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INTRODUCTION OF FRUIT AND NUT TREES TO ATOLL COUNTRIES

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ABSTRACT

An assessment has been made of fruit and nut trees with potential for atolls of five Pacific Island countries. This study involved visits to the Cook Islands, the Federated States of Micronesia, Kiribati, Marshall Islands and Tuvalu, to observe those species presently grown, as well as consideration of atoll soils, salinity factors, climate patterns, and fruit and nut tree species reported from atolls elsewhere in the world. Those grown with success in the Caribbean and the Maldives were identified.

Special mention is made of the diseases of banana in atoll countries and, in particular, the impact of black Sigatoka disease on the varieties grown, their frequency and distribution. Characteristics of varieties resistant to black Sigatoka are noted, and some are recommended for importation and testing.

Several factors need to be considered before introductions of fruit and nut trees are made. These concern the quarantine regulations controlling plant importations, delays that may occur in transit to isolated destinations, the lack of propagation facilities and inadequate potting mixtures. Because of these problems, most introductions should be made from nurseries in Australia and, except for a few importations of clonal material to Pohnpei, importations should be made as seeds. A list of species recommended for testing on atolls is provided.

RÉSUMÉ

Il a été procédé à une évaluation des arbres fruitiers et nucifères présentant un intérêt pour les atolls de cinq pays insulaires du Pacifique, à savoir les Îles Cook, les États fédérés de Micronésie, Kiribati, les Îles Marshall et Tuvalu, où des missions ont été conduites afin d'observer les espèces cultivées et d'examiner les sols, les facteurs de salinité et les conditions climatiques caractéristiques de ces atolls. Les espèces d'arbres fruitiers et nucifères cultivées sur des atolls dans d'autres régions du monde ont été étudiées, et celles qui poussent bien aux Caraïbes et aux Maldives ont été identifiées.

Une attention particulière est accordée aux maladies de la banane dans les atolls, et notamment à l'incidence de la cercosporiose (maladie de Sigatoka) sur les espèces cultivées, à la fréquence et à la répartition de cette maladie. Les caractéristiques des variétés résistantes ont été enregistrées, et il a été recommandé d'en importer certaines afin de procéder à des essais.

Il faut prêter attention à plusieurs facteurs avant d'introduire des arbres fruitiers et nucifères. Il s'agit notamment des réglementations phytosanitaires applicables aux importations de végétaux, des retards qui peuvent intervenir dans le transport vers des destinations isolées, de l'insuffisance de matériel de multiplication et du manque de bonne terre. Pour toutes ces raisons, la plupart de ces arbres doivent d'abord être élevés en pépinière en Australie et, à part quelques importations de matériel de clonage à Pohnpei, il convient d'importer des graines. On trouvera également une liste des espèces que l'on recommande d'introduire à titre d'essai sur les atolls.

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I am grateful for the assistance and hospitality provided by officers of the governments and other institutions of Cook Islands, Federated States of Micronesia (National and State), Kiribati, Marshall Islands, Tokelau and Tuvalu.

I would also like to acknowledge the assistance provided by Dr G. Jackson and other staff of the Plant Protection Service, South Pacific Commission, Fiji; Mr J. Liew, Project Coordinator, UNDP/OPS Integrated Atoll Development Project; staff of the University of the South Pacific in Fiji and Western Samoa; and organisers and participants of the International Conference on Developing Agricultural Research Programmes for the Atolls, Pacific Harbour, Fiji, November 1990.

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1. INTRODUCTION

1.1 Background

In recent years a characteristic trend in atoll societies has been a shift from traditional foods to those high in starch, sugar and fat, and low in fibre and vitamins. This has led to nutritionally-related diseases, of which diabetes, coronary thrombosis and xerophthalmia (night blindness) have reached epidemic proportions.

In recognition of this problem, the introduction of fruit and nut trees is considered important, as it could make a substantial contribution to dietary improvement. Coralline soils are, however, a limiting factor in fruit and nut tree production; many species which thrive on high islands with soils of volcanic origin cannot tolerate the high pH of the atolls. It is for this reason that few species are present.

The South Pacific Commission (SPC) Plant Protection Service has until now concentrated on the safe transfer of elite root crops, banana and vanilla because of the special quarantine difficulties associated with the international movement of these crops. This present project, to introduce and test new species of fruit and nut trees that might have potential in Micronesia, is seen as a logical extension of this work.

In recognition of the problems that exist, the SPC and the United Nations Development Programme/Office of Special Services Integrated Atoll Development Project (UNDP/OPS) obtained support from the AIDAB[1]/UNDP Trust Fund for Pacific Island Countries in 1990 for a project entitled 'Introduction of Fruit and Nut Trees to Atoll Countries'. This project had four components: the identification of exotic (and indigenous) species likely to thrive in atoll environments; the supply of material from nurseries in Australia to communities in selected atolls; training of local staff in the handling and care of imported germplasm; and exchange of experiences between horticulturists in participating countries. This report documents the results of the first part of the project, the identification of exotic species for introduction. The work was carried out by Mr Brian Watson, Manager, Kamerunga Horticultural Research Station, Redlynch, Queensland.

1.2 Terms of reference

The consultant visited five of the six participating countries and territory—Cook Islands, Federated States of Micronesia (FSM), Kiribati, Marshall Islands and Tuvalu—from 22 October to 23 November 1990. Representatives from Tokelau were met in Western Samoa.

The consultant was requested to:

- report on the status of existing fruit and nut trees in the six atoll countries and territories;
- report on the capacity of the departments of agriculture to successfully receive, propagate and disseminate fruit and nut tree material;
- report on species and varieties of fruit and nut trees which might be successfully established on the coralline soils of the atolls.

1.3 Itinerary and persons met

23 October	Discussions with Dr G. Jackson, Plant Health Officer, SPC; Mr J. Liew, Project Coordinator, UNDP Integrated Atoll Development Project; and University of the South Pacific (USP) staff, Suva
24–26 October	Travel to Yap, FSM
26–27 October	Discussions with Mr K. L. Karmacharya and Mr J. Hanoliao, UN Volunteers; Mr F. Matearíki, UNDP/OPS consultant; and the following officers of the Yap State Government: Mr P. Sogaw, Plant Quarantine & Protection Service; Mr H. Ducai, Chief of Agriculture; Mr J. Solith, Chief of Planning; Mr P. Taweripry, Outer Island Agricultural Co-ordinating Officer; Mr J. Gajdusek, Deputy Director, Department of Resources and Development; and Mrs. M. Falanruw, Yap Institute of Natural Science

[1] Now known as AusAID, Australian Agency for International Development

28–31 October	Pohnpei, FSM. Discussions with Mr A. Lorens, Chief, and Mr K. Hadley, Extension Agent, Division of Agriculture, Pohnpei State Government; Mr S. Henry, Administrator, Division of Agriculture, Department of Resources and Development, FSM National Government; Mr P. Shrestha, UN Volunteer Agronomist; Mr W. Raynor, College of Micronesia; Mr B. Weilbacher, Director of Conservation and Resource Surveillance, Pohnpei State Government; Father E. Soucie, Pohnpei Agricultural Trade School
1–2 November	Majuro, Marshall Islands. Discussions with Mr D. Garel, Chief of Agriculture, and Mr J. Joseph, Director of Agriculture, Division of Agriculture; Mr Chang-Ta-Chang, Director, Taiwan (ROC) Agricultural Technical Mission
2–6 November	Tarawa, Kiribati. Discussions with Mr R. Teaotai, Chief Agricultural Officer, Division of Agriculture; Mr S. Edwards, Coconut Agronomist, Division of Agriculture
7–8 November	Funafuti, Tuvalu. Discussions with Mr S. Seluka, Agricultural Officer, Department of Agriculture
11–14 November	Rarotonga, Cook Islands. Discussions with Mr W. Hosking, Secretary, Ministry of Agriculture; Mr P. Joseph, Plant Protection Officer; Mr P. Samuel, Chief Quarantine Officer; Mr R. Bobier, UN Volunteer, Ministry of Internal Affairs; Mr A. Ryan, Ministry of Planning (Northern Group Development)
16–18 November	Apia, Western Samoa. Discussions with Mr K. Kirifi, Agricultural Officer, Department of Agriculture and Fisheries; Mr J. Campbell, UNDP/FAO Fruit Development Project, Mr S. Aveau, Assistant Director, Department of Agriculture; and staff of the Office for Tokelau Affairs
19–23 November	Suva, Fiji. Discussions with Mr J. Liew, Project Coordinator, UNDP/OPS; Dr G. Jackson, SPC; and attendance and presentation of findings of country visits at the International Conference on Developing Agricultural Research Programmes for the Atolls at Pacific Harbour
23 November	Return to Cairns

2. SUMMARY OF RECOMMENDATIONS

There are few fruit and nut species that are suitable for the atolls, and much research will be required to ensure that potential candidates are well tested before wide-scale distribution. For the present, the task is to ensure that consignments from overseas are safely imported, and this a complex process with both logistical and quarantine implications.

There is a lack of propagation facilities and suitable potting medium in all countries. There is also little experience in clonal propagation within the departments of agriculture or elsewhere.

It is recommended that training under the project should be done within the region in order to increase the number of participants. This, and the inclusion of people from the private sector, will promote the chance of sustaining plant propagation over the long term. The topics covered by the training should be general plant care, raising plants from seed, and understanding techniques of sexual plant propagation.

For the present programme of importations, it is recommended that they be confined to seed. The reasons for this are:

- To enable government institutions, and the private sector, to become familiar with the crops and learn best cultural practices;
- To determine the species suitable for atolls as quickly as possible;
- To facilitate the ease of transfer of large amounts of germplasm.

For the existing atoll crops of banana, pandanus, papaya and breadfruit, it is recommended that there be immediate action to organise a wider distribution of existing clones, and that some additional varieties be imported. Only banana requires substantial imports from outside the region; for this crop, importations should be made as pathogen-tested plantlets growing in tissue culture.

3. COLLABORATION WITH PARTICIPATING COUNTRIES

The views of countries were obtained on the appropriateness of the project aims and on whether or not they wished to participate in the project's activities.

3. 1 Cook Islands

Mr W. Hosking, Secretary, Ministry of Agriculture, said that the northern atoll group inhabitants were enthusiastic about increasing fruit and nut species, and quite a number had been introduced in the past. Puka Puka residents are particularly active in this regard. Mr Tiara Mataroa, an agricultural officer previously stationed on Puka Puka, and currently studying at USP, was identified as a possible propagation trainee.

Mr A. Ryan, Ministry of Planning, said that the Cook Islands Government was actively soliciting projects for the northern atoll group and would be prepared to recommend support for the fruit and nut tree project.

3.2 Federated States of Micronesia

3.2.1 Yap State

Officials in Yap State indicated that the inhabitants of the atolls were keen to be involved in the development of new fruit and nut species and in improving the performance of existing crops. However, the nursery infrastructure and organisation of the Agriculture Division is such that it may be very difficult to arrange imports with a fair probability of success. This may be additionally difficult when the UN Volunteers, Messrs Karmacharya and Hanoliao, finish their contracts.

On the other hand, it may be possible to make arrangements through the Yap Institute of Natural Science. Mrs M. Falanruw is keen to assist in propagation schemes for the atolls, and has a propagation house plus imported potting materials.

3.2.2 Pohnpei State

The Chief of Agriculture, Mr A. Lorens, was enthusiastic about the project and offered propagation facilities for materials destined for the atolls.

The skill levels at the State nursery are reasonably high. Pohnpei staff were also interested in improved clonal material of rambutan, carambola and some other species. Mr W. Raynor, College of Micronesia, also offered assistance via his agroforestry programme, but there is no guarantee of sustained involvement.

3.3 Kiribati

Kiribati has a reasonable history of plant introductions through projects supported by the British Development Division and USP. However, nursery infrastructure does require upgrading. The Chief Agricultural Officer, Mr R. Teaotai, is keen to see further development of fruit tree species for the atolls. Mr Ione, an officer from the department, was recommended for training in propagation techniques

3.4 Marshall Islands

All discussion was through Mr D. Garel, Chief of Agriculture, who said that there was strong interest in the project, from both the people and the Government. However, nurseries are not well developed and local expertise in handling fruit trees is not good. Mr Garel said he has applied for funds for fruit-tree importation and these are assured.

3.5 Tokelau

Unfortunately Mr Foua Toloa, Director, Department of Agriculture and Fisheries, Office for Tokelau Affairs, was not available for discussions. From the opinion of junior staff, there is interest in introducing more fruit and nut species to the atolls.

3.6 Tuvalu

The Agricultural Officer, Mr Seluka, is very keen to expand fruit and nut development not only for the coralline atolls, but also for those with guano deposits (e.g. Niulakita) where 'difficult' species such as mango could be satisfactorily grown. Nursery infrastructure on Funafuti is satisfactory, although not elaborate, and would require upgrading.

4. CLIMATE OF ATOLL COUNTRIES

All six atoll countries in this study lie within 15° North and South of the equator and the majority are within 10°. Rainfall varies substantially within the island groups, but temperatures are generally very even and predictable, within the range of 20°–32°C. Occasionally, temperatures up to 35°C are recorded in some countries (e.g. Marshall Islands). The mean annual temperature is about 27°–28°C. Extremes of heat are generally tempered by the trade winds (from the South East below the equator, and from the North East above the equator), except in the equatorial convergence belt. There is a difference in day length of up to one hour throughout the year.

Rainfall is the most significant climatic factor. In the central and western Pacific, where atolls are common, there is a rainy belt on each side of the Equator, the rainfall lessening northward and southward. This is seen most strikingly in the Marshall and Gilbert Archipelagoes. The Line Islands are exceptional in this, becoming wetter north and westward, from dry Christmas Island in the Doldrums to increasingly wet Fanning, Washington and Palmyra. However, south from the Gilberts into Tuvalu, rainfall increases, with Funafuti receiving an average of 3,600 mm.

Table 1: Rainfall, selected atolls (mm)

Month	Majuro, Marshall Islands (7°N)	Tarawa, Kiribati (2°N)	Fakofa, Tokelau (9°S)	Penrhyn, Cook Is. (9°S)
January	203	308	320	228
February	158	216	286	227
March	232	182	180	161
April	307	182	180	161
May	308	141	191	141
June	313	140	176	149
July	322	163	218	141
August	289	103	174	160
September	333	106	196	121
October	390	93	222	151
November	347	115	249	170
December	285	201	341	212

Annual mean rainfall: FSM range, 2,000–3,000 mm; Marshall Islands, 1,400 (Eniwetok)–4,000 mm (Jaluit) decreasing from south to north; Cook Islands (Northern Group), 2,000–2,800 mm; Tokelau, 2,600–3,000 mm; Kiribati, 400–3,000 mm (400–1,300 in Phoenix Group); and Tuvalu, 2,300–3,600 (increasing from north to south).

The luxuriance of vegetation, or lack thereof, is a good indicator of the amount and reliability of rainfall. Year-to-year variation is also considerable, with occasional extensive periods of below average rainfall. These dry periods can severely reduce coconut yields and those of other crops, and result in saltwater intrusion in *Cyrtosperma* pits. Drought can lead to death of breadfruit trees—as in Tarawa in 1984–85. Orographic rainfall is, of course, completely lacking on these flat atolls. Trade-wind showers and more widespread monsoon rains from the South-West, and, more rarely, peripheral hurricane rains, are the principal sources of rainfall on atolls.

Hurricanes or typhoons are a climatic factor of much importance, and greatly feared in most parts of the tropics, less so along the equator, but increasingly damaging westward in the Pacific. Their ferocity is exemplified in the damage done by the series that hit Jaluit Atoll in 1958, and that which struck the Tuamotu and Society Islands in 1982.

Another phenomenon of great importance, both in shaping natural vegetation on atolls and in influencing coral atoll agriculture, is wind-blown salt spray. A great many common plants simply cannot thrive on atolls because of this, while others only do well if protected by windbreaks, either natural or artificial.

Species such as avocado are extremely sensitive to salt spray, and this is probably the main reason why they have not been established on most atolls. It may be best to test the least tolerant species of fruit and nuts well away from the windward side of the larger atolls.

5. SOILS AND HYDROLOGY

5.1 Soils

Atoll soils are universally characterised by their formation from coral deposits. They have extremely good drainage (except when at very low elevation in relation to sea level), variable texture (cobbly and rubble land along the ocean side of the islands, grading to sands and loamy sands along the lagoon) and variable organic matter content (usually higher in protected areas, e.g. interior of the islands). Organic-matter maintenance is critical to sustainable horticultural cropping (both for nutrition and water-holding capacity), whether by import of organic material from other areas on the atolls or by 'resting' areas, allowing them to return to native vegetation for a while. The practice of 'cover cropping' with introduced species has not been particularly successful, due to the requirement for inorganic fertilizers to grow the plants satisfactorily.

Chemically, the soils are characterised by high pH (6.6–9.0) low organic carbon, low nitrogen, moderate-to-high total phosphorus (but phosphorus availability is limited by high pH and high calcium carbonate content), low exchangeable potassium and sodium, moderate-to-high exchangeable calcium, low to moderate exchangeable magnesium, and low manganese, zinc, copper and iron. The trace elements zinc and iron, in particular, are very low for plant availability, although some species (e.g. breadfruit and coconut) are efficient in extracting these elements or have a low requirement.

The systems available to overcome nutrient imbalances on the atolls, without recourse to import of inorganic fertilizers, are generally well known by the inhabitants, but it requires substantial effort to gather and incorporate plant organic matter, animal and fish wastes and rusting metal, etc.

Soils on atolls are generally of one of three basic types:

- Soils degraded from frequent cultivation or regular removal of ground cover so that organic matter levels are much reduced;
- Soils of average to higher fertility from regular addition of organic matter, or from leaving the site under native vegetation;
- Soils which have guano deposits. These may be in parts of an atoll, e.g. Vaitapu, Tuvalu or cover them entirely, as in Niulakita (Tuvalu) and Fais (FSM). These atolls offer considerable potential for fruit and nut species since, with higher fertility and lower pH, the range of species capable of being grown is much greater. Unfortunately, the total land mass with guano deposit is very small.

Atolls are generally low in profile; the highest points are seldom more than 2–3 m above high water level. Cyclonic disturbances can occasionally carry salt water over the entire land surface and may kill species that are not salt-tolerant.

5.2 Hydrology

The behaviour of the freshwater lens on an atoll is critical for both drinking and cooking water if the inhabitants do not have rain run-off storage tanks. It is even more critical for satisfactory pit culture of *Cyrtosperma* and banana, particularly on atolls with generally low or intermittent rainfall.

Fruit and nut tree species are generally given lower attention than crops grown in pit culture, in terms of maintaining a satisfactory water supply in dry periods. Periods of dry weather affecting breadfruit trees to the point of death are well documented. Increasing organic matter levels (mulching or incorporation) and cutting back the top foliage of trees may allow plants to survive in a drought.

The location for fruit and nut species should be well considered before planting, so that factors such as salt-water intrusion, wind-carried salt spray, availability of irrigation water and provision of high organic-matter levels in the soils do not become limiting factors on growth. For cropping within 200 m of the windward side of atolls, wind breaks are essential for most species.

5.3 Salinity

Salinity has its effects on atolls in terms of both wind-blown salt spray and ground-water intrusion. There is also the effect of temporary salt intrusion from tsunami- or cyclone-induced inundation over the atoll. The extent of damage due to these effects depends on the result of physical impact due to the sea or wind, and the amount of rainfall received subsequently to wash the salt off the plants and through the soil profile. Plants with extreme susceptibility to salt may be damaged relatively quickly.

In the case of wind-blown salt spray, some plant species are very intolerant. Avocados, for example, are extremely susceptible and cannot be grown except on the larger, wider atolls where they can be planted more than 300 m from the windward side. For these sensitive species, it may be worthwhile selecting for tolerance within the gene pool of the crop. Examples of relative salt tolerance of selected crops are shown in Table 2.

Table 2: Relative salt tolerance of some common crops

Crop	Scientific name	Soil salinity Ece*		
		90% Yield	75% Yield	50% Yield
Avocado	*Persea americana*	1.8	2.5	3.7
Orange	*Citrus sinensis*	2.3	3.3	4.8
Grapefruit	*Citrus paradisi*	2.4	3.4	4.9
Sweet potato	*Ipomoea batatas*	2.4	3.8	6.1
Grape	*Vitis* spp.	2.6	4.1	6.8
Tomato	*Lycopersicon esculentum*	2.8	3.6	5.0
Sugarcane	*Saccharum officinarum*	3.4	5.9	10.2
Rock melon	*Cucumis melo*	3.6	5.6	9.1
Soybean	*Glycine max*	5.5	6.3	7.5
Squash	*Cucurbita pepo*	5.8	7.4	10.0
Zucchini	*Cucurbita pepo* var. *melopepo*	5.8	7.4	10.0

*ECe = conductivity in m.mhos.cm

Where ground-water-salt intrusion is a possibility, careful site selection is important and plants should not be irrigated with brackish lens water in times of drought.

6. FRUIT AND NUT SPECIES FOR ATOLL COUNTRIES

6.1 Criteria for species selection

The adaptation of plant species to coralline soils is poorly researched in oceanic areas. It is not known, for example, why some species (e.g. breadfruit and coconut) are so well adapted compared to others. One suggestion is that their roots have better foraging ability due to acid exudates which facilitate extraction of trace elements from the coral. Natural selection within the species may favour those with a capacity to survive on low levels of nutrients. Varieties of coconuts on atolls show leaf levels of nutrients that are a fraction of others growing on non-coralline soils, and yet they produce relatively well. The fact that one species within a genus reacts so differently from another (e.g. breadfruit compared with jackfruit) is likely to result from genotypic differences in physiology.

In many cases, when considering the introduction of new species into the region with better foraging ability is being considered, data from the Maldives and the Caribbean can be used. However, there appears to be very little information available on the use of rootstocks with better adaptation to atoll conditions.

Species adaptation is relevant not only in terms of nutrient extraction or use, but also of intolerance to wind-blown salt spray and salt-water incursion. It has already been mentioned that avocado, for instance, has low tolerance to salt spray, but in this species there are genotypic differences in relation to reaction to ground-water salinity, so tolerance to wind-blown salt is also a possibility.

Thus, the areas of research required in Pacific atolls are:

- screening species and varieties known to grow well in atoll around the world;
- screening rootstocks, either in laboratory or field situations, or both;
- research into mechanisms of adaptation, leading to quick tests for screening purposes.

6.2 Species known to be suitable for the region

Fruit and nut tree species adapted to the region are breadfruit, pandanus, papaya, Indian almond (*Terminalia catappa*), fig (*Ficus carica* and *Ficus tinctoria*), coconut, lime (*Citrus aurantifolia*) and banana.

These are already widely distributed, but there is need to provide supplies where requested. In some cases, the range of varieties should be increased to improve productivity and to extend the growing season (e.g. for breadfruit), and to provide resistance to specific diseases (e.g. black Sigatoka in bananas).

6.3 Species grown with success in the Maldive Islands

6.3.1 Anacardiaceae

Generally, mango is not grown in Pacific atolls and the basic assumption is that it is highly intolerant of high pH leading to iron and zinc deficiencies and possibly those of other trace elements. However, there are a few trees in the Marshall Islands, some on guano soils on Fais in FSM and, more commonly, in the Maldives. The possible answer to this anomaly is that there are some genotypes in the world gene pool with the capacity to forage better for trace elements, and that these can be grown without the need to apply chelated or other forms of nutrients. The Maldives situation may well be one of selection over a long period—particularly since there is a major gene pool nearby in India and Sri Lanka. Recent introductions of grafted mango selections from India into the Maldives have not performed well (Mohammed Zuhir, pers. comm.), which suggests that tolerance to high pH is not found throughout the Indian germplasm. A root stock (13/1) selected in Israel for tolerance to salinity is worth investigation for alkaline conditions.

Mango is a fruit particularly desired by atoll populations and efforts should be made to import seed from the Maldives for testing. Alternatively, seedlings from the Maldives could be screened for high pH tolerance and low trace-element extraction in a laboratory in Queensland, Fiji or Western Samoa. Another fruit in the family worth screening is maprang (Bouea macrophylla).

Hog plum (*Spondias cytherea*) has the common name of 'Vi' in some countries. It is grown extensively on the high islands in the Pacific (Western Samoa, Fiji and Cook Islands) and whilst not seen on the atolls, would be worth testing. The red mombin (*Spondias purpurea*) should also be tested.

6.3.2 Annonaceae

The annonas are very poorly represented in the region, but *Annona reticulata* (bullock's heart or mamon) is present in the Marshall Islands. Trees in the Governor's garden at Majuro are producing well, albeit with the aid of inorganic fertilizers. *Annona squamosa* (sugar apple) is reputed to perform well in the atolls of the northern Cook Islands.

In the Maldives, *A. glabra* (pond apple), *A. reticulata, A. muricata* (soursop) and *A. squamosa* (sugar apple) are well represented and quoted as being relatively easy to grow. These fruits are popular. Seed of these species should be distributed in the region, and investigation carried out to discover rootstocks with high pH/low trace element tolerance.

6.3.3 Bromeliaceae

Pineapple (*Ananas comosus*) is not common in the atolls of Pacific Island countries and territories or in the Maldives, but production is possible in raised beds of high organic matter. Decayed coconut roots offers a suitable material. There is no data to suggest whether Smooth Cayenne types are more suitable than Queen or Singapore Spanish.

6.3.4 Combretaceae

Terminalia catappa (Indian almond) is well distributed, although relatively unimportant in Pacific atolls. In the Maldives, *T. chebelu* and *T. bellerica* are both planted, and *T. samoensis* is represented in FSM. and Marshall Islands. All are worth testing, as well as *T. okari* from Papua New Guinea.

6.3.5 Caricaceae

Papaya is grown throughout the Pacific atolls and is an important fruit, but it does require high organic matter in order to avoid trace-element chlorosis. Sunrise Solo does not crop as well as Waimanolo and some of the dioecious strains. It appears that selection within the gene pool present on the atolls is practicable.

6.3.6 Ebenaceae

Pomegranate (*Punica granatum*) is grown in the Maldives with relative ease. Both seed and clonal material should be introduced for screening in the atolls of the Pacific.

Black sapote (*Diospyros digyna*) is growing in the Governor's garden on Majuro, but, possibly because of insufficient chilling, it is not flowering or setting fruit adequately. However, the mabolo (*Diospyros discolor*) is another member of the family worthy of introduction.

6.3.7 Leguminosae

Tamarind (*Tamarindus indica*) is occasionally found in the region and appears chlorotic, probably due to trace element deficiencies; it is common in the Maldives.

Polynesian chestnut (*Inocarpus fagiferus*) exists on a few atolls. It should be tested further, but care must be taken not to introduce seed weevils at the same time. *Pithecellobium dulce* (guayamochil) is also worth testing.

6.3.8 Moraceae

This family has fair representation on the atolls. Two important members are breadfruit, *Artocarpus mariannensis*, and *Ficus tinctoria*.

F. carica (the European fig) grows well and is very precocious on the atolls (Majuro and Tarawa) and should be further distributed. A range of European fig varieties should also be introduced— on the basis that some may produce sweeter fruit than those grown at present.

Mulberry (*Morus alba*) is present in the Maldives and selections should be introduced into the region. It may, however, require pruning to stimulate flowering.

6.3.9 Moringaceae

Moringa (*Moringa oleifera*) is present in the Maldives and grows well. The leaves and young seed pods are used as a vegetable.

6.3.10 Myrtaceae

Generally, myrtaceous species are well adapted to coralline soils and whilst none except, perhaps, guava (*Psidium guajava*) is particularly in demand on world markets, they are important fruits in tropical countries. Few species are planted in the Pacific Islands. In the Maldives, however, the jambolan (*Syzygium cuminii*), guava, Malay apple (*S. malaccensis*) and wax jambu (*S. samarangense*) are represented. Only the Malay apple occurs in the atolls of the FSM. In addition, other myrtaceous species worth screening are bell fruit (*S. aqueum*), yellow cattley guava (*Psidium littorale*) and jaboticaba (*Myrciaria cauliflora*).

6.3.11 Oxalidaceae

The carambola (*Averrhoa carambola*) shows trace element deficiencies at high pH, but is grown satisfactorily in the Maldives, as is bilimbi (*Averrhoa bilimbi*). Both are present in the high islands of FSM, but quality is inferior to improved varieties in Australia.

6.3.12 Palmae

Apart from coconut, *Borassus flabellifer* (Palmyra palm) and *Areca catechu* (betel) are grown in the Maldives. Betel nut is not grown on Pacific atolls and probably requires high organic matter.

6.3.13 Pandanaceae

Pandanus (principally *P. tectorius*) is well represented in the region and particularly in the Marshall Islands. The crop is worthy of further study to increase representation throughout the atolls, particularly for clones which bear over a long period of the year.

6.3.14 Passifloraceae

Passionfruits (*Passiflora* spp.) are only grown occasionally on Pacific atolls, whereas they are more important in the Maldives. Some species, *P. incarnata* (maypop), *P. laurifolia* (water lemon) and P. maliformis (sweet cup) may be better adapted for the atoll environment but *P. edulis* (P. flavicarpa) should not be discounted. Bee populations on the atolls are small or non-existent in some cases, and passionfruits normally require hand pollination. However, a strain selected in the Cook Islands is self-pollinating.

6.3.15 Polygonaceae

Sea grape (*Coccoloba uvifera*) thrives on the atolls and, as well as providing fruit for jellies etc., it could be used more widely as a windbreak since it withstands strong salt-laden winds. Coccolobas seen in the region appear unproductive and selection of better fruiting types from the Caribbean is warranted.

6.3.16 Rhamnaceae

The Indian jujube (*Zizyphus mauritiana*) is grown extensively in the Maldives, but not at all on Pacific atolls. It is a productive tree with fruit of good appeal. Both grafted varieties and seed should be imported.

6.3.17 Rutaceae

The Rutaceae family includes citrus species as well as *Murraya koeniggii* (curry leaf) and *Triphasia trifolia* (chinita) which are grown in the Maldives. Citrus is very popular in the atolls, but results have been variable due to lack of organic matter and iron. In many cases, even the very adaptable key lime (*Citrus aurantifolia*) has not grown well.

Successful culture depends on management, choice of species/varieties and, most importantly, rootstock. Work in Kiribati and Tuvalu has identified rough lemon (*C. jambhiri*), Rangpur lime (*C. x limonia*) and Volkameriana (lemon) rootstocks as the most suitable. Volkemariana appears to be the best. In the West Indies, sour orange (*C. aurantium*) is regarded as a good rootstock for key lime.

Within the Pacific atolls lemon (*C. limon*), sweet orange (*C. sinensis*), sour orange (*C. aurantium*), calamondin (*Citrofortunella mitis*), key lime, Tangelo (*C. reticulata x paradisi*), grapefruit (*C. paradisi*) and mandarin (*C. reticulata*), are all reported to produce reasonably well under good management, but the rootstocks used are often not reported.

On Nukuoro Atoll (FSM), sweet orange is reported to be growing extremely well and has spread in a semi-wild state. It should be investigated, since it may be worth distributing and may also be a good rootstock.

Pummelo (*C. maxima*) is only reported from Fais atoll, FSM. It is possible that it will only grow well where there are guano deposits, unless grafted to a suitable rootstock. In Australia, pummelo appears to perform well on pummelo, swingle, citrumello and Troyer citrange rootstocks.

Growing citrus on atolls is obviously a considerable challenge and will require a more extensive examination of suitable varieties, rootstocks and management practices.

Bacterial canker is present in Yap and Chuuk States of FSM, but not in Kosrae; the latter is somewhat of a specialist citrus centre in the western Pacific. Due care should be taken not to introduce citrus canker into islands where it is not yet present.

6.3.18 Sapotaceae

The Sapotaceae family has considerable potential for the atolls, despite the fact that it is practically unknown at present.

Sapodilla (*Manilkara zapota*) is planted in the Governor's garden on Majuro and is growing well, but not fruiting. Seedling sapodillas are notorious for providing sterile pollen, and grafted, selected, varieties should be tested. Only in a few varieties (e.g. Prolific) will a large number of seedlings develop true to type.

A relative of sapodilla, *Mimusops browniana* (wongi), grows wild on the three coral atolls in the Torres Strait between Australia and Papua New Guinea. This species is also worth introduction, although the fruit is smaller than sapodilla.

The canistel (*Pouteria campechiana*) is present on Majuro, but appears to show iron chlorosis and poor pollination and fruit set.

Another species that should be introduced is the mamey sapote (*Pouteria sapota*) which grows well on the coralline soils of south Florida. It is a large fruit with excellent flesh. Both seed and grafted varieties should be tested.

6.4 Species not represented on Pacific atolls or in the Maldives

There are a number of species which may be suitable for the atolls that are not present in either the Maldives or the Pacific Islands. These are discussed below using information obtained from the Caribbean; a few other species, which may also be suitable for Pacific atolls, are also suggested, based on speculation and supposition.

Mammea americana (mammee), from the family Clusiaceae, is reputedly grown in coral sand in the West Indies. It is a fruit of good quality, but possibly shy-bearing.

Pometia pinnata (taun) and *Melicoccus bijugata* (mamoncillo) are members of the family Sapindaceae. Mamoncillo does well in coral soils in the Caribbean, although few varieties have been selected which give good thick aril recovery. The trees are dioecious. Taun is native to the high islands of the South Pacific and Fiji, but may perform adequately on coral soils if provided with sufficient organic matter.

Barringtonia edulis and *B. procera* are barringtonias with edible nuts which may do as well as the non-edible species that are present on the atolls. The edible species are present in the Cook Islands, Solomon Islands and other countries of Melanesia.

Bamboo varieties are not present in significant numbers on the atolls, and whilst not a fruit or a nut, introduction could provide a vegetable (bamboo shoots) and building materials. The UNDP/OPS project has already been involved with transfer of bamboo in the Maldives.

Annex 1 gives a summary of the important fruit and nut trees present in Pacific atolls and the Maldives.

6.5 Banana development

6.5.1 Current situation on atolls and recommended importations

The banana is extremely important on most atolls, although production is usually best in locations with well-distributed rainfall throughout the year and totals exceeding 2,500 mm. The crop is probably more important than breadfruit, particularly as it is available throughout the year.

In the past 20 years, the influence of black Sigatoka (*Mycosphaerella fijiensis*) has changed the spectrum of bananas cultivated on the atolls. In FSM, where there is a very extensive gene pool on the high islands of Yap, Chuuk, Pohnpei and Kosrae, susceptible varieties have been replaced by highly resistant ones such as Saba (cooking type from the Philippines) and Mysore (sweet eating). Only a few susceptible varieties such as Silk (Sugar) remain despite the reduction in bunch size. Saba has now spread across the western Pacific to the Marshall Islands. In Tokelau and the northern Cook Islands, Kalapua and Bluggoe have replaced other susceptible cooking types. Kalapua was possibly taken from Papua New Guinea. Tuvalu and western Kiribati have relatively few banana varieties, and are still free from black Sigatoka. Annex 2 lists the varieties present in Pacific atolls.

The highly resistant cultivar Mysore now grows in all atoll countries, with the possible exception of the northern Cook Islands. Future introductions of varieties highly resistant to black Sigatoka, but not yet present in the region, are recommended. These can safely be accessed and distributed without pest and disease risk by using pathogen-indexed tissue cultures available from regional centres or Australia.

Those recommended for introduction are:

- T8 (Tu8) (AAAA), a tetraploid hybrid with Cavendish characteristics. This cultivar may, however, not grow well under atoll conditions;
- 3481 (AAAB), another tetraploid hybrid which has the characteristics of the Queensland Lady Finger (Prata), but is a dwarf. It has good-sized bunches, but may not be very hardy under atoll conditions. This cultivar is less resistant to black Sigatoka than T8;
- Ducasse (ABB) (and Dwarf Ducasse), a sweet-eating type with good vigour and production, even under relatively unfavourable conditions;
- Bluggoe (ABB) (cooking type), a hardy cultivar not present in Kiribati, Marshall Islands, Tokelau and Tuvalu. A dwarf type is also available;
- Sucrier (AA) (Amas/Emas/Mas/Senorita), which produces a small bunch and finger size, but is extremely sweet and a popular fresh-eating cultivar in Asia. It has a short cycle which offsets bunch size and is highly resistant to black Sigatoka;
- Yangambi (AAA), a sweet-eating type from Africa which may do well on atolls;
- Kandrian (PNG148) (ABB/ABBB), an extremely vigorous cooking type from Papua New Guinea and the Torres Strait.

6.5.2 Present distribution of banana varieties

Cook Islands (Northern group)	Cavendish (Giant Cavendish), Lady Finger, Mairana (Tarua), Maoi, Miti Ruki, Rokua

Guam	Dama, Galayan, Guahu (Dwarf Cavendish), Halom tano, Lakatan, Long, Makao, Manila (Silk), Pahong, Paladang, Palau, Taiwan (Robusta?), Tanduki, Williams hybrid,
Federated States of Micronesia	
Kapingamarangi Atoll	Ingasio, Taiwan, Utin Fiji, Utin Lihli, Utin Wai,
Mwoakilloa Atoll	Inasio, Kaimana, Preisihl, Uht en Fiji, Uht en Menihla
Nukuoro Atoll	Fiji, Inasio, Lakadahn, Manihla, Preisihl, Taiwan, Utin Motilok, Utin Ruk
Pingelap Atoll	Inacio, Mangat, Utin Fiji, Utin Ruk, Utin Wai (Williams)
Pohnpei	Akadahn, Akadahn en Wai, Daiwan (Taiwan), Dukuru, Inasio (Tukuru), Ipali, Kaimana, Karat, Karat en Iap, Kirou Rohi, Kudud, Mangat, Mangat en Alohkapw, Menilah (Silk), Ruk (Saba), Tunwal, Utiak en Angaur, Utiak en Pohnpei, Utimwahs, Utin Guam, Utin Iap, Utin Kerenis, Utin Menihle, Utin Pihsi, Utin Presil, Utin Ruk (Utin Rik, Trukese, McKenzie), Utin Wai
Sapwuafik Atoll	Utin, Fiji, Inasio, Lakadahn, Mangat, Manihla, Preisihl, Taiwan, Utin Lihli, Utin Wai
Yap	American, Aray, Asakar, Askar ni Row, Awatwat (Pithothaw), Caneyoko, Daber, Fakewel), Florida (Fiji, Fal'bon), Gaf, Gumoy (Ngariy, Gumoy Ni Miriken, Gumoy Ni Waab), Guwam, Lakatan, Longruwepawriy, Malayou, Miriken, Mulegyebningabchey, Suga, Tafgif, Taiwan, Tall'ey, Taneyboch (Manila), Tangret, Tunbab, Tunfel, Urfiy, Yurnim
Kiribati	Taboniba (Teoraora), Te Umum (Kuburoburo)
Marshall Islands	
Majuro	Ailingken (Joruwat), Brown, Chinese, Fiji (Jilubuki), Jok, Lakatan, Manila (Apple), McKenzie, Mokarkar, Taiwan, Williams Hybrid
Tokelau	Misiluki, Nefu, Pata
Tuvalu	Brown, Fuamaulunga, Funafuti - Fuamaulolo, Inisi (Misiluki), Kefu, Nefu, Pata, Tokelau Misiluki, Williams

6.5.3 Banana pest and disease spectrum and influence on varietal trends

Cook Islands	In the northern atolls, the principal cultivar is Rokua Mairana (70%), followed by local Cavendish (Giant Cavendish) (12%) and Lady Finger (Pome) (14%). Some Miti Ruki is present on Pukapuka. Black Sigatoka is reputedly present and, possibly, freckle (on Rokua Mairana). The northern Cook Islands is the only atoll group without Mysore. A notable feature of all countries visited (except northern Cook Islands and Yap) is the absence of freckle (*Guignardia musae*).
Federated States of Micronesia	
Pohnpei	Black Sigatoka is present, but, apparently, none of the other pathogens. Only Ruk (Saba) (30%), introduced in the 1950s, appears to have good black Sigatoka resistance. Even Inasio (Bluggoe) (25%) shows black Sigatoka lesions on lower leaves. Taiwan (Robusta) (8%) is severely affected, as is Lakadhan (10%) and Menihla (Silk) (18%), but the latter is popular as a fresh-eating type. It is the principal cultivar traded on the Pohnpei market, and is also exported to Guam, despite the small bunch

size. It is usually de-suckered regularly and receives better attention by growers than other varieties.

Many of the older varieties (both pre-European and more recent introductions) are being lost because of the effect of black Sigatoka on yield or because they are naturally low yielding and lack acceptable taste.

Yap

Black Sigatoka and freckle are present. The proportion of varieties now grown is strongly towards those resistant to black Sigatoka—Gumoy (30%), Florida (30%) and Awatwat (10%); but Taneyboch (Silk) (20%) is still highly regarded and widely grown despite the reduction in bunch size. Most other varieties with susceptibility to black Sigatoka have apparently declined in recent years.

Guam

Banana bunchy top, Panama (Race 1?), Moko and black Sigatoka, plus banana skipper (highly parasitised) are all present.

Kiribati

Tarawa is free of black and yellow Sigatoka, and so are all the other atolls in the country.

There are only two banana varieties on Tarawa: Te Umum (Blue Java) (40%) and Tabonibai/Teoraora (Mysore) (60%). Williams Hybrid and Lady Finger (Pome) are being grown at the Department of Agriculture.

The taro beetle (*Papuana* sp.) is present at the southern end of Tarawa and infests bananas.

Marshall Islands

On Majuro, Black Sigatoka is present, but no other debilitating pests or diseases. All bananas appear to be relatively recent introductions, probably since the arrival of the missionaries.

McKenzie (Saba) was imported from Pohnpei in the 1950s, and Fiji (Mysore) was also introduced recently. Jok (Blue Java), Ailingken/Joruwat and Jorukur (Maias Maoli/Poloulu types) may be older introductions. Varieties McKenzie and Jok (Blue Java) account for about 40% of the bananas grown. Williams hybrid is reputed not to do well in the Marshall Islands, in contrast to its performance on the atolls of Pohnpei State.

Black Sigatoka is not readily visible on bananas on Majuro where the atoll is narrow, even on susceptible varieties. However, at the southern end of the atoll, where it is wider, the disease is severe on most varieties, excluding McKenzie (Saba). Fruit fly pests appear to be absent.

Tokelau

It is uncertain if black Sigatoka is present. The main varieties—Misiluki (Mysore) (50%), Pata (30%) and Nefu (20%)—are all highly resistant. Cavendish fruit is regularly imported from Apia for sale in Tokelau, and there is no restriction on planting material; thus, it is likely that black Sigatoka has been introduced.

Tuvalu

Funafuti (and reputedly all of Tuvalu) is free from black and yellow Sigatoka. The two varieties, Pata (40%) and Inisi (Mysore) (50%), do very well even when grown at high density. Fruit fly pests appear to be absent.

7. NURSERY ORGANISATION ON ATOLLS AND HIGH ISLANDS

The primary problems with the introduction of fruit and nut tree species into atolls are:

- quarantine concerns,
- complications due to plant materials being delayed in transit,
- a lack of facilities for establishing bare-rooted plants, and

- an absence of suitable potting mixtures.

7.1 Quarantine

Quarantine requirements for plant importations vary between Pacific Island countries, and there may be internal quarantine regulations governing movements within a country (e.g. citrus in FSM). Most countries require introductions of plant material to be fumigated with methyl bromide or to be dipped in a suitable insecticide on arrival or, preferably, in the country of export. It is mandatory in most countries for the consignments to be accompanied by a phytosanitary certificate stating, inter alia, the treatments that have been given. However, normal fumigation rates or insecticides do not significantly affect fungi, bacteria and viruses.

In Australia, mandatory fumigation precludes the need for phytosanitary certification, and is a more satisfactory arrangement than trying to make detailed inspections and still run the risk of introducing mites, scale insects, borers, etc. which are sometimes hard to detect. The material could be fumigated in the country of origin, but plant material needs to be aerated following treatment and this holds up dispatch. For the purposes of the present project, the most satisfactory solution is to carry out fumigation and fungicide treatments on arrival and then quickly dispatch the material to the atolls, unless there are quarantine facilities where the plants can be potted-up and grown-on at the point of arrival, and sent to the atolls at a later date. Suggested methods for each country are given below.

7.2 Avoiding delays in transit

Federated States of Micronesia	Receive and pot-up in Pohnpei, and then dispatch to atolls or treat and send directly to the atolls.
Kiribati	Receive and pot-up in Tarawa, and then send to atolls later.
Marshall Islands	Receive and pot-up in Majuro, and then send to atolls later.
Northern Cook Islands	Receive and pot-up at Totokoitu Research Station and dispatch to atolls later.
Tokelau	Receive and pot-up in Apia, and send to Tokelau later. This suggestion has serious quarantine implications, as consignments may become contaminated with pests present in Western Samoa. However, most pests that are present have probably already been introduced, by virtue of the trade which exists between the two countries.
Tuvalu	Receive and pot-up in Funafuti, and then send to atolls later.

7.3 Facilities for establishing plants after introduction

Bare-rooted plant imports need to be kept under conditions of low stress so that they can recover and regenerate. If plants are fumigated on arrival, they should be aerated for 3–4 hours, but while this is being done they should be kept beneath damp newspaper.

The potting mixture must be free-draining, and the pot size restricted so that, initially, the plant is grown in a container somewhat smaller than before. This ensures that there is less risk of over-watering. The height of containers should be at least twice that of the diameter.

After potting-up, plants should be transferred immediately to a humid shaded environment. A plastic tent within a shade house covered with at least 80 per cent shade cloth is ideal. If temperatures within the plastic tent exceed 42°C then extra shade cloth should be added.

Great care should be taken to prevent over-watering. Bare-rooted trees, with little or no foliage, should not be watered at less than 3–4-day intervals initially, but the atmosphere in the tent should be kept at maximum humidity.

7.4 Potting mixtures

Potting mixtures of the kind suitable for re-establishing plants from overseas are difficult to organise on atolls and even on some high islands.

On atolls, a mixture of ground pumice and decayed coconut root ball (coconut peat), with a suitable amount of major trace element mixture (taking care not to over-fertilize), is probably the best choice. If pumice is unavailable, then fine coral soil, with a high organic matter content (e.g. from natural vegetation areas), would be the next best choice.

On the high islands, ground pumice, crusher dust or sharp (clean) river (not coral) sand, can be mixed with compost or a very light loam soil (high in organic matter) or coconut peat.

On Yap, it may be necessary to use coconut peat and imported sand/crusher dust, because of lack of other materials. If necessary, imported perlite, vermiculite, peat and sharp sand can be used.

The need to have a correct potting mixture cannot be over-emphasised; problems are currently occurring in nurseries throughout the region because of mixtures which are too heavy (e.g. heavy clay on Yap) or with not enough organic fraction to counteract high pH effects causing trace element deficiencies. With some ingenuity there is probably no need to import potting mixture ingredients.

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Annex 1: Distribution of fruit and nut trees, and other useful species, in atoll countries

Family	Maldives	Cook Islands (northern group)	Federated States of Micronesia	Kiribati	Marshall Islands	Tokelau	Tuvalu
Anacardiaceae	*Mangifera indica*	*Mangifera indica**	*Mangifera indica*		*Mangifera indica*		*Mangifera indica**
Annonaceae	*Annona glabra* *A. muricata* *A. reticulata* *A. squamosa*	*A. squamosa*	*A. muricata*		*A. reticulata*		
Bromeliaceae	*Ananas comosus**		*A. comosus**	*A. comosus**			
Capparaceae			*Crateva speciosa*				
Caricaceae	*Carica papaya*	*C. papaya*	*C. papaya*	*C. papaya*	*C. papaya*		*Carica papaya*
Combretaceae	*Terminalia bellerica* *T. catappa* *T. chebelu*		*T. catappa* *T. samoensis*	*T. catappa*	*T. catappa*	*T. catappa*	*T. catappa*
Ebenaceae	*Punica granatum*						
Elaeocarpaceae	*Muntingia calabura*						
Euphorbiaceae	*Phyllanthus acidus*						
Leguminosae	*Tamarindus indica*		*Inocarpus fagifer*	*T. indica*			
Meliaceae	*Azadiracta indica* *Xylocarpus moluccensis*						
Moraceae	*Artocarpus mariannensis* *Morus alba*	*A. mariannensis* *Ficus tinctoria*	*A. mariannensis* *Ficus prolixa* *F. tinctoria*	*A. mariannensis* *Ficus carica* *F. tinctoria*	*A. mariannensis* *F. carica* *F. tinctoria*	*A. mariannensis* *F. tinctoria*	*A. mariannensis* *F. tinctoria*
Moringaceae	*Moringa oleifera*						
Musae	*Musa* sp.	*Musa* sp.	*Musa* sp.	*Musa* sp.	*Musa* sp.	*Musa* sp.	*Musa* sp.
Myristicaceae			*Myristica fragrans*	*Myristica fragrans**			
Myrtaceae	*Psidium guajava* *Syzygium cuminii* *S. malaccensis* *S. samarangense*		*S. malaccensis* (Satawal & Fais)				
Oxalidaceae	*Averrhoa carambola* *A. bilimbi*						

* few present

Family	Maldives	Cook Islands (northern group)	Federated States of Micronesia	Kiribati	Marshall Islands	Tokelau	Tuvalu
Palmae	*Cocos nucifera* *Areca catechu* *Borassus flavellifer*	*C. nucifera*	*C. nucifera*	*C. nucifera*	*C. nucifera*	*C. nucifera*	*C. nucifera*
Pandanaceae	*Pandanus odoratissimus* *P. leram* *P. amaryllifolius* *P. tectorius*		*Pandanus* sp.	*Pandanus* sp.	*Pandanus* sp.	*Pandanus* sp.	*Pandanus* sp.
Passifloraceae	*Passiflora* spp.						
Piperaceae	*Piper betel*						
Poaceae	*Arundinaria* spp. *Bambusa* spp. *Dendrocalamus* spp. *Saccharum officinarum*			*Dendrocalamus* spp. *S. officinarum*			
Polygonaceae	*Coccoloba* spp.			*Coccoloba* spp.			Coccoloba spp.
Rhamnaceae	*Ziziphus mauritiana*						
Rutaceae	*Citrus aurantia* *C. aurantifolia* *C. decumana* *C. medica* *Murraya koeniggii* *Triphasia trifolia*	*C. aurantifolia* *C. limon**	*C. aurantifolia* *C. aurantium* *C. maxima* (Fais) *C. sinensis (Nukuoro)* *Citrofortunella mitis*	*C. aurantifolia* *C. limon* *C. reticulata x paradisi* *C. sinensis*		*C. aurantifolia*	*C. aurantifolia*
Sapotaceae	*Pouteria campechiana* *Mimusops elengi* *Manilkara zapota*		*M. zapota*		*M. zapota*		
Solanaceae				*Physalis angulata*			
Theaceae	*Camellia sinensis*						
Vitaceae	*Vitus vinifera*						
Zingiberaceae	*Elettaria cardamomum* *Curcuma domestica*			*Zingiber officinale* *C. domestica*			

Annex 2: Banana varieties of Pacific Island atolls and their local names

Accepted name	Genome	Federated States of Micronesia (Yap & atolls)	Federated States of Micronesia (Pohnpei & atolls)	Marshall Is. (Majuro)	Kiribati (Tarawa)	Tuvalu (Funafuti)	Tokelau	Cook Islands (Northern gp.)
Sucrier	AA	Suga						
Lacatan	AA	Lakatan	Lakatan	Lakatan				
Dwarf Cavendish	AAA	P	P	Chinese		Fuamaulolo		
Williams	AAA		Utin Wai			Williams		?
Giant Cavendish	AAA		Tunwal		P			Local Cavendish
Robusta	AAA	Taiwan/Valery	Taiwan			Fuamaulunga		
Red Dacca	AAA			Brown		Brown		
Mysore	AAB	Florida	Utin Fiji	Fiji/Jilubuki	Taboniba/ Teoraora	Inisi/Misiluki	Misiluki	
Silk/Sugar	AAB	Taneyboch	Utin Menihia	Manila/Apple				Miti Ruki
Lady Finger	AAB				P			P
Maia Maoli/ Popoulu	AAB	American		Ailingken/ Jouruwat				?
Bluggoes	ABB	Awatwat/ Pithothaw	Inasio					
Blue Java	ABB	?	?	Jok	Te Umum/ Kuburoburo	Kefu	Nefu	
Kalapua	ABB/ABBB?					Pata	Pata	Rokua Mairana/Tarua
Saba	BBB/ABB?	Gumoy	Utin Ruk	McKenzie				
Fehi			Karat					

P = present but local name not recorded

Annex 3: Action plan and list of fruit and nut tree species for Pacific atolls

1. *Seed and plant supply to Cook Islands, Federated States of Micronesia, Marshall Islands, Kiribati, Tokelau, Tuvalu*

- May 1991. SPC or UNDP/OPS to request import permits for all the nominated fruit and nut species from the six countries
- Mid-June. Seed to Yap and Marshall Islands, up to 9 species
- Mid-to late June 1991. Clonal material and seed supply to FSM (Pohnpei) and Kiribati
- August 1991. Seed supply to FSM (Pohnpei), Kiribati and Tuvalu—species missed from first consignments and others available
- November 1991 to February 1992. Balance of seed of all species from Australia and elsewhere, to all countries including Cook Islands and Tokelau
- April 1992. Review success of the seed introductions and resupply if necessary

2. *Clonal introductions and training in propagation techniques*

- May to June 1992. Trainees from the atoll countries to meet in Pohnpei for 7 days training in clonal propagation, including grafting, air-layering, cutting techniques and general plant care
- A nucleus of clonal material of fruit trees will be established for later distribution to atolls
- Mid-June 1992. Consultant to visit atolls to review success of introductions and adaptation of species to atoll environments
- Based on the results of the review recommendations will be made for further introductions of fruit and nut tree species

3. *Seed and clonal material to be obtained in 1991–92*

- Mid-to late June 1991:

Averrhoa carambola	(carambola)
Bouea macrophylla	(maprang)
Diospyros discolor	(mabolo)
Genipa americana	(genipap)
Hylocereus guatamalensis	(pitaya)
Lansium domesticum	(langsat)
Mangifera indica	(mango)
Matissia cordata	(matissia)
Piper nigrum	(pepper)
Pouteria campechiana	(canistel)
Pouteria pinnata	(taun)
Psidium littorale	(yellow guava)
Syzygium malaccensis	(Malay apple)

- June 1991 to May 1992

Annona glabra	(pond apple)
Annona muricata	(soursop)
Annona squamosa	(sugar apple)
Averrhoa bilimbi	(bilimbi)
Averrhoa carambola	(carambola)
Bouea macrophylla	(maprang)
Citrus aurantifola	(lime)
Diospyros digyna	(black sapote)
Manilkara zapota	(sapodilla)
Moringa oleifera	(horse-radish tree)
Myrciaria cauliflora	(jaboticaba)
Passiflora species	(passionfruit)

Pouteria campechiana	(canistel)
Pouteria sapota	(mamey sapote)
Psidium guajava	(guava)
Sandoricum indicum	(santol)
Spondias cytherea	(ambarella)
Syzygium aqueum	(bell fruit)
Syzygium cuminii	(jambolan)
Syzygium malaccensis	(Malay apple)
Syzygium samarangense	(wax jambu)
Tamarindus indica	(tamarind)
Volkamericana	(citrus rootstock)
Zizyphus mauritiana	(Indian jujube)

- Seeds to be obtained from outside Australia

Barringtonia edulis	(Solomon Islands?)
Barringtonia procera	(solomon Islands?)
Citrus sinensis (sweet orange)	(Nukuoro atoll, Pohnpei State, FSM)
Annona reticulata	(Majuro, Marshall Islands)
Coccoloba uvifera	(West Indies)*
Mammea americana	(West Indies)*
Mangifera indica	(Maldives and Israel)*
Meliccus bijugatus	(West Indies)
Pometia pinnata	(Solomon Islands, Fiji, Papua New Guinea)
Terminalia bellerica	(Maldives)
Terminalia chebelu	(Maldives)
Terminalia okari	(Papua New Guinea)

*Consultant to arrange; other, UNDP/OPS

- Importations of clonal material to Pohnpei from Australia, May to June 1992

Averrhoa carambola	(carambola)
Bouea macrophylla	(maprang)
Manilkara zapota	(sapodilla)
Pouteria caimito	(abiu)
Pouteria campechiana	(canistel)
Psidium guajava	(guava)
Spondias cytherea	(ambarella)
Syzygium cuminii	(jambolan)
Zizyphus jujuba	(jujube)

Annex 4: List of abbreviations and acronyms

FAO	Food and Agriculture Organization of the United Nations
FSM	Federated States of Micronesia
IRETA	Institute for Research, Extension and Training in Agriculture (USP)
OPS	Office of Project Services
ROC	Republic of China
SPC	South Pacific Commission
UN	United Nations
UNDP	United Nations Development Programme
USP	University of the South Pacific