Breadfruit Manual

A Manual for Growing and Marketing Breadfruit

prepared by
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About PIFON

Pacific Island Farmers Organisation Network began operating informally in the region since 2008 and in 2013, it registered and has its Secretariat based in Nadi, Fiji. PIFON serves as a Regional umbrella organization for national farmer organizations. Since formation the network has progressively and sustainably added members and now has 30 member organizations in twelve countries (Cook Islands, Federated States of Micronesia, Hawaii, Marshall Islands, New Caledonia, Papua New Guinea, Samoa, Solomon Islands, Timor Leste, Tonga, Vanuatu and Fiji,)

This publication is supported by the Farmers' Organizations for Africa, Caribbean and Pacific (FO4ACP) programme; it aims to increase the incomes and improve the livelihoods, food and nutrition security, and safety of organized smallholders and family farmers in African, Caribbean and Pacific countries by strengthening regional, national and local farmers' organizations. The programme is expected to directly benefit 150 000 farmers in the Pacific region comprising of 72 000 men, 64 000 women and 14 000 youth involved in Pacific Farmer Organisations. The programme is implemented by six regional farmers' organizations, PAFO, AgriCord, and the FAO Regional Office for Latin America and the Caribbean.

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Preface

The vision of Nature's Way Cooperative (NWC) is to develop into a world class exporter of fruit and vegetables and we have made steady progress towards this goal over the past 25 years, growing to a membership of 350 farmers and exporters and handling 4 key export commodities: breadfruit, eggplant, mango and Fiji Red papaya.

Sant Kumar, the founding Manager of NWC from 1996, identified a market in New Zealand for fresh breadfruit, which at the time was a neglected crop. He initiated a program to develop a fresh breadfruit export pathway and to establish the Bilateral Quarantine Agreement (BQA) between New Zealand and Fiji.

Breadfruit still features prominently in NWC's strategic plan. It is a traditional crop that we have been steadily working to promote and develop over the past 20 years, and we are now starting to see the initial results of this long-term investment, so the future looks promising.

Since the last publication of this Manual in 2005, progress has been seen with the move from wild-harvesting to orchard-style commercial breadfruit production, and the introduction of quality control and post-harvesting handling procedures for the export market.

In 2011, the Pacific Breadfruit Project (PBP) was established with the support of the Australian Center for International Agricultural Research (ACIAR). A major part of their work was to re-characterise all breadfruit varieties around Fiji, including the varieties that were planted at the Seaqaqa, Sigatoka and Legalega Research Stations, and the breadfruit found in the genetic "hot spot" of Natewa Bay. The work of the PBP laid the foundation for the development of a commercial breadfruit industry.

In 2005, NWC launched 'A Manual for Growing and Exporting Breadfruit from Fiji.' Production of this manual was coordinated by Dr. Andrew McGregor with assistance from Alan Harre, Grantley Chaplin, Jim Hollier, Kyle Stice, Simione Tukidia and both the late Aremogan Pillai and Luke Tirimaidoka.

This manual builds on the 2005 publication and incorporates learnings from the PBP and other research and development activities over the past 15 years. Production of this manual was coordinated by Dr. Andrew McGregor with assistance from Kaitu Erasito, Kyle Stice and Livai Tora. Funding for this manual was provided through the Pacific Islands Farmer Organisations Network (PIFON) under the ACIAR PARDI2 program and the Farmer Organisations for Africa, Caribbean and the Pacific (FO4ACP) program.

Our members extend a hearty Vina Du Riki for this assistance in helping us realise our Vision.

Livai Tora
Chairman
Nature's Way Cooperative

Abbreviations and acronyms

ACIAR	Australian Centre for International Agricultural Research
ACP	African, Caribbean, Pacific
AUSAID	Australian Aid
BQA	Bilateral Quarantine Agreement
EU	European Union
FMOA	Fiji Ministry of Agriculture
FO	Farmer Organisation
FO4ACP	Farmer Organisations for Africa, Caribbean and the Pacific
FOB	Free on Board
FODMAP	Fermentable, oligosaccharides, disaccharides, monosaccharides, and polyols
GI	Glycemic Index
HTFA	High Temperature Forced Air
IBS	Irritable Bowel Syndrome
IFAD	International Fund for Agricultural Development
NCD	Non-communicable disease
NWC	Nature's Way Cooperative
PARDI2	Pacific Agribusiness Research Development Initiative Stage 2
PBP	Pacific Breadfruit Project
PICs	Pacific Island Countries
PIFON	Pacific Island Farmer Organisations Network
SPC	Secretariat of the Pacific Community
TC	Tissue Culture
TRTC	Tutu Rural Training Centre

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Acknowledgements

This manual was prepared by the Pacific Island Farmers Organization (PIFON) and builds on multiple reports and studies related to breadfruit research and development in Fiji over the past decade. Nature's Way Cooperative Fiji Ltd has been at the forefront of much of this research and development and this manual expands on an earlier 'Fiji Breadfruit Manual' produced by the cooperative in 2005.

The lead author for this manual is Andrew McGregor of Koko Siga Pacific supported by Kaitu Erasito, Kyle Stice and Livai Tora.

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And last but not least we would like to acknowledge the immense contribution and dedication of our resource owners in Vanua Levu and our orchard growers who have committed and participated in the development of the breadfruit industry. In particular Prakash of Johnson Road Lautoka, Sahn Ali fo Buabua in Lautoka as well as the Tutu Rural training center in Taveuni.

Photo credit: Rob Rickman

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The breadfruit market: now and in the future

2.1 Introduction

Breadfruit, the classical Pacific food crop, is widely cultivated in the Pacific islands where it is often a part of traditional agroforestry systems. Breadfruit can be cooked and eaten at all stages of maturity and is a highly nutritious food. It is high in desirable complex carbohydrates, rich in fibre and low in fat. In some Pacific island countries, such as Samoa, breadfruit is a major food staple. In other PICs, such as Fiji and Vanuatu, breadfruit overall is regarded as a minor food staple. However, even in these countries there are some areas, such as Natewa Bay in Fiji and Malo island in Vanuatu, where breadfruit is an important food staple.

For more than a decade Fiji, Tonga and Samoa have been permitted to export fresh breadfruit to New Zealand, treated by the approved High Temperature Force Air (HTFA) quarantine treatment for fruit flies. The quantities exported have been small and well below market demand. Larger quantities of frozen breadfruit are exported to Australia, New Zealand and the United States. There are substantial and immediate market opportunities to expand fresh and frozen breadfruit export markets – however, significant marketing constraints need to be overcome. This manual identifies these constraints and provides practical advice on how they can be overcome

For the future, there are major opportunities in supplying processed breadfruit products to export markets. These markets are divided into two broad segments: the gluten/grain-free product market; and, the market based on processing advantages potentially offered by breadfruit. However, for these markets to be realised, breadfruit supply needs to increase significantly, together with substantial capital investment and private sector involvement in breadfruit processing.

Much more immediate market opportunities exist for processed breadfruit products on local markets. A particular opportunity is for breadfruit flour as a substitute for imported grains, particularly wheat flour. This large domestic market is expected to be driven by non-communicable disease (NCD) health concerns, together with the future impact of climate increasing the relative price of imported grains.

2.2 Fiji's genetic resource base and breadfruit as a traditional crop

Fifty five (55) years ago in 1966 Dominiko Koroveibau named and published 70 breadfruit varieties in Fiji. These varieties are distinguished by tree size,fruit shape (round,oblong and oval) fruit size,leaf type,eating and keeping quality. Names also vary between various locations in Fiji. The main identified varieties that are being exported are Uto Dina and Balekana. These two superior varieties have good keeping and eating qualities.

In early 2012 Kaitu Erasito characterized and published 20 known varieties in Natewa Bay ,Cakaudrove Province in Vanua Levu. This work can be accessed in the following link.

Furthermore 7 more breadfruit varieties were identified and characterised in the island of Rotuma by Kaitu Erasito in the villagers of Saulei, Malhaha, Pepejei, Itumuta and Motusa village. This work can be accessed in the following link. http://www.rotuma.net/os/lajereports/Breadfruit_Survey.pdf This important study was funded by Laje Rotuma - http://lajerotuma.org.fj/

The Pacific Breadfruit Project (PBP), which commenced in 2011, began the task of identifying the varieties best suited for commercial production; and, collecting planting material for the emerging breadfruit industry. A major part of their work was to re-characterize all breadfruit varieties around Fiji including Government Research Stations. The work of the PBP laid the foundation and development of a commercial breadfruit industry.

These are the characteristics that are needed for breadfruit to be suitable for fresh export:

- Good eating qualities when harvested at the mature green stage – especially as perceived by the Samoan ex-pat community (the main fresh export market).
- Tolerance at the mature green stage of ripeness to the High Temperature Forced Air (HTFA) quarantine treatment;
- Smaller uniform size (when mature) required for quarantine treatment, packing, shipping and marketing; and,
- Fruiting season(s) that would allow for extension of the marketing period.

Table 1: Fiji's main commercial breadfruit varieties

Uto Dina

Oval-shaped & can weigh up to 2-3kg per fruit. Seedless.

Traditional variety grown throughout Fiji Islands. Shelf life of 3-5 days. Good eating quality when boiled.

Uto Buco ni Samoa

Shape and size varies; either oval weighing up to 2-3kg per fruit or round weighing up to 2kg. Yellow flesh with 1-2 seeds.

Samoan variety with a few characteristics of traditional buco variety. Good eating quality but should be harvested when fully mature due to problem with heavy latex flow if harvested immature. Shelf life of 3-4 days.

Uto Loa/Vonu

Can weigh up to 3-4kg per fruit. Seedless variety with good flesh content.

Eating quality similar to *uto dina* when boiled or roasted. Better harvested when fully mature due to heavy latex flows if harvested immature. Shelf life of 2 days.

Uto Koga

Round shape white-fleshed variety weighing up to 2-3kg per fruit. Similar flesh content to *uto dina*.

Tastes best when boiled. Good eating quality – 1 fruit can feed 3 people. Good fruiting season with shelf life of 3-4 days.

Uto Buco

Seedless variety weighing up to 5-6kg per fruit with more flesh content than other varieties.

One of the biggest traditional varieties. Good eating quality. Can feed 5 members of the family. Shelf life of 4-5 days.

Bale Kana

Small size white-fleshed fruit, round-oval in shape weighing 500g-1kg.

Smallest variety but very good eating quality, best when boiled or roasted. Makes flour of attractive appearance (as with all white-fleshed varieties). Shelf life 4-5 days.

Photo credit: Rob Rickman

2.3 Fresh and frozen breadfruit exports

The large Samoan diaspora living in New Zealand, Australia, and the United States, together with other Pacific islands communities, has long been identified as a substantial market for fresh breadfruit. This is in addition to the Indian, Malaysian and Sri Lankan consumers who also use breadfruit in curry dishes.

Since the early 1980s, Fiji has been exporting small quantities of frozen breadfruit to these markets. Breadfruit is a fruit fly host, and thus fresh exports were not permitted until 1997, when the High Temperature Forced Air (HTFA) facility was certified for export of fresh breadfruit to New Zealand. It was not until 2001, when the first HTFA treated export was made. The expectations at that time were that fresh breadfruit exports would soon become a major export commodity with fresh exports projected to exceed 400 tonnes within 5-years. These projections were regarded as conservative, based on an in-depth New Zealand market study (Grandison 2002) and the expectation that market access to Australia and the United States would soon be in place. However, actual exports fell far short of these projections. It had become clear that if anywhere near market potential was to be realized the transition had to be made from "wild harvest" to growing breadfruit as an orchard crop How to achieve this transition is the focus of this manual.

2.3.1 The current export market situation for fresh and frozen breadfruit

Consultations were held with importers and retailers in New Zealand and Australia as part of the Pacific Island Breadfruit Market and Marketing Study (McGregor and Stice 2018 (https://pafpnet.spc.int/about-papp/our-areas-of-focus/policy-development/855-breadfruit-marketing-study). The estimates of breadfruit demand based on these consultations are summarized below:

New Zealand

Fresh breadfruit: It is estimated at the current pricing the demand for fresh breadfruit will be around 8 tonnes per week from all sources and all markets. If six months of supply can be achieved this would be a total annual volume of around 190 tonnes. If a number of improvements in the value chain were made including bringing down the price of fresh breadfruit, it is estimated that demand would increase to around 12 tonnes per week from all sources and all markets. If six months of supply can be achieved; **this would be a total annual volume of around 300 tonnes.**

Frozen breadfruit: The overall estimated demand for frozen breadfruit at current pricing would be around 5 tonnes per week over a 12-month period which is 240 tonnes per annum. For frozen breadfruit supplying for 6-months **(120 tonnes/annum)** is more readily achievable

Australia

Fresh breadfruit: There is some domestic supply (around 20 tonnes/annum) of breadfruit from North Queensland, which is sporadic and expensive. With the prospect of finally obtaining market access for HTFA treated breadfruit from Fiji, a wholesale price of AUD $7/kg for fresh breadfruit was calculated. Based on feedback from importers and retailers, at is estimated that the immediate demand in Melbourne and Sydney would be around 9 tonnes per week. An additional 3 tonnes per week is estimated as the potential demand from Brisbane. If six months of supply can be achieved this would be a total annual volume of some **300 tonnes to all markets.**

Frozen breadfruit: overall estimated demand for frozen breadfruit at current pricing would be around 4 tonnes per week over a 12 month period from all suppliers to all markets which is **240 tonnes per annum**. Frozen breadfruit market demand will always be linked to other root crops such as taro and cassava and if supply/prices fluctuate significantly, this will affect the demand for breadfruit.

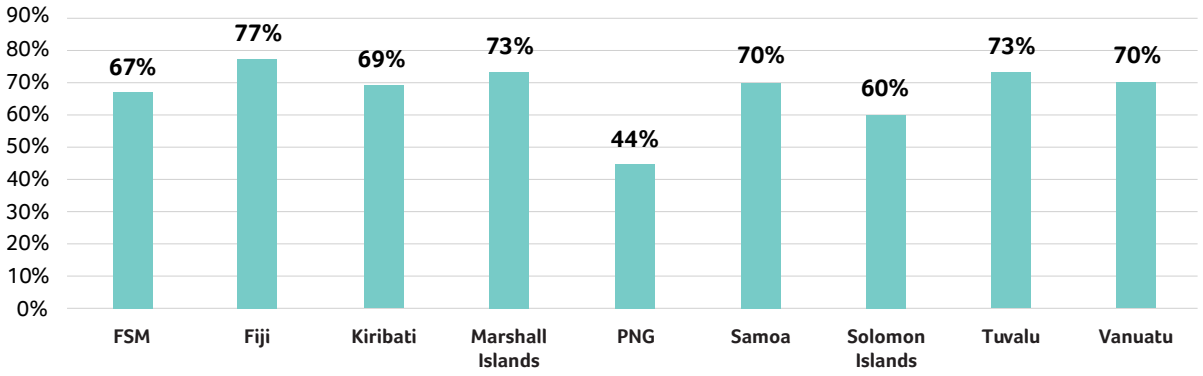
Issues raised in market consultation: There were two main areas of concern raised in the 2018 breadfruit market consultations that need to be addressed if market opportunities are to be realised. These were the need to improve: i) quality (variety, maturity and handling); and ii) supply consistency and season length. These are all issues that the PBP addressed in facilitating the transition of breadfruit from a "wild harvest" to orchard-based industry and these benefits are just now starting to be realised.

2.4 Market opportunities for breadfruit created by health and nutrition considerations

2.4.1 The Pacific island nutrition and NCD crisis

The Pacific islands has undergone a 'nutrition' transition from diets largely based on locally grown food to those primarily based on processed, imported, foods. Current diets are generally considered as nutritionally-inferior and have been identified as a major contributor to two types of malnutrition. The prevalence of overweight adults in the PICs is among the highest in the world and in some of the smaller island countries exceeds 60 percent of the adult population. Non-communicable diseases (NCDs) are now the leading cause of death in most countries in the Pacific, ranging from an estimated 60 per cent of deaths in Solomon Islands to over 75 per cent of deaths in Fiji.

Estimated percentage of total deaths caused by NCDs in PICs*



** Source: Xiaohui Hou, Ian Anderson, Ethan-John Burton-Mckenzie . Pacific Possible: Health & Non-Communicable Diseases. Background Paper. World Bank, July 2016 (https://thedocs.worldbank.org/en/doc/942781466064200339-0070022016/original/pacificpossiblehealth.pdf)*

Diabetes is particularly relevant in the Pacific islands and has increased steadily over the last four (4) decades. The PICs now rank the highest in the world in terms of the prevalence of diabetes – with 7 PICs ranked in the top 10 countries in the world in terms of diabetes prevalence according to the International Diabetes Federation.

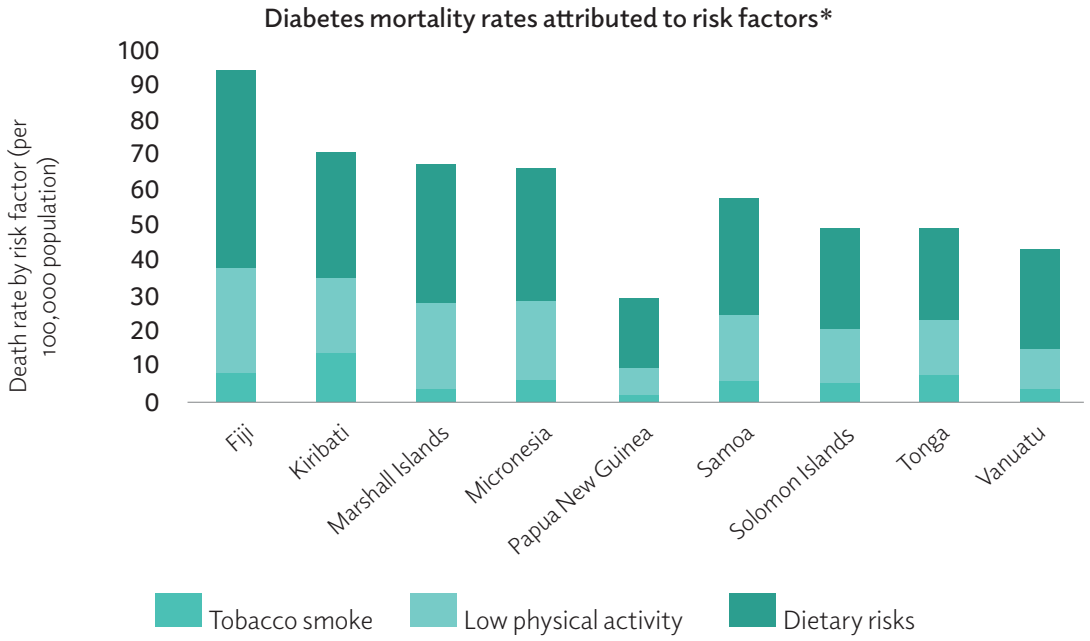
Table 2: Top ten countries/territories for diabetes prevalence in the world*

Country/Territory	2013 - Prevalence (%) of diabetes (20-79 years)
Tokelau	37.5
Federated States of Micronesia	35.0
Republic of the Marshall Islands	34.9
Kiribati	28.8
Cook Islands	25.7
Vanuatu	24.0
Saudi Arabia	24.0
Nauru	23.3
Kuwait	23.1
Qatar	22.9

**International Diabetes Federation (2013)*

(https://scholar.google.com/scholar?q=International+Diabetes+Federation+(2013)&hl=en&as_sdt=0&as_vis=1&oi=scholart)

In the Pacific islands NCDs have been declared a health and economic crisis that threatens sustainable human development (WHO/SPC 2011) (https://iris.wpro.who.int/handle/10665.1/5269). While many social and economic factors have contributed to the rapid increase in diabetes in the Pacific islands, an overall greater consumption of imported foods in preference to traditional foods and diets has undoubtedly played the pivotal role with diet being dominant contributor as shown by the graph below.



Source: World Bank 2016 p, 3.

2.4.2 Nutritional benefits offered by breadfruit

There are three (3) key positive nutritional features of breadfruit food products that can contribute to an overall reduction in NCDs in Pacific island countries. Breadfruit products are:

- gluten free and low in FODMAP elements;
- have a moderate glycemic index; and,
- a high fibre and non-digestible carbohydrate context (high amylose content).

The nutritional advantages of these features are summarised below and are discussed in more detail the **Pacific Island Breadfruit Market and Marketing Study with a focus on Fiji and Samoa** (https://pafpnet.spc.int/about-papp/our-areas-of-focus/policy-development/855-breadfruit-marketing-study)

Gluten free and being low in FODMAP elements

Gluten is found in grain products such wheat, rye, maize and barley – however, it is not found in rice. Fruit and vegetables including breadfruit do not contain gluten. Gluten is the key ingredient in bakery products as it facilitates their ability to rise when baked.

Gluten free products are now widely perceived as health foods, even though being gluten free in itself is only of significant health benefit for a small percentage of the population. Gluten intolerance can bring with it serious health consequences for people who have celiac disease which results in destruction of the bowel lining (Viali Asiata. Ulu & Health. Pacific and Global Breadfruit Summit: Samoa 2017). Celiac disease is a genetic disorder which affects about 1% of the population worldwide (Green PH, Cellier C. Celiac disease. N Engl J Med. 2007;357:1731-1743. International Diabetes Federation (2013). Diabetes Atlas, 6th Edition.). This disease is much more common amongst ethnic Caucasians. Amongst Pacific Islanders (Melanesians, Polynesians and Micronesians) gluten intolerance is particularly low. Thus, for this demographic the direct health benefits related to celiac disease from consuming products that are gluten free are minimal. However, Celiac diseases is not the only potential health consequence of consuming products that contain gluten. People suffering from

irritable Bowel Syndrome (IBS), a much more widespread disease[1], have been found to benefit from a gluten free product diet. It is not gluten per that is directly causing IBS but rather it is caused by something else known as FODMAP elements, that is also found in food containing gluten such as wheat, barley, rye. Breadfruit is not only gluten-free, but importantly it is also happens to be low FODMAP (https://www.ibsdiets.org/fodmap-diet/fodmap-food-list/). It can be expected that the **low FODMAP 'market'** will far overshadow the **gluten free celiac disease 'market'.**

The availability of raw material supply and the large capital investment requirements means that the initial focus for processed breadfruit products needs to be for domestic and not export markets. For domestic Pacific island markets being gluten free is probably only for limited benefit from a health perspective – although "gluten free" labeling can expect to be a marketing advantage for higher income market segments. However, there are two other substantial health benefits that breadfruit offers and that need to be promoted in domestic Pacific island markets. These are:

- a moderate glycemic index (rate of rise in blood sugar); and,
- a high fiber high non-digestible carbohydrate context (high amylose content).

Moderate glycemic index (GI)

Breadfruit has a moderate glycemic index, which is lower than that of substitute carbohydrates such as potatoes, white rice, white bread, taro and cassava. Lower GI diets result in the body more slowly converting food into energy and keeping blood sugar levels more stable. A lower glycemic diet is regarded as effective in the control of diabetes particularly when in food with a higher carbohydrate content (Diabetes.co.uk). Breadfruit is such a food that provides for this.

High fibre and non-digestible carbohydrate context (high amylose content).

Breadfruit starch, in contrast to products made up of simple sugars, is slow to digest. This capacity to resist digestion reduces the propensity of consumers to feel hungry and thus to over eat, which in turn raises blood sugar levels and insulin sensitivity contributing to diabetes. Breadfruit products or other products fortified with breadfruit have thus been identified as a means of regulating blood sugar levels and insulin sensitivity.

The combination of moderate GI and high amylose content in breadfruit products

In the fight against NCDs, obesity and in particular diabetes, there is increased interest in processed food products that combine a low GI and high fiber content (Lafiandra, D., Riccardi, G., & Shewry, P. R. (2014). Improving cereal grain carbohydrates for diet and health. Journal of Cereal Science, 90, 312e326.). Breadfruit flour and paste is such a food. Breadfruit is also seen as a useful source of vitamin C, potassium, magnesium, and calcium, with small amounts of thiamin, riboflavin, niacin and iron. The actual level of these additional benefits will vary with variety and how the breadfruit is processed.

The overall conclusion: A substantial increase in breadfruit consumption can be expected to make a significant contribution to the reduction of NCDs and thus have large social and economic benefits.

2.5 Breadfruit flour as a partial substitute for wheat flour used in mainstream market bread and buns

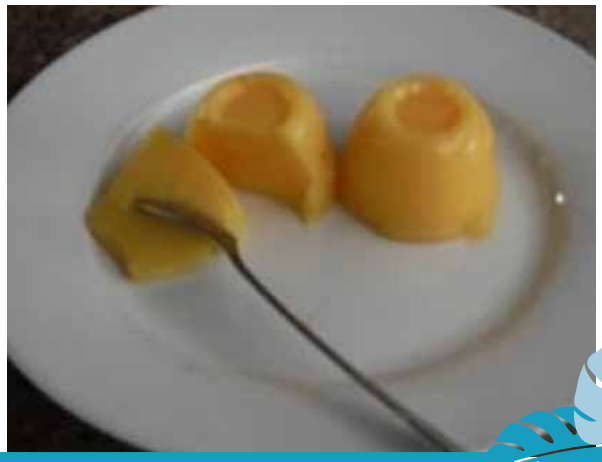
In Pacific island countries wheat flour bread and buns is a major mainstream consumer item for all income classes in both rural and urban areas. Fiji, imports 135,000 tonnes of wheat flour annually for a landed value in excess of $100 million (Fiji Bureau of Statistics). It is not realistic, however, for the foreseeable future, to expect anywhere nearly near full import substitution for wheat. It must be kept in mind that the gluten contained in wheat is a necessary ingredient to make bread and buns rise. However, the Tutu Rural Training Centre experience has demonstrated that breadfruit flour can be mixed with wheat flour up to a maximum ratio of one third and can produce more than satisfactory conventional bread and bun products for local consumers. Work undertaken by the University of the West Indies, Trinidad and Tobago presented at the 2017 Pacific & Global Breadfruit Summit in Samoa found similar results.

[1]The incidence of IBS is far greater than celiac disease, impacting on up to 20% of the population in some Western countries such as Australia (http://www.ibis-australia.org).

However, even a relatively small partial substitution of wheat flour with breadfruit flour offers a sizable market opportunity. If Fiji was to substitute only 10% of wheat product imports with breadfruit flour this would represent a market of over 12,000 tonnes of flour (approx. 60,000 tonnes of fresh breadfruit) valued at some FJD 10 million at current prices. This would bring with it large economic and social benefits in terms of improved public health and foreign exchange saved. Such a volume represents a market well in excess of the capacity to supply for the foreseeable future.

2.6 Market opportunities created by processing characteristics

There are other areas that have been identified where breadfruit has significant processing advantages. In particular breadfruit paste has excellent thickening properties at low temperature and gelling features at high concentrations. Food technologist Dr. Richard Beyer provided technical assistance to the Taveuni based Tutu Rural Training Centre (TRTC) in the processing of breadfruit flour for bakery products[2]. His work at Tutu identified breadfruit starch as a particularly valuable natural thickener for food processing. A thickener from breadfruit flour can be derived, without the particles disaggregating, by simply adding water. It is not necessary to heat the liquid (as is the case with cornstarch) or to add chemical derivatives (as required for cassava starch). Thus, breadfruit flour offers the prospect of producing a variety of gluten free mixes without heating or the addition of chemical additives. These include high value products such as: custard and Bisto™ sauce mixes, blancmange[3] and a variety of dips. Richard Beyer's work at Tutu successfully demonstrated this on a cottage industry scale. He is of the view that this could be readily scaled up to larger processing operations.



Tutu Rural Training Centre flour dissolved in cold water and used as a thickener for custard gel

The conclusions drawn from Dr Beyer's work at Tutu:

- Breadfruit flour is instantly dispersible in cold water at low concentrations (1% w/v unheated) and being highly viscous.
- At high concentrations, this breadfruit product will form a gel.

[2]Dr. Beyer in his presentation the 2017 Breadfruit Summit in Samoa noted: Hydrocolloids that are commonly used as thickening are starch, xanthan, guar gum, locust bean gum, gum karaya, gum tragacanth, gum Arabic and cellulose derivatives. The gelling type hydrocolloids are alginate, pectin, carrageenan, and agar. Polysaccharides [Greek poly = many; sacchar = sugar] are complex carbohydrates, composed of from 10 to up to several thousand monosaccharides arranged in chains. The most common monosaccharides that appear as parts of polysaccharides are glucose, fructose, galactose and mannose. Breadfruit starch compared with the likes of cassava and corn starch have "longer" (more elastic) gels – with a larger strain at failure. This increases the viscosity of products that use breadfruit starch.

[3]Blancmange is a sweet dessert commonly made with milk or cream and sugar thickened with gelatin, cornstarch or Irish moss, and often flavoured with almonds. It is usually set in a mould and served cold.

2.7 Market opportunities for breadfruit created by climate change

Breadfruit, as identified in the SPC published book "Vulnerability of Pacific agriculture and forestry to climate change", is one of a number of traditional Pacific island staple food crops expected to adapt well to climate change (Taylor et.al 2016, Chpt. 4 https://www.spc.int/resource-centre/publications/vulnerability-of-pacific-island-agriculture-and-forestry-to-climate). The optimum climatic conditions for breadfruit production are temperatures ranging from 21-32 °C and an annual rainfall of 1500-2500 mm. Breadfruit trees are prone to damage from high winds; however, trees are seldom uprooted by cyclones, with damage usually confined to outer branches . The NWC Breadfruit Research and Extension Officer (Kaitu Erasitu) reported the following damage from category 5 Cyclone Winston that severely impacted western Viti Levu:

- At the time of TC Winston, the 10 leading breadfruit orchards had approximately 1430 breadfruit trees established.
- 3 trees were broken (I tree was broken right at the base which later had side shoot and is now growing well again). The other two trees were at Prakash and Shan Ali breadfruit orchards in Johnston Rd Lautoka. They just had the top terminal broken. The rest of the branches recovered well in less than two months. Whereby new leaf, new side shoots have started to grow bigger into new branches and new shoots.
- Fruit production at the time was severely impacted. The main production season for both *Uto Dina* and *Balekana* variety is January, February and March. At the time we were expecting at least 4 tonnes from our orchards and this would have been their first significant production.
- It was 3 months too next fruiting season and the breadfruit trees to recover before they could yield again – which they all did.
- For the *Uto Dina* variety the fruit loss was higher (around 70 %) compared with that for the *Bale Kana* variety. It was higher for Uto Dina because there were lots of tall trees and more broken branches which with heavy fruiting were easily broken.

Breadfruit requires relatively high levels of rainfall to thrive but can survive droughts of 3-4 months after the tree is established. It is unlikely that the increasing temperature will have too much impact on breadfruit production, at least to a 2 °C increase (Taylor et.al 2016 p 188).

2.8 Breadfruit "the crop of the future"

Breadfruit is identified as a key crop for the future food security of the Pacific islands for a combination of reasons. The breadfruit crops:

- ability to secure food energy from the atmosphere, thanks to its large leaves and canopy and being relatively undemanding on the soil;
- high tolerance to climate change and climate extremes;
- compatibility to intercropping within agroforestry systems; and,
- ability to sequester carbon.

The forecast situation for breadfruit in the face of climate change contrasts markedly to that of grain crops. Climate change is expected to have a significant negative impact on global grain production, and in particular, Asian rice production. This means that the real price of imported grains for the Pacific islands is projected to increase significantly in coming decades (Taylor et al, Chpt 9). This has major negative economic implications for the PICs, where imported grains already represent more than half of their food imports and where food imports for many of these countries already far exceeds the value of their total exports. Thus, for a number of traditional staples, including breadfruit, climate change creates a major market opportunity with the real price of imported grains increasing. The challenge for Pacific island farmers and agribusiness is to be able to take advantage of this opportunity. This will require a transition from a "wild" harvest fresh fruit to an orchard grown tree crop that is processed into products that can be substituted for imported grains. The initial steps have been made in breadfruit orchard development in Fiji and with breadfruit processing development in Fiji, Samoa and Tonga.

Photo credit: Rob Rickman

3

The Pacific Breadfruit Project (PBP)

The transition from wild harvest system

To commercial orchard production

3.1 The rational for the PBP

Breadfruit has been identified as a key crop of the future food security of the Pacific islands, based on a number of considerations (McGregor, Tora and Lebot 2015).

Breadfruit is a traditional crop that is largely found in agro-forests, household backyard gardens or around villages. While such scattered cropping systems make a useful contribution to food and nutrition security for local people, they are unable to make a major contribution to future national food security and do not provide the basis for the development of a commercial industry, either for export or the domestic market. Intensification using horticultural orchard development principles was therefore seen as an essential requirement for the development, to take advantage of the immense opportunities this traditional crop offered.

There has been only limited experience in the development of commercial breadfruit orchards, and this had been confined to the small island countries of the Eastern Caribbean countries (Medlicott, 1997). Thus, it has been necessary to develop nursery and orchard nursery systems for this "new" commercial fruit tree crop in the Pacific. Basic applied research and extension activities were required in areas such as: planting material selection; propagation and distribution (including commercial private sector nursery development); orchard management practices (including intercropping to ensure financial viability and to reduce risk); and post-harvest handling. A major identified constraint was the limited number of outstanding identified varieties (seedless triploids) from a commercial perspective. Thus there was a need to mass propagate these selected varieties to establish orchards with elite planting material.

To assist smallholder farmers to transition from breadfruit being an opportunist "wild harvest" food tree to growing breadfruit as an orchard crop a funding proposal was submitted to the ACIAR for funding.

A two-stage applied research was proposed to facilitate the development of breadfruit as significant commercial industry. The focus of the first stage was on commercial orchard production and post-harvest handling for fresh exports. The second stage was to deal with the commercial processing of breadfruit – with the understanding that the two stages are interrelated. Commercial processing depends on the existence of an efficient and accessible production base. The availability of a significant domestic processing market will in turn encourage further investment in small breadfruit orchards. ACIAR agreed to fund the 1st stage (orchard production and post-harvest handling), deferring the 2nd phase until a successful proof of concept of the 1st phase. **The former has been achieved, although funding of the 2nd phase is still to be obtained.**

The Pacific Breadfruit Project (PBP), which focussed on Fiji, involved a partnership between Kokosiga Pacific (a Fijian company), Nature's Way Cooperative (an industry owned quarantine treatment business for fresh exports), the Fiji Ministry of Agriculture (FMOA) and the SPC's Centre for Pacific Crops and Trees (CePaCT). The initial focus of the Project was on Fiji with the intention of later extending to other PICs. The PBP was designed as a collabourative research effort involving Kokosiga Pacific, SPC's CePaCT, the Research Division of FMOA and the private sector (NWC, exporters, farmers and commercial nurseries).

3.2 An outline of the PBP

The aim of the PBP was to enhance rural livelihoods through the development of an effective and sustainable breadfruit supply chain. To achieve this aim, the Project had 3 objectives supported by a number of activities as listed below.

1. **To identify varieties that will significantly expand the breadfruit production season and develop systems for propagating them**

   Supporting activities:

   - Collect and characterise available breadfruit diversity from Fiji.
   - Collect information on specific collections that exist elsewhere in the Pacific.
   - Expand on the diversity that exists in the Fiji gene pool.
   - Identify a methodology for the mass propagation of breadfruit in vitro

2. **To develop best practices for the establishment and management of small-scale commercial breadfruit orchards**

   Supporting activities:

   - Set up trials to determine best propagation system for mass production of breadfruit seedlings of market preferred varieties
   - Establish field trials to determine best agronomic practices for commercial breadfruit orchards.
   - Conduct economic analysis to support identification of best practices for a commercial breadfruit orchard.
   - Disseminate information that promotes best practices for commercial breadfruit production.

3. **To establish harvesting and post-harvest systems to meet export market requirements**

   Supporting activities:

   - Establish harvesting and post harvest trials to determine the best practice to maximise quality and shelf-life.

The PBP began implementation at the beginning of 2011 and at the end of the four (4) years of Stage 1 Project nearly 2,000 breadfruit trees have been planted – involving 36 farmers on 16 ha of land. All but one of these farms are located in western Viti Levu with ready access to NWC's quarantine treatment facility. The one exception is the TRTC on Taveuni, which has led the way in small scale breadfruit processing development.

These trees are predominately the Balekana variety with some Uto Dina. These were the two varieties that were approved for fresh export to *New Zealand* – using HTFA quarantine treatment. The Balekana planting material (root suckers and marcotts) was sourced for Natewa Bay *Vanua Levu* and *Taveuni*, and distributed through the PBP's Natalau, Nadi nursery and other private nurseries.

Despite the setback of TC Winston (Feb 2016), most of these trees are now fruiting, and at full production they are capable of producing 450 tonnes for export (fresh and frozen) and domestic processing.

The breadfruit trees planted under the PBP were found to commence fruiting after two years, if the recommended orchard package of practices was adopted. This compares with four to five years normally expected for breadfruit. This much earlier fruiting greatly enhances the financial viability of breadfruit farming.

Photo credit: Rob Rickman

3.3 The sourcing and developing of appropriate genetic material for breadfruit orchards

3.3.1 Why establish breadfruit orchards?

Orchards are an essential requirement to support commercial processing and fresh exports. Without developing proper commercial orchards, wild harvest will still be practiced along with the negative impacts it causes along the supply chain.

The aim was establishing commercial breadfruit orchards but the problem was the absence of high quality planting material of the desired variety. The varieties selected had a profound fruiting pattern (fruits 3- 4 times in a year) and should be a seedless variety. The two varieties that were chosen for supplying export market are Uto Dina and Balekana ni Samoa as these were the two varieties already approved for fresh exports to *New Zealand*. The PBP *implemented* 5 different strategies to source sufficient breadfruit planting material to develop commercial breadfruit orchards. https://drive.google.com/file/d/1bHa7IR7LOA_-wMoIxIoo2Lhttps://drive.google.com/file/d/14RiTsiD2FIyEvgnvxHjeby12tAONhQMQ/view?usp=sharingkvi6s2LSHM/view?usp=sharing

3.3.2 Lessons learnt

- **The need to transition from wild harvest to commercial breadfruit production system came with its challenges. These included what are covered by the strategies which follow.**

3.3.3 Strategy 1: Sourcing root suckers

Mature breadfruit trees have roots close to the surface. New shoots or 'suckers' grow from these roots, especially when the roots are wounded. Varieties such as Balekana produce a lot more root suckers than others, including Uto Dina.

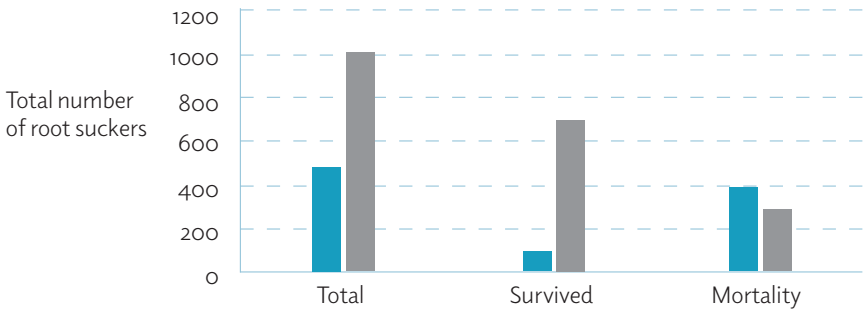
The PBP collection of root suckers

The PBP collected Uto Dina root suckers from the Sabeto valley in Nadi and Balekana root suckers from Natewa Bay. These root suckers were then planted out at the PBP nursery at Sabeto in Nadi. It was found that the Balekana variety was far better suited to root sucker propagation than Uto Dina. Not only did Balekana trees *produce* far more root suckers, their rate in the nursery was significantly higher. Clearly Balekana are a much more economical planting material option. However, the challenge facing the PBP was that Balekana was not commonly found on Viti Levu. The PBP was, however, successful in sourcing a significant quantity of Balekana planting material from Natewa Bay and TRTC of Taveuni. Viti levu nurseries still have access to these supply links. Over the next few years, as the Balekana trees planted mature, there will be a more than adequate supply of Balekana root suckers available on Viti Levu for the continued expansion of the breadfruit orchard production base.

Breadfruit collection from Natewa.

Potting of commercial breadfruit collection at Bula Agro nurseries in Nadi.

Table 3: Results of root suckers collection of the two elite varieties



	Total	Survived	Mortality
Uto Dina(VitiLevu)	490	94	396
Balekana Taveuni	1000	700	300

The high mortality rate was due to the size of planting material, condition of planting material and the time of planting out in the field.

3.3.4 Lessons learnt

- **Future supplies for root suckers may well get more expensive in the future due to seedling availability and logistical costs that may be uneconomical**
- **The need to switch to mass commercial scale volume will require high quality planting material which only Tissue Culture technology can supply. The technology has been successful internationally and should be investigated**

3.3.5 Strategy 2: The mass propagation of Uto Dina and Balekana through marcotting

Marcotting, or aerial laying, is a method used to achieve quick fruiting. The procedure involves taking young green branches up to 20 mm diameter. This can be induced to produce roots in a 'bandage' containing a mixture of damp soil and peat while it is still attached to the tree. Roots are established in the soil and peat mix, which gives the plant a head start. Properly done, these will be high yielding trees, that produce fruit closer to the ground. Early bearing substantially increases the financial viability of the orchard. On the down side, plants obtained from marcotting tend to initially have weaker root systems that make trees more susceptible to uprooting from cyclones.

The PBP's mass propagation through marcotting

The PBP undertook breadfruit propagation through marcotting for Uto Dina (at Sabeto Valley, Nadi) and Balekana (at TRTC on Taveuni). As with root sucker propagation, far better results were achieved with Balekana than Uto Dina. Although the poor performance of the Uto Dina marcotts was partly due to cyclone damage at the time.

Newly planted marcotted Bale kana at the Tutu rural training center

Established marcotted Bale kana at Tutu.

3.3.6 Lessons learnt

- The size of the planting material needs to be at the juvenile vegetative growth phase which is around 2-3 feet in height;
- The optimum condition for planting seedlings is as soon as it is uprooted . The longer the time to plant out in the nursery the higher the chance of survival.
- The most optimum time for planting is during the rainy season (Oct - Dec) to minimise costs incurred for supplementary irrigation during dry periods.
- Root suckers that were planted out in the field had a deeper rooting system than breadfruit trees that were marcotted (shallow rooting system)., hence the latter withstood cyclonic winds better.
- Different varieties responded differently to marcotting. Many factors may have affected the high mortality rate such as marcotting technique, moisture content of peat moss, plant neglect and differences in cultivar.

3.3.7 Strategy 3: Utilising the Natewa Bay Breadfruit hot spot as a source of root Sucker planting material for Viti Levu orchard development

Breadfruit hot spots on Vanua Levu

The PBP was introduced to villagers along the Natewa Peninsula, the hot spot for Balekana and a number of other unique varieties in Fiji. The PBP was linked to these villages through its long standing relationship with (TRTC). Despite large losses that were incurred during a transportation a total sum of 6,000 viable Balekana root suckers were sourced from Natewa Bay, which was sufficient to establish the orchard required for the development of commercial breadfruit industry in western Viti Levu. An important lesson, learnt for the future, is that planting materiasl should be shipped in small quantities.

3.3.8 Lessons learnt

- To avoid future logistical problems from source to nursery it is recommended that Tissue Culture technology be investigated.
- It will not be viable in the future to source material from traditional resource owners because we have enough orchards under NWC around the Nadi area that can supply us with planting material all year round.
- It is more efficient to collect root suckers (of the preferred variety) in small amounts than large bulk purchasing.
- The rooting system needs to be well protected and fully intact for transport to allow a greater survival rate.

3.3.9 Strategy 4: Tissue Culture material (CePact) Centre for Pacific Crops and Trees

Arshni from SPC CePaCT propagating Balekana breadfruit via tissue culture using a bioreactor

Breadfruit inside a bioreactor ready for transplanting into pots

In a small trial, CePaCT was able to supply the PBP with 176 tissue cultured balekana breadfruit plants. These were transplanted in Sabeto nursery for 3 weeks before they were distributed to three participating farmers in the Nadi area, where they started to bear fruit after 2-3 years. This small trial was deemed as a successful proof of concept. However, the constraint now is to attract commercial investment to scale up the supply of tissue culture planting material for breadfruit and other suitable horticulture and floriculture crops.

3.3.10 Lessons learnt

- **TC sourced material will have a uniform crop with the preferred variety.**
- **TC sourced material are nursed in a highly sophisticated sterile environment where they are protected from harmful pests and diseases.**
- **The technology has been successful internationally and should be investigated.**
- **Accessing low cost, high value, disease free Tissue culture planting materials is the challenge for farmers who want to invest in large scale orchard establishment**

3.3.11 Strategy 5: Developing a village-based nursery for potted breadfruit

Following the high loss rate with large shipment of root suckers from Natewa Bay (Strategy 3) it was decided to establish small village based nurseries in Natewa Bay . A total of 5 nurseries (Vusasivo, Naqaravutu, Natewa, Muana and Wailagi) were built. Villagers were taught how to practice breadfruit marcotting and planting breadfruit root suckers. They were supplied with salon cloth, planter bags and peat moss for marcotting. Once ready, the potted root suckers and marcotts were purchased for $5/bag at farm gate price. Unfortunately, the interest in these village nurseries soon waned after the initial surge of interest. Logistical problems were also encountered during shipping the planting material to the PBP nursery in Nadi.

During the project in 2011 the PBP was still able to source some 1,000 potted Balekana seedlings (both root suckers and marcotts) from TRTC. These seedlings arrived at the PBP's Sabeto nursery in good condition and were ready to be planted out in field after two months. Unfortunately, the 50-year flood that struck the Sabeto River in early March 2012 washed away more than 300 breadfruit seedlings that were ready for replanting. About 10% of the seedlings washed away were recovered from the river and successfully repotted. While the March 2012 flood was a major set back for the PBP, at least sufficient balekana planting material was now in place to start establishing the orchard production base needed for the development of a commercial breadfruit industry. This initial planting material supply was supplemented in late 2018 when an additional 1,000 root suckers were sourced from Vanua Levu which were supplied to 5 private nurseries in western Viti Levu.

3.3.12 Lessons learnt

- **Not a viable exercise because funding will not be available in the future to sustain the program**
- **Other crops such as kava and root crops take given more priority for rural farmers**

3.4 Breadfruit orchard development

Fiji began exporting fresh HTFA treated breadfruit to New Zealand in October 2001 – with one tonne shipped that year (table 7). The NWC 5-year Strategic Plan (2002 – 2006), encouraged by the estimated size of the New Zealand fresh breadfruit market discussed above, made optimistic projections for breadfruit treatments: 20 tonnes (2002); 100 tonnes (2003, 2004 and 2005) and 150 tonnes (2006). The projections were based on a combination of positive indicators:

- proven suitability of breadfruit for HTFA treatment;
- the large identified market in New Zealand; and,
- the expected market access to Australia and the United States – which also had a significant identified market.

There was steady growth in breadfruit exports which reached 15 tonnes in 2005. However, this fell far short of the Strategic Plan projection of 100 tonnes in that year. It had become clear that if anywhere near market potential was to be realized the transition had to be made from "wild harvest" to growing breadfruit as an orchard crop. The fresh export breadfruit "wild harvest" value chain is shown in figure 14. This cropping system and value chain could not provide sufficient supply of produce of consistently good quality for market development. With "wild harvest" fruit it was also very difficult to meet the bait spraying requirement under the bilateral quarantine agreement (BQA) for export of fresh breadfruit to New Zealand. The same consistent supply constraint applied to both fresh and frozen breadfruit exports. Thus, the development of breadfruit orchards was deemed an essential requirement to support breadfruit exports (both fresh and frozen) and eventually commercial processing (McGregor et al 2014).

Block orchard (left), with a linear orchard (right)

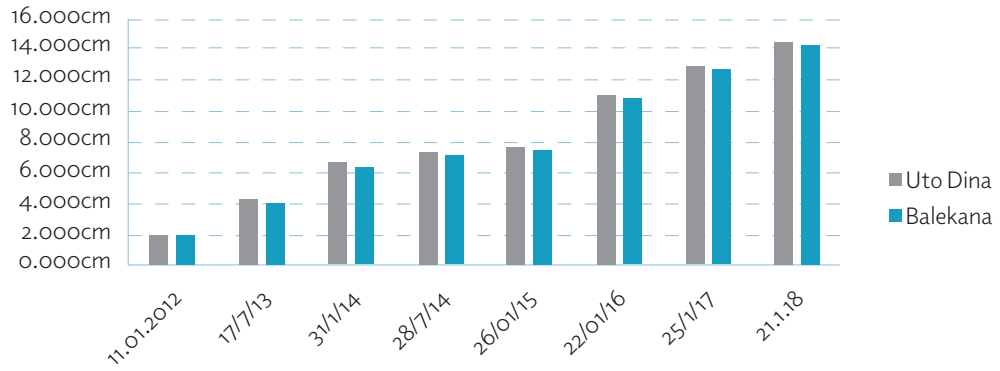
To facilitate the transition from "wild harvest" to orchard breadfruit production NWC prepared a project proposal that was submitted the Australian Centre for International Agricultural Research (ACIAR) for funding. The basis for this proposal is schematically represented in figure 13. This project was further designed to become a Pacific Breadfruit Project (PBP), which commenced implementation in 2011 with ACIAR funding. The key objective of the four (4) year PBP was to establish breadfruit as a commercial small- holder based orchard industry in Fiji. https://drive.google.com/file/d/1bHa7IR7LOA_-wMoIxI002Lkvi6s2LSHM/view?usp=sharing.

3.5 Breadfruit field trials: summary of what we learnt

3.5.1 Growth rate

The graph below was observed over a 6-year period, whereby there was very little difference between the size (stem girth) of the two varieties. It was noted that the Balekana variety produced significantly more side branches, and thus will produce significantly more fruit than the Uto Dina variety.

Table 4: Stem girth of Uto Dina and Balekana planted at Legalega - 2012-2018 (cm)



Most of the trees planted of at Legalega survived despite quite severe climate conditions (including a severe drought, a cyclone and major flooding) and began to fruit after 3 years[1]. This was the result of the orchard management interventions that were adopted.

- The Uto Dina variety grew more vertically but produced less side branches.
- Balekana grew more horizontally producing more side shoots and branches.
- Balekana trees produce significantly more fruit.
- Uto Dina fruit size was much larger (up to 3kgs per fruit compared with around 1 kg for Balekana).
- However, the overall yield in terms of total fruit weight was about the same for both varieties.

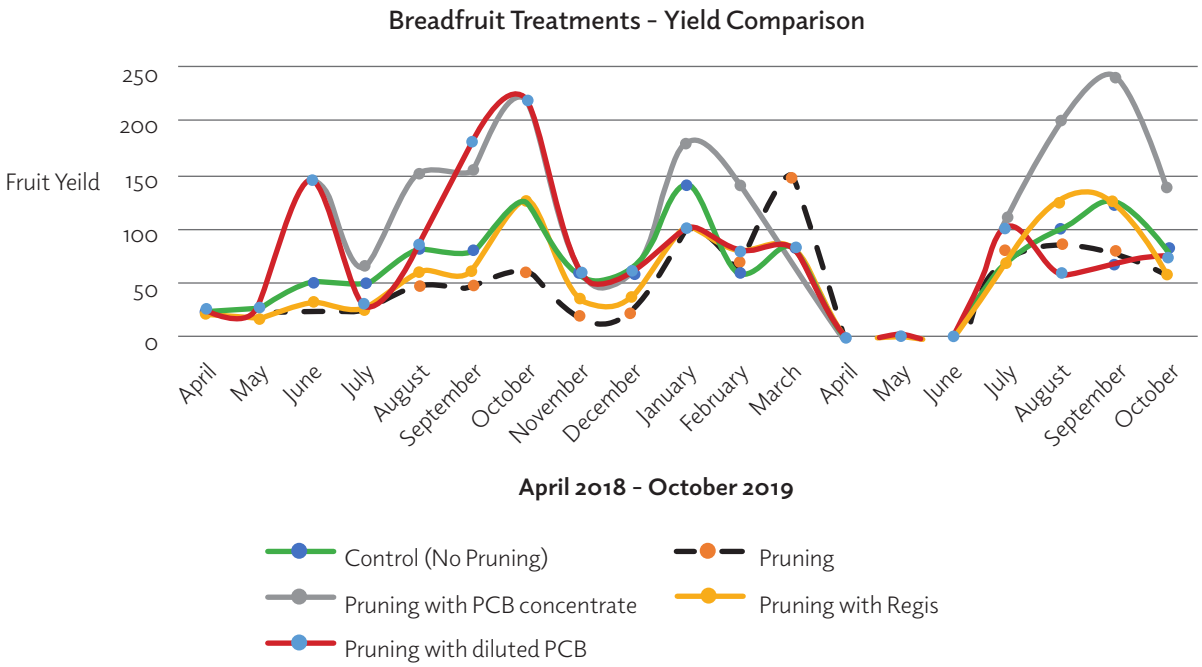
3.5.2 Yield – impact of pruning

Traditionally, "wild harvest" breadfruit trees, have not been pruned in Fiji. This is in contrast to Samoa where breadfruit trees planted around villages are commonly pruned. The basic principle of pruning is to keep trees shorter and stresses the tree to grow horizontal branches, and thereby increasing yield and facilitating easier harvesting.

Data collected by the PBP showed that when new side shoots develop after pruning it took around one year for the side shoot to yield new fruit. The positive impact on breadfruit yield resulting from appropriate pruning is illustrated in the table, which represents data collected from a two year trial conducted at a PBP orchard at Votualevu, Nadi[2].

Photo credit: Rob Rickman

Table 5: Breadfruit Pruning Trial



PCB is paclobrutazol. It is a chemical to induce flowering in Mango. It is applied after heavy pruning is done on mango trees to reduce vegetative growth, but induce flowering. This was the first time it was used on Breadfruit with similar pruning practices as in Mango. However, this trial was to investigate the correct doze PCB for the Breadfruit trial where we applied 30ml of PCB and 40 m consecutively

3.6 Extending the breadfruit fruit season

Prior to the PBP the main breadfruit variety grown in western Viti Levu is the Uto Dina variety. This particular variety has a productive fruiting season of around 5 months (November through March) with a peak season of 3 months (December through February). This relatively short period imposed a major constraint to commercial industry development. In contrast, the Balekana variety in Natewa Bay had a fruit season extending for nearly 9 months (October through June) with a peak season of 5 months (December - April) as illustrated in the table below. Hence, establishing Balekana breadfruit orchards in western Viti Levu was a major component of the PBP. Initial indications from the lead PBP participants is that the fruiting pattern of Balekana in western Viti Levu is similar to that in Natewa Bay. In addition these farmers have been able to realise particularly encouraging yields from their Balekana plantings.

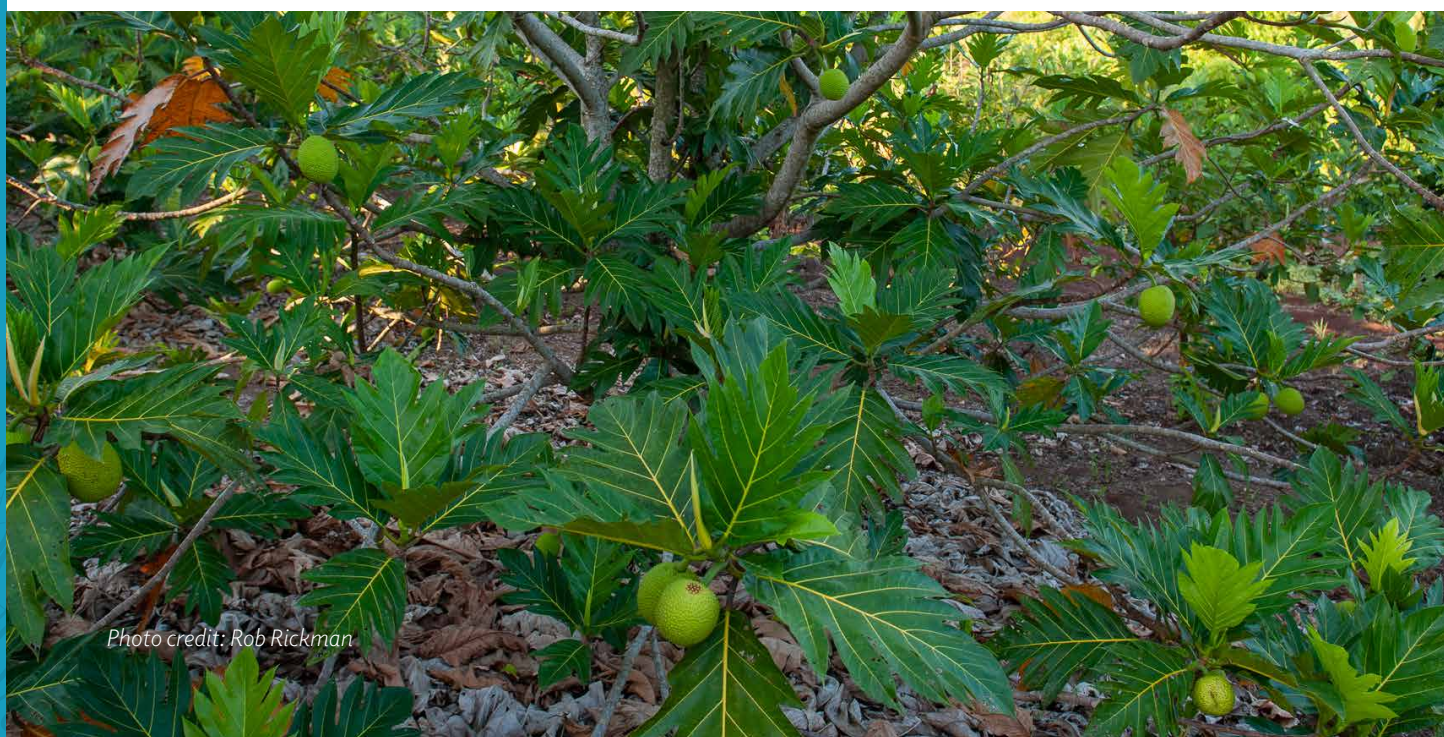


Photo credit: Rob Rickman

3.6.1 Indicative seasonal fruiting pattern for Uto Dina and Bale Kana breadfruit

Variety	January	February	March	April
Uto Dina				
Balekana				

Variety	May	June	July	August
Uto Dina				
Balekana				

Variety	September	October	November	December
Uto Dina				
Balekana				

Peak Fruiting Fruiting Flowering

3.7 The performance of alternative breadfruit seedlings for mass propagation

There are a few ways that breadfruit can be propagated. They can be propagated through either root suckers, air layering or marcotting , and stem propagation . In addition the PBP had access to Tissue culture breadfruit planting material supplied by SPC's CePaCT. However, tissue culture breadfruit planting material is not yet commercially available to breadfruit farmers. The PBP compared the performance of these three types of propagation in terms of growth rate (measured in terms of stem girth) and the commencement of fruiting.

In terms of stem growth over a 48-month period from the time of planting root suckers performed the best for Uto Dina, while marcotts performed the best for Balekana, with the Uto Dina root suckers having the best overall growth performance. For Balekana, root suckers had the slowest overall growth performance. Whether the slower growth performance of Balekana root suckers impacts future yields relative to the other propagation methods remains to be seen as more data is generated. However, it could be significant given that Balekana is a much more prolific generator of root suckers than Balekana. Tissue culture has encouragingly shown good infield growth for both Balekana and Uto Dina. This hopefully will provide a further incentive for commercial tissue culture production.

The marcott plantings were the first to produce fruit, as early as two years for both varieties. However, the fruit drop was quite high due to prolonged drought conditions. The trees propagated from root cuttings generally took a bit longer to fruit, approximately three to four years. Tissue culture breadfruit seedlings planted at the Sigatoka Research Station were able to produce fruit in 2 to 3 years for both varieties. The overall finding of the PBP was that Balekana and Uto Dina seedlings (root suckers, marcotts, or tissue culture) planted in a reasonably well maintained orchard can be expected to commence fruiting within three years, which is less than half the time normally expected for a "wild harvest" tree.

4 Best practice propagation systems

4.1 Root suckers

Breadfruit can be propagated by root suckers (shoots that grow from roots), root cuttings (cut pieces of roots that will grow into plants) and aerial (air) layering or marcotting (inducing roots from a young green branch about 1-2 cm in diameter). Below are the traditional and most common method practiced on small farms. The roots are wounded to stimulate production of more suckers at the damaged areas. Rooted suckers are removed attached to a piece of the parent root, and transplanted. Survival rate can be as low as 20%, but very high (approaching 100%) for experienced practitioners and when rooted suckers are first transferred into nurseries with some protection, shade and misting or other regular watering system. Some breadfruit varieties produce considerable numbers of root suckers (such as bale kana) while others (such as uto dina) produce few or no suckers.

When selecting juvenile root suckers, 75% of leaves are to be removed. Root suckers must not be allowed to dry out as drying decreases viability. The nursery must have 70% intense shading with additional coconut leaves to keep the root sucker cool during the seedling phase. This method is the fastest propagation method with time taken to raise plants between 4 – 6 months.

Higher success rates are achieved with root cuttings which are taken from mature trees at the beginning of the rainy season, with root sucker segments planted into a nursery (Fig. 2) or favourable environment (part-shaded with moist soil). Root cuttings can suit mass propagation. Root cuttings can take 9-12 months before they are ready for field planting.

A video from the Caribbean demonstrates root cuttings and can be found on this link: https://www.youtube.com/watch?v=k2WHyHtMDEo

Photo credit: Rob Rickman

1

Root Suckers for planting

2

Pruning excess leaves

3

Pruning excess roots

4

Preparing poly bags

5

Planting of
root sucker

6

Watering of plant

7

Two months
after planting

8

Transferring root sucker
plant to ground

4.2 Marcotting or air layering

Aerial layering/marcotting produces a large plant that is quickly ready for transplanting to the field and is capable of achieving quick fruiting. However, trees initially have weaker root systems which can make the trees more susceptible to uprooting when there are strong winds and cyclones. Further, few plants can be produced from each parent tree and some varieties are not amenable to marcotting.

This method is appropriate for limited and quick plant production. It requires a large plant population where re-growth is common (upright shoots give better results than laterals). This method is labour intensive compared with other propagation methods and requires an additional further nurturing of two months on the tree and in the nursery. Below outlines the steps involved in marcotting.


4a


4b

4a: Remove strips of bark from newly-developed shoots (not one that has flowered or fruited).

4b: Continue bark removal right around the stem. Go to next stage immediately.


4c


4d

4c. Hold a piece of clear plastic, cut to a convenient size. Apply the damped soil/ peat moss/ coconut coir mix evenly around the stem as illustrated.

4d. Encase the mix with the plastic wrapping. Squeeze the mixture firmly into shape. Adjust the wrapping so that it holds the soil mixture tightly.

4e. Using a pre-cut rubber strip secure plastic sleeve at top and bottom. Rubber allows branch to expand as it grows.

4f. During next few months roots will develop. The branch can be cut below the bottom tie and rooted cutting planted in a nursery area where it can be watered and cared for. After six weeks it should be ready for planting.

4.3 Tissue culture micro propagation

Tissue culture (micropropagation) techniques have been developed for some cultivars of breadfruit providing vigorous, disease-free plants that can begin bearing fruit in 2.5 to 3 years. The cost of breadfruit (planting material) is approximately FJD 10-15 depending on method of propagation and size. It is recommended that you propagate your own breadfruit plant locally to keep costs down, and ensure better quality and known planting stock. Note: larger plants produced through marcotting often do not travel well due to rough roads/shaking and wind damage. Prior to road transport breadfruit plants need to be very well watered, and are best transported on cloudy/rainy days, and/ or in a covered van, and/or at low speeds to reduce desiccation and wind damage.

Tissue culture technology enables large batches of uniform planting material to be produced which are free of virus, bacteria or any infectious diseases. The SPC's CePaCT utilise a bioreactor, which is capable of producing 5,000 plants in one batch.

5

An assessment of risk

5.1 Land tenure

Land tenure is a key element to the success of a commercial size breadfruit orchard. Since breadfruit like any other tree crop takes years for it to come to full production, the absence of long term land security is detrimental. A key lesson from the PBP is that if the land is suitable but the farmer/owner does not have the necessary agreements/lease in place, then it should raise red flags. Farmers who were selected for this project fell victim to land issues from relatives and partners, and orchards ended up being bulldozed or cut down due to external elements. The valuable lesson from this is if you decide to invest in a full-scale breadfruit commercial orchard you must acquire at least a minimum Agricultural lease of 50 years. This secures long term investment and provides the time frame to realise the full potential of breadfruit orchards.

5.2 Crop neglect

A major issue with these long-term fruit tree crops is that it takes a long time to bear fruit and start providing an income. Different geographical locations provide different results in terms of growth rate, tree adaptability and yield. The commercial scale model for breadfruit emphasises regular irrigation, regular fertilising, regular pruning and importantly, the maintenance of hygiene and sanitation of the orchard. The results of these interventions have shown uniform growth, early bearing trees and easily harvested fruit. When these interventions are neglected we can assume the crops will suffer a natural death. From the onset the farmer must be prepared to provide the necessary tools, time and effort to successfully execute these interventions. Bearing in mind several years of no income can be frustrating especially if the elements are not on our side. The fortunate thing is those who have succeeded have proven that commercial scale breadfruit orchards can be achieved through the proper package of practice that have been identified.

5.3 Unavailability of high quality , low cost disease free planting material

This has been the stumbling block for the development of commercial breadfruit orchards in Fiji and the region. The bottle neck has discouraged farmers who want to invest in commercial scale breadfruit farming. There is an absence of a dedicated agricultural enterprise to provide large numbers of uniform , disease free, high quality low cost planting material to the private sector.

The void has created discussion on how we can access large numbers of breadfruit planting material at a low cost. The obvious answer was through Tissue culture propagation systems. The collaboration with SPC/CePact provided the opportunity to explore and document the field development of a root sucker planting material Vs Tissue culture planting material Vs marcotted planting material for several years.

The results indicated there was no significant difference between the growth pattern and fruiting patterns of the 3 propagation techniques. All of these trees were irrigated and fertilized at uniform intervals. These simple interventions provided the optimum conditions for a healthy early bearing , low branch bearing, high yielding breadfruit orchard.

Hence it is imperative that if an industry is to be developed from the status qou for the access to sterile, high quality ,disease free planting material at a reasonable cost should be investigated by potential breadfruit farmers.

5.4 Capital startup for commercial scale orchards

Investing in a commercial scale breadfruit orchard is expensive. In the process of wanting to invest in a commercial scale breadfruit orchard the farmer must realise that establishment costs and ongoing costs are quite high. Apart from the land itself, water source is critical for irrigation equipment investment. The water must be of good quality to produce healthy trees and quality fruit. Successful breadfruit orchards have proven that breadfruit trees respond well to regular fertiliser/irrigation applications. Since this intervention has revealed ideal results, it is advised that bulk purchasing of fertiliser will be a requirement opposed to small irregular purchases from the counter. Ideally orchards must be clean and clear from dead leaves and debris at all times, and this will also come at a cost. The issue of quality breadfruit seedlings also comes at a cost. A good conditioned well maintained breadfruit seedling ranges from $25 -$50FJD. It is advisable to first source quality elite varieties from a reputable nursery supplier, prior to initiation. Planting at the same time encourages uniformity in growth.

5.5 The right labour

If family labour is not used hiring of skilled labour will be beneficial. The cost of hired labour varies and may be subject to different rates. The idea here is that the farmer will provide a set program and provide oversight. The skilled labour will work accordingly and provide the best advice on how to maximise his/her time to achieve tasks. On a commercial scale it is advised that to minimise cost of labour, it is advisable to invest in a small family unit that can take care and nurture these trees to full potential. Hiring of good labour for the long term can dictate the success of the project. A good skilled labour can plan out work well so that other activities around the farm are producing other essential crops to compliment the investment in the breadfruit orchard. These crops will supplement farm income and offset extra expenses as they arise.

5.6 Climatic and unfavorable weather conditions

Unfavorable weather conditions can determine the success of a commercial breadfruit orchard. Cyclones and droughts are the major risks in breadfruit production. However, to minimise these risks, proactive approaches can be applied to reduce collateral damage. In particular, site selection, preferably a location which is not in a flood prone region is advised. The location should be sheltered enough from prevailing winds and not exposed to coastal sea spray if possible. During a cyclone, strong winds tend to break and bend branches. This opens up the opportunity for the trees to be uprooted. To minimise this risk farmers are advised to constantly prune branches every 6 months. It must be noted that over pruning can have detrimental effects to the trees as well. Hence skilled labour is required to make proper decisions and careful selections during pruning which are important. Over pruning may also expose the fruits to too much sunlight and the export quality fruit is minimised.

5.7 Pest and disease infestation in commercial orchards

The risk is very high especially if the farmer is practicing mono cropping system.Proper farm sanitation is important to minimise pest and disease infiltration. Large scale commercial farms are exposed to harmful pests at all stages of growth. Pests and diseases are attracted to exposed debris, piles of dead leaves, rotten fruit and orchards full of weeds. To register the breadfruit farm for exports the (Bio Security) personnel will regularly check for compliance issues. Farms that are not well maintained are subjected to snap checks that sometimes lead to suspension of farms. Failure to comply will lead to deregistration of the farm under BAF protocol between Australia and New Zealand. These are the risks that threaten the viability of the commercial scale breadfruit orchards.

6

A package of practices for a small commercial breadfruit orchard in Fiji

Photo credit: Rob Rickman

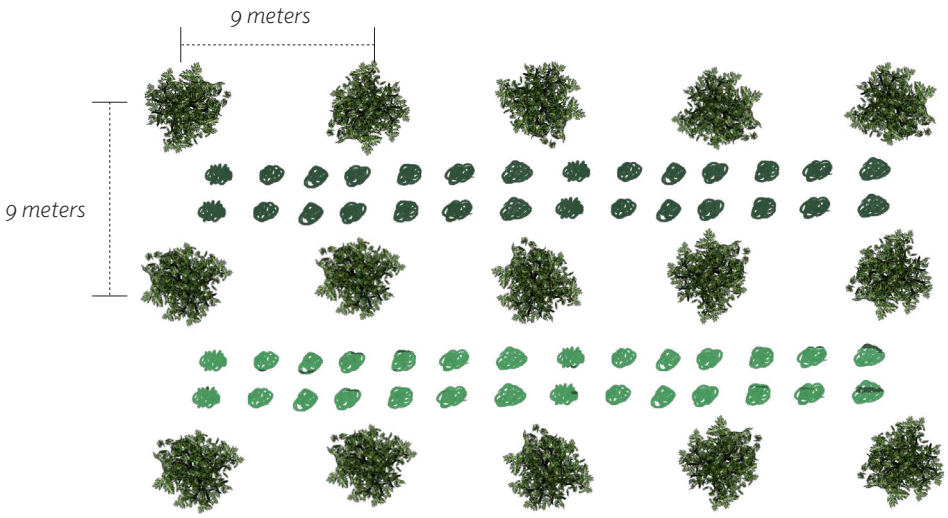
6.1 How big an orchard?

On 1 acre of land one can plant 50 trees on it using 9m by 9m spacing. This spacing provides plenty of room for inter cropping, which will provide income while waiting for the breadfruit trees to come into product (after 2 to 3 years). However, you can reduce the spacing to 7m by 7m if there is a shortage of land for the breadfruit orchard. At the Sigatoka Research station, they are using 10m by 10m spacing in their breadfruit orchard. However, 10 years later the trees have grown big and the space in between the trees is becoming less as the branches are touching each other as you try to move in between trees. Whichever spacing you use, a farmer needs to make sensible decisions in terms of spacing, nutrient requirements, pruning skills and other management requirements before planting so that eventually the trees will grow bigger and taller. If you have the land available you may wish to establish large orchard – 5 to 10 acres. However, in making such a decision one needs to take full account of the management practices required and the labour available. Moko's drone of footage of Pakask's breadfruit orchard/food forest (https://drive.google.com/file/d/11F1rzOELHe35axayChJkNsW6RAGcNMS1/view?usp=sharing)

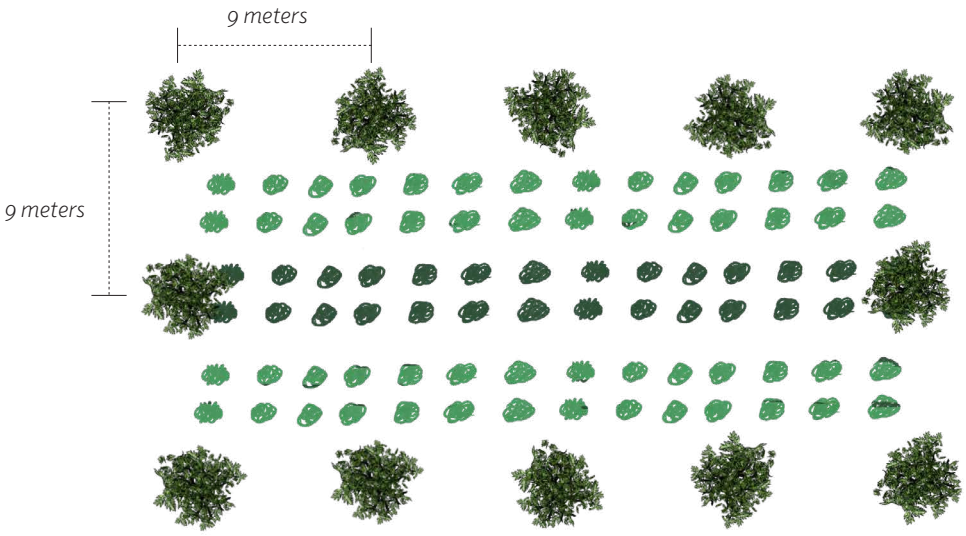
6.2 Type of orchards - a block or a linear/perimeter orchard and food forest orchard system

When establishing the breadfruit orchard we came up with 2 types of orchard system, namely:

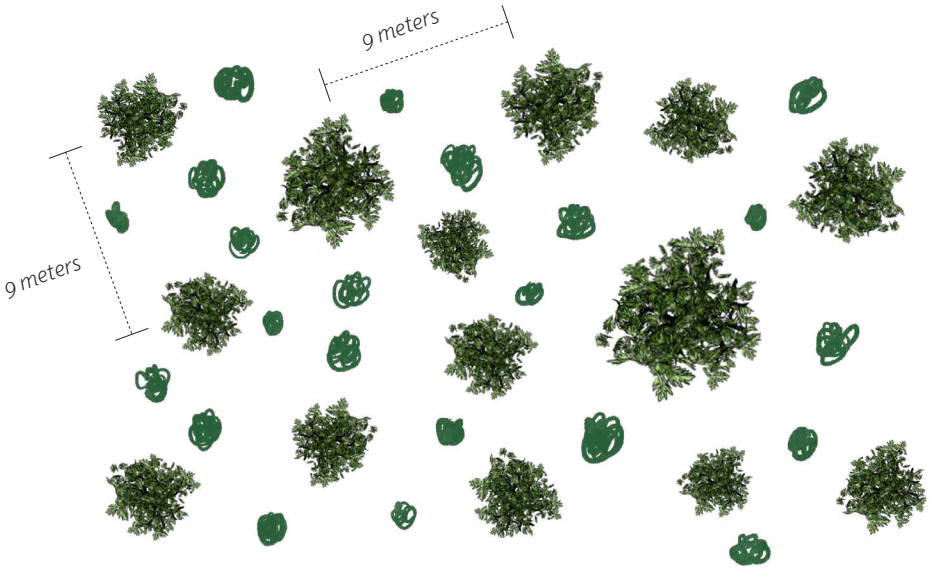
A block orchard – consists of planting breadfruit trees in rows using up all the space available in a given area.



The perimeter or linear orchard – consists of planting breadfruit around the perimeter of the farm or along the road.



Food forest system – consist of fruit trees and assorted agro-forestry trees



- long term trees (high) e g coconut trees, breadfruit, sandalwood.
- medium term crops (medium) e g coffee, cocoa, citrus, pineapples
- and short term crops (low) e.g assorted vegetables and root crops

6.3 Land preparation

Before planting the breadfruit seedlings, it is important to cull unwanted trees, undergrowth and weeds. If relatively flat land, ploughing and harrowing should be undertaken to break down the soil into finer pieces to facilitate root development. If planting on sloping land it is recommended that drains with a drop structure be built. This is to slow down water run-off and reduces soil erosion.

6.4 Planting and spacing

Breadfruit seedlings should be planted in well-enriched holes around 40cm deep and 50cm wide. If you wish to intercrop during the first few years the spacing should be at least 9m x 9m. A "linear" orchard may be considered for farmers who plant trees in a single row along the boundary of their land, beside a river or creek or along internal roads.

6.5 Sourcing planting material from nurseries

Following the PBP there are now 6 nurseries that supply breadfruit seedlings (both root suckers and marcotts). all of whom in 2021 had an at nursery price range of $10 to $15 per seedling.

These are:

Nursery owner	Location
Mun Sami	Tavua
Jai Ram Khelawan	Rarawai flats, Ba
Prakash Chandra	Johnson Road,Lautoka
Sant Kumar	Carreras Rd, Nadi
Yashwant Kumar	Lawai, Sigatoka
Tutu Rural Training centre	Taveuni

Photo credit: Rob Rickman

7

Suitable mixed cropping systems for breadfruit orchards (other income earning crops)

Breadfruit is regarded as a long-term tree crop. It takes 3 - 4 years for a breadfruit seedling to start producing fruit. Farmers have been encouraged to practice mixed farming system in cooperating short, medium term and long term crops.

Farmers who have practiced such systems have provided current information that is discussed below.

7.1 Cassava

Cassava is a medium-term crop and it takes 9 -12 months until it reaches maturity. It is a low labour high input crop to manage in regards to weed control as well as zero fertilizer inputs. Cassava reduces nematodes infestation in the soil as well. It is used for home consumption and also can be sold in the domestic market for $60 per 50kg bag. It can also be sold as a frozen product. A farmer planting 1Ha can make a good livelihood from around $60 per 50kg bag cassava into their farming system. One hectare of cassava can yield 6 Tonnes of marketable cassava.

7.2 Eggplant

Eggplant is a short-term crop which takes 3-4 months to mature. It is consumed at home and also sold in the export and local market. The price fluctuates depending on supply and demand issues. Current price of a 25kg bag[3] of eggplant is sold at $20 in the local market. A farmer planting 1Ha can make a good livelihood from eggplant into their farming system. 1Ha of eggplant can yield 10 -15 Tonnes of marketable eggplant.

7.3 Kumala

Kumala is also a short-term crop which takes 3 - 4 months for the crop to be mature. In the event with all the optimum conditions met and absence of a natural disaster a 1Ha block can yield 700kgs of marketable kumala. A farmer planting 1Ha can make a good livelihood from kumala into their farming system. 1Ha of kumala can yield 10 -15 Tonnes of marketable Kumala .

7.4 Pineapple

It will be 18 months before any income is earned from pineapples with around $8,200 invested in setting up the cropping system. By the end of 2nd year around 35,000 kgs of pineapples will have been sold for $26,000. In the 2nd year a gross margin (revenue – cost) of approximately $16,000 will be earned. By the end of year 3 the maximum annual production of 50,000 kgs of pineapples will have been reached with the cropping system fully in place. This will allow for an annual gross margin of $27,000 from the 1 ha planted to pineapples. This will remain steady for the next 6 years as summarized in the table below,

Why we think ? Pineapple is a suitable inter-crop

Pineapple does not have high demands on land and fertility, as long as the land is well drained. As such it fits perfectly as an intercrop in a breadfruit orchard on poor talasiga soils on flats, as well as on sloping hill sites.

It is however to be understood, that the pineapple (inter) cropping will demand a fair amount of additional effort and input, if positive results are required and expected, with an initial start-up period of 18 to 24 months.

To avoid direct competition between breadfruit trees, which tend to spread their roots in the early stages in the surface top soil, and the pineapple planted in between the tree rows, it is advised to place root barriers between breadfruit trees and pineapple beds. For this purpose, some old “roofing” iron can be used, where a piece of standard width roofing iron which is 30+ cm long is pushed in the soil 1 metre from the tree centre, extending equal sides from tree centre. These root barriers are only used in the space strips where pineapple is planted.

[3]The current prices (2021) were extracted from personal interviews with farmers. middle men and market vendors.

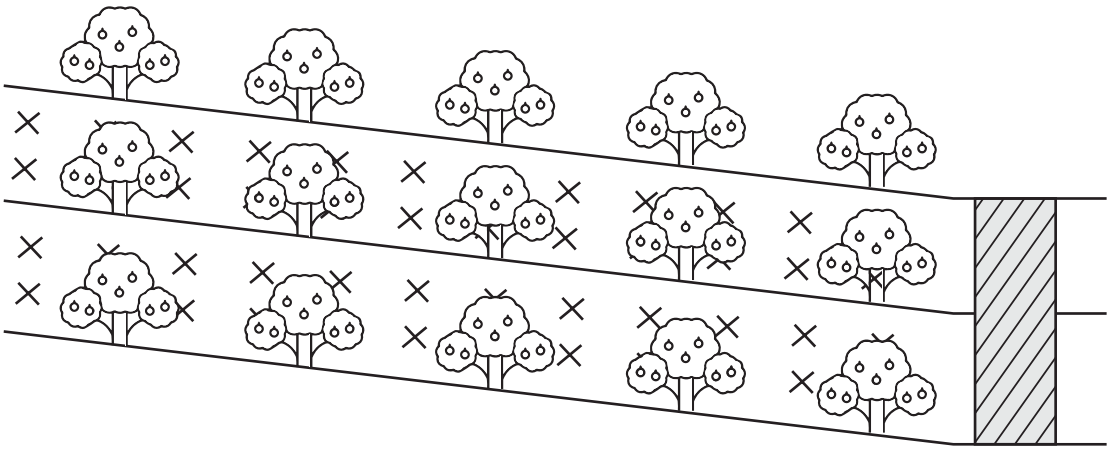
Place these root barriers at an early stage, just after planting, so there is less chance to damage tree roots in pushing the roofing iron into the soil. After placing these barriers roots from the trees will be encouraged to grow and develop in the deeper soil layers, but will not be damaged.

On steeper slopes along hill side orchards, contour lines are marked every 9 metres on these slopes with the use of a contour drop structures. (See below on erosion control for construction and use of these contour drop structures).

7.5 Establishing drains to reduce soil erosion

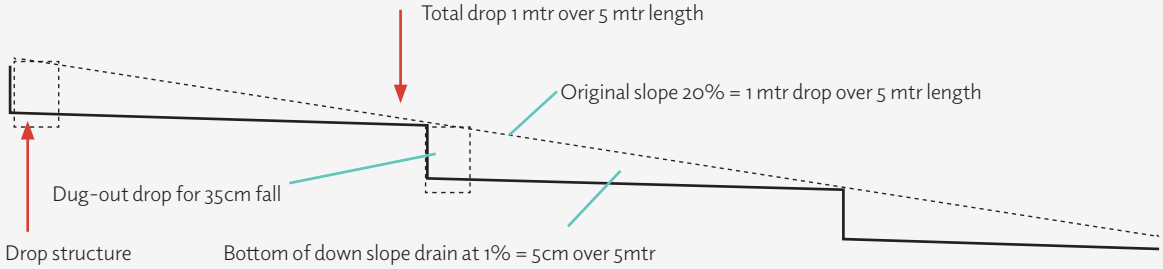
After heavy rain, to avoid soil erosion, "step-wise" drains can be built to allow for a non-damaging gentle flow of the excess water that can't be absorbed by the soil and thereby substantially reduce soil erosion.

- The farm is on moderately sloping land (< 100). To minimise soil erosion, rows of vetiver grass are planted along the contours with the pineapples planted between the rows of vetiver grass. An A frame is used to mark the contours. A two-wheel tractor is used to prepare the land for planting.
  How to make an A frame (https://drive.google.com/file/d/1zpKLyW5BCcRyoX6Vz41dzohuv1APgKJf/view?usp=sharing)



How to use an A frame (https://drive.google.com/file/d/1GUNWchbssyoS-wxaQEo1tfTIbnQ2j7xC/view?usp=sharing)

- Drop structures are installed on the drains to improve drainage and to reduce soil erosion. This will be particularly important during period of intense rainfall and flooding that can be expected to increase with climate change.



A step-wise downward drain to allow a gradual non-damaging flow of water

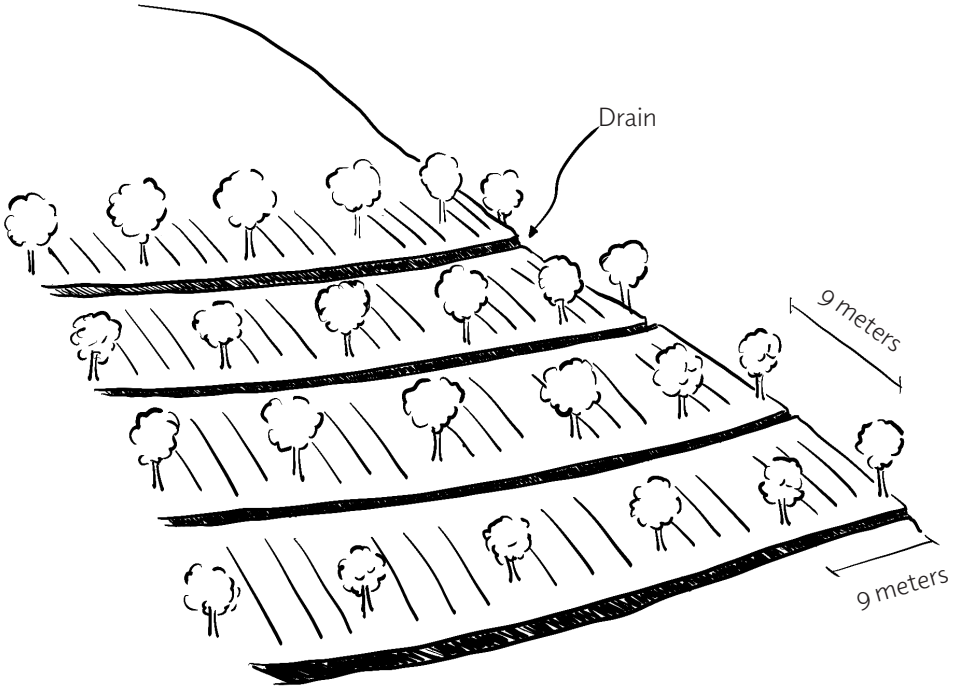
The use of drop structures to allow for a more gradual water flow.

[4]A detailed cropping budget for a 10-year period for this sustainable pineapple cropping system can be found at the following link

7.5.1 How it actually works

7.6 Lay-out for intercropping

Three different lay-out patterns are discussed below for possible implementation by the PBP:



- Planting on sloping talasiga soils with tree spacing of 9 metres in the rows along the contour lines and 9 metres between the rows. This layout allows for;
- At least 1 metre space all around the base of the tree and,
- Provision for a surface drain of approximately 1 metre wide for surface contour drainage and erosion control, on the lower slope side of the tree row line, in between the tree rows.
- Which leaves a space of 6 metres for 4 beds of pineapple, following the contour lines
- Certain places, especially where slopes become steeper, contour lines come closer to each other and might interrupt the spaces of our lay-out of trees and pineapple beds. However, contour drains are to follow the real contour lines if they are to be effective, only tree spacing and pineapple bed spacing can differ a bit from contour lines to remain in their planned spacing.

- Planting on flats, where no contour drains are needed, and where a slightly different tree spacing is implemented to allow for some more beds of pineapple in between the trees .For this lay-out the breadfruit trees are planted still at 9 metre in tree lines and alternatively at tree line spacing of 1x 7 metre and 2 x 10.4 metres. This lay-out allows for 2 "road spaces" to be planted with 6 beds of pineapple with a bed spacing of 1.4 metres centre to centre, and 1 road to serve access to the pineapple and trees on both sides.

There can be many other crops that can be used for mixed cropping but the most important thing is the management practices that are involved when dealing with this crop, the input requirements, irrigation application, weed control and other required information that needs to be implemented by the farmer in order to have maximum yield.

7.6.1 Tree management practices (fertilisation, pruning etc.)

For the next few years breadfruit for export will continue to come from the existing trees and also from the commercial breadfruit orchards that were established by the PBP. Measures should be taken to improve the performance of these trees. Breadfruit trees prefer full sun. Mulching with the large fallen leaves and other organic materials like chicken manure is beneficial and provides nutrients, protects roots, and helps keep the soil moist during dry periods. In Samoa, village breadfruit trees are pruned and shaped to keep them low and make harvesting easier. The pruning of the trees after fruiting is recommended to stimulate new shoots. It can be expected that this practice will also over time increase production. Building a drop structure at the barracks insert (https://drive.google.com/drive/folders/1qGHg5OlJRC85vh89Y9N3swvgBNpzkPn7?usp=sharing)

- At an early stage (1 – 6 months) urea fertilisers are required at 200 grams every month to boost leaf and early growth development.
- After 6 months and onwards 200 grams of N.P.K (13:13:21) is recommended to be applied monthly by the farmer.
- After 3 years of planting pruning is essential as it keeps trees low for easy harvesting. Radical pruning is recommended by which all the main terminal branches are removed leaving all side branches/ shoots to grow and later develop fruit. This will leave the main terminal branch that has been to only focus on new side shoot growth (new vegetative growth). Pruning is only done after harvesting.
- Heavy pruning (pruning all branches including the main terminal and side branches) will allow trees to produce vegetative growth. It takes 1 year for this new side shoots to develop fruit. However a new trial done by NWC with the use of Paclobutrazol can quicken the fruit development for breadfruit after heavy pruning.

Radical Pruning – prior to pruning

Radical Pruning – after pruning

Radical pruning in progress . Trees respond faster when interventions like supplementary irrigation and fertilization is adopted post pruning. Insert: New branches formed post pruning after 8 weeks.

8

Pest and diseases and their management

8.1 Fruit flies:

In Fiji its the Pacific fruit fly (Bactrocera xanthodes). The level of physical damage to the fruit is generally not great, compared with the situation in some other Pacific Islands. However, to export to New Zealand, farmers and exporters must follow an agreed quarantine pathway. It is expected that a similar pathway will soon be in place for the Australian and US markets.

The New Zealand breadfruit pathway requires that:

- Fruit for export must be sourced from trees and farmers that are registered by Fiji Quarantine.
- Trees must be bait sprayed each week for a period of seven weeks prior to harvesting.
- All fruit for export must be HTFA treated at the NWC facility at Nasoso Rd Nadi Airport.

Bait spraying

Female flies need to ingest protein before they lay their eggs. Protein can be obtained from the waste yeast left over after the brewing of beer. Sprayed on leaves, this protein induces rapid bacterial growth, which causes an odour which attracts female fruit flies. The flies eat the protein along with the added insecticide (usually malathion), and are killed. The bait is sprayed, using a knapsack spray, onto the underside of the leaves where fruit flies normally feed. As the bait attracts the flies, it is not necessary to spray the entire foliage. This reduces the risk of pesticide residue in the fruit as well as the loss of pollinators and other desirable insects.

The bait spray component of the breadfruit pathway requires:

- 15 mls of protein and 4mL malathion per litre of water.
- 10 mL spot per tree to be sprayed.
- spraying to be conducted once a week for seven weeks before harvesting (spraying to be monitored by extension officers).

Bait spraying is a mandatory requirement for the export of breadfruit. All care must be taken to ensure that bait spray procedures are correctly followed. If they are not, there is a high risk that fruit fly eggs will be found by New Zealand Quarantine Officials. The clearance of the consignment will be held up for several days while it is determined if the eggs have been killed by the HTFA treatment.

Requirement: Farmers and exporters must ensure that bait spraying procedures are correctly followed.

Photo credit: Rob Rickman

8.3 Other pest and diseases

mealy bug at base of punduncle

Gentle washing with soft sponge to remove mealy bug

8.3.1 Pests

Other insect pests of concern are white fly, scale and mealy bugs. Quarantine officers from importing countries can be expected to order fumigation if these pests are detected. Fumigation will destroy breadfruit. These pests are usually found around the stalk. Care must be taken in removing these pests as breadfruit skin is very sensitive – any rough abrasion will lead to more sap release, bruising, blackening and reduced shelf life. The practice of some exporters to use a high pressure water hose to remove mealy bugs is not recommended.

Requirement: Insects, such as scale and mealy bugs, must be removed in a way that does not damage the sensitive skin of the fruit. Do not use a pressure hose to remove insects.

8.3.2 Diseases

Fungal diseases are likely to be the major disease problem encountered with breadfruit in Fiji. The main fungal diseases are fruit rot *(Phytophthora palmivora)*, brown stem rot (Phellinus noxius) and leaf anthracnose *(Colletotrichum gloeosporioides)*.

Fruit rot is caused by the same pathogen that causes black pod in cocoa. The main control strategy is good site selection and field sanitation. In Samoa, the harvesting of all mature fruit and the removal of diseased fruit was found to effectively control fruit rot (Gerlach and Salevao 1984).

Brown stem rot is the most serious breadfruit disease, which in extreme situations can kill the tree. At present, there are no control measures available. However, to minimise the risk of the disease spreading, trees should not be planted too closely. The best way to deal with fruit rots is to remove affected fruits from the tree and not allow fruits to ripen on the tree or rot on the ground. Such measures are not practical when fruit is gathered from scattered wild trees. However, it is a practice that would have to be followed in a breadfruit orchard.

Requirement: To minimise disease problems in breadfruit orchards, practice good sanitation (remove affected fruit from the tree, do not allow fruit to ripen on the tree or rot on ground) and use wide spacing for planting (12m x 12m).

9

Field sanitation for increased yields, improved quality and meeting phytosanitary requirements

9.1 Harvesting

9.1.1 Fruit maturity

At ambient (normal) air temperature, mature breadfruit will start softening (ripening) within days of harvesting. Once ripening has commenced, the fruit is inedible. Breadfruit for local consumption is harvested at full maturity, just prior to the commencement of ripening. This is achieved at about 12 – 18 weeks after flowering. At this stage the skin should be greenish-yellow with slight brown cracking or crusting around the individual sections and a few splotches of dried sap. The fruit is usually consumed within 24 hours and keeping quality is not an issue. Immature fruit (0 – 11 weeks), over mature fruit (19 weeks – 20 weeks) and ripe fruit (20 weeks above) are disregarded for export.

Breadfruit at the stage of maturity desired for home consumption cannot be expected to last more than 2 days in the warm conditions of Fiji. This would not be sufficient time to allow for export. For export maturity, a breadfruit must have a sufficiently long life to reach the pot (or umu) of the overseas consumer and still taste good. From the time a breadfruit is picked it must have a minimum of six days storage life, calculated as follows:

Picking and delivery to the exporters shed for sorting, grading and Fiji Quarantine inspection	1 day
Delivery to NWC for treatment and packing	1 day
Air freight, quarantine clearance by importing country, delivery	1 day
Warehouse to retailer	1 day
Retailer's shelf life	1 day
Consumer's storage prior to cooking	1 day
	6 days

Breadfruit for export has to be harvested at slightly less than full maturity, to achieve the necessary balance between shelf-life and acceptable eating quality. Such fruit is best described as mature green. Small (< 100 mm radius for uto dina) dark green fruit are not acceptable. The eating quality of such fruit will not be acceptable, either in an umu, boiled or curried. NWC will also reject such fruit because it has unacceptable heat transfer properties for HTFA quarantine treatment.

Recommendation: Breadfruit for export should be harvested at slightly less than full maturity (mature green).

Requirement: Small dark green fruit are not acceptable for quarantine treatment.

9.2 Time of harvest

Breadfruit ideally should be harvested early in the morning, or late in the afternoon, to avoid build-up of field heat. However, harvesting and treatment schedules need to be linked with airline timetables. Also, the harvesting of breadfruit from wild scattered trees is a labour intensive activity which can take 2 to 3 hours to harvest 1,000 kgs fruit. Thus, it is inevitable that at least some of the fruit will be harvested during periods of full sun.

It is important that as soon as the breadfruit is harvested it be placed in the shade. This is to avoid the heating up of the fruit and sun burn damage. The skin of breadfruit is extremely sensitive and as little as 10 minutes of exposure to the sun is sufficient to cause sun burn damage.

Immature Balekana Fruit

Mature Balekana fruit

Balekana fruit from a 7 year old tree

Requirement: Harvested breadfruit should never be exposed to direct sun. A good sign of maturity is the trickling of the sap around the fruit.

Balekana from Natewa now grown in commercial breadfruit orchards in Fiji

9.2.1 Harvesting method

Previous harvesting methods of breadfruit was often difficult, time-consuming and sometimes dangerous activity. Trees grow tall in forest environments (commonly up to 20m or more), in part due to competition for light, and individual branches especially in the upper parts of the trees are fragile and inclined to snap. Fruit pickers must invariably climb trees to reach fruit located in the higher parts of the tree. Fruit pickers use no safety harness, which they should.

However current exporters (2021) are harvesting primarily from NWC established orchards. The efficiency of harvesting from low bearing and high yielding trees have resulted in higher margins for farmers and exporters.

Recommendation: It is highly recommended that breadfruit trees planted for export purposes must well pruned and managed during the cropping calendar. The standard current practice is pruning the terminal growth to a height of 7 -8 meters for easier harvesting.

10

The economic returns to farmers from investing in sustainable commercial breadfruit production

For breadfruit farmers to invest (both time and money) in commercial breadfruit production, using sustainable agricultural practices is necessary and it must be economically worthwhile for them. This means that the practices must be financially rewarding to them and their family for the money spent and effort put in..

In this section, farm management budgets are presented that compare sustainable and unsustainable cropping practices. These examples are

10.1 A financial model for x 50 tree breafruit orchard

The detailed 16 year cropping budget for the breadfruit farmer adopting the NWC R&E recommendations for sustainable remunerative cropping on a 1 acre block of land is presented below.

Assuming the farmer plants 50 breadfruit trees in or around his property. Note that economic period begins in year 4. Using the current farm gate price (2021) which is @ $0.60/kg and supplying a market which is undersupplied.

The average annual gross margin per area (1 acre) = $3901

Average annual gross margin per tree = $78

Breadfruit yield and quality (particularly for export), will be substantially lower for those farmers who don't adopt the recommended sustainable cropping practices. The specific reasons for this include:

- Without supplementary irrigation breadfruit yield will be much lower
- Without proper pruning practices post-harvest damage will increase
- Without regular supplementary fertilizing program of recommended inputs the yield will be much lower
- The impact of cyclones and flooding will be much more severe on those farmers who have not adopted the recommended practices by NWC R&E particularly those relating to improving drainage to avoid water logging

Table 6: A financial model for a x 50 tree breadfruit orchard

Year	Number of trees @ 9 x 9 m	Marketble yield per tree (# of fruit/tree)	Marketble yield per tree (kg)	Total marketable production (kg)	Sales ($) @ $0.60/kg	Cash expenditure ($)	Root suckers 50 @ $5 each
1	50	0	0	0	0		250
2	50	0	0	0	0		
3	50	0	0	0	0		
4	50	15	22.5	1125	675		
5	50	30	45	2250	1350		
6	50	50	75	3750	2250		
7	50	60	90	4500	2700		

Year	Number of trees @ 9 x 9 m	Marketble yield per tree (# of fruit/tree)	Marketble yield per tree (kg)	Total marketable production (kg)	Sales ($) @ $0.60/kg	Cash expenditure ($)	Root suckers 50 @ $5 each
8	50	100	150	7500	4500		
9	50	150	225	11250	6750		
10	50	150	225	11250	6750		
11	50	150	225	11250	6750		
12	50	150	225	11250	6750		
13	50	150	225	11250	6750		
14	50	150	225	11250	6750		
15	50	150	225	11250	6750		
16	50	150	225	11250	6750		
					65475		

Fertiliser	NPK 13:13:21 50kg @ $80/bag	Bait spray cost	Harvesting equipment & pruning equipment	Stick picker @ $30 each)	Pruning saw (@ $45 each)	Plastic field bins @ $28/ each	Total non labor cash expenditure	Gross margin (Total revenue - total cost)
1	160						410	-410
2	80				45		125	-125
3	80						80	-80
4	80	20		30		560	690	-15
5	80	20				560	660	690
6	80	20					100	2150
7	80	20					100	2600
8	80	20					100	4400
9	80	20					100	6650

Fertiliser	NPK 13:13:21 50kg @ $80/bag	Bait spray cost	Harvesting equipment & pruning equipment	Stick picker @ $30 each)	Pruning saw (@ $45 each)	Plastic field bins @ $28/ each	Total non labor cash expenditure	Gross margin (Total revenue - total cost)
10	80	20					100	6650
11	80	20					100	6650
12	80	20					100	6650
13	80	20					100	6650
14	80	20					100	6650
15	80	20					100	6650
16	80	20					100	6650
							3065	62410

Labour	Clearing	Cutting, lining and digging holes	Planting	Weeding/ fertilizing	Pruning	Bait spray application	Harvesting sap control and packing in field baskets (150kg/day)	Total labor output
1	5	7	1	6	0			19
2				12	1			13
3				12	1			13
4				12	2	10	11	35
5				12	2	10	11	35
6				12	2	10	22	46
7				12	2	10	22	46
8				12	2	10	22	46
9				12	2	10	22	46
10				12	2	10	22	46

Labour	Clearing	Cutting, lining and digging holes	Planting	Weeding/ fertilizing	Pruning	Bait spray application	Harvesting sap control and packing in field baskets (150kg/day)	Total labor output
11				12	2	10	22	46
12				12	2	10	22	46
13				12	2	10	22	46
14				12	2	10	22	46
15				12	2	10	22	46
16								621
	80	20					3065	62410

Average annual gross margin per area (1 acre)	**$3901**
Average annual gross margin per tree ($)	**$78**

Assuming the farmer plants 50 breadfruit trees in or around his property
Note that production begins in year 4
Using the current farmgate price (2021) which is @ $0.60/kg
Average annual gross margin per area (1 Acre) = $3901
Average annual gross margin per tree ($) = $78

10.2 A financial model for x 500 tree breafruit orchard

The detailed 16 year cropping budget for the breadfruit farmer adopting the NWC R&E recommendations for sustainable remunerative cropping on a 1 acre block of land is presented below.

Assuming the farmer plants 500 breadfruit trees in or around his property.Note that economic production begins in year 4. Using the projected future farm gate price which is @ $0.25/kg due to oversupply and expected high freight costs.

The average annual gross margin per area (10 acre) = $8195

Average annual gross margin per tree = $ 164

In the first year, there are significant initial costs incurred in establishing the sustainable remunerative cropping system. These include land preparation, installing a drip irrigation system and drainage system to prevent water logging. If the irrigation and drainage systems are well maintained, they can last beyond 10 years of a breadfruit cropping cycle and thus future investment in the cropping system will be reduced.

Production and thus revenue are highest and consistent from Year 9 onwards. Thus, the total gross margin from breadfruit for the whole farm will be more evenly spread through time. Having several blocks at different stages of the production cycle also helps minimise the impact of cyclones. Other measures (irrigation, drainage, pruning and fertilizing) recommended by the NWC R&E assists the farmer to adapt to climate extremes.

Table 7: A financial model for a 10 acre commercial breadfruit orchard (500 trees) using hired labor

Year	Number of trees @ 9 x 9 m	Marketble yield per tree (# of fruit/tree)	Marketble yield per tree (kg)	Total marketable production (kg)	Sales ($) @ $0.60/kg	Cash expenditure ($)	Root suckers 50 @ $5 each
1	500	0	0	0	0		2500
2	500	0	0	0	0		0
3	500	0	0	0	0		0
4	500	50	50	25000	6250		0
5	500	100	100	50000	12500		0
6	500	100	100	50000	12500		0
7	500	100	100	50000	12500		0
8	500	100	100	50000	12500		0
9	500	100	100	50000	12500		0
10	500	100	100	50000	16000		0
11	500	100	100	50000	12500		0
12	500	100	100	50000	12500		0
13	500	100	100	50000	12500		0
14	500	100	100	50000	12500		0
15	50	100	100	50000	12500		0
16	50	150	150	7500	1875		0
					137875		

Fertiliser	NPK 13:13:21 50kg @ $80/bag	Bait spray cost	Harvesting equipment & pruning equipment	Stick picker @ $30 each)	Pruning saw (@ $45 each)	Plastic field bins @ $28/ each	Total non labor cash expenditure	Gross margin (Total revenue - total cost)
1	1600						4100	-4100
2	80				45		125	-125
3	80						80	-80
4	80	20		30		560	690	5560
5	80	20				560	660	11840
6	80	20					100	12400
7	80	20					100	12400
8	80	20					100	12400
9	80	20					100	12400
10	80	20					100	15900
11	80	20					100	12400
12	80	20					100	12400
13	80	20					100	12400
14	80	20					100	12400
15	80	20					100	1150
16	80	20					100	1775
							6755	131120

Family Labour (person days)	Clearing	Cutting, lining and digging holes	Planting	Weeding/ fertilizing	Pruning	Bait spray application	Harvesting sap control and packing in field baskets (150kg/day)	Total labor output
1	5	7	1	6	0			19
2				12	1			13
3				12	1			13
4				12	2	10	2.2	26.2
5				12	2	10	11	35
6				12	2	10	22	46
7				12	2	10	22	46
8				12	2	10	22	46
9				12	2	10	22	46
10				12	2	10	22	46
11				12	2	10	22	46
12				12	2	10	22	46
13				12	2	10	22	46
14				12	2	10	22	46
15				12	2	10	22	46
16				12	2	10	22	46
								612.2

Average annual gross margin per area (10 acre)	**$8195**
Average annual gross margin per tree ($)	**$164**

Assuming the farmer plants 500 breadfruit trees on a 10 acre block using a 9 x 9 spacing
Note that production begins in year 4
Using the future estimated farmgate price which is @ $0.25/kg
Average annual gross margin per area (10 acre): $8,195
average annaual gross margin per tree ($): $163.90

11

Returns from exporting breadfruit

Consultations with importers and retailers of breadfruit in New Zealand provided valuable information on sources, pricing and availability, this is summarized below:

- Fresh breadfruit in New Zealand is currently supplied exclusively from Fiji. Tonga had resumed fresh exports in 2015 and 2016 however this trade was suspended due to compliance issues.
- Breadfruit is seasonal it provides a unique buying opportunity and Pacific Islanders will often 'buy it while they can' for a special occasion. Other root crops such as a cassava, yams and kumala are readily available and often provide cheaper alternatives to breadfruit.
- Fiji breadfruit wholesales in Auckland at around NZD $7/kg and is sold in 10 kg cartons. The average fruit size is 1.2 kgs. Fresh breadfruit retails in Auckland at around NZD $8 – 10/kg. As a comparison, fresh taro retails at around NZD $2- 6/kg.
- Fresh breadfruit is generally available in New Zealand between December – March and June- August.

Table 8: Returns from exporting 1 tonne of breadfruit to New Zealand (Pre Covid)

Costs	$/kg Purchased	$/kg Exported	$/carton Exported	$/t
Breadfruit purchased (1.1tonnes @ $0.60/kg) from Prakash	0.6	0.5	5.94	600
Purchase of (NWC)Protein bait spray for grower ($50/ltre required for 1 tonne purchased)	0.05	0.5	0.6	35
Checking breadfruit at farm(1 person for 3 hours)	0.1	0.02	0.18	15
Cartage from Johnson Rd to the pack-house ($60)	0.06	0.04	0.48	60
Depreciation allowance for plastic crates ($100)	0.09	0.1	1.2	100
Grading and sorting at pack-house (3 people for 3 hours)	0.03	0.03	0.33	30
Transport to HTFA facility ($50)		0.05	0.6	50
Quarantine treatment and packing (72c/kg)		0.72	4.8	720
Carton (waxed with dividers $3/carton 12 kg net weight)		0.23	2.73	230
Telecommunications ($10)		0.01	0.12	10
Electricity ($400 spread over 20 tonnes)		0.02	0.24	20
Pack house rental $200/month for 3 months spread over 20 tonnes)		0.02	0.28	30
Fixed labour costs ($500/month over 3 months spread over 20 tonnes)		0.08	0.9	75
Total fob costs		**2.32**	**18.4**	**1975**

Freight to New Zealand	$/kg Purchased	$/kg Exported	$/ Carton exported	$/t
$1470 for LD3 @2.50/kgs (Fiji Airways pre covid freight charge) 1000 kgs		0.89	10.66	890
New Zealand fees (documentation and inspection) $F150		0.15	1.8	150
Total cf costs		1.04	12.46	1040
Total costs		4.9	49.26	4655
Revenue				
New Zealand landed price (@NZ $7/kg) $1NZ=$F1.2		8.4	70.56	8400
Exporter gross margin		3.5	21.3	3500

Consultations with importers and retailers of breadfruit in New Zealand provided valuable information on sources, pricing and availability, this is summarized below:

- Fiji breadfruit wholesales in Auckland at around NZD $7/kg and is sold in 10 kg cartons. The average fruit size is 1.2 kgs. Fresh breadfruit retails in Auckland at around NZD $8 – 10/kg. As a comparison, fresh taro retails at around NZD $2- 6/kg.
- Although freight prices have increased significantly the high demand for a scarce product has been able to cushion the impact of high freight costs.
- Some segments of the New Zealand Asian community buy breadfruit but in relatively small volumes - There exists a very large Indian and Asian community across New Zealand with a significant concentration in Auckland. Indians and Asians will purchase breadfruit when it is available however the fruit is generally cooked as a curry and served as an accompaniment and not the main meal and thus the volume purchased per household is much lower compared to the Pacific Island consumer.
- Price is an important factor and breadfruit will compete with other root crops - The Pacific Islanders living in Auckland are generally price conscious consumers however the large number of family and community island functions results in high purchasing of Pacific foods including breadfruit. It is very common for most members of the Samoan and Tongan community to attend church on Sunday followed by a family or community lunch – this meal almost always includes traditional 'island foods'.

Table 9: Returns from exporting 1 tonne of breadfruit to New Zealand (Post Covid)

Costs	$/kg Purchased	$/kg Exported	$/ Carton exported	$/t
Breadfruit purchased (1.1tonnes @ $0.60/kg)	0.6	0.5	5.94	600
Purchase of bait spray for grower ($50/ltre required for 1 tonne purchased)	0.05	0.05	0.6	50
Checking breadfruit at farm(1 person for 3 hours)	0.01	0.02	0.18	10
Cartage to the pack-house ($40)	0.04	0.04	0.48	40
Depreciation allowance for plastic crates ($100)	0.09	0.1	1.2	90
Transport to HTFA facility ($40)		0.05	0.6	50

Costs	$/kg Purchased	$/kg Exported	$/ Carton exported	$/t
Quarantine treatment and packing (72c/kg)		0.4	4.8	400
Carton (waxed with dividers $3/carton 12 kg net weight)		0.23	2.73	230
Telecommunications ($10)		0.01	0.12	10

Freight to New Zealand	$/kg Purchased	$/kg Exported	$/Carbon exported	$/t
$2,500 for LD3 (Fiji Airways post covid freight charge)		0.0089	10.66	8.9
New Zealand fees (documentation and inspection) $F150		0.15	1.8	150
Total cf costs		1.04	12.46	1040
Total costs		3.2289	30.85	3228.9
Revenue				
New Zealand landed price (@NZ 7/kg) $1NZ=$F1.2		8.4	70.56	8400
Exporter gross margin		5	40	5171

Consultations with exporters sending frozen breadfruit to Canada provided valuable information on sources, pricing and availability, this is summarized below:

- Frozen breadfruit – Based on feedback from importers and retailers the overall estimated demand for frozen breadfruit at current pricing would be around 5 tonnes per week over a 12 month period which is 240 tonnes per annum. Frozen breadfruit market demand will always be linked to other root crops such as taro and cassava and if supply/prices fluctuate significantly this will affect the demand for breadfruit.
- Frozen breadfruit wholesales at around USD $4/kg and retails at around USD $9/kg. As a comparison, frozen taro retails at around USD $3.99/kg.
- Frozen breadfruit in Canada is currently supplied from Fiji, Samoa and Tonga. Frozen breadfruit is generally sent as part of mixed frozen consignments that may including taro, cassava and a mix of ethnic vegetables.

Table 10: The costs and return from exporting 1 Ton of Frozen Breadfruit to Canada

Costs of fruit	$/kg	$/kg Carton	Total shipments($)
Breadfruit purchased from Farm (1.2 tonnes @ $0.60/kg)	0.60	3.00	720
Transportation	**$/kg**	**$/kg Carton**	**Total shipments($)**
Farm to exporters shed	0.06	0.36	72
Exporters shed to Freight agent	0.01	0.73	13
Materials	**$/kg**	**$/kg Carton**	**Total shipments($)**
Cartons	0.30	1.50	300
Sponges and tape	0.02	0.26	17
Carton dividers	0.05	0.24	48
Labour Costs	**$/kg**	**$/kg Carton**	**Total shipments($)**
Lead Supervisor (8 hours @ $4/hour)	0.03	0.16	32
Pack house supervisor (5 hours @ $3/hour)	0.02	0.08	15
Washing (2 hours @$2.50/hour)	0.01	0.06	13
Grading and packing (3 hours $2.50/hour)	0.01	0.04	8
Overheads	**$/kg**	**$/kg Carton**	**Total shipments($)**
Telecommunications ($150/month spread over 10 tonnes of produce)	0.02	0.08	15
Electricity ($210 spread over 10 tonnes)	0.02	0.11	21
Rental of pack house ($150/month spread over 10 tonnes)	0.02	0.08	15
Miscellanous ($300/month spread of 10 tonnes)	0.03	0.15	30
Total FOB costs (to point of export)	**1.19**	**6.83**	**1318**
Fob price	2.14	11.52	2443
Exporters Gross Margin (20% Fob cost)	0.36	1.80	1125
Fob price	1.55	8.63	2443
$2500 Freight to LAX connect to Vancover (for LD3 1,000kgs)	6.63	33.15	8619
LAX fees (documentation and inspection)	0.20	1.00	200
US landed price@9.50/kgs/US$1/FJD 2.50	8.38	42.78	11262
US wholesale price (20% of landed price)	8.40	42.00	4200

12

Post-harvest Handling for fresh and frozen exports

12.1 In-field Handling

12.1.1 Sap Management

Sap on the skin of breadfruit is inevitable. There are two kinds of sap to be considered:

- that which is observed mainly as small globules on various parts of the skin and which are considered an indicator of fruit maturity, and
- that which oozes in copious amounts from the stem after the fruit has been picked or from abrasions on the skin.

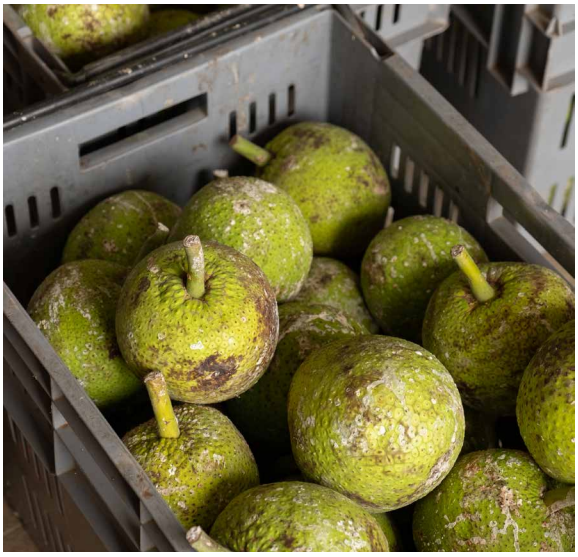
The former poses little problem, the latter causes unsightly discolouration of the fruit and is considered a marketing problem.

1. All current breadfruit exporters carry out various procedures aimed at removing the bulk of unsightly sap. These measures are centred around immersion in water and physical scrubbing. These are unsatisfactory and often make the problem worse.
2. The following simple and effective measures virtually eliminate ooze-sap from harvested fruit:
    i. remove each fruit from the catching tarpaulin immediately after it falls;
    ii. place the fruit in shade, holding the fruit stem-down at all times to prevent sap from dripping down the stem onto the surface of the fruit;
    iii. wrap a wad of tissue-type paper around the end of the fruit stem to absorb ooze sap;
    iv. Place fruit either on the ground until sap flow ceases, generally after 10-15 minutes or directly into the plastic crate with the paper wad retained.

This technique can eliminate the necessity for hand washing and scrubbing to remove sap. However, gentle washing may still be necessary to remove foreign matter and insects. It should be noted that sap flow can recur many hours after harvest from fresh wounds to the stem or surface of the fruit and from the abrading of the pointy tissue in the middle of individual segments in the fruit skin. Continued careful handling of the fruit is required through all subsequent stages in the export chain.

12.2 Recommendations

Adopt field measures to eliminate sap flow at source for sap stain "prevention is the best form of cure".



12.2.1 Use of plastic field bins

1. After harvesting, fruit is sometimes placed directly into used polypropylene sacks (flour and rice bags) for carrying from the field. This is an unacceptable practice. These bags are made from finely woven material and does not allow for ventilation for the produce. They are also difficult to clean and allow for the build-up of damaging organisms and pathogens with repeated use. Worst of all, the bags offer no compact protection for the fruit which results in bruising and a further spreading of the sap.
2. Even in the most difficult terrain, breadfruit must be placed in plastic crates for removal from the field to the exporters pack house.

12.2.2 Handling in the pack house

Washing and cleaning fruit

1. Currently all exporters carry out some form of post-harvest washing or cleaning of the fruit. This is usually done in a large trough of water. Individual fruit are generally rubbed or "scrubbed" with a cloth or sponge, which on its own appears only moderately successful in removing adhering sap from the fruit and has a high risk of microscopic injury to the fruit skin. The same tank of water is generally used for all fruit from a given harvest, and an accumulation of field debris was observed as well as increasing cloudiness of the water due to the build-up of removed sap.
2. The neck of the fruit of some varieties is often deep and requires cleaning to remove any debris or insects such as mealy bugs. Some use a paint brush for this purpose and one exporter used a water blaster which on occasion was so strong that it caused a rapid release of sap all around the base of the stem thereby increasing the problem and not reducing it. Gentle wiping with a soft sponge or soft brush is the only acceptable means to remove insects and foreign matter.
3. In the Caribbean, household bleach ("janola" - sodium hypochlorite 100 ppm) is used at the packing shed to remove fresh latex stains (Medlicott p, 2). Such methods are unnecessary if the sap stain can be prevented in the field.

Recommendation: Cleaning for sap removal is not recommended. The emphasis needs to be on field prevention. Gentle brushing or wiping around the neck of the fruit to remove debris and insects will sometimes be necessary.

12.2.3 Soaking of fruit

Throughout the Pacific Islands the immersion in water is a traditional method for handling harvested breadfruit to prevent premature softening. The storage of breadfruit in water is a common practice throughout the Pacific Islands. Research (Worrell and Carrington, 1997) in Barbados found that fruit submerged and held at 130C, with daily changes of water, retained a bright green colour for almost 3 weeks (p, 352). One Fiji exporter holds breadfruit overnight in a "swimming" pool especially constructed for that purpose. He believes this achieves worthwhile results.

Recommendation: The overnight soaking of fruit to inhibit softening could be considered by exporters if it can be fitted into their shipping schedules program.

12.2.4 Selection and grading

1. It is the responsibility of exporters to select and grade fruit in the pack-house. In grading it must be remembered that importers require:
   - consistency in quality
   - consistency in size grading

12.2.5 The following grading guidelines apply

General

Fruit shall be whole, well-formed, firm and be free from surface moisture or contaminants.

Pests and diseases

All fruit shall be free of visible signs of insects and/or disease.

Variety

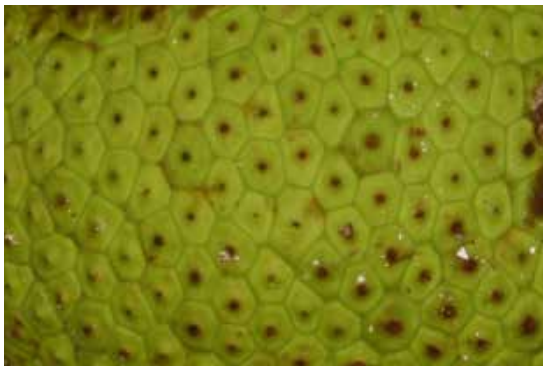
The current recommended varieties for export are Uto dina and Balekana. Each carton should contain breadfruit of only one variety that are typical in shape and colour for the variety.

Maturity

Only mature green fruit should be packed. Small dark green fruit (< 100 mm radius for uto dina) is not acceptable. It is not acceptable for eating or for quarantine treatment. Spongy fruit, and the colour change indicative of ripening is not acceptable.

Surface deposits

No contaminants or foreign matter should be present on the fruit. For example, no soil, bird droppings, grease, fruit pulp and weed seeds.



Rots

Any sign of rotting is not acceptable.

Bruising

Bruised fruit is not acceptable. Bruising may result from impact such as dropping or from placing fruit in bags after harvesting. Unfortunately, the effect of bruising may not be visible at the pack-house, although they become apparent after HTFA treatment.

Comment: Handle fruit carefully. Fruit dropped on the ground during harvest should not be presented for export.

Fresh physical damage

Fruit should be rejected if it displays fresh damage to the skin, such as picking damage, cracks, cuts and abrasions.

Skin defects

Fruit with skin defects, such as excessive sap stain, sunburn, and physical damage is not acceptable.

Shape

Fruit of the same shape should be packed together. Malformed fruit is not acceptable.

Stem length

Fruit should have the stems still attached. Stems can be trimmed to allow for more efficient packaging – standard length of 20 mm is suggested. Tip: The end of trimmed stems can be dipped in wax to prevent the reflow of sap.

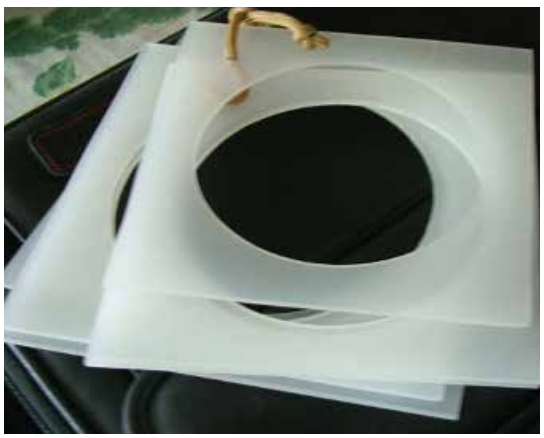
Sizing

Most importers prefer cartons to contain fruit of similar size. It is recommended that size grading be sufficient to have packages of breadfruit graded into three sizes:

- Small (with a minimum size)
- Medium
- Large (with a maximum size)

For the typical uto dina that is exported, it is suggested that the following size grades apply:

- Large: > 140 mm diameter
- Medium: 120 mm - 140 mm diameter
- Small: 100 mm – 120 mm diameter
- Reject: < 100 mm diameter



For Uto Dina, buyers prefer a minimum diameter of about 120 mm and a maximum weight of 2 kg. Graders may wish to use a set of sizing rings to assist with size grading.

13

HTFA quarantine treatment for Fresh export

13.1 In-field Handling

Before fresh breadfruit can be exported from Fiji, it must undergo HTFA treatment at the NWC facility at Nadi Airport. NWC is owned by the fresh produce export industry. Growers and exporters who require quarantine treatment for their produce must be shareholders. Exporters pay $200 and farmers pay $52.30 to join the Cooperative.

The primary function of NWC is to treat and pack fruit for export, and they have no specific responsibility for quality control. Individual exporters supply cartons and other packing materials. They also prescribe the specific packing requirements for their export fruit. NWC will reject fruit that is not suitable for quarantine treatment, such as small immature fruit. Too much variation in fruit size for a given treatment also does not allow for efficient treatment.

HTFA treatment involves slowly heating the fruit until the temperature required to kill fruit fly eggs and larvae is reached (47.2 oC), and held for the appropriate time (20 minutes), after which the fruit is rapidly cooled. The time taken to heat breadfruit to the kill temperature is around 4.5 hours. The cooling time can range from ½ to 1 ½ hours, depending on the cooling time regime adopted.

13.1.1 Quarantine inspection

A quarantine inspection occurs at the exporter's pack-house. The inspector certifies that the fruit has been sourced from registered growers who have followed the required bait-spray program which should be 6 weeks. A transfer form is then signed that authorises the exporter to take the breadfruit to the quarantine treatment facility for treatment. A Quarantine Officer is responsible for certification of the HTFA quarantine treatment protocol and associated documentation.

13.1.2 Preparation of breadfruit for freezing

There are no limitations on the varieties that are exported frozen. Only Uto Dina and Balekana are allowed for fresh export. As expected, all frozen breadfruit should be done at the exporters packing shed. The requirements are as follow:

- Breadfruit should be peeled properly and neatly.
- Inner peduncle should be removed.
- Breadfruit is sliced into 4 quarters.
- The sliced breadfruit is placed in the boiling water. The sliced breadfruit are boiled in turmeric boiling water (as required from overseas market). It should only be half cooked.

- After boiling the breadfruit are left for 30 minutes to cool down.
- The sliced breadfruit is packed in 1kg / 2 kg bags. (10 – 15 pieces per pack)
- The breadfruit are taken into the freezer for cooling (below 18 – 20 degrees Celsius).
- The BAF should be monitoring once a week within 7 – 10 days.
- If all requirements are followed by the exporter, the BAF declares and approves that yjr frozen breadfruit to be exported.
- Exporter is then allowed to export the frozen breadfruit.

13.2 Packaging for export – fresh and frozen

Currently, most exporters use cartons made from 3-ply low grade board.

These are low-cost cartons. They appear sound at the time of packing at NWC but by the time they reach New Zealand, these cartons fail in their primary role of physical protection for the fruit enclosed.

Such packaging seriously limits market development for breadfruit. Exporters need to liaise with local carton manufacturers for the adoption and use of stronger, economic cartons for export breadfruit.

13.2.1 Current packing practice at NWC

Failed cartons arrive with an Auckland importer, Waxed Cartons, with the recommended full length dividers.

The use of waxed cartons is recommended for the export of breadfruit. A waxed carton with full length dividers has two particular features that provide significant extra strength:

Waxing minimises absorption of water vapour from the enclosed fruit which causes the cartons to lose rigidity.

Full-length fruit dividers add appreciable strength and resistance to crushing.

An additional potential benefit of fruit dividers is that they provide an "in-built" mechanism for fruit size grading. Some form of physical separation of fruit between the two layers should be used. This could be by a layer of sponge rubber or a sheet of corrugated fibre board.

An alternative would be to use half-height dividers at the bottom and top layer and separated by a full-size sheet of fibre board between the two layers.

Recommendation: Waxed cartons with dividers should be used for breadfruit exports. Exporters need to liaise with local carton manufacturers.

13.3 Post-HTFA storage

Refrigeration of HTFA-treated breadfruit is not routinely practiced in Fiji.

Currently all breadfruit exports are air freighted, and the priority is movement of the produce as quickly as possible to the market. After treatment and packing, consignments are usually loaded directly into an airfreight container which is collected by Airport Terminal Services (ATS). These containers are then transferred directly to an aircraft or held overnight in the ATS cool room. If there is a delay in shipping, the fruit will have to be held in the NWC cool room.

The optimum temperature for the storage of breadfruit is 15°C. After HTFA treatment, fruit ideally should not be packed prior to being placed in the cool room, as it will take longer to reach the optimum storage temperature of 15°C. Tropical fruits such as breadfruit are susceptible to chilling injury if exposed to temperatures below about 12°C.

Recommendation: The optimum temperature for the storage of breadfruit is 15°C. Breadfruit should not be exposed to temperature below 12°C as this will result in chilling injury.

Mature green breadfruit held in cool storage at 15°C can remain fully firm for more than 10 days. Thus, in the future, after the necessary research, it may be feasible to sea freight breadfruit in reefer containers, at least to the New Zealand market. Breadfruit could share a container with taro, which can also be stored at 15°C. These two products can be expected to enter the same marketing chain.

Photo credit: Moko production

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Annex

Fiji breadfruit varieties characterization

Information sheet

Accession number: MUA001
Local name: Uto Elesi

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Muana village
Site:	Grown beside Silio Qila's House
Geocode (GPS):	16°S35.460, 179°E44.613
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Uto Elesi
Local name of the cultivar	Uto Elesi
Significance of this local name	Fruits 2 times in a year, tasty
Biological status	Locally cultivated
Habitat, associated plants	Grown with 2 other breadfruit of the same variety
Origin	Wallis and Futuna

Description

Mature Fruits	The fruit shape is oval (Length =19cm, width at midpoint = 14cm, weight is = 1.5kg) with a peduncle of 10cm of length. The skin is yellow, spiky with hard raised center point. The flesh is yellow with heavy latex. The split fruit does contain sparse seeds.
Leaf	Green, glossy, flexible with 8-11 lobes, deeply dissected, and with a close but no overlapping spacing between lobes. The leaf margin is slightly wavy. There are very few long hairs on upper veins.
Ethno-botany	Vanua Levu

Collecting Data

Collecting institute	Kokosiga,MPI, SPC, TRTC
Collecting people	Livai, Kelera, Arshni, Manoa, Maleli, Kaitu
Photographs	Leaves, mature fruit, split fruit, fruit skin texture, tree, fruits on tree.
Collecting samples	None
Collecting date	Unknown
Nursery planting date	Unknown
Label in the field.	Unknown

Uto Elesi
Vanua Levu Island, Cakaudrove Province

Mature leaf with young leaf

Mature fruit

Fruit skin texture

Mature fruit

Fruit skin texture

Fruit of Tree

Accession number: MUA001
Local name: Uto Elesi

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Muana village
Site:	Grown beside Silio Qila's House
Geocode (GPS):	16°S31.482, 179°E48.610
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Buco Coka
Local name of the cultivar	Buco Coka
Significance of this local name	Large variety, local cultivated
Biological status	Traditional cultivar
Habitat, associated plants	Grown with a balekana variety
Origin	Unknown

Description

Mature Fruits	The fruit shape is oval (Length =19cm, width at midpoint = 14cm, weight is = 1.5kg) with a peduncle of 10cm of length. The skin is yellow, spiky with hard raised center point. The flesh is yellow with heavy latex. The split fruit does contain sparse seeds.
Leaf	Green, glossy, flexible with 8-11 lobes, deeply dissected, and with a close but no overlapping spacing between lobes. The leaf margin is slightly wavy. There are very few long hairs on upper veins.
Ethno-botany	

Collecting Data

Collecting institute	Kokosiga,MPI, SPC, TRTC
Collecting people	Livai, Kelera, Arshni, Manoa, Maleli, Kaitu
Photographs	Leaves, mature fruit, split fruit, fruit skin texture, tree, fruits on tree.
Collecting samples	None
Collecting date	Unknown
Nursery planting date	Unknown
Label in the field.	Unknown

Buco Coka
Vanua Levu Island, Cakaudrove Province

Mature leaf with young leaf

Mature fruit

Fruit skin texture

Split fruit

Fruits on tree

Fruit on Tree

Accession number: MUA003
Local name: Uto Dina (Kasa balavu)

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Muana village
Site:	Grown beside Silio Qila's House
Geocode (GPS):	16°S31.478, 179°E48.621
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Uto Dina (Kasa Balavu)
Local name of the cultivar	Uto Dina (Kasa Balavu)
Significance of this local name	Fijian variety with longer peduncle
Biological status	Traditional cultivar
Habitat, associated plants	Grown with cassava vegetation
Origin	Unknown

Description

Mature Fruits	The fruit shape is round (Length =14cm, width at midpoint = 13cm, weight is = 1-2kg) with a peduncle of 8cm of length. The skin is yellow, smooth. The flesh is yellow with heavy latex. The split fruit does contain sparse seeds.
Leaf	Green, glossy, flexible with 9-10 lobes, deeply dissected, and with a wide but no overlapping spacing between lobes. The leaf margin is wavy. There are many long hairs on upper veins.
Ethno-botany	

Collecting Data

Collecting institute	Kokosiga, MPI, SPC, TRTC
Collecting people	Livai, Kelera, Arshni, Manoa, Maleli, Kaitu
Photographs	Leaves, Mature fruit, split fruit, fruit skin texture, tree, fruits on tree
Collecting samples	None
Collecting date	Unknown
Nursery planting date	Unknown
Label in the field.	Unknown
Field planting date	Unknown

Uto Dina (Kasa balavu)
Vanua Levu Island, Cakaudrove Province

Mature leaf with young leaf

Mature fruit

Fruit skin texture

Split fruit

Fruits on tree

Fruit on tree

Accession number: MUA004
Local name: Uto Dina (Kasa leka)

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Muana village
Site:	Grown beside Village hall
Geocode (GPS):	16°S31.478, 179°E48.621
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Uto dina (kasa leka)
Local name of the cultivar	Uto dina (kasa leka)
Significance of this local name	Fijian variety, fruits 2 times in a year
Biological status	Local cultivar
Habitat, associated plants	Grown beside a croton and sandalwood tree
Origin	Unknown

Description

Mature Fruits	The fruit shape is oval (Length =17cm, width at midpoint = 15cm, weight is = 1-2kg) with a peduncle of 7cm of length. The skin is yellow, rough, and sandpapery with persistent stigma dots. The flesh is yellow with heavy latex. The split fruit does contain sparse seeds.
Leaf	Green, glossy, flexible with 8 lobes, deeply dissected, and with a wide but no overlapping spacing between lobes. The leaf margin is wavy. There are many long hairs on upper veins.
Ethno-botany	

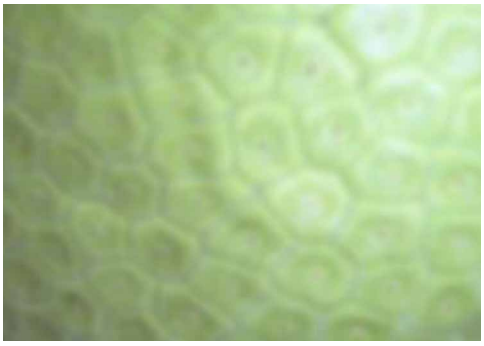
Collecting Data

Collecting institute	Kokosiga,MPI, SPC, TRTC
Collecting people	Livai, Kelera, Arshni, Manoa, Maleli, Kaitu
Photographs	Leaves, mature fruit, split fruit, tree, fruits on tree, fruit skin texture
Collecting samples	None
Collecting date	Unknown
Nursery planting date	Unknown
Label in the field.	Unknown
Field planting date	Unknown

Uto Dina (Kasa leka)
Vanua Levu Island, Cakaudrove Province

Mature leaf with young leaf

Mature fruit



Fruit skin texture

Split fruit

Uto Dina tree (Kasa leka)

Fruit on tree

Accession number: NAT 002
Local name: Uto Kogo

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Natewa village
Site:	Beside Tomu's house
Geocode (GPS):	16°S35.399, 179°E44.074
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Uto Kogo
Local name of the cultivar	Uto Kogo
Significance of this local name	none
Biological status	Well known cultivar around Cakaudrove
Habitat, associated plants	Cultivated alone, more spacing around tree.
Origin	Unknown

Description

Mature Fruits	The fruit shape is round (Length =17cm, width at midpoint = 16cm, weight is = 1-2kg) with a peduncle of 9cm of length. The skin is yellow green, rough - sandpapery with persistent stigma dots. The flesh is white with light latex. The split fruit does contain sparse seeds.
Leaf	Dark green, glossy, flexible with 8 lobes, deeply dissected, and with a wide but overlapping spacing between lobes. The leaf margin is very wavy. There are many long hairs on upper veins.
Ethno-botany	Eaten roasted or boiled with water

Collecting Data

Collecting institute	Kokosiga, SPC, MPI, TRTC
Collecting people	Livai, Kelera, Manoa, Maleli, Arshni, Kaitu
Photographs	Leaves, split fruit, peduncle insertion, tree, fruits on tree,
Collecting samples	None
Collecting date	Unknown
Nursery planting date	Unknown
Label in the field.	Unknown
Field planting date	Unknown

Uto Kogo
Vanua Levu Island, Cakaudrove Province

Mature leaf with young leaf

Mature fruit

Fruit skin texture

Split fruit

Mature tree with broken branches
from Cyclone Evan

Fruit on tree

Accession number: NAT 003
Local name: Virosola

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Natewa village
Site:	Grown beside Tomu Baca's House
Geocode (GPS):	16°S35.38, 179°E44.07
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Virosola
Local name of the cultivar	Virosola
Significance of this local name	Variety that stays green when mature
Biological status	Traditional cultivar
Habitat, associated plants	Grown beside shrubs vegetations
Origin	Unknown

Description

Mature Fruits	The fruit shape is oval (Length =13cm, width at midpoint = 12cm, weight is = 1 - 1.7kg) with a peduncle of 6cm of length. The skin is light green, rough - sandpapery with persistent stigma dots. The flesh is yellow with heavy latex. The split fruit does contain sparse seeds.
Leaf	Green, glossy, flexible with 8 lobes, deeply dissected, and with a wide but not overlapping spacing between lobes. The leaf margin is slightly wavy. There are few long hairs on upper veins.
Ethno-botany	Tasty when cooked under earth oven. Can also be boiled.

Collecting Data

Collecting institute	Kokosiga, MPI, SPC, TRTC
Collecting people	Livai, Kelera, Manoa, Arshni, Maleli, Kaitu
Photographs	Leaves, split fruit, mature fruit, fruits on tree, male flower, fruit skin
Collecting samples	Unknown
Collecting date	Unknown
Nursery planting date	Unknown
Label in the field.	Unknown
Field planting date	Unknown

Virosola
Vanua Levu Island, Cakaudrove Province

Mature leaf

Mature fruit

Fruit skin texture

Split fruit

Male flower

Fruit on tree

Accession number: NAT 004
Local name: Uto Buco

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Natewa village
Site:	Grown beside a kitchen, near to the seashore
Geocode (GPS):	16°S35.37, 179°E44.06
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Uto Buco
Local name of the cultivar	Uto Buco
Significance of this local name	One of the largest variety, has a white flesh color
Biological status	Traditional cultivar
Habitat, associated plants	None, more space to grow
Origin	Unknown

Description

Mature Fruits	The fruit shape is oval (Length =25cm, width at midpoint = 17cm, weight is = 2-3kg) with a peduncle of 11cm of length. The skin is light green, spiky - hard raised centre point. The flesh is white with heavy latex. The split fruit does contain abundant seeds.
Leaf	Dark green, glossy, flexible with 8 lobes, moderately deeply dissected, and with a close and overlapping spacing between lobes. The leaf margin is slightly wavy. There are very few long hairs on upper veins.
Ethno-botany	

Collecting Data

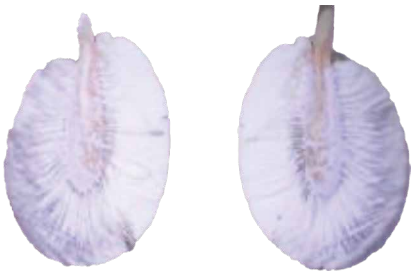
Collecting institute	Pacific Breadfruit Project
Collecting people	Livai, Kaitu
Photographs	Mature leaves, split fruit, mature fruit, tree, fruits on tree, peduncle insertion.
Collecting samples	none
Collecting date	Unknown
Nursery planting date	Unknown
Label in the field.	Unknown
Field planting date	Unknown

Uto Buco
Vanua Levu Island, Cakaudrove Province

Mature leaf

Mature fruit

Peduncle insertion



Split fruit

Uto Buco tree

Fruit on tree

Accession number: NAT 005
Local name: Bokasi

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Natewa village
Site:	Beside the seashore, inside the church compound
Geocode (GPS):	16°S35.38, 179°E44.05
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Bokasi
Local name of the cultivar	Bokasi
Significance of this local name	Traditional cultivar
Biological status	Consumed locally
Habitat, associated plants	Grown beside otherbreadfruit varieties
Origin	Unknown

Description

Mature Fruits	The fruit shape is round (Length =15cm, width at midpoint = 13cm, weight is = 1kg) with a peduncle of 7cm of length. The skin is yellow, spiky with hard raised centre point. The flesh is yellow with heavy latex. The split fruit does contain sparse seeds.
Leaf	Dark green, glossy, flexible with 8-9 lobes, deeply dissected, and with a close and overlapping spacing between lobes. The leaf margin is slightly wavy. There are very few long hairs on upper veins.
Ethno-botany	Eaten under earth oven, boiled or even roasted

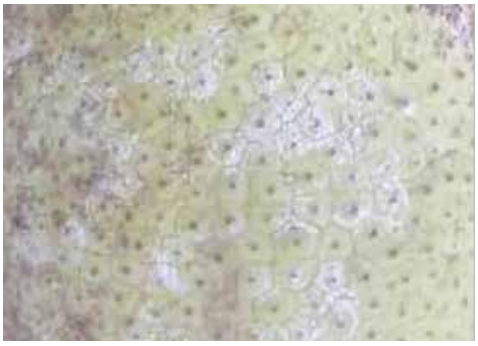
Collecting Data

Collecting institute	Kokosiga, MPI, SPC, TRTC
Collecting people	Livai, Kelera, Manoa, Maleli, Arshni, Kaitu
Photographs	Mature leaf, mature fruit, split fruit, fruit skin texture, tree, fruit on tree
Collecting samples	none
Collecting date	Unknown
Nursery planting date	Unknown
Label in the field.	Unknown
Field planting date	Unknown

Bokasi
Vanua Levu Island, Cakaudrove Province

Mature leaf

Mature fruit



Fruit skin texture

Split fruit

Bokasi tree

Fruit on tree

Accession number: NAT 006
Local name: Uto Dina (yellow flesh)

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Natewa village
Site:	Grown beside aother uto dina variety, beside the church
Geocode (GPS):	16°S35.38, 179°E44.05
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Uto Dina
Local name of the cultivar	Uto Dina
Significance of this local name	Local variety
Biological status	Traditional cultivar
Habitat, associated plants	Grown beside another Uto Dina variety
Origin	Unknown

Description

Mature Fruits	The fruit shape is oval (Length =19cm, width at midpoint = 15cm, weight is = 2-3kg) with a peduncle of 7cm of length. The skin is light green, rough, sandpapery with persistent stigma dots. The flesh is yellow with light late . The split fruit does contain sparse seeds.
Leaf	Green, glossy, flexible with 6-8 lobes, deeply dissected, and with a wide but not overlapping spacing between lobes. The leaf margin is slightly wavy. There are many long hairs on upper veins.
Ethno-botany	

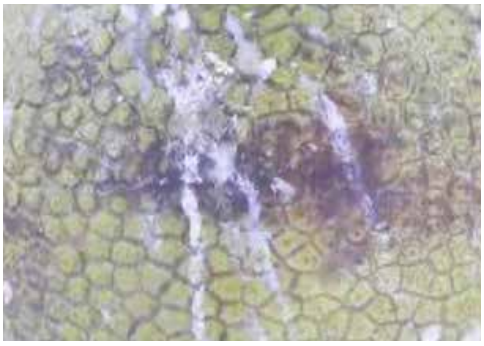
Collecting Data

Collecting institute	Kokosiga, MPI, SPC, TRTC
Collecting people	Livai, Kelera, Manoa, Arshni, Maleli, Kaitu
Photographs	Mature leaves, mature fruit, Split fruit, tree, fruits on tree, fruit skin texture
Collecting samples	None
Collecting date	Unknown
Nursery planting date	Unknown
Label in the field.	Unknown
Field planting date	Unknown

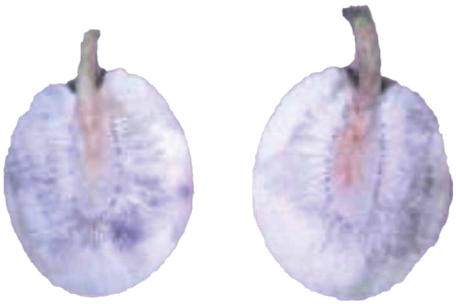
Uto Dina (Yellow flesh)
Vanua Levu Island, Cakaudrove Province

Mature leaf

Mature ruit



Fruit skin texture



Split fruit

Uto Dina (Yellow flesh) tree

Fruit on tree

Accession number: NAT 007
Local name: Uto Dina (white flesh)

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Natewa village
Site:	Grown beside the church, along with another uto dina variety.
Geocode (GPS):	16°S35.40, 179°E44.04
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Uto Dina
Local name of the cultivar	Uto Dina
Significance of this local name	Local variety
Biological status	Traditional cultivar
Habitat, associated plants	Cultivated with Uto Dina variety
Origin	Uknown

Description

Mature Fruits	The fruit shape is round (Length =19cm, width at midpoint = 19cm, weight is = 3-4kg) with a peduncle of 10cm of length. The skin is green, rough, and sandpapery with persistent stigma dots. The flesh is white with no latex. The split fruit does contain sparse seeds.
Leaf	Green, glossy, flexible with 8 lobes, deeply dissected, and with a wide but not overlapping spacing between lobes. The leaf margin is wavy. There are many long hairs on upper veins.
Ethno-botany	

Collecting Data

Collecting institute	Kokosiga, MPI, SPC, TRTC
Collecting people	Livai, Kelera, Manoa, Arshni, Maleli,Kaitu
Photographs	Leaves, mature fruit, split fruit, fruit on trees, tree, fruit skin texture.
Collecting samples	None
Collecting date	Uknown
Nursery planting date	Uknown
Label in the field.	Uknown
Field planting date	Uknown

Uto Dina (white flesh)
Vanua Levu Island, Cakaudrove Province

Mature leaf

Mature fruit

Fruit skin texture

Split fruit

Uto Dina (white flesh) tree

Fruit on tree

Accession number: NAT 008
Local name: Uto Lasawa

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Natewa village
Site:	Grown alone beside the church
Geocode (GPS):	16°S35.41, 179°E44.02
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Uto Lasawa
Local name of the cultivar	Uto Lasawa
Significance of this local name	Local variety
Biological status	Traditional variety
Habitat, associated plants	Grown with other croton and frangipani tree.
Origin	Unknown

Description

Mature Fruits	The fruit shape is oval (Length =10cm, width at midpoint = 14cm, weight is = 1-2kg) with a peduncle of 8cm of length. The skin is yellow, rough, and sandpapery with persistent stigma dots. The flesh is yellow with light latex. The split fruit does contain sparse seeds.
Leaf	Green, glossy, flexible with 8 lobes, deeply dissected, and with a wide but not overlapping spacing between lobes. The leaf margin is wavy. There are many long hairs on upper veins.
Ethno-botany	Roasted, can be boiled with water

Collecting Data

Collecting institute	Kokosiga, MPI, SPC, TRTC
Collecting people	Livai, Kelera, Arshni, Manoa, Maleli, Kaitu
Photographs	Leaves, mature fruit, fruit on tree, tree, split fruit, fruit skin texture
Collecting samples	none
Collecting date	Unknown
Nursery planting date	Unknown
Label in the field.	Unknown
Field planting date	Unknown

Uto Dina (white flesh)
Vanua Levu Island, Cakaudrove Province

Mature leaf

Mature fruit

Fruit skin texture

Split fruit

Uto Lasawa tree

Fruit on tree

Accession number: NAT 009
Local name: Uto Liva

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Natewa village
Site:	Grown beside Seru Taqali's residence
Geocode (GPS):	16°S35.41, 179°E44.02
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Uto Liva
Local name of the cultivar	Uto Liva
Significance of this local name	Local variety, fruits 4 times in a year
Biological status	Traditional cultivar
Habitat, associated plants	Grown beside an Uto Buco Tree.
Origin	Lovonivonu, Taveuni

Description

Mature Fruits	The fruit shape is oval (Length =12cm, width at midpoint = 11cm, weight is = 1kg) with a peduncle of 8cm of length. The skin is yellow, rough, and sandpapery with persistent stigma dots. The flesh is yellow with heavy latex. The split fruit does contain abundant seeds.
Leaf	G reen, glossy, flexible with 8 lobes, deeply dissected, and with a close but not overlapping spacing between lobes. The leaf margin is slightly wavy. There are many long hairs on upper veins.
Ethno-botany	

Collecting Data

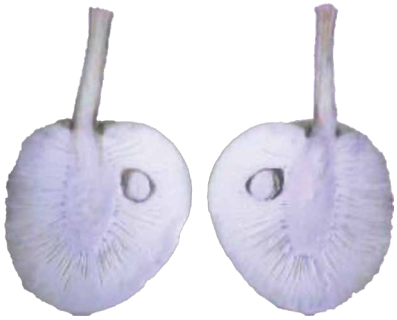
Collecting institute	Kokosiga, MPI, SPC, TRTC
Collecting people	Livai, Kelera, Arshni,Manoa, Maleli, Kaitu
Photographs	Leaves, split fruit with seeds, mature fruit, tree, fruits on tree, peduncle insertion,
Collecting samples	None
Collecting date	Unknown
Nursery planting date	Unknown
Label in the field.	Unknown
Field planting date	Unknown

Uto Liva (white flesh)
Vanua Levu Island, Cakaudrove Province

Mature leaf

Mature fruit

Fruit skin texture



Split fruit

Uto Liva tree

Fruit on tree

Accession number: NAT 010
Local name: Uto Savisavi

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Natewa village
Site:	Grown beside Seru Taqali's House
Geocode (GPS):	16°S35.45, 179°E44.04
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Uto Savisavi
Local name of the cultivar	Uto Savisavi
Significance of this local name	Local Variety fruits 2 times a year
Biological status	Traditional cultivar
Habitat, associated plants	Grown beside other breadfruit variety
Origin	Unknown

Description

Mature Fruits	The fruit shape is round (Length =8cm, width at midpoint = 14cm, weight is = 2-3kg) with a peduncle of 7cm of length. The skin is yellow, rough, irregular raised flatten section. The flesh is yellow with heavy latex. The split fruit does contain sparse and abundant seeds.
Leaf	Green, glossy, flexible with 10-11 lobes, deeply dissected, and with a wide but not overlapping spacing between lobes. The leaf margin is wavy. There are very few short hairs on upper veins.
Ethno-botany	

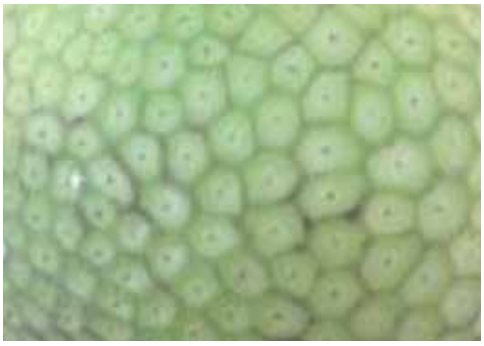
Collecting Data

Collecting institute	Kokosiga, MPI, TRTC, SPC
Collecting people	Livai, Kelera, Arshni, Manoa, Maleli,Kaitu
Photographs	Matured leaf, mature fruit, split fruit, fruit skin texture, tree, fruits on tree.
Collecting samples	
Collecting date	Unknown
Nursery planting date	Unknown
Label in the field.	Unknown
Field planting date	Unknown

Uto Savisavi
Vanua Levu Island, Cakaudrove Province

Mature leaf

Mature fruit



Fruit skin texture

Split fruit

Uto Savisavi tree

Fruit on tree

Accession number: NAT 3
Local name: Buco ni Samoa

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Natewa village
Site:	Grown beside Simi Bemana's House
Geocode (GPS):	16°S35.50, 179°E44.02
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Buco ni Samoa
Local name of the cultivar	BUco ni Samoa
Significance of this local name	One of the large variety of breadfruit.
Biological status	Traditionally cultivated
Habitat, associated plants	Grown beside another variety of breadfruit
Origin	Unknown

Description

Mature Fruits	The fruit shape is oval (Length =20cm, width at midpoint = 15cm, weight is = 1kg) with a peduncle of 7cm of length. The skin is yellow, spiky with hard raise centre point. The flesh is creamy with heavy latex. The split fruit does contain sparse seeds.
Leaf	Dark green, glossy, flexible with 8-10 lobes, deeply dissected, and with a wide but not overlapping spacing between lobes. The leaf margin is slightly wavy. There are many long hairs on upper veins.
Ethno-botany	Roasted or boiled with water

Collecting Data

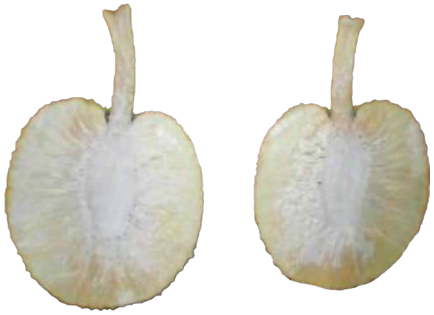
Collecting institute	Kokosiga, MPI, SPC, TRTC
Collecting people	Livai, Kelera, Arshni, Manoa, Maleli, Kaitu
Photographs	Leaves, mature fruit, split fruit, fruits on tree, tree, fruit skin texture.
Collecting samples	none
Collecting date	Unknown
Nursery planting date	Unknown
Label in the field.	Unknown
Field planting date	Unknown

Buco ni Samoa
Vanua Levu Island, Cakaudrove Province

Mature leaf

Mature fruit

Fruit skin texture



Split fruit

Buco ni Samoa tree

Fruit on tree

Accession number: NAT 011
Local name: Uto Samoa

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Natewa village
Site:	Grown beside Simi Bemana's House
Geocode (GPS):	16°S35.50, 179°E44.03
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Uto Samoa
Local name of the cultivar	Uto Samoa
Significance of this local name	Fruits 2 times in a year
Biological status	Locally cultivated
Habitat, associated plants	Grown beside Buco ni Samoa variety
Origin	Unknown

Description

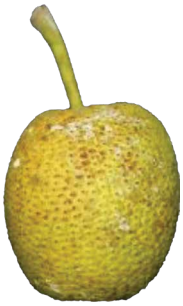
Mature Fruits	The fruit shape is round (Length =13cm, width at midpoint = 13.5cm, weight is = 1.7kg) with a peduncle of 11.5cm of length. The skin is yellow green, moderately rough to smooth with persistent stigma dots. The flesh is white with much latex . The split fruit does contain abundant seeds.
Leaf	Green, glossy, flexible with 6 lobes, moderately deeply dissected on upper half of leaf, and with a close with no overlapping spacing between lobes. The leaf margin is wavy. There are very few short hairs on upper veins.
Ethno-botany	

Collecting Data

Collecting institute	Kokosiga, MPI, SPC, TRTC
Collecting people	Livai, Kelera, Manoa, Arshni, Maleli, Kaitu
Photographs	Leaves, tree
Collecting samples	None
Collecting date	Unknown
Nursery planting date	Unknown
Label in the field.	Unknown
Field planting date	Unknown

Uto Samoa
Vanua Levu Island, Cakaudrove Province

Mature leaf



Mature fruit

Fruit skin texture

Split fruit

Uto Liva tree

Fruit on tree

Accession number: NAT 013
Local name: Balekana ni Samoa (small variety)

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Natewa village
Site:	Grown inside church compound andgrown beside Uto Bokasi Variety
Geocode (GPS):	16°S35.38, 179°E44.05
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Balekana ni Samoa (small Variety)
Local name of the cultivar	Balekana ni Samoa (small Variety)
Significance of this local name	Fruits all year around, tasty
Biological status	Cultivated locally
Habitat, associated plants	Near Uto Bokasi
Origin	Unknown

Description

Mature Fruits	The fruit shape is oval (Length =10cm, width at midpoint = 10cm, weight is = 600g) with a peduncle of 7cm of length. The skin is yellow, rough, and sandpapery with persistent stigma dots. The flesh is yellow with heavy latex. The split fruit does contain sparse seeds.
Leaf	Dark green, glossy, flexible with 6-8 lobes, deeply dissected, and with a close with no overlapping spacing between lobes. The leaf margin is slightly wavy. There are many long hairs on upper veins.
Ethno-botany	Roasted, earth oven or even boiled with water

Collecting Data

Collecting institute	Kokosiga, MPI, SPC, TRTC
Collecting people	Livai, Kelera, Manoa, Arshni, Maleli, Kaitu
Photographs	Leaf, matured fruit, split fruit, fruit skin texture, tree, peduncle insertion
Collecting samples	None
Collecting date	Unknown
Nursery planting date	Unknown
Label in the field.	Unknown
Field planting date	Unknown

Balekana ni Samoa (small variety)
Vanua Levu Island, Cakaudrove Province

Mature leaf

Mature fruit

Fruit skin texture

Split fruit

Balekana ni Samoa (small variety)

Peduncle insertion

Accession number: NAT 014
Local name: Balekana ni Samoa

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Natewa village
Site:	Grown beside uto Bokasi
Geocode (GPS):	
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Balekana ni Samoa (Large variety)
Local name of the cultivar	Balekana ni Samoa(Large variety)
Significance of this local name	Best variety, grown by most households, fruits all year around.
Biological status	Locally cultivted
Habitat, associated plants	Grown beside young root suckers
Origin	Unknown

Description

Mature Fruits	The fruit shape is oval (Length =16cm, width at midpoint = 12cm, weight is = 1.5kg) with a peduncle of 10cm of length. The skin is yellow, rough, and sandpapery, with persistent stigma dots. The flesh is yellow with light latex. The split fruit does contain sparse seeds.
Leaf	Green, glossy, flexible with 8 lobes, deeply dissected, and with a close and overlapping spacing between lobes. The leaf margin is wavy. There are many long hairs on upper veins.
Ethno-botany	

Collecting Data

Collecting institute	Kokosiga, MPI, SPC, TRTC
Collecting people	Livai, Kelera, Arshni, Manoa, Maleli, Kaitu
Photographs	Leaves, mature fruit, split fruit, fruits on tree, fruit skin texture, tree.
Collecting samples	None
Collecting date	Unknown
Nursery planting date	Unknown
Label in the field.	Unknown
Field planting date	Unknown

Balekana ni Samoa
Vanua Levu Island, Cakaudrove Province

Mature leaf

Mature fruit

Fruit skin texture

Split fruit

Uto Liva tree

Fruit on tree

Accession number: NAT 014
Local name: Balekana ni Samoa

Location

Country:	Fiji
Province:	Cakaudrove
Island:	Vanua Levu
Location:	Natewa village
Site:	Grown beside uto Bokasi
Geocode (GPS):	
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Balekana ni Samoa (Large variety)
Local name of the cultivar	Balekana ni Samoa(Large variety)
Significance of this local name	Best variety, grown by most households, fruits all year around.
Biological status	Locally cultivted
Habitat, associated plants	Grown beside young root suckers
Origin	Unknown

Description

Mature Fruits	The fruit shape is oval (Length =16cm, width at midpoint = 12cm, weight is = 1.5kg) with a peduncle of 10cm of length. The skin is yellow, rough, and sandpapery, with persistent stigma dots. The flesh is yellow with light latex. The split fruit does contain sparse seeds.
Leaf	Green, glossy, flexible with 8 lobes, deeply dissected, and with a close and overlapping spacing between lobes. The leaf margin is wavy. There are many long hairs on upper veins.
Ethno-botany	

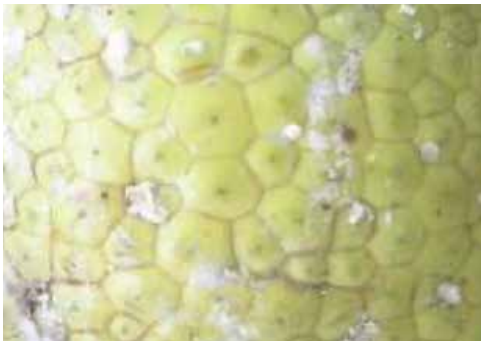
Collecting Data

Collecting institute	Kokosiga, MPI, SPC, TRTC
Collecting people	Livai, Kelera, Arshni, Manoa, Maleli, Kaitu
Photographs	Leaves, mature fruit, split fruit, fruits on tree, fruit skin texture, tree.
Collecting samples	None
Collecting date	Unknown
Nursery planting date	Unknown
Label in the field.	Unknown
Field planting date	Unknown

Balekana ni Samoa (small variety)
Vanua Levu Island, Cakaudrove Province

Mature leaf

Mature fruit



Fruit skin texture

Split fruit

Balekana ni Samoa (large variety)

Fruit on tree

Annex

Rotuma breadfruit varieties characterization

Information sheet

Accession number: ROT 01
Local name: Ulu Pulpul

Location

Country:	Rotuma, Fiji Islands
Province:	Malhaha
Island:	Rotuma Island
Location:	Paphauna village
Site:	Grown beside the cemetery at Malhaha
Geocode (GPS):	
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Ulu Pulpul
Local name of the cultivar	Ulu Pulpul
Significance of this local name	none
Biological status	Traditional cultivar
Habitat, associated plants	Grown with an ulu fiti breadfruit
Origin	Unknown

Description

Mature Fruits	The fruit shape is round (Length =14cm, width at midpoint = 13cm, weight is = 1-2kg) with a peduncle of 8cm of length. The skin is yellow, sand papery. The flesh is white with less latex. The split fruit does not contain seeds.
Leaf	Green, glossy, flexible with no lobes. The leaf margin is wavy. There are fewer hairs on upper veins.
Ethno-botany	

Collecting Data

Collecting institute	Leje Rotuma
Collecting people	Kaitu, Monifa, Rupeti
Photographs	Leaves, Mature fruit, split fruit, fruit skin texture, tree, fruits on tree
Collecting samples	None
Collecting date	15/03/19
Nursery planting date	none
Label in the field.	ROT 01
	unavailable

Ulu Pulpul
Rotuma Island, MalhahaProvince

Picture of tree

Mature fruit

Fruits with leaves characteristics

Split mature fruit

Fruit skin texture

Peduncle insertion

Accession number: ROT 02
Local name: Ulu Formarori

Location

Country:	Fiji
Province:	Malhaha
Island:	Rotuma Island
Location:	Paphaua village
Site:	Grown inside Jioje Fereti's resident.
Geocode (GPS):	
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Ulu Formarori
Local name of the cultivar	Ulu Formarori
Significance of this local name	Smooth skin, best variety to make desert
Biological status	Traditional cultivar
Habitat, associated plants	Grown with other breadfruit varieties
Origin	Unknown

Description

Mature Fruits	The fruit shape is round (Length =14cm, width at midpoint = 13cm, weight is = 1-2kg) with a peduncle of 10cm of length. The skin is yellow, smooth when mature. The flesh is yellow with less latex. The split fruit does contain 2 -3 seeds.
Leaf	Green, glossy, flexible with 6 - 8 lobes, not deeply dissected, and with a narrow but no overlapping spacing between lobes. The leaf margin is wavy. There are many long hairs on upper veins.
Ethno-botany	

Collecting Data

Collecting institute	Leje Rotuma
Collecting people	Kaitu, Monifa, Rupeti
Photographs	Leaves, Mature fruit, split fruit, fruit skin texture, tree, fruits on tree
Collecting samples	None
Collecting date	15/04/19
Nursery planting date	15/04/19
Label in the field.	ROT 01
Field planting date	unknown

Ulu Formarori
Rotuma Island, MalhahaProvince

Picture of tree with owner

Mature fruit

Male and female flower

Split mature fruit

Fruit skin texture

Mature leaf and fruit

Accession number: ROT 03
Local name: Ulu Saule

Location

Country:	Fiji
Province:	Juju
Island:	Rotuma Island
Location:	Saule village
Site:	Grown beside other breadfruit varieties
Geocode (GPS):	
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Ulu Saulei
Local name of the cultivar	Uto Saulei
Significance of this local name	Local variety and only found in Saulei village
Biological status	Traditional cultivar
Habitat, associated plants	Grown with other breadfruit variety
Origin	Unknown

Description

Mature Fruits	The fruit shape is oblong (Length =20cm, width at midpoint = 13cm, weight is = 2 -3kg) with a peduncle of 8cm of length. The skin is yellow, smooth. The flesh is yellow with no latex. The split fruit does contain 1 -2 seeds.
Leaf	Green, glossy, flexible with 3 - 6 lobes, not deeply dissected, and with a shallow but no overlapping spacing between lobes. The leaf margin is wavy. There are many long hairs on upper veins.
Ethno-botany	

Collecting Data

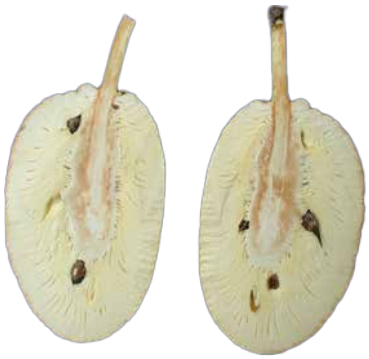
Collecting institute	Leje Rotuma
Collecting people	Kaitu, Monifa, Rupeti
Photographs	Leaves, Mature fruit, split fruit, fruit skin texture, tree, fruits on tree
Collecting samples	None
Collecting date	15/03/19
Nursery planting date	none
Label in the field.	ROT 03
Field planting date	unavailable

Ulu Saulei
Rotuma Island, Juju Province

Picture of tree with owner

Mature fruit

Seed insertion and flesh colour



Split mature fruit

Fruit skin texture

Mature leaf

Accession number: ROT 04
Local name: Ulu Fiti

Location

Country:	Rotuma Fiji
Province:	Itu tiu
Island:	Rotuma Island
Location:	Motusa village
Site:	Grown beside other breadfruit varieties
Geocode (GPS):	
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Ulu Fiti
Local name of the cultivar	Ulu Fiti
Significance of this local name	Local variety
Biological status	Traditional cultivar
Habitat, associated plants	Grown with other breadfruit variety
Origin	Unknown

Description

Mature Fruits	The fruit shape is oblong (Length =20cm, width at midpoint = 13cm, weight is = 3 -4kg) with a peduncle of 10cm of length. The skin is yellow, smooth. The flesh is white with heavy latex. The split fruit does not contain any seeds.
Leaf	Green, glossy, flexible with 6 -8 lobes, not deeply dissected, and with a shallow but overlapping spacing between lobes. The leaf margin is wavy. There are many long hairs on upper veins.
Ethno-botany	

Collecting Data

Collecting institute	Leje Rotuma
Collecting people	Kaitu, Monifa, Rupeti
Photographs	Leaves, Mature fruit, split fruit, fruit skin texture, tree, fruits on tree
Collecting samples	None
Collecting date	15/03/19
Nursery planting date	15/03/19
Label in the field.	ROT 04
Field planting date	None

Ulu Fiti
Rotuma Island, Itutiu Province

Picture of tree with owner

Mature fruit

Mature fruit and leaves

Split mature fruit

Fruit skin texture

Mature leaf

Accession number: ROT 05
Local name: Ulu Samoa

Location

Country:	Rotuma Fiji Islands
Province:	Itu tiu
Island:	Rotuma Island
Location:	Motusa village
Site:	Grown beside other breadfruit varieties
Geocode (GPS):	
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Ulu Samoa
Local name of the cultivar	Ulu Samoa
Significance of this local name	Breadfruit from Samoa, Balekana ni Samoa, Ma'afala
Biological status	Traditional cultivar
Habitat, associated plants	Grown with other breadfruit variety
Origin	Unknown

Description

Mature Fruits	The fruit shape is round (Length =10cm, width at midpoint = 8cm, weight is = 500g - 1kg) with a peduncle of 5cm of length. The skin is yellow, smooth. The flesh is yellow with less latex. The split fruit does not contain seeds.
Leaf	Green, glossy, flexible with 8-10 lobes, deeply dissected, and with a shallow and overlapping spacing between lobes. The leaf margin is wavy. There are many long hairs on upper veins.
Ethno-botany	

Collecting Data

Collecting institute	Leje Rotuma
Collecting people	Kaitu
Photographs	Leaves, Mature fruit, split fruit, fruit skin texture, tree, fruits on tree
Collecting samples	None
Collecting date	15/03/19
Nursery planting date	none
Label in the field.	ROT 05
Field planting date	Not available

Ulu Samoa
Rotuma Island, Itutiu Province

Picture of tree

Mature fruit

Mature fruit and leaves

Split mature fruit

Fruit skin texture

Mature leaf

Accession number: ROT 06
Local name: Ulu Rotuma

Location

Country:	Rotuma Fiji Islands
Province:	Itutiu
Island:	Rotuma Island
Location:	Motusa village
Site:	Grown beside other breadfruit varieties
Geocode (GPS):	
Elevation:	

Classification

Scientific Name:	*Artocarpus altilis*
Common crop name	Ulu Rotuma
Local name of the cultivar	Ulu Rotuma
Significance of this local name	Local variety
Biological status	Traditional cultivar
Habitat, associated plants	Grown with other breadfruit variety
Origin	Unknown

Description

Mature Fruits	The fruit shape is round (Length =18cm, width at midpoint = 13cm, weight is = 2 -3kg) with a peduncle of 8cm of length. The skin is yellow, smooth. The flesh is white with less latex. The split fruit does not contain seeds.
Leaf	Green, glossy, flexible with 9-10 lobes, deeply dissected, and with a wide but no overlapping spacing between lobes. The leaf margin is wavy. There are many long hairs on upper veins.
Ethno-botany	

Collecting Data

Collecting institute	Leje Rotuma
Collecting people	Kaitu
Photographs	Leaves, Mature fruit, split fruit, fruit skin texture, tree, fruits on tree
Collecting samples	None
Collecting date	15/03/19
Nursery planting date	none
Label in the field.	ROT 06
Field planting date	None

Ulu Fiti
Rotuma Island, Itutiu Province

Picture of tree with owner

Mature fruit

Peduncle insertion

Split mature fruit

Fruit skin texture

Mature leaf and fruit

Notes: