Natures Way Cooperative (Fiji) Ltd

A Manual for the Growing and Marketing of Breadfruit for Export

October 2005

Cover painting by Charmian McGregor

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Preface

We at Natures Way Cooperative have a vision that Fiji can develop into a world class exporter of fruit and vegetables. With the implementation of our Strategic Plan, we are making good progress to achieving this vision.

Breadfruit features prominently in our Plan. Breadfruit exports began in October 2001 and have grown to currently stand at around 15 tonnes annually. This growth confirmed that it is feasible to export this perishable crop. However, the performance is well below the potential for the crop we identified in our Strategic Plan where we expected to be exporting 100 tonnes by now. It is clear to us that achieving anywhere near breadfruit's market potential will require concerted effort in two main areas. These are: 1) moving from wild harvesting of fruit to growing breadfruit as a crop; and, 2) introducing appropriate quality control and Postharvest handling procedures. This manual is intended to assist our growers and exporters in meeting this challenge.

Andrew McGregor coordinated the production of this manual with assistance from Alan Harre, Aremogan Pillai, Grantley Chaplin, Jim Hollier, Kyle Stice, Luke Tirimaidoka and Simione Tukidia. A draft manual was reviewed by our members and other stakeholders at the breadfruit Conference held earlier this year. Their enthusiastic participation and contribution is greatly appreciated.

I would like to give special thanks to Natures Way's Manager, Sant Kumar for his leadership of our Breadfruit industry development program.

Funding for the manual was provided by NZ AID, which were administered by The Pacific Enterprise Development Facility of the World Bank Group. Our shareholders extend a hearty vinaka vakalevu for this assistance in helping us realise our vision.

Tim Casey
Chairman
Natures Way Cooperative

Acronyms and glossary of terms

Acronyms

ATS	Airport Terminal Services
HTFA	High Temperature Force Air (quarantine treatment)
MASLR	Ministry of Agriculture Sugar and Land Resettlement
NPK	Nitrogen, Phosphorous and Potassium
NWC	Natures Way Cooperative (Fiji) Ltd.

Glossary

Aerial layering	Inducing roots from a young green branch. Method used to achieve early fruiting. Also known as marcotting.
Bait spray	Yeast sprayed to attract female fruit flies so they can be poisoned.
Bale Kana	A popular Fijian breadfruit variety – the second main variety that is currently exported
Cambium	Soft sap-conducting tissues under the bark of the stem or roots
Fruit fly host	A fruit in which fruit flies lay their eggs
Gross Margin	Income after meeting all fixed and variable costs.
High Temperature Force Air (HTFA)	A method of quarantine treatment that kills any fruit fly eggs and larvae through slowly heating the fruit

Marcotting	Inducing roots from a young green branch. Method used to achieve early fruiting. Also known as aerial layering.
Optimum	Most favourable conditions
Perishable	Subject to speedy deterioration and decay
Post harvest	Measures taken after the fruit has been harvested
Propagate	Multiply plants from a parent tree
Protocol	Agreed steps to be followed
Orchard	An area where all fruit trees are planted together in rows
Quarantine treatment	A method for killing fruit fly eggs and larvae
Root cuttings	Cut pieces of roots that will grow into plants
Root suckers	Shoots that grow from roots
Uto dina	A popular Fijian breadfruit type – makes up most of current exports
Umu	The Samoan name for an earth oven, equivalent to the Fijian lovo

A Manual for growing and marketing breadfruit for export

Background

Breadfruit *(Artocarpus altilis)*, is a member of the Moraceae (fig) mulberry family. In Fiji, breadfruit known as utu or buco, is a popular traditional food staple. It is boiled, roasted, cooked in a lovo, or curried. The fruit is high in carbohydrates and a good source of minerals and vitamins.

In Fiji, breadfruit is a minor seasonal food staple, that represents only a small fraction of the consumption of cassava and less important than taro and kumala. This is in contrast to the situation in Samoa, where breadfruit is a major basic food. The large Samoan community living in New Zealand, Australia, and the United States offer the main market for fresh breadfruit.

Umu cooked breadfruit in plentiful supply at the Fugalei market in Samoa

Breadfruit is a fruit fly host and requires quarantine treatment if it is to be exported fresh. The approved quarantine treatment is high temperature forced air (HTFA). This is undertaken by the Natures Way Cooperative (Fiji) Ltd., at Nasoso Road, Nadi International Airport.

Fresh breadfruit is a highly perishable commodity that requires very careful handling if it is to be successfully exported. This Manual provides advice to growers and exporters on the handling of breadfruit for successful export.

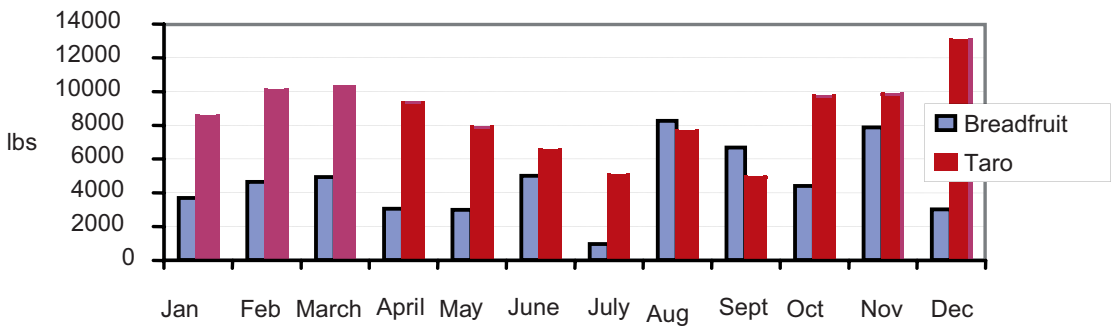
The export market for fresh breadfruit

The main buyers of breadfruit are Pacific Island people, especially Samoans for which breadfruit is a culturally important food. For a Samoan household living overseas the inclusion of breadfruit in their Sunday "umu" would be of considerable value. Frozen vacuum packed or precooked breadfruit just does not have the same appeal.

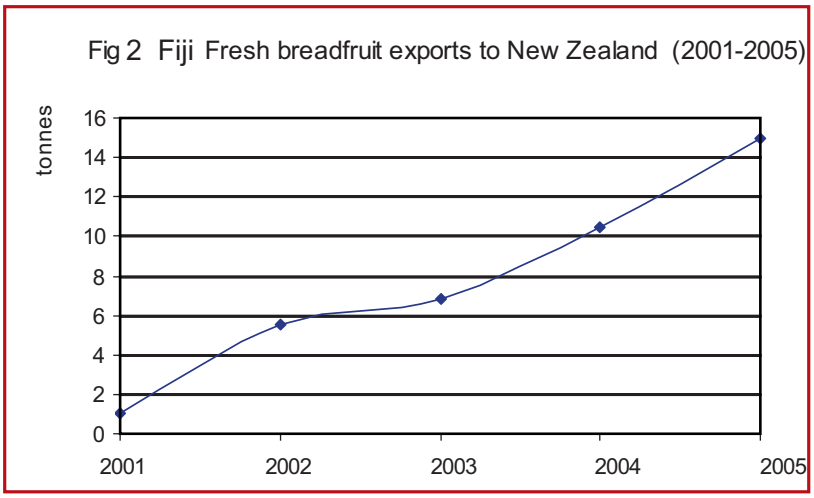
There are some 115, 000 Samoans living in New Zealand (2001 Population Census). Indian, Malaysian and Sri Lankan people who also use breadfruit in curry dishes. This gives a consumer base of 330,000 people in New Zealand alone. Equivalent market potential exists in Australia and in the west coast of the United States, once quarantine approvals for export have been obtained.

Taro provides a guide to what the potential export market for fresh breadfruit might be. Figure 1 compares the sales of breadfruit and taro on the Samoan local market in 2001 (Samoa Breadfruit Profile 2001, p, 19). In that year, breadfruit sales in Samoa were approximately 40% of taro sales. On this basis it could be concluded that the potential market for fresh breadfruit in New Zealand is around 40% of taro exports to that market. Fiji currently exports around 4,000 tonnes of taro annually to New Zealand. Thus the upper market potential for breadfruit in New Zealand is in order of 1,500 tonnes. A conservative estimate of the market for breadfruit in New Zealand would be around 500 tonnes annually.

Fig. 1: A comparison of breadfruit and taro sales at the Fugalei market (monthly average of Friday availability) 2001.



Gordon Grandison (2004) found that importers considered that the New Zealand market could easily sell 4 tonnes per week if the fruit was available. He concluded: "Following discussions with all the breadfruit importers in New Zealand and a selection of retail supermarkets and small shops they unanimously agreed that the major hindrance to satisfying the present market demands and possible enlargement of the market is supply and quality" (p, 2).



Export performance to date

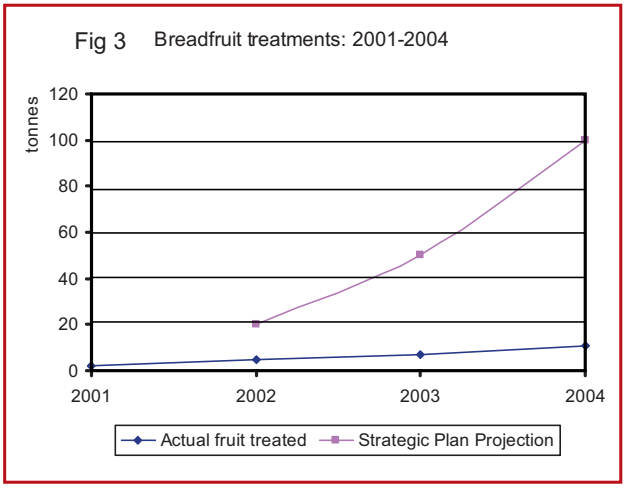


Figure 2 shows annual fresh breadfruit exports from Fiji to New Zealand since they began in October 2001. The steady growth in exports has proven that it is feasible to export HTFA treated breadfruit. However, the performance has been well below market potential and the projections of Natures Way Cooperative Strategic Plan (Figure 3). The Plan makes optimistic projections for breadfruit treatments. These were 20 tonnes (2002); 100 tonnes (2003); 100 tonnes (2004 and 2005); and 150 tonnes (2006).

These projections were based on a combination of positive indicators:

- proven suitability to HTFA treatment;
- the existing production base;
- a large New Zealand market is already in place;
- Australia offers similar market potential to New Zealand; and,
- the possibility of entry into the United States market.

Achieving breadfruit's market potential will depend on:

1. Moving from wild harvesting of fruit to growing breadfruit as a crop.

2. Introducing appropriate quality control and postharvest handling procedures

This manual is intended to assist growers and exporters to contribute to this process.

The current production base

In 1966 Dominiko Koroveibau named 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 have been exported are Uto Dina and Bale Kana. These two varieties have good keeping and eating qualities.

Breadfruit in Fiji is not yet grown as a crop, it is either grown "wild" in forests, in household compounds or around villages. According to the last comprehensive Agricultural Census (1991), there were 183,000 bearing breadfruit trees.

Fruit currently exported is harvested from small groves of trees from 3 locations:

1. Vaivai behind Lautoka
2. Bila Levu near Nadi
3. Mavua in the Sigatoka Valley

Uto Dina from Vaivai near Lautoka

1. Vaivai (behind Lautoka) - a round uto dina variety type (probably kasa leka; Koroiveibau p, 21) of small to medium size fruit. Around 70% of current exports are obtained from the Vaivai area. The fruit is harvested from trees 15 – 18 metres (50' to 60') high. This variety has proven to have good eating and keeping quality.

Harvesting at Bila near Nadi

Recommendation: Vaivai should be used as a source for planting material for breadfruit orchards.

2. Bila (near Nadi) - described as a medium sized oblong bale kana "type" (probably bale kana dina). The fruit is harvested from 10 – 15 metre (30' to 40') trees. Proven to have good eating and reasonable keeping qualities. However, keeping quality does not appear to be quite as good as fruit sourced from Vaivai.

3. Bila Levu, Mavua (Sigatoka Valley) – wide variety of types.

A package of practices to achieve export quality production

This manual presents a package of practices for the current situation (the collection of breadfruit from registered scattered trees) and for the future situation (small breadfruit orchards specifically planted for the export market).

1. Locations best suited for breadfruit production

Agronomic conditions

Breadfruit grows best at altitudes below 600-650 metres and flourishes in temperatures between 21-32° C (Breadfruit Institute 2005). Optimum annual rainfall is 1500-3000 mm. Best yields will be achieved in deep, fertile, well-drained soils. There is evidence that prolonged dry weather inhibits flowering and therefore decreases production. A site with consistent rainfall could avoid this problem.

Proximity to the Nadi International Airport

Breadfruit for export is sorted and graded at the exporter's packing shed. It is then taken to Natures Way's HTFA facility at the Nadi International Airport for quarantine treatment and packing. Due to its perishability breadfruit needs to be harvested from locations that are within two hours drive to the Nadi International Airport and that preferably have good road access.

A range of breadfruit varieties at a Sigatoka Valley pack-house

2. *Varieties suitable for export*

Desirable characteristics for breadfruit for fresh export are:

- good eating qualities when harvested at the mature green stage, particularly from the perspective of the Samoan community;
- good keeping qualities when harvested at the mature green stage, including tolerance to the HTFA quarantine treatment;
- smaller uniform size (when mature) – preferred for quarantine treatment, packing, shipping and marketing; and,
- a fruiting season(s) that would allow for extension of the marketing period.

A number of the uto dina and bale kana variety types have proven to have these characteristics. Koroiveibau describes some of these types as follows:

'Uto Dina' Leaf moderately deeply dissected on upper half. --- fruit oblong; to 15 cm (6 inches) long and 7.5-9 cm (3 to 3 1/2 in) wide; seedless; skin slightly rough to smooth at mature stage; green to yellowy green at the mature stage;

stalk 2 to 3 inches. ---- eating quality very good – recommended as the best variety - need not be peeled after cooking --- fruiting time Jan, Feb/March/April/May ---Tree 18-21 m (60 to 70 ft) high.

'Uto Dina' Leaf moderately deeply dissected on upper half — fruit round; 11.5-12.5 cm (4 1/2 to 5 in) wide; seed less; skin slightly rough to smooth at mature stage. Highly recommended. -- fruiting time Jan to March/April/May -- Tree 7.5-9 m (25-30 ft) tall.

Uto Dina

'Uto Dina'('Kasa Leka') Leaf deeply dissected --- fruit round; 10 cm (4 ins) long; seedless; skin slightly rough to smooth at mature stage; green to yellowy green at the mature stage. – eating very good ---fruiting time Oct to Dec. ; Jan – March. --- Tree 12 to 15 m (40 – 45 ft) tall

'Bale Kana Dina' Leaf moderately dissected--- fruit oval; 15-20 cm (6 to 8 ins) long, 7.5-12.5 cm (3 to 5 in) wide; seeds sparse, skin rough to moderately rough when mature. - eating very good, considered as the best variety especially when boiled. --- fruiting time Dec to March/April to May.

Bale Kana

'Bale Kana' (Bale Kana "Waikava" or "Samoa Lailai"). Leaf deeply dissected – fruit oval; 10 cm (4 ins) long, 7.5 cm (3 in) wide; seedless; green to yellow and moderately rough when mature. eating very good; excellent keeping quality - highly recommended as best quality. tree 21-24 m (70 to 80 ft) high. --- fruiting time Sept. – Dec/Jan - March.

Samoa currently exports two varieties: ma'afala and puou. Ma'afala would appear to be similar to Bale Kana in fruit appearance, eating qualities and

keeping. Puou has close similarities to round uto dina currently harvested from Vaivai.

All of these varieties appear suitable for establishing small breadfruit orchards. The Ministry of Agriculture Sugar and Land Resettlement (MASLR) Research Division is currently collecting and testing varieties from throughout Fiji with the view of extending the seasonal availability of acceptable varieties. Some promising initial results have been achieved. For example the variety known as "Uto Yasawa" collected from tress near Vuda has has shown promising results in terms of keeping and eating quality and tolerance to HTFA treatment.

Puou in the Apia market

Uto Yasawa

Planting breadfruit orchards

The future development of a fresh breadfruit export industry will depend on harvesting fruit from small orchards. Harvesting fruit from orchards allows for improvements in:

- production through the adoption of appropriate agronomic techniques (propagation, pruning and fertilizing);
- control measures for fruit flies (more efficient and lower cost bait spraying);
- harvesting (easier, less dangerous, less damage to fruit, better sap control); and,
- post harvest handling (improved fruit selection and better packing).

A breadfruit orchard at the Atele Horticulture Center in Samoa

Orchards of 10 to 20 trees are envisioned. The only experience with commercial breadfruit orchards is in the small Eastern Caribbean countries of St Lucia, Barbados, Grenada, Dominica and St. Vincent. These countries export breadfruit to the expatriate West Indian populations in the UK and Holland. In some years these exports have exceeded 1,000 tonnes, giving an indication of the potential scope of a breadfruit export industry.

Requirement: The future development of a fresh breadfruit export industry requires farmers to plant and maintain small orchards.

Propagation

There are three common ways to propagate breadfruit trees.

1. Root suckers
2. Root cuttings – for bulk multiplication of breadfruit plants
3. Aerial layering (also known as marcotting)

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. Some varieties produce a lot more root suckers than others. Some varieties such a bale kana have a greater tendency to produce root suckers.

Root suckers

When the shoot is more than 0.3 meter high, cut the root 100 mm on either side of the sucker. Using a spade gently lift the cut section of root together with the sucker from the ground. The complete plant can be removed and planted in a damp shaded area in a nursery. It should remain in the nursery until it has developed a strong root system of its own.

Tip. The young plant can be planted directly into the new orchard if it is well watered and cared for. It should not be allowed to wilt. If directly transplanted into the field, the sucker should be placed in a hole containing plenty of organic material.

Root Cuttings

This method is used for mass propagation of planting material. It is best to collect roots after the fruiting season is over and when the tree is in an active vegetative stage, producing new leaves. Select healthy roots growing slightly below the soil that are 1.5 to 6 cm in diameter (3-4 cm is best). Cut into 12 to 30 cm long sections. Roots should be scrubbed clean and kept moist. Plant directly into the ground in loose, organic soil or in a pot with well-drained soil. Roots can be oriented horizontally below the surface of the soil or diagonally with the upper few centimeters exposed to air. Make sure that the end that is cut

Root cuttings

from closest to tree is the one that goes into the ground. To avoid confusion the tip end should be cut diagonally.

Aerial layering

This method is used to achieve quick fruiting. Aerial layering involves taking young green branch 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. With appropriate training these will be high yielding trees, with fruit found close to the ground. Early bearing substantially increases the financial viability of a breadfruit orchard. On the down side, plants obtained from aerial layering tend to initially have weaker root systems that make trees more susceptible to uprooting from cyclones.

A tree obtained from an aerial layered seedling flowering within 12 months at Atele in Samoa

The method of air layering

Materials and tools required:

- A variety of breadfruit tree with a young shoot suitable for 'aerial layering'
- A small, sharp knife
- A plastic bucket to hold the soil/peat mix
- Soil/peat mixture – a half measure of each, mixed well, damp but not too wet. About two large handfuls are required for each 'layer'
  Clear plastic strips cut to about 250 mm x 200 mm
- Rubber ties. These may be cut from an old inner tube from a car or truck, about 250 mm x 15 20 mm

Step 1

Select a shoot. Using a sharp knife remove strips of bark about 75 mm long. Along this length all the bark and the soft cambium under the bark should be removed. Do not cut into the hard woody stem. Select newly developed shoots (2-4 cm diameter) and do not use the ends of branches that have previously flowered or fruited.

Step 2

Continue the bark removal right around the stem. ***Tip.*** It will help the process to cut a circle around the stem at the top and bottom of bark removed. After the bark has been removed, go to the next stage immediately.

Step 3

Hold a piece of clear plastic, cut to a convenient size. Apply the damp soil/ peat mix evenly around the stem as illustrated.

Tip. The plastic should be long enough to wrap around the stem twice. The soil/peat mixture should be damp but not so wet that water can be squeezed out of it. Clear plastic enables root development to be observed so that the branch can be cut from the parent tree at the correct time.

Step 4

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

Step 5

Using one of the pre-cut rubber strips, wind it tightly two or three times around the branch so that it holds the plastic sleeve tightly in place. (You will need someone to help you.) Knot the rubber strip twice so it will remain firmly in place. -Repeat the tying process for the bottom of the plastic sleeve. Using rubber allows the branch to expand as it grows. Tightly bound rubber keeps the moisture in, and unwanted water out.

Step 6

During the next few months roots will grow out into the damp soil mixture. When this happens, but before the soil mixture dries out, the branch can be cut below the bottom rubber tie. The bandage and ties are removed, and the rooted cutting planted in a nursery area or a plastic bag where it can be watered and easily cared for. The planting medium should be course weathered sand mixed with organic matter. Avoid the use of fine sand or sand that has been sourced close to the sea. While in the nursery, the roots will continue to develop. After a few weeks in the nursery the healthy plant will be ready for planting.

Planting and Spacing

Breadfruit seedlings should be planted in well-enriched holes around 40cm deep and 50cm wide. In the Caribbean, breadfruit is planted at a distance of around 8 to 12 meters. A wider spacing should be considered in Fiji for disease control and to allow for the intercropping. The Breadfruit Institute recommends a 12 – 14 meter distance for orchard planting in the Pacific Islands (Ragone 2004 p, 14). A "linear" orchard may be considered for farmers who plant trees in a single row along the boundary of their land or beside a river or creek.

Tree management

Fertilizer Application

No systematic work has been done on fertilizer application for breadfruit. The Breadfruit Institute recommends that at the time of planting the use of small amounts of slow release fertilizer (8-8-8) at the bottom of the hole (Ragone 2004 p, 9). Caribbean breadfruit growers often apply standard mixtures of NPK after each season. Once bearing age is reached, 2kg of superphosphate is often applied annually to improve fruit quality. Coronel (1983) recommended the application of 100 – 200 g ammonium sulphate per tree 1 month after planting and then again at 6 months. To avoid fertilizer burns in the first year, keep fertilizer at least 500 mm from the trunk of the tree. This amount should be gradually increased until the plants start to bear fruit; then 50 – 100 gms of complete fertilizer should be applied to each tree twice a year. Breadfruit roots grow shallow and stretch far out. It is important to fertilize the tree as far out as the leaves reach to get maximum benefit. Trees can also benefit from a good composting and mulching program. The economic benefits from fertilizer application to breadfruit in Fiji needs to be researched.

Care of existing trees

For the next few years breadfruit for export will continue to come from existing trees. 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 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.

A well pruned breadfruit tree in Sigatoka

Heavy pruning of an existing breadfruit tree

Yields

The Breadfruit Institute reports that under orchard conditions breadfruit yields range from 16 to 50 tonnes per hectare (or 160 to 500 kgs per tree) based on 100 trees/ha. Research is required to more accurately determine the yields that might be expected in breadfruit orchards.

Plants obtained from root suckers can commence fruiting in two years, provided they are planted out in good soil. Full production will be achieved in 4 to 5 years. Plants obtained from aerial layering can start flowering within a year, with some production achieved in the second year. Full production can be achieved in 3 to 4 years. Breadfruit usually fruits twice a year.

Pests and diseases and their control

Fruit flies

In Fiji, breadfruit is a host to the fruit fly species, *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[1] 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 Natures Way Cooperative facility at Nasoso Rd Nadi Airport.

[1]Full details of the New Zealand pathway can be found in "Procedures for the Export of Breadfruits from Fiji to New Zealand" available from Fiji Quarantine.

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. Because the bait attracts the flies, it is not necessary to spray the entire foliage. This reduces the risk of pesticide residue in the fruit a well as the loss of pollinators and other desirable insects.

The baitspray component of the breadfruit pathway requires:

- 15 mls of protein bait and 4mL malathion per litre of water.
- 10m 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).

Baitspraying is a mandatory requirement for the export of breadfruit. All care must be taken to ensure that baitspray 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.

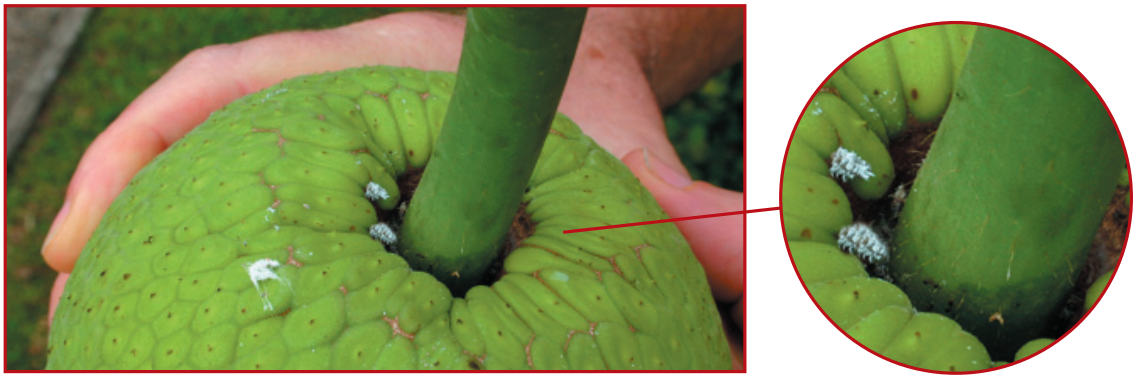
Requirement: Farmers and exporters must ensure that bait spraying procedures are correctly followed.

Other quarantine 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.

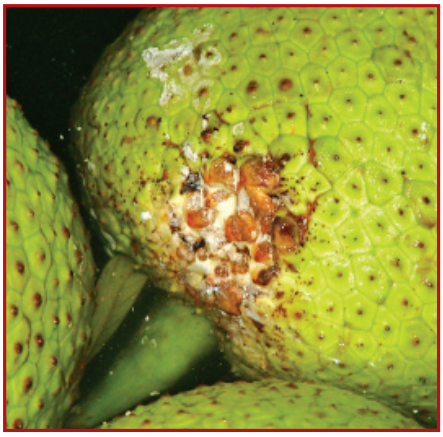
Requirement: Insect such as scale and mealybugs must be removed in a way that does not damage the sensitive skin of the fruit. Do not use a pressure hose to remove insects.



Mealy bug

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*).



Phytophthora fruit rot

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

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 minimize 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 minimize 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).

Harvesting

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 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.

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 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.

A green mature Uto Dina suitable for export

The time of harvest

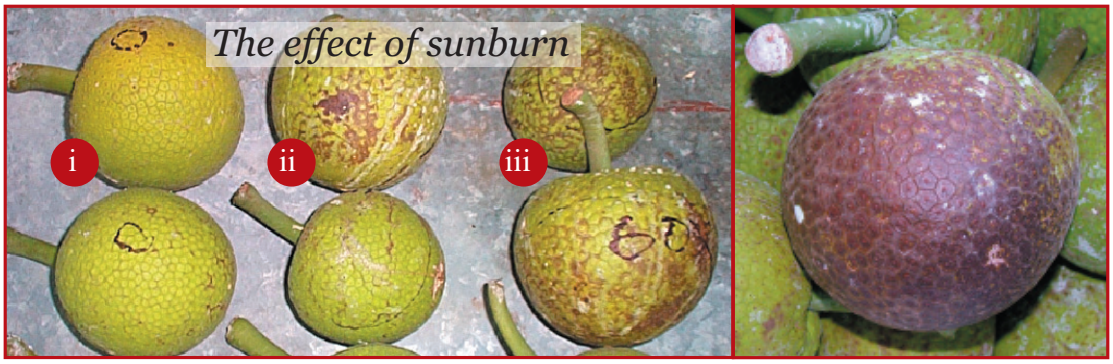
Breadfruit ideally should be harvested early in the morning, or late in the afternoon, to avoid build up of field heat. However, harvesting and treatment schedules need to be linked with airline timetables. Also the harvesting of breadfruit from wild scattered trees is a labour intensive activity, which can take 2 to 3 hours to harvest a tonne 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. Placing of leaves over the fruit can be a temporary protection form the sun until the bins are placed in full shade.

Requirement: Harvested breadfruit should never be exposed to direct sun.

Harvesting method

Current harvesting of breadfruit is often a difficult, time-consuming and sometimes a dangerous activity. Trees grow tall in forest environments (commonly up to 20m or more) in part due to competition for light and



i. No exposure to sun, ii. 30 min exposure to sun, iii. 60 min exposure to sun

The result of extreme sun burning

20m up the tree picking fruit !!!

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.

Recommendation: A safety harness should be used by pickers climbing high trees.

The selection of the fruits to be harvested appears to be somewhat arbitrary and dependent in part on the accessibility of the fruit irrespective of maturity and quality factors. Fruits are detached from the tree using a picking pole.

Two pole designs are currently used:

Once detached, the fruit are allowed to fall to ground level and may be caught individually by hand or, more commonly, caught in a tarpaulin held in each corner by a field worker. Often, several fruit

Bamboo pole with slot cut in one end to slide either side of the fruit peduncle or stem

Wooden pole with natural “hook” at one end

Top : A tarpaulin is used to catch the breadfruit.
Right : Fruit caught in a tarpaulin.

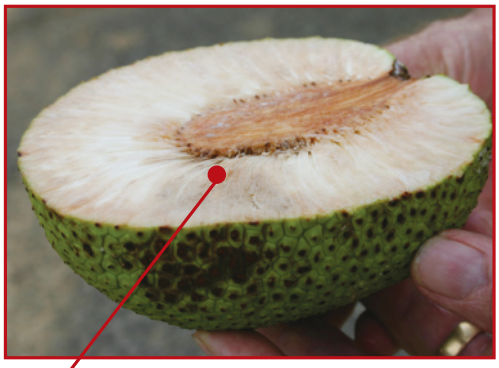
are allowed to accumulate before the tarpaulin is emptied. This results in fruit impacting against one another with a significant risk of fruit bruising. There is also a high incidence of sap, which exudes freely from the stem scar, covering a large area of the fruit's surface. To avoid risk of bruising and the spread of sap, each fruit should be removed from the tarpaulin as it is 'caught' by another worker.

Recommendation: Fruit should be removed immediately from the tarpaulin before another one "hits".

Fruit that has fallen to ground should not be presented for export. The impact will result in bruising. Bruising will not immediately be apparent – but will later lead to discolouration and premature softening of the fruit.

Recommendation: Fruit that falls to the ground should not be presented for export. It is only when orchards are established with trees bearing close to the ground so that efficient harvesting that does not damage the fruit will be possible.

Requirement: Breadfruit orchards are required for the efficient harvesting that does not damage the fruit.



A internally bruised fruit from hitting the ground

Postharvest handling

In-field handling

Sap management: "prevention is the best form of cure"

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.

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.

Sap as an indicator of maturity

Unsightly sap that oozed from the stem

Tissue used to stop sap flow

Breadfruit transported using plastic field bins

The following simple and effective measures virtually eliminates ooze-sap from harvested fruit:

- remove each fruit from the catching tarpaulin immediately after it falls;
- 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;
- wrap a wad of tissue-type paper around the end of the fruit stem to absorb ooze sap and

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 e.g. 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.

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

Use of plastic field bins

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 breadfruit. They are also difficult to clean and allow for the build-up of damaging organisms and pathogens with repeated use.

Using a sack to remove fruit from the field : A NO NO!

Using plastic field bins to transport breadfruit from the field: A MUST!

Worst of all, bags offer no compaction protection for the fruit which results in bruising and a further spreading of the sap.

Even in the most difficult terrain, breadfruit must be placed in plastic crates for removal from the field to the exporters pack house.

Requirement: Breadfruit must be removed from the field in plastic crates.

Handling in the pack house

Washing and cleaning fruit

Currently all exporters carry out some form of postharvest 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 but with 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.

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. 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 to remove insects and foreign matter.

The cleaning by scrubbing or brushing is an unsatisfactory procedure to remove sap

Water blasting to remove mealy bugs – not recommended

The result – more sap and damage to the fruit

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.

Soaking of fruit

Throughout the Pacific Islands the immersion in water is a traditional method for holding harvested breadfruit to prevent premature softening. Research by Worrell and Carrington (1997) in Barbados found that fruit submerged and held at 13°C, 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.

Overnight soaking of fruit by a Sigatoka exporter

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

Selection and grading

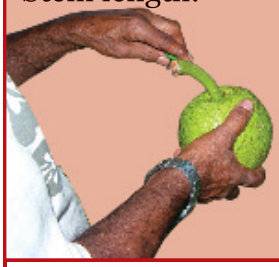
It is the responsibility of exporters to select and grade fruit in the pack-house. In grading it must be remembered that importers require:

- consistency in quality
- consistency in size grading

The following grading guidelines apply:

General:	Fruit shall be: Whole, well formed and firm and be free from surface moisture or contaminants.
Pests and diseases**:**	All fruit shall be free of visible signs of insects or disease.
Variety:	The current recommended varieties for export are uto dina and bale kana. Each carton should contain breadfruit of only one variety that are typical in shape and colour for the variety.

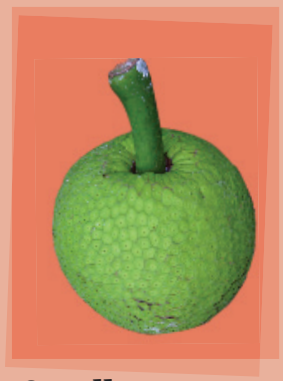
Maturity: 	Only mature green fruit should be packed. Small dark green fruit (< 100 mm radius for uto dina) is not acceptable. It is not acceptable for eating or for quarantine treatment. Spongy fruit, and the colour change indicative of ripening is not acceptable. **◀ Small (< 100mm) immature fruit unsuitable for export**
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. Requirement: Handle fruit carefully. Fruit dropped on the ground during harvest should not be presented for export.
Fresh physical damage:	Fruit should be rejected that 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 healed 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 shall be 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 possible 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

Sizing (cont..):

Large > 140 mm diameter

Medium 120 mm to 140 mm diameter



Small 100 mm to 120 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.

Quarantine treatment

Before fresh breadfruit can be exported from Fiji it must undergo high temperature forced air HTFA treatment at Nadi Airport. HTFA treatment involves slowly heating the fruit until the temperature required to kill fruit fly eggs and larvae is reached (47.2 °C) 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.

HTFA treatment is undertaken by Natures Way Cooperative, which 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 $50 to join the Cooperative.

The primary function of Natures Way Cooperative 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.

Probe being inserted in the largest fruit prior to HTFA treatment

Too much variation in fruit size for a given treatment also does not allow for efficient treatment.[2]

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 baitspray program. A transfer form is then signed that authorizes 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.

Packaging for export

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, cost effective cartons for export breadfruit.

[2]Four temperature probes are placed in the largest fruit in "coolest" spot in the treatment chamber. All four probes must satisfy the minimum quarantine requirement (47.2°C for 20 min.) for an approved treatment. If there is a large range in fruit size, the smaller fruit will tend to be over treated.

Current packing practice at NWC

Failed cartons arrive with Auckland importer

Best Practice : Waxed cartons with 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 fibreboard.

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

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

Post-HTFA storage

Chilling injury

Refrigeration of HTFA-treated breadfruit is not routinely practiced in Fiji.
Currently all breadfruit exports are air freighted and movement of the produce as quickly as possible to the market is the priority. 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.

The financial returns from commercial breadfruit production and marketing

Growing breadfruit for export

A financial model for a breadfruit orchard of 20 trees is developed in Table 1. It is assumed that a household using entirely its own labour operates the orchard. The trees are planted at a 12-m square spacing, requiring an area of approximately 0.3 ha. The wide spacing is to minimize the incidence of fungal disease problems and to allow for inter-cropping. Seedlings derived from aerial layering are planted. Some production is realized in the second year, with full production achieved in 4 years.

Yield estimates are based on the limited information available for the Caribbean and other sources. The yield estimates are regarded as conservative and need to be refined as reliable yield data for breadfruit orchards in Fijian conditions becomes available. It is assumed that no fertilizer is applied, although subsequent research may show that applying fertilizer is economically worthwhile. A farm gate of $0.50/fruit ($0.45/kg) is assumed. This is the price currently paid for fruit picked from scattered trees. The quality of fruit from the orchard can be expected to be superior with a lower rate of rejection at the exporter's pack house.

Over a 16 year period the average annual labour input of the household is 37 days. The estimated average annual gross margin from the 20 trees is $1,200 (or $60/tree). The estimated return to household labour is about $33/person day. Some additional income from inter-planting other crops in the first 3 years can be expected. The returns are high because of relatively low labour requirement for breadfruit production.

The estimated financial returns are sensitive to yield. If marketable yield could be increased by 50 %, the following results are achieved:

Average annual gross margin per area - .3ha ($)	1,671
Average annual gross margin per tree ($)	84
Returns per family day of labour ($)	38

These results suggest that research into the economic returns from fertilizer application would be justified.

Table 1: A financial model for a 20 tree breadfruit orchard

Year	1	2	3	4	5	6
number of trees @12mx12m	20	20	20	20	20	20
marketable yield per tree (no of fruit/tree)	0	15	75	150	150	150
marketab le yield per tree (kg)	0	16.5	82.5	165	165	165
total marketable production (kg)	0	330	1650	3300	3300	3300
Sales ($) @ $0.45/kg	0	148.5	742.5	1485	1485	1485
Cash expenditure ($)						
grafted seedling 20 @ $2 each	40					
harvesting and pruning equipment						
stick picker (@ $30 each)			30			
prunning saw (@$30 each)		30				
pruning lopper (@$100 each)			100			
ladder (@ $200 each)			200			
plastic field bins ($20/each)		80	40		20	
Total cash expenditure	40	110	370	0	20	0
Gross margin ($), excluding labour	-40	38.5	372.5	1485	1465	1485
Family labour (person days)						
Clearing	8					
Cutting, lining and digging holes	3					
Planting	1					
Weeding	6	5	4	3	3	3
Pruning	0					
Bait spray application		10	10	10	10	10
Harvesting, sap control and packing in filed baskets (150 kg/day)		2.2	11	22	22	22
Total labour input	18	12.2	21	32	32	32
Average labour input/annum	37					
Imputed cost of labour at $20/day	360	404	600	800	800	800
Average annual gross margin per area - .3ha ($)			**$1,212**			
Average annual gross margin per tree ($)			**$61**			
Returns per family day of labour ($)			**$33**			

	7	8	9	10	11	12	13	14	15	16
	20	20	20	20	20	20	20	20	20	20
	150	150	150	150	150	150	150	150	150	150
	165	165	165	165	165	165	165	165	165	165
	3300	3300	3300	3300	3300	3300	3300	3300	3300	3300
	1485	1485	1485	1485	1485	1485	1485	1485	1485	1485
		30								
	30									
		100								
	20		20		20		20		20	
	50	130	20	0	20	0	20	0	20	0
	1435	1355	1465	1485	1465	1485	1465	1485	1465	1485
	3	3	3	3	3	3	3	3	3	3
	10	10	10	10	10	10	10	10	10	10
	22	22	22	22	22	22	22	22	22	22
	32	32	32	32	32	32	32	32	32	32
	800	800	800	800	800	800	800	800	800	800

Exporting breadfruit

The model in Table 2, is for an exporter shipping a tonne of breadfruit to New Zealand. This exporter meets all marketing costs to the point the breadfruit lands in New Zealand. Some importers will pay for freight, deducting this amount from what is paid to the exporter. The model is based on landed price in Auckland of $F3.10/kg, derived from a retail price of $NZ4/kg ($F4.80/kg). Current (March 2005) retail prices for breadfruit are around $NZ6/kg. However, as supplies increase more modest prices can be expected.

The exporter ships his breadfruit in an LD3 container (1,430 kgs) shared with other HTFA treated products. The March 2004 Air Pacific "Incentive" freight rate of $1, 270 (including all other charges). Waxed cartons are used with a net weight of 12 kgs.

The breadfruit is purchased from orchard growers. A 10% reject rate in the packing shed is applied – which is lower than might be expected when fruit is sourced from scattered trees.

Table 2: Returns from exporting 1 tonne of breadfruit to New Zealand

	$/kg purchased	$/kg exported	$/carton exported	$/t exported
Costs				
Breadfruit purchased (1.1tonnes @ $0.45/kg)	0.45	0.50	5.94	495.00
Purchase of bait spray for grower ($50/ltre required for 1 tonne purchased)	0.05	0.05	0.60	50.00
Checking breadfruit at farm(1 person for 3 hours)	0.01	0.02	0.18	15.00
Cartage to the pack-house ($40)	0.04	0.04	0.48	40.00
Depreciation allowance for plastic crates ($100)	0.09	0.10	1.20	100.00
Grading and sorting at pack-house (3 people for 3 hours)	0.03	0.03	0.33	27.50

Transport to HTFA facility ($40)		0.05	0.60	50.00
Quarantine treatment and packing (40c/kg)		0.40	4.80	400.00
Carton (waxed with dividers $3/ carton 12 kg net weight)		0.23	2.73	227.27
Telecommunications ($10)		0.01	0.12	10.00
Electricity ($400 spread over 20 tonnes)		0.02	0.24	20.00
Pack house rental $150/month for 3 months spread over 20 tonnes)		0.02	0.28	23.00
Fixed labour costs ($500/month over 3 months spread over 20 tonnes)		0.08	0.90	75.00
Total fob costs		**1.53**	**18.39**	**1532.77**
Freight to New Zealand				
$1,270 for LD3 (AirPac Incentive Rate March 2005) 1,430 kgs shared with other products)		0.89	10.66	888.11
New Zealand fees (documentation and inspection) $F150		0.15	1.80	150.00
Total cf costs		1.04	12.46	1038.11
Total costs		**2.57**	**30.85**	**2570.88**
Revenue				
New Zealand landed price (@NZ2.60/kg) $1NZ=$F1.2		**3.12**	**37.44**	**3120.00**
Exporter gross margin		**0.55**	**6.59**	**549.12**
Exporter margin as percentage of total costs		**21.36%**		

This particular exporter earns a gross margin of $0.55 kg of breadfruit shipped, or $555 per 1,000 kg consignment. This represents a 21% return on the total expenditure on the shipment. Over a year a breadfruit exporter would look to make 20 shipments, which would generate a net return around $11,000 for the year.

An assessment of risk

Growing and exporting breadfruit is shown to give an attractive rate of return provided reasonably high yields are achieved. These rates of return would appear to more than compensate the risks involved. However, there are risks inherent in planting a long-term tree crop for export markets.

Cyclones

The most obvious risk factor for any tree crop is cyclones. In a major cyclone, breadfruit trees lose their fruit, leaves and major limbs. However, breadfruit recovers from cyclones faster than most other tree crops. Clarke describes the recovery of breadfruit in Samoa following the devastation of Cyclone Ofa in the early 1990s:

> Observation three months after the cyclone were that trees still standing and even many of those blown over were refoliated. Many trees in villages had a dead or damaged limbs pruned off and had a new flush of leaves up the trunk and remaining branches. Shoots coming from roots of fallen trees took a few months to come up to the size ready for transplanting. There was an abundance of these to replace fallen trees. Most trees flowered later and were bearing a heavy crop of immature fruit by October. The first mature fruit after the cyclone were seen in the Aleipata area (Clarke p, 71).

Depending on the severity of the cyclone the breadfruit orchard could expect to be back in full production within a year.

Diseases

Scattered breadfruit trees do not face significant disease problems. Brown stem rot (*Phellinus noxius*) is known to kill breadfruit trees, with the danger of infection accentuated in an orchard situation. However, it is anticipated that this risk is minimized with the wide spacing (12m x 12m) that is proposed.

Quarantine

Fiji's industry operated quarantine facility is highly reliable and posses little risk. Since the beginning of NWC quarantine treatment operations in 1996 over 5,000 tonnes of fruit have been treated. During this period there has never been an interception of a live fruit fly larvae and eggs.

If correct bait spray procedures are not followed, fruit fly eggs may be present on some of the fruit. The HTFA treatment, doing its job, will kill the eggs. However, should inspection by New Zealand Quarantine discover just one egg, "dead or alive" verification will be required. Such verification usually takes 3 days. The loss of 3 marketing days would be disastrous for a breadfruit shipment and a complete write off could be expected. Importers, exporters and growers all share this loss. Importers lose because they do not have breadfruit to sell. Exporters have purchased fruit from farmers, paid for packaging and quarantine treatment and paid for air freight. The landed value in New Zealand of a tonne of breadfruit was shown to be nearly $2,600 (table 2). To this lost money has added the cost of disposing of dumping the breadfruit in New Zealand. It will take 5 additional shipments before the exporter can recover his loses. With this experience the exporter may decide to cut his loses and leave the breadfruit export industry. Farmers have no market if exporters decide to suspend breadfruit shipments.

Requirement: Extra diligence is required on the part of farmers and exporters to ensure that all bait spray procedures are strictly adhered to.

Fruit softening

Once ripening has commenced, breadfruit it is inedible. The transition from firm to soft happens quickly, with breadfruit going soft in a matter of hours. If softening happens when breadfruit is still with the wholesaler or retailer, claims for compensation can be expected against the exporters and future orders may be curtailed.

Recommendation: To minimize the risk of fruit softening in the market, growers and exporters need to closely follow the guidelines presented in this manual.

The role of inter-cropping

Planting breadfruit will give a good average return to household labour. However, it takes 3 to 4 years before full production is achieved and might be viewed as too long by most households; particularly if land and labour resources were scarce. The cash flow situation in the early years could be significantly improved by inter-cropping, with the wide spacing (12m x 12 m) that is recommended. Inter-cropping will also reduce the cost for breadfruit of weeding and other maintenance activities. Several rows of pineapples, bananas or papaya could be planted between the rows of breadfruit trees.

Recommendation: Farmers should intercrop breadfruit with short term food and cash crops to improve the cash flow in the early years of the orchard.

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