to have considerable impact on the coconut industry is the vegetative propagation of coconut palms in vitro. Vegetative propagation may involve a range of techniques including embryo multiplication, meristem culture or embryogenesis.

Tall varieties of coconuts are outcrossing and therefore highly heterogeneous. High-yielding, early-bearing individual palms exist in tall populations. There would be obvious advantages in being able to propagate vegetatively individual outstanding trees.

Nursery Practices

Nursery practice is widely recognised as an important factor in coconut improvement. Current recommendations are based mainly on IRHO research. Selection is carried out on the germinating nuts. Seed nuts are placed in germination beds and the first 50% of talls and first 60% of hybrids to germinate are selected and the remaining nuts discarded.

The basis of selection on tall varieties is believed to be associated with the removal of nuts produced from self-pollination in individual tall trees. Hybrid seed nuts are first selected to remove non-hybrid seeds but the basis of the presently recommended 60% selection is not clear.

The nuts selected from the germination beds are then grown in either inground or polybag nurseries. Coconut seedlings grown in polybag nurseries are said to bear 6–12 months earlier than seedlings grown inground.

There are a number of problems with the polybag system for the small farmer. Polybag nurseries require considerable resources, including fertilisers, plastic bags and reliable irrigation. Because of their high capital expense, polybag nurseries are usually located at regional centres. Many small farmers live in isolated areas and it is impractical to transport heavy seedlings in polybags. It is more convenient to transport seed nuts. This necessitates the use of village nurseries. It is also difficult to convince the small farmer to discard 40% of seed nuts, particularly if they have been purchased and transported considerable distances.

There is a need to identify the key factors inducing early bearing in polybag nurseries and develop a new technology based on village nurseries rather than centralised nurseries.

Planting Systems

The currently recommended replanting systems of several major international organisations involve the removal of all palms before replanting. The

complete removal of palms is ideal for the establishment of young palms but it is not a system favoured by the small farmers.

A small farmer from the Philippines made the following comments on replanting systems involving total removal of all palms: (1) What would be his source of income for his family during the period until the new palms come into bearing? (2) If he removed all his trees at one time, the next replanting would only be required in 50 years and his grandchildren would not know how to replant; and (3) What would he use as an overstorey for his intercrops?

Conclusion

On small farms there is a whole diversity of 'non-ideal' situations and most management decisions involve compromise. There is a need to understand the practical constraints on small farmers and provide relevant information for the development of replanting systems which are suited to the small farmers' requirements. Key areas of current technology need to be identified and modified to gain maximum benefit in the 'non-ideal' situations commonly found on the smallholder properties.

Coconut will always be an important crop in isolated areas, particularly on islands where there are few alternative crops. However monocultures of coconuts may not be economically viable when farmers are close to markets and may grow a wide range of other crops. In this situation selection characteristics may need to be altered. The most economically desirable coconut may be selected on the basis of maximum yield with an open canopy that allows sufficient light penetration for the intercrop below. The future of coconuts on smallholdings will continue to involve gaining maximum output with minimal input. To achieve this it is necessary to optimise the efficiency of a biological ecosystem, and that is a very complex challenge.

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Biological Control of Pests and Weeds in the South Pacific

D. F. Waterhouse*

A workshop on the biological control of the major invertebrate and weed pests in the Southwest Pacific was held from 16 to 26 October 1985 in Tonga. The workshop was sponsored by ACIAR, the German Agency for Technical Cooperation (GTZ), the Tongan Government, the South Pacific Commission and the UNDP/FAO-SPC Project for Strengthening Plant Protection and Root Crop Development in the South Pacific. The Commonwealth Scientific and Industrial Research Organization (CSIRO) Australia, the Department of Scientific and Industrial Research (DSIR), New Zealand, the Commonwealth Institute of Biological Control (CIBC), and the University of Hawaii provided biological control experts as speakers. Some 25 individuals from about a dozen Pacific countries participated.

The rationale for the workshop was that most of the major pests of the Pacific region were introduced. Most of them are unimportant or far less important in other parts of the world where they are controlled by natural enemies that did not accompany the pests into the Pacific. Classical biological control (the introduction and establishment of such natural enemies) has been found to be more often effective in island communities than in more complex large land masses.

Although there have been many biological control successes over the years in Hawaii and Australia, and also in the late twenties and early thirties in Fiji and a few other South Pacific countries, the results of attempts in the Southwest Pacific in recent decades have generally been disappointing. A major exception is the introduction and establishment of *Baculovirus oryctes* which, in many islands, has produced excellent control of the rhinoceros beetle, which can be a serious pest of coconut palms.

The many unsuccessful attempts at biological control in more recent times have been due to a variety of reasons, including the lack of suitably trained staff, the lack of necessary reference literature in most of the countries, inadequate planning and funding and a general lack of appreciation of some of the elements essential for successful biological control. Another problem has been the lack of readily available knowledge of exactly where in the region the various major pests occur, so that collaborative ventures have not been easy to plan.

Accordingly, ACIAR invited me to assemble the background information necessary for an effective workshop and to take overall responsibility for the program. The local organisation in Tonga was the responsibility of Dr D. Stechmann, leader of the Tongan-German Plant Protection Project.

The first major task was to identify the major invertebrate pests by consultations with the 17 participating countries (Cook Islands, Fiji, French Polynesia, Kiribati, Marquesas, New Caledonia, Niue, Papua New Guinea, American Samoa, Western Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, Wallis and Futuna and Guam). The tables and distribution maps in which the results are summarised show the distribution and occurrence of the major insect pests and weed species. They have been rechecked with all participating countries and also with taxonomic and other experts elsewhere. These tables and maps of key pests dramatically highlight not only major quarantine risks, but opportunities for collaborative action.

In the foregoing survey all countries in the region were asked to assign a rating to their major pests and to indicate which they considered to be their top 10 most important arthropod pests and their top 10 weeds. When the results of this survey were compiled a group of 22 insect pests and 14 weeds stood out as being of prime importance. Dossiers were then prepared for each of these. The dossiers are designed to provide an overview of the origin, distribution, life history, pest status and natural enemies of each pest. The information on natural enemies includes data on their occurrence, and on their effectiveness if they have been used for biological control. The dossiers provide the basic information required by Pacific countries in deciding on the most relevant and promising targets to attack by traditional biological control means. The dossiers will be published in book form by Inkata Press on behalf of ACIAR in 1987. The proceedings of the

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workshop will be published by GTZ and ACIAR in 1987.

In summary, the objective of the workshop was to provide a sound technical basis for decisions nationally and regionally on the biological control of the major pests of the region. The workshop critically reviewed the justification for biological control and also its procedures. It considered the dossiers and arrived at considered views on what projects should receive priority attention. Advice was given on information that must be included in any persuasive submission for funding by development agencies.

Farming Systems Research in the South Pacific

Euan Flemming*

ACIAR is supporting research on smallholder farming systems in the South Pacific with a view to identifying constraints to development. The project addresses the socioeconomic aspects of smallholder systems in Solomon Islands and the Kingdom of Tonga. Small farms provide not only a major source of employment in the region but the bulk of agricultural production there. However, local attempts to raise production levels have often had disappointing results. This project seeks to identify the constraints that have limited production increases on the smallholdings, and to assess the potential for introducing selected new technologies to remove those constraints. The research team expects to develop constructive recommendations for feasible changes in agricultural policies and programs and to make specific suggestions for agricultural research and technology testing.

As its first priority, the team established an accurate and quantified description of the present smallholder systems in terms of the resources available, resource productivity, present technologies, economic behaviour and goals. It also identified and assessed the importance of social and economic factors such as access to markets, prices and costs, land tenure, risks and risk aversion and access to information. Data collected on physical and biological factors affecting system performance—available cultivars, soil and climatic conditions, diseases, pests and weeds—will help in assigning priorities in agricultural research. Finally, the team attempted to identify and assess the scope for improving system performance—using, for example: evidence of underutilised resources; between-farm differences in productivity; observed responses to economic stimuli; budgetting, programming or econometric modelling studies of system performance; and the results of testing improved technologies on experimental stations and farms.

To gather the necessary information about smallholders' constraints, goals and incentives, the project incorporated three methods of data collection: sample surveys of smallholders, field studies and a few intensive case studies.

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Sample surveys (the main data-gathering component) obtained details of resources available and their use, and of other constraints, for different categories of farms. They covered approximately 100 farm households in each country, comprising 25 smallholders from each of four villages or groups of neighbouring villages. Localities were selected to represent a range of agricultural conditions and of economic distance, which reflects not only distance from the urban centre but the position of the island in relation to inter-island shipping routes and facilities.

Field studies surveyed the physical, economic and institutional conditions under which smallholders operate. Information was gathered on relevant agrobiological research results and production alternatives for the farms, together with marketing opportunities. The intensive case studies sought a better understanding of the effect on economic behaviour of personal and social variables. Aspects studied included, for example, motivation, beliefs and preferences, goals, attitude to risks and response to community attitudes and beliefs.

Both Tonga and Solomon Islands contain varied production environments, and the results should prove useful in a number of areas. Indeed, a subsidiary aim of the project is to make its research approach productive, 'portable' and replicable.

Tonga

The five survey villages selected in Tonga were: (1) *Ha'akame/Ha'alalo, Tongatapu*—on the main island close to the capital, Nuku'alofa; (2) *Navutoka, Tongatapu*—on the main island close to the capital, Nuku'alofa; (3) *Navutoka, Tongatapu*—also on the main island but in a more remote location; (4) *Mataika, Vava'u*—in a remote island group but with close sea transportation facilities to Tongatapu; and (5) *Ha'ano, Ha'apai*—a remote location with poor access to markets.

Major activities during the early months of the work in Tonga included general reconnaissance and selection of case study villages, recruitment of Tongan field assistants, preparation and field testing of village census schedules and resource-base surveys in the four surveyed villages. In addition, the weekly household diaries were prepared in Tongan, discussed with assistants, pretested and

printed. These diaries cover household composition and labour force, income and expenditure, and cropping and other activities. Weekly recording of the diaries has been initiated for all sample households in all villages. There are also separate diaries kept for intensive recording of food consumption and time allocation for sample periods of one week. These have been prepared in Tongan, pretested and implemented for two households per week in each village.

Marketing Constraints in Tonga

Some preliminary data were analysed to identify the effects of agricultural marketing constraints on development. These analyses have relied on secondary data sources and the findings will be tested further on completion of data collection in Tonga. The preliminary findings are summarised below.

(1) The importance of smallholder agricultural production in contributing to economic growth is expected to continue despite some suggestions that a switch to a 'plantation system of management' is the best path to follow in future.

(2) The nature of agricultural marketing systems in the South Pacific region provides certain obstacles to smallholder agricultural development; to focus on production constraints is expected to be a necessary but not sufficient condition for accelerating agricultural development.

(3) Smallholder producers and market participants respond positively to market price incentives, even for staple food commodities, such as root crops and bananas, and for perennial crops, such as coconuts. The nature of this response generally appears to be inelastic but nevertheless quite substantial.

(4) Export price risk does not appear to deter smallholder producers from supplying agricultural export markets; on the other hand, institutional risk does appear to dampen enthusiasm for expanding marketed surplus.

(5) The agricultural marketing systems do not appear to have responded well to changes in demand for foodstuffs caused by changes in such factors as incomes, remittances, urbanisation and education.

Fisheries Resources in the Pacific and ACIAR-Related Activities

J. W. Copland*

THE fisheries sector plays an important part in the social and economic welfare of the Pacific Islands. This is due to their small size, location, use of the sea as a supply of animal protein, and of transport. The full potential of the fisheries resource has yet to be realised in the South Pacific although some species are approaching maximum sustainable yield. These species include certain tunas, giant clams and certain reef fish which have been overfished by both poachers and local consumers. A review of the fisheries sector in the South Pacific is given by May (1980) and only the major features will be given here.

The fisheries can be divided into the following groups:

Industrial

Capital-intensive, large vessels, sophisticated gear, processing facilities, deep-water fishery and export oriented.

Artisanal

Commercial Low capital, labour-intensive, small vessels, fish sold locally, relatively simple techniques, no processing.

Subsistence As for commercial artisanal fishing but fish caught for family consumption.

The major species caught are tuna (50 000 t), finfish (25 000 t), crustaceans (1800 t) and molluscs (800 t). Papua New Guinea has significant inland fisheries with *Tilapia* spp. The majority of the finfish caught are demersal species, such as snapper, mullet, shark and a variety of reef fish.

The tuna fishery is the most important in the region and is dominated by Japanese interests. The tuna is a highly mobile species whose migration route passes through the waters of different countries thereby resulting in potential areas of conflict between non-South Pacific countries and member states of the Pacific region. The tuna fishery consists of four species—the yellowfin, albacore, skipjack and bigeye, and small increases in absolute catches are expected. The size of the catch is dependent on world prices which until recently have been depressed. Tuna are caught by several methods—longlines, purse seining around Fishery Aggregating Devices (FADS) and pole and lining using bait fish. The latter is the method mainly used for skipjack tuna, and the supply of baitfish is often a constraint to improved catches.

The shift from subsistence fishing to commercial artisanal fishing has resulted in the use of motor-powered boats of improved design. Also the increased capacity of improved fishing methods has depleted stocks of reef fisheries and upset the reef fisheries' delicate ecosystems.

In absolute terms the demand for fish in the South Pacific countries is limited due to the small populations. In spite of the relative abundance of fresh fish there is a large importation of tinned fish, and it is frequently the cheapest animal protein available.

The basic fisheries trade pattern is to export high value products, mainly tuna, to earn foreign exchange and import low value tinned fish. Small foreign-assisted canneries are being developed in the region. However, managerial difficulties have resulted in their operations being intermittent. Import substitution of tinned fish is possible only after adequate facilities for postharvest preservation are available, such as ice, fish dryers and smoking. This is an aspect where appropriate technology could greatly benefit the artisanal section.

All South Pacific Forum countries have declared 200 mile Exclusive Economic Zones (EEZ) or fishing zones, which has had a far-reaching effect, particularly in relation to the migratory species such as tuna. A great deal of attention has been given to managing this recently acquired resource. Frequently, the resource is managed by joint ventures and licenced foreign fisheries companies are being allowed to fish in the EEZ areas. New joint ventures are being negotiated and there is an increase in the use of locally-owned vessels and share facilities.

The management of the tuna fisheries has required considerable regional cooperation which is supplied by the South Pacific Commission in the research areas and the Fisheries Forum Agency in the management/marketing area.

Research in the form of stock assessment of tuna is particularly important to the South Pacific countries. Often it is fragmented and the lack of a

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data-base has hampered the development of management models. The Skipjack Survey is a good example of the type of regional research that is required to manage the migratory species. Research and development funds have been received from FAO, ADB and various other bilateral donors. Most of the funding has gone to the purchase of equipment, loans for purchase of additional fishing boats and infrastructure support.

In view of the importance of research to establish the data base to manage the fisheries, and that this is a research-related seminar, details of Australia's capacity to carry out fisheries research, and a description of the research capacity within the region, are summarised below.

Australian Research Profile

Australia has a coastal length of approximately 20 000 km and with the 200 nautical miles Exclusive Economic Zone (EEZ) Australia assumes responsibility for an area of ocean greater than its land mass and one of the three largest in the world. Of this area 50% lies in the tropics and involves substantial areas of the Indian and Pacific oceans.

Australia shares extensive 'wet boundaries' with Indonesia, Papua New Guinea and Solomon Islands, which highlights the common interest of the three countries in migratory fish species, fish population dynamics and tropical reef ecology.

The research base in Australia to develop collaborative research projects in the ACIAR mode is significant. CSIRO has a Division of Fisheries which has the following research programs of relevance to tropical waters: migratory species (tuna and bill fish); fish taxonomy; fish population dynamics; tropical demersal fisheries; fish population genetics; tropical fish biology; prawn biology; bacterial and sea-grass production; and coastal ecology.

Other institutes involved in tropical reef and fisheries research are the Australian Institute of Marine Science and the Great Barrier Reef Marine Park Authority, and the seven State fisheries authorities also have a core of scientists involved in the more applied side of fisheries research, with a strong emphasis on State or Territorial research priorities. In addition there are active marine science programs at Queensland, James Cook, Griffith, and Sydney universities and several Colleges of Advanced Education.

The economic profile of the fisheries interests in Australia is in the order of $A400 million a year with approximately 60% exported; this is larger than several animal industries.

In general Australia is not heavily involved in deep-sea fishing for high value fish such as tuna; most activity is in the prawn and barramundi (*Lates calcarifer*) fisheries and coastal fisheries. Licences are issued to overseas countries such as Taiwan, Thailand and Japan to enable their ships to fish within the 200 mile EEZ areas. The greatest area of employment-related activities is within the continental shelf fishing zones.

Research Agencies Involved in the South Pacific Fisheries

South Pacific Commission (SPC)

The SPC is one of the regional agencies in the South Pacific which has an interest in fisheries (other interested agencies listed below). Past emphasis has been on the stock assessment and management of the migratory stock, particularly the tuna fisheries under licence to Japan. The SPC also acts in a coordinating role for the Pacific countries by having an annual fisheries meeting. The number of research-oriented scientists at the SPC is approximately six. The other emphasis of the SPC is on the training of fishery techniques developed by Master Fishermen applicable to the various member countries.

The Forum Fisheries Agency (FFA)

The FFA is solely involved in the development and policy aspects of fisheries in the South Pacific, particularly in the licencing fees for migratory fish, catches, and the protection of the regional resources. There is little biological research conducted. However, considerable economic and market research is carried out on large ranges of fish products relevant to Pacific countries.

University of the South Pacific: Institute of Marine Resources

The University of the South Pacific in Fiji is the base for the Institute of Marine Resources, which is involved in research and education. It acts as a data resource for marine fisheries.

International Center for Living Aquatic Resources Management (ICLARM)

ICLARM, a small centre based in the Philippines, has four main programs: traditional fisheries in which socioeconomic studies are emphasised, resource development and management, aquaculture, and education and training. ICLARM is currently working with ACIAR on the Giant Clam Project.

Other Organisations

The Food and Agriculture Organisation (FAO) has limited activities in fisheries in the South

Pacific compared to its activities elsewhere. Amongst the bilateral aid agencies the Japanese International Cooperation Agency (JICA) is prominent particularly in the tuna industry and in related fisheries administration; the UK Overseas Development Agency (ODA), the Canadian International Development Agency (CIDA) and the Australian Development Assistance Bureau (ADAB) are all involved. The East-West Center of the University of Hawaii currently supports a Pacific Island Development Program (PIDIP) which has some interest in fisheries research.

National Research Profiles of the South Pacific Countries

The level of fisheries research varies greatly amongst the Pacific Islands and frequently reflects their population size. In general the lack of a 'critical mass' of trained scientists and facilities has hampered the development of an adequate research capacity. Fisheries and related research investigations are considered to be a high priority in most Pacific countries, and support is given both to the enhancement of the high capital and low employment characteristic of the export fisheries, and to the domestic fishery which is characterised by low capital, high employment with a coastal location.

ACIAR's Current Projects

The current ACIAR fisheries projects relevant to the South Pacific are: Project 8381—Growth and Recruitment on Coconut Crab (*Birgus latro*) population in Vanuatu; Project 8332—The Culture of the Giant Clam (*Tridacna*) spp. for Food and Restocking of Tropical Reefs; Project 8313—Fish Drying in East Java, Indonesia; and Project 8304—Prediction and Control of Spoilage of Fresh Cured and Dried Tropical Fish in Indonesia.

The two projects being conducted in the South Pacific, on coconut crab and giant clams are described in the section on ACIAR's South Pacific Program, elsewhere in this volume.

Impressive results have already been achieved by the Giant Clam Project in its first year, where the researchers have induced spawning 'at will' with the clam (*Tridacna gigas*) and have reared the larvae to the juvenile stage in large numbers. Due to the achievements of the biological component, a socio-economic study of the impact of various forms of clam culture in the South Pacific, market description and reef ownership patterns is soon to be carried out. Such study will allow the transfer of the biological knowledge for the appropriate development phase of clam hatcheries in various South Pacific countries.

The Coconut Crab Project now has a research scientist to work with the Department of Fisheries, Vanuatu.

The two postharvest fish projects currently operating in Southeast Asia will have considerable relevance to the South Pacific in both the identification of the spoilage organisms and the reduction of their ability to spoil fish by drying.

Potential Areas for ACIAR Project Development

The *Giant Clam Project* currently operates with Fiji and Papua New Guinea. Other Pacific countries may wish to be involved in the project at a later stage.

The *Establishment of Bait Fish Supplies:* The tuna industry requires a regular supply of live bait fish which are found near the coastal reefs. A population dynamics study and stock assessment must be made before large numbers of bait fish are removed due to their role in the food chain of highly valued reef fish. The impact of the removal of bait fish after a source has been identified, and evaluation of the potential conflict patterns, must be established prior to the adoption of the fisheries as a supply of bait fish.

Another potential area is that of extending aspects of ACIAR's current postharvest fish project to the fish market suppliers of various countries in the South Pacific.

Other areas that may be important for research are in prawn culture and resource management, barramundi culture and artisanal fisheries.

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Livestock Resources in the South Pacific Region and Potential Research Topics for ACIAR

J. W. Copland*

A detailed sector review of livestock in the South Pacific has been provided by Quartermain (1980). The past emphasis has been on the development of large ruminants in Papua New Guinea, Fiji and Western Samoa. However, the focus of attention in recent years has been on the production of small ruminants under a variety of systems, from intensive production systems to fully integrated production systems. There is considerable diversity of environment in the Pacific Islands and this influences management of crops and the related livestock sector.

Initially domestic stock were pigs, fowls and dogs, introduced by the Pacific Islanders. Subsequent introductions have been made since 1945 by many national governments in the South Pacific, often assisted by development agencies. The recent introduction and expansion of the livestock sector has resulted in a major advantage in that few serious infectious diseases are present in the South Pacific. However, there is also only a small base of livestock experience to call on in the development of the livestock industry.

Justifications for the improvement of livestock production in the Pacific Islands are: provision of adequate animal protein supply for increasing demand expected by the increased adoption of a cash economy; import substitution; increase in productivity per unit area due to increasing population demands; the cost of importing animal products/feedstuffs into the island communities is high and is therefore an additional incentive for local livestock development.

Estimates of the livestock population in various Pacific countries are given in Table 1 (grazing animals) and Table 2 (non-ruminants).

Cattle

Details of the cattle production systems are given by Quartermain (1980). Large grazing areas are present in Papua New Guinea, Fiji and Solomon Islands, where much of the grasslands are not used for crop cultivation. However, land tenure and land disputes have prevented the utilisation of additional grazing areas for cattle. In Papua New Guinea a midi-ranch concept has been adopted where villages lease the land to the government which in turn assists in the development of a cooperative to develop the land. The grazing management of these grasslands requires additional input in order to preserve the productive capacity of the land and prevent overgrazing and the development of erosion.

Integrated cattle raising with tree crop forests, particularly coconuts, has attracted considerable attention in the past, particularly in Solomon Islands. Additional research inputs are required in the development of pastures under coconuts, the optimisation of the coconut/cattle production system and a study of the integration of cattle and goats under tree crops.

Pigs and Poultry

A large proportion of pigs are still managed in the subsistence sector based on low inputs and a scavenging diet (Table 2). The pig is an animal common to all the Pacific Islands although most pigs are located in PNG. Importation of high producing pig genetic stock such as Landrace, Tamworth and others has not been successful outside the intensive piggery management system. Interest in and experience with pigs is present in the South Pacific countries, but until an economic feed source is found that will improve the financial returns it is unlikely that rapid increases will occur in this area.

In most Pacific countries a modern sector poultry industry has been developed and efforts to develop periurban village poultry units have been successful in countries such as Papua New Guinea, Western Samoa and Vanuatu. Again, the major constraint is the lack of a continuous supply of economically priced feeds.

The lack of supply of economically priced feeds for both the pig and poultry industry is mainly due to the following: limited number of different crops grown with various nutritional characteristics; marked seasonal supply of crop by-products, particularly on atolls where the major crops are coconut, breadfruit, pandanus and swamp taro; lack of

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Table 1. Pacific region: estimates of livestock population (grazing animals).

Country	Horses	Donkeys	Cattle			Buffalo	Sheep	Goats
			Dairy	Beef	Total			
Cook Islands	9 000	Nil	Nil	250	250	Nil	Nil	3 000
Federated States of Micronesia	Nil	Nil	Nil	120	120	40	Nil	1 500
Fiji	39 000	6	51 000	104 000	155 000	Nil	400	125 000
Kiribati	Nil	Nil	Nil	Nil	Nil	Nil	Nil	42
Marshall Islands	Nil	Nil	Nil	Nil	Nil	Nil	Nil	n.d.
Nauru	Nil	Nil	Nil	Nil	Nil	Nil	Nil	n.d.
Niue	Nil	Nil	Nil	700	700	Nil	Nil	Nil
Papua New Guinea	1 000	n.d.	10 000	112 000	122 000	1 500	2 500	2 000
Republic of Belau	Nil	Nil	Nil	55	55	30	Nil	100
Solomon Islands	Nil	Nil	4 000	21 000	25 000	Nil	Nil	300
Tokelau	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Tonga	15 000	Nil	600	9 000	9 600	Nil	Nil	12 000
Tuvalu	Nil	Nil	Nil	Nil	Nil	Nil	Nil	58
Vanuatu	1 000	Nil	22 000	98 000	120 000	Nil	200	2 500
Western Samoa	10 000	n.d.	2 000	23 000	25 000	Nil	Nil	100

Note: As the data available are fragmentary and often contradictory, these are estimates based on available data and personal discussions in the countries.

Sources: FAO (1981) Production Yearbook 1982, 35. FAO: Rome.
ADB (1979) South Pacific Agricultural Survey, Feb.–June 1979. ADB: Manila.
Government reports and personal discussions with government personnel.

n.d. = no data available.

Table 2. Pacific region: estimates of livestock population (non-ruminants).

Country	Pigs			Fowls			Ducks	Other Poultry
	Scavenger	Penned	Total	Scavenger	Penned	Total		
Cook Islands	14 000	3 000	17 000	60 000	n.d.	60 000	750	n.d.
FSM	12 000	3 500	15 500	34 000	5 000	39 000	a few	a few
Fiji	24 000	6 000	30 000	380 000	440 000	820 000	46 000	30 000 turkeys
Kiribati	Nil	12 000	12 000	85 000	7 000	92 000	Nil	Nil
Marshall Islands	4 500	500	5 000	15 000	1 000	16 000	200	n.d.
Nauru	Nil	2 000	2 000	4 000	Nil	4 000	n.d.	n.d.
Niue	700	100	800	15 000	2 000	17 000	a few	n.d.
Papua New Guinea	1 400 000	12 000	1 412 000	1 000 000	340 000	1 340 000	n.d.	geese guinea fowls turkeys
Republic of Palau	Nil	3 500	3 500	15 000	6 000	21 000	n.d.	n.d.
Solomon Islands	56 000	5 000	61 000	140 000	6 000	146 000	a few	a few geese
Tokelau	200	400	600	3 000	Nil	3 000	n.d.	n.d.
Tonga	60 000	30 000	90 000	120 000	4 000	124 000	4 000	n.d.
Tuvalu	Nil	3 000	3 000	10 000	Nil	10 000	n.d.	n.d.
Vanuatu	10 000	40 000	68 000	100 000	25 000	125 000	n.d.	n.d.
Western Samoa	112 000	3 000	115 000	250 000	25 000	275 000	n.d.	n.d.

Note: As the data available are fragmentary and often contradictory these are estimates based on available data and personal discussions in the countries.

Sources: FAO (1981) Production Yearbook 1982, 35. FAO: Rome.
ADB (1979) South Pacific Agricultural Survey, Feb–June 1979. ADB: Manila.
Government reports and personal discussions with government personnel.

n.d. = no data available.

communication between island countries so that surplus by-product animal feed in one country or island is not readily transported economically to countries or islands where there is a feed deficit; lack of suitable small-scale equipment to process limited quantities of crops and crop residues, and lack of technology for the conservation of seasonally-produced crop by-products; lack of storage for locally produced and/or imported feed; a limited knowledge base of the production systems and the nutritional characteristics of the crop by-products for pigs and poultry.

Two potential solutions are: (1) importation of cheap animal products such as mutton flaps, and dairy produce, rather than expensive animal feeds and livestock. This is already occurring significantly throughout the region, and (2) importation of limited quantities of essential feed ingredients such as vitamins, mineral premixes and either high quality energy or protein feed depending on the location and the availability of cheap locally-produced feeds. This would particularly benefit the monogastric animals.

Although the above solutions are well recognised by the Pacific Island governments, the difficulties of implementation are due to insufficient knowledge of the nutritive value of a variety of locally available feed sources and the marked seasonal patterns of supply. The identification of cheaper sources of feed for poultry has received considerable attention in Papua New Guinea, and much of these data could be relevant to other Pacific countries.

The crops and crop by-products that might be used in pig and poultry feeding are listed in Table 3.

Table 3. Crops and crop by-products with potential for pig and poultry feeding.

Common English name	Botanical name	Potential animal feed	Environmental requirements	Countries where it is available
Tree Crops				
Banana	*Musa* spp.	Culled green bananas; overripe bananas; stems	Coast to 2000 m; moderate to high rainfall	All islands except small atolls
Breadfruit	*Artocarpus altilis*	Surplus, fresh, dried and ensiled fruit	Coast to 300 m; moderate to high rainfall	All islands, dominant in some; most common in Polynesia and Micronesia
Citrus	*Citrus* spp.	Surplus spoilt fruit pulp	Special local conditions on many islands	No major industries; but important in Cook Islands, Niue and Kosrae
Coconut	*Cocos nucifera*	Nutwater; fresh coconut; copra; copra meal	All atolls and small islands; coastal plains on volcanic islands to 300 m	All islands
Oil palm	*Elaeis guineensis*	Palm kernel cake; waste pulp	Coastal plains; high rainfall	Very limited areas at present on PNG, Solomons, Vanuatu
Pandanus	*Pandanus brosimus P. juliannetti*	Fruit pulp;	Frost resistant; grows up to 200–300 m	PNG
	P. tectorius P. dubius	Fruit pulp; nuts	Coastal areas; littoral soils; will grow in drier areas	All islands; particularly on atolls and small coralline islands
Sago	*Metroxylon sagu*	Split logs for pigs; waste from sago manufacture	Lowland swamps; tolerates brackish water; high rainfall	Common in Melanesia; some in Fiji, Western Samoa and Micronesia
	M. salomenense		Greater adaptability than *M. sagu*; grows up to 250 m if rainfall sufficient	Solomon Islands
Root Crops				
Cassava (Tapioca)	*Manihot esculenta*	Leaves and roots of sweet varieties dried or ensiled, roots of all varieties	Generally well adapted up to 1000 m; prefers light alluvial soils	All volcanic islands; common in Fiji and Tonga; not grown on atolls and small coralline islands
Fiji taro	*Xanthosoma sagittifolium*	Ensiled leaves; roots	Lowland coastal areas to 1000 m	On all volcano islands in small quantities; not grown on atolls
Giant taro	*Alocasia macrorrhiza*	Stem/root	Very adaptable	Almost all countries except atolls
Sweet Potato	*Ipomoea batatas*	Vines fresh, dried and ensiled; tubers	Very adaptable up to 2500 m; possesses some tolerance to drought	Major crop in PNG; common elsewhere except on atolls

(Continued)

Table 3. *(Continued)*

Common English name	Botanical name	Potential animal feed	Environmental requirements	Countries where it is available
Root Crops *(Continued)*				
Swamp taro	*Cyrtosperma chamissonis*	Leaves; tubers	Adapted to swamp and slightly brackish water and/or rain coast conditions	Widespread in high rainfall area; major crop on atolls where it is grown in pits dug to the water lens
Taro	*Colocasia esculenta*	Ensiled leaves; tubers	Different varieties for swamp or dryland in high rainfall areas up to 600 m	Major food crop in many countries; not common on atolls
Yam	*Dioscorea alata*	Tubers	Dry lowlands to 1500 m	Grown in most countries except atolls; often a traditional feast food
	D. esculenta	Tubers	Dry lowlands to 500 m	
Miscellaneous Crops				
Bele	*Hibiscus manihot*	Leaves	High to moderate rainfall areas in lowlands	Melanesia, particularly Fiji; Western Samoa
Maize	*Zea mays*	Whole plant fresh or ensiled; grain; grain by-products	Not well adapted to coralline soils	Very little grown
Pineapple	*Ananas comosus*	Pulp, fresh or ensiled	Not well adapted to coralline soils	Grown in small quantities on volcanic islands; moderate scale in Cook Islands
Rice	*Oryza sativa*	Grain, rice bran	Specific soils	Only grown in Fiji and Solomons
Sorghum	*Sorghum bicolor*	Whole plant, fresh or ensiled; grain	Grows under dry conditions	Of no importance anywhere in region
Sugarcane	*Saccharum officinarum*	Whole plant, green or ensiled; leaves bagasse, molasses	Drier areas of volcanic islands	Only of importance in Fiji; new industry in PNG
Wing bean	*Psophocarpus tetragonolobus*	Bean, tubers, mature whole plant	Grows up to 2000 m	Only of importance in PNG

Source: Quartermain (1980).

Goats

Only in Fiji is there a sizeable population of goats, largely due to the influences of the Indian population. Details of the Fijian goat production are given by Walkden-Brown (1985). At the Director of Agriculture and Livestock Officers' regional meeting in 1985, goats were given the first priority amongst livestock for further research and development. The advantages of the goat are that it is a suitable size for semi-subsistence, tree crop smallholder systems; it reproduces well in the tropical environment; the meat is acceptable to most island palates; the per unit cost is more manageable than cattle; and the goat will browse and survive on brush and weeds. Also, it is more easily managed and integrated into the tree cropping system, being an adaptable animal tolerant of a wide range of climates, rainfall and temperatures.

However, the goat does have the following disadvantages: it is an indiscriminate browser; there are limited goat management skills in the Pacific Islands; goats are susceptible to internal parasites in suboptimum management systems; and resources in the past have been too limited to determine proper management systems for goats and their environmental impact on atolls and small islands.

ACIAR Livestock Projects in the South Pacific

ACIAR supports a project titled 'The epidemiology and control of gastrointestinal nematodes in small ruminants in the Pacific Islands.' This is the first of four projects in preparation on goat production research in the tropics. The research priorities were established at a Workshop to which several scientists from Asia and the South Pacific were invited. The project addresses a major constraint to production in Fiji, that of intestinal parasites. Emphasis is on the use of management and environmental interactions to control the parasites, to reduce the constant high level use of anthelmintics and the likely development of resistant parasites. In

addition to addressing the specific research problem, the project provides research support on a collaborative basis to other South Pacific countries that are currently developing a goat industry. As part of a research network the project will allow South Pacific scientists to learn of research activities on aspects of nutrition, management and reproduction of goats in Asia which may be relevant to the South Pacific.

Another research area that has been identified as critical to the South Pacific is the impact of goats on the environment of the delicate atoll ecosystems. Currently, discussions are taking place between Australian scientists and ACIAR to identify the most appropriate scientific group to carry out this multidisciplinary study, in cooperation with interested national governments in the region.

It is important that the animal component, be it cattle, or cattle/crop, or pigs and poultry, be successfully integrated into the production system. Due to the general distribution of the pig in the South Pacific, its importance as a ceremonial animal, and the recent discovery that village pork consumption is higher than originally thought (Hide, pers. comm.), revaluation and identification of research inputs may be warranted using the farming systems approach to establish the research components in this complicated traditional production system.

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ISNAR's Activity in the South Pacific Countries

H. K. Jain*

AGRICULTURE in most developing countries continues to be of a subsistence kind. Nowhere is this more true than in the South Pacific countries where most agriculture is still traditional. Visiting these countries, one can also see that traditional agriculture is not the disaster it is sometimes made out to be. There are no serious food shortages in the region.

This is true as long as the human population remains small and the needs are few. Most developing countries began to think of modernising their agriculture in the last 20 years in the wake of their rapidly increasing populations, and with increasing consciousness of the need for improvement in standards of living. The South Pacific countries are no exception and many import large quantities of food. This reappraisal of the state of agriculture in the developing countries is leading to far-reaching reforms in the reorganisation of their research services, and in the creation of a new infrastructure for production, supply and distribution of modern farm inputs. It is being increasingly recognised that the transformation of the traditional systems of farming will have to be spearheaded by a new kind of agricultural technology.

Now the important point for the purpose of our present discussion is that little of this new thinking has permeated the countries of the South Pacific. The reasons are not difficult to understand. First, their food needs are not so pressing, nor their population growth so explosive. Secondly, many of these small countries are isolated from the rest of the world. Thirdly, the policy environment for making science the instrument of their social and economic growth does not exist in countries where traditional values and cultures are still highly cherished.

It was against this background that ISNAR came to the South Pacific in the early 1980s. We have worked in the last 5 years mainly in Papua New Guinea, Fiji and Western Samoa at the request of governments in these countries. In all these countries, ISNAR's starting point was to review the national research systems as they currently existed. The review reports have documented the state of the country's agriculture, the important crop and animal production systems, the institutions and research infrastructure which is in place, their weak and strong points, resources of scientific staff, and linkage of research institutions with the policymaking level in the government on the one hand, and with the extension services on the other. Following this broad diagnostic phase, a series of recommendations has been made for the strengthening of national research systems in these countries.

Papua New Guinea

ISNAR came to Papua New Guinea in the wake of preparations for a World Bank project for substantial improvement in agricultural support services. The main issue highlighted in the ISNAR report related to the organisation of the research system and planning the development of scientific personnel. It was noted that no single department, division, section or group in the Ministry of Primary Industries could be identified as having overall responsibility for the planning and directing of research. The set-up at the headquarters consisted of a number of disciplinary groups and there was no one to coordinate their activities. Similarly, the field stations lacked focus in terms of their capacity to correlate their work with national priorities of development, and advice came from the different disciplinary groups at the headquarters.

The first recommendation made by ISNAR related to the creation of a position of Director of Research, whose task it would be to combine all the dispersed elements of the research service into a coherent organisation and who would be involved in policymaking at the higher levels of the government. It was proposed that the newly appointed Director of Research should become a member of the influential secretariat of the interministerial National Agricultural Council. The other important recommendation was for promoting a major program of advanced training for the national staff. A large and long-term training program was built into a new World Bank program despite some opposition with regard to its size.

Many of these recommendations are in various stages of implementation. In 1982, a senior ISNAR

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staff member joined the national staff in Papua New Guinea in the course of discussions with the World Bank Appraisal Mission. In 1983, the project was accepted for implementation. In 1984, the Public Service Commission approved the creation of the new position of Director of Research and ISNAR was asked to help in the selection of a scientist for this position. Some basic organisation changes have been made within the Department of Primary Industries. Inderdisciplinary teams have been constituted and a number of team leaders appointed. Regrettably, the position of Director of Research has not yet been filled.

Fiji

In Fiji, ISNAR's involvement has been of a different kind. The review team found that Fiji did have the essential components of a research service and basically it had the right kind of organisation and structure. The main problem was that of improving the status and image of this service. For some time past, there had been no great expectation from research and no serious thought of strengthening it. ISNAR's contribution in the last 2 years has been to work with the scientists and policymakers in that country in preparing a research plan with a 10-year perspective, and in this process interacting closely with the scientists and the administrators. The role of research and the need for upgrading the research service through simple reforms such as improving the balance between salary costs and operating funds, consolidating the service into fewer stations, organisation of research-extension linkages and creating a new position of Director of Experimental Stations so that the head of the research service could devote his time to policymaking, have received a great deal of attention. Based on this work, the higher levels of the government in Fiji now have a better appreciation of the value of research and the research service is beginning to be more articulate in projecting its needs.

Western Samoa

Of the three South Pacific countries with which ISNAR has worked intensively, Western Samoa has the least support in terms of research for its agriculture. Research has been built into a number of externally aided projects but there is no separate research identity in the Department of Agriculture. ISNAR has made two major suggestions. First, that Western Samoa should organise a very modest research service of its own, for the purpose of making more effective use of external assistance and for taking over responsibility when the expatriate scientists leave. Secondly, ISNAR has prepared a research plan for Western Samoa including a major component of staff development. The greatest need in Western Samoa is in terms of trained scientific personnel.

Summary

ISNAR's work in the South Pacific countries has been concerned with the strengthening of the national research services. The main purpose has been to make these services more effective. These countries would need continued support in the field of personnel development and research management. They may need the placement of advisers in the region for this purpose. ISNAR values the concept of partnership in research which is the hallmark of ACIAR's work. ISNAR's own approach is based on a partnership with the national research systems of developing countries.

Agricultural Research in the South Pacific: The Role of the South Pacific Commission

K. Tama*

THE powers and functions of the South Pacific Commission are very broad; in short, the Commission may undertake any activity which promotes the economic and social welfare and advancement of the peoples of its member countries. Its work program and budget are reviewed annually by the Committee of Representatives of Governments and Administrations (CRGA) for recommendation to the South Pacific Conference for approval. There are 27 member countries of the Commission, 22 of which are Pacific countries and 5 are metropolitan countries with interests in the region.

With respect to agriculture, the South Pacific Commission's program has evolved over the years in keeping with the changing nature and needs of the region. From 1947 to 1963, most of its activities were devoted to undertaking studies into problems of commercial and subsistence agriculture in the region, providing technical advice to governments, and developing technical information for use by national agricultural services.

The Commission initiated and implemented projects covering a broad range of activities in agriculture; the studies it undertook generated much-needed information and identified common problems, thus enabling governments to focus their attention on priorities. The Commission also became a useful vehicle through which metropolitan governments and multilateral aid organisations could assign a proportion of their resources to assist the region as a whole.

In subsequent years a change took place in terms of the emphasis of the Commission's work program; there was a gradual withdrawal from active involvement in research with a greater emphasis being placed on providing technical advice, organising regional short-term training courses and providing assistance directly to national agricultural services. The last major research project undertaken by the Commission was the Coconut Beetle *(Oryctes rhinoceros)* Project which was begun in 1953 and handed over to FAO in 1972.

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Some of the more important developments which strongly influenced the reorientation of the Commission's work program were: (1) much progress had been made in strengthening national agricultural services to an extent that many of the technical services that had been provided by the Commission could now be provided locally; (2) the establishment of the Universities of the South Pacific, Papua New Guinea and Guam and the South Pacific Bureau for Economic Co-operation (SPEC) meant that many specialised technical services could now be provided by other institutions in the region. In addition, all island countries had access to the resources of metropolitan countries on a bilateral government-to-government basis and a smaller number of countries could utilise the resources of the UN organisations as well.

It therefore became inappropriate for the Commission to persist in providing services in areas which were being dealt with effectively by national governments or which other organisations were better equipped to deal with. Thus in a period of a little under 40 years, the emphasis of the work program has shifted from basic research to adaptive research projects, and more recently to short-term training and technical advice and assistance.

Today in compliance with the wishes of its member countries, the Commission has adopted a more selective approach, concentrating on a limited number of projects which have tangible practical applications for many of its island member countries. The main emphasis of the work program is to assist the countries to deal with many of their problems themselves.

The Regional Conference of Directors of Agriculture in the region is the advisory body to the Commission which reviews the work program and advises on priority needs of member countries.

Current Activities

Whereas the South Pacific Commission would give highest priority to the support of development activities and projects, it is nevertheless conscious of the fact that without an adequate research base many of the projects would not achieve the expected

success. An element of flexibility in the work program therefore exists to allow countries to utilise funds for small research projects if it is deemed to be the most appropriate course of action at the time. The main role of SPC insofar as research is concerned is one of promoting and facilitating projects judged to be meeting the priority needs of the region, and, as appropriate, soliciting the assistance of those organisations better placed to undertake the work.

Assistance to Applied Research Experiments and Field Work

Since its inception, the South Pacific Commission has continued to set aside funds to be provided in the form of grants to island governments to assist them to carry out small research projects. The list of projects is too long to reproduce here but in general the countries use this assistance to augment temporary shortfalls in local budgets. With a few exceptions, the funds are nearly always used for the purchase of equipment and materials needed for the project. The demand on this fund has been increasing from year to year and since its establishment the demand for assistance has always exceeded the resources available.

Short-Term Experts and Specialist Services

Although no specific mention is made of support to research, the majority of past services provided under this program have involved some advice to national agricultural services on research requirements related to the particular problem for which the specialist's advice is sought. The purpose of this program is to enable the Commission to respond quickly to urgent requests from island countries. Most of the funds for this program are provided by UNDP/ESCAP and the Government of Australia whilst SPC budgetary resources are also utilised.

Inter-Country Study Visits and Travel Grants

Provisions under this program enable member countries to send technical staff on short-term attachment to suitable centres of expertise within the region so that they may benefit from working side-by-side with staff having some particular skill.

Food Crops Diversification

The main objective of this project when it was originally established was to assist country efforts to improve productivity of traditional staples. Assistance towards diversification of food crop sources had tended to emphasise exotic vegetables. It is planned to expand the scope of this project to cover the promotion and development of tropical fruit crops as well.

A main difficulty in promoting tropical fruit crops is that many agriculturalists in the region are not aware of the potential for the exploitation of these crops. The Commission is seeking to organise a study tour to three ASEAN countries for Directors of Agriculture from selected countries in the region so they can see and sample the range of fruits available and observe at first hand how they are grown.

Those countries interested would need assistance in developing appropriate programs with adequate resources to ensure success. Within our region the Queensland Department of Primary Industries is well known for having developed expertise in tropical fruit crop trees. It could be the ideal organisation to provide the technical backstopping for such a program.

Many of the exotic fruit trees which eventually became established in the region were brought in by interested individuals, usually from unimproved stock. Today, at least six countries in the region have established new crop evaluation programs (especially tree crops) and no doubt others will be interested in similar programs once they become aware of the possibilities.

Coconut Development

Coconut is the single most valuable crop throughout the region; it remains an important source of food and cash. On atoll islands it is clearly the most important crop in the subsistence economy and it is their only cash crop. In spite of the advances made in containing the threat of major pests and the development of improved management and production methods, copra production has shown little increase over the past 30 years; in some countries production has actually declined. In addition, the results of rehabilitation schemes have fallen below expectation. It is doubtful whether a significant increase in production will ever be achieved if we persist in using inferior planting materials in rehabilitation schemes.

Experience in other regions of the world has proven the superiority of high-yielding hybrids over local talls, and the countries in the region should take more positive steps in order to take advantage of this new technology. There will be many obstacles in the way, but the experience gained in the fight to contain the threat of the rhinoceros beetle *(Oryctes rhinoceros)* has clearly shown what can be achieved given determination and adequate resources. The rhinoceros beetle threat was contained because it was recognised as a regional problem and as such all the resources that became available to the region were channelled to it.

It is suggested that many of the constraints which have limited the widespread use of coconut hybrids in the region can only be effectively dealt with at the regional level. The basic problem the countries of the region are facing is unavailability of hybrid material. A strategy needs to be devised to determine the best possible methods to ensure that the materials will become available within a reasonably defined period.

Some alternatives to be considered could be: importation into each country of sufficient quantities of materials from outside the region to enable them to establish a sufficient area of seed gardens; massive importation of high-yielding materials for use in replanting schemes as a stop-gap measure while awaiting sufficient materials to become available from breeding programs within the region; and for the region to acknowledge the importance of the present breeding programs in Vanuatu, Western Samoa, Solomon Islands, and Papua New Guinea and to support financially or otherwise these programs to ensure their continued operation.

The present quarantine guidelines on the transfer of coconut materials within the region as well as from outside into the region are very restrictive. Island countries have accepted this without question. In view of the present decline in the industry, the whole issue should be reexamined and in the final analysis it should be determined whether the imposition of such stringent quarantine regulations is economically and/or socially justifiable.

The first activity under this program would be to bring together a team of specialists consisting of a coconut breeder, an agricultural administrator from the region, an economist familiar with the industry, and a plant quarantine specialist to assess and recommend viable alternatives to facilitate the use of hybrids at the earliest opportunity.

Plant Protection

Indications from member countries suggest a continuing need for the Commission to provide technical advice and subregional training courses in quarantine and plant protection.

The Regional Technical Meeting on Plant Protection advises the Commission on the priority needs of the region and offers valuable guidance on the future direction of the work program. Valuable assistance to the program is also provided by the UNDP/FAO/SPC Root Crop and Plant Protection Development Project, based in Fiji.

Throughout the region, there is an increasing interest in the use of biological control agents to control major pests and diseases. To this end the interest shown by ACIAR in this area is welcomed by all countries.

I might add also that ACIAR's support of the current investigation on what has been commonly referred to in the region as the 'Vanuatu Disease' of coconut (foliar decay induced by *Myndus taffini*) is most important. One of the most advanced coconut breeding programs in the region is being conducted at the IRHO/Vanuatu-Saraoutou Research Station. The finding of this disease on the station has had a negative impact on Saraoutou as a source of hybrid material for the region.

Regional Agricultural Research

From the Commission's experience, the requests for assistance on small research projects have always exceeded its financial resources. The major problem has always been the lack of capital. As the request must pass the scrutiny of the departments of Development Planning and Foreign Affairs in each country, we would naturally expect that the project for which assistance is required fits into the development priorities of the country concerned.

There is, however, a growing concern that many of the smaller countries are maintaining research programs they can ill afford. In some, the entire program is totally dependent on aid donors for financial support and on expatriate workers on contracts. When one of these factors is withdrawn, the entire program collapses. The need for ongoing research into their problems is real enough, but these countries have little capital to finance development and research projects simultaneously, and the lack of qualified personnel is acute. There is therefore a need to find a way in which the collective resources of the region could be utilised to help the smaller countries.

It appears that collaboration amongst research institutions in the region is desirable and will in the end benefit all countries including the larger ones. Such a move has been talked about but to date no action has been taken to determine how it could be brought about.

A survey of agricultural research in seven island countries in the region, conducted by the International Service for National Agricultural Research (ISNAR), was sponsored by the Asian Development Bank in 1981. The survey team found that in all seven countries agricultural research is underfunded and undersupported. The major constraints to research in the region were identified as lack of funds and qualified personnel, inadequate facilities, ineffective organisation and poor planning, and isolation of researchers.

On the organisation of research the team found: (a) little evidence of interaction between national scientists and fellow colleagues in the region or with the larger world scientific community; (b) scientists

tended to be discipline-oriented rather than problem-oriented—the research product is passed from one discipline to another and the extension staff are often expected to put it all together so it will make sense to the farmer; and (c) no evidence in any of the countries visited of a truly effective interaction between research and extension.

The team stressed the need for new approaches to organise research to meet the needs of small countries, for the region to find some way in which research could be linked together in some kind of a network so that the chances of a successful outcome would be greatly increased. The team especially stressed the need to plan research projects on an integrated or team approach which focuses on the problems of the farmers so that the resulting product is more closely related to their situation.

In these times when money and qualified personnel are limited, many countries in the region cannot afford or sustain the type of research service needed to satisfy all their requirements, yet they have as much need for solutions to their agricultural problems as everyone else. Such countries could derive benefit from a regional pool of agricultural knowledge.

At the 1984 Regional Conference of Permanent Heads of Agricultural and Livestock Production Services in Noumea, the Commission invited Dr D. M. Leslie of the New Zealand Soil Bureau to discuss a proposal on an Oceania Benchmark Sites Network for Agrotechnology Transfer, and Dr H. Eswaran of the USDA Soil Conservation Service to discuss the principles of agrotechnology transfer and the International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT), a USAID-funded project. The Fiji Soils and Crop Evaluation Project (SCEP) was also discussed as an example of a national network.

The proposal for an Oceania Network received unanimous support from the Conference delegates. However it was decided that a more detailed study be conducted to assess the practical feasibility of the proposal, the resource base of potential participating countries and other research institutions in the region, and costs.

The OBSNAT proposal is an innovative approach at coordinating and organising research in the region into a network of interlinked Pacific nations jointly contributing to a regional pool of knowledge. More importantly the network would focus on experiments designed to produce data on the interactions of crop-soil-weather and management factors for any crop or crop production system. Given a total understanding of the interactions of these factors, it would be possible to formulate appropriate technologies at the farm level. The proposal, if it does eventually come to fruition, will help minimise many of the constraints reported by the ISNAR survey team.

Many of the requirements for the network to become operational are available in the region; technical linkages when required for support are available particularly from CSIRO, DSIR, ORSTOM, GERDAT, USDA, universities, and SMSS which is set up to provide support to networks for agrotechnology transfer. Finally, the experience and expertise of the IBSNAT Project based at the University of Hawaii will provide access to data bases from other regions.

The Commission supports the concept and hopes that it will in time demonstrate a cost-effective approach to realising our region's goal of increasing agricultural productivity.

Potential Interactions with ACIAR

The Commission is most appreciative of the vital role of ACIAR as a link between the Pacific countries and the many institutions in Australia with the resources to help us with our research problems. It is pleasing to note that all the projects being supported by ACIAR are relevant to several countries in the region.

Reference was made earlier to two projects which have region-wide applications. The Commission is especially pleased that a project to study the smallholder farming systems and their constraints is finally underway. We regard this project as of utmost importance as this after all is the predominant farming system in the region and will likely continue to be so in the future. There is no doubt that the failure of many agricultural projects in the past has resulted from a lack of understanding and appreciation of a system and its constraints. A great deal of time and effort was spent in trying to replace the system rather than trying to improve it. Real improvement after all can begin only after we understand the system.

Other areas where ACIAR could assist would be: new crops development, especially tropical and subtropical fruit tree crops; expanded support to the coconut industry to cover support to present breeding programs; to consider seriously the concept advanced in the OBSNAT proposal on soils research and to assist in its promotion and development.

In conclusion, the Commission urges ACIAR to consider the training of researchers in the region as an integal part of its projects in order to ensure that the impact created by the project is not lost after a few years.

Agricultural Research and Development Activities of the University of the South Pacific

Dennis F. Osbourn*

THREE of the four schools of the University of the South Pacific (USP) have been contributing to agricultural research in the South Pacific Region. These are the School of Social and Economic Development (SSED) and School of Natural Resources (SNR) established in Fiji in 1968 and the School of Agriculture (SOA) established in Western Samoa in 1977. Associated with the schools are a number of research institutes established specifically as the vehicles by which the growing concentration of resources in the schools could be channelled into the solution of the problems of the region.

The SSED and its associated Institute of Social and Administrative Studies with the disciplines of Accounting, Administration, Economics, Geography, Sociology and Land Management is undertaking research into many aspects of agriculture in the region. Current projects are in the area of agroforestry, food systems and food supplies, economic analyses of motivation, cooperatives, government policies and price forecasting.

The School of Natural Resources sustains the disciplines of biology, chemistry, physics and earth sciences and together with the two associated Institutes of Natural Resources and Marine Resources is engaged in research into geophysics, environmental physics, soil chemistry and taxonomy, the ecology of tropical forests, renewable energy resources, materials science, the chemistry and pharmacology of natural products and marine and freshwater biology.

The School of Agriculture, operating largely through its associated Institute for Research, Extension and Training (IRETA), has well-developed programs in the area of germplasm collection, selection and breeding of tropical root crops (aroids, sweet potatoes and yams), with research in Western Samoa, Tonga and Kiribati. Varietal evaluation of tomatoes in Western Samoa and Vanuatu, and cucumbers and bulb onions is also in progress.

Research in cereals (maize, rice, sorghum) and pulses (pigeonpea, cowpea, winged bean) is concerned with varietal evaluation, rotation of these crops with taro and systems of minimum tillage. Research into tree crops is concerned primarily with the description of existing varieties of mangoes, breadfruit and avocado and the introduction of improved varieties of papaya.

Smaller research programs are concerned with nitrogen mineralisation and release from fertilisers and the use of coral to ameliorate the acidity of soils; pink disease of cocoa, and *Pythium* rots of aroids. In the field of economics and farm management, marketing, supply responses, the influence of farm size and enterprise costing are under investigation. Livestock research is confined to the evaluation of by-products for pigs and ruminants and husbandry aspects of goat production.

Attempts to contribute to the solution of the problems of atoll countries, for example by the introduction of drip irrigation and nutrient film techniques for vegetable production and selection of salt-tolerant clones of *Cyrtosperma* have proved difficult to maintain in Kiribati.

The Institute for Rural Development based in Tonga has concentrated its research efforts on appropriate technology in the design of wood and charcoal stoves, solar dryers and simple desalination procedures.

Problems of Sustaining Research of Regional Relevance

In the South Pacific distance between countries and within territories between islands is a major problem giving rise to lack of communication, difficulties with maintaining supplies, equipment in repair, and maintaining and training staff in post. It was for these reasons that IRETA was set up as a residential centre for regional training courses and workshops and the Extension Section of the School of Agriculture has concentrated its effort on developing an information network centred on the staff and library at Alafua, and radiating out by means of satellite radio and electronic data transfer to eight agricultural liaison officers placed in the Agriculture Departments of the major territories of the region.

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There is a rapid turnover of expatriate staff on short-term contracts and of regional staff undergoing further training. This together with a multitude of aid agencies offering too rigid, unbalanced, often small packages of aid support for the currently fashionable technology leads to a dissipation of effort and resources over too wide a front and a high incidence of ad hoc inconclusive, unpublished research. The recent review of aquaculture activities in the Pacific Islands showed that for the last 35 years the same mistakes were made successively in each territory and that for all the effort involved no viable aquaculture systems were developed.

The paucity of trained professional staff and particularly the lack of technicians is, of course, a major difficulty which justifies the need for a regional university linking closely with national institutions of tertiary education. That is why the School of Agriculture is offering courses to train teachers of agriculture and develop curriculum materials for primary and secondary schools.

Potential Interactions with ACIAR

The School of Agriculture is already associated with ACIAR in the South Pacific Root Crops projects, one concerned with chemical analysis of Pacific root crops (Australian National University) and the other with the elimination of plant viruses from sweet potatoes (Department of Agriculture and Rural Affairs, Victoria). This latter link is of particular interest as the development of tissue culture at the school will give us an outreach service into the region which will be invaluable both to the territories in the region and to our own regional image and usefulness. Ongoing programs of ACIAR with which we might form a beneficial link are the utilisation of fibrous residues as ruminant feeds, smallholder farming systems, and the proposed program on draught animal power.

An area I believe to be important is the development of stable systems of mixed tree and annual crop farming in the humid tropics, with particular attention being given to the cycling of minerals and the fixation and slow release of nitrogen by legumes in such systems.

South Pacific Agriculture: ADAB's Experience

Don Saville*

THE Australian Development Assistance Bureau is involved in a wide range of agricultural projects in the South Pacific (Table 1). Many of these already have a research component or have the potential for a research component. Potential research areas have been identified (Table 2) which are relevant to a

Table 1. South Pacific agricultural projects supported by the Australian Development Assistance Bureau (ADAB).

	Project	Components	Research
Fiji	Mutton Sheep	(a) Development of an appropriate breed (b) Identification of appropriate agricultural system (c) Sociological impact (d) Extension (e) Marketing	(a) Sheep breeding research (b) Pasture research
	Beef Cattle (Yalavou I and II)	(a) Integrated farm development (b) Smallholder farms (c) Infrastructure (d) Extension (e) Training	
	Rice Development	(a) Irrigation development (b) Field experimentation (c) Extension (d) Social impact	(a) Impact of changed farming system on the community
	Brucellosis Eradication Scheme	(a) Equipment and operating expenses for eradication in dairy herds (b) Proposal to extend to beef herds in Western Division	
	Ginger and Turmeric	(a) Facilities for postharvest fumigation (b) Assistance with marketing and export	
	Hardwood Reafforestation	(a) Forest replanting (b) Evaluation of phase 1 (c) Future components may include: —marketing —personnel planning —infrastructure —replanting	(a) Marketing research (b) Resource management for hardwoods
	Soil-Crop Evaluation	(a) Field experiments for major crops on range of soil types	(a) Soils and plant nutrition research

(Continued)

* Australian Development Assistance Bureau, Pacific Regional Team, 225 Clarence Street, Sydney, Australia.

Table 1. *(Continued)*

	Project	Components	Research
		(b) Equipment and cash grant (c) Establishment of soils research unit	
	Vunindawa Regional Development	(a) Feasibility completed (b) Applied research into hill farming (c) Agricultural settlement schemes (d) Reafforestation (e) Infrastructure (f) Transport (g) Industry	(a) Farming systems research
Kiribati	Agricultural Development Study	(a) Identified and documented agricultural development projects	(a) Local ingredients for monogastric diets
Solomon Islands	Forestry Project	(a) 1983 report being updated (b) Components may include: —forest inventory —reafforestation —timber inspectorate —research	(a) Identification of species for specific uses
	Cattle Under Trees Phase II	(a) Pasture development in conjunction with reafforestation (b) Pasture research	(a) Identification of pastures and pasture systems to combine with forestry
	Animal Production Research Assistance	(a) Provision of research assistant at University of Queensland	
	Livestock Development Project	(a) Funds and equipment to Livestock Development Authority	
Tuvalu	Fisheries Development Program	(a) Provision of fisheries manager/adviser (b) Equipment for fish market	
Tonga	Desiccated Coconut Factory	(a) Construction (b) Provision of manager (c) Coconut collection scheme	
	Coconut Pest Research	(a) Biological pest control trainees	
	Fisheries Advisory and Training Centres	(a) Construction of facilities (b) Training and information systems	
Vanuatu	Beef Cattle Development	(a) Industry review in progress (b) Veterinary services (c) Cross breeding (d) Pastures	(a) Pasture improvement research
	Cocoa Development	(a) Extension (b) Planting schemes (c) Processing (d) Training	
Western Samoa	Cocoa Development	(a) Research and experimentation (b) Extension	(a) Biological control of rose beetle

(Continued)

Table 1. *(Continued)*

	Project	Components	Research
		(c) Processing and marketing (d) Training	(b) Control of Pink disease (c) Plant breeding for yield, canker and blackpod resistance
Regional	Integrated Outer Island Development	(a) Preparation and implementation of an integrated development strategy for Christmas Island (Kiribati), Ha'apai (Tonga) and Tuvalu (b) Includes agriculture, forestry, fisheries, transport, infrastructure, communications, health education, etc.	(a) Economic planning (b) Social constraints to development in smallholder farming systems (c) Marine resource management
	Assistance to Agricultural Depts	(a) Assistance in planning and structure of departments (b) Planning and priorities for research	

Table 2. Potential research areas relevant to many Pacific countries.

- Land use planning
- Marine resource management
- Postharvest technology for export fruit and vegetables
- Rural sociology—relationship between the household, land aspirations and development
- Stockfeeds for monogastrics—development of local ingredients and ration formulation
- Smallholder rabbit production
- Pasture research
- Coconut improvement and constraints to replanting

number of Pacific countries. Some of these are already being addressed by ACIAR.

Small countries such as those in the Pacific should consider carefully if it is appropriate for them to become involved in basic research. The large gap between what is known and what is adopted and the high recurrent costs associated with research make justification difficult. These countries should encourage international research organisations to conduct the basic research for them while they concentrate on applied research and development.

There are some particular problems associated with conducting research in the Pacific, including: an extreme shortage of trained staff; those that are trained have been trained in a foreign country where they can get a false sense of importance of research to their country; people with tertiary training are usually quickly promoted to administrative jobs; high recurrent costs for research in isolated communities; constraints on the applications of results due to social, religious and land tenure issues; and lack of appreciation of local issues by expatriate researchers.

I believe there is little value in continuing agricultural research in the Pacific unless it is coupled with integrated development programs. Only through this approach are the aspirations and social constraints of the community likely to be taken into account. In addition, if the communication, transport, marketing and education chain is not complete, then new technology will not be adopted. For these and other logistical reasons much would be gained by ACIAR working closely with ADAB and other development agencies in research and development in the Pacific.

South Pacific Agricultural Development and Research: New Zealand Participation

W. J. Burns*

THE application of New Zealand's technical assistance to agricultural development is clearly prescribed by the official Overseas Development Assistance (ODA) policy. The two significant elements of current policy in this context are the overall priority which is given in the ODA program to the South Pacific region, and a direction to seek opportunities to assist development in the productive sector.

In operational terms the opportunities for involvement are influenced by the fact that New Zealand responds to initiatives which have been defined by the partner country, directing attention to those areas which receive priority in the country's current development program.

A further requirement which has a bearing on the nature of activities undertaken, is an internal administrative requirement to restrict the duration of programs to a finite time frame. Although there is no specific limitation defined, the fact that program planning is undertaken on a rolling 3-year basis gives an indication of the desirable period for implementation.

Impact of Policy and Research Orientation

Interpretation of the above parameters makes it fairly clear that agricultural development in the South Pacific conforms with the broad ODA policy, and activities can be selected which are acceptable to both parties. The more restrictive components of operational policy do, however, have an influence on the research component in agricultural systems development. To meet the stated criteria, New Zealand involvement must be primarily result-oriented, and this requirement obviously favours the selection of projects which clearly have a prospect for relatively short-term involvement. Application of technology appears to be a more promising avenue of investment than the derivation or adaptation of technology. Accordingly research emerges as a by-product of a specific project rather than as a project or program per se (Table 1).

An alternative approach which conforms to the policy requirements is the application of assistance to a specific component of research activity, either in the provision of material, technical assistance, or training which supports or extends existing research capability.

Research-Oriented Activities

Leaving aside the project-generated research activity identified above, there are broad areas of involvement in which New Zealand contributes towards research in agricultural development in the South Pacific Region.

Facilities

Financial support may be provided for the provision of buildings, plant and equipment where professional and technical performance is inhibited by the absence or inadequacy of existing facilities.

Staff Development

Given the philosophy that development is built on human development, training is regarded as a priority activity in the ODA program. Considerable attention is given to this activity both 'in-country' and through attachments to scientific institutions in New Zealand.

Training is not only confined to technical or disciplinary performance; research management, in its broadest sense, and laboratory management specifically, are also areas where appropriate training is considered important in improving performance and efficiency.

Resource Evaluation

In the course of New Zealand's involvement in the South Pacific over the last decade, the identification and assessment of the region's basic agricultural resources—land and water—have been progressively developed through the ODA program. The soil resource surveys which have been undertaken have been initiated as bilateral programs with individual countries, but the potential is now emerging to integrate these basic studies into a broader regional program—taking the studies further

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Table 1. New Zealand projects in the South Pacific with a research component.

Country/ Agencies	Project	Research components	Institutions
Cook Islands	Research Station (Totokoitu)	Management/Technical Assistance	CIMAF/NZDSIR*
Fiji	Vet lab.	Building/Training/TA	MPI/NZMAF
	Plant protection lab.	Building/TA	MPI/NZMAF
	Soil-Crop Evaluation Project (SCEP)	TA	MPI/NZDSIR/ ADAB/USAID
	Timber properties for utilisation (Nasinu)	End use research/TA	NZFS
PNG	Soils and plant lab.	Building/TA	DPI/NZMAF
	Postharvest handling	TA	DPI/ACIAR
	Sheep project	Animal/Pasture/TA	DPI/NZMAF
Tonga	Banana industry	Plant Protection/TA	MAFF/NZDSIR/ACIAR
	Water resources	Hydrology/TA	MAFF/NZDSIR
	Coffee research	Finance	MAFF
	Soils lab.	Equipment/Training	MAFF/NZDSIR
	Coconut stem utilisation	TA	MAFF/NZFS
Pacific Region	Timber utilisation	Veneer slicing	NZFS
	Plant pest and disease surveys	TA	NZDSIR/NZMAF

Notes:

CIMAF	Cook Islands Ministry of Agriculture and Fisheries	ADAB	Australian Development Assistance Bureau
NZDSIR	New Zealand Department of Scientific and Industrial Research	USAID	United States Agency for International Development
MPI	Ministry of Primary Industry	NZFS	New Zealand Forestry Service
NZMAF	New Zealand Ministry of Agriculture and Fisheries	DPI	Department of Primary Industries
		MAFF	Ministry of Agriculture, Fisheries and Forestry

towards the interpretation, correlation and evaluation of the basic information, and its potential application on a wider regional basis.

Hydrological studies are also a key issue in many of the small island nations where the availability of water is critical not only to agricultural development but more importantly to human needs and health. Identification and quantification of the water resources of these countries attracts appropriate resources through the ODA program.

Plant and Animal Health

The influence of pests and diseases on productivity of both plants and animals is acknowledged in New Zealand's program. Their significance in international trade justifies the priority which is accorded to the regional program and considerable resources have been provided in association with the multilateral organisations towards the definition of the pest and disease status of individual nations in the Pacific.

Problems Encountered with Research

The size and relative instability of professional and technical resources in many of the smaller island nations increases problems in securing continuity in research operations, developing experience in establishing research priorities, and in managing research. Professional isolation inhibits personal development in many cases.

The establishment of relevant priorities is, in some circumstances, influenced by the priority research needs of externally financed development projects. Where resources are limited, such project-related activities may supersede the basic needs of the country.

A perceived gap between the extent of existing technology and emerging research information and the application of this technology by farmers may restrict development to a greater extent than does the need for additional technology.

A lack of collaboration or coordination between research institutions within and outside the region reduces the potential impact of existing technology. There is an increasing prospect for further confusion with the number of multilateral agencies which are developing programs to redress this situation.

Possible Interaction with ACIAR

New Zealand Perspective—Resource Application

As New Zealand has a well-established research base and shares with Australia a common interest in agricultural development in the South Pacific, there are practical advantages in pooling scientific resources. The concept of a common scientific resource for regional application may be a long-term ideal, but in the immediate future there are real prospects of identifying areas of complementarity and integrating special areas of skill into mutually acceptable collaborative activities.

Initiatives are being taken to open and develop a more effective dialogue between ACIAR and New Zealand agricultural research activity in the region. It seems that the interactive process is well catered for within the consultative structure that has been established by ACIAR.

Because of the flexibility implicit in ACIAR's mandate, it is possible that South Pacific nations might benefit by directing ACIAR's attention to areas such as: using ACIAR's resources to support national participation in regional research programs e.g. OBSNAT; involving ACIAR in projects which have a social benefit or impact rather than an economic pay-back; and ACIAR may consider that it has a role in facilitating the professional development among the scientific staff in the region.

ACIAR's South Pacific Program

ACIAR has been supporting research activities in the South Pacific since 1984. There are currently 18 ACIAR projects in Papua New Guinea and other South Pacific countries. These projects are listed in Table 1.

The projects involve collaborative research between agricultural scientists in Australia and those in one or more Pacific countries. ACIAR's projects have been developed primarily on a bilateral basis. However, some common themes have been identified where the research is of interest to more than one country, and in some instances scientists in two or more Pacific countries participate in the project.

The projects cover a range of topics including the improvement of traditional crops such as coconut and root crops, and the introduction of potential new crops such as pigeonpeas; the control of insect pests, weeds, and plant diseases; postharvest handling of fruits and vegetables; farming systems and socioeconomic surveys; animal disease control; and fisheries.

The scope of individual projects and the results achieved up to December 1986 are described below.

Table 1. ACIAR's South Pacific program—December 1986.

ACIAR Project Number	Title	Collaborating countries/institutions	Australian research institutions	Year commenced
Coconut Palm				
8442	Coconut and Cocoa Improvement	Papua New Guinea (Cocoa and Coconut Research Institute), University of the South Pacific (Western Samoa)	Victorian Department of Agriculture and Rural Affairs, Melbourne University	1986
8403	Virus-like Diseases of Coconut Palm in the South Pacific	Vanuatu (Saraoutou Oil Crops Research Station, IRHO)	University of Adelaide	1985
8402	Cadang Cadang Disease of Coconut Palm	Philippines (Philippine Coconut Authority) and Micronesia	University of Adelaide	1986
Root Crops				
8204	South Pacific Root Crops: Nutritional Studies	Fiji, Papua New Guinea, Solomon Is., University of the South Pacific (Western Samoa)	Australian National University	1984
8433	Sweet Potatoes: Pathogen-tested Germplasm for the South Pacific	Papua New Guinea, Tonga, Solomon Is., University of the South Pacific (Western Samoa), FAO Regional Root Crops and Plant Protection Project, Fiji	Victorian Department of Agriculture and Rural Affairs	1985
8568	Yaqona wilt	Fiji (Ministry of Primary Industries)	University of New England	1986
Other Crops				
8567	Pigeonpea Improvement	Fiji (also India, Thailand, Indonesia)	University of Queensland	1984
Forages				
8527	South East Asian/Pacific Forage Research and Development Network	Fiji	CSIRO Division of Tropical Crops and Pastures	????
Biological Control of Pests and Weeds				
8342	Biological Control of Arthropod Pests and Weeds	All Pacific Countries	ACIAR Consultant (Dr D. F. Waterhouse)	1984

Table 1. *(Continued)*

ACIAR Project Number	Title	Collaborating countries/institutions	Australian research institutions	Year commenced
Postharvest Technology				
8354	Transport and Storage of Fresh Fruit and Vegetables in Papua New Guinea	Papua New Guinea (Dept of Primary Industries)	NSW Dept of Agriculture, CSIRO Division of Food Research	1984
Fisheries				
8332	Culture of the Giant Clam (*Tridacna* sp.)	Fiji, also International Centre for Living Aquatic Resources and Management (ICLARM, Philippines)	James Cook University, Townsville	1985
8381	Coconut Crab Studies in Vanuatu	Vanuatu	Queensland Dept of Primary Industries, University of Queensland, Queensland Institute of Technology	1985
Animal Health				
8418	Epidemiology and Control of Gastrointestinal Nematodes of Small Ruminants in the South Pacific	Fiji, Vanuatu, Western Samoa	CSIRO Division of Animal Health	1986
Farming Systems and Socioeconomics				
8205	Smallholder Farming Systems in the South Pacific: Constraints on Development	Tonga, Solomon Islands	University of New England	1984
8558	Development of Smallholder Farming Systems in Tonga	Tonga	University of New England, Bureau of Agricultural Economics, Canberra	1984
8383	Papua New Guinea Export Tree Crops Study	Papua New Guinea	Queensland Department of Primary Industries	1985
8435	Commodity Price Stabilisation in Papua New Guinea	Papua New Guinea	Bureau of Agricultural Economics, Canberra	1986
8522	Nutrition and Policy Implications of Cash Cropping in Papua New Guinea	Papua New Guinea	University of New England	1986

Coconut Improvement (Project 8442)

The coconut palm, *Cocos nucifera*, is widely grown throughout the Pacific Islands and Papua New Guinea. Almost every part of the coconut tree is used and it is often referred to as the 'Tree of Life.' Coconuts are predominantly grown by smallholders, with approximately 70% of production being derived from properties of less than 2 ha. The coconut provides the small farmer with most of the essentials of life, including a source of cash. It forms an integral part of the functioning of local communities, particularly small island communities, and supplies a major source of foreign exchange for many countries—Tonga, for example, earns 60% of its export income from coconut products.

The Pacific Island countries grow approximately 600 000 ha of coconuts and together form a region that is the fourth largest producer in the world after the Philippines, Indonesia and India. In 1982, coconut production in Papua New Guinea (PNG) and other Pacific Islands totalled 2.2 million t, of which approximately 30% (755 000 t in 1982) was produced in PNG. However, the productivity of many coconut palm plantations is declining and the most significant factor is the age structure of plantings. Current statistics from PNG and other Pacific Island nations suggest that at least 50% of the existing plantings are considerably older than their commercial life. In order to maintain production for local consumption and to remain competitive on international markets, there is an urgent need for extensive replanting of coconut palms.

PNG provides an excellent example of multipurpose and changing roles of coconuts. In some areas coconuts are being replaced by large, highly capital-intensive oil palm plantations; in others, large areas of cocoa are grown under coconuts; and in coastal and island regions the coconut remains an integral part of village life. PNG accords high priority to research on coconuts and its government has recently established a new institute near Rabaul, New Britain, for research on coconut and cocoa.

The establishment of a research program on coconut improvement in PNG is necessarily long-term and involves: (1) breeding of improved genotypes; (2) multiplication of improved genotypes; (3) distribution of improved genotypes; (4) nursery establishment and selection; (5) field establishment of improved genotypes. The aim of the ACIAR Coconut Improvement project is to initiate research on items (2) and (3) and apply the results to devise new nursery management strategies (4). From this will arise a system for the production, rapid multiplication, distribution and establishment of improved coconut germplasm in PNG. This will involve both the initiation of long-term experiments in areas such as suitable planting density and intercropping studies for coconut and cocoa, and specific short-term studies in key research areas essential for the establishment of the coconut improvement program.

The objectives of the collaborative research program in Australia and PNG are to: (1) establish coconut embryo culture technology suitable for use in PNG in a coconut improvement program; (2) establish techniques for the clonal multiplication of coconut embryos; (3) investigate the potential of somatic embryogenesis in coconut improvement programs; (4) establish efficient distribution systems for coconut seednuts, and coconut palm in-vivo and/or in-vitro cultures, to eliminate the problem of germination of nuts during transport. These studies will compare alternative systems of distributing improved planting material such as dry-rooted seedlings, polybag seedlings, seedlings excised from the nut, and cultured embryos; (5) develop improved nursery management strategies applicable to smallholders in PNG; (6) obtain quantitative data to evaluate replanting strategies for coconut in PNG; (7) identify which of the above technologies may be applicable to other Pacific Island countries for their replanting programs; (8) identify and describe the major coconut types in some of the smaller Pacific Island countries; (9) develop a micropropagation system for cocoa in the project.

Expected benefits and application of in-vitro studies of coconuts include the development of embryo culture techniques in conjunction with disease indexing systems, especially for virus and viroid diseases, which will allow the safe and routine exchange of coconut germplasm between countries. Clonal multiplication of embryos would further facilitate the exchange of germplasm. It could also replace labour-intensive hybrid seed gardens as a means of producing coconut hybrids. A limited number of carefully controlled crosses would be made and the resultant hybrid embryos cloned in vitro. Embryo rescue technology from immature nuts would allow a dramatic increase in yield of hybrid plants from existing seed gardens as 90% of nuts fail to reach maturity. The successful development of in-vitro culture techniques will overcome many of the difficulties of transporting improved plant material.

Results

Tissue Culture

Research activities commenced in August 1986 with the appointment of Dr Gowri Maheswaran (scientific officer) and Ms Mary Huberts (technical assistant) at the Horticultural Research Institute, Knoxfield, Victoria. The project is also supporting Mr Terry White in a postgraduate research position at the Plant Cell Biology Research Centre, Melbourne University.

The recommendations from the Fourth South Pacific Island Regional Meeting on Agricultural Research, Development Extension and Training in Coconuts held at the Saraoutou Research Station, Vanuatu in August 1986 stated: 'It is recommended that techniques for the safe routine transport of embryo cultures, free from phytosanitary risk, be developed for the Pacific Islands as soon as possible. Such techniques would greatly assist germplasm collection and exchange.' The initial research thrust is thus to establish universal media and practical technology for the in-vitro growth, transport and establishment of coconut embryos. With advice from IRHO, these techniques are being established at Knoxfield, and should be available for use in the Pacific in 1987.

The tissue culture research is being conducted in collaboration with Dr Y. Tan of the Cocoa and Coconut Research Institute, Papua New Guinea, and Dr Jane O'Hara of the University of the South Pacific, Western Samoa.

Germplasm Survey in the Pacific Islands

An early initiative in the project was to commission a survey of coconut germplasm and current improvement programs in several Pacific countries. The study was conducted by Mr Mike Foale of the CSIRO Division of Tropical Crops and Pastures in August–September 1986, and has been published by ACIAR (Technical Report No. 4: 'Coconut germplasm in the South Pacific Islands').

Papua New Guinea Activities

The new Cocoa–Coconut Research Institute has been established in PNG and Mr Peter Turner appointed as Director of Research. Mr Turner will take up his appointment in April 1987. He visited Melbourne and discussed the research program with the Victorian scientists in November 1986. The ACIAR project is assisting in the purchase of equipment at the new institute. The initial priority of the coconut research program in PNG is the collection of coconut germplasm.

Collaborating Scientists

Australia

Department of Agriculture and Rural Affairs, Victoria
Dr G. Frith, Dr Bill Thompson, Dr G. Maheswaran, Dr Jim Hutchinson, Ms Mary Huberts

DARATECH, Melbourne
Dr John Raff

Melbourne University
Prof. Bruce Knox, Mr Terry White

CSIRO Division of Tropical Crops and Pastures, Brisbane
Mr Mike Foale

Papua New Guinea

Cocoa and Coconut Research Institute
Dr Peter Turner, Dr Y. Tan

Virus-Like Diseases of Coconut Palm in the South Pacific (Project 8403)

Research in this project aims to identify the causal agent of foliar decay transmitted by *Myndus taffini* (FDMT). The disease—seen since 1965 in Vanuatu but only on introduced coconut varieties—causes different symptoms from those of other wilts: first the middle leaves turn yellow, then diseased palms usually die within 2–4 years. While the local 'Vanuatu tall' variety is resistant, the disease severely affects potentially high-yielding hybrids or cultivars, such as yellow Malayan Dwarf, preventing their introduction for breeding or planting programs. A current government replanting program is confined to Vanuatu tall, although a seed garden has been established to provide Vanuatu tall × Rennel tall hybrids, which show some tolerance and have 30% better production than the local talls.

The vector is a cixiid bug *Myndus taffini*. It spreads the disease from the native vegetation to the introduced palms. *Myndus* spp. similar to *M. taffini* occur in islands of neighbouring countries in the South Pacific. Islands where no introduction of FDMT-susceptible cultivars has been attempted may have similarly resistant local palms, so the distribution of the wilt remains unknown.

Accordingly, this project seeks to determine the etiology of FDMT on coconut palm in Vanuatu, to develop diagnostic tests and to determine the distribution of the disease in the South Pacific.

Work in Vanuatu is concentrating on transmission of foliar decay and on other biological aspects, and work at the Waite Institute will be directed towards identifying a virus or virus component associated with it.

Results

At the commencement of the project in 1984, it was known that feeding groups of the cixiid bug collected in the field could induce the disease in sensitive cultivars within 6–8 months. This suggested that the disease was transmissible, and that it could have been induced either by an insect toxin or by transmission of an infectious agent such as a virus or mycoplasma.

Research workers at the Saraoutou Oil Crops Research Station, Vanuatu, and the Institut de Recherches pour les huiles et oléagineux (IRHO) recently demonstrated that between two and eight insects collected from the field can induce the disease in unaffected trees following a single feed lasting between 20 and 60 min. This finding makes the toxin hypothesis essentially untenable.

They also found that diseased seedlings and trees cannot be 'cured' by treatment with the antibiotic tetracycline, and that mycoplasma-like organisms cannot be detected with electron microscopy. This indicates that mycoplasmas are not involved. In addition, they could detect no viroid-like RNA in diseased palms, so neither lethal yellowing nor cadang-cadang disease—the presently known important diseases of coconuts—could be involved.

In tests for the possible involvement of a virus, conducted at the Waite Agricultural Research Institute, Adelaide, a single-stranded DNA with a molecular weight greater than 2 million has been consistently isolated from diseased palms, but not from healthy ones. So presence of this DNA may be a reliable indicator of infection. Attempts to detect a specific protein or virus-like component from the diseased tissue have not given consistent results, and an attempt to produce antibody to one virus-like component yielded antibody that also reacted with healthy coconut palm tissue.

An attempt is now being made to simplify the extraction and detection of the DNA so that sufficient samples can be tested to confirm whether it is uniquely associated with the disease. Making it easier to obtain larger DNA samples will also make it possible to adapt an appropriate test for use directly in Vanuatu, and the development of a purification procedure for a particle that is associated with the DNA will permit the development of serological assay techniques. Cloning the DNA is also being considered. Achieving this could allow development of a 'dot-blot' diagnostic test.

Development of suitable diagnostic tests will permit determination of the range and distribution of the foliar decay agent, permit breeding for tolerance or resistance in palms for planting, and enable studies of how the agent causes the disease and how it is transmitted.

Many South Pacific countries are currently embarking on coconut replanting programs. The knowledge gained about foliar decay disease from this project will help avoid losses arising from the disease by the inadvertent planting of susceptible cultivars.

A major paper is now in press in the journal Phytopathology (Randles, J. W., Julia, J. F., Calvez, C. and Dollet, M. 1986. Association of single stranded DNA with the foliar decay disease of coconut palm in Vanuatu).

Collaborating Scientists

Australia

Dr John Randles
Waite Agricultural Research Institute, Glen Osmond, South Australia

Vanuatu

Dr C. Calvez, Dr J. F. Julia
IRHO, Saraoutou Oil Crops Research Station, Vanuatu

Cadang-Cadang Disease of Coconut Palm in the Philippines and Micronesia (Project 8402)

Cadang-Cadang disease has killed some 30 million coconut palms in the Philippines since it was first recorded there about 1918, making it one of the most serious diseases of coconut in the world. In 1973, Dr J. Randles of the Waite Institute and his colleagues discovered the viroid causing the disease during a collaborative program involving the Waite Institute, the Philippine Coconut Authority and FAO/UNDP. In the ensuing 10 years, that program has: developed methods of mechanical transmission; developed diagnostic methods based on polyacrylamide gel electrophoresis and molecular hybridisation; demonstrated that other palm species are susceptible to infection with the viroid; detected the viroid in Guam; and sequenced the viroid. The present ACIAR project is continuing these investigations.

Discovery of the viroid in Guam and its recent tentative identification in the North Mariana and Caroline Islands indicates the widespread importance of the disease. Interestingly, the symptoms found in Micronesia differ from those reported in the Philippines, suggesting the possibility of finding mild strains of the viroid or resistant or tolerant coconut cultivars.

The project, which has recently commenced, has four main objectives. Determining the mode of natural spread of the viroid has some priority since control strategies will ultimately depend upon the solution of this major problem. Standard surveys in areas of high incidence and at boundaries of distribution will determine the rate and range of disease movement. Early indications suggest that pollen may carry the viroid, and field trials will test this possibility. Its distribution patterns will be studied in Micronesia, to compare them with patterns in the Philippines and to determine whether site affects the epidemiology of the disease.

Since such disease surveys rely heavily on diagnosis, the second objective is to improve the speed, sensitivity and reliability of the diagnostic procedures. Present procedures use bi-directional gel electrophoresis combined with sensitive silver staining and hybridisation analysis. Modifications are constantly being attempted, particularly for use in surveys where facilities are limited. Much of this research will take place in the Philippines.

In a third objective, the scientists will seek suitable coconut breeding material and test it for resistance to the viroid. They will improve inoculation procedures by determining optimum test plant ages and pretreatments, inoculum preparation and inoculation methods.

As their fourth objective, the scientists will seek biological variants of the viroid and purify and sequence these to detect sites of variation in the molecule that may determine pathogenicity. They will use any mild variants that emerge from this work in interference experiments to test the possibility of mild-strain protection.

Collaborating Scientists

Australia

Dr John Randles
Waite Agricultural Research Institute, University of Adelaide, Glen Osmond, South Australia

Philippines

Ms J. S. Imperial
Philippines Coconut Authority, Albay, Philippines

South Pacific Root Crops: Nutritional Studies (Project 8204)

Taro, giant taro, swamp taro, yams, sweet potato and cassava are all major root crops in the South Pacific. While their relative importance varies from one country to another, collectively these staple foods play a vital nutritional role in the region, where they form the basis of subsistence agriculture. Other aroids have local importance.

Selection and breeding programs are already under way in several countries, including Papua New Guinea, Solomon Islands, Vanuatu, Fiji, Tonga and Western Samoa, to develop locally adapted cultivars with increased yield, pest and disease resistance and other desirable agronomic characters. However, the generally low protein content in Pacific diets makes it important to determine the quantity, quality and availability of protein and other nutritional aspects of the new cultivars.

This program has involved close collaboration between the project leader (Dr J. H. Bradbury) in Canberra and various collaborators (agronomists, plant breeders, agriculturalists) in Fiji, Western Samoa, Tonga, Kiribati, Solomon Islands, Vanuatu, Papua New Guinea and Ponape (Federated States of Micronesia). Samples of the popular varieties (as well as of elite cultivars) of staple food crops of the region, viz. sweet potato, taro, giant taro, swamp taro, yam (various species) and cassava, have been sent to Canberra and analysed for their chemical composition. The effect of cooking on the nutrients present in the major root crops has also been measured. Various antinutritional factors present in the root crops have also been studied, including cyanide in cassava, enzyme inhibitors, calcium oxalate crystals and acridity in the various taro samples.

This work is a comprehensive study over eight countries in the South Pacific, which are representative of all types of environments (atolls, high islands and the different conditions of the PNG lowlands and highlands). It has involved a full range of food analyses of 14 different types and species of root crops, most of which have been obtained from at least two different countries. For example, sweet potato has been analysed from the highlands and lowlands of PNG and from four other countries, taro from four countries and cassava from three countries. The comprehensiveness of this study makes it significant not only for the South Pacific but also for many other regions of the world.

Results

The following results of significance have been obtained:

Complete chemical analyses for nutrients are available for 14 root crops.

The effect of cooking (boiling, steaming and baking) on nutrients present in the major root crops will be described for the first time, since only small incomplete studies have so far been available, with nothing at all on taro.

The trypsin inhibitor content of the root crops has been extensively studied for the first time, including its inactivation by cooking and the chemistry and biochemistry of the proteins concerned.

The popular root crop cultivars, including many obtained from the markets have been analysed, and the results will be available for use in food composition tables for the South Pacific.

Elite cultivars have been analysed from plant breeding programs of taro and sweet potato from Fiji, Western Samoa, Tonga, Solomon Islands and PNG.

The effect of environmental factors on nutrient content needs much more study. We have studied this for sweet potato and yam (*Dioscorea esculenta*) and found for example that sweet potato cultivars from a malnutrition area of PNG had a very low protein content, 40% of the normal value.

We are assisting analytical laboratories at the PNG University of Technology, Lae, and at the University of the South Pacific, Suva, to develop new analyses, by providing a full manual of our analytical procedures, and by provision of prototype equipment.

The results of the 3-year program have been compiled and submitted to ACIAR for publication. The book should be available in late 1987.

Collaborating Scientists

Australia

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Sweet Potatoes: Pathogen-Tested Germplasm for the South Pacific (Project 8433)

Sweet potato is a major food crop in several South Pacific countries: it provides the staple food of Papua New Guinea and Solomon Islands, has importance in Tonga and Vanuatu and is generally gaining in popularity in the region. Local breeding and selection programs to improve the yield and quality of the crop have begun, but the presence of virus diseases and other pathogens hinders the acceptance and distribution of the emerging new cultivars. Papua New Guinea maintains major and diverse collections of sweet potato that will provide potentially valuable germplasm to breeders throughout the region. So too will a breeding program established in Tonga by IRETA (Institute for Research, Extension and Training in Agriculture), at the University of the South Pacific, Western Samoa. This program aims to provide cultivars with resistance to the scab disease caused by the fungus *Elsinoe batatus*, which causes large economic losses each year.

Eradication of pathogens from this valuable germplasm will enable proper screening and assessment of the material for yield potential, disease resistance and other qualities, exchange of material between countries and the development of facilities for rapid multiplication of pathogen-tested stocks to improve local sweet potato cropping. The four Pacific countries participating in the project are: Papua New Guinea, Solomon Islands, Tonga, and Western Samoa (University of the South Pacific).

The aims of the project are: (1) the identification of the best sweet potato cultivars from the Pacific Islands (as identified by the agronomists and breeders in the collaborating countries); (2) development of in-country facilities and suitably trained personnel to maintain and multiply the pathogen-tested material supplied; (3) preparation and supply of pathogen-tested sweet potato germplasm to collaborating countries; (4) assessment in Pacific countries of the relative performance of pathogen-tested and infected material, rates of reinfection of pathogen-tested material, cultivar evaluation, etc.; (5) the long-term safe storage of the pathogen-tested sweet potato germplasm in Australia, to provide a source of germplasm to resupply the Pacific countries.

Results

The initial role of the scientists at the Plant Research Institute (PRI), Burnley, Victoria, was to develop and utilise technology to produce the pathogen-tested material and to provide training in tissue culture and rapid multiplication techniques for personnel from Pacific countries.

The second phase of the project involved the establishment of tissue culture laboratories and screen houses in the four Pacific countries. PRI has been involved in the design of these facilities and the supply of all essential equipment and materials. Followup visits have been made to each country to enable the sorting out of any unforeseen problems.

The third phase of the project has involved the use of these in-country facilities to rapidly multiply germplasm, and the development of agronomic assessment trials in each country.

Eighty-one cultivars have now been imported from the South Pacific for disease eradication. These plants are maintained at the Commonwealth Quarantine Station within the Burnley Gardens complex in Melbourne. All 81 cultivars are at various stages of disease eradication. Some cultivars are now ready to be released from quarantine and exported back to the South Pacific. So far, we have exported two local cultivars each back to Tonga, Western Samoa and Papua New Guinea. Another three cultivars from Papua New Guinea, two from Solomon Islands and three from Western Samoa are soon to be released from quarantine and exported.

In relation to sweet potato virus indexing, substantial progress has been made in the development of serological tests for five sweet potato viruses. Immunosorbent Electron Microscopy (ISEM) tests for five viruses have been established, and Enzyme-linked Immunosorbent Assays (ELISA) have been set up for two viruses, with good results. The ELISA will be further refined to increase the efficiency of the virus indexing for routine work. This will also enable us to cope with the large amount of testing required for the initial cultivar trials to be conducted in the collaborating countries. Many new meristem tissue culture media have been evaluated and are now used in the routine culture work within the project. A number of methods of multiplication of germplasm for field trials have been assessed (i.e. in-vitro stem cuttings, leaf cuttings).

Other developments have been the final organisation of tissue culture facilities and screenhouses in the four collaborating countries. This provides each country with the necessary equipment and expertise to perform initial cultivar trials with pathogen-tested and field material. Trials will be conducted in Tonga, Western Samoa, Papua New Guinea and Solomon Islands in 1987.

Collaborating Scientists

Australia

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Papua New Guinea

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Yaqona Wilt (Project 8568)

Yaqona (*Piper methysticum*) is an important cash crop in Fiji and in other island nations of the South Pacific. The beverage kava, which is made from the ground roots and basal stem parts of the yaqona plant, plays an important role in traditional rituals and ceremonial events in parts of Melanesia and Polynesia. Yaqona is cultivated in the Marquesas, Tahiti, Rarotonga, Hawaii and the Fijian, Samoan and Tongan groups.

In Fiji over 9000 yaqona farms exist and the yaqona crop is worth in excess of $26 million to Fiji's economy. It gives higher economic returns per hectare than alternative root crops such as taro (2.8 times less) or cassava (5 times less). In some regions such as Kandavu, a 'yaqona economy' exists, where yaqona is used to purchase day-to-day commodities, and short-term monetary income is measured by the number of mature yaqona plants that a person or group has in the ground.

The yaqona plant is a source of drugs useful to the pharmaceutical industry. A demand exists, particularly in the USA where legislation favours use of natural rather than synthetic products as pharmaceuticals, and interest is likely to increase in other countries also. At present virtually all yaqona produced in Fiji is used for domestic consumption, and the potential export market would be likely to absorb any substantial increase in production.

The most serious constraint to yaqona production is a disease of unknown cause, often referred to as yaqona wilt. Conservative estimates indicate that the disease causes annual losses of about 50%. The disease is known to occur in Fiji, Vanuatu and Tonga, and possibly also in other regions.

The benefit : cost ratio of this project should be very favourable. Yaqona wilt is estimated to reduce yield by 50%. A 30% yield increase which is a reasonable expectation from a successful project (expanding into the export market mentioned above) would be worth over $15 million per annum to Fiji, for a total investment of $0.25 million over the 3 years of the project.

The objectives are as follows: (1) to identify and isolate the cause of yaqona wilt; (2) to determine how the pathogen survives. Factors influencing survival and spread of inoculum will also be investigated; (3) to investigate possible strategies to control yaqona wilt, such as: use of resistant cultivars, cultural practices, chemical and physical treatments to remove the pathogen from planting material, from soil or to protect plants from infection, biological control; (4) in addition to working on the yaqona project, about 10% of the pathologist's time will be devoted to advising local plant pathologists on disease problems that exist in ginger.

A plant pathologist is being recruited in Australia to work full-time on yaqona wilt in Fiji for at least 2 years, in cooperation with Mr J. Kumar (plant pathologist) and Mr D. Singh (plant nematologist). It is expected that the pathologist will take up the appointment in Fiji in mid 1987.

Collaborating Scientists

Australia

Associate Professor John Brown
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Fiji

Mr P. Sivan, Mr J. Kumar, Mr D. Singh
Koronivia Research Station, Ministry of Primary Industry

Pigeonpea Improvement (Project 8567)

Phase I of Project 8201 on pigeonpea improvement was completed on 30 November 1985, and in September 1985 a review team recommended a second 3-year program. This second phase now incorporates the recommendations of the review. It continues the collaborative research on pigeonpea improvement in Indonesia, Fiji, Thailand and Australia, and the close collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). In addition collaborative research will be extended to the All India Coordinated Pulse Improvement Project.

Phase I demonstrated that pigeonpea has potential applications in Indonesia, Fiji and Thailand. This extension will address the problems that remain to be solved, and will expand to include research in India, where pigeonpea is an important crop, occupying 2 million ha. In the past both production and research have been dominated by long-season, photoperiod-sensitive plant types, but the interest in new short-season pigeonpeas is growing.

In Fiji, research to determine the factors causing flower drop and subsequent poor pod retention in some genotypes will continue. The identification of germplasm resistant to stem canker caused by *Botryosphaeria xanthocephala*, the mode of inheritance of this disease and incorporation of resistance into adapted genotypes will be high priority research areas. Aspects of management of the crop, and of its adaptation and productivity on acid low-fertility soils with high aluminium saturation, will also receive emphasis.

Pigeonpea is consumed in Fiji as dhal, a preparation of the dry split seed, by people of Indian origin. Most production is from tall, late varieties grown in backyard plots for home consumption. Demand considerably exceeds local supply. Some pigeonpea is imported from Africa, but excess demand is largely met by imports of field pea from New Zealand. Split pea imports from New Zealand currently exceed 3000 t annually.

The ACIAR pigeonpea improvement project has collaborated with the Ministry of Primary Industries since 1983 in a multidisciplinary evaluation of the potential of early and mid-season pigeonpea types for production in Fiji. Studies have investigated genotype adaptation, sowing date, plant density, soil fertility and amendment, weed control, plant pathology, and entomology. The potential productivity indicated by these studies is sufficient to enable profitable production by smallholder farmers, providing a number of specific limits can be overcome.

The most serious of these limits include plant diseases and nematodes, acid soils, and factors affecting the availability of soil water. Further, poor pod-set has been a widespread problem, particularly in early genotypes. It has not been possible to identify a specific cause of this problem, but it is likely that some interaction of the above factors is responsible. These limitations should be able to be overcome by a combination of improved crop management and the development of better-adapted genotypes, and current research is proceeding with this dual emphasis.

Results

Disease Studies

Stem canker disease has been observed in Fiji since 1984. Original studies identified the causal organism as *Botryosphaeria xanthocephala*, but surveys in 1986 revealed a range of disease symptoms, which suggested that other organisms may also be involved. Small pustular cankers, similar to those caused by *Xanthomonas campestris* cpv *cajani*, a problem in parts of India, were common. Diseased plant material was imported into Australia in November 1986 under quarantine conditions, for studies aimed at isolating and identifying pathogenic organisms.

Field studies in Fiji have demonstrated substantial seasonal and genotypic differences in disease expression. Serial sowing studies indicated that incidence of *Botryosphaeria* sp. declined as sowing was delayed after November (so that most plant growth occurred after the wet season). Progeny rows sown in February 1986 developed none of the usual symptoms of *Botryosphaeria* stem canker but the 172 lines displayed considerable variability in the incidence of the pustular canker.

A project review meeting proposed to conduct a detailed survey of experimental and commercial sowings in 1987 to determine the seasonal incidence of various symptoms. In addition, further screening will be conducted with introductions of elite lines from the University of Queensland. If pathogens can be isolated at UQ, cultures may be reintroduced to Fiji to investigate the possibility of establishing suitable laboratory and field screening techniques.

Nematodes

Several studies have investigated the incidence of nematodes in pigeonpea. In general root infestation (numbers of nematodes) during early growth is less in the early lines introduced from UQ than in the

local, longer-season lines. The best control strategy is thought to be a combination of genotypic tolerance and sowing after maize or rice with an intervening short fallow.

Plant Nutrition

Many of the soils likely to be used for pigeonpea production in Fiji are strongly acid (pH 4.5–5.5), with high levels of aluminium saturation. Field liming studies have indicated that a major effect of soil acidity is to restrict root growth and thus predispose plants to serious water limitation. Studies have also indicated apparent differential genotypic effects, as roots of cv. Hunt are able to penetrate acid soil profiles to a greater extent than those of cv. Royes.

In pot studies comparing possible soil amendments, plant growth has been greater with sugarcane mill mud than with agricultural lime or coral sand of equivalent neutralising value. These results suggest that mill mud is also providing one or more limiting nutrients. Considerable variability is known to exist in mill mud produced from different sugar mills and at different times in the season. A study is proposed to determine the variation in chemical composition between various sources and sampling times.

Field studies have also been conducted on the other major potential soil types for pigeonpea production, the Nadruka or lowland series. These high clay soils have a high water-holding capacity, and excellent growth has been achieved in post-rice (April–August) sowings, with seed yields of up to 2.5 t/ha. The incidence of stem cankers has been low on these soils.

In summary, while promising growth and yield of pigeonpea has been demonstrated in Fiji, insufficient information is available on the causal agents of stem canker to enable release for commercial production of any of the currently available lines of early pigeonpea. The program of collaborative research proposed should bring the attainment of that goal considerably closer.

Collaborating Scientists

Australia

University of Queensland, Department of Agriculture
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Fiji

Ministry of Primary Industries
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Southeast Asian/Pacific Forage Research and Development Program (Project 8527)

The objectives of the Project are: (1) to assist in developing the research capability of forage scientists in countries where there are active research programs in institutions with the necessary facilities and a commitment to forage research; (2) to strengthen linkages between research, extension and farmers in order to improve ruminant production through the adoption of relevant forage and animal management practices; (3) to provide small quantities of forage seeds to research and extension personnel for evaluation; (4) to improve communications in forage research and development.

In the South Pacific, the only country presently a core member of the program is Fiji, although other countries receive support through provision of seeds and information on pasture research and development.

Results

The Project commenced in Fiji in March 1986 with a meeting to explain its objectives and mode of operation. The meeting was attended by forage researchers, veterinarians, extension officers and administrators responsible for agricultural research and extension. This was the first occasion that a multidisciplinary group had been involved in research and development discussions on the role of forages in ruminant production. In August 1986 a second meeting was held to discuss in depth future research programs in Fiji. The Project leader was invited to comment on research proposals relating to forage research.

In other areas the project has provided literature searches of international databases on specific research areas such as woody weed control measures and utilisation of feed by-products in ruminant production. Abstracts of relevant research and reprints of published papers and technical memoranda have been supplied on request. Seed of new germplasm of forage species has been provided, and advice given on publication of research papers.

Interaction with other South Pacific Countries

The Newsletter has been forwarded to government agencies, libraries and individuals in Papua New Guinea, Tonga, Western Samoa, Solomon Islands and Vanuatu; specific requests for advice from scientists in Vanuatu and New Caledonia on research methodology have been answered; requests for seed of forage species have been received from Solomon Islands, Fiji, Niue, Tonga, Vanuatu, Western Samoa and New Caledonia. A range of grass and legume species selected on environmental parameters has been forwarded to each country; attempts have been made to standardise evaluation of new species in order to obtain information on genotype-environmental interactions that could refine the selection of new species for specific environments.

Collaborating Scientists

Australia

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Fiji

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Transport and Storage of Fresh Fruits and Vegetables in Papua New Guinea (Project 8354)

The most populous areas in PNG are in the Highlands. The people traditionally grow vegetables for their own needs and sell any excess at local markets for other necessities. The Highland people are self-sufficient in most food supplies and have access to pig meat. However, there is a deficit of protein which is now usually overcome by eating imported fish. Many highlanders want to expand production of vegetables to obtain cash for medicine, education, canned fish and other items of value. Government extension staff have been unable to recommend the expansion of vegetable production because of the lack of markets. Recent migration to the capital and to mining areas, such as Kieta in the northern Solomons, has resulted in a need for PNG to import food, including fresh vegetables. The national and provincial governments would like to see urban people use more traditional foods to reduce the need for imports. The increased production of traditional foods would provide employment at the village level and might reduce migration to the towns.

Currently vegetables are transported in small quantities from the Highlands to Port Moresby by air, but the poor quality of much of the produce on arrival has led to a belief by the trade that PNG vegetables are an inferior product. The poor quality produce was mainly the result of mechanical damage and microbial attack due to rough handling, lack of protective packaging and high speed travel over rough roads.

The constraints on self-sufficiency in fresh vegetables included the lack of a surface transport system, the high cost and unreliability of air freight, lack of knowledge of the most suitable cultivars to grow and seasonal shortages of supply of some of the staple foods. There appeared to be a need to overcome these seasonal shortages, or oversupply, with short-term, low-cost storage systems. This particularly involves the storage of cooking bananas, sweet potatoes and Irish potatoes.

The major aim of the project is to develop a handling and transport system for vegetables from the Highlands to markets in Lae and Port Moresby.

Results

A containerised transport system was developed to carry mixed loads of vegetables from the Highlands, by road to the port and thence by sea to Port Moresby. The journey would take about 10 days at ambient temperatures of 20–40 °C. Refrigeration would be essential for most of the produce and it was decided to investigate the use of a refrigerated container to cool and to transport the produce. These containers were designed to maintain the temperature of pre-cooled produce only, but it was considered that if loading was restricted to 2–3 t/day the load could probably be cooled over a 3-day period. The use of additional containers on site could reduce this time if necessary. If the hypothesis was correct then the high cost of providing cooling plants in each production area would be avoided. The containers would be hired and could be relocated to other centres of production at short notice, provided the site could be reached by road and power was available. There was a problem of lifting the container on and off the road vehicle. This was solved by locating the initial study at Goroka where a heavy forklift truck was available. It was understood that other cheaper means, such as jacks, could also be used for loading and unloading the container but these were not available at the time at Goroka.

Difficulties were experienced in hiring a container to take to the Highlands, as refrigerated containers arriving at PNG ports from overseas are unloaded at the wharf and the empty containers are returned to the ship. An Australian company, 'Chep,' agreed to lease a container to the project at modest cost. The company had a modified unit which had a division length-wise down the container so that different temperatures could be maintained in the two compartments. It was considered that this container was an added bonus as the availability of two temperatures would allow mixed loads of a wider range of produce.

The two-temperature zone container was transported from Sydney to Goroka and a static storage trial of several kinds of vegetables was carried out in November 1984. The produce was harvested and carefully handled by the investigators and held for 10 days under refrigeration to simulate transport to Port Moresby. At the end of the period the vegetables were in very good condition and were judged to be far superior to the local produce observed at Port Moresby market. This study indicated that PNG produce if handled carefully and refrigerated had sufficient shelf life (10 days) to be transported to Port Moresby using surface transport.

During the next 18 months, four shipments were made to Kieta and Port Moresby. Irish potatoes were cured in the warm side of the container and transported at 12 or 20 °C. Leafy vegetables such as lettuce, cabbage, Chinese cabbage were transported in the cold side of the container. Small quantities of tomatoes were carried with the potatoes at 12 °C. The main problem observed was shrivel with the vegetables. This was generally overcome by packing in unsealed plastic bags and by discharging the defrost water on to the floor of the container. Studies on the cooling of the vegetables suggested that about 1–2 t could be cooled each day by the container. Shipment from the Highlands to the seaport at Lae did not pose any difficulties, and the main difficulty was locating sufficient supplies of particular produce in the production area when required. The lack of a packing station meant that the produce had to be packed on the ground and often in the sun. Packages used were hessian bags (coffee bags), plastic fertiliser bags and an assortment of cartons and wooden boxes. The produce shipped was acceptable to the trade in Port Moresby and Kieta. The potatoes which were free of wastage were particularly well received, as wastage in potatoes is generally very high. Quality could be further improved by developing better packages and using better cultivars. Work was concentrated at first on introduced cool climate vegetables because of their higher value and ready sale in supermarkets. Small quantities of sweet potatoes and traditional vegetables have also been carried, with similar results.

Several standard containers are now in commercial use transporting potatoes and some vegetables from Wabag to Port Moresby. Collaboration with the New Zealand Ministry for Foreign Affairs has made this possible since the New Zealand Government has paid for the hire of the containers.

The project has shown that produce can be transported by surface at reasonable cost (approximately half the air freight cost) from the Highlands to distant centres. Further development is needed to make the process self-sustaining. Several small packaging stations at various centres are required with access for the container and a suitable power supply. There is a need for a horticulturalist at each centre to give advice on correct cultivars to grow and to develop improved packing methods. Ideally, containers should also be fowarded to the traditional market at Port Moresby. Traditional small sellers could buy from the container and resell in the normal way. Management of the overall system will be important so that hire cost and freight costs are recovered. The final development and the setting up of a management system would be a suitable project for a development agency. The system may also have application in other Pacific countries where outer islands could supply a main island with fresh vegetables. There may be scope for an export/import operation between the various Pacific countries. Increased trade with Australia and New Zealand may also be possible using the new system.

Collaborating Scientists

Australia

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Papua New Guinea

Mr George Gorogo, Mrs C. Warisaiho
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New Zealand

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Biological Control of Arthropod Pests and Weeds in the South Pacific (Project 8342)

Biological control offers the prospect of pest and weed control by methods that are environmentally safe and available to low-income farmers not able to afford pesticides. This project aims to evaluate the potential for pest control by biological means in the South Pacific, and to identify individual pests and weeds that would be suitable targets for specific biological control projects.

Results

Two major results from the project have been a set of dossiers on the important pests and weeds of the Southwest Pacific, and a workshop to discuss biological control in a Pacific context and assess priorities for establishment of individual control projects.

The dossiers on Pacific pests and weeds have provided a valuable reference source for biological control workers and all connected with agriculture and pest control in the region. They were compiled by Dr D. F. Waterhouse and Dr K. R. Norris, in consultation with South Pacific workers at a number of stages of preparation. Each dossier describes the distribution, habits and economic importance of the pest or weed, its known natural enemies, the results of previous attempts at biological control and an assessment of the likelihood of successful control on South Pacific Islands.

The dossiers provided an essential database for discussions at the workshop, and have been hailed with such enthusiasm that ACIAR is supporting their commercial publication (by Inkata Press, Melbourne, 1987).

In October 1985 ACIAR also sponsored, in cooperation with the German Agency for Technical Cooperation (GTZ), the South Pacific Commission and the Government of Tonga, a ten-day workshop on biological control in the South Pacific. Held in Tonga, the workshop was attended by 55 participants from 20 countries, including representatives from virtually every South Pacific country, both Anglophone and Francophone. Three main aims were interwoven in the workshop program: (1) to explain the operation of classical biological control to persons likely to be involved in implementation of biocontrol projects in the South Pacific; (2) to identify the most important arthropod and weed problems in the South Pacific region, and to determine which would be most amenable to biological control; (3) to identify and discuss the constraints to implementation of biological control projects in the South Pacific.

The workshop provided a valuable exchange of information between people of varying expertise, to put future biological control activities in the South Pacific on a much sounder footing. The proceedings of the workshop, including useful information papers and a record of the discussions will be published by GTZ in Tonga in 1987.

Following the workshop ACIAR is considering support for several biological control projects in the South Pacific, and is investigating these further at present.

Collaborating Scientists

Australia

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ACIAR Consultant on Biological Control
Dr K. Harley, Dr D. Sands
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Pacific Islands

Plant Protection Officers in numerous Pacific countries
Mr R. Macfarlane
South Pacific Commission (Plant Protection Officer) University of the South Pacific

Other Agencies

German Agency for Technical Cooperation (GTZ), Federal Republic of Germany (through its plant protection projects in Tonga and Western Samoa)

New Zealand

Dr Peter Maddison
Division of Entomology, Department of Scientific and Industrial Research (DSIR), Auckland

Culture of the Giant Clam (*Tridacna* sp.) (Project 8332)

Giant clams form a significant component of the diets of the people of Oceania and Southeast Asia, being completely edible except for the kidney. The adductor muscle is a highly prized food in Southeast Asia. However, the combined effects of increased demands, pollution and habitat destruction and the depredations of poachers have severely reduced stocks of these clams throughout the Indo-Pacific area. Apart from large size, giant clams are notable for maintaining symbiotic algae in their exposed fleshy mantle tissue, which supply them with photosynthetic products. Thus clams are phototrophic, with similar environmental requirements to plants, and are the only potential farm animals that feed themselves. Some species grow rapidly and current studies suggest that annual production rates of 60 t of clam meat per hectare are considered quite feasible.

If they could be cultivated, tridacnid clams would add substantially to the supply of low-cost, locally produced acceptable protein food, simultaneously providing a high-value exportable product in the form of dried adductor muscle. Research work done to date on the maricultural possibilities of giant clams, although fragmentary and on a small scale, has not revealed any major impediments to commercial-scale cultivation, but further research is necessary. The largest living species, *Tridacna gigas*, grows rapidly to as much as 137 cm, which makes it a prime target for additional research. The known extinction of *T. gigas* and *Hippopus hippopus* in some areas, the threatened status of these and other species elsewhere and the consequent or threatened loss of genetic diversity provide additional justification for substantial research effort.

The main objectives of the project are to: (1) assess giant clam stocks at various localities; (2) study growth rates in natural populations and the effects of environmental factors; (3) elucidate the reproductive biology of giant clams; (4) determine the optimum conditions for development of larvae and juveniles; (5) apply the results of this research to the development of large-scale mariculture techniques.

Results

Substantial progress has been made in all these objectives in the 2 years of the Project's operation. A comprehensive survey of giant clam stocks is the primary objective of the Fiji research group. Their surveys of Fijian reefs are more than three-quarters completed. They have confirmed the recent extinction of the largest species, *Tridacna gigas*, in Fiji and have shown that there is heavy pressure on stocks of the next largest species, *T. derasa*, in many areas. This pressure is from local fishing and also, apparently in more remote regions, from foreign fishermen. Estimates of growth rates of *T. derasa* indicate slow growth of sub-adults and older clams of this species. Plans are in hand for the reintroduction of *T. gigas* to Fiji through importation of juveniles from James Cook University.

Research at the University of Papua New Guinea falls into two major areas: chemical studies and experimental mariculture. Data concerning the nutritional value of fresh clam products have been collected, including shell to meat weight ratios, lipid, nitrogen, amino acid, heavy metals and energy contents. Data on annual reproductive cycles have been collected for comparison with similar data at other centres. Experimental treatments of mass-cultured larvae have sought to define optimum conditions in extensive culture. They indicate the importance of feeding the larvae with an appropriate algal diet. Growth studies of juvenile clams of two species, *T. gigas* and *T. squamosa*, in nursery tanks and in the field have provided baseline data on suitable conditions for these culture phases.

Research at James Cook University has been concentrated on the mariculture of *T. gigas*, the largest and fastest-growing species of giant clam. A number of biological problems for mariculture of *T. gigas* have been overcome, including selection of brood-stock, spawning induction and heavy mortality of early juveniles during the nursery phase. In a comparison of growth and survival of *T. gigas* juveniles in four positions for holding them during the ocean-nursery phase, the intertidal benthic position gave near maximum growth rates and very high survival. A protected fringing reef gave much better growth rates than an exposed fringing reef. A major research effort is now being made to develop large-scale systems for mariculture of giant clams in the intertidal environment. This environment has distinct advantages for mariculture in Pacific countries where SCUBA techniques are inappropriate.

In addition to increasing the protein food supply in Oceania and Southeast Asia, extensive clam mariculture would reduce the pressures leading to overexploitation of coastal fish stocks in Pacific waters. Harnessing the tropical reef, the greatest natural resource of the Pacific Islands, could be a strong incentive to preserve the marine environment and would highlight the benefits of conservation.

Collaborating Scientists

Australia

Associate Professor D. Lucas
James Cook University

Fiji

Dr A. Lewis
Ministry of Agriculture and Fisheries

Papua New Guinea

Dr J. Pernetta
University of Papua New Guinea

Coconut Crab (*Birgus latro*) Studies in Vanuatu (Project 8381)

Coconut crabs (*Birgus latro*) are among the most highly terrestrialised decapod crustaceans and can grow to a weight of as much as 5 kg. Because of their size, land-dwelling habits and delicate flavour they have traditionally been regarded as a prized food item by the inhabitants of islands in the Pacific and Indian oceans. However, increasing human populations and changing land-use patterns in areas where coconut crabs were once abundant have contributed to a general decline in local stocks, frequently to the point of virtual extinction.

The Republic of Vanuatu is one of the few countries in which natural populations of this unusual species are still large enough to support an exploitative industry. Improvements to the transport and marketing infrastructure, as well as promotion of the product to the tourist trade, have resulted in considerable pressure being applied to the country's crab stocks. The harvesting industry (although relatively small) is of significant socioeconomic importance to communities in the more remote islands.

A management regime is needed to establish balance between natural population size and desirable harvesting procedures. A record of growth rates, and a comprehensive understanding of the larval stages of the crab's life cycle, are essential for devising an efficient management program. Any attempts to farm the crab will rely on this information.

The main objectives of the study are: (1) to estimate the crab's natural growth rate; (2) to examine the effects of harvesting pressure on population structure and density; and (3) to elucidate recruitment processes. Growth estimation is being approached both by freeze-brand mark-recapture experiments and by monitoring a population of captive animals. Population structure is being assessed through a field sampling program at sites along the east coast of the island of Espiritu Santo and by measuring crabs on sale at local markets. Recruitment studies have necessitated investigation of techniques to differentiate amphibious coconut crab glaucothoe from those of other coenobitid species, as well as extensive land-based searches for juvenile crabs and sampling of the marine planktonic zoea larvae.

Results

Juvenile and adult crabs are captured in coastal scrub and rainforest habitats using the traditional baited transect technique employed by local ni-Vanuatu hunters. This involves slashing a trail through the forest and laying out a series of half-coconut baits (securely attached to rocks or stakes) at dusk, and patrolling the transect periodically throughout the night. All crabs encountered are routinely sexed, measured, weighed, freeze-branded, marked with an identifying number scratched on the carapace (for intermoult mark-recapture population estimates), then released. Measurement of the distance between abdominal tergal scutes provides an index of abdominal expansion or fullness which, in turn, is related to the immediacy of the forthcoming moult.

Rainforest associated with a substratum of weathered fossil coral limestone appears to be a favoured environment, as it provides an abundance of refuges (caves, ledges and crevices) in which the crabs hide during the day. While habitats of this type usually occur within a few hundred metres of the coast, substantial crab populations have been located up to 3 km inland, and the animals are known to occur much further inland than that. Coconut crabs are generally nocturnal, especially in areas which have been heavily exploited in the past. However diurnal activity has been observed at sites not previously harvested.

Foraging activity is greatest soon after dark, with more than 80% of the total number of crabs being encountered during the first transect patrol of the evening. Evidence of seasonal changes in availability has also emerged at most sampling sites: catch rates peak in the wet season and decline in the dry. This variation in availability or catchability appears to be associated with the crabs' seasonal moulting cycle. Size composition of populations varies considerably between sites, and there is a positive correlation between population density and mean body weight. This probably reflects the pattern of harvesting, as collectors tend (naturally enough) to take the largest crabs first.

Freeze-brand marks, created by dipping a shaped sponge-rubber applicator into liquid Freon 12 then immediately pressing it against one of the tergal scutes, have been shown to transfer to the developing sub-carapace of a captive crab, although not as distinctly as was hoped. Abdominal expansion indices rose to a peak in April, indicating the general onset of moulting. However the pattern for females was confused by a peak around November due to ovarian enlargement prior to spawning.

Moulting takes place in subterranean burrows over a period of several weeks, and the crabs then eat their exuviae to recycle nutrients needed for

calcifying their new shells. Moulting or immediate post-moult crabs dug up by collectors appear most frequently in the markets during winter months. The small number of pre- to post-moult carapace length increments obtained to date indicates a very slow growth rate, and that marketable-sized crabs may be as much as 10 years old.

Ovigerous females with full term eggs migrate to the sea to release their larvae, which emerge from the egg mass within seconds of its coming in contact with sea water. Searches after dark along the rock foreshore during the spawning season have yielded valuable data on spawning behaviour and size at first maturity, and enabled the collection of large numbers of Stage 1 zoea larvae for rearing experiments. A few zoeae were identified from the plankton samples, but as yet no shelled glaucothoe have been found despite extensive searches in a wide range of potential habitats. A complete series of larval stages has been reared under basic experimental conditions, but no success has yet been achieved in avoiding the mortality associated with metamorphosis from glaucothoe to the juvenile crab 1 stage.

It appears that the coconut crab is characterised by a relatively slow growth rate. Natural populations of the crab may suffer regular recruitment failure, depending on the vagaries of oceanic current systems responsible for larval transport, and the question of the relationship between recruits and local spawners (i.e. the genetic integrity of substocks) is by no means clear. These factors suggest that populations of coconut crabs may be particularly susceptible to overexploitation, and will consequently require very careful management if harvesting practices are to remain commercially viable.

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Epidemiology and Control of Gastrointestinal Nematodes of Small Ruminants in the South Pacific (Project 8418)

Meat consumption in Pacific Island countries far exceeds local production, and several countries are striving to expand their sheep and goat flocks. A meeting of Directors of Agriculture for Pacific Island Nations in 1984 resolved that small ruminant production would take the highest priority in the development of livestock industries in the Pacific.

Gastrointestinal parasites, especially the nematode *Haemonchus contortus*, are a serious impediment to expansion of small ruminant flocks. It has been estimated that 25% of the Fiji goat herd dies annually from this parasite. Outbreaks of haemonchosis kill up to 50% of goats in some goat-farming projects. In Vanuatu, 50% of lambs born are lost to gastrointestinal parasitism before they are weaned. Control of these parasites relies on anthelmintic treatment every 3 weeks. However, the high cost of anthelmintics, their uncertain availability and the appearance of drug resistance is further limiting small ruminant production.

Considerable success has been achieved by parasitologists from CSIRO's Division of Animal Health in controlling the nematode parasites *Haemonchus contortus* and *Trichostrongylus colubriformis* in sheep in the high-rainfall temperate regions of Australia. These control programs have been based on detailed knowledge of the epidemiology and population dynamics of the parasites in relation to host and environmental factors. Similar knowledge is lacking for these same parasities for wet tropical environments.

The goals of this project are to provide a basic epidemiological understanding of the problem, and, in the light of this, to devise effective control strategies that minimise the use of anthelmintics and selection for drug-resistant parasite strains.

This thorough investigation should reveal methods of management which control parasites using minimal amounts of anthelmintics. Although based in Fiji, research scientists will support and advise on relevant research in nearby countries, and their findings will be significant for the South Pacific region. Results of research will be conveyed to livestock officers in the nations involved. Furthermore, ACIAR will receive advice on other potential priority research areas.

The objectives of the project are: (1) to determine the extent of anthelmintic resistance; (2) to examine the epidemiological factors influencing helminthosis in small ruminant populations; (3) to construct a computer simulation model to aid in the design of management strategies aimed at parasite control with minimal use of anthelmintics; (4) to test these strategies in the field; (5) to pass on results to national extension officers.

Results

Anthelmintic Resistance Survey

Ten out of eleven herds surveyed from commercial goat farms in various parts of Fiji have parasite populations resistant to one or more anthelmintics. On several farms the degree of resistance has advanced to the stage where egg counts from drenched animals are similar to those from untreated controls. Both multispecies and multiple-drug resistance have been detected. If the present trend in the survey continues, then anthelmintic resistance in Fijian goat herds is even more serious and more widespread than was originally anticipated, and further demonstrates the urgent need for the development of alternative methods of parasite control.

In an effort to reduce the advance of resistance (and hence 'buy' more time for the development of alternative methods), the project has made its services available to farmers through the extension service. Farmers reporting a breakdown in parasite control can have their herd tested to differentiate between genuine resistance and faulty drenching technique. Fiji Government policy is now to release the drench 'ivermectin' only to farms shown to be suffering from genuine resistance to both 'levamisole' and 'benzimidazole.' The project has also helped produce guidelines for correct drenching which have been translated into Fijian and Hindi and are now affixed to all bottles of anthelmintic sold in Fiji. Recommended dose rates for goats have been set at 150% of the dose for sheep of similar weight until effective rates for goats are reported in the scientific literature.

Development and Survival of Free-living Stages of Nematodes

Low pasture larval counts were recorded from the July 1986 contamination of the trial plots at the Sigatoka site. The results are encouraging as they may indicate a break in transmission during the dry season. This would be important information in the development of a strategic drenching program.

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Smallholder Farming Systems in the South Pacific—Constraints on Development (Project 8205)

The South Pacific Smallholder Project is being conducted in the Kingdom of Tonga and in Solomon Islands. Its aim is to identify constraints on, and opportunities for, the development of smallholder agriculture in the South Pacific.

Small farms provide not only a major source of employment in the region but the bulk of agricultural production there. However, local attempts to raise production levels have often had disappointing results. This project seeks to identify the constraints that have limited production increases on the smallholdings, and to assess the potential for introducing selected new technologies to remove these constraints. The research team expects to develop constructive recommendations for feasible changes in agricultural policies and programs and to make specific suggestions for agricultural research and technology testing.

As its first priority, the team will establish an accurate and quantified description of the present smallholder systems in terms of the resources available, resource productivity, present technologies, economic behaviour and goals. It will also identify and assess the importance of social and economic factors such as access to markets, prices and costs, land tenure, risks and risk aversion and access to information.

The team will also identify and assess the scope for improving system performance using, for example: evidence of underutilised resources; between-farm differences in productivity; observed responses to economic stimuli; budgetting, programming or econometric modelling studies of system performance; and the results of testing improved technologies on experiment stations and farms.

To gather the necessary information about smallholders' constraints, goals and incentives, the project will incorporate three methods of data collection: sample surveys of smallholders, field studies and a few intensive case studies.

Sample surveys (the main data-gathering component) will obtain details of resources available and their use, and of other constraints, for different categories of farms. They will probably cover at least 100 farm households in each country, comprising 25 smallholders from each of four villages or groups of neighbouring villages. Localities will be selected to represent a range of agricultural conditions and of economic distance, which reflects not only distance from the urban centre but the position of the island in relation to inter-island shipping routes and facilities.

Field studies will survey the physical, economic and institutional conditions under which smallholders operate. Information will be obtained on relevant agrobiological research results and production alternatives for the farms, together with marketing opportunities. The intensive case studies will seek a better understanding of the effects on economic behaviour of personal and social variables. Aspects studied will include, for example, motivation, beliefs and preferences, goals, attitude to risks and response to community attitudes and beliefs. Both Tonga and Solomon Islands contain varied production environments, and the results should prove useful in a number of areas. Indeed, a subsidiary aim of the project is to make its research approach productive, 'portable' and replicable in other countries.

Results

Data have been collected on land use, the allocation of time of household members, levels of production of both cash and subsistence products, and household incomes and expenditures. Considerable attention is being given to marketing constraints to the expansion of rural production and to the responsiveness of smallholders to economic incentives. In supplementary studies, the effect of cash cropping on the nutritional status of children in the households is being investigated. The aim of these studies is to ensure that nutritional well-being will not be impaired in the development process.

Preliminary results of the project contradict some notions about the reluctance of Polynesian farmers to respond to economic incentives. Some farmers in the northern part of Tonga where vanilla production has been successfully introduced have been operating on a commercial basis and earning substantial incomes.

In Solomon Islands, the findings again highlight the importance of economic incentives for smallholder producers, and some ways of improving these that would raise the standard of living of rural people have been identified.

Perhaps the main benefit arising from work so far has been the focus it has given to the importance of the smallholder sectors in most Pacific Island countries. Results point clearly to the scope for

improvements in smallholder production and living standards, and to measures that can be taken to allow that potential to be realised.

The project has a particular relevance to Solomon Islands since Cyclone Namu devastated some of the islands in May 1986. Extensive damage was caused to oil palm, coconut and cocoa plantations, and large numbers of cattle (including the national nuclear breeding herd) perished. The project workers are well-placed to survey rehabilitation needs and to make recommendations for replanting and redevelopment strategies.

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Analysis of the Opportunities for the Development of Smallholder Farming Systems in the Kingdom of Tonga (Project 8558)

This project builds on earlier achievements under Project 8205, which involved collection and analysis of detailed information from a sample of some 120 households at four locations in the Kingdom of Tonga. However, this research suffered three primary limitations. First, observations covered only one year so results may be atypical and not reflect year-to-year variability. Second, the already heavy recording burdens placed on respondents limited the scale of recording, resulting in very small sample sizes which give little idea of variability between farms and fail to provide statistically reliable estimates. Third, the project lacked detailed examination or on-farm testing of improved technologies. Further, although the project did generate and add to the stock of skills and experience in farming systems research in Tonga, a transition period is required before the skills can be absorbed into the Ministry of Agriculture, Fisheries and Forests. This follow-on project is intended to provide that transition while also initiating a program of on-farm trials of smallholder-oriented new technologies.

The ultimate goal of this project is to raise agricultural output for both domestic and export markets and thereby improve the standard of living of rural people in Tonga. To this end, the project will strengthen the data base on smallholder agriculture; establish routine procedures practicable within Tonga for summarising and analysing the data obtained; and generate a flow of data useful in guiding the Ministry's research and extension programs and in formulating agricultural development projects. The major thrust of the research, however, will be on-farm testing of new technologies to throw light on means of improving the productivity of smallholder agriculture in Tonga, and some spillover benefit for the South Pacific generally is anticipated.

Within the Ministry of Agriculture, Fisheries and Forests, the project will assist in creating an effective capacity to conduct socioeconomic research in agriculture, contribute to a farming systems approach to research and develop appropriate microcomputer-based data recording and analysis skills.

Results

During 1986 routine procedures and personnel have been set in place to pursue the objectives set for the project, and collection of input-output data has begun at all sites. Resource base surveys and farm mapping are complete in Tongatapu and 'Eua, and crop recording has commenced at these sites; in Vava'u, the surveys are largely complete and some crop recording has started, but mapping has yet to be done. In the light of experience, some minor changes to the recording instruments are being implemented.

Introduction of a farming systems research approach to technology assessment began with on-farm trials of disease-free sweet potato cultivars derived from another ACIAR project (Project 8433: Sweet Potatoes—Pathogen Tested Germplasm for the South Pacific). Other foci for other on-farm trials are still to be determined, but possible candidates include: adoption of mechanised root-crop production; farmer vs. Ministry-managed banana-spraying systems; grower-managed coffee production and alternative organisation of postharvest processing; bush fallowing systems, including a study of the effects of a serious pest infestation of leucaena; and the role of livestock in smallholder systems. Initially, the proposed on-farm tests will involve small plots and perhaps only three or four case-study farmers. If preliminary results warrant, plot size and the numbers of farmers and locations can be increased.

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Papua New Guinea Export Tree Crops Study (Project 8383)

Tree crops—principally coffee, cocoa and coconuts—contribute about 80% of Papua New Guinea's agricultural export income. However, production of cocoa and coconuts has declined in the past decade, and the outlook for coffee expansion is uncertain due to the limited availability of suitable land, much of which is required for food crops, and low prices for over-quota production. About 1000 plantations still grow at least one of these crops and continue to provide most of the rural employment plus some employment in urban-based support services. However, smallholder production has now outstripped that of plantations. Some 450 000 households depend on small-scale farming systems that combine subsistence food production with cash crops. Most remain village-based, although increasing numbers occupy contiguous blocks often involving larger areas of cash crop.

For policy purposes it is important to monitor the shift towards smallholder production. Several recent reviews have provided data on such matters as population, land use, subsistence agriculture, nutrition and ecological zones. The resultant data banks and sampling frames are a useful beginning to facilitate future choice of sampling procedures, questionnaire design and survey implementation procedures aimed at providing regular and reliable physical and economic data on trends in the largeholder and smallholder/village sectors. Nevertheless, available data on which to base future planning and policies still contain gaps.

The aim of this project is to develop and test low-cost survey methods and develop a suitable analytical framework for an agroeconomic study of both the largeholder and smallholder/village sectors of the Papua New Guinea cocoa, coffee and coconut industries, with surveys to provide reliable and regular data on: areas planted and rates of new plantings, replantings and retirements; cost and input data needed to evaluate different development modes and price stabilisation options; the extent of adoption of new technology (including planting material, fertilisers, weedicides, pesticides and agronomic practices); and the constraints to production (including availability of marketing, storage and processing facilities). Similarly the research team was to develop and test a suitable survey method and analytical framework for incorporation into future national and area surveys aimed at providing information on variables such as householder income and expenditure, the allocation of land, labour and capital to subsistence food production and to cash cropping, and monitoring of food reserves and household nutrition levels.

Results

Substantial progress had been made with the largeholder survey component by late 1986. Initial problems arose with design of questionnnaires, and with differences in background financial and production data available from different plantations. The experience gained in the solution of these problems has led to various improvements in survey techniques for the future. Reports have been produced on the Copra/Cocoa and the Coffee Largeholder Sectors, which have been received enthusiastically by the relevant producers' groups.

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Commodity Price Stabilisation in Papua New Guinea (Project 8435)

Four crops—coffee, cocoa, copra and oil palm—account for about half of Papua New Guinea's total export earnings. Their prices fluctuate widely, so the government operates price stabilisation schemes which, as a result of recent high commodity prices, have accumulated funds now totalling between 20 and 30% of the country's money supply.

At the request of the Papua New Guinea Government, ACIAR has organised a collaborative project to review existing arrangements for the funds and to investigate alternatives with a view to ensuring that exports are maintained and moneys held in the stabilisation schemes are used effectively. Involved in the work are the Department of Primary Industry, the Commodity Boards for Coffee, Cocoa, Copra and Palm Oil, and the Department of Finance and Planning in Papua New Guinea, and the Bureau of Agricultural Economics and University of Melbourne in Australia.

The objectives of this project are: (1) to review the role and justification for the stabilisation funds from a micro- and macro-economic point of view; (2) to develop an objective basis for determining payments into and out of the funds; (3) to develop methodology for forecasting future developments in the export tree crops sector.

Initially the team will seek an objective basis for determining the levies on, or rebates to, producers. They will examine the costs and benefits of the funds, both from the perspective of the individual producer and from that of the national economy, and analyse the distribution of those costs and benefits.

Secondly, team members will investigate the relative efficiencies of different stabilisation formulae. The investigations will include both appropriate trigger mechanisms for payment of levies and bounties and alternative investment portfolios for the funds, including the advisability of investing stabilisation funds in research and development.

Thirdly, the project will aim to develop empirical models that will simulate the impact of alternative stabilisation strategies on the national economy. This approach will involve adaptation of a new input-output model developed by the Papua New Guinea Department of National Planning and the Australian Bureau of Statistics. The adapted model should identify such important indicators as the effects of different stabilisation formulae on the balance of payments and the money supply, and hence on the rate of economic growth.

Fourthly, the team will develop a methodology for reducing errors in forecasting harvests and prices for the crops. This needs to be simple, cheap and quick to implement. Priority will be given to means of forecasting domestic output in the short term, identifying appropriate indicators; methodology for making projections of supplies and prices in the longer term will follow later. An important input into this phase of the project will be the results of ACIAR Project 8383, a 3-year project that examines trends in the export tree crop sector, which commenced in 1984.

Results

The project commenced with reciprocal visits between the Australian and Papua New Guinea project workers, enabling extensive discussion of the problems and possible solutions with a wide range of economists, commodity board personnel and other relevant experts in both countries. As a result of these meetings, a draft report was prepared which included discussion of the main issues related to price stabilisation for each of the relevant commodities, and micro- and macro-economic aspects of the stabilisation schemes.

Further meetings, including a 2-day coordination meeting and workshop, have since been held to discuss the preliminary report and to gather additional information. The workshop meeting endorsed the draft as a basis for the final project report, and a revised and expanded version is now being prepared. The final version will consist of five parts: a section on general issues, and four sections dealing with specific issues on stabilisation of each of the four commodities under consideration. This report will be widely disseminated and discussed in public forums.

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Nutrition and Policy Implications of the Spread of Cash Cropping in Papua New Guinea (Project 8522)

In recent years, emphasis in PNG agriculture has moved towards production of cash crops for export. In 1984 cash crops accounted for 45% of the country's total export income, and 75% of non-mining exports. However, lack of firm data has led to considerable debate concerning food security and the nutritional implications of this trend to cash cropping. Food imports typically absorb 60–75% of the value of earnings from tree-crop exports. Moreover, cheap imported rice and other cereals have effectively reduced the growth in demand for domestic staples (such as sweet potato, taro and bananas). Cereals now provide about 25% of the average Papua New Guinean's minimum daily energy requirements. Thus, the increased participation of smallholders in the cash economy has not only meant food dependency but possibly affected nutrition. Effects vary considerably between regions. For example, people in the highlands, where coffee is the main crop, seem to have benefited from increased cash incomes, but elsewhere the result is more equivocal.

This project will address both the import dependency and nutrition issues. The project will examine, at village level, shifts from subsistence food-crop to cash-crop production, and assess their effects on household real incomes, family food consumption, expenditures for non-food goods and services and the nutritional status of preschool children in various settings. It will also analyse the process by which such shifts exert their effects.

Research will concentrate on three sites, chosen to represent various ways in which rural people participate in the cash economy. Selection will depend on: highland vs. lowland location; whether smallholder, nucleus estate or settlement scheme; and type of cash crop grown. Sites should also meet the following criteria:

- Some structural change relevant to cash income of the rural population has occurred in the area.
- Information is available from previous anthropological, economic, health and nutritional studies, preferably including data on nutritional status of young children.
- Current studies of relevance are being carried out in the area.
- Reliable information is available on population structure and the ages of children.

At one site, an intensive study will sample 65 households over a 16-month period, with continuous assessment of household income plus four measurements of expenditure and three of food intakes. Studies at the other two sites—each on 25 households for 8 months—will measure income, expenditure, and food intakes twice.

Selection of households for each sample will depend on an initial detailed population census to determine household size, age and sex structure (of population and of households) and degree of participation in the cash economy. The nutritional status of all preschool children will be assessed cross-sectionally, based on height, weight, age and sex relative to altitude-specific averages. Measurements will involve at least 200 preschool children at each site (600 in all), and comparisons with the results of previous surveys will show whether significant changes in their growth have occurred. To control for possible genetic differences within and between areas, the team will measure mid-parental height for incorporation into the analysis. For a general assessment of beliefs and knowledge about nutrition and child care and of attitudes to cash cropping, the team will use a combination of ethnographic and survey methods—developed for use in Papua New Guinea by the Institute of Medical Research—paying specific attention to beliefs, knowledge and behaviour concerning purchased foods. More detailed assessments, in the sample households, will take account of the total garden areas devoted to food-growing and to cash crops and of the number and age of crop trees, where relevant.

On the important issue of food dependency, data from this project will allow estimates of the demand for imported food with changes in income. On the nutritional effects of cash cropping, a finding of neutral or positive effects will remove uncertainty in policy development; a negative finding will necessitate active exploration of ways to neutralise the effect. Participation in the international network of studies being coordinated by the International Food Policy Research Institute (IFPRI) will contribute to a broader international understanding of the effects of the shift from subsistence to cash cropping.

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