Strengthening of Plant Genetic Resources for Food and Agriculture : Conservation and Utilization in the Pacific

A Status Report

Asia-Pacific Association of Agricultural Research Institutions
c/o FAO Regional Office for Asia and the Pacific
Bangkok, Thailand

Strengthening of Plant Genetic Resources for Food and Agriculture: Conservation and Utilization in the Pacific

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Contents

Foreword

The pacific region is geographically, ecologically, socio-economically diverse and faces numerous challenges towards maintaining and improving the productivity from agriculture sector and protecting its biological diversity. The geographical isolation of the region and small size of many of the islands have resulted in a narrow genetic and production base. Somehow, agricultural productivity has not kept pace with the population growth. Hence, dependence on imported food due to limited agricultural production is in fact one of the major threats facing the region.

The Pacific region is the center of diversity for a number of crops. The roots and tuber crops are of particular importance from the point of view of food and nutrition security, income generation and cultural diversity. In order to save the valuable genetic diversity from possible extinction, all countries in the region are engaged in plant genetic resources activities to varying degrees and a number of externally funded projects are being implemented on various aspects of collecting, characterization, evaluation, documentation, conservation and utilization. The regional PGR strategy is in place and the regional collections of important crops, with funding support from the Global Crop Diversity Trust (GCDT), is in progress for conservation, exchange and utilization. The Regional Germplasm Center (RGC), which later became the Center for Pacific Crops and Trees (Ce Pa CT) has the responsibility to safely conserve the plant genetic resources for food and agriculture (PGRFA) and to facilitate access to useful diversity both within and outside the region. The regional network “Pacific Plant Genetic Resources Network (PAPGREN)” has made significant impact towards strengthening PGR activities in the region.

This publication entitled "Strengthening of Plant Genetic Resources for Food and Agriculture: Conservation and Utilization in the Pacific" describes the historical perspective, extent of genetic diversity of major crops, the institutions involved, genebank holdings, crop improvement, utilization of genetic resources, training and capacity building and public awareness. It also highlights the regional efforts for PGR conservation and use, the current issues and the way forward for agricultural research for development.

The Asia-Pacific Association of Agricultural Research Institutions (APAARI) has been publishing success stories and status reports on various aspects of research and development that have large scale impact and have brought tangible benefits to both the farmers and consumers alike. So far, more than 40 such reports from the region on diverse topics have been published by APAARI, details of which are available on APAARI website: www.apaari.org. It is felt that dissemination of this report will help in large scale adoption of new technologies, thus benefiting mainly the resource poor farmers.

We are highly thankful to Dr Mary Taylor, the author of this publication, for synthesizing all relevant information relating to conservation and utilization of plant genetic resources in the pacific region. We are also acknowledging the excellent technical input provided by Dr Prem Mathur and Dr Bhag Mal in compilation and editing of this report. It is our expectation that APAARI members, stakeholders and other readers will find this publication both informative and useful.

Raj Paroda
Executive Secretary
APAARI

Acronyms and Abbreviations

ACIAR	:	Australian Center for International Agricultural Research
AusAID	:	The Australian Government's Overseas Aid Programme
CCI	:	Cocoa and Coconut Institute, PNG
CePaCT	:	Center for Pacific Crops and Trees
CGIAR	:	Consultative Group on International Agricultural Research
CHEEF	:	Culture, Health, Environment, Economic and Food Security
CNMI	:	Commonwealth of the Northern Mariana Islands (CNMI)
CREES	:	Cooperative Research, Extension and Education Services
CRGA	:	Committee of Representatives of Governments and Administrations
EU	:	European Union
FAO	:	Food and Agriculture Organization of the United Nations
FSM	:	Federated States of Micronesia
GCDT	:	Global Crop Diversity Trust
GDP	:	Gross Domestic Product
IAC	;	Institut Agronomique néo-Calédonien
IARCs	:	International Agricultural Research Centers
IFCP	:	Island Food Community of Pohnpei

ITPGRFA	:	International Treaty on Plant Genetic Resources for Food and Agriculture
KGA	:	Kastom Gaden Association
LRD	:	Land Resources Division
MAFF	:	Ministry of Agriculture, Fisheries and Forests
MASLR	:	Ministry of Agriculture, Sugar and Land Replacement
MLS	:	Multi-lateral System
NARI	:	National Agricultural Research Institute
NARS	:	National Agricultural Research Systems
NGO	:	Non-Governmental Organizations
NISM	:	National Information Sharing Mechanism
NTBG	:	National Tropical Botanic Garden
NZAID	:	New Zealand Aid Programme
PAPGREN	:	Pacific Agricultural Plant Genetic Resources Network
PGR	:	Plant Genetic Resources
PGRFA	:	Plant Genetic Resources for Food and Agriculture
PICTs	:	Pacific Island Countries and Territories
PRAP	:	Pacific Regional Agricultural Programme
RGC	:	Regional Germplasm Center
RMI	:	Republic of Marshall Islands
SMTA	:	Standard Material Transfer Agreement
SPC	:	Secretariat of the Pacific Community
SPYN	:	South Pacific Yam Network
TIP	:	Taro Improvement Programme
TLB	:	Taro Leaf Blight
UNDP	:	United Nations Development Programme
UNITECH	:	University of Technology, PNG
USP	:	University of the South-Pacific
VARTC	:	Vanuatu Agricultural Research and Technical Center

Strengthening of Plant Genetic Resources for Food and Agriculture : Conservation and Utilization in the Pacific

1. The Pacific in Perspective

The Pacific region is geographically, ecologically, sociologically and economically diverse. This region has a population of 9.5 million on a land area of 550,000 km^2, surrounded by the largest ocean in the world. Five islands (Fiji, New Caledonia, Papua New Guinea (PNG), Solomon Islands and Vanuatu) account for 90% of this land area, and more than 85% of the population. The world's smallest island states and territories, for example, Nauru, Tuvalu and Tokelau are in the Pacific. The importance of agriculture in sustaining livelihoods varies across the region. In the larger islands, such as Papua New Guinea, Solomon Islands and Vanuatu, agriculture and forestry remain the mainstay of the economy and employment, contributing significantly to household income and increasingly the export earnings. In contrast, subsistence dominates in some of the smaller islands.

The Pacific region faces numerous social and physical challenges in maintaining and improving the productivity of its agriculture sector and protecting its biological diversity. The geographical isolation of the region and the small size of many of the islands have resulted in a narrow genetic and production base with limited opportunities for scaling up production. These constraints hamper the recovery from natural disasters which are showing an increasing pace of occurrence. Movement of goods and people, through trade and tourism have exacerbated the risk of introducing

unwanted plant and animal pests, weeds, diseases, and other alien invasive species, threatening the fragile ecosystems and resource base of the region.

Significant social challenges exist which affect the agriculture sector. The population is projected to grow at an annual rate of 2% in Melanesia, 1.84% in Micronesia and 0.7% in Polynesia[1]. Urban populations are growing at a faster rate, and are expected to double in the next 25 years in Melanesia. This rural to urban migration has resulted in reduced agricultural production and increased reliance on imports. Diets that include an increasingly higher proportion of imported food with little nutritive value are causing or contributing to enhanced rates of non-communicable diseases, malnutrition, and micronutrient deficiencies (SPC, 2008).

Dependence on imported food, as a result of the limited capacity of the small-holder agriculture sector to supply and satisfy the needs of the domestic market, is in fact one of the major threats facing the Pacific. The leaders of Pacific countries recognized the threat that food insecurity poses to the future well-being of people across the region and under the Pacific Plan[2], prioritized the actions on food security. In the Pacific Forum Leaders' Niue Communique[3], the leaders recognized that: (a) high food prices provide a strong incentive to increase Pacific food production; (b) committed their governments to immediate action to address food security issues regionally; and (c) called on regional technical agencies to assist in supplementing national capacity in agriculture by assisting in research and development through more robust national policies, programmes and responses. More recently, the Framework for Action for Food Security agreed on at the 2010

[1]The Pacific region is commonly divided into three sub-regions, Polynesia, Melanesia and Micronesia

[2]Pacific Plan: Pacific Island Forum Secretariat http://www.forumsec.org.fj/pages.cfm/about-us/the-pacific-plan/ (2005)

[3]Pacific Forum Leaders' Niue Communique, August 2008

Pacific Food Summit[4] declared that "A return to a subsistence way of life with the expectation of being able to feed the whole population is unrealistic. However, local production needs to remain the core of the food system and the capacity of farmers and fishermen to trade their produce locally, regionally and internationally needs to be supported and extended." The 2010 Framework also recognized that "Food security will be improved when the availability, access, stability and use of locally produced food is increased sustainably."

Traditional food production and preparation techniques play an important role in maintaining community resilience to shocks such as those resulting from globalization and climate change. However, with the exception of Fiji, all countries in the region are net importers of food. Agricultural productivity has not kept pace with population growth. Although in Vanuatu, Fiji, Samoa and Cook Islands, agriculture (including fishing) still contributes in excess of 10% of GDP, and in Papua New Guinea, the Solomon Islands and Tonga, it contributes in excess of 25%, both the relative and absolute value of agriculture output has been declining fairly steadily over the last decade and in the small Micronesian countries, agriculture (including fishing) now contributes only about 3% of GDP. Nevertheless, food production activities continue to employ the highest percentage of the labour force (SPC, 2008).

Climate change is adding an extra dimension to the challenges being faced in the Pacific. The fragile ecosystems and in many cases the fragile infrastructure will be tested to the limits. The region is used to face disasters but as per the climate change predictions, these disasters will increase in intensity and become more unpredictable with climate change. Such an impact has been demonstrated very clearly in 2009 and 2010 in Fiji with the occurrence of severe flooding and two cyclones followed by a

[4]Framework for Action for Food Security Pacific Food Summit, Vanuatu, 2010

drought in the west of the country. These disasters impose serious constraints to development in the islands, so much so that some islands seem to be in a constant 'recovery-mode'. With urbanization and an increase in imported food consumption comes also the loss of traditional knowledge and practices of local farmers which are likely to be critical in finding solutions to future challenges such as climate change.

Challenges such as climate change, nutritional well-being and developing niche markets all need crop diversity. This essential tool can provide the means to manage climate change, to meet market needs and importantly ensure food and nutritional security. A wide range of crop diversity will be required to satisfy this basket of needs.

2. Pacific Crop Diversity

2.1. Diversity of major crops

The Pacific is a center of diversity and/or origin for a number of crops. Root and tuber crops are of particular importance in the region for food and nutritional security, income generation and cultural identity. The region is a primary center of diversity for taro (*Colocasia esculenta*), the Pacific genepool being separate to that found in Southeast Asia (Lebot *et al.*, 2004). Similarly, Micronesia and the atolls are primary centers of diversity for giant swamp taro (*Cyrtosperma merkusii*). The corm diversity in giant swamp taro in the Pacific is depicted in Fig. 1. The varietal diversity of giant swamp taro with respect to flesh colouration, an indication of carotenoid (and possibly anthocyanin) content, is exhibited in Fig. 2. The analysis of four varieties for flesh colour in Fedrated State of Micronesia (FSM) showed that the variety 'Ebon' having very light colour (not yellow) had low carotenoid content, while the variety 'Sari' having yellow flesh colour possessed high carotenoid content. The remaining two varieties having light yellow colour of flesh possessed medium

Fig. 1. *Giant swamp taro (Cyrtosperma merkusii) in the Pacific*

carotenoid content. Taro corm diversity in Samoa is depicted in Fig. 3. For yams, the picture is more complex; primary and secondary centers are found in the Pacific. Melanesia, for example, is the primary center of diversity for *Dioscorea alata* (Lebot, 2009). Papua New Guinea is a secondary center of diversity for sweet potato.

Papua New Guinea is a primary center of diversity for banana, being home to nine wild bananas of which one species, *Musa ingens*, is found only in Papua New Guinea (Elevitch, 2006). The other species include *M. peekelii*, *M. boman*, *M. iododensis*, *M. maclayi*, *M. bukensis*, *M. schizocarpa*, *M. balbisiana*, and *M. acuminata* ssp. *banksii* (Daniells, 1994). Unique to the Pacific are the Iholena and Maoli-Popo'ulu bananas, which together form the Pacific plantains. The Fe'i bananas, belonging to the Australimusa section are also important in the Pacific, particularly in French Polynesia. Fig. 4 shows Fe'i bananas in Pohnpei (FSM). This group of bananas has recently been receiving global attention for their high beta-carotene content (Englberger and Lorens, 2004).

Fig. 2. *Varietal diversity for flesh colouration in giant swamp taro*

Fig. 3. *Taro corm diversity in Samoa*

Fig.4: Fe'i bananas in Pohnpei (FSM)

The Pacific is a primary center of diversity for breadfruit (*Artocarpus* spp.). The species is significant for food and nutritional security and also cultural value, and has nourished Pacific Islanders for more than 3,000 years. The breadfruit exhibition at the first International Symposium on Breadfruit Research and Development held at Nadi, Fiji on 16-19 April 2007 exhibited a high diversity in breadfruit (Fig. 5). Genetic diversity is the richest within the cultivars from Melanesia and Micronesia, which are mostly seeded, out-crossing, fertile diploids or hybrids. In contrast, the breadfruit diversity in Polynesia represents a much narrower genetic base and the sterile triploids predominate (Ragone, 2007).

2.2. Institutions involved in PGRFA activities

All Pacific islands and countries are engaged in plant genetic resources for food and agriculture (PGRFA) activities to varying

Fig. 5. *Sampling breadfruit diversity in the first international symposium on breadfruit research and development held at Nadi, Fiji on 16-19 April, 2007*

degrees. In the first phase of the Pacific Agricultural Plant Genetic Resources Network (PAPGREN), 11 Pacific island countries were members, namely, the Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Republic of Marshall Islands, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu. Non-governmental organizations including Kastom Gaden Association (KGA), Planting Materials Network and Melanesia Farmers First Network were also involved. In the second phase, the membership of the network expanded to also include American Samoa, the Commonwealth of Northern Mariana Islands, French Polynesia, New Caledonia, Niue and Tuvalu. All PAPGREN member countries have PGRFA focal points attending PAPGREN meetings (Fig. 6) and reporting on PGRFA-related activities. Table 1 shows the organizations participating in PAPGREN.

Fig. 6. *Participants of PAPGREN Annual Meeting, Suva, Fiji (2009)*

Table 1. Organizations participating in PAPGREN

Country	Organization	Focal point contact
American Samoa	American Samoa Community College – Land Grant Programme	Emily Ilaoa emily_ilaoa@yahoo.com
Commonwealth of the Northern Mariana Islands (CNMI)	Cooperative Research, Extension and Education Service (CREES), Saipan	Dilip Nandwani dilipnandwani@yahoo.com
Cook Island	Ministry of Agriculture	William Wigmore research@oyster.net.ck
Federated States of Micronesia (FSM)	Pohnpei Agriculture of the Office of Economic Affairs	Adelino Lorens pniagriculture@mail.fm

Contd...

Table 1 contd.

Country	Organization	Focal point contact
Federated States of Micronesia (FSM)	Island Food Community of Pohnpei (NGO)	Lois Englberger nutrition@mail.fm
Fiji Islands	Ministry of Primary Industries	Poasa Nauluvula Poasa_n@ymail.com
French Polynesia	Ministere de l'Agriculture et de l'Elevage	Maurice Wong Maurice.wong@rural.gov.pf
Kiribati	Ministry of Environment, Lands and Agricultural Development	Tianeti Beenna jetuati@gmail.com
New Caledonia	Institut agronomique neo-Caledonien (IAC)	Valerie Kagy kagy@iac.nc
Niue	Department of Agriculture	Alana Tukuniu, atukuniu@niue.nu Brandon Tauasi flextauasi@yahoo.com
Republic of Marshall Islands	Ministry of Resources and Development	Henry Capelle kikurto@yahoo.com
Palau	Palau Community College	Aurora Del Rosario Aderose929@yahoo.com
Papua New Guinea	National Agriculture Research Institute (NARI)	Rosa Kambuou rosa.kambuou@nari.org.pg Janet Paofa Janet.paofa@nari.org.pg
Samoa	Ministry of Agriculture and Fisheries	Parate Matalavea pmatalavea@lesamoa.net
Samoa	University of the South Pacific (USP)	Tolo Iosefa Iosefa_t@samoa.usp.ac.fj

Contd...

Table 1 contd.

Country	Organization	Focal point contact
Solomon Islands	Ministry of Agriculture and Livestock	Jon Bosco J_sulifoa@yahoo.com
Solomon Islands	Kastom Gaden Association (KGA)	Jack Kalisto jackk@kastomgaden.org
Tonga	Ministry of Agriculture, Food, Forests and Fisheries	Manaia Halafihi mhalafihi@gmail.com
Tuvalu	Ministry of Agriculture and Forestry	Itaia Lausaveve ilausaveve@gov.tv
Vanuatu	Vanuatu Agriculture Research and Training Center	Marie Melteras m_melteras@vanuatu.com.vu

At the regional level, the Secretariat of the Pacific Community with the Land Resources Division (LRD) Genetic Resources Programme is the Secretariat for PAPGREN and is also responsible for the management of the Center for Pacific Crops and Trees (CePaCT). The Secretariat of the Pacific Community is also the "agent" to support the Contracting Parties to the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) in the implementation of the Treaty. The University of the South Pacific (USP), in particular the Samoa-based Campus, is the host to the participatory taro breeding programme called as Taro Improvement Programme (TIP) and also has the responsibility for duplicating the Pacific accessions held in the CePaCT.

The Pacific regional strategy[5], submitted to the Global Crop Diversity Trust (GCDT) in 2006, describes how all these institutions collaborate to ensure coordination for effectively implementing the PGRFA activities in the Pacific. For example, the Vanuatu Agricultural Research and Training Center (VARTC), Vanuatu

[5]Pacific Regional Strategy www.croptrust.org/documents/regionalstrategies/pacific

maintains important collections of crops, breadfruit and coconut. There is significant expertise available within VARTC in the field of plant breeding, mainly for taro, sweet potato, yams and coconut. With the exception of the plant breeding programmes in Samoa and Papua New Guinea, expertise for plant breeding in the Pacific is limited and as such VARTC can provide new breeding lines for evaluation in other countries. Virus testing to ensure safe exchange of material is carried out by CePaCT.

The National Agriculture Research Institute (NARI) of Papua New Guinea is currently implementing a project funded by the European Union (EU). This project, with collaboration between Papua New Guinea, Solomon Islands and Vanuatu, focuses on capacity building.

2.3. Genebank holdings

The Pacific regional strategy detailed the key collections maintained in the region and highlighted where significant diversity could be found. This strategy has guided the Global Crop Diversity Trust's activities in the region, ensuring a rationalized approach to conservation and utilization. Details of the collections held in Pacific Island countries and territories (Guarino, 2004) can be found in the Directory of Plant Genetic Resources (Fig. 7).

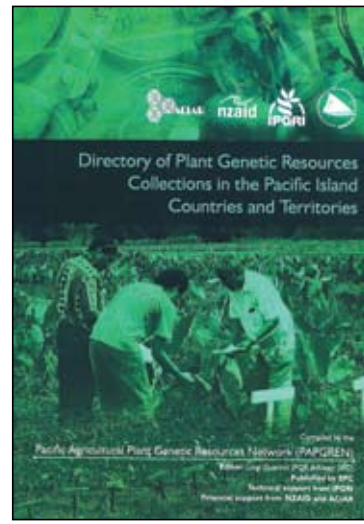

Fig. 7. *Directory of plant genetic resources in the Pacific*

This Directory will soon be web-based facilitating regular updating. Significant collections of a number of important crops, in particular

taro, sweet potato, yam, banana, cassava and bele (*Abelmoschus manihot*) are found in Papua New Guinea, maintained by the National Agriculture Research Institute (NARI). Similarly, Vanuatu, through the Vanuatu Agriculture Research and Training Center (VARTC), maintains collections of taro, yams, sweet potato, and cassava which are used in breeding programmes. More recently, VARTC has established collections of banana, bele and breadfruit. A major breadfruit collection is held by the National Tropical Botanic Garden (NTBG) in Hawaii. The Pacific region is working to establish its own collection of breadfruit, and several collections are being established in French Polynesia, Vanuatu and Fiji. For those countries that are unable to sustain field collections, such as atolls, samples are provided to the CePaCT for the breadfruit *in vitro* collection. Similarly, with support mainly from the Global Crop Diversity Trust, the region is establishing a Pacific banana collection with the focus on Fe'i, Iholena and Maoli-Popo'ulu bananas. Table 2 shows a list of the genebank holdings as reported at the 2009 PAPGREN meeting.

3. Importance of Sharing Genetic Diversity

Taro production in the Pacific region was adversely affected in the past due to the prevalence of taro leaf blight disease which posed a serious problem. Hence, the need was felt to address this problem on priority. Several chemical and cultural control methods were developed and evaluated but these were either not cost effective or were not realistic in fully controlling the disease. In addition, the issue of sustainability in production was an important consideration. At the same time, local varieties were also being tested for their resistance to taro leaf blight(TLB), but all were found to be highly susceptible. In response to requests from Samoa for taro varieties with TLB resistance, the Philippines provided a variety known as PSB-G2. From the Pacific region, varieties from the Federated States of Micronesia and Palau were also evaluated. Ngerruuch, a variety from Palau was particularly successful, both

Table 2. List of the genebank holdings as reported at PAPGREN meeting (2009)

Location	Country	Type	Banana	Breadfruit
Totokoitu Research Station	Cook Islands	Field	19	
Micronesia Plant Propagation Centre	FSM	*In vitro*	30	
Pohnlangas Pilot Farm	FSM	Field	38	6
College of Micronesia	FSM	*In vitro*	10	
Koronivia Research Station	Fiji	Field		
Taveuni Coconut Centre	Fiji	Field		
Sigatoka Research Station	Fiji	Field		15
Naduruloulou Research Station	Fiji	Field		5
Wainigata Research Station	Fiji	Field		
Seaqaqa Research Station	Fiji	Field		
Dobuilevu Research Station	Fiji	Field		
Hiva Oa	French Polynesia	Field	16	
Central Nursery, Bikenibeu	Kiribati	Field		8
Division of Agriculture HQ, Tanaea	Kiribati	Field	8	
Arrak Agricultural Research Station	RMI	Field	10	6
College of the Marshall Islands	RMI	*In vitro*	7	
Station de Recherches Fruitières de Pocquereux	New Caledonia	Field	71	5
Centre des tubercules tropicaux	New Caledonia	Field		
Palau Community College R&D Station	Palau	Field		
NARI-Aiyura	PNG	Field	26	
NARI-Keravat	PNG	Field	71	
NARI-Laloki	PNG	Field	235	
NARI-Bubia	PNG	Field	37	
UNITECH	PNG	Field		

Cassava	Coconut	Cocoyam	Giant swamp taro	Sweet potato	Taro	Yams	Total
7	6	4			23		59
					23		53
8			20		11	10	93
							10
27		2		30	112	128	299
	14						14
							15
							5
	14						14
						128	128
				30		128	158
							16
	7						15
					4		12
							16
				15	24		46
							76
25				17	80	150	272
50				22	98		170
34				1311			1371
40		4		108	205		430
77				16	19	348	695
29				22	859		947
				50			50

Contd...

Table 2 contd.

Location	Country	Type	Banana	Breadfruit
CCI	PNG	Field		
CCI	PNG	*In vitro*		
Atele Research Station	Samoa	Field		13
Nu'u Research Station	Samoa	Field	21	
Nu'u Research Station	Samoa	*In vitro*	41	
Olomanu Research Station	Samoa	Field		
Fote Field Experiment Station	Solomon Islands	Field		16
Dala Field Experiment Station	Solomon Islands	Field		
Tenaru Field Experiment Station	Solomon Islands	Field		13
Newi Field Experiment Station	Solomon Islands	Field		13
Russell Islands Plantation Estate	Solomon Islands	Field		
Kasdom Gaden Association, Burns Creek	Solomon Islands	Field	8	
PMN Vanga Seed Centre	Solomon Islands	Field		
PMN Seed Centre, Manivovo Rural Training Centre	Solomon Islands	Field	100	
Makira Highlands Banana Collection, Central Bauro	Solomon Islands	Field	30	
Vaini Research Division	Tonga	Field	15	
VARTC	Vanuatu	Field		
SPC-RGS, Suva, Fiji	Regional	*In vitro*	14	
USP, Alafua	Regional	*In vitro*		
USP, Alafua	Regional	Field		
Tatal			**807**	**100**

in its response to TLB and also for its acceptability by the Samoans. It was, therefore, concluded that PSB-G2 and Ngerruuch were

Cassava	Coconut	Cocoyam	Giant swamp taro	Sweet potato	Taro	Yams	Total
	49						49
	22						22
							13
					9	3	33
		1			123		165
	13						13
							16
						300	300
							13
							13
	17						17
							8
				2			2
							100
							30
				9	10	5	39
26	60	8		52	260	300	706
28	8			123	727	139	1039
					172		172
					79		79
351	**210**	**19**	**22**	**1807**	**2838**	**1639**	**7793**

the two varieties that supported the revival of taro production in Samoa, a case of "crop diversity to the rescue".

When Samoa was able to resurrect taro production through the use of taro leaf blight tolerant varieties obtained from the Philippines and Palau, attention was focused on the importance of sharing PGRFA. The disaster in Samoa had major consequences for the country and hence there was no reason for ignoring the fact that crop diversity was important and an essential component of any food production chain. The need to be able to access diversity from elsewhere, demonstrating that no country is self-sufficient in crop diversity, had also been realized and highlighted. However, the countries can only have access to crop diversity outside their borders only if others are willing to share. This was a key message for the Pacific region where many crops have strong cultural associations.

At the same time, studies showed that collections established in the late eighties with UNDP/FAO funding, had been partly or completely lost by 1994[6], with limited human and financial resources, pest and disease outbreaks and climatic disasters being the major causes. In addition, consumer behaviour for moving away from traditional to imported food added another threat to the existence of crop diversity.

In response to the increasing concern of the loss of crop diversity that was occurring and its potential impact on food security, the Secretariat of the Pacific Community (SPC)[7] held a meeting in 1996, at which the Pacific Ministers of Agriculture resolved to put in place, both in their countries and through regional cooperation, policies and programmes to conserve, protect and use their plant genetic resources effectively and efficiently for agricultural

[6]Collections of taro in nine Pacific Island countries in 1986, 1994 (Anonymous 1999) and 2000 (TaroGen Annual Report 1999/2000)

[7]The Secretariat of the Pacific Community (SPC) is an inter-governmental organization that provides technical and policy advice and assistance to its Pacific Island members. SPC was established as an international organization in 1947 and has 22 Pacific Island Countries and Territories (PICTs) as members.

development. In 1998, the "Taro Genetic Resources: Conservation and Utilization" (TaroGen) project, funded by AusAID, was initiated. This provided support for the establishment of the Regional Germplasm Center (RGC), now the Center for Pacific Crops and Trees (CePaCT) which was the immediate response from SPC to the ministerial recommendation.

The TaroGen project illustrated that relatively limited taro diversity existed in the Pacific and highlighted further the importance of access to diversity from outside the region. Over 2,000 taro accessions were collected from within the region. Morphological and molecular approaches were used to determine the diversity that existed in the collection and to identify accessions for the core collection, representative of the diversity in the whole collection, reducing the size of the collection from 2,000 to 200 (Mace *et al.*, 2006). The subsequent molecular comparison between Asian and Pacific taro germplasm confirmed the limited genetic diversity that existed in the Pacific, compared to Asia (Lebot *et al.,* 2004).

One of the important components of the TaroGen project was the Taro Improvement Programme (TIP), a participatory breeding programme which involved farmers at an early stage of the plant selection (Fig. 8). It has taken some five cycles of crosses and selection for the breeding programme to incorporate agronomically useful levels of resistance or tolerance to taro leaf blight into varieties that are acceptable to farmers and consumers. Five varieties generated by the TIP have now completed evaluation by farmers and some consumer acceptability testing and have been approved by the government for export purposes. More resistant materials from Cycle 6 (Fig. 9) and Cycle 7 are now being evaluated by farmers but require assessment for consumer acceptability before they can be commercialized for the domestic and export markets.

Fig. 8. *Taro farmers participating in selection programme in Samoa*

Fig. 9. *Cycle 6 taro breeding line in Samoa*

The response of SPC to the 1996 ministerial decision was not limited to the regional genebank. SPC facilitated the development of a Framework for Plant Genetic Resources Conservation, Management and Use in the Pacific[8] which was presented to the Directors of Agriculture in May, 2001 who recommended that a Pacific Agricultural Plant Genetic Resource Network (PAPGREN) be established. PAPGREN was launched in September, 2001 with funding support from NZAID. The overall objectives of PAPGREN were to strengthen national PGR programmes and collaboration among them so as to use scarce resources – human, financial and genetic – more effectively to solve common problems. In 2002, SPC prepared the strategy paper "Plant Genetic Resources for Food and Agriculture in the Pacific: The Way Forward for SPC". This resulted in the Land Resources Division[9] (LRD) establishing a Genetic Resources Team within LRD recognizing that conservation and use of PGRFA provides the foundation for SPC's support of agricultural development in the Pacific. The two components (PAPGREN and CePaCT) of the Genetic Resources Programme within the LRD of the SPC ensure its functioning as an effective regional hub and also equally important, as an active and wide-reaching network, which supports both national and regional activities.

4. Importance of Regional *In Vitro* Genebank in the Pacific

As detailed in Section 2, the collections were established in many of the Pacific Island countries in the late eighties, but maintaining these collections proved to be extremely difficult. Pest and disease outbreaks, cyclones, civil strife, all impacted on the collections such that significant losses occurred (Jackson, 1994). In

[8]The authors of this framework document were, the PNG-NARI Principal Scientist for PGR, Rosa Kambuou, the senior agronomist of Fiji's MASLR, Aliki Turagakula, and the SPC's RGC Adviser, Dr Mary Taylor,

[9]The Land Resources Division is one of six divisions within SPC, based in Suva, Fiji

the early nineties, the European Union funded the Pacific Regional Agriculture Programme (PRAP) which consisted of several projects, one of which was the "Provision of Tissue Culture Services in the Region". This project worked closely with the tissue culture laboratory within the Plant Protection Service of the SPC. Through the SPC project, countries began to see the benefits that tissue culture can bring in facilitating exchange of planting material. Virus tested tissue culture plantlets were acceptable to the quarantine divisions of the countries. This improved the movement and sharing of germplasm. The EU-funded PRAP project increased the understanding of the benefits of tissue culture. Through the facilities established at the Alafua Campus, University of the South Pacific, the collections of sweet potato, yams, taro and cassava were conserved and the accessions multiplied and distributed to countries in the Pacific region for evaluation. The benefits of tissue culture were evident which included conservation, multiplication and distribution. Through tissue culture, crop diversity in the region could be safely conserved and shared. In addition, the tissue culture methodologies enabled multiplication rates to be manipulated.

5. The Center for Pacific Crops and Trees (CePaCT)

The EU funded PRAP tissue culture project was successful in highlighting the significant contribution that *in vitro* technology can make to agricultural development in the region. Consequently in 1998, the Regional Germplasm Center (RGC) was established with funding support from AusAID and the EU. The Center initially focused solely on the taro accessions collected during the implementation of TaroGen project. However, with the passage of time, it was evident that the Center needed to expand its crop priorities and activities. In the early part of the 21st century, the crop collections increased. The yam collection, in particular, expanded as a result of an EU-funded South Pacific Yam Network (SPYN)

project which saw countries collecting and evaluating varieties of *Dioscorea alata*, for specific traits. Selected varieties were transferred to the RGC for safe conservation and distribution. In 2004, the RGC became the Center for Pacific Crops and Trees (CePaCT). The region agreed that the genebank should acknowledge the importance of tree crops to food security, for example, breadfruit and also that there was a need to share not only the diversity of food crops, but also the unique tree diversity (often multifunctional) of the Pacific.[10]

The basic aim of the CePaCT is to provide the region with the means to safely and effectively conserve their PGRFA, and to facilitate access to useful diversity both within and outside the region. *In vitro* methodology is used, and collections now exist in the genebank for aroids, yam, sweet potato, banana, breadfruit, and cassava. Since its establishment, the Center has significantly expanded its operations, both with regard to collections conserved, crops/accessions distributed and research conducted. CePaCT now holds a globally unique collection of over 850 accessions of taro, and is also expanding its focus from *Colocasia esculenta* to include the other aroids, namely, *Xanthosoma sagittifolium*, *Alocasia macrorrhizos* (often known as *A. macrorrhiza*) and *Cyrtosperma merkusii*. The yam collection currently consists of 247 accessions, mainly of *D. alata*, but also *D. esculenta*, *D. nummularia*, *D. pentaphylla* and *D. bulbifera*. The importance and uniqueness of the collection of taro and Pacific yams has been acknowledged internationally and the CePaCT now receives a long-term grant from the Global Crop Diversity Trust (GCDT) for conservation of these collections. The Trust is also providing support to establish a Pacific banana collection which will focus on the Fe'i bananas and Pacific plantains. Breadfruit is also receiving increased attention because of its importance in the region.

[10]The Center will establish a tree seed genebank which will support the safe movement of tree germplasm and develop conservation methodologies. This is likely to be functioning in 2011

CePaCT has generated interest in the use of diversity through its distribution programme. The countries are keen to evaluate new varieties, increasingly so due to the concern in the context of climate change. The offer of crops and varieties in the "climate ready collection" further enhances the interest in the use of "new" diversity. AusAID under the International Climate Change Adaptation Initiative has provided funding to the LRD Genetic Resources Programme for climate change adaptation work. A major component of this work is the establishment of a "climate ready collection" – a collection composed of crops and varieties with climate tolerant traits, such as drought tolerance, salinity tolerance, etc.

The work programme of the CePaCT also includes research. Capacity building is an integral part of the Genetic Resources Programme such that most research is carried out by Masters' students. The research topics mainly cover salinity tolerance of swamp taro, drought tolerance of taro, elimination of viruses from taro, cryopreservation of aroids and micropropagation of sandalwood, etc.

In 2010, the CePaCT moved to a new location which has provided significantly expanded and improved infrastructure facilities (Fig. 10). The genebank now has considerably increased space with separate rooms for conservation, multiplication and research activities. A separate laboratory exists to cater for the cryopreservation work. Importantly, CePaCT now has its own virus testing facilities. Prior to the move, these facilities were shared, which posed logistical and quality control problems and challenges. The new facility has enabled significant progress in the area of virus testing, from the processing of substantially increased number of samples to expanding the diversity of crops that can be tested.

Fig. 10. *The SPC Center for Pacific Crops and Trees (CePaCT), Suva, Fiji*

6. The Establishment of Pacific Agricultural Plant Genetic Resources Network (PAPGREN)

In 2001, the Pacific Agricultural Plant Genetic Resources Network (PAPGREN) was launched in response to the ministerial recommendation of 1996. At the same meeting, an Action Plan for the Network was developed. This Action Plan was implemented by SPC in partnership with national institutes through their PGR focal points. Technical support was made available by Bioversity International. Funding was provided by NZAID and ACIAR in Phase 1,while in Phase 2, the operational activities were funded by NZAID with the position of PGR Officer funded by SPC. At the time of inception, the membership of the network included 11 Pacific Island Countries. The non-governmental organizations, including Kastom Gaden Association (KGA), Planting Materials

Network, Melanesia Farmers First Network and the University of the South Pacific (USP) were also involved. The membership later increased to 17 Pacific Island Countries and Territories.

When PAPGREN was established, it faced some significant challenges. Understanding these challenges allowed for a good understanding of the progress made by the network. Some of the major limitations and challenges are given below:

- Poor understanding across the region of the importance of PGRFA/crop diversity and the significant contribution it makes to food and nutritional security; very low priority given to PGRFA at the national level in the majority of countries
- A general lack of appreciation regarding the genetic diversity that exists in the Pacific region
- Lack of awareness of the limitations of the existing diversity considering the many challenges posed by biotic and abiotic stresses
- Limited understanding of the need and importance to share PGRFA
- Very limited resources at the national level to support PGRFA activities, to a large extent the result of the poor priority given to PGRFA
- Poor capacity at the national level for sustainable conservation and use of PGRFA
- Very limited networking outside the region with respect to both the acquisition of knowledge and also PGRFA, the region being quite isolated from the global PGRFA arena

The objectives of Phase 1 of PAPGREN focussed on strengthening national PGRFA programmes through a coordinated

and cooperating network, raising the profile of the need for and benefit of PGRFA conservation and use, increasing understanding among the network members of the international legal and policy issues on the conservation and use of PGRFA and sharing the benefits of PGRFA collections. PAPGREN worked in collaboration with other initiatives and projects to achieve its objectives.

PAPGREN made significant progress in the early years (Phase 1) in developing a strong foundation on which to build the network. Annual meetings supported the building of relationships between the members representing the different countries and raised awareness about the common challenges and more importantly the new ideas/innovations that could be evaluated in different countries. It was at an annual meeting of the network where the PAPGREN members first heard about the good work done on the Fe'i bananas in Pohnpei and the high carotenoid content of varieties, such as Karat. This highlighted the unique banana diversity that can be found in the Pacific and stimulated other countries to assess their banana diversity. The publication and dissemination of "PGR News from the Pacific" proved extremely useful to sustain communications and interest outside the annual meetings and helped in motivating the researchers to take a pride in the PGRFA work in the Pacific. National consultations were very effective in raising awareness in countries as participants from outside the agriculture sector were also invited to participate in these consultations. Phase 1 also saw the development of regional strategies for the major crops of the region submitted to the Global Crop Diversity Trust and also the publication of the Directory of PGR collections.

In Phase 2, there was more focus on building capacity and generating the tools and publications to support national activities, for example, the development of the web-based PGR Directory and the exposure of PAPGREN members to the National Information Sharing Mechanism (NISM). Annual network meetings continued

and wherever possible, incorporated training, such as genebank management training (Fig. 11). National consultations were extended to countries not covered in Phase 1, and at the request of the countries, specific issues such as the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), were addressed. The national consultation in Palau was particularly successful which is evident from the fact that shortly after the consultation, Palau acceded to the ITPGRFA.

Fig. 11. *Genebank management training at Suva, Fiji (2009)*

"Regional cooperation and policies to conserve, protect and best utilize the region's plant genetic resources" was the basic premise on which PAPGREN was founded. PAPGREN through the activities implemented in Phase 1 and Phase 2, contributed significantly towards supporting and strengthening regional cooperation. There is probably no better example of regional cooperation than the formal placing of Annex. 1 regional collections held in trust in the

SPC CePaCT into the Multi-lateral System (MLS) of the ITPGRFA by the Samoan Agriculture Minister on behalf of Pacific Ministers of Agriculture and Forestry at the Third Session of the Governing Body of the Treaty in June 2009 (Fig. 12). This clearly indicates that the region as a whole has recognized the importance of both sharing diversity and having access to diversity by being part of the global system of PGRFA.

Fig. 12. *The Minister of Agriculture of Samoa placing the Annex. 1 regional collection held by SPC CePaCT into MLS at the 3rd Session of the Governing Body of ITPGRFA*

PAPGREN is truly a learning network that has successfully engaged stakeholders beyond the traditional focal points of SPC i.e. Governments and made important linkages between non-governmental organizations, farming communities and other sectors, including health. The involvement of the Island Food

Community of Pohnpei (IFCP) has enabled significant sharing of knowledge and tools on the nutritional value of diversity, which has been taken up by other country members, and indicates the impact that can be achieved by a network beyond the immediate objectives/results of the project framework of the network.

PAPGREN has made significant impact in strengthening capacity in PGRFA and this was more evident in Phase 2 rather than Phase 1. Different approaches were used to implement the capacity building activities such as training which clearly demonstrated that capacity needs to be built across the board and not just at one level. Capacity of national agricultural research systems (NARS) had been strengthened through the formal education system with Masters' scholarships and then at the informal level through training and workshops on various technical aspects of genetic resources e.g. collecting, and characterization, banana virus indexing, etc. Training also occurs, albeit indirectly at the annual meetings, where the experience and information are shared. National workshops/consultations also assisted in capacity building. The mix of stakeholders at these workshops/ consultations contributed towards increased awareness about PGRFA. More importantly, these consultations helped those who were outside the PGRFA arena and recognized the valuable contribution that PGRFA can make to agricultural development. A capacity assessment was carried out in 2007 and 2009 by the network. The external consultant who was assigned this task found a great improvement with respect to awareness, knowledge and understanding relating to PGRFA conservation and use in the region, and asserted that this progress was directly linked to PAPGREN. The details of various meetings/workshops, training courses and annual PAPGREN meetings organized are presented in Tables 3-5.

Information and knowledge on PGRFA was very limited before PAPGREN came into existence. The information existed but

Table 3. National and regional workshops organized for PAPGREN partners

Topic	Venue	Year
The workshop on agricultural PGR in the pacific: Formation of a regional network for conservation, management and use	Suva, Fiji	2001
Regional workshop on PAPGREN progress and future plans	Suva, Fiji	2002
PNG national PGR workshop	PNG	2002
Fiji national PGR workshop	Suva, Fiji	2002
Regional workshop on on-farm conservation	Suva, Fiji	2002
Regional consultation on breadfruit conservation	Suva, Fiji	2002
Samoa national PGR workshop	Apia, Samoa	2003
Cook Islands national PGR workshop	Rarotonga, Cooks Islands	2003
PGR education : Prospects for the pacific	Apia, Samoa	2004
3rd Taro symposium	Nadi, Suva	2003
PGR documentation workshop	Suva, Fiji	2004
A workshop on PGR law and policy	Suva, Fiji	2005
National consultation workshop	Federated States of	2008
National consultation workshop	French	2008
National consultation workshop	Kiribati	2008
National consultation workshop	Palau	2008
National consultation workshop	New	2008
National consultation workshop	Niue	2008
National consultation workshop	Tonga	2008

Contd...

Table 3 contd.

Topic	Venue	Year
Consultation on Crops for the Future: Towards food, nutrition, economic and environmental security in the pacific	Nadi, Fiji	2009
Workshop on International Treaty on Plant Genetic Resources For Food and Agriculture (ITPGRFA)	Nadi, Fiji	2009

Table 4. Training courses organized for PAPGREN members

Topic	Venue	Year
Training on tissue culture techniques	Suva, Fiji	2004
Application of LUCID	Suva, Fiji	2006
Public awareness	Suva, Fiji	2007
Banana morphological characterization and genebank management	Brisbane, Australia	2008
Technical guidelines for characterization, evaluation, utilization and documentation	Suva, Fiji	2009

Table 5. Annual PAPREN meetings organized

Title	Venue	Year
PAPGREN annual project meeting	Suva, Fiji	2003
PAPGREN meeting - Planning for the future	Apia, Samoa	2004
PAPGREN annual project meeting	Vanuatu	2005
PAPGREN annual project meeting	Nadi, Fiji	2006
PAPGREN annual project meeting	Suva, Fiji	2007
PAPGREN annual project meeting	Suva, Fiji	2009

was either not documented or if documented was only available within country. PAPGREN developed several public awareness

materials (Fig. 13) and greatly facilitated the flow of information from within and outside the region through 'PGR News from the Pacific'. Valuable information had been documented such as the Directory of PGR Collections in the Pacific. PAPGREN also facilitated the sharing of information generated by the countries, such as the minimum descriptor lists for aibika (*Abelmoschus manihot*), cassava and yams compiled by the PGR staff within NARI, Papua New Guinea. Technical advice was provided to a Masters' student at the University of the South Pacific carrying out an ethnobotanical and genetic diversity study of *Cyrtosperma*. This resulted in the development of a minimum descriptor list for swamp taro. The network has also produced several DVDs such as "Let's Go Local", which greatly helped in promoting the food and nutritional security benefits of traditional crops, in particular, the staple crops.

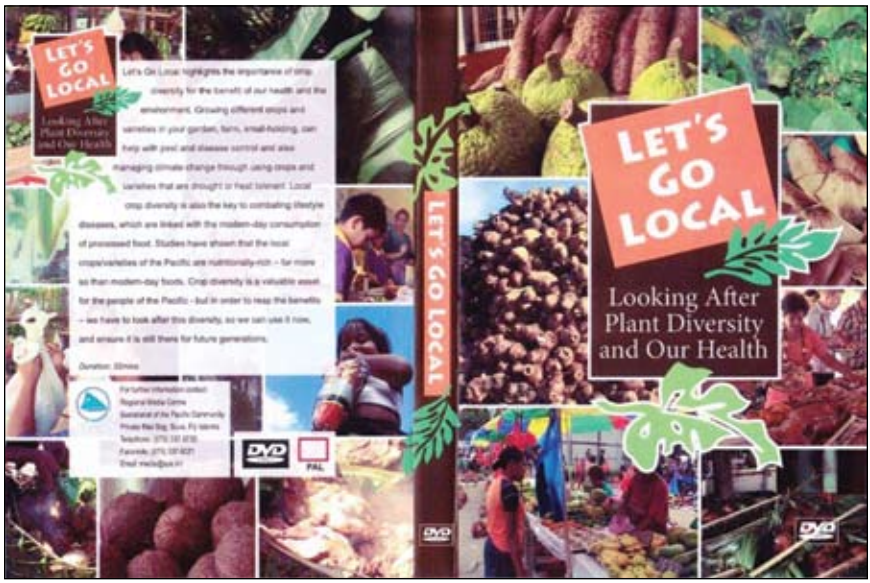

Fig. 13. *Public awareness materials developed by PAPGREN*

The enthusiasm and interest generated by the network has led some countries, for example French Polynesia, to undertake collecting missions and establish the genebanks of unique diversity using their own resources. French Polynesia is also keen to host the regional field genebank of unique Pacific banana accessions. This is a good example of a country taking a leadership role for the conservation of PGRFA where they have the resources (human and financial) and where there is recognition of the uniqueness of the genetic resources from the region. The latter is certainly an achievement of PAPGREN Phase 2, as the activities on banana occurred only during Phase 2 and French Polynesia became a member of the network only in Phase 2 of the project.

The existence of PAPGREN had helped in the development of proposals either electronically or through meetings. For example, recently the Crops for the Future meeting[11] (September 2009) brought together all the PAPGREN focal points and a regional strategy for the development of Crops for the Future in the Pacific was formulated. The existence of the network also enabled the implementation of projects, such as the Crop Regeneration Project funded by the Global Crop Diversity Trust. Under this project, nine countries are being supported to regenerate their collections of taro, giant swamp taro, sweet potato, yam, breadfruit, coconut, giant taro (*Alocasia macrrorhizos*) and cocoyam (*Xanthosoma sagittifolium*).

At the SPC Committee of Representatives of Governments and Administrations (CRGA) 2009, under Agenda item 4 'Maximizing Impacts of Regional Programmes at the National Level', the Center for Pacific Crops and Trees (CePaCT) was selected from the Agriculture programme as 'one of the best examples demonstrating the value of regional programmes at the national level'. The

[11]Regional Consultation Towards Crops for the Future: Towards Food, Nutritional, Economic and Environmental Security in the Pacific, 2010 http://www.apaari.org/publications/consultation-crops-for-the-future.html

success of the Center is very closely linked to PAPGREN which facilitated the establishment of linkages between the CePaCT and the national programmes. The CePaCT *in vitro* genebank has received international recognition through being the first genebank outside the international CGIAR system to receive a long-term grant for its collections. The Center has been successful in its operations because of the support of the network – promoting the importance of PGRFA and facilitating the collecting and evaluating the PGRFA.

Perhaps the most significant impact of PAPGREN is the fostering and facilitating the development of trust between the participating countries. This has only been possible as a consequence of implementing the two phases of PAPGREN during which the network partners were in regular contact with each other through network meetings. This allowed countries to see the value and benefits of regional collaboration, understand the challenges faced by their neighbours and build the rapport with regional colleagues. Having international instruments such as the ITPGRFA in place to guide and safeguard countries' genetic resources from exploitation also contributed towards building this trust among the network members.

6.1. Testimony of the selected PAPGREN country members

The best illustration of the impact of network project is evident from the feedback of some of the countries involved in that project as follows:

- **Cook Islands:** Cyclones had wiped out local taro varieties on the island of Pukapuka. At a National Food Summit, the islanders were made aware of these varieties being conserved at SPC CePaCT and that these were available for their use. Communities are now aware of the importance of CePaCT, as well as the need to carry out in-country

conservation programmes. Farming communities also became aware of other crop varieties that they could access through CePaCT, thus consolidating the importance of being part of this regional collaboration. The role of PAPGREN in facilitating the availability, exchange, use and conservation of these genetic resource materials was specifically significant.

- **French Polynesia:** Raising awareness on PGRFA at the community level led to the request made to the Government for its involvement in PGRFA activities. This made it easier to collect PGR material with the support of the community. The Government recognized the importance of the PAPGREN network, especially in learning about common issues faced by neighbouring countries and knowing about nutritional quality of local crops. This provided strong incentives to support and to be involved with SPC. PAPGREN provided the opportunity to learn about collecting and conservation of local genetic resources.
- **Palau:** People recognized the importance of their crop diversity, especially the taro varieties that are resistant to fungal disease (taro leaf blight). The passion of the people had led to positive moves in overcoming the attempts to patent these materials and making them freely available. Products of hybridization using Palau taro varieties are being repatriated to Palau through the CePaCT as a result of which there is no need for Palau to start costly taro hybridization programmes. PAPGREN provided Palau with climate-ready collections of sweet potato, yam and banana for testing and evaluation which will greatly help the country in making use of the best lines identified as a result of the testing programme.

7. Impact of Conservation and Use of PGRFA in the Pacific

The regional approach to the conservation and use of PGRFA has many benefits. The CePaCT provides a central hub in which significant collections of unique diversity from the Pacific are conserved and can be shared. This is of particular benefit to the smaller island countries with limited diversity and where land and other constraints prevent the establishment of field collections. The CePaCT also allows the smaller island countries to safely conserve their germplasm where national facilities do not exist, for example, breadfruit and swamp taro from Kiribati and swamp taro from Tuvalu. All exchanges of germplasm, breeding lines and varieties are made using the Standard Material Transfer Agreement (SMTA) of the ITPGRFA.

The CePaCT enables diversity from the larger countries such as Papua New Guinea to be virus tested and safely shared with other countries. Improved breeding lines from countries such as Vanuatu and Samoa can also be safely shared. Taro leaf blight (TLB) resistant taro varieties/lines from the participatory breeding programme in Samoa are being made available to other countries in the region that are at risk from TLB, and more recently a selection of TLB resistant taro has been sent to Nigeria using the SMTA to assist them in facing with the recent problem on account of TLB.

Banana diversity has been distributed to several atoll countries in the Pacific, for example, Kiribati. Access to this diversity has provided these countries with varieties that have performed well in somewhat challenging conditions, greatly enhancing food and nutritional security. In addition, the information obtained has been of value to the CePaCT in making recommendations with regard to these varieties, especially to other atoll and low-lying areas.

As a result of the efficient use of diversity, high yielding varieties have been developed in several crops through selection and hybridization and are now available to farmers for cultivation. The produce of these varieties can be seen in local markets for sale (Fig. 14). In addition, high yielding and taro leaf blight resistant varieties of taro having good consumer acceptability are now being exported to other countries (Fig. 15).

The CePaCT has established a climate-ready collection comprising of crops and varieties with traits such as drought and salinity tolerance. This collection is conserved in the CePaCT and is being widely distributed for evaluation in different countries in the region. The accessions in this collection have been sourced from within the Pacific and also from the International Agricultural Research Centres (IARCs). Providing this diversity to the farmers

Fig. 14. *Produce of different crops in local market in Tonga*

Fig. 15. *MAFF Staff inspecting and preparing taro for export*

will greatly assist them in managing the varying scenarios predicted under climate change.

All the activities described above are implemented through the PAPGREN. Through this regional mechanism, countries have increased opportunities for identifying PGRFA that will better satisfy their needs as compared to local PGRFA, whether for managing the risks due to climate change or for supporting market ventures. The collecting, conservation and evaluation of breadfruit will help some countries, for example, Fiji and Samoa to strengthen their export market in breadfruit through making available varieties that will enable year-round production.

8. Important Issues Requiring Attention

Significant progress has been made at the regional and national level since the establishment of PAPGREN. Despite the lack of funding for activities, such as annual meetings, the network remains active through other activities such as germplasm and information exchange. Funding for the initiatives relating to PGRFA such as climate change is also proving to be helpful in providing support for in-country activities. In addition, the Global Crop Diversity Trust continues to support the priority activities identified in the regional strategy for PGRFA conservation and use in the Pacific. However, these important issues need priority attention.

The issue relating to countries in the region acceding to the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) needs urgent attention. To date, only five countries (Cook Islands, Fiji Islands, Kiribati, Palau and Samoa) and two French Territories (French Polynesia and New Caledonia) are the Contracting Parties to ITPGRFA. Other countries are actively engaged in the consultations and processes required to accede to the Treaty. It is important that all the countries of the Pacific become Contracting Parties to the Treaty so that they can play an important role in the Governing Body of the Treaty and also become eligible for the benefits, whether monetary or non-monetary.

The implementation of crop strategies, in particular, the strategies for banana and breadfruit are ongoing. National collections are being established with the aim of establishing regional collections. For both these crops, the field and *in vitro* collections will be essential. The Pacific region is working on establishing regional genebank of banana and breadfruit collections. In this regard, a good progress is being made and it is essential that this momentum is maintained so that the unique diversity

of the Pacific is collected, conserved, evaluated, documented and utilized.

Documentation also requires further concerted efforts. This is an area that remains somewhat neglected, mainly because of lack of resources. Recently, some progress has been made with the establishment of a CePaCT database, both for internal and external users. The internal database using Excel has been established for monitoring and recording all information relating to the genebank and its accessions. This will be used only by the staff of the genebank. In contrast, PacGen will enable germplasm users to see what accessions CePaCT holds and any relevant information associated with these accessions.

9. The Way Forward

The genetic resources are recognized as an important thematic area within the SPC Land Resources Division. The CePaCT is now one of the core functions of the Genetic Resources Programme and this has been acknowledged in the long-term sustainable funding strategy of SPC. A solid foundation exists on which to build and develop PGRFA activities.

PAPGREN has focused to a large extent on collecting and conservation. Expertise and knowledge in best practices for collecting and conserving has been shared. The region now has a genebank that operates as per the international norms/standards and is recognized internationally. National PGRFA focal points have been trained in internationally approved systems and procedures for collecting and conserving PGRFA. The time is right and the mechanisms are in place to put more concerted efforts towards the utilization aspect, recognizing the need for characterization and evaluation of collections. To date, PAPGREN has concentrated on the more traditional characterization of PGRFA, which generates

morphological and molecular data, and mainly supports the genebank manager and the breeder. There is very little data to support other important aspects such as market development and economic growth. Such data would include nutritional quality traits and also the processing traits for value addition, etc. Utilization of the germplasm from the viewpoint of climate change is obviously very important bearing in mind the evidence that exists to show the impact of the predicted weather patterns on crop production. Information on biotic and abiotic stress-resistant crops and varieties is urgently needed to ensure that farmers can continue to produce yields under predicted adverse climatic conditions in the future.

The recent State of the World Report highlighted that reaching the levels of food production required for projected food security needs efficient utilization of crop diversity through plant breeding with effective seed delivery systems. The report pointed out that plant breeding capacity globally has not changed significantly since 1996. Active breeding programmes now exist in Papua New Guinea, Vanuatu and Samoa. The researchers under the programme in Samoa work closely with farmers, following a participatory approach that focuses on taro. The programme in Papua New Guinea is currently focusing on breeding taro lines, resistant to taro leaf blight (as in Samoa), sweet potato with orange/yellow flesh and aibika for tolerance to water-logging. In Vanuatu, the breeding programme encompasses taro, yams, sweet potato and cassava. It could be argued that provided these programmes continue, the breeding lines produced can be shared through regional cooperation. However, considering the challenges posed by climate change, concentrating more on location-specific breeding is likely to have more immediate and long-term impact. With this in mind, capacity building in participatory varietal selection and participatory plant breeding need to be given greater thrust that would be of great benefit to the region at the national and community level.

This participatory approach to crop improvement is indicative of the need to focus PGRFA efforts at the community level recognizing the importance of strengthening knowledge, awareness and capacity at that level to ensure community resilience. Crop and livestock productivity, market access and the effects of climate are all extremely location specific and therefore, to have impact in these areas, technical and capacity building support must reach the local communities. Working more at the community level would also allow for greater efforts for on-farm conservation. The focus with crop conservation to date has been on *ex situ* conservation, with very little focus on any other conservation methodology. At the same time, PAPGREN recognized that for any crop, a complementary strategy for germplasm conservation should be developed. Increased efforts for on-farm conservation would be in line with improved utilization and greater involvement at the community level.

Additionally, there is the much neglected area of underutilized species or crops which are extremely important for the future, which were the focus of the September 2009 "Pacific Crops for the Future" meeting (Fig. 16). Thirty participants from 15 countries as well as regional and international organizations participated in this consultation which was held over two days and consisted of plenary and working group sessions. Three working groups basically representing the three sub-regions (Melanesia, Micronesia and Polynesia), developed a list of priority species/species groups for the respective sub-regions (Mary *et al.*, 2009) and at the same time provided justification for their sub-regional importance (Table 6). Regional priorities were clearly breadfruit (*Artocarpus altilis*), bananas of the Fe'i group and/or Pacific plantain, Polynesian chestnut (*Inocarpus fagifer*) and tava (*Pometia pinnata*). Other species, which were not prioritized in these sessions due to being underutilized, yet had been identified as important in the various

Fig. 16. *Participants of Crops for the Future Meeting held at Nadi, Fiji Islands on 21-22 September 2009.*

country reports and preceding discussions, are bele (*Abelmoschus manihot*), pandanus (*Pandanus tectoris*) (Fig. 17) and the lesser aroids such as *Alocasia macrorrhizos*, *Xanthosoma sagittifolium* and *Cyrtosperma merkusii*.

In addition to the list of priority species, a strategy was developed during the course of the consultation which consisted of six distinct elements: i) generation and collection of knowledge and undertaking research; ii) communication and dissemination; iii) policy advocacy iv) market development; v) partnerships; and vi) capacity building and institutional strengthening. All elements of the strategy are equally important but the resources and time required to address these effectively will vary for each element. The participants agreed that good progress could be achieved

Table 6. List of periority underutilized species in the sub-regions in the Pacific.

Sub-region I Papua New Guinea, Solomon Islands, Vanuatu, New Caledonia, Fiji		Sub-region II Tonga, Samoa, French Polynesia, Cook Islands		Sub-region III Kiribati, Niue, CNMI, Palau, FSM	
Species	**Justification**	**Species**	**Justification**	**Species**	**Justification**
Artocarpus alitilis (breadfruit)	Staple during food storage, market potential, nutrition	*Artocarpus alitilis* (breadfruit)	Nutritional value, staple crop, market potential - fresh or processed, cultural heritage importantce, environmental services	*Artocarpus alitilis* (breadfruit)	Culture, Health, Environment, Economic and Food Security (CHEEF)
Abelmoschus maihot (bele)	Nutritional value, adapted to PICs, market potential	*Xanthosoma* spp., *Alocasia* spp. (lesser aroids)	Nutritional, staple crop, climate change (dry/wet), market potential	*Cyrtosperma merkusii* (giant swamp taro)	CHEEF
Saccharum edule (pitpit, duruka)	Nutritional value, adaptation to climate ch;ange, market potential	*Musa* spp. (Fe'i bananas/ plantan)	Health, cultural value, market potential	*Pandanus* spp.	CHEEF
Musa spp. (plantain)	Nutritional value, adapted to environment, market potential (export and local)	*Inocarpus fagifer* (Polynesian chestnut)	Market potential, environmental services, firewood, nutritional	*Musa* spp. (Fe'I bananas)	CHEEF

Contd...

Table 6 contd.

Sub-region I Papua New Guinea, Solomon Islands, Vanuatu, New Caledonia, Fiji		Sub-region II Tonga, Samoa, French Polynesia, Cook Islands		Sub-region III Kiribati, Niue, CNMI, Palau, FSM	
Species	**Justification**	**Species**	**Justification**	**Species**	**Justification**
Canarium ovatum (galip nut)	Limited to Western Pacific, good market potential	*Pometia pinnata* (tava)	Nutritional, timber and firewood, soil adaptation (atoll and volcanic islands), market potential	*Cocos nucifera* (coconut)	CHEEF
Dioscorea spp. (yam)	Food and nutritional security, cultural, market potential	*Cocos nucifera* (coconut)			
Citrus spp.	Nutritional, market potential				
Inocarpus fagifer (Polynesian chestnut)	Market potential, environmental services, firewood, nutritional				
Metroxylon sagu (sago)	Food security cultural (PNG only)				
Amaranthus spp (aupa)	Nutritional (PNG), Fiji, Solomon Islands only)				

in the first instance, with basically no resources, through the development of a matrix for the assessment of ongoing work on and opportunities for these species in the Pacific.

Fig. 17. *Pandanus (Pandanus tectorius) in Republic of Marshal Islands*

Finally, diversification must take into account the seed sector. As most staple crops of the Pacific are vegetatively propagated, the seed sector has received very little attention and support. However, with the need to diversify crop production, the increasing importance of the vegetable sector both for home consumption for improved nutrition and health and to supply to the hotels and restaurants in those countries where tourism is important, the seed sector is gaining importance. A recent study conducted by SPC in Fiji, Tonga, Kiribati and Vanuatu with support from FAO, highlighted the problem of poor seed supply in these countries. The important reasons identified were: i) varieties poorly adapted to local conditions; ii) inconsistent supply of quality seed; iii) lack of open-pollinated seeds; and iv) limited seed production capacity. There is an urgent need to strengthen local capacity at the national and community level in order to enhance production and distribution of quality seed.

In conclusion, the value of agricultural biodiversity for sustainable development is finally being acknowledged across many development sectors. The need for genetic diversity becomes

far more apparent in the context of climate change. Agriculture has to adapt to a wide range of challenges posed by unpredictability and increased intensity of weather patterns. The Pacific region is particularly vulnerable in this respect due to its food security being more dependent on crops which do not receive the research attention as received by other crops such as wheat and maize. For these globally important crops, there is significant funding being channelled to international research institutes to determine the impact of climate change through climate modelling and also in both conventional and non-conventional breeding programmes. In contrast, the Pacific region is reliant on the traditional crops with significant diversity which have sustained agriculture in the region for generations. The progress made in conservation and utilization of PGRFA over the last decade is significant and has provided the region with a strong foundation to effectively use its diversity to meet the many challenges, not just those of climate change, but also those relating to nutrition and identifying and sustaining markets. Addressing the pending issues outlined above and also putting in place the programmes as outlined in the road map will do much to prepare Pacific communities for future challenges in agriculture.

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