Breadfruit Conservation Strategy

Global Crop Diversity Trust

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DISCLAIMER

This document, developed with the input of a large number of experts, aims to provide a framework for the efficient and effective *ex situ* conservation of globally important collections of breadfruit.

The Global Crop Diversity Trust (the Trust) provided support for this initiative and considers this document to be an important framework for guiding the allocation of its resources. However the Trust does not take responsibility for the relevance, accuracy or completeness of the information in this document and does not commit to funding any of the priorities identified.

This strategy document (dated 11 September 2007) is expected to continue to evolve and be updated as and when circumstances change or new information becomes available.

In case of specific questions and/or comments, please direct them to the strategy coordinator, Dr Grahame Jackson (gjackson@zip.com.au).

Abbreviations

ABS	Access and benefit sharing
ACIAR	Australian Centre for International Agricultural Research
NZAID	New Zealand's International Aid & Development Agency
IPGRI	International Plant Genetic Research Institute
Bioversity	Bioversity International - previously International Plant Genetic Resources Institute
AFLP	Amplified Fragment Length Polymorphism
CCRISP	Canadian Conservation Research Institute for Sacred Plants
CePaCT	Centre for Pacific Crops and Trees, formerly Regional Germplasm Centre
DNA	Deoxyribose nucleic acid
EU	European Union
FSM	Federate States of Micronesia
GRIN	Germplasm Resources Information Network
Ha	Hectare
HORDI	Horticultural Crop Research & Development Institute
HTFA	High temperature forced air
IBPGR	International Board for Plant Genetic Resources
ITPGRFA	International Treaty on Plant Genetic Researches for Food and Agriculture
MTA	Material Transfer Agreement
NARI	National Agriculture Research institute
NGO	Non-government organisation
NTBG	National Tropical Botanical Garden
PAPGREN	Pacific Plant Genetic Resources Network
PGRRI	Plant Genetic Resources Research Institute
PICts	Pacific Island Countries and Territories
QUT	Queensland University of Technology
RGC	Regional Germplasm Centre
SPC	Secretariat of the Pacific Community
SPRIG	South Pacific Initiative on Forest Genetic Resources
TK	traditional knowledge
USDA/ARS	United States Department of Agriculture/Agriculture Research Service
UWI	University of the West Indies
VARTC	Vanuatu Agricultural Research and Training Centre

1. Introduction

1.1 Process of developing the strategy

The development of a strategy for the global conservation and use of breadfruit (*Artocarpus* species) has been entrusted to the Secretariat of the Pacific Community, an intergovernmental organisation with headquarters in Noumea, New Caledonia, and a division for agriculture in Suva, Fiji. SPC, in turn, has sought the assistance of staff at the Breadfruit Institute, National Tropical Botanical Garden, Hawaii, as well as other scientists and curators worldwide with an interest in the crop.

The period of consultation and collaboration started in early 2007 with the development of a questionnaire (Annex 1), which was sent to collaborators to obtain information upon which to develop the Strategy. Later, many recipients, from the Pacific, the Caribbean and Africa, met at The First International Breadfruit Symposium in Fiji, 16-20 April 2007, hosted by SPC and the Breadfruit Institute (Ragone *et al*. in press). Conservation and use of the crop was a major theme of the meeting. A list of those attending the Symposium (Annex 2) is provided.

1.2 The species and centres of diversity

Breadfruit belongs to the genus *Artocarpus* (family Moraceae), which numbers about 60 wild species native to Southeast Asia and the Indo-Pacific (Jarrett 1959a,b). Within the breadfruit complex there are three species (*Artocarpus altilis*, *A. mariannensis, A. camansi*) and hybrids. The origin and taxonomy of the species has been reviewed recently (Ragone 1997; Zerega *et al*. 2004, 2005, 2006).

Breadfruit (*A. altilis* [Parkinson] Fosberg) has its origin in the western Pacific. New Guinea and nearby islands of the Bismark Archipelago form the centre of diversity for wild, seeded forms. The centre of diversity for seedless and few-seeded forms is further east in Polynesia. Breadfruit has been a source of carbohydrate in Oceania for millennia and hundreds of cultivars exist (Wilder 1928; Ragone 1997), some of which have been distributed throughout the world. The visits of Captain William Bligh in 1793 resulted in Tahitian cultivars being introduced to St Vincent and Jamaica, and during that time France collected cultivars from Tonga for its tropical colonies. Over the next two centuries, also a few Pacific cultivars spread to Central and South America, Africa, India, Southeast Asia, Indonesia, Sri Lanka, northern Australia, as well as Madagascar, the Seychelles, the Maldives and Mauritius. Some cultivars are fertile diploids (2n = 56), others are sterile diploids, possibly resulting from continuous vegetative propagation accumulating genetic abnormalities or they are sterile triploids (2n = 84) (Ragone 1997; Ragone 2001; Zerega *et al*. 2004).

Genetic diversity is greatest within cultivars from Melanesia and Micronesia, which are mostly seeded, out-crossing, fertile diploids; those of Polynesia, by contrast, represent a much narrower genetic base and sterile triploids predominate (Zerega *et al*. 2006). However, in Polynesia unique variation occurs within island groups, where diversity has resulted primarily from somatic mutations and selection by growers. Cultivars outside Oceania show low genetic diversity. Breadfruit in the Caribbean is derived from only six cultivars from Tahiti, those of the French territories from a

single Tongan cultivar and the breadfruit of West Africa from a single introduction (Leaky 1977; Zerega *et al*. 2005b).

A. mariannensis Trecul (dugdug, chebiei) is a wild endemic to the high islands of the western north Pacific (uplifted limestone islands and coastal areas of Palau and the ravine forests of the Mariana Islands) (Fig. 1). The chromosome number is 2n = 56 and viable seed is produced. Introgression has occurred between this species and *A. altilis* and cultivated hybrids are common (Zerega *et al*. 2005). *A. mariannensis* has been introduced to the Federated States of Micronesia and recently to Tuvalu, Tokelau and Hawaii (Zerega *et al*. 2005).

A third species, *A. camansi* Blanco (breadnut) is a spiny, seeded form. Zerega *et al*. (2005), referring to Jarrett (1959b), maintain that it is indigenous to New Guinea where it is common in the lowlands, growing in flooded riverbanks, secondary and primary growth forest, freshwater swamps and in cultivation (Fig 1). It may also be indigenous to the Moluccas and introduced to the Philippines; it is absent from Micronesia, but occurs occasionally as an introduction in the South Pacific and widely in the Caribbean, Central and South America and coastal West Africa (Leakey 1977; Ragone 1997). Its chromosome number is 2n = 56 and viable seeds are produced.

Fig. 1: Natural range of *Artocarpus camansi* and *A. mariannensis*, indicated by dashed and solid lines, respectively (*A. camansi* may also be native to the Philippines and Moluccas). From Zerega *et al*. 2004.

1.3 Origin of the species and distributions

The origins of breadfruit are complex, with both *A. camansi* and *A. mariannensis* involved to different degrees in different parts of the Pacific (Zerega *et al*. 2006). From a study using AFLP markers, it appears that cultivars of breadfruit have arisen in two ways: in Melanesia and Polynesia, they are derived from a single species, *A.*

camansi; while in Micronesia, breadfruit originated by hybridisation of seeded *A. altilis* cultivars derived from *A. camansi* - introduced, historically, by Lapita people - with *A. mariannensis* as the other parent. This was followed by subsequent introgression with *A. mariannensis* and/or *A. altilis*. In both cases, human selection over thousands of years has resulted in the diversity seen today, which includes both sterile and fertile diploids and sterile triploids (Ragone, 2001; Zerega *et al*. 2004, 2005). Triploids in Melanesia and Polynesia are probably autotriploids, as the cultivars there are derived from a single species, whereas in Micronesia they have resulted from unreduced gametes of one of the two progenitors (Zerega *et al*. 2005).

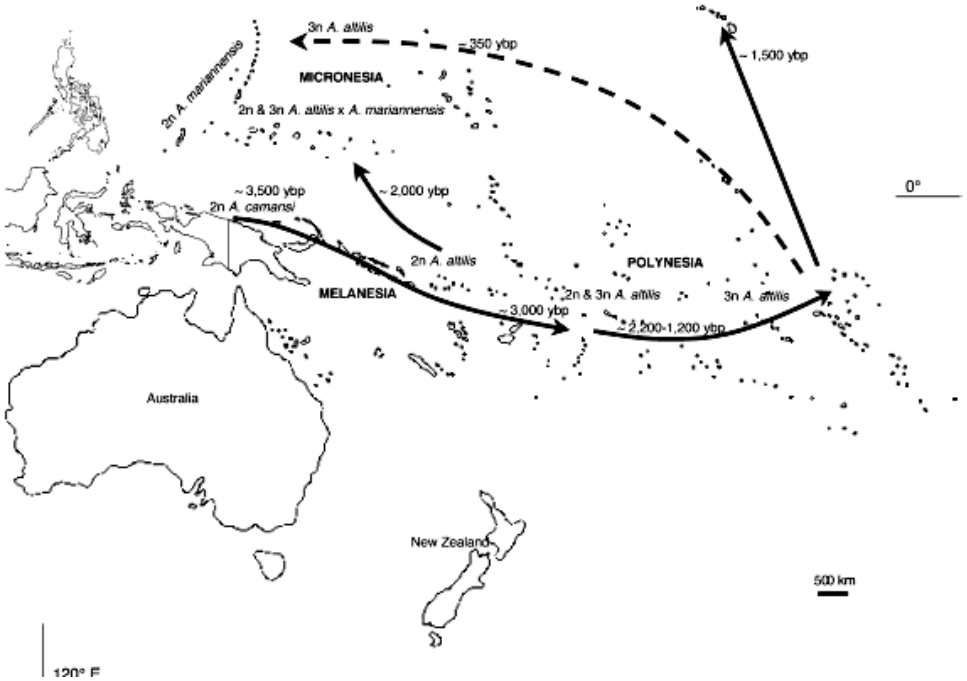

Fig. 2: Proposed dispersal of breadfruit with human migration in Oceania; the dashed arrow is the post-European contact route. Ploidy levels and dates, as years before present, are provided. From Kirch (2000) and Zerega *et al*. 2006).

It is speculated that it is in the eastern Solomon Islands and Vanuatu, where few-seeded diploid cultivars begin to appear and, in western Polynesia (i.e., the Samoas) where few-seeded, seedless and seedless triploids become more common (Ragone 1997), that seedless triploids were preferentially selected, propagated and taken further eastwards into Polynesia by ocean voyagers (Ragone 1991; 2001; Zerega *et al*. 2004; 2006). These authors also suggest that *A. camansi* was taken directly from eastern Melanesia to Micronesia and, further, there were reciprocal transfers, resulting in *A. mariannensis*-specific markers in cultivars from Solomon Islands and Vanuatu and also in those of Polynesia (Fig. 2).

That hybridisation between *A. altilis and A. mariannensis* occurs has been demonstrated in Tokelau, where the two species were introduced after most trees were destroyed by a cyclone in 1914 (Ragone 1991; 2001). New cultivars have arisen with characteristics of both species, and the residents refer to these as “half-caste breadfruits” (Zerega *et al*. 2005).

1.4 Taxonomy

Taxonomists have not always agreed on the nomenclature of breadfruit and the other two species or how to separate them (Zerega *et al*. 2005). *A. altilis* is the accepted name of breadfruit, whether seeded or not, the binomial having taxonomic priority over *A. incisus* and *A. communis*, names that were given to seedless specimens collected during Cook's voyages to Tahiti in 1768-71 (Fosberg 1941, 1960).

Previously, Jarrett (1959a) recognized one highly variable species, *A. communis*, which included domesticated breadfruit and its closest relatives. Trecul (1847) recognized two species: *A. incisa* (= *A. altilis* domesticated, sterile forms) and *A. mariannensis*, endemic to Guam, the Northern Mariana Islands and Palau. Fosberg (1960) also recognized *A. altilis* and *A. mariannensis*, seedless, domesticated and wild seeded breadfruit, and that hybridization was occurring between them in Micronesia. Quisumbing (1940), by contrast, saw two species: the seedless domesticated breadfruit *(A. rima* Blanco = *A. altilis*) and a wild relative, *A. camansi*, native to New Guinea and, possibly, the Moluccas and the Philippines. Recent studies with molecular markers have clarified the relationships between the species.

The conclusion from isozyme (Ragone 1991, Zerega *et al*. 2006) and AFLP studies (Zerega *et al*. 2004, 2005, 2006) is that *A. camansi* is distinct, although closely related, from the other species. *A. camansi* and *A. mariannensis* "represent two morphologically and geographically distinct monophylectic lineages, which both contributed to the evolution of domesticated breadfruit" (Zerega *et al*. 2005). These two species "and at least two different events (vegetative propagation coupled with human selection in Melanesia and Polynesia, and introgressive hybridization in Micronesia) were involved in the origins of breadfruit" (Zerega *et al*. 2004, 2006). *A. altilis* appears to represent a monophyletic lineage and human selection led to a species which is now morphologically distinct from its progenitors (Zerega *et al*. 2005).

1.5 Networking and the Pacific Island countries

There is no established network for breadfruit genetic resources, regional or global. However, countries of the Pacific Islands have made breadfruit a major priority of PAPGREN, the Pacific Agricultural Plant Genetic Resources Network, and this network has been instrumental in providing a platform for developing a collaborative programme for crop improvement in the Pacific and beyond. PAPGREN was launched in September 2001, by the Land Resources Division of SPC in collaboration with Bioversity International (formerly known as IPGRI) and funding from NZAID. This resulted in a regional PGR Action Plan. The overall objectives of PAPGREN are to strengthen national PGR programmes and collaboration among PICTs.

A PGR Adviser was recruited by SPC under a complementary Bioversity project supported by ACIAR, to work closely with the Centre for Pacific Crops and Trees (CePaCT), formerly the Regional Germplasm Centre (RGC). Annual PAPGREN meetings have been held and statements made on breadfruit and strategies

outlined, but it is realized that the network is limited in its capacity as it is charged with the development of genetic resources programmes of a number of priority crops. It is, therefore, reliant on partnerships with centres of excellence to develop complementary activities for the conservation and use of the crops of concern. In the case of breadfruit, this is the Breadfruit Institute. PAPGREN's strength lies in its ability to obtain funding for network activities and technical meetings, such as the *Regional Workshop on Conservation and Sustainable Use of Breadfruit Genetic Resources in the Pacific*, November 2002, and the *First International Symposium on Breadfruit Research and Development* in April 2007, as well as working in partnership with CePaCT and the Breadfruit Institute to disseminate breadfruit germplasm as pathogen-tested tissue cultures, in particular within the Pacific region.

The Breadfruit Institute on the other hand, has a mandate to manage the breadfruit collection at the NTBG; carry out research to solve key problems in breadfruit conservation and use; develop partnerships to distribute and plant breadfruit cultivars worldwide; provide a safe repository for breadfruit germplasm, *ex situ* and *in vitro*; document and conserve knowledge about breadfruit; and provide information and training on breadfruit and its genetic resources.

2. Overview of breadfruit germplasm collections

2.1 Pacific Island collections: successes and failures

In the 1950s, the South Pacific Commission (now the Secretariat of the Pacific Community) established a major regional collection of breadfruit in Samoa, with more than 200 accessions from 14 countries planted at various locations. Duplicates were sent to the Naduruloulu Agriculture Station, Fiji and to Tahiti. Later, local collections were also made in Pohnpei and Kosrae, Federated States of Micronesia (1970s) and Solomon Islands (1980s). With the exception of the Solomon Island plantings, there is little or no provenance data for any of these collections and all have been neglected or abandoned (Table 1). However, it is not only the collections that have suffered: in recent years, there has been erosion of the genetic resource within the traditional farming systems throughout the Pacific and, with it, a loss of traditional knowledge.

Table 1. Pacific breadfruit germplasm collections established in the late 1950s and early 1960s by SPC, in the Federated States of Micronesia in the 1970s, in Solomon Islands in the 1980s, and their present status. (From *Regional Workshop on Conservation and Sustainable Use of Breadfruit Genetic Resources in the Pacific*, SPC, Suva, November 2002).

Country	Accessions	Status
Fiji	(70)	Never existed
Federated States of Micronesia		
▪ Kosrae	*c*.20	Abandoned
▪ Pohnpei	*c*.25	Abandoned
Samoa	260	Abandoned
Solomon Islands (Tenaru Field Experiment Station)	25	Abandoned (active 1995)
Tahiti	No data	No data

A survey by PAPGREN of Annex 1 crops of the ITPGRFA in 2004 recorded breadfruit collections in Pacific Island countries in addition to those established by SPC and other agencies in the '70s and '80s (Table 2); there is little or no provenance data on these accessions, however.

Table 2. Breadfruit accessions in Pacific Island country collections. (From *The Directory of Plant Genetic Resources Collections in the Pacific Island Countries and Territories*, PAPGREN, SPC, 2004.

Country	Locality	No. of accessions reported
Fiji	Sigatoka Research Station	15
	Naduruloulou Research Station	5
Fed. States of Micronesia		
▪ Kosrae	Tofol Department of Agriculture	20
▪ Pohnpei	Pohnlangas Pilot Farm	6
Kiribati	Central Nursery, Bikenibeu	8
New Caledonia	Station de Recherches Fruitières de Pocquereux	5
Rep. of Marshall Islands	Arrak Agricultural Research Station	6
Samoa	Atele Research Station	13
Solomon Islands	Fote Field Experiment Station	16
	Newi Field Experiment Station	13
Vanuatu	Vanuatu Agricultural Research and Technical Centre	36

The *Regional Workshop on Conservation and Sustainable Use of Breadfruit Genetic Resources in the Pacific* in 2002 reported that the loss of breadfruit in the Pacific islands was due to four main factors:

- Cultural change and loss of traditional knowledge, uses, and husbandry practices [see Ragone *et al*. (2004) on naming of cultivars and the vulnerability of traditional cultural knowledge held by elderly experts in the Samoas].
- Environmental factors such as cyclones and droughts.
- Pests and diseases.
- Limited replanting of cultivars.

Two studies illustrate the problems. Since 1996, traditional uses of breadfruit, methods of food preparation and storage (pit fermentation) have been documented on the islands of Pohnpei (Ragone 2002). Over this time, many of the elderly experts have died, and their children and grandchildren are not as knowledgeable about breadfruit, or as active in growing and using it.

In 2000, 350 people were interviewed in Samoa and American Samoa about the names of breadfruit cultivars and more than 40 names were recorded (Ragone *et al*. 2004). The average number known by a person was six and one person knew 20 names. Sixty people were identified as experts, knowling at least 10 cultivar names each. Some of the cultivars were known by only one or a few people, and efforts were made to locate these rare cultivars. In 2002, a village on the island of Saipipi was revisited and several experts were interviewed. They reported that cultivars had

disappeared following the cyclones of the early 1990s and replaced by common ones.

History shows that without a long-term commitment of land, staff and other resources, tree crop collections are very vulnerable. As traditional knowledge disappears, genetic diversity of breadfruit also disappears, and the rare cultivars can be lost very quickly. It also suggests that research of the kind described from the Samoas should be carried out in other Pacific Island countries to assess breadfruit diversity and to identify cultivars at risk.

2.2 The National Tropical Botanical Garden, the Breadfruit Institute and its collections

The NTBG is a privately funded non-profit organization that was created by a US Congressional charter in 1964. It is dedicated to saving tropical flora through scientific research, conservation, and education, with particular emphasis on species at risk. The institution manages over 1,800 acres in five gardens and three preserves in the Hawaiian Islands and Florida. The NTBG established the Breadfruit Institute (http://www.breadfruit.org) in 2002 to promote the conservation and use of breadfruit for food and reforestation. The broader aim is to establish a centre of excellence for the conservation of breadfruit diversity and ethnobotanical research, documenting traditional uses and cultural practice.

Breadfruit is the signature collection of the NTBG and in the mid-1970s the institution committed to "developing a definitive collection of varieties of breadfruit and breadnut." The main collection of 200 accessions is located at Kahanu Garden, Maui. Numerous trees of a local variety were long established at the site, and 32 accessions from Samoa, French Polynesia, Pohnpei, FSM and the Seychelles were planted in the late 1970s. The collection was expanded between 1988-91, when 129 accessions were added as part of an IBPGR/USDA-supported project to collect, describe and document the traditional uses of breadfruit throughout the Pacific (Ragone 1997). Passport data, ethnographic information, herbarium specimens and photographs were collected for 400 accessions in 17 Pacific Island groups and 45 islands. Since that time, another 100 accessions have been collected and documented and 35 added to the collection. There are also 35 accessions at the McBryde Garden on Kauai; 29 of these are duplicates of the Kahanu Garden collection. See Annex 3 for lists of clones presently in major collections.

The NTBG now manages the largest collection of breadfruit in the world, representing a broad range of diploid, triploid and hybrid cultivars and wild relatives, from the Pacific islands, Honduras, Indonesia, Papua New Guinea, the Philippines, and Seychelles (Table 3). All three species of breadfruit/breadnut are included: *A. altilis* (seeded and seedless types); *A. camansi* (seeded breadnut), *A. mariannensis* (seeded); and natural hybrids between *A. altilis* and *A. mariannensis* (seeded and seedless).

The number of each species currently held at the NTBG and the potential maximum size of the collection is given below (Table 4).

Table 3. Country of origin for accessions of three breadfruit species and hybrids maintained at the National Tropical Botanical Garden (Maui and Kauai), Hawaii.

Country of origin	*A. altilis*	*A. mariannensis*	*A. camansi*	*A. altilis* x *A. mariannensis*
Cook Islands	7			
Fiji	8			
▪ Rotuma	8			
Guam		1		
Hawaii[1]	2			
Honduras			1	
Kiribati		1		1
Federated States of Micronesia				
▪ Chuuk	1			6
▪ Kosrae	1			
▪ Pohnpei	12	2	1	10
▪ Yap				2
French Polynesia				
▪ Marquesas	8			
▪ Society Islands	47		1	4
Indonesia			1	
Palau	3		1	5
Papua New Guinea	1		10	
Philippines			1	
Northern Mariana Islands		4		1
Samoa	20			
Solomon Islands	7			
Seychelles	3			
Tokelau				17
Tonga	3			
Unknown	11			
Vanuatu	7			
Number of Countries	**13**	**3**	**7**	**8**

[1] Numerous trees of the local 'Hawaiian' cultivar are well established on site, but have not been accessioned.

Table 4. Number of accessions, including duplicates (no. of trees), of *Artocarpus* species held by the NTBG and the maximum capacity of the genebank.

Artocarpus species	No. currently held		No. potential maximum
	Accessions	Trees	Accessions/Trees
A. altilis	150	187	200
A. camansi	16	33	30
A. mariannensis	8	15	20
A. altilis x *A. mariannensis*	46	62	60
Total	**220**	**297**	**310**

Unfortunately, 158 accessions are represented by a single tree; 52 by two; and 10 by 3-5 duplicates. A majority of the trees have been taxonomically verified using morphological descriptors and molecular markers (Table 5).

Table 5. Characterisation of the NTBG collections: morphological descriptors and molecular markers.

***Artocarpus* species**	**% morphological descriptors**	**% DNA markers**
A. altilis	90	80
A. camansi	30	25
A. mariannensis	75	25
A. altilis x A. mariannensis	90	77

Gaps in diversity
The collection at the NTBG is a valuable resource and, as already stated, unique. However, there are gaps. If funding is sufficient and countries allow collecting, for example under the benefit sharing provision of the ITPGRFA (breadfruit is on Annex 1), then the following is required:

- *A. altilis* from Solomon Islands, Vanuatu, Fiji and the Caribbean Islands.
- *A. altilis* x *A. mariannensis* from Chuuk and Kosrae, Federated States of Micronesia, Marshall Islands, Palau and Tuvalu.
- *A. mariannensis* from Palau, Guam and the Mariana Islands.

Safety-duplication
The collection is partly duplicated, with 11% of accessions at USDA/ARS Tropical Plant Genetic Resource Management Unit, Hilo, Hawaii. It includes a number of accessions from other collections, as follows:

- 2 accessions: Solomon Islands, Fote Field Experiment Station.
- 1 accession: Pohnpei, FSM, Pohnlangas Pilot Farm.
- 1 accession: Kosrae, FSM, Agriculture Station, Tofol.
- 26 accessions: former SPC Regional Breadfruit Collection, Vailima, Vaea, and Nafanua Agriculture Station.

Like all collections, that of the NTBG is vulnerable to damage by cyclones. A root and trunk rot disease (*Phellinus noxius*) is also a concern. Part of the collection is duplicated as mentioned above, but this is insufficient. Some trees need to be replanted, and this offers an opportunity to propagate the entire collection and to find a duplicate site either within the gardens of the NTBG or elsewhere. The costs involved will be considerable wherever it is made. The alternative is to propagate the entire collection *in vitro*. Either way, considerable resources will be required.

Despite the challenges experienced by many countries in retaining breadfruit collections, there has been renewed interest in breadfruit conservation and use throughout the tropics in recent years and some minor collections have been established, albeit mostly with cultivars from the NTBG rather than from new collecting. A total of 33 accessions of breadfruit, including 24 duplicate accessions from the NTBG collection, are maintained in the USDA/ARS National Plant

Germplasm System at the Pacific Basin Tropical Plant Genetic Resources Management Unit, Hilo, Hawaii and the National Germplasm Repository, Mayaguez, Puerto Rico (Table 6).

Table 6. Collections maintained by the USDA/ARS National Plant Germplasm System at Hilo, Hawaii and Mayaguez, Puerto Rico.

Country of origin	Hilo, Hawaii		Mayaguez, Puerto Rico	
	A. altilis	***A. camansi***	***A. altilis***	***A. camansi***
Barbados			1	
French Polynesia	15			
Federated States of Micronesia				
▪ Chuuk	4			
▪ Pohnpei	3			
Malaysia (Sabah)		1		
Northern Mariana Islands	1			
Solomon Islands	1			
Unidentified/no information	5			2
Total	**29**	**1**	**1**	**2**

In 1992, 24 cultivars from the NTBG collection were sent to the University of the West Indies to establish field trials. These and local cultivars are now growing at UWI's Trinidad and Tobago campus. The collection contains cultivars collected locally (7%) and others from neighbouring regions (36%); to date there are 28 cultivars in total and all have been described morphologically (Laura Roberts-Nkrumah, UWI; pers. comm.). The entire collection is duplicated as potted plants maintained in a greenhouse, and some (43%) of the accessions have been sent to the UWI Mona Campus, Jamaica, and distributed locally to farmers. The collection in Trinidad and Tobago is being evaluated for agronomic and other traits.

In 2004, Vanuatu initiated an in-country survey and collection of breadfruit with PAPGREN support, and Samoa established a planting of local cultivars at the Atele Horticultural Centre in an effort to commercialise breadfruit as an export to New Zealand. These and other minor collections of the Pacific islands, the Caribbean and West Africa are provided (Table 7).

Table 7. Minor collections of breadfruit: Pacific, Caribbean and West Africa and elsewhere (From *1st International Symposium on Breadfruit Research & Development,* Fiji, April 2007)

Country	Genebank	No. acc.	Notes
American Samoa	America Samoa Community College	4	Planted 1989. Local germplasm.
Australia	Etty Bay Exotics	5	Private collection. Some evaluation. Further introductions needed to spread crop.
Australia	Kamerunga Research Station	6	Closed
Fiji	Sigatoka Research Station	12	Established 2006 in conjunction with a marketing project. Needs characterization and further collecting. Should be duplicated at NTBG?

Country	Genebank	No. acc.	Notes
Fiji	Naduruloulou Research Station	5	Old trees. Not clear whether same varieties as Sigatoka.
Fiji	Legalega Research Station	10	Duplicate of material at Sigatoka.
Fiji	SPC Regional Germplasm Centre	10	2 Samoan, 10 Fijian varieties in tissue culture. NTBG collection to be duplicated here in vitro and cryopreservation once protocols finalized.
FSM	Pohnlangas Pilot Farm	13	On-farm conservation seen as main strategy. This collection will concentrate on rare and threatened material. No duplication elsewhere
FSM	Pohnpei Botanical Garden	30	Old trees, Pohnpei and Chuuk varieties, including 2 from South Pacific. Not labeled, no provenance data.
FSM	Kosrae Agriculture Department	20	Old trees. Local and Pohnpei varieties. Not labeled, no provenance data.
Ghana	PGRRI, Bunso	8	Need characterization, evaluation, new introductions.
Jamaica	University of the West Indies, Mona Campus	10	Material from NTBG planted 1992-1993. Need human resources for maintenance, data collection, propagation.
Kiribati	Central Nursery, Bikenibeu	8	21 varieties introduced from NTBG in 1993. 5 of these remain.
Marshall Islands	Arrak Agricultural Research Station	6	Need safety duplication at NTBG?
New Caledonia	Station de Recherches Fruitières de Pocquereux	5	From NTBG, planted 2000.
Papua New Guinea	NARI, Keravat	Few	New collections being made by EU funded atoll project. Will need characterization, evaluation, and duplication at NTBG.
Samoa	Atele Research Station	13	Still collecting. Characterization ongoing.
Seychelles	Grande Anse Research Station	Few	Old trees.
Solomon Islands	Fote Field Experiment Station	16	Collection threatened due to virtual abandonment of research station. Need rehabilitation and safety duplication at NTBG.
Solomon Islands	Tenaru Field Experiment Station	13	2 accessions duplicated at NTBG.
Solomon Islands	Newi Field Experiment Station	13	
Sri Lanka	HORDI	4	Need evaluation. Not a priority crop. Not duplicated.
Tanzania	Sokoine University of Agriculture	2	Need characterization, evaluation, new introductions.
Trinidad & Tobago	University of the West Indies, St Augustine Campus	33	Some accessions from NTBG + local varieties from Trinidad, Jamaica and St Vincent. NTBG accessions sent in 1990, some of these were sent on to Mona campus.
USA	USDA, Hilo, Hawaii	40	24 accessions duplicates of NTBG collection

Country	Genebank	No. acc.	Notes
USA	M Greenwell, Hilo, Hawaii	20+	Private collection. From NTBG.
Vanuatu	VARTC, Vanuatu	36	Established in 2005. Further collecting needed. Will need safety duplication at NTBG.

2.3 Collections that meet standards

The NTBG collection is the sole collection that meets standards for conservation, although its ability to distribute material is constrained by factors to be discussed. The collection is maintained solely as a field gene bank and, as such, the conservation of these long-lived trees is subject to the constraints and challenges of sufficient financial resources. Land is not a limiting factor as the garden property in Hana recently expanded from 50 ha to 120 ha. A master plan for the garden developed in 2004 dedicates a sufficient land base to regenerate and expand the collection as needed. While the curatorial component of the collection's management has been good, proper horticultural care and maintenance of the trees has been sporadic, due to staffing constraints over the years. The remote location, limited labour pool, and high cost of living, make it difficult to recruit and retain competent horticultural and technical staff.

Another challenge is that the trees, many of which are 10 m or more in height, produce large quantities of fruit that cannot be reached, and subsequently fall and rot on the ground. Reducing the height of the existing trees is not feasible, but additional plantings can be pruned and shaped annually to keep them to a reasonable height and size.

In the short-term, providing staff with training opportunities at other germplasm facilities, bringing in experts to advise on proper tree care, contracting a certified arborist to prune and shape the trees annually, implementing a composting and mulching program and planting green manures, will all contribute to better horticultural care and health of the trees. Improving the condition of the trees will enhance production of suitable propagating material for *in vitro* research and to regenerate accessions.

Accelerating collaborative research programs to develop and refine *in vitro* protocols and identify a genetic core collection is critical. Funding via an endowment is essential and is being investigated. to ensure that the collection, both *ex situ* and *in vitro*, is properly maintained for the long term.

2.4 Pacific Regional conservation strategy

Breadfruit was the seventh overall crop priority identified in the Action Plan agreed by partners of PAPGREN at a regional workshop in November 2002. It was close to sweet potato and cassava and second only to coconut among tree crops. Fiji, Palau, Kiribati, Samoa singled out the species for action. A specific recommendation of the PAPGREN Plan of Action called for increased access by Pacific Island Countries and Territories to the *ex situ* collection in the NTBG, Hawaii, in particular the transfer of selected lines for evaluation and use. Parts of the Action Plans of PAPGREN, as they relate to breadfruit, have been included in the *Regional Strategy for the Ex Situ*

Conservation and Use of Crop Genetic Diversity in the Pacific Islands Regions prepared with support from the Trust and others. At the PAPGREN meeting in 2004 and 2005, a prioritization exercise involving the Annex 1 crops of the International Treaty on Plant Genetic Resources for Food and Agriculture selected crops based on the following criteria:

- Role in food/nutritional security (especially if the crops were important throughout the region or specifically important in atolls).
- Levels of genetic diversity and of genetic erosion (both in the field and in existing genebanks).
- Cultural value; potential for income generation (especially through value-added products).

Under this scheme, breadfruit was given the highest priority by a majority of countries. In addition, it was recognized that the region was a primary centre of diversity of the crop, its cultural value was high and so was its use in food security strategies. Two collections were identified in the Pacific Strategy as being the greatest importance to the region; these were the collection at the NTBG and one at VARTC, Vanuatu (Table 8).

Table 8. Priority-level collections of breadfruit in the Pacific Islands. (*From Regional Strategy for the* ex situ *Conservation and Use of Crop Genetic Diversity in the Pacific Islands Region*).

Holder	Priority and reason
National Tropical Botanical Garden, Maui, Hawaii	▪ Unique collection (field): largest and most extensive global collection of breadfruit (200 accessions of which 120 from the Pacific) ▪ Some characterization and ethnobotanical research completed ▪ Duplication (including *in vitro*) and utilization (by countries) of collection required ▪ Selection of 20 elite varieties carried out
VARTC, Vanuatu	▪ Well characterized national collection ▪ Material lacking at NTBG

2.5 Conservation status

The entire NTBG breadfruit collection is labeled and mapped. A computerised database containing location, accession numbers, names, provenance information and general descriptions has been developed to facilitate management of the collection. The collection is being studied intensively: the accessions are being characterized using 55 specially developed morphological descriptors and with molecular markers, and it is being evaluated for yield and seasonality. An illustrated web-based catalogue of the collection currently features a “utility core” set of 20 elite cultivars. Those cultivars have been evaluated for fruit quality, nutritional composition and yield. The website will be expanded to include descriptors, photographs and other information about these and other accessions in the collection. Data for selected accessions is also available via GRIN. Information about the breadfruit accessions maintained by the USDA-Pacific Basin Tropical Plant Genetic Resource and its distribution policy can be accessed at http://ars.usda.gov/main/site_main.htm?modecode=53-20-03-45

2.6 Distribution status

The National Tropical Botanical Garden considers its unique collections as a global resource. Although it has received requests for germplasm from countries around the world, it has not been able to fulfill these requests for various reasons. These include:

1) Difficulty in procuring satisfactory planting material without damaging the trees.

Propagating material in the form of root shoots or root cuttings is required for seedless cultivars and preferred for seeded cultivars. However trees rarely produce root shoots and it is often difficult to determine the parent tree for a particular root shoot. Many of the trees are growing in rocky, lava soil, and it is difficult to find roots of the proper size and condition to harvest. Root harvesting is also detrimental to the health of the tree.

2) Remoteness from USDA-APHIS inspection centres and shipping facilities.

Kahanu Garden is located in the small, remote community of Hana (1200 residents) served by two grocery stores and a gas station. It is 85 km from the county seat of Kahului, where USDA-APHIS has their inspection center and where there is an airport, shipping facilities and stores. It is reached by a narrow, winding road that is frequently closed during the rainy season due to flooding and landslides. The garden property itself is inaccessible when an adjacent stream floods and blocks the road.

Facilities and infrastructure are being improved; these include a Breadfruit Institute Field Station, containing a small laboratory and work area (2006), and a greenhouse and shade house (2007). Both facilities are operated by solar power and are on rain catchment water systems.

3) Cost of handling and shipping.

Digging and preparation of roots (they must be individually washed and scrubbed to remove soil) is laborious and time consuming. Shipping costs from Hawaii via air are expensive, and roots are bulky and heavy.

4) Financial and staffing constraints.

Kahanu Garden encompasses over 120 ha and has a small staff who are responsible for maintaining the entire property, including living collections, education programs, etc. The Breadfruit Institute also has a small number of staff: a Director, Administrative Assistant, and a part-time project coordinator (all based on Kauai), and a part-time gardener at Kahanu Garden who tends to the breadfruit trees (mainly mowing and occasional pruning). A staff person has not been available who could gather and prepare propagating material, including seeds, and make the 170 km return drive for inspection, shipping, etc: a full days' endeavour.

For these reasons, there has been limited distribution of materials from the NTBG collection since its establishment. Vegetative planting materials have been provided

in the form of root cuttings to recipients who visited Kahanu Garden and were responsible for arranging quarantine inspection, packaging and shipping.

To date, germplasm has been distributed to:

1990 University of the West Indies, Trinidad
1991 M Greenwell, Hilo, Hawaii
1993 Department of Agriculture, Kiribati
1999 Department of Agriculture, New Caledonia

So that distribution of breadfruit from the NTBG collection can be done effectively, the Breadfruit Institute is collaborating with the Canadian Conservation Research Institute for Sacred Plants (CCRISP; University of Guelph, Ontario, and the University of British Columbia, Canada) and CePaCT to develop methods for *in vitro* propagation, focusing on a "utility" core of 20 cultivars that bear over an extended season. Thus far, CCRISP has developed *in vitro* protocols for six accessions. Five of these have been provided to CePaCT.

The "utility" core was virus-indexed by SPC and the Breadfruit Institute in collaboration with Queensland University of Technology, Australia in 2006, and will be re-tested in 2007. None of 20 cultivars examined by electron microscopy and dsDNA analysis showed evidence of virus infection. (Rob Harding, Associate Professor, School of Life Sciences, QUT; pers. comm.).

As part of a collaborative project to distribute breadfruit varieties to farmers, from November 2006-July 2007, a total of 3,000 plantlets produced *in vitro* were provided to Sustainable Harvest International, an NGO working with farmers in Central America. This was a pilot project to utilize plantlets grown as a result of experiments to mass propagate breadfruit using bioreactor systems at CCRISP.

The NTBG wishes to make germplasm from the collection widely available to users in all countries, after signing an MTA and, possibly, payment of fees for processing, shipping and permits. However, distribution will be limited to accessions conserved *in vitro*. Vegetative material will not be distributed. Although seeds are recalcitrant, they may be made available as staffing and resources allow. Because the NTBG does not have the facilities or resources to manage *in vitro* collections, CCRISP and CePaCT will serve as the long-term repositories and distribute breadfruit germplasm on behalf of the NTBG.

3. Collaboration towards efficient and effective conservation and use

3.1 Collaborative arrangements

The Regional Workshop *Conservation and Sustainable Use of Breadfruit Genetic Resources in the Pacific*, November 2002, identified actions that would make the most of perceived opportunities, while addressing the most pressing needs (Table 9).

The activities fall into three main areas:

- A survey of breadfruit genetic resources across the region according to a standardised methodology, including assessments of diversity, traditional knowledge and risks of genetic erosion.
- Preparation of a catalogue of NTBG collections, including results from surveys, enabling countries to decide what material they want to receive for evaluation. Quarantine issues and the current lack of (rapid) propagation methods that need to be addressed.
- Promotion of breadfruit cultivation and consumption for better nutrition and health – a public awareness exercise needing the collaboration of various ministries (health, education women, etc.) as well as NGOs, targeting both local populations and Pacific Islander communities living abroad.

Table 9. Opportunities and needs for the conservation and sustainable use of breadfruit genetic resources in the Pacific. (Modified from *Regional Workshop on Conservation and Sustainable Use of Breadfruit Genetic Resources in the Pacific*, SPC, Suva, November 2002).

Opportunity	Potential benefits to countries globally	Requirements to fulfil potential
The Breadfruit Institute established	▪ Information on breadfruit ▪ Training in breadfruit conservation and use ▪ Research on breadfruit conservation and use	▪ Funding ▪ Collaboration with breadfruit-growing countries
Regional field collection maintained at NTBG	▪ Material appropriate for different localities and uses and associated information ▪ Safety duplication of national collections	▪ Material from countries not previously sampled ▪ Missing material from already sampled countries ▪ Morphological information (descriptor list) ▪ Information on old SPC collection in Tahiti ▪ Information on germplasm needs of countries
20-cultivar “core” collection for year-round production and good fruit quality identified at NTBG	▪ Elite set of material for use	▪ Agreed ABS policies ▪ Safe transfer guidelines (pest risk assessment) ▪ Evaluation for key features: salinity tolerance, nutritional quality, processing
NTBG collection generating hybrids	▪ New diversity for evaluation and use	▪ Agreed ABS policies ▪ Safe transfer guidelines (pest risk assessment)
Some national collections still exist	▪ Material appropriate for different localities and uses and associated information	▪ Rehabilitation of collections under threat ▪ Safety duplication for some ▪ Documentation, characterization, evaluation
Variation exists in the field, but is threatened in many places	▪ Material appropriate for different localities and uses and associated information	▪ Assessment of level of genetic variation and associated TK in all countries ▪ Assessment of past erosion of diversity and of TK, and risk of future erosion ▪ Evaluation
High levels of carotenoids in	▪ Combating vitamin A	▪ Promotion of breadfruit for

Opportunity	Potential benefits to countries globally	Requirements to fulfil potential
some cultivars	deficiency and associated problems	better nutrition and income generation
Historical documentation of germplasm exchange exists (plant introduction bulletins)	▪ Information on origin of material found in different countries	▪ Documentation and analysis
Considerable expertise and knowledge available at government establishments and in communities (e.g Samoa)	▪ Capacity to conserve and use breadfruit genetic resources sustainably	▪ Documentation of TK ▪ Increased transmission of breadfruit knowledge from old to young (and other support to maintenance of TK)
Village-based conservation activities in place (e.g. in Samoa)	▪ Capacity to conserve and use breadfruit genetic resources sustainably	▪ Documentation and wider application ▪ Promotion of breadfruit for better nutrition and income generation
Active seedling selection practiced in Eastern Solomon Islands	▪ Method for generating new diversity in situ	▪ Documentation and dissemination of information
Need to replant in some areas	▪ Conservation of threatened cultivars and introduction of new material	▪ Adequate quality and quantity of planting materials ▪ Promotion of breadfruit for better nutrition and income generation ▪ Promote growing different cultivars rather than just 1-2 recommended ones
Inclusion of breadfruit in agroforestry systems being investigated	▪ Complementary method of conservation and use	▪ Further research ▪ Documentation and dissemination of information
Documentation of numerous preservation, processing (traditional, modern) and cooking methods	▪ TK resource	▪ Test different materials for response to processing ▪ Wide dissemination of information
Some experience of tissue culture available at NTBG and RGC	▪ Complementary method of conservation	▪ Research to overcome problem of variable success of technique with different cultivars
Video of rapid propagation system for tropical trees available	▪ Effective method for rapid propagation and dissemination of planting material	▪ Research on applicability to breadfruit
Grafting technique has been tested	▪ Effective method for field conservation and evaluation	▪ Further research
Multipurpose nature of the species	▪ Variety of products	▪ Research (e.g. breadnut development)
Information on the importance of breadfruit available in various countries (SPRIG surveys)	▪ Evidence of importance of crop to nutrition and income generation	▪ Dissemination of information ▪ Promotion of breadfruit for better nutrition
Samoa and Fiji working on commercialization (including export to New Zealand), using HTFA to treat fruits	▪ Potential for conservation through increased use	▪ Dissemination of information
Better husbandry practices being tested to overcome die-back on atolls	▪ Complementary method of in situ conservation	▪ Research ▪ Dissemination of information

The *First International Symposium on Breadfruit Research and Development* in April 2007 discussed how utilization and use could be best done globally. It saw the NTBG as a global base collection providing information and germplasm to other centres, and suggested priorities for the Breadfruit Institute in terms of a global strategy:

- Continue the partnership with CCRISP to develop tissue culture and cryopreservation protocols, and the establishment of an *in vitro* collection.
- Distribute the tissue culture protocol to regional and international partners when it is published (a publication detailing the method is in press).
- Establish *in vitro* and distribute the 20 elite cultivars through CePaCT, identified by NTBG, based on seasonality and other useful agronomic characteristics, for recipients to evaluate.
- Develop a core collection representative of the genetic diversity that exists in the present collection, using molecular techniques and transfer the core in tissue culture to national and regional labs in Africa, Asia, the Caribbean and the Pacific.
- Identify other “multipurpose” or “utility” collections such as one with salinity tolerance or those appropriate for atoll conditions.
- Develop a breadfruit database, possibly using pc-GRIN (some accessions held by USDA/ARS are already on it).
- Duplicate the NTBG collection *in vitro* and, possibly, as a field collection elsewhere.
- The NTBG to provide information to a global network, in particular, on breadfruit literature, published and unpublished.

The Symposium was particularly grateful to the NTBG for the work that it had done on breadfruit in the last 20 years (Appendix 5). It was also very concerned about the vulnerability of the collection, with further cyclonic events an increasing possibility. Safeguarding the collection was a priority.
A number of activities were identified that would be done collaboratively as part of a newly formed network of collaboration; they would be done overtime and as finances allowed:

- Agreement on a descriptor list, based on that used by the NTBG; this would include evaluation characteristics, such as collection of data on yield, nutritional content, salt tolerance, etc, and be used in national surveys.
- Surveys to produce national inventories of germplasm of each country within the network, including the collection of indigenous knowledge and uses.
- Based on the survey results, establish national collections and ensure that duplicates are present within the NTBG collection.
- Develop best practices for the management and exchange of germplasm, with the clarification of quarantine and policy issues.
- Take every opportunity to create awareness about breadfruit - its importance in farming systems, nutritional benefits, potential for commercialisation - using food fairs, media releases and the inclusion of breadfruit in school curricula.

There were some activities suggested that the network has still to allocate responsibility; these were:

- Investigations into prolonging seed storage sufficiently for the exchange of germplasm between countries.
- Development of convenience foods with long shelf life as alternatives to less nutritional snack foods.

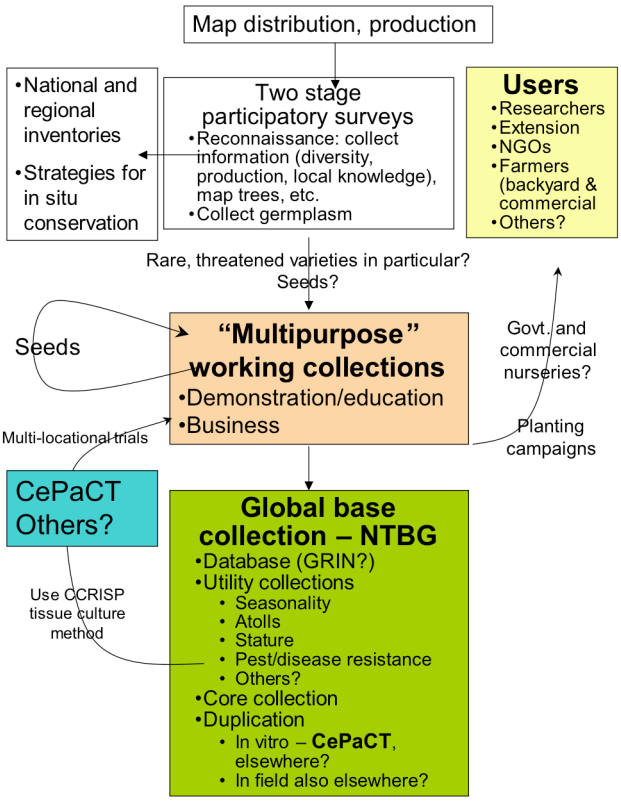

Fig. 3: Schematic representation of the network activities envisaged by the *First Breadfruit Symposium on Research & Development*, Fiji, April 2007.

The collaborative partnership between the Breadfruit Institute, CCRISP and CePaCT has been outlined above. In order to establish an *in vitro* collection of all of the cultivars in the NTBG breadfruit collection for conservation, protocols for rapid production of the genetic core collection and other cultivars for distribution, and protocols for induction of shoot and root organogenesis must be optimized for each cultivar or physiological status. Sufficient cultivar-to-cultivar differences exist that protocols for one cultivar are frequently not successful with other cultivars and some cultivars are recalcitrant to regeneration.

Bioreactor development and assessment of plant performance in different growth systems is a crucial component of the project. The basic function of a bioreactor is to provide a self-contained, sterile environment with tight control of the growth microenvironment. A bioreactor system can produce unlimited volumes of cultured plant material in a short time. The application of the technology to breadfruit has resulted in an optimized system for large-scale production (Murch *et al*., 2007). The current capacity of the existing bioreactors is about 5,000 plants per batch and an average batch takes about 3 months to mature. Current studies have focused on accelerated production of only two of the breadfruit varieties that are fast growing, multiply rapidly and are robust. Further studies are required to optimize procedures

for more recalcitrant cultivars and cultivars that do not exhibit prolific regeneration. Plans for transfer of this technology to the CePaCT labs in Fiji are already underway for large scale propagation and plant production there.

4. Conclusions

Breadfruit is important to food security, sustainable agriculture, and income generation in many areas of the Pacific, where it has long been an important staple food. Breadfruit also plays a significant role in the Caribbean, Maldives, Seychelles, and parts of Africa.

Although grown throughout the tropics, it is under-utilized because only a few cultivars are cultivated in most countries. Although an important staple crop in the Pacific with hundreds of cultivars recognized, breadfruit diversity is declining because of hurricanes and droughts and a lack of interest to replant. Cultural knowledge is being lost. Actively managed collections exist in Hawaii at the National Tropical Botanical Garden and USDA National Plant Germplasm System Hilo Repository, in Vanuatu, and at the University of the West Indies (Trinidad and Jamaica).

Countries where breadfruit is a crop of concern have identified two priorities: first, to conserve breadfruit diversity *in situ* and to ensure cultural knowledge is not lost; second, to make available the unique genetic resource that exists in the breadfruit collection at NTBG; this requires:

- Improving horticultural practices for maintaining the NTBG collection.
- Completing the descriptors for the NTBG breadfruit collection.
- Assembling morphological and molecular data in an accessible database and generating a practical field key for identification of breadfruit cultivars.
- Selecting a core collection, which is essential for conservation and distribution.
- Replicating and conserving the core collection *in vitro*.
- Developing methods for long-term conservation of breadfruit germplasm by cryopreservation.
- Developing large-scale production systems generating and distributing breadfruit varieties.
- Ensuring that the breadfruit varieties are distributed through internationally recognised indexing procedures and meet phytosanitary requirements
- Distributing breadfruit cultivars in compliance with appropriate plant genetic resources access and sharing agreements.
- Networking with other scientists, extensionists and farmers.
- Increasing awareness of conservation issues/needs related to breadfruit.
- Providing assistance with technical standards and practices related to germplasm management.
- Developing regional strategies and collaborative partnerships to conserve breadfruit diversity and cultural knowledge, *in situ* and *ex situ*.
- Raising awareness about breadfruit and conservation and research needs.

These goals were defined by breadfruit experts at a recent international meeting hosted by the Breadfruit Institute and the Secretariat of the Pacific Community in Fiji, 2007. Some of the recommendations are part of on-going activities of the Breadfruit

Institute, in particular the development of collections *in vitro*, specification of a core collection using morphological and molecular methods and, where possible, the distribution of varieties. Many others, especially the development of a global network with its various components will need additional resources. The potential of breadfruit to provide a nutritious food to many people in need in many parts of the world will, no doubt, help to deliver the resources required.

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Annex 1. A Survey to Build a Global Conservation Strategy for Breadfruit

Background

The Global Crop Diversity Trust (the Trust) is helping to develop strategies for the conservation of crop diversity. The Trust has commissioned the Secretariat of the Pacific Community (SPC) to coordinate the development of a global conservation strategy for Breafruit. This questionnaire is for people caring for major breadfruit collections to help develop that strategy. The Trust will base its support for the conservation of breadfruit genetic resources on this strategy, once developed and adopted. As a key curator of a breadfruit collection, please complete the questionnaire. SPC is keen to ensure your active participation in the development of the global breadfruit conservation strategy and will keep you informed of progress and consult you until it is completed.

1. General:

Please state what species of aroid you are reporting on. (**If you maintain more than one edible aroid species, please use a SEPARATE form for each**):

Artocarpus altilis □ yes
A camansi □ yes
A mariannensis □ yes
Hybrids: A altilis x A mariannensis □ yes

Name and address of organisation holding/maintaining edible aroid collections	
Address:	
City:	
Postal Code:	
Country:	
Web site:	
Curator in charge of the edible aroid collection:	
Name:	
Address:	
City:	
Telephone:	
Fax:	
Email:	
Name of respondent to this questionnaire if different then above	
Contact details:	
Date of response:	

Is the organisation holding the aroid collection:
□ A - an independent organisation
□ B - part of a larger organisation

In the case of (B) please provide the name and address of the larger organisation:
_____

Is the organisation holding the collection part of a government agency?
□ yes □ no
If no, what type of organisation is it?
_____

Who is financing the conservation of the collection, and to what extent (%age)?
□ Government _____%
□ Private sector _____%
□ International or regional organisation/agency_____%
□ Other funding agencies (specify):_____%

Is the institution in charge of the collection the legal owner of the collection?
 yes no

If no, who is the owner (state if no owner is recognised)?

2. Details on the collection

Year the collection was established: _____

Present size of the collection:

Type of germplasm	Number of species	Number varieties	Freely available for distribution or not?
Related wild species			
Wild species			
Farmers' varieties			
Other (eg research material			
Total			

What is the maximum capacity of the collection in terms of existing infrastructure?

In the field: number of plants: _____
In the lab: number of plantlets: _____

What are the average annual costs for maintaining the collection?
Staff: _____
General maintenance of infrastructure: _____
Inputs (field and lab costs): _____
Other: _____

Origin of the collection. Please state how many countries are represented in the collection:
Geographic coverage of the collection (quantify %age of collection from different countries):
Home country: _____%
Neighbouring countries:_____%
Countries in other regions: _____%
Unknown _____%

Is passport data (collecting information) available for the collection?
 yes Partially no

If yes or partially how many accessions have full/partial passport data?
- Related wild species: _____(%)
- Farmers' varieties: _____(%)
- Breeders' varieties: _____(%)
- Breeders' lines: _____(%)
- Others _____(%)

3. PGR management of the collection

3.1 Acquisition

Has the collection been enlarged during the **last 5 years** with new germplasm?
 yes no

If yes, how many new accessions have been included of the following:
- Related wild species: _____
- Farmers' varieties: _____
- Breeders' varieties: _____
- Breeders' lines: _____
- Others _____

How was the newly obtained germplasm acquired?

- □ Collecting in own country
- □ Collecting in other countries
- □ Introduction from other collections, institutes or private organisations in country
- □ Introduction from other countries
- □ Other sources, please specify: _____

Are there important gaps in the collection?

□ yes □ no

- If so, what are they:

_____

_____

Do you plan to fill these gaps in the next 5 years? □ yes □ partly □ no

- If yes or partly, how:

_____

_____

- If no, what are the main reasons why not:

_____

_____

Do you plan new collecting missions in the next 5 years?

□ yes □ no

3.2 Storage and maintenance (seed, *in vitro*, field)

Please indicate how germplasm is maintained for long- and medium-term storage (give number of accessions).

Type of germplasm	**Stored as seed**	**Maintained in field**	**Maintained in pots etc in screen house**	**In vitro: *slow growth***	**In vitro: *Cryo conservation***
Related wild species					
Wild species					
Farmers' varieties					
Other (eg research material					

*more than one option for the same type of material is possible

What are the storage facilities and conditions of the genebank?

	Type of facility	**Describe the conditions**		
		Temp	**RH**	**Lighting**
Botanical seed				
***In vitro:* slow growth**				
***In vitro*: Cryo conservation**				

How are the plants maintained in the field and screen house?

Type of germplasm	No. of plants per accession	Distance between rows	Distance between plants
Related wild species			
Wild species			
Farmers' varieties			
Other (eg research material			

Numbers of plants of the different types maintained in the lab?

Type of germplasm	Number of plants per accession
Related wild species:	_____
Wild species:	_____
Farmers' varieties:	_____
Other, eg research material:	_____

Do you apply tests to control the quality of stored germplasm?

□ yes □ no

What tests?

_____

_____

If yes, do you check whether the *in vitro* plantlets are true-to-type □ yes □ no

Please explain how these tests are done:

_____

_____

3.3 How is the collection replanted or recultured

How often do you replant or reculture at least part of the collection?

Type of germplasm	As seed	Vegetatively	In vitro
Related wild species			
Wild species			
Farmers' varieties			
Other (eg research material			

More than one option for the same type of material is possible

How much of the collection do you replant or reculture each time?

Type of germplasm	As seed	Vegetatively	In vitro
Related wild species			
Wild species			
Farmers' varieties			
Other (eg research material			

More than one option for the same type of material is possible

3.4 Identification (classification) and characterization (described)

Is the collection taxonomically **identified**?

□ yes □ partially □ no

If partially, please state the percentage **NOT** identified: ……. %

Do you have assistance of a taxonomist to identify the germplasm?

□ yes (fulltime) □ occasionally □ no

Please indicate how the collection is being **characterised**.

Type of germplasm	Descriptor list available & used	% of the collection characterised	
		Morphologically	Molecular
Related wild species	Yes / no		
Wild species	Yes / no		
Farmers' varieties	Yes / no		
Other (eg research material	Yes / no		

For DNA characterization, specify the system used, number of markers used and the %age characterised using each system.

_____

_____

For morphological characterization, specify the number of descriptors used.

Which type of descriptor list is used for characterisation?

□ Standard IPGRI descriptor list
□ Your own independently developed list
□ List developed by another organisation, please specify:

_____

_____

3.5 Documentation and access to information about the collection

Do you use a computerized information system for the management of the collection?

□ yes □ no

If yes, what software do you use for documentation?

What data have been computerised? Please circle the appropriate answer.

Type of germplasm	Passport data	Characterisation/ evaluation data	Management data*
Related wild species	Yes / partly / no	Yes / partly / no	Yes / partly / no
Farmers' varieties	Yes / partly / no	Yes / partly / no	Yes / partly / no
Breeders' varieties	Yes / partly / no	Yes / partly / no	Yes / partly / no
Other, eg research material	Yes / partly / no	Yes / partly / no	Yes / partly / no

* data related to storage, regeneration, distribution, etc.

In case the collection is not computerised, are there plans to do so in the future?

□ No plans
□ Computerisation planned within next 1 year

Is information on the aroid collection accessible through the Internet?

□ yes □ partly □ no

If yes/partly, please provide URL: _____

Are data of the collection included in other databases?

- National □ yes □ partly □ no
- Regional □ yes □ partly □ no
- International □ yes □ partly □ no

If yes/partly, specify the database:

_____

_____

3.6 Health of germplasm

Is the collection affected by diseases that can restrict the distribution of the germplasm?

□ yes □ no

If yes, which types of diseases are causing this restriction?

□ Seed-borne diseases

□ Infection of corms and/or suckers/cormels

If *in vitro* samples are distributed **within the country** are they virus indexed?

□ yes □ some □ no

If *in vitro* samples are distributed **outside the country** are they virus indexed?

□ yes □ some □ no

Is knowledge available at your institution and are there facilities for eradication of these diseases?

□ yes □ limited □ no

Do you need assistance to improve the health status of the collection?

□ yes □ limited □ no

If yes, what type of assistance is required?

1) _____

2) _____

3) _____

3.7 Distribution

Do you distribute material outside your institute?

□ yes □ occasionally, special conditions □ no

How many accessions have you distributed **within** the country in the past 3 years to the following users (specify whether material sent as seed, corms/cormels or *in vitro*):

	0-10	**10-50**	**50-200**	**>200**
Farmers				
Breeders				
Researchers/students				
NGOs				
Gene banks				
Extensionists				
Others, and specify				

What is the average number of samples sent per accession per shipment?

	1-5	**5-10**	**10-50**	**>50**
In vitro plantlets				
Suckers/cormels				
Stem cuttings				
Seeds				

Do you distribute germplasm outside the country?

□ yes □ no

How many accessions have you distributed outside the country in the past 3 years to the following users (specify whether material sent as seed, corms/cormels or in vitro):

	0-10	10-50	50-200	>200
Farmers				
Breeders				
Researchers				
NGOs				
Gene banks				
Extensionists				
Others, and specify				

What is the average number of samples sent per accession per shipment?

	1-5	5-10	10-50	>50
In vitro plantlets				
Suckers/cormels				
Stem cuttings				
Seeds				

Are you distributing more material now than 5 years ago?

□ more □ the same □ less

Do you expect to distribute more material in 5 years' time than now?

□ more than now □ the same □ less than now

Do you keep records of the distribution? □ yes □ no

What information is included in these records:

_____

_____

How are the services of the collection publicized to users and how effective are these methods in terms of increased use of the collection?

	High impact	Medium impact	Low impact	Don't know
Scientific publications				
Institutional reports				
Extension Leaflets				
Oral presentations				
Group visits to the collection				
Other				

Have any requests for material been refused? If yes, specify

How do the users of the germplasm influence the management of the collection?

	Through feedback on the material?	Through formal consultations	Through participation in the governing body of the genebank	Other (specify)
Farmers				
Breeders				
Researchers				
NGOs				
Gene banks				
Extensionists				
Others, and specify				

3.8 Safety duplication

Are the accessions of the collection safety-duplicated in another genebank?

□ yes, fully □ partly □ no

If yes/partly, please specify where the germplasm is safety-duplicated, what part (%) of the collection and under what storage conditions

Is there any germplasm of other collections safety-duplicated at your facilities?

□ yes □ no

If yes, can you specify the name of the holder of the aroid collection safety-duplicated at your genebank, including the number of accessions duplicated?

3.9 General management

How many staff are working on the collection (full-time staff equivalents)?

	<1	1	2	3-5	>5
In the field					
scientists					
technical assistants					
field workers					
students					
In the lab					
scientists					
technicians					
students					

Have you established a quality management system or written procedures and protocols for:

- □ Acquisition (including collecting, introduction and exchange)
- □ Regeneration/Replanting and/or sub-culturing
- □ Characterisation
- □ Storage and maintenance
- □ Documentation
- □ Health of germplasm
- □ Distribution
- □ Safety duplication

In case you have written procedures and protocols, can you provide the Trust with this information or include a copy of it? □ yes □ no

Does the existing capacity in numbers and skills of staff meet the needs of the collection in the long term?

If no, please describe what is needed?

_____

_____

4. Utilisation of the collection

For what purposes is the collection used?

- □ Research activities (e.g. taxonomical studies, diversity studies, evolution studies, etc.)
- □ Characterisation
- □ Evaluation for important agronomic traits (production and quality)
- □ Screening for biotic and abiotic stress resistances
- □ Conventional plant breeding
- □ Participatory plant breeding
- □ Biotechnology (e.g. gene isolation, molecular studies, functional genomics, etc)
- □ Distribution to farmers
- □ Return of germplasm to country of origin

Do you have a systematic program to evaluate the collection for agronomic and other traits?

□ yes □ planned □ no

If yes, can you list the most important traits the collection is evaluated for?

1) _____
2) _____
3) _____
4) _____
5) _____

Do you have collaboration with an *in situ* conservation programme

□ yes □ planned □ no

If yes/planned, give details: _____

5. Networks of edible aroid genetic resources

Do you collaborate (or have you collaborated in the past 5 years) in (a) plant genetic resources network(s) as a collection holder (specify if collaboration is ongoing)?

□ yes □ no

If yes, please indicate what kind of network:

	National level	Regional level	Global	None
Exchange of germplasm				
Exchange of information				
Training				
Other, please specify				

Please specify if the activity is regular or occasional and/or whether it was in the past only or on-going

Please list the main benefits of the collaboration as you see them, if any

1) _____
2) _____
3) _____
4) _____
5) _____

What are the major activities of the network(s) in which you participate or have participated in the past 5 years?

□ Joint conservation of aroid germplasm
□ Evaluation or characterisation of aroid germplasm
□ Establishment of central database
□ Rationalisation of the collections
□ Safety duplication of aroid germplasm
□ Others
Note: more than one option is possible

Do you consider a worldwide network for edible aroid genetic resources important and would you consider participating in such network?

□ yes □ no

What will be your major interest for participation in an edible aroid PGR network?

1) _____
2) _____
3) _____

6. Policies with regard to access of the collection

What is your policy regarding distribution of germplasm?

Geographic coverage

□ Distribution only to users in your country
□ Distribution only to users in certain countries
□ Distribution to users in all countries

Conditions of distribution

□ Distribution to any user, without further conditions
□ Distribution to any after signing of an MTA (Material Transfer Agreement)
□ Distribution only on a mutually agreed exchange basis
□ Other conditions, please specify: _____

Cost for distribution of germplasm

- □ No cost, distribution gratis to all users
- □ No cost, but reciprocal exchange of material required
- □ Costs charged to some users (e.g. private sector) or some countries only
- □ Request to contribute for processing and shipping; specify amount: _____
- □ Request to pay for each requested accession; specify amount: _____
- □ Other, please specify: _____

Please attach examples of your organisation's long-term commitment to long term conservation of aroid collection, for instance:

- □ Legal statues
- □ Institutional constitution
- □ Mandates
- □ Published strategic plans
- □ National conservation strategy
- □ Actions plans
- □ Other: _____

7. Future developments regarding the aroid collection

Will the collection be enlarged with new material or rationalized in the next 5 years?

- □ collection will remain approximately the same size
- □ collection will be expanded to a limited extent (5-10 %)
- □ collection will be substantially increased (> 20%)
- □ collection will be reduced due to duplication with other collections and internal rationalisation
- □ collection will be reduced as a result of lack of funding or facilities

Are there any constraints for the maintenance of the collection?

□ yes □ no

If yes, what type of constraints do you face?

- □ Insufficiently trained staff
- □ Capacity to replant/maintain the collection in field and/or in vitro limited
- □ Facilities for optimal maintenance of the collection not satisfactory
- □ Others, please state:

_____

Will some of the above constraints result in a loss of germplasm?

□ yes □ only incidentally □ no

If yes, what is the most important constraint, which may contribute to genetic erosion within the collection?

_____

8. Further remarks

Do you have any further remarks or suggestions?

_____

_____

Many thanks! Please return the completed questionnaire, no later than 31 December 2006 to:

GVH Jackson
24 Alt Street, Queens Park, NSW, 2022, Australia
Fax: +61 2 9387 8004, Email: grahame@pestnet.org

Annex 2. Participants 1st First International Symposium on Breadfruit Research & Development

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Annex 3. List of clones represented in breadfruit collections

NTBG collections (curator Dr Diane Ragone)

Name	Trees per accession	Species	Origin
Aarue	1	A altilis	Society Islands
Abareba	1	A altilis	Solomon Islands
Afara	1	A altilis	Society Islands
Afara	1	A altilis	Society Islands
Ahani	1	A altilis	Society Islands
Anahonaho	2	A altilis	Society Islands
Apu	1	A altilis	Society Islands
Apuapua	2	A altilis	Society Islands
Araarahaari	1	A altilis	Society Islands
Atu	1	A altilis	Cook Islands
Aue	2	A altilis	Society Islands
Aumee	1	A altilis	Society Islands
Aveloloa	1	A altilis	Samoa
camansi 1	1	A camansi	Palau
camansi 2	1	A camansi	Society Islands
Dugdug 1	3	A mariannensis	Mariana Islands
Dugdug 2	2	A mariannensis	Mariana Islands
Dugdug 3	1	A mariannensis	Mariana Islands
Dugdug	3	A mariannensis	Mariana Islands
Ebechab 1	1	A altilis x A mariannensis	Palau
Ebechab 2	1	A altilis	Palau
Enua 1	2	A altilis	Cook Islands/SPC
Enua 2	1	A altilis	Cook Islands/SPC
Errud	1	A altilis x A mariannensis	Palau
Fafai 1	2	A altilis	Society Islands
Fafai 2	1	A altilis	Society Islands
Faine	1	A altilis x A mariannensis	Truk, FSM
Forari2	1	A altilis	Vanuatu
Furau	2	A altilis	Rotuma/SPC
Hamoa (Maopo)	1	A altilis	Society Islands
Havana pataitai	1	A altilis	Society Islands
Huehue	1	A altilis x A mariannensis	Society Islands
Huero	1	A altilis	Society Islands
Huero ninamu	1	A altilis	Society Islands
Ioio	1	A altilis	Society Islands
Kamansi	1	A altilis	Philippines
Kapiak 1	1	A camansi	Papua New Guinea

Name	Trees per accession	Species	Origin
Kapiak 2	1	A camansi	Papua New Guinea
Kapiak 3	1	A camansi	Papua New Guinea
Kapiak 4	1	A camansi	Papua New Guinea
Kapiak 5	4	A camansi	Papua New Guinea
Kapiak 6	1	A camansi	Papua New Guinea
Kapiak 7	2	A camansi	Papua New Guinea
Kapiak 8	1	A camansi	Papua New Guinea
Kapiak 9	3	A camansi	Papua New Guinea
Kapiak 10	1	A camansi	Papua New Guinea
Kapiak 11	3	A camansi	Papua New Guinea
Karawa 1	1	A altilis	Rotuma/SPC
Karawa 2	1	A altilis	Fiji
Kea	1	A altilis	Tonga
Kukumu tasi	2	A altilis	Solomon Islands/SPC
Kuru kiniti	2	A mariannensis	Pohnpei, FSM
Lemae 1	2	A altilis	Mariana Islands
Lemae 2	2	A altilis x A mariannensis	Mariana Islands
Lipet 1	3	A altilis x A mariannensis	Pohnpei, FSM
Lipet 2	1	A altilis x A mariannensis	Pohnpei, FSM
Luthar	1	A altilis x A mariannensis	Yap, FSM
Ma'afala	1	A altilis	Samoa
Mahani	1	A altilis	Society Islands
Maire	2	A altilis	Society Islands
Malphang	1	A altilis	Vanuatu/SPC
Mamaha	1	A altilis	Society Islands
Manang	1	A altilis	Vanuatu/SPC
Manua	1	A altilis	Samoa
Masee	1	A altilis	Samoa
Mei arephe	2	A altilis	Pohnpei, FSM
Mei aueka	1	A altilis	Marquesas Islands
Mei chocho	2	A altilis x A mariannensis	Truk, FSM
Mei chon	1	A altilis	Truk, FSM
Mei kakano	2	A altilis	Marquesas Islands
Mei kalak	2	A altilis	Pohnpei, FSM
Mei kalak en mei kuet	1	A altilis	Pohnpei, FSM
Mei kauhiva	1	A altilis	Marquesas Islands
Mei kiiahi	1	A altilis	Marquesas Islands
Mei koeng	1	A altilis x A mariannensis	Truk, FSM
Mei koeng 1	1	A altilis x A mariannensis	Truk, FSM
Mei kole 2	1	A altilis x A mariannensis	Pohnpei, FSM
Mei kole 3	1	A camansi	Pohnpei, FSM

Name	Trees per accession	Species	Origin
Mei kole 4	1	A mariannensis	Pohnpei, FSM
Mei kopumoko	1	A altilis	Marquesas Islands
Mei maoi	1	A altilis	Marquesas Islands
Mei puau	1	A altilis	Marquesas Islands
Mei puou	1	A altilis	Marquesas Islands
Mei pwet	1	A altilis	Pohnpei, FSM
Mei saip	2	A altilis	Pohnpei, FSM
Mei sei	2	A altilis	Pohnpei, FSM
Mei tehid 1	1	A altilis	Pohnpei, FSM
Mei tehid 2	1	A altilis	Pohnpei, FSM
Mei tehid 3	1	A altilis	Pohnpei, FSM
Mei uhpw	1	A altilis	Pohnpei, FSM
Mein padahk	1	A altilis x A mariannensis	Pohnpei, FSM
Mein pohnsakar	2	A altilis x A mariannensis	Pohnpei, FSM
Mein pwahr	1	A altilis x A mariannensis	Pohnpei, FSM
Mein pwuht	1	A altilis x A mariannensis	Pohnpei, FSM
Mein uwe	1	A altilis	Pohnpei, FSM
Meion	1	A altilis x A mariannensis	Truk, FSM
Meriaur	2	A altilis	Palau
Midolab	2	A altilis x A mariannensis	Palau
Momolega	1	A altilis	Samoa
Nahnmwal	1	A altilis	Pohnpei, FSM
Niue 1	1	A altilis	Cook Islands
Niue 2	1	A altilis	Cook Islands
Otea	1	A altilis	Society Islands
Ouo	1	A altilis	Society Islands
Paea	2	A altilis	Cook Islands
Patara	2	A altilis	Society Islands
Piipiia 1	1	A altilis	Society Islands
Piipiia 2	2	A altilis	Society Islands
Porohitii	1	A altilis	Society Islands
Puaa 1	1	A altilis	Society Islands
Puaa 2	1	A altilis	Society Islands
Pulupulu	2	A altilis	Rotuma/SPC
Puou 1	1	A altilis	Samoa
Puou 2	1	A altilis	Samoa
Puou 3	1	A altilis	Tonga
Puou 4	1	A altilis	Vanuatu/Wallis
Puupuu	1	A altilis	Society Islands
Puurea	2	A altilis	Society Islands
Rare	1	A altilis	Society Islands
Rauulu	1	A altilis	Rotuma/SPC

Name	Trees per accession	Species	Origin
Roihaa	1	A altilis	Society Islands
Rotuma 1	1	A altilis x A mariannensis	Society Islands
Rotuma 2	1	A altilis	Society Islands
Sagosago	2	A altilis	Samoa
Samoan 1	1	A altilis	Fiji
Samoan 2	2	A altilis	Fiji
Samoan 3	2	A altilis	Fiji
Sewan	2	A altilis x A mariannensis	Truk, FSM
Siviri2	2	A altilis	Vanuatu
Siviri3	1	A altilis	Vanuatu
Tahitian (Puou)	2	A altilis	Cook Islands
Tapehaa	1	A altilis	Society Islands
Te bukiraro	2	A altilis x A mariannensis	Kiribati
Te mai	1	A mariannensis	Kiribati
Teahimatoa	1	A altilis	Society Islands
Tedailir	1	A altilis	Vanuatu
Tehelewa	2	A altilis	Solomon Islands/SPC
Timbul	1	A camansi	Indonesia
Toneno	1	A altilis	Society Islands
Toro	2	A altilis	Solomon Islands/SPC
Tuutou	1	A altilis	Society Islands
Tuutou, auena	1	A altilis	Society Islands
Tuutou, ooa	1	A altilis	Society Islands
Tuutou, taatoe	2	A altilis	Society Islands
Ulu	1	A altilis	Hawaii
Ulu afa 1	1	A altilis x A mariannensis	Tokelau
Ulu afa 10	1	A altilis x A mariannensis	Tokelau
Ulu afa 2	2	A altilis x. A mariannensis	Tokelau
Ulu afa 3	2	A altilis x A mariannensis	Tokelau
Ulu afa 4	1	A altilis x A mariannensis	Tokelau
Ulu afa 5	2	A altilis x A mariannensis	Tokelau
Ulu afa 6	3	A altilis x A mariannensis	Tokelau
Ulu afa 7	1	A altilis x A mariannensis	Tokelau
Ulu afa 8	1	A altilis x A mariannensis	Tokelau
Ulu afa 9	2	A altilis x. A mariannensis	Tokelau
Ulu afa elise	2	A altilis x A mariannensis	Tokelau
Ulu afa hamoa 1	1	A altilis x A mariannensis	Tokelau
Ulu afa hamoa 2	1	A altilis x A mariannensis	Tokelau
Ulu ea	1	A altilis	Samoa
Ulu elise 1	2	A altilis x A mariannensis	Tokelau

Name	Trees per accession	Species	Origin
Ulu elise 2	1	A altilis x A mariannensis	Tokelau
Ulu fiti 1	1	A altilis	Rotuma/SPC
Ulu fiti 2	2	A altilis	Rotuma/SPC
Ulu fiti 3	1	A altilis	Rotuma/SPC
Ulu fiti 4	1	A altilis	Rotuma/SPC
Ulu hamoa 1	1	A altilis x A mariannensis	Tokelau
Ulu hamoa 2	1	A altilis x A mariannensis	Tokelau
Ulu sina	2	A altilis	Samoa
Ulu tala	1	A altilis	Samoa
unidentifed 1	1	A altilis	Samoa
unidentifed 2	1	A altilis	Solomon Islands
unidentifed 3	1	A altilis	Samoa/SPC
unidentifed 4	2	A altilis	Samoa/SPC
unidentifed 5	1	A altilis	Samoa/SPC
Unidentified 2	1	A altilis	Solomon Islands
Unidentified 3	1	A altilis	Samoa
Unidentified 4	1	A altilis	Samoa/SPC
Unidentified 5	1	A altilis	Samoa/SPC
Unidentified 6	1	A altilis	Samoa/SPC
Unknown 1	1	A altilis	Unknown
Unknown 10	1	A altilis	Unknown
Unknown 11	1	A altilis	Unknown
Unknown 2	1	A altilis	Unknown
Unknown 3	1	A altilis	Unknown
Unknown 4	1	A altilis	Unknown
Unknown 5	1	A altilis	Unknown
Unknown 6	1	A altilis	Unknown
Unknown 7	1	A altilis	Unknown
Unknown 8	1	A altilis	Unknown
Unknown 9	1	A altilis	Unknown
unnamed 1	1	A altilis	Society Islands
Unnamed 2	1	A altilis	Solomon Islands
Uto dina	1	A altilis	Fiji/SPC
Uto ni viti	1	A altilis	Fiji
Uto samoa (Puou)	1	A altilis	Fiji
Uto vula	1	A altilis	Fiji
White variety	3	A altilis	Seychelles
Yap variety	1	A altilis x A mariannensis	Palau
Yellow variety	1	A altilis	Seychelles
Yuley	1	A altilis x A mariannensis	Yap, FSM

University of the West Indies (curator Dr. Laura Roberts-Nkrumah)

Varietal name and origin
From NTBG, Hawaii
Ma' afala
Fafai
Momolega
Tapeha' a
Puou
Ulu tala
Ulu ea
Otea
Aarue
Aipu'u
CV Yellow
Afara
Mahani
Ahani
Porohiti
Puupuu
Mei tehid
Piipiia
Roihaa
Hueheue
Puaa
Toneno
Meinpadahk

Trinidad
Local Yellow
Local White

St. Vincent
Creole
Hope Marble
Kashee
Cocobread
Hog Pen

Jamaica
Macca
Yellowheart
Timor
Cassava

VARTC collection, Vanuatu

Accession no.	Variety name	Status
VUT 001	Tiomal	Alive collection
VUT 002	Novan	Alive collection
VUT 003	Baïwok	Dead in nursery
VUT004	Nambroser	Dead in nursery
VUT 005	Passis	Alive collection
VUT 006	Lesrakenobos	Alive collection
VUT 007	Benewos	Alive collection
VUT 008	Tatarlihu	Alive collection
VUT 009	Hamosa	Alive collection
VUT 010	Hotabulu	Dead in nursery
VUT 011	Malahati	Alive collection
VUT 012	Huhadundu	Alive collection
VUT 013	Wawahisao	Alive collection
VUT 014	Buesuhu	Alive collection
VUT 015	Hota	Alive collection
VUT 016	Unduruhu	Dead in nursery
VUT 017	Birbiri	Alive collection
VUT 018	Buruvaharua	Dead in nursery
VUT 019	Noswokgaï	Dead in nursery
VUT 020	Nesewoyuting	Alive collection
VUT 021	Nowokwawa	Alive collection
VUT 022	Neseu	Dead in nursery
VUT 023	Wanbaon	Dead in nursery
VUT 024	Neseutaban	Alive collection
VUT 025	Nafranis	Dead in nursery
VUT 026	Suhumte	Alive collection
VUT 027	Natvig	Dead in nursery
VUT 028	Naqalmat	Alive collection
VUT 029	Namnerlap	Alive collection
VUT 030	Natantige	Alive collection
VUT 031	Naglohou	Dead in nursery
VUT 032	Natalotop	Dead in nursery
VUT 033	Nitilto	Dead in nursery
VUT 034	Nuauau	Alive collection
VUT 035	Kaosaos	Alive collection
VUT 036	Niko	Dead in nursery
VUT 037	Laguna	Alive collection
VUT 038	Kengen	Dead in nursery
VUT 039	Wuikar	Alive collection
VUT 040	Sipo	Alive collection
VUT 041	Natikrei	Alive collection
VUT 042	Kreivi	Alive collection
VUT 043	Mogobu	Dead in nursery
VUT 044	Nefitan	Dead in nursery
VUT 045	Namkali	Dead in nursery
VUT 046	Inmereanggo	Dead in nursery
VUT 047	Nahanemmek	Alive collection
VUT 048	Inmerepuyerv	Dead in nursery
VUT 049	Inmeretuanga	Alive collection
VUT 050	Inmotancat	Dead in nursery
VUT 051	Nidsuanavar	Dead in nursery

VUT 052	Naïev	Alive collection
VUT 053	Nupsinma	Dead in nursery
VUT 054	Nefitan mokom	Dead in nursery
VUT 055	Intopoos	Alive collection
VUT 056	Navetogo	Dead in nursery
VUT 057	Natelat	Dead in nursery
VUT 058	Navairogo	Alive collection
VUT 059	Natego garavares	Alive collection
VUT 060	Nanatsina	Alive collection
VUT 061	Gortsaro	Alive collection
VUT 062	Hare-hare	Dead in nursery
VUT 063	Riovkar	Dead in nursery
VUT 064	Akavon	Alive collection
VUT 065	Tegonaïto	Dead in nursery
VUT 066	Narito	Dead in nursery
VUT 067	Mahoure	Dead in nursery
VUT 068	Haspere	Dead in nursery
VUT 069	Wile bredfrut	Dead in nursery