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Coconut Germplasm in the South Pacific Islands

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Contents

Foreword

The coconut palm *(Cocos nucifera)* is the most important crop in the Pacific Islands. It is often referred to as the 'Tree of Life,' since it is used to provide the essentials of life, such as food, drink, shelter, as well copra for cash sale, in many island communities.

Approximately 600 600 ha of coconuts are grown in the Pacific Islands, making the region collectively the world's fourth largest producer after the Philippines, Indonesia and India.

Coconuts are the major source of foreign exchange in many Pacific Islands with some countries deriving 60% or more of export earnings from coconut products. Atoll countries are heavily reliant on coconuts for domestic use and export income. Papua New Guinea is also a significant producer of coconut products, which are of particular importance for domestic consumption and as a source of cash for small farmers in coastal and isolated island regions.

When developing a portfolio of collaborative research projects in the Pacific, ACIAR considered which aspects of the coconut industry would benefit from increased research effort. ACIAR is currently supporting three projects on coconut research and development in Papua New Guinea and the South Pacific. These are concerned with (1) coconut improvement, (2) virus diseases, and (3) socioeconomic surveys of coconuts.

The survey described in this report in selected Pacific countries was conducted by Mr Mike Foale in August and September 1986. The survey is one of the early activities of the ACIAR Coconut Improvement Project, which involves collaborative research amongst scientists from the newly established Cocoa and Coconut Research Institute in Papua New Guinea, the Institute for Research, Extension and Training (IRETA) of the University of the South Pacific in Western Samoa, the Knoxfield Horticultural Research Station of the Victorian Department of Agriculture and Rural Affairs, and the University of Melbourne, Australia.

ACIAR would like to thank the many agriculturalists in the Pacific Islands who cooperated with Mr Foale during the course of the survey. Particular thanks are due to Dr L Fernando, Director of IRETA, University of the South Pacific, for inviting ACIAR to commission the survey on behalf of the Pacific regional coconut network, which IRETA coordinates.

We also thank M de Nuce de Lamothe of IRHO, Paris, and M. C. Calvez of the IRHO-Saraoutou Research Station, Vanuatu, for their assistance including the hosting of the regional coconut meeting in August 1986, at which the survey was launched.

We trust that the report of the survey will be a useful resource document for those interested in this important crop in the Pacific Islands.

G.J. Persley
Research Program Coordinator
ACIAR

Summary

Survey trips were made to Vanuatu, Solomon Islands, Tuvalu, Fiji, Western Samoa, American Samoa, and Cook Islands to inquire into coconut improvement work. In all except Vanuatu and Fiji, some cultivar description was undertaken, with emphasis on fruit analysis.

Coconut production in the Pacific is currently depressed due to the low price of copra and coconut oil. There is interest in developing alternate products for export as coconut is a vital part of the export economy of all these countries except American Samoa. Productivity of coconuts is poor except on the Levers Solomons Plantations where extensive replanting with a hybrid has been achieved. Elsewhere technology is at hand to improve productivity but the economic incentive is lacking.

Several potentially useful coconut cultivars were identified. The nut types ranged from the Niu Vai of Samoa (the largest fruited coconut ever described) to the small fruited 'wild' type of Tuvalu, and several different types of dwarf in Samoa and the Cook Islands. Specific nut traits may be valuable in producing nuts for a whole-nut market, while the adaptation and breeding potential of particular cultivars needs to be assessed.

A great deal of experience in coconut improvement has been accumulated at Institut de Recherches pour les Huiles et Oleagineuse (IRHO) in Santo and Levers Solomons in Yandina. In addition the level of practical field technology at Yandina is undoubtedly the highest in the Pacific area. High productivity is already achievable, but the future challenge is to reduce production costs and develop new markets.

Introduction

Coconut *(Cocos nucifera)* is an indigenous species in the Pacific Islands and may have first reached many of the islands by natural dispersal hundreds of thousands of years ago. A strong case has been presented for long-distance movement of coconut seeds by flotation in the sea (Harries 1978), although present wind and current patterns in the Pacific do not favour eastward movement from the likely centre of origin in the Indonesia/New Guinea region (Levison et al. 1973). It is possible that these patterns were quite different in the past.

There has been human habitation in Central Polynesia (Tonga, Samoa) for at least 3500 years, and in Fiji and Melanesia for much longer. Evidence has been found of coconuts in Vanuatu before human colonisation (Spriggs 1984). The most common forms of coconut are naturally cross-pollinating, so that intermediate forms are generated rapidly when dissimilar types are grown within range of pollination. The mixing of cultivars introduced by man with the long-standing wild population has possibly contributed to the wide range of variability that is found in most modern coconut populations.

There are two forms of coconut favoured by tribal people. These are large-fruited forms that provide a substantial amount of both water and food for travellers, especially at sea, and small-fruited dwarf palms which are the source of drinking nuts suited to consumption by one person in or near the home village. Cultivars bearing large nuts are favoured by the Polynesians who were traditionally a seagoing people. Small-fruited dwarfs are common in villages throughout Polynesia and Melanesia. In addition, the Polynesians selected other palms that bore fruit which contained long fibres to make strong twine and ropes for use in construction of both buildings and boats. It is likely that people who were highly dependent on their selected types of coconut would seek means of identifying true progenies at the seedling stage so that palms planted close to their villages would produce what was required. An effort was made during this survey to find evidence of this type of selection.

Coconut palms were first cultivated on a 'plantation' scale in the mid 1800s following an upsurge in demand in Europe for oil suitable for soap-making

(Harries 1978). The production of copra generally required the extraction of the fresh meat for drying. As this process was simpler if the nuts were large, this was a trait sought after by plantation management. Since much plantation development took place in short periods of intensive investment activity by European companies, it is unlikely that there was an adequate supply of large nuts from local villages to meet the demand. Many early plantations were probably planted with the more plentiful small nuts found in groves more or less remote from villages and exploited only on a casual basis by the local people.

The first hybrid coconut palms produced by artificial pollination were grown in Fiji by Marechal (1928), who crossed an introduced Malayan Red Dwarf cultivar with the Fijian Green Dwarf, known as Niu Leka. It was the enormous variability shown by the F_2 progenies of the original Fijian hybrid material, planted at Yandina in the Solomon Islands in 1956, that convinced Levers (Unilever Plantations Group) and perhaps reaffirmed for IRHO the potential benefit of breeding in coconuts. In the last 20 years hybrids have been produced, in both the Solomon Islands and Ivory Coast, that yield 30% higher than the best parent.

Apart from seeking higher yield potential under ideal conditions there is a need to recognise the role of adaptation in coconut palm performance. There is evidence that palm populations have adapted to soil type, water deficit, pests (such as *Scapanes* and *Brontispa)*, diseases such as Foliar Decay induced by *Myndus taffini* (FDMT), and strong wind. It may be necessary to incorporate a 'local' parent into any hybrid to ensure its survival under the influence of a particular local factor.

Previous Surveys

A survey of some large-fruited coconut cultivars was carried out by Parham (1960) with funding from the South Pacific Commission. This resulted in the movement of seed from Rotuma, the Markham Valley and KarKar Island (PNG) to a number of research centres.

In 1964 a survey and collection were carried out by Whitehead (1966) for the Coconut Industry Board of Jamaica, in quest of genetic resistance to Lethal Yellowing Disease. It was Whitehead who drew attention to some of the extreme fruit types and to the generally high level of genetic diversity of Pacific coconut palm populations. The data of Whitehead on fruit composition, combined with data collected by IRHO and many other workers on a global scale, provided Harries (1978) with the information that he used to develop a general theory of evolution and dissemination of the coconut species.

The ACIAR Survey

The survey described here had the primary objective of describing coconut cultivars present in countries not visited by Whitehead in 1964. The criteria remain much the same as then, including fruit composition, palm morphology and phenology (which includes speed of germination, and precocity), and some details of the environment that might have given rise to particular adaptations in the coconut population.

The countries surveyed were Tuvalu (only Funafuti atoll), American Samoa (Tutuila), and Cook Islands (Rarotonga and Aitutaki) (see Appendix A for detailed itinerary).

A second objective of the survey was to obtain general information about the local coconut industry and coconut improvement activity. In this connection visits were also made to Vanuatu, Solomon Islands, Western Samoa, and Fiji. Some further fruit analysis was carried out at Yandina in the Solomon Islands and in Western Samoa. At Yandina material was analysed that had been introduced during the 1960s from Sri Lanka, Kiribati (both from Tarawa and Christmas Island), and within the Solomon Islands (Vanikoro). In Western Samoa, nuts of three cultivars not measured by Whitehead were also processed.

The report contains a separate section for each country visited discussing briefly the coconut industry and any improvement program. The possible value of indigenous cultivars to local and other coconut improvement work is raised. The data from the fruit analysis are all presented together with a brief discussion of their significance. Finally there is a general section on the future problems faced by the coconut industry on both a regional and a global scale, with comments on possible future developments.

Centres Visited

The remainder of this report includes a statement of impressions gained in each centre where coconuts were studied in the field. There is no section on Fiji or New Zealand where I had discussions which contributed in a general way to my impressions recorded in this report. The reports on centres are followed by a section on the fruit composition data.

Santo–Vanuatu

Coconut Research in Vanuatu

The IRHO initiated a program of coconut research in Vanuatu in 1962. The research station at Saraoutou has since been developed into a facility of global significance for the coconut industry. In spite of the presence of FDMT disease, a collection of 11 exotic tall and 13 exotic dwarf cultivars has been built up in addition to talls from seven sources within Vanuatu (Calvez et al. 1985).

IRHO scientists were the first to recognise the presence of FDMT which had undoubtedly prevented the survival of introduced coconut material in the past. Recent understanding of the transmission of the disease (Julia 1982) has allowed the IRHO to develop a technique for screening exotic cultivars for resistance to FDMT, and also to protect non-resistant material from the disease. In more recent work in an ACIAR-sponsored project on coconut virus diseases in the Pacific Islands, scientists from the Waite Institute, University of Adelaide, and IRHO have shown that the causal agent is a high molecular weight DNA pathogen, probably a virus (Randles et al. in press). Current work is aimed at developing a rapid indexing method for FDMT.

The work of IRHO in Vanuatu is described elsewhere (Calvez et al. 1985; Biberson et al. 1985). As the techniques employed for hybrid seed and seedling production in Santo are highly successful these are described here.

Some observations on nursery management practised by IRHO in Vanuatu: Polybag seedlings are produced for sale to the Coconut Development Project (CDP) of Vanuatu. These are hybrids between Vanuatu Red Dwarf (VRD) and Vanuatu Tall (VTT). The VRD has a red petiole colour which is a recessive trait that is used as a colour marker. Any red sprouts in the prenursery are rejected as selfs rather than hybrids. About 60% of the nuts in the prenursery produce suitable seedlings which are planted into polybags filled with good quality loam (Pomier 1972).

A mixture of fertiliser containing 1:2 of N and K (the ingredients are sulfate of ammonium and muriate of potash) is applied to the polybags at the rate of 25, 50 and 50 g at 1, 3 and 5 months, respectively.

The nursery is watered with fixed sprinklers whenever needed and sprayed every 2 weeks (or as required) with a mix of fungicide and insecticide (for control of *Bipolaris incurvata* and *Brontispa*). At 6 months the seedlings are selected for sale, based on 'normal' appearance, which means healthy leaves having neither too early nor too late separation of leaflets, and a good ratio between the robustness of the stem base and the number and size of the leaves.

Seedlings are sold for 160 vatu ($A3 approximately) to the CDP which in turn sells them for 60 vatu to farmers, delivered to the farm.

Comments on the practice of assisted pollination for hybrid seed: The IRHO has a collection of several mother dwarf cultivars and produces hybrid seed by bagging the emasculated inflorescences and introducing pollen from selected tall palms. This is quite an expensive practice but it has a number of advantages over establishing specific seed-gardens for each hybrid that might be wanted.

Assisted pollination means that the mother cultivars do not need any particular isolation from other palms and indeed they can be part of a genealogical collection on a research station. Also there is complete flexibility about which talls may be used as male parents. The talls may be located some distance away, even on another island or in another country. New knowledge of combining ability of particular talls and dwarfs can thus be obtained without assembling the cultivars into one location. Commercial production of hybrid seed can also be carried out by transporting the pollen from another centre.

Possible problems with a large area of dwarfs include the high vulnerability of dwarfs to cyclonic wind damage, especially from the fifth year up to at least the fifteenth (Marty et al. 1986). Duplication of a set of dwarf mothers might be advisable about every 5 years to ensure against loss at a vital stage of a seed production program.

For best results emasculation should be done on dwarf spathes 24 hours before the sheath would have opened. Only an experienced and alert operator can recognise when the spathe is ready. Following emasculation a bag is fitted that has an observation window with a taped-over hole in the centre for insertion of a tube to carry the pollen/talc mixture into the bag when the female flowers are receptive. Most dwarfs have a female phase that lasts 10–14 days and pollen should be introduced about day 3, day 6 and day 9.

The bag is removed after the last female flower has advanced beyond receptivity. Nut-set can be improved by removing bunches of developing nuts that are not required. A palm that has a reduced fruit load is likely to shed less of the nuts from the spathe that has been artificially pollinated.

In seed-gardens where there is no foreign pollen being conveyed by either wind or insects, bagging of the inflorescence is not necessary. Instead the pollen is simply blown over the spathe every 3 days during the female phase.

Levers Solomons, Yandina-Solomon Islands

Background

Coconut research has been carried out at Yandina since 1952. The first work was done by A.H. Green, who concentrated on fertiliser needs of both medium-age to old palms, and replanted palms. Green also introduced in 1956 about 300 progenies (F_2) of Malayan Red Dwarf (MRD) × Niu Leka (NL), a green Fijian Dwarf, and about 30 Bellona palms from seed obtained on Bellona Island. In 1960 I understudied Green while establishing the Joint Coconut Research Scheme (JCRS) between Levers and the Solomon Islands Government. This scheme which was equally funded by the two organisations continued for 15 years, and since 1975 coconut research has been solely under the direction of Levers.

The JCRS work was first oriented to replanting techniques, testing coconut varieties and continuing nutritional work. Further genetic material was introduced from the Pacific area and later from Malaysia. A program of pollen exchange and artificial pollination was set up for producing mainly hybrids between selected palms including talls and dwarfs both locally and in the Ivory Coast and Jamaica.

With the appointment of a plant breeder (A.D.S. Duff) in 1965 the production of hybrids was increased, concentrating especially on dwarf × tall hybrids. The early promise of the Rennell variety, which had good *Brontispa* resistance, early bearing and large nuts led to this being the first tall to be used in a seed garden. Other seed gardens were established with Local Tall and Malayan (FMS) Tall as male parents. In all gardens the MRD was the female parent as there was a good supply of MRD seeds from Kira Kira. Comparative trials have shown that all hybrids outyield the parents but the MRD × RLT has been outstanding. Levers have now replanted several thousand hectares using this hybrid and estate yields up to 5 t/ha of copra have been obtained.

The JCRS pioneered the use of polybags for coconut seedlings (Foale 1968), and a trial comparing various ages of transplanting, and testing seedling selection, has shown that polybag seedlings are superior to bare root seedlings in early copra production (to 11 years).

An outbreak of disease in the Yandina commercial nursery in 1979 was found to be associated with the presence of the fungal organism *Marasmiellus cocophilus,* previously unrecognised in the Pacific. An export ban was placed on MRD × RLT seednuts from Yandina on the advice of I.D. Firman of the UNDP/FAO-SPC in Suva. A recommendation that this ban be lifted was made in 1986 by E.H.C. McKenzie following 7 years in which the disease has not recurred. McKenzie (1986a) cites evidence that the disease could not be reproduced artificially at Yandina, and also that its reported occurrence in Tanzania was likely associated with previous weakening of seedlings by a lethal yellowing disease.

Current Resources and Activity

The MRD × RLT seed garden has a capacity to produce 240 000 seednuts per year and Levers have a substantial surplus to their own needs. Other genetic material that has been collected at Yandina includes 10 tall cultivars and six dwarf cultivars (see Appendix B).

Current work at Yandina includes the regular consignment of somatic immature spathe tissue on culture medium to Colworth House, U.K., where Unilever are working on somatic embryogenesis. An indication of progress in this work is the presence near the Managing Director's house of a single palm, planted in the field in 1985, that was produced from callus in Colworth House.

Levers Solomons appears to be well placed to continue research as they have adequate land available to do trial work and to preserve genetic material. Limitations on genetic improvement work include the advanced age of the 'tall' collection and the limited range of dwarf cultivars. Besides the MRD and MYD, which have produced outstanding hybrids with a number of talls around the world, there is a need to obtain Cameroun Red Dwarf (CRD) and Brazil Green Dwarf (BGD), which are recommended by IRHO based on experience in West Africa.

As Levers have underplanted much of their replanted area with cocoa, they are studying the interaction of these crops, the optimum palm spacing to suit the cocoa (which currently provides a much higher return per hectare) and the youngest age at which coconuts may be underplanted profitably with cocoa. Cattle also graze some areas and significant research has been done by the University of Queensland on pasture under coconuts on Levers' estates and elsewhere (e.g. Smith and Whiteman 1983).

Possible Future Activities

Levers have developed the polybag nursery system to a high degree of efficiency using techniques based on many years experience. Equally their policy regarding the removal of old palms when replanting is based on both experimentation and plantation experience. They remove half the old palms when replanting and the other half 2–3 years later when the new palms are beginning to flower. New palms that are less precocious due to climate, cultivar or soil, would not require the second phase of removal until they are 4–5 years old. An observation of considerable interest made by the Plantation Director at Yandina (Mr M. de Neve de Rodin) was that palms emanating from a widely spaced nursery flowered after only 2 years in the field while those from a more crowded nursery flowered 6–12 months later. Confirmation of this response in a trial would have clear consequences for any replanting programs in other parts of the Solomons. The case for the use of centralised polybag nurseries in subregions of such a scheme is quite strong. The IRHO model used by the Coconut Development Project in Santo is a good example of this (Biberson et al. 1985).

Yandina has a potential role for the future development of coconut planting material for the whole of the Solomons, in addition to its immediate capacity to supply MRD × RLT hybrid seeds. All of the tall cultivars at Yandina have potential value in a breeding program and effort should be directed at renewing this collection which is 'out of reach' due to its age. Possible additions to the collection are Gazelle Tall from Rabaul which has some tolerance to *Scapanes* beetle attack, Santa Cruz Tall and Ontong Java Tall which, due to geographic isolation may have particular combining ability with the proven dwarf mother varieties. Tests for combining ability should be given high priority.

It would be prudent to duplicate a renewed collection of talls on Guadalcanal under the supervision of the Ministry of Agriculture and Lands (MAL) to insure against destruction of trees by cyclone. Coconut trees in the 5–15-year age bracket are quite susceptible to cyclone damage as they have a large crown, a trunk not yet long enough to be flexible, and a peripheral root system that is not yet fully developed. Dwarf palms of any age are susceptible because of the narrow base on the trunk, weakly developed peripheral roots, and fragile upper trunk (Marty et al. 1986).

Specific Traits Required in Future Cultivars

The presence of Christmas Island Tall and Tarawa Tall at Yandina may be of interest to Kiribati since, like the Polynesian Tall of Rangiroa (which is also present at Yandina), these are likely to combine with a dwarf female to produce hybrids that are more suited to atolls than hybrids whose male parent was Rennell or West African Tall. Rennell hybrids may be suited to the high rainfall conditions of Tuvalu, however, since Rennell Talls growing on Funafuti are highly productive.

The question of size of nut arises in relation to the cultivars of the future. Large nuts are preferred for copra production, and medium-sized nuts are suited to sale as fresh mature nuts at home or overseas. The sale of fresh immature nuts both locally and overseas for drinking would likely be based on small nuts having an outside diameter of about 95 mm, which corresponds to a liquid content of 360 ml. Perhaps drinking coconuts can compete directly with imported canned soft drinks in the countries of origin and eventually also in Australia, New Zealand. Hawaii, and even mainland USA and Japan.

Tolerance to *Scapanes* has already been mentioned for the Gazelle Tall. There might also be tolerance in some cultivars to *Amblypelta* as it has been noted in West Africa that Rennell Tall shows some tolerance to *Pseudotheraptus* which is also a nutfall bug (M. de Nuce de Lamothe, pers. comm.).

Tolerance to cyclonic wind is another issue, and among talls it has been noted that Rennell has greater tolerance than both Solomon Island Tall and FMS at Yandina (JCRS 1968). Planting method has considerable influence on survival in cyclonic winds. In Vanuatu a basin of about 1 m diameter and 0.3 m deep is excavated and the planting bole is placed in the centre. As the palm develops soil accumulates in the basin achieving close contact with the outer edge of the bole. This encourages the early growth of peripheral roots which anchor the palm more securely. It is likely that a highly precocious cultivar will have poor wind resistance at least when it is young as nut production competes with trunk and root development. The grower must assess the risk of exposure to high wind when making a decision about the precocity desired in replanting material.

Funafuti–Tuvalu

It was possible to visit only Funafuti Atoll where the international airfield is located. This is also the centre of government of this tiny country which has a population of 8500. Tuvalu comprises nine atolls of which eight are permanently inhabited. The rainfall is well distributed and totals 3000–3500 mm/year (Table 1).

Table 1. Long-term climatic data for some Pacific Islands (Anon 1981).

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Mean temp (°C)													*Avg*
Funafuti (Tuvalu)	28.0	28.0	28.1	28.2	28.2	28.0	27.7	27.7	28.0	28.0	28.1	28.0	28.0
Apia (W. Samoa)	26.9	26.9	26.9	27.0	26.7	26.4	26.0	26.0	26.2	26.5	26.6	26.7	26.6
Rarotonga (S. Cook Is.)	25.8	26.2	25.9	25.1	23.6	22.5	21.9	21.7	22.2	23.1	24.0	24.9	23.9
Rakahanga (N. Cook Is.)	27.6	27.8	28.0	28.1	28.0	27.8	27.6	27.3	27.5	27.5	27.7	27.7	27.7
Aitutaki (S. Cook Is.)	27.0	27.0	27.1	26.7	25.5	24.7	24.2	24.1	24.5	25.1	25.8	26.3	25.7
Total rainfall (mm)													*Total*
Funafuti	407	353	307	247	240	231	254	267	197	262	297	407	3469
Apia	436	361	358	244	171	135	101	105	147	209	266	374	2907
Rarotonga	253	223	275	183	172	108	94	129	104	124	144	229	2038
Rakahanga	330	241	199	157	150	143	136	155	143	193	223	282	2352
Aitutaki	223	242	214	175	168	84	83	84	86	116	176	236	1887

The coconut palm grows on many islets within the atolls in a truly wild state, forming a woodland with undergrowth of fern, pandanus and several dicotyledonous tree/shrub species. These woodlands are visited by the people of inhabited islets but there is no sign that the coconuts are managed in any way. Although the density of palms is too high for prolific nut production, and although it is well known that an injection of iron sulfate stimulates greatly improved growth and nut production, the islanders are content just to harvest what nature provides.

It seemed likely that a truly 'wild' type of coconut might be found in this situation, that is a nut type that filled H.C. Harries' criteria for natural dispersal across the sea. Traits that assist in such dispersal are a high proportion of husk in the nut, and late germination (which would increase the chance that nuts that found their way into the sea had not already germinated).

Fruit analysis was done on one sample of ten nuts from each of five separate locations. The mean husk content of fresh nuts was 59% and mean nut weight was 1.16 kg (Table 2). This composition is well within the definition of the Niu Kafa type described by Harries (1978) as primitive.

Externally the nuts were angular and elongated but the shelled part was generally quite spherical (Fig. 1). There was no information on speed of germination but there are reports that Tuvalu palms flower early. A notable feature of seedling growth was that the leaflets remained fused together on at least the distal end of leaves up to position 10 or higher. One seedling was found on the islets with a wholly fused structure in leaf number 12. This is very distinct from the leaf form in the Solomons and Papua New Guinea where leaflet separation is usually complete by about position 6.

Coconut Varieties in Tuvalu

Other survey work on coconut fruit characters has been done by Mr K.Trewren who surveyed several of the atolls (Anon 1982). His data do not fit readily into the Harries classification as the nuts were not harvested from the trees in the 'newly ripe' condition. The nut samples were apparently collected after falling and it is not certain that each nut in a sample came from a separate tree. Nevertheless the data are valuable in giving an indication of meat content of nuts from the areas surveyed. Mean fresh weight of meat per nut from Trewren's survey and the present survey are (in grams): Nanumea 403, Nui 330, Niutao 340, Vaitupu 340, Nukulaelae 405, and present survey (Funafuti) 254.

There is clearly a difference between the populations sampled in the two surveys. The explanation is, possibly, that Trewren took nuts from 'farmed' areas close to settlements where the islanders have probably been selecting for larger nut size in many generations of palms. The character of nut size is highly heritable so it can be selected for with some success. It is fairly natural for people to favour large nuts in selection.

The few nuts containing more than 300 g of meat in the Funafuti data were from areas with more frequent access by local people, and therefore more likely to have had selected nuts planted in them.

Future coconut development and selection (or special seed production) should take into account the future market for coconut products. There is a possibility of sales for fresh mature nuts to Sydney, Australia. The size specification is for approximately 38 cm circumference (G. Pritchard, pers. comm.), corresponding to a diameter range of 114–127 mm. Such nuts would have a meat content around 370 g.

Table 2. Summary of fruit analysis. The value in parentheses in the Meat column is % of meat in fruit after deducting weight of Water.

Cultivar	Weight (kg) Fruit	Husk	Shell	Water	Meat	Meat thick. (mm)	Nut diam. (mm)
1. Vanikoro (Yan)	1.24	.54	.16	.22	.32	12.0	
	%	43	13	18	26 (31)		
2. Christmas I. (Y)	1.45	.76	.16	.19	.34	13.4	
	%	52	11	13	24 (27)		
3. Sri Lanka (Yan)	1.46	.67	.20	.19	.40	14.0	
	%	46	14	13	27 (32)		
4. Kiribati (Yan)	1.05	.59	.12	.11	.23	12.2	
	%	57	11	10	22 (24)		
5. MRD × RLT (Dodo Ck.)	1.16	.30	.19	.29	.38	13.4	
	%	26	16	25	33 (44)		
6. Tuvalu (Funafuti)	1.16	.69	.13	.089	.25	13.6	92
	%	59	11	8	22 (23)		
7. Niu Vai (SNV)	3.53	1.19	.41	1.03	.90	14.8	158
	%	34	12	29	25 (36)		
8. Niu Afa (Kafa) (SNA)	2.91	1.61	.30	.41	.59	14.0	126
	%	56	10	14	20 (24)		
9. Niu Samatao (SNS)	2.21	.94	.28	.41	.58	14.4	134
	%	42	13	19	26 (32)		
10. Tutuila Tall (TLT)	1.60	.75	.22	.22	.41	14.0	117
	%	47	14	14	25 (30)		
11. Niu Ati (Yellow)	1.01	.40	.12	.20	.29	11.2	104
	%	39	12	20	29 (36)		
12. Rarotonga (CIT)	1.81	.92	.22	.21	.46	14.0	118
	%	51	12	12	25 (29)		
13. Aitutaki Tall (CIT)	1.72	.89	.24	.22	.39	11.8	118
	%	50	14	13	23 (26)		
14. MRD (Rarotonga)	1.13	.54	.14	.15	.30	12.3	103
	%	48	12	13	27 (31)		
15. Niu Papua	0.78	.39	.11	.08	.20	11.1	90
	%	50	14	10	26 (29)		

(Meat content varies within any nut size range, as meat thickness ranges from 12 to 15 mm.) The average meat content from most of Trewren's areas was less than 370 g, showing that the proportion of nuts of suitable size for export will be fairly low. Sprouted nuts will also be rejected for export which indicates that perhaps five times the number needed to fill an export container will need to be handled.

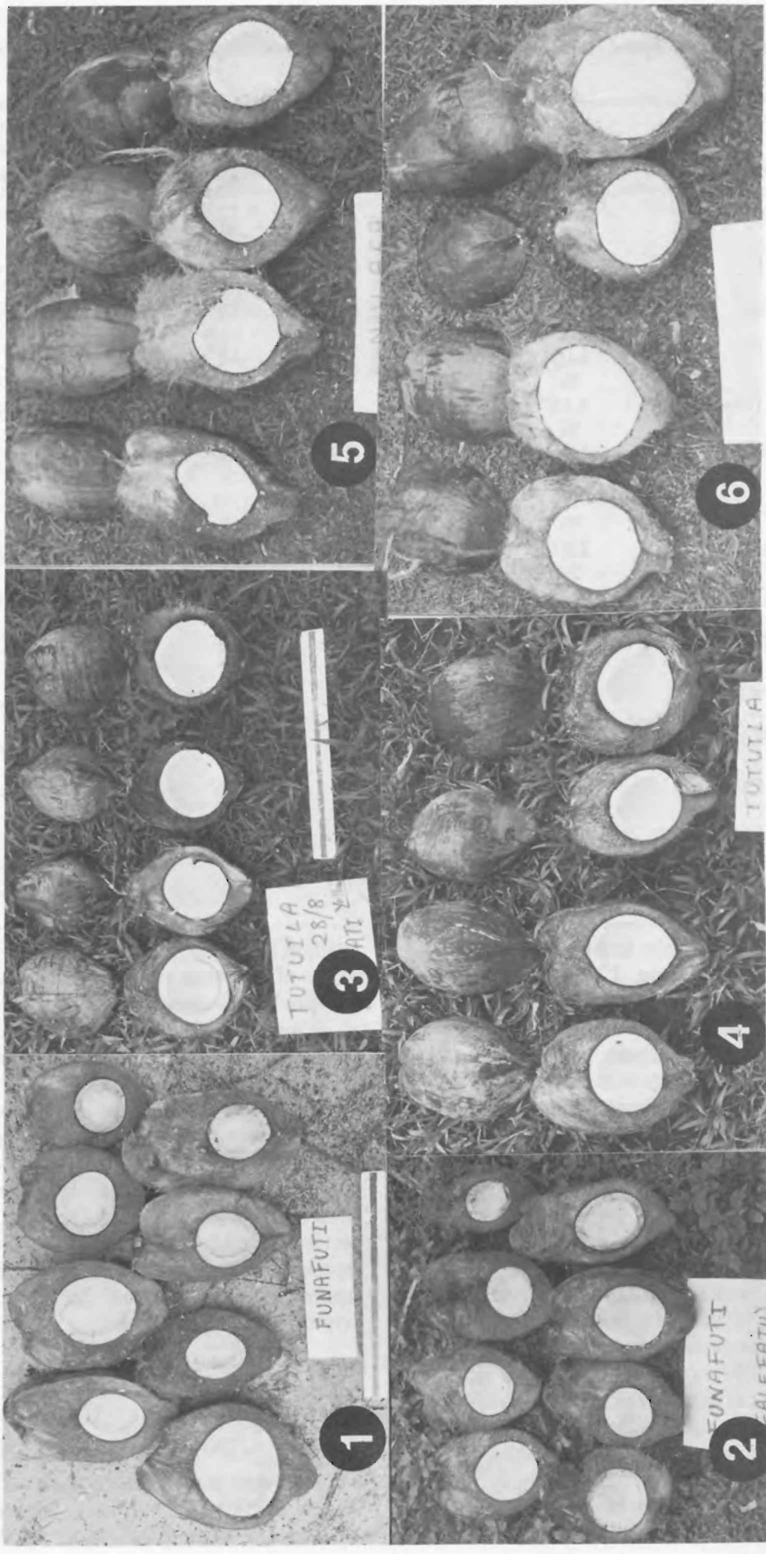
Whole mature nuts should have a long-term export future, so it is worth considering planting new material that will produce a large nut to suit this market. The Rennell palms on Funafuti have large nuts, actually being above the size range specified for Sydney. Hybrids between Rennell and Dwarf (either MRD or MYD, which are both present) should achieve an average close to the preferred size.

Another possible export market is for drinking nuts in cooled containers. The market for this product has not yet been developed in Australia, but if drinking nuts are to compete with canned drinks a volume similar to large cans would be indicated, i.e. 375 ml. This corresponds to a diameter of about 95 mm which is close to the mean of the 'wild' populations I sampled on Funafuti. Clearly there are two quite distinct sizes of nut that may be marketable. It would be worthwhile to increase the number of trees that produce nuts to meet the mature nut market, while there are many trees that already produce nuts that would suit the drinking nut market.

It must be emphasised at this point that the drinking nut market has not yet been developed in Australia and there are also many unknowns about transport and presentation of drinking nuts in an overseas market. However, in Thailand, attractively presented drinking coconuts compete directly (and sucessfully) with canned soft drinks, retailing at approximately the same price (G.J. Persley, pers. comm.)

Upolu–Western Samoa

This visit was confined to the island of Upolu on which the town of Apia is located. I was shown around the seed production operation by Mr A.


1
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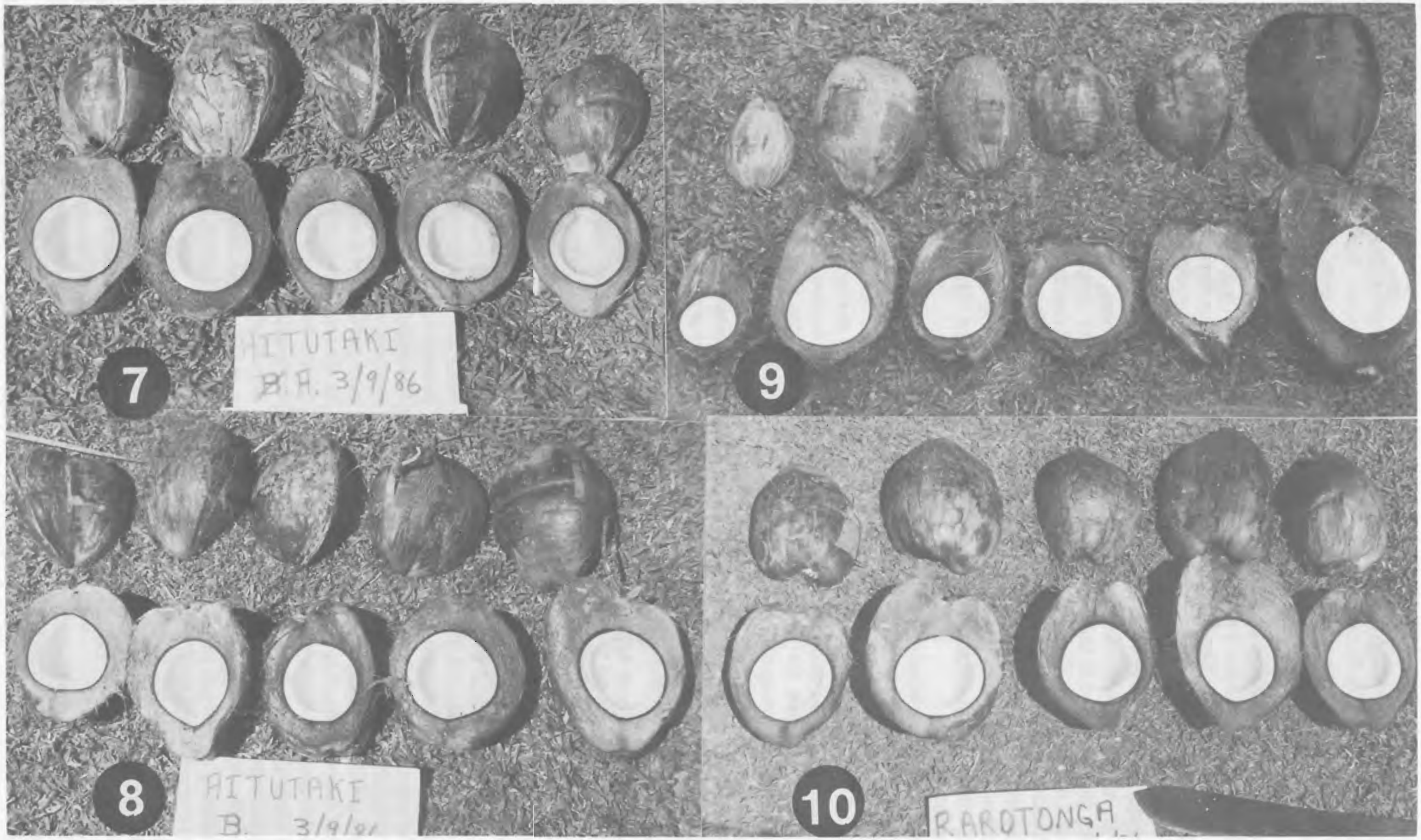

Fig. 1 Cross-section of nuts from sampled areas. 1. Vaiaku islet, Funafuti. 2. Falefatau islet, Funafuti. 3. Niu Ati cultivar from Tutuila, American Samoa. 4. Local Tall (TLT) from A. Samoa, 5. Niu Afa (SNA), Western Samoa. 6. Niu Vai (SNV), Western Samoa. 7. Cook Islands Tall (CIT) from Tapeutai, Aitutaki. 8. CIT from Akaiyami, Aitutaki. 9. Six different cultivars from Rarotonga, Cook Islands: (left to right): Niu Papua, Fiji Green Dwarf, Red Malayan Dwarf, Local Green Dwarf, Red fruited 'solid Dwarf', CIT. 10. CIT, Rarotonga. A uniform scale has been used in this figure so that direct comparison of size between cultivars can be made by eye.

Mendoza, Coconut Technical Adviser of the UNDP mission, and Mr Siaosi Efu from the Department of Agriculture, Western Samoa.

The scheme is designed to provide hybrid seed of MRD × RLT parentage. Crossing is achieved by assisted pollination following emasculation of the dwarfs. Mr Mendoza said that production had lifted markedly in the last year. The load of fruit on the dwarf mothers was large when sighted. Great care and close supervision is needed, as elsewhere in the world, to ensure that the proportion of legitimate nuts produced is at least 90%. Several other dwarf cultivars are growing close to the MRD block, comprising Niu Lea, Samoan Green Dwarf, so-called Malayan Yellow Dwarf (though this has smaller fruit and a much paler yellow colour than the MYD at Yandina, Solomon Islands) and Niu Ati, an indigenous Red Dwarf with fruit that are smaller and of different shape from the MRD.

A collection has been assembled of palms, now 10 years old, of three distinct local tall varieties, which are all different from the type grown in the extensive plantations of WESTEC (Western Samoan Trust Estates Company). These three are Niu Vai (SNV – the large 'water nut' that the Polynesian mariners reputedly carried on voyages), Niu Afa (SNA – a large elongated nut with a high proportion of fibre), and Niu Samatao (SNS), which is regarded as a superior local type for more general use, as it has a low proportion of husk. Samples of these three were taken for fruit analysis.

In Samoa hybrids of both MRD × SLT (Samoan Local Tall) and MRD × RLT have been tested for yield against SLT. The hybrids begin to bear earlier, and their copra yield exceeds 1 t/ha in the second year of production when the SLT of the same age is only just beginning to produce fruit. B.J. Leach. who worked in Samoa in the mid 1970s, was responsible for the introduction of the RLT cultivar direct from Rennell Island in the Solomon Islands. Leach was aware of the outstanding performance of the MRD × RLT hybrid in Solomon Islands and was convinced that it could perform well also in Samoa. Results to date are very encouraging. It is worth mentioning that RLT has a number of characters that contribute to its success as a hybrid parent. It is tolerant to *Brontispa*, it shows better wind resistance than other talls in the Solomons, it flowers early, and it has a large nut. The general similarity of Rennell and the Niu Vai (SNV) type is quite remarkable. The SNV may also be a suitable hybrid parent, though at present only a very limited number of palms are available, and it may well share the high susceptibility of the SLT to *Brontispa*.

The colour of the three tall cultivars sampled was 100% 'bright' green, in contrast to the SLT observed in WESTEC estates which had about 50% palms with a strong yellowish brown colour. Brown fruited SNS palms have also been reported (A.M.R. Mendoza, pers. comm.). The RLT has over 50% of yellowish brown or a strong brown colour which is a trait that distinguishes it from SNV.

It is interesting that the three special cultivars SNV, SNA and SNS are almost exclusively green. As hybrids between green and brown generally result in a light brown progeny it seems likely that Samoans have traditionally selected for the green colour as they know that it is an indication of trueness to type. This could result, however, in hybrids between SNA and SNV for instance, and the fruit analysis (Table 2) showed that this may well have happened. Two of the SNA fruit had a dehusked nut weight well within the range of the SNV nuts and the husk accounted for only 56% of whole fruit weight compared to the expected value of 70%.

Marasmiellus in Coconut Nurseries

There has been a major problem of seedling loss due to the presence of *M. inoderma* in the husk, which causes death of the sprouting seedling, often before the sprout emerges from the husk. E.H.C. McKenzie, a consultant plant pathologist, reported a number of findings in relation to this disease (McKenzie 1986b). These are: (1) No *Marasmiellus* is present in the husk of MRD × RLT hybrid seed when first harvested from the mother palms; (2) Up to 40% of nuts have *Marasmiellus* in the husk after 3 months in the nursery; (3) There is wide variation in seedling loss between cultivars and hybrids – MYD × RLT is more susceptible than MRD × RLT, while SLT is least affected; (4) Seed nuts that are set vertically in the prenursery do better, possibly because there is freer penetration of water to the sprout before it emerges from the husk (Mr Mendoza reported that *Marasmiellus* is less of a problem if the prenursery is irrigated regularly); (5) The success in Malaysia in reducing *Marasmiellus* damage in the nursery with fungicides indicates a need to try this approach. (In Solomon Islands following an outbreak of disease associated with *M. cocophilus* in 1979 there has been no further problem following increased general care and cleanliness in nursery management.The predisposing cause of the original outbreak in the Solomons remains a matter for conjecture (McKenzie 1986a).)

Tutuila–American Samoa

There is no coconut export industry on Tutuila but there are coconut palms growing throughout the residential settlements which are widely dispersed around the island. Fresh mature coconuts are sold at the Pago Pago market and are widely used by householders in cooking and to provide sauce.

The same range of coconut cultivars appears to be present on Tutuila as in Western Samoa except for the small-fruited pale Green Dwarf. Both SNA and SNV were seen in the settlements and there appear to be some hybrids between dwarf and tall, bearing small light brown fruit and having little bole development on an otherwise robust trunk with very close leaf scars. The predominant fruit colour in Tutuila Local Tall (TLT) is medium brown and the crown is generally lax with leaflets well separated. The Samoan Yellow Dwarfs (SYD) had a distinct yellow colour in contrast to the pale greenish yellow fruit on the 'yellow' dwarfs of Western Samoa.

The leaf beetle *Brontispa longissima* was accidentally introduced into American Samoa about 10 years ago. *Tetrastichus brontispae,* a parasite of *Brontispa,* has been released on the island, but its effect on the pest is not yet apparent. There is evidence that the parasite has become established (A.M. Vargo, pers. comm.). MRD, Niu Ati and SYD may have some field resistance to *Brontispa*. RLT and MRD × RLT hybrids show resistance in the Solomon Islands. The Department of Agriculture recently imported some hundreds of MRD × RLT hybrid seeds from Western Samoa, so the opportunity to observe resistance to *Brontispa* is at hand. In view of the problem experienced in Western Samoa with *Marasmiellus* in seednuts in the prenursery, it would be a useful trial if half the MRD × RLT seed was treated by having a piece of husk sliced off above the position of the germ pore. As this aids both penetration of water and emergence of the sprout (Kenman 1973), being standard practice in prenurseries in Solomon Islands and Vanuatu, it may reduce *Marasmiellus* damage.

Metarrhvzium anisopliae fungus has been sprayed on *Brontispa*-infested palms in the hope of obtaining control, but there are no data to indicate any effect. Waterhouse and Norris (1987) report that an *Agonoxena* pupal parasite had been introduced from American Samoa to Hawaii. The *Agonoxena* damage in American Samoa is more severe than any that I have observed in this survey, including Vanuatu, Solomon Islands, Tuvalu, and Western Samoa.

My attention was drawn to some yellow patches on coconut fronds located within 1–2 m of high voltage power lines. The same effect had also been shown to me on Upolu by Mr Mendoza. Either the fluctuating electric field associated with AC power or the transmission of current if the fronds touched the power line could possibly cause such damage.

Rarotonga and Aitutaki-Cook Islands

Rarotonga is densely populated and the majority of coconut palms are grown by homeowners for household use. It is therefore difficult to identify a 'Local Tall' as home gardeners have shown the same desire for exotic characters in coconut as in ornamental flowers and shrubs.

There was some plantation development on Rarotonga at the beginning of the 20th century and a few remnants of this period remain. Possibly the oldest coconut palms in the South Pacific are found on Rarotonga. Red dwarf seed nuts were brought from Papua a long time ago and all red-fruited dwarfs are known as Niu Papua. In fact MRD was introduced from Fiji around 1948 (W. Hosking Sr, pers. comm.) and as the difference from Niu Papua is discernible only to an experienced observer this cultivar is lumped into the Niu Papua group by palm owners. Whitehead (1966) reported that a similar red dwarf in French Polynesia was called Haari Papua due to its Papuan origin.

A unique type of 'solid' dwarf palm has become widespread as a result of the preference of home planters. This type has an extremely thick trunk (diameter 300–350 mm at 2 m height compared to 200–250 mm for MRD or Niu Papua) with small to moderate bole development. The crown is large and compact, with medium-sized nuts of light brown or green colour, with only a small proportion having orange fruit. This type of palm is reputed to have come from a single original parent at the Arorangi CICC mission house. That palm is now quite old but it has the general appearance of a hybrid between a dwarf and tall parent. The trunk lacks a pronounced bole, and the leaf scars are quite close together. Progeny from this palm at the mission showed considerable variation in bole character but were uniformly thick in the trunk higher up, and had close leaf scars. Some progeny had orange fruit. Such a thick trunk is not generally seen in MRD × tall hybrids in other countries. Perhaps it is produced by a cross between Niu Papua and the Rarotonga Tall. Certainly the old talls around the western and southern sides of the island possessed thicker trunks than is common in talls in other parts of the South Pacific. Whereas a diameter of 300 mm is common among talls many on Rarotonga exceeded 400 mm and the largest one measured was 500 mm.

The speculation about the origin of the robust dwarf type is complicated by the presence of a small number of Niu Leka type palms. There is no local knowledge of the introduction of Niu Leka, and this type may indeed be indigenous. Niu Leka characteristics in the Fiji Hybrid Dwarfs at Yandina (Solomon Islands) include some thick trunks, but nothing quite like those seen on Rarotonga.

On Aitutaki the same mix of palm types was found as on Rarotonga, including one Niu Papua type which had pale green nuts that turned yellow just before maturing. Inquiries about the origin of any 'solid' dwarf palms invariably showed that they originated from Rarotonga.

Sampling and measurement were done on some of the motus or islets of Aitutaki where soil conditions were very similar to the islets of Funafuti. However, the climate of Aitutaki (see Table 1) is cooler (mean annual temperature of 25.7°C) and drier (mean annual rainfall of 1890 mm). There was a large difference in palm health and productivity on different motus. Where the land area was small the palms were unproductive and showed signs of mineral deficiency and of water stress. On the one large motu visited (Akaiyami), the palms were very robust and productive and did not differ much in appearance from those on the main island of Aitutaki which is elevated, or from Rarotonga. The fruit analysis (Table 2) showed that there was close similarity between the Rarotonga and Aitutaki Tall cultivars. The main difference was in meat weight which reflected meat thickness, a trait that is quite sensitive to nutrient deficiency.

Seed nuts have been collected for local replanting from high-yielding palms of good appearance on Aitutaki. The superiority of these palms is likely to be due to environment, however, and therefore not transmissible to any progeny.

There are sufficient Malayan Red Dwarfs on both Rarotonga and Aitutaki for the small-scale production of dwarf × tall hybrids using simple emasculation of the dwarf palms. Hybrid seed could be used in demonstration plots to assess the performance of MRD × CIT hybrid in different environments.

Adaptation to Cool Conditions

The productivity of the coconut palms on Rarotonga was high, especially in view of the mean annual temperature of 23.9°C. It appears that soil conditions are favourable for the supply of both nutrients and water. The soil is generally recent volcanic of good depth. The one area on Rarotonga where there was coralline soil, at the eastern end, carried impoverished palms.

A trial was proposed that would compare the growth of Rarotonga Tall and Puka Puka Tall. The latter is from an atoll in the Northern Cooks (lat 10°S) where the mean annual temperature is around 27°C (Table 1). A comparison of leaf growth in midsummer and midwinter for 2 years of these two cultivars, would give an indication of any difference in response to low temperature. The mean temperature on Rarotonga in July is 21.9°C which is close to the proposed lower limit for productive growth of 21°C (Foale 1986). There were no reports, and certainly no indication from the appearance of the palms, that production of nuts slows down in the winter season.

The large trunk diameter of the CIT palm is an interesting trait. There is the possibility that the local environment favours such a trunk but there is nothing unusual about the trunk development of the MRD palms. Possibly the CIT has a genetic character for robustness which combines with the dwarf character of Niu Papua or Niu Leka to give the unique 'solid' dwarf type described above.

The CIT would be an interesting type to introduce to other countries for comparison. If robustness is indeed of genetic origin this trait may be useful in developing palms that tolerate strong wind.

The Cook Islands are free of most serious insect pests, though *Graffea* (stick insect) is present on most islands and a termite is present on three of the atolls of the Northern Cook Islands. Some nuts were observed with 'abrasions' or rough patches on the surface. Dr Peter Madison of the Department of Scientific and Industrial Research, Auckland, suggested that this may be due to mites which are known to cause similar damage in other countries (Moore 1986). Some nuts showed distortion and appeared to be undersized because of this damage, so the situation should be studied closely.

Coconut Fruit Composition

Data were obtained in Solomon Islands, Tuvalu, Western Samoa, American Samoa, and Cook Islands. The method followed closely that used by R.A. Whitehead in the Pacific in 1964, and later by many other workers, as reported by Harries (1978). Briefly the method is to collect one nut per palm at a 'half ripe' stage, when the fresh colour of the fruit has become brown on about 50% of its surface. The fresh weights of the whole fruit and its four components are then obtained, as well as the thickness of the meat. As there is interest in alternative uses for coconuts besides copra production, the diameter of the nut was also measured. This is relevant to quality and transport of both drinking and mature nuts. Mean values for weight, percentage of components, and the two linear measurements of 15 samples are presented in Table 2.

Husk Content

There is a large range of nut weight between the Niu Vai at the upper extreme and the Niu Ati at the lower end of the range. The mean weight for Niu Vai of 3.53 kg is the highest that has been published. This remarkable cultivar is planted commonly around settlements in Samoa and Tonga and the large nut character has been preserved in spite of natural cross-pollination. Possibly the bright green colour invariably associated with Niu Vai is used as a marker to eliminate out-crossed progeny at the seedling stage.

Apart from the weight extremes many of the cultivars fall within a moderate range but exhibit large differences in proportion of husk. In the middle of the range there are four tall cultivars, from Sri Lanka, American Samoa and both samples from the Cook Islands. These show close similarity to the data for Sri Lanka and Samoa published by Harries (1978) and may be described as cultivars showing introgression between the two extremes of husk content. Cultivar 1 from Vanikoro in the Solomons differs in size rather than type from these intermediate types and is similar to other Solomons material. The Christmas Island sample was comparable in mean weight but showed a higher husk content than these four and resembles Rangiroa in Harries' data.

Cultivars 4 and 6, from Kiribati and Tuvalu, are similar to each other, having a low weight and a high proportion of husk. There is little sign of introgression as perhaps the original inhabitants of these islands did not have access to domesticated coconut types to plant alongside the wild populations that were present before the atolls were settled. They are similar to some of Harries' (1978) data for Seychelles and India.

Cultivar 5 is the only 'man-made' type present, being a hybrid between MRD and Rennell Tall. After allowing for dry husk this would still stand at the extreme low end of the range for husk content in talls, though Harries (1978) shows data for some dwarfs with a similar size and husk percentage.

The three small-fruited dwarfs (11, 14 and 15) fall within the range for similar domestic dwarfs in many other parts of the world.

Meat Content

The 'meat' column in Table 2 shows the fresh meat weight and its percentage of whole nut weight and whole nut less water (in parentheses). A high absolute value for meat weight is desirable for industrial processing as handling costs are less. From the point of view of productivity, however, the percentage of meat in the non-liquid parts of the nut gives an indication of the partitioning of dry matter to the usable component. On this count the hybrid is greatly superior at 44%, while the Kiribati and Tuvalu 'primitive' type shows the opposite extreme at 23%.

Size of Nut

Nut diameter is of interest in relation to whole-nut markets. Large nuts, of uniform size, are preferred for mature nut sales so that the customer becomes familiar with the quantity of milk or cream that can be obtained. The preferred size for the Australian market is 113–127 mm diameter, but nuts slightly larger or smaller can be found in the shops. Nuts for drinking should also be graded, to match particular quantities of liquid that are familiar to drinkers of canned drinks. For example 375 ml is a common can size and this corresponds to a spherical nut 95 mm in diameter, with 3 mm shell thickness. If some meat has already formed the quantity of liquid will be reduced accordingly. From Table 2 it appears that the dwarfs and the Tuvalu nuts have the right size for sale as drinking nuts. Pacific Islanders have traditionally used dwarfs, which are grown around their villages, as the main source of drinking nuts, while the SNV type was, where available, reserved for sea voyages.

Other Palm Characters

Other observations made on the cultivars listed included general morphology of trunk and crown, fruit colour, and leaf type in seedlings (where possible). The Tuvalu cultivar had a hemispherical crown with 24–28 leaves under good conditions. The majority of palms carried pale green fruit with about 25% carrying pale to medium brown fruit, as also in the Cook Islands. The three Samoan cultivars SNV, SNA and SNS all carried green fruit as mentioned above. In both Samoas, and even more so in the Cook Islands, tall palms had quite robust trunks. It is not clear whether this character is associated with environment (particularly the volcanic soil was common to all three places) or to genotype. Observations of these cultivars alongside introduced material would provide an answer.

There were many apparent hybrids between talls and dwarfs and later progeny from such hybrids in the Cook Islands. These had distinctive 'solid' trunks with little bole and a tendency for the trunk diameter to remain unchanged up to several metres in height. Some palms of this type were also present in American Samoa, but the presence of the Niu Leka type (which is a distinct green-fruited dwarf that has a bole and very narrow leaf scars) confused the situation.

Possible Value of Surveyed Cultivars in Coconut Improvement

The general principles of breeding coconuts for high yield are outlined by Nuce de Lamothe et al. (1980). Experience has shown that the best crosses are between cultivars that are unrelated and have complementary characteristics. Harries (1978) used fruit composition as an indication of difference between coconut types based on their dissemination and degree of 'selection under cultivation' by people.

It may be concluded therefore that the extreme types shown in Table 2 would be worth collecting for use in breeding, specifically, cultivars 4/6 (Tuvalu/Kiribati), 7 (SNV), 8 (SNA) and 9 (SNS), and perhaps 12/13 (CIT) as representative of the large intermediate group. Cultivar 11 (Niu Ati Yellow) and its pale green variant would also be of potential value. Niu Papua (15) and MRD (14) are both widely distributed in Papua New Guinea already.

Attention must also be paid to other characters such as the robust trunk of the CIT with its potential for wind resistance. It is unlikely, on the other hand that CIT or Kiribati/Tuvalu possess resistance to such pests as *Brontispa* and *Scapanes* to which they have not been exposed. The Kiribati may possess some drought tolerance while the Tuvalu probably does not.

A large program of testing many crosses between coconut cultivars of diverse type and origin will be required to assess the transmission of desired traits to the hybrid progeny. The first task is to assemble as much genetic material as possible into a collection where the expression of useful traits can be thoroughly assessed. In the short term the most useful crosses are likely to be dwarf × tall but in the long term traits such as a specific size of nut, resistance to pests, diseases, drought or wind, and special qualities such as meat or water flavour will require attention.

Marketing Prospects For Coconut Products

Coconut products in the South Pacific have for over 100 years been marketed at two levels, industrial and domestic. The industrial products include copra and coconut oil and goods manufactured from oil, principally soap. In recent years there has also been diversification in a small number of countries into the edible products, desiccated coconut and coconut cream. The domestic market is for fresh mature nuts which are used widely in the kitchens of Melanesia and Polynesia to make coconut milk and coconut cream and sauce for immediate use. There is also widespread use of fresh immature coconuts for drinking, especially on atolls but also in coastal villages on high islands. Mature and immature coconuts are available in local markets all over the Pacific.

The future of coconut oil on the world vegetable oil markets is uncertain. Apart from a temporary shortage of oils in 1983–1984 there has generally been a decline in demand for coconut oil.

The recent diversion of cereal-growing land in Europe to annual oilseed crops has further dampened demand for vegetable oil in world trade. This indicates that the future for coconut products must lie in expansion of the market for both whole nuts and value-added coconut products.

Whole Nut Market

Coconut is a traditional food source throughout the Pacific, ranging in importance from vital, on the atolls, to important, in the coastal villages of Polynesia and Melanesia, to marginal in the interiors of high islands. In recent years exotic foods and drinks have become popular, especially in urbanised areas, at the expense of coconut sources.

A well-presented marketing campaign that emphasised eating and drinking 'local' products should boost the market for whole nuts quite rapidly. It is a sad irony to see young atoll-dwellers consuming imported canned drinks while coconuts fall unwanted to the ground, and while there is a need perceived by national leaders to develop new coconut exports. Reaffirmation of the nutritional value of fresh and mature nuts, and the fostering of pride in this bountiful natural resource, might rekindle the interest of the younger people in coconut.

There is a market for fresh mature nuts overseas, for example in New Zealand and Australia. This relies on the needs of expatriate Pacific Islanders, especially in New Zealand, but there is also a novelty market among the general population. This interest could well expand with vigorous promotion and education in both the uses of coconut and in the techniques of making milk and cream from whole nuts. The export of canned coconut cream from Niue, Western Samoa and Cook Islands to New Zealand has dampened demand for whole nuts from the people of island background.

Whole immature nuts for drinking is virtually an unexplored market overseas. Even at the local level drinking nuts are available only on a limited scale and much could be done to promote them as an alternative to canned soft drinks. Research would be needed on preservation and transport before any marketing could be attempted in urbanised countries.

Industrial Products

Coconut oil is extracted, at least on a small scale, in practically all Pacific countries. This is being used for soap manufacture and an attempt is being made in the Cook Islands to produce oil of cooking quality. Small quantities of oil are marketed for cosmetic use in most countries. Local self-sufficiency in all products that are derived from coconut oil should be a basic objective, but this would still leave a great surplus of productive capacity for which uses need to be found.

Diversification of Food Products Based on Fresh Coconut

A wide variety of coconut products is produced in many countries, notably Brazil and the Philippines. Sweet products containing desiccated coconut are universally popular. Local manufacture of desiccated coconut for direct export and for incorporation into other sweets should be possible in most countries. The Pacific Islands generally have the advantage of relatively low wages to make their products competitive. They have the disadvantage that few workers currently possess the technical and managerial skills needed to sustain small manufacturing enterprises.

Specialty Food and Drinks

In Polynesia and Micronesia coconut is often consumed in the form of 'utu,' which is the germinated nut with its cavity filled with the utu or haustorium. The utu is eaten direct or used to make a drink after blending and mixing with water. The meat from such nuts has a quite distinct flavour which is also enjoyed. It should be possible to grow utu from imported mature nuts in New Zealand and Australia, to meet the likely limited demand. Quarantine regulations would probably prevent utu itself from being imported.

In Kiribati and Tuvalu toddy is obtained by tapping the sheath of the unopened inflorescence. This is an important part of the diet of atoll dwellers and the possibility of selling toddy overseas has been raised. A great deal of promotion would be needed to arouse the interest of others besides expatriates from Tuvalu and Kiribati.

Coconut Oil as Fuel

The current price level of petroleum fuels does not encourage interest in vegetable oil alternatives. As cheap oil will not be available indefinitely knowledge should be acquired about fuel derived from coconut oil. The process of esterification, which requires equipment and skill readily acquired by small Pacific countries, converts coconut oil to a product that can be directly substituted for diesel fuel. This offers the possibility of operating stationary generators and other motors including local shipping, on home-manufactured fuel.

Other Products

There are many other possible coconut-derived products which could be manufactured and marketed on a limited scale. These include timber from the trunks of redundant palms, ropes and mats derived from coconut fibre, and curios for the tourist trade. The ingenuity and energy of the peoples of the Pacific will be evident wherever marketing opportunities arise.

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Appendix A

Itinerary and Contacts

The centres visited were Santo (Vanuatu), Honiara and Yandina (Solomon Islands), Suva (Fiji), Funafuti (Tuvalu), Apia (Western Samoa), Pago Pago (American Samoa), Rarotonga and Aitutaki (Cook Islands), and Auckland (New Zealand).

Itinerary

Santo, Vanuatu (4–8 August 1986) was the venue for a meeting of the IRETA (Institute for Research, Education and Training in Agriculture) on coconut matters. The Director of IRETA, Dr L. Fernando, convened the meeting which was held at the IRHO station and was attended by delegates from many South Pacific countries and by members of the Agriculture School of the University of the South Pacific, Alafua, Western Samoa. The IRHO group was led by Dr M. de Nuce de Lamothe, Director of the Coconut Section of the IRHO, assisted by Mr C. Calvez, Director of the Santo station.

In Solomon Islands (11–13 August 1986) I was accompanied by Mr J.B. Abington, Chief Research Officer. Discussions were held with Mr A. Leng, Director of Research, and Mr C. Chorlton, Managing Director of Levers Solomons Ltd., at Yandina. In Honiara I reported my impressions to Mr B.C.G. Smith, Undersecretary for Agriculture.

In Suva, Fiji (14–17 August 1986) I discussed plans for coconut development with Mr R. Manciot, former Director of the IRHO in Santo (1962–75), and Mr Jamil Martin, both based at the Agriculture Research Station, Koronivia.

In Funafuti, Tuvalu (18–22 August 1986) I was given facilities for field work by Mr F. Pullen, Agricultural Officer. Assistance was given by Mr Tavau Teii for the collection and analysis of nut samples.

In Apia, Western Samoa (24–26 August 1986) Mr A. Mendoza, Director of the seed production program and Mr Siosi Efu showed me the seed garden for which they are responsible. Discussions were also held with Mr A.S. Aveau, Assistant Director (Planning and Research) of the Department of Agriculture, Forests and Fisheries, and with Mr K. Newton, leader of the Cocoa Development Project.

In American Samoa (26–29 August 1986) I was assisted in field work by Mr Sipaia Fatuesi, and in general arrangements by Mr Sene Porotesano, both of the Department of Agriculture. I had discussions with Mr Maluia, Deputy Director of Agriculture.

In Cook Islands (1–6 September 1986) I was assisted on Rarotonga by Messrs M. Purea and T. Mateora, and on Aitutaki by Mr J. Jessy. I had discussions with Mr W. Hosking, Secretary of the Ministry of Agriculture, and Mr F. Charlie, Chief Agricultural Officer on Aitutaki.

In Auckland, New Zealand (7 September 1986) I had discussions with Drs E.H.C. McKenzie (pathologist), P. Madison (entomologist), and R. Fullerton, of the Department of Scientific and Industrial Research, all of whom have worked in the South Pacific.

Appendix B

Summary of Tall and Dwarf Cultivars at Yandina

Talls. Introduced during the operation of the JCRS: Markham Valley; Rotuma; Sri Lanka; Christmas Island; Kiribati (Tarawa); Vanikoro; Polynesian (Rangiroa); Rennell. Also present: Malaysian – known as FMS, mostly crossed to an unknown extent with Solomon Islands); Solomon Islands; Samoan.

Dwarfs. Red Malayan Dwarf, three origins – Kira Kira, Kukum (Guadalcanal) and direct from Malaysia; Yellow Malayan Dwarf; Green Malayan Dwarf; Local Dwarf (Faiami); Spicata Dwarf; Niu Leka. There are also progenies (F_3) of the Fiji Hybrid Dwarfs (F_2) planted at Banika in 1956.

Other material. There are many palms (listed elsewhere) derived from artificial pollination using imported and local pollen. In addition there is one Makapuno palm* (No. 28/17 in Banika 9), and a few Spicata Rennell palms. Spicata is a character that could be of value in mother palms in seed gardens as they require minimal emasculation. The factor apparently has a simple dominant inheritance, however, so either 50 or 100% of the progeny from any individual would exhibit the Spicata character. The effect of the unbranched inflorescence on potential yield is not known.

*Makapuno nuts contain a soft jelly with a pleasant 'coconut' flavour. They are much sought-after in the Philippines for the production of ice cream and candy.

ACIAR Technical Reports

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