Australian Government
Australian Centre for International Agricultural Research

Final report

project

Cost effective disinfestation treatments for Pacific horticulture

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1 Executive summary

The project was undertaken to assess the potential for use of disinfestation technologies in export crops of Pacific Island Countries (PICs) to satisfy the market access quarantine requirements of their major trading partners, Australia and New Zealand.

A number of agricultural commodities such as taro, ginger, yam, sweet potato and ornamentals have market access to Australia and New Zealand for some PICs (such as Fiji) but not for others. There is also the potential to export a new range of commodities. However, the inability to meet biosecurity requirements limits the capacity of PICs to export. Crops are often fumigated with methyl bromide before export and again on arrival in Australia or New Zealand when live insects, nematodes or snails are found, diminishing quality and shelf life or completely destroying the produce.

Good alternative treatments exist but need to be developed for local crops and conditions. Making available acceptable treatment technologies and facilities will encourage growers and exporters to increase volumes and the range of commodities traded.

The need and scope of the project was assessed through site visits and meetings with major stakeholders in Fiji including growers, Government regulatory, extension and research staff, Secretariat of the Pacific Community (SPC) experts, commercial exporters, and marketing agencies.

Priority crops were identified as taro, cutflowers and foliage. Fiji was identified as the priority country in which to initiate the project since it has the most experience in exporting agricultural produce and has the best infrastructure to conduct research, development and extension.

Fiji is proposed as a priority country. This will be followed by other PICs such as Samoa, possibly Tonga, and PNG as the research-and-development (R&D) and export programs are developed and experience gained in the new technologies.

The disinfestation technologies with the best potential to satisfy quarantine and quality criteria after treatment were identified as hot water treatment (HWT) for taro and some species of cutflowers; and fumigation using a commercial ethyl formate gas mixture (Vapormate) for external insects of taro roots, leaves, cutflowers and ornamental foliage.

The appropriate lead organisation is the Department of Agriculture and Food, Western Australia, working jointly with SPC as the in-country project co-ordinator and implementer.

The main collaborators are the Ministry of Agriculture, Fiji especially the research, extension and quarantine services.

Commercial partners are all the major exporters of taro and specialised floriculture grower exporters.

The outcomes of this study are: (i) a revision of the disinfestation project proposal to allow it to proceed to Phase 2 of implementation by cooperating agencies; (ii) a methodology for research on HWT and fumigation to achieve market access; (iii) an approach towards improving the post farmgate supply chain process for taro and cutflowers; (iv) a methodology for commercial development of the selected disinfestation treatments; and (v) a process of training Fijian staff for scientific capacity building.

Action is required to present the revised project proposal to all collaborating parties and institutions and negotiate service delivery and implementation.

2 Background

In Fiji and other PICs, increasing numbers of smallholder farmers and their communities are involved in the production and export of agricultural and horticultural produce, including root crops, fruits and vegetables, and flowers, offering numerous opportunities for commercial development and employment, in transport and processing, as well as production. However, the profitability of current commodity chains is threatened by a number of quality problems (including frequent interceptions and enforced fumigation of consignments) that threaten the viability of those chains for all actors. Clearly, disinfestation procedures are a key problem. On the other hand, the exact nature of the problem (pest species involved, their status in relation to the regulations of importing countries, their interaction with other quality problems) and their place among other supply chain problems is poorly defined by the research-and-development community and scarcely understood by the commodity chain actors themselves. This scoping study is intended to clarify the researchable issues and open the way for research investment (an ACIAR project) and then for investment by the private sector and others.

Historical and cultural ties, as well as geographical proximity, make Australia and New Zealand the major trading partners of Pacific Island Countries (PICs). The Australian and New Zealand Governments, via the PACER (Pacific Agreement on Closer Economic Relations) arrangement through the Pacific Islands Forum Secretariat (PIFS), Pacific Islands Trade and Investment Commission (PITIC), and the Secretariat of the Pacific Community (SPC) have been assisting in encouraging increased trade between PICs, as well as with Australia and New Zealand.

A number of agricultural commodities such as taro, ginger, yam, sweet potato and ornamentals already have market access to Australia and New Zealand for some countries (such as Fiji) but not for others. There is also the potential for PICs to export a new range of commodities. However, the PICs' inability to meet biosecurity requirements limits their capacity to export. It is therefore anticipated that making available acceptable treatment technologies and facilities will encourage growers and exporters to increase volumes and the range of commodities traded.

A preliminary project proposal was developed for an R&D project looking at the development of HWT disinfestation protocols for Pacific crops. This proposal was submitted to IHR 196 on the 27 July 2008. The IHR group supported the proposal in principle but was of the view that the project needed to be modified to look at other disinfestation treatments in addition to HWT, that the priority commodities and countries needed to be confirmed and that the appropriate lead organisation, collaborators and commercial partners should be reconsidered.

The IHR supported the proposal moving to Phase 2 subject to the implementation of a scoping study which would:

- Confirm the priority commodities and countries.
- Identify the appropriate disinfestation treatments to be included in the project.
- Identify and confirm the appropriate lead organisation, research collaborators and commercial partners for the project.

3 Objectives

Within the broader development goal of facilitating the export of the products of smallholder agriculture and horticulture products from selected Pacific Island countries and establishing commodity chains that help to improve the livelihoods of resource-poor producers and their communities, the specific purpose of this SRA is to clarify the R&D strategy for a full-scale project on developing disinfestation protocols for such commodities and products, based on a proposal for such a project previously submitted to ACIAR by SPC.

To achieve this purpose the SRA had the following objectives:

- Confirming the priority commodities and countries, bearing in mind the volumes of commodities currently being traded, the potential for increase and the existing constraints on the present commodity chain (i.e. is disinfestation the main obstacle or just one among many?).
- Identifying the appropriate disinfestation treatments to be included in the project, bearing in mind the priority commodities, their relevant pest and disease problems, and the impact of these problems on trade.
- Identifying and confirming the appropriate lead organisation, research collaborators and commercial partners for the project, bearing in mind their management and research capacity and their relationship to existing commodity chains.

4 Methodology

The field work was done in Fiji since the project proposal under assessment for revision was planned for implementation in Fiji as the PIC most advanced in exporting the target crops to the desired markets. A successful outcome in Fiji will provide the basis for transfer of technology to other PICs; however, this does not exclude the possibility of including other countries, on a pilot basis, as a full project proposal is finalised.

In the course of a one-week field visit to Fiji, in consultation with the SPC and the ACIAR Pacific Crops office, the Consultant met and gathered information from (and regarding):

1. Fiji public sector decision-makers and managers involved in Planning, Quarantine, Research, Extension and commodity marketing (concerning commodities currently important or considered as important targets for development)
2. Researchers at SPC and at government facilities at Koronivia and Sigatoka (including assessment of facilities and capacity)
3. Commodity chain actors including farmers, transporters, traders, processors and exporters (including visits to pack houses, existing disinfestation facilities, processing facilities) – focusing initially on taro and taking into account other actual or potential commodities (flowers, fruit, other root crops), depending on the advice received along the way.

On returning to Australia, the consultant gathered information from key contacts in regulatory and research agencies in Australia and New Zealand, especially concerning the need for further data collection in relation to disinfestation protocols for commodities exported from PICs and their associated pest and disease problems.

5 Key results and discussion

5.1 Key results

The results of the investigations of this consultancy are given in the form of conclusions and recommendations for further R&D investment by ACIAR and partners.

The proposal previously submitted by SPC to ACIAR (Alternative Disinfestation Treatments for Fresh Produce Commodities from Pacific Countries. HORT/2007/118) has been revised based on the findings of this consultancy.

5.2 Discussion

5.2.1 Potential outputs of the proposed project

- New disinfestation technologies and data packages suitable for overseas quarantine authorities to permit market access for taro and cutflowers using hot water and fumigation treatments.
- Treatments selected will cause little or no damage, make the produce more marketable, give it a longer shelf life and increase profitability to growers and exporters.
- The detailed results of the project will be written up in various formats suitable for publication and the extension of the treatments to additional users.

5.2.2 Potential outcomes of the proposed project

- Training and capacity building in Fiji to undertake the R&D of quarantine disinfestation treatments for market access (including that needed for additional products).
- Training in insect, mite and nematode rearing techniques and establishing disinfestation facilities.
- Training of one or more staff in Fiji and Australia in the science of postharvest disinfestation potentially leading to a higher degree qualification, in collaboration with the University of Fiji and the Research Institute of the Fiji Department of Agriculture.
- The detailed results of at least one successful treatment each for taro and cut flowers will be presented to Australia and New Zealand for market access.
- The treatments developed in the project will reduce the rate of rejection or requirements for re-treatment in Australia, New Zealand and USA and other countries due to live insects by more than 80%.

6 Conclusions and recommendations

This scoping study addresses 6 issues: priority crops; priority countries; biosecurity concerns; appropriate disinfestation; R&D partners; and commercial partners.

6.1 Conclusions

A consensus was found among all parties: SPC specialists, Fiji Department of Agriculture directors and staff (research, quarantine and extension), commercial operators, exporters and non-profit ventures on the main areas of concern.

6.1.1 Priority crops

Taro, cutflowers (and ornamental foliage) are the priority crops for export because they directly benefit those most in need of support - the vast majority of growers in rural areas and socially disadvantaged women (single mothers and widows).

6.1.2 Priority countries

Fiji is the recommended priority country to initiate this project. It produces a large surplus of taro which has an increasing market in the PIC diaspora in New Zealand, Australia and USA. Fiji has the natural conditions to grow a wide variety of cutflowers and ornamental foliage that has a competitive advantage over other non-PIC countries (e.g. Mauritius, Singapore etc.) if disinfestation issues can be resolved.

Other countries that can benefit from a follow-up to this project are potentially Samoa, Tonga and PNG, based on the information available on exports to Australia and New Zealand and on the national R&D strategies of those countries.

6.1.3 Secondary crops

1. Root crops like ginger and cassava that are rotation crops with taro should be considered next in a system of reducing nematode load in the soil. This can be followed by sweet potato and yams which have fewer pests but different postharvest issues.
2. Other crops that will benefit from disinfestation are pineapples; native flowers not subject to CITES regulation; and over 30 species of vegetables that lose quality because of methyl bromide fumigation for live insects.
3. Fruit fly host crops. HWT is a potential low-cost option for heat treatment of fruitfly hosts. HWT may prove to be more suitable for some crops due to faster transfer of heat, reducing total treatment time and improving quality by controlling postharvest fungal infections.

6.1.4 Biosecurity concerns

The main interceptions in Australia and New Zealand are nematodes, taro mites, snails and soil. Other interceptions leading to methyl bromide fumigation are external pests including scales, mealybugs, mites, beetles, thrips, several species of ants etc. Disease infected taro leaves are occasionally found. Both New Zealand and Australia will welcome pest-free produce from PICs.

6.1.5 Appropriate disinfestation

Reducing the pre-harvest pest burden and achieving the best quality post farmgate to enable more effective disinfestation to be achieved requires attention to the whole system,

from selection of appropriate varieties, through production to market. This planning is underway for taro and will require that various stakeholders address:

- *Nematodes in soil* - HWT of ginger seed to reduce the amount of soil inoculum of nematodes for subsequent rotation crops taro and cassava, as well as to improve ginger yields and reduce nematodes in marketed ginger exports.
- *Soil* - Removal of soil on-farm from harvested taro to minimise loss in soil fertility, transport of soil to urban areas, and urban waste issues.
- *Handling* - Use of re-usable plastic bins in 50 to 500 litre capacities to preserve quality in transport, minimise multiple handling, and for ease in cleaning and disinfestation.
- *HWT* - An inexpensive suitable treatment for nematodes in the skin of fresh taro and in root hairs. It is also suitable for some cutflower species.
- *Ethyl formate fumigation* - A non-phytotoxic treatment suitable for external insects and mites in taro roots, leaves, cut flowers and ornamental foliage.

6.1.6 R&D Partners

The primary partners are the Fiji Ministry of Agriculture and the SPC with scientific advice and training provided by the Department of Agriculture and Food Western Australia.

Supporting partners capable of investment and advice are ACIAR related projects especially FACT.

Collaborating partners are the University of Fiji to assist with scientific capacity building, commercial exporters, women's development groups, AusAID and NZODA projects promoting self help (e.g. PHAMA). The Luta Co-operative (non-profit group) and the Fiji Agro Marketing Authority are interested in supporting this project and will be a good starting point for developing the farm to market systems approach of achieving quality in exports.

6.1.7 Commercial Partners

There are at least 12 taro and 2 cut flower exporters (including non-profit groups) who are very keen to develop the enormous potential in Fiji and other PICs to satisfy the requirements of overseas markets through successful disinfestation methods.

6.2 Recommendations

That the project will:

1. Develop good postharvest and disinfestation methods for export of taro and cutflowers.
2. Develop a capacity building strategy to achieve market access outcomes:

- Train collaborating staff in Fiji and Australia to conduct disinfestation R&D.
- Supply equipment to conduct laboratory work.
- Supply sufficient 50 – 500 litre bulk bins for transport of taro as a pilot project.
- Supply hot water treatment systems (2 cubic metres).
- Supply fumigation systems (in 20 or 40 ft refrigerated containers).
- Train in quality assessment methods for taro, cutflowers and foliage.
- Train in monitoring for regulatory certification.
- Prepare training manuals for R&D and commercial operators.

3. Make available disinfestation data packages to quarantine agencies in importing countries for their approval.
4. Make available disinfestation data packages and all scientific and commercial scale methods to other PICs for consideration in future funding by ACIAR and partners.

7 Appendices

7.1 Appendix 1: Briefing notes in Fiji after field visit

7.1.1 Preliminary de-briefing notes, Sunday 5 April 2009, at the end of Consultancy Visit: 30 March -6 April 2009.

Dr CPF De Lima

Meeting: 10:00 am 5th April 2009.

Purpose: Review project proposal and modify based on scientific requirements for market access and local capability. 5 issues: list of priority crops; biosecurity concerns, appropriate disinfestation; R&D partners; Commercial partners.

Present: Dr CPF De Lima (Consultant), Dr RH Markham (ACIAR), Mr Nacanieli Waqa (SPC)

Summary of findings

Priority crops: (1) **Taro** - is shipped to NZ on a regular basis but is often fumigated with methyl bromide leading to a decline in exports. The demand abroad remains high and successful treatments will greatly aid the rural economy in terms of employment as well as income. (2) **Ornamentals** – flowering gingers, heliconias, anthuriums, orchids, guzmanias, ornamental foliage, etc. are grown by women's groups and others. Disinfestation of pests will facilitate access in NZ, USA and Australia and income for displaced women. (3) **Crops for secondary focus**: ginger, cassava, yam, and sweet potato. Ginger root is an issue waiting Import Risk Analysis by Australia.

Biosecurity issues: taro (mites, mealybugs, nematodes, snails, soil, devitalisation); cutflowers (thrips, aphids, mites, mealybugs, ants, devitalisation, etc.); ginger (diseases). Other root crops may have common issues (also scale insects).

Disinfestation treatments: hot water dips (HWT); fumigation (ethyl formate BOC Gases: Vapormate®). Both treatments are to be used as surface treatments and will work well since the pests involved are attached to or within 2mm in the skin surface.

Soil: high pressure washing of taro by one exporter works well and preserves the fine root hairs that is a quality requirement. Waste disposal is a problem.

Devitalisation: physical topping and tailing of taro is a current issue and affects shelf life. An alternative will be looked into. Treatment of cutflowers may be required in Australia.

R&D partners: Several local partners exist in a number of fields -nematology, entomology, pathology, extension, floriculture, etc. These include the University of Fiji, the Department of Agriculture Research and Extension divisions, SPC / PIC. Local human resources dedicated to the project for conducting the day to day science and technology transfer is unavailable. Recruitment of 2 full time research officers is essential.

Commercial Partners: Several local partners exist and are anxious to participate.

- Taro supply chain: Taro is a hardy crop and takes (within limits) a great deal of rough handling. Although taro is grown almost everywhere in Fiji, most of the high quality pink taro is sourced from the island of Taveuni. Exports take place from several ports in Fiji and are dependent on the exporter's preferences. To provide community benefit, value adding by cleaning and processing taro for export near main community centres will preserve soil nutrients. Refrigerated containers are readily available and taro is held at 5-8°C while awaiting shipment to NZ. Transhipment time is 3 – 7 days. Both HWT and fumigation fit into this supply chain since they are short duration treatments (20 min HWT; 1-2 hours fumigation at 5 - 25°C).

- Cutflowers supply chain: this is a relatively small enterprise based in Suva and Nandi. The process is well understood by the main exporters who are helping to develop the women's group. Other opportunistic exporters exist. The insect pests listed can all be killed by Vapormate® fumigation and will not affect shelf life but small scale proving tests are required using local crops. Plain water will remove 70% of the external pests; hot water will kill some pests but may affect shelf life.
- The acceptable level of pest risk in importing countries will be an issue to resolve in developing quarantine treatment protocols for Fiji exports.

Summary of recommendations:

1. Focus on HWT and fumigation treatments for taro and cutflowers.
2. Prepare revised project draft targeting taro and cutflowers for discussion with AQIS, BA and MAF NZ to address their concerns and advice on minimum data requirements.
3. Finalise the project work program and budget including salary for project research officers, scientific equipment and small scale treatment plants (HWT & Fumigation) in discussion with SPC and ACIAR by 30 July 2009.

Other issues:

Other findings including those relating to HTFA data requirements for access to Australia of papaya, mango, egg plant and breadfruit will be discussed in the full report of this consultancy, for ACIAR and SPC future use. There are a wide range of vegetable crops that have potential for export. Currently they are exported opportunistically to NZ and are often fumigated with methyl bromide.

Discussion and Comments:

1. Provision of BSc & MSc scholarships will be a good way of recruiting scientific capability and training PIC staff.
2. One of the research officers should be from the Ministry of Agriculture to give the Fiji Government 'ownership' in the project.
3. Secondment of an entomologist from Fiji Ministry of Agriculture to SPC is an option to pursue.
4. The FACT programme will be a valuable investor in the project for pilot commercial-scale treatments.
5. Enquire regarding import review status of ginger and taro.

7.2 Appendix 2: Report on field visit to Fiji 30 March - 6 April 2009, and follow up discussions in Australia

7.2.1 SRA PROJECT: Cost Effective Disinfestation Treatments for Pacific Horticulture

Scoping Study. PC/2008/029.

CONSULTANT:

Dr CPF De Lima

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30 June 2009

Summary of main points from Meetings and Field Visits in Fiji

Mr Nacanieli Waqa (SPC) kindly organised the meetings described in this report and accompanied me to all of them (acronyms are given at the end of this report).

30 March 2009 – 8:30 am

ACIAR & SPC Office, Suva, Fiji

Dr Lex Thomson (FACT Team Leader, Suva); Dr Richard Markham (ACIAR program Manager, Suva); Aleki Sisifa (Director, Land Resources Division, SPC, Suva); Talei Tuinamuana (ACIAR, SPC, Suva).

- The priority crops of concern are: pineapples, bananas, taro, yams, sweet potatoes.
- Loss >30% occur in exports of root crops especially yams and taro after MB fumigation. Treatment may occur twice – once in Fiji and again in NZ. Taro leaves are also exported as a vegetable and often fumigated.
- Taro are Colocasia and Xanthosoma spp. Xanthosoma stores well for several months.
- Replacement for MB fumigation is considered a very high priority for exports.
- Frozen and fresh processed taro is sold in NZ to overcome the loss incurred from fresh unprocessed taro. However the Pacific Islanders living in NZ, Australia, USA will pay a premium for fresh unprocessed taro.
- NZ is not stringent on root hairs, but this means more pests are present.
- Australia requires taro to be topped, tailed and de-eyed or otherwise devitalised to prevent plantings in Australia.
- In NZ inspects fresh produce imports at the airport, wharf or at designated warehouses and requires fumigation if pests are found. With the current rate of MB fumigation of taro it appears that the treatment is virtually mandatory.
- NZ Biosecurity is looking into legislation for Fiji taro.
- In 2005 a pathway document for export to NZ and Australia was prepared by SPC and the Fiji Ministry of Agriculture for postharvest handling. However this initiative was not progressed because of the absence of a viable disinfestation treatment. Thereafter, tests using hot water dips have offered a potentially viable method, leading to the (ACIAR) project proposal for disinfestation.
- An export manual has been developed by SPC and the Fiji Ministry of Agriculture and is currently under consideration.
- Fiji uses HTFA to export papaya, breadfruit, eggplant and mangoes to NZ and sometimes papaya to Australia.
- Chillies – 3 varieties are exported to NZ under the non-host status treatment.
- Other PICs should be considered if the project delivers results.

30 March 2009 – 11:45 am

Dr Andrew McGregor (Managing Director, Trade & Development Office, Suva)

- Taro and other root crops are considered a priority not only for Fiji but for the Pacific Islands as a whole since the Pacific Islanders abroad have a preference for their fresh crops sourced in their own countries. Nematodes, Taro mite and Taro leaf blight are issues of concern.
- Cutflowers are also considered a priority for Fiji & PIC exports.
- Ornamental foliage and crouton leaves are important export opportunities.

- Exports of ginger from Fiji were being assessed for biosecurity concerns in Australia. Root knot nematode is an issue. This could be addressed in the HWT.
- There are issues regarding HTFA in NZ and it was suggested to discuss with Kevin Nalder in NZ.
- The disinfestation project could benefit several economies in the region if successful.

30 March 2009 – 1:00 pm

Waisiki Gonemaituba, Chief Economist, Ministry of Agriculture

- Taro (mites), pineapple (mealybugs) and cutflowers (several pests) are considered priority quarantine issues for access to markets in NZ, Australia and USA.
- There is a wide geographical spread in the cultivation of taro and internal transport can incur higher costs within Fiji than the cost from Lautoka port to NZ.
- Infrastructure and institutional issues are being considered since the major source of pink taro is from the island of Taveuni. A Taro Farmers Association is operating in Taveuni, but is unsupported since the Root Crops Council is not functional at the present time.
- The Taro Pathway Plan developed by the Ministry of Agriculture is awaiting disinfestation treatments. Farmers grow taro surplus to their needs to supply the export markets and the major towns.
- Ginger was second to taro in exports before being priced out of the market by China. However Fiji ginger has unique flavour. Scales and nematodes are quarantine issues. Ginger is washed clean and held at 5°C for shipment.
- Cutflowers – heliconias, flowering ginger and indigenous species not subject to CITES regulation are good export opportunities because of the high demand overseas.
- On staff issues, local counterparts are available. Some staff members are currently involved in an (ACIAR) IPM project.
- Funding is a problem and project allocation will help in progressing taro exports.

30 March 2009 – 3:00 pm

Director Fiji Biosecurity, Mere Salusalu (Acting Director of Quarantine. Senior Agricultural Officer Western Division), Ilaisa Dakaica (Entomologist) & Joseva Vueti (Quarantine Officer, Fumigation).

- Taro and cutflowers are the two priorities for export for which disinfestation is required to enable clean produce to be sent to NZ, USA and Australia.
- MB fumigation is applied for export treatment of taro at present.
- The Quarantine Entomologist has assisted in conducting the trials on HWT of taro at SPC on taro mites and nematodes. There is good potential in HWT.
- Flowers are a high priority for disadvantaged women folk (single mothers, widows and partially disabled) since it supplies them with income to avoid destitution. Heliconia and flowering gingers are important exports but insects were found in exports to NZ and USA. HWT e.g. as tested in Hawaii may benefit since HTFA was not found suitable for treatment as it severely affects shelf life.
- MB fumigation destroys the flowers and suitable alternatives would benefit.

30 March 2009 – 5:00 pm

Director Extension, Fiuwaki Waqalala

- Taro is of the first importance followed by papaya, breadfruit, cutflowers and vegetables for disinfestation issues for export.
- The project should review these issues. Many species of vegetables are exported but are often fumigated in NZ.
- The Pathway plan is a good start for Taro exports and will be implemented. This will assist growers in achieving technical expertise for producing high quality taro for export.

31 March 2009 – 8:00 am

Koronivia Research Station - Director Research, Dr. Moti Lal Autar

- The research is presently focussed on field control of pests and quarantine research. There is a shortage of scientists. The research staff are partnering with other agencies including with SPC.
- Several research staff are collaborating in 4 ACIAR projects: ginger, IPM, taro and fruit flies. These projects involve several entomologists, plant pathologists and weed scientists from Australia.
- The new policy is to recruit university graduate staff (BSc) for postgraduate research to raise the standard and also to offer postgraduate training.
- There is potential for one or more graduates to do MSc or higher degrees by research in the proposed disinfestation project.
- Staff from the Directorate of Research collaborated in the HTFA research on fruit flies for export of mango, breadfruit, eggplant and pawpaw, and the non-host status testing of chillies to NZ.
- Testing for pumpkin at 47.2°C was found to disinfest *Bactrocera passiflorae* for Fiji and *Bactrocera xanthodes* for the Pacific region.
- The taro mite appears to be living symbiotically with the microflora in the roots. There are some positive disinfestation results from HWT.
- Ginger requires HWT of 10-12 minutes to kill nematodes. HWT was tested in 44 gallon drums at 51°C by a nematologist Mr Takaniko Ruabete now working with SPC.

Mr. Tolei Vasuidveketi (Research Officer, Plant Protection, Ministry of Agriculture)

- Research Work with HWT of taro mite looks promising. Some heat damage to taro is found at 51°C. But further work is required.

Mrs. Millie Nawailula (Chemistry Laboratory) – Head of Soil

- The department has good information on soil types where taro is grown. This will help with the development of the cleaning process to remove soil from taro. There is no charge for soil analysis.

31 March 2009 – 11:00 am

Extension Officers Central Division, Nausori & Lakena

Principal Agriculture Officer, Central Division, Kini Namoumou

Senior Agriculture Officer, Rewa, Yatendra Sewak

Agricultural Assistant, Lower Naitasiri, Waisake Maseikula

- Most farmers have their own taro planting materials, but if they are in need they can source material from outside the Taro Beetle Restricted Areas. Tausala is a pink variety that is exported. Hybrid white and yellow varieties are also exported. Dromodromo is another Taro species.

- Crop rotation is commonly practiced. Ginger is followed by Taro and then cassava. The land is left fallow to reduce nematodes and then a second taro crop is planted.
- There are 2 seasons in Fiji. The cool season is the off season and the price paid by exporters rises. In the warm season the major planting of taro takes place.
- In the past Taveuni was the main source of exports, but with increasing demands from NZ, USA and Australia, all areas are providing taro to exporters. The price exporters' pay/kg ranges from Fiji $2 – $3.50 and sometimes drops to $1.20 or lower.

31 March 2009 – 12:30 am

Fiji Agro Marketing Authority (AMA) – IIaise Caru (CEO)

- The proposed project for disinfestation is considered long overdue. The FAO/ITC workshop held in Nadi in 2008 requested development of a treatment for taro to enhance exports. The AMA had stopped exporting since March 2008.
- The AMA had a bad record of exports to Australia in 2007 with a high level of rejects. Trade letters for $700,000 had not been paid because of the poor quality of taro after MB fumigation which caused the price to drop from $1.50 to 90 cents/kg. However, since the AMA is a statutory body it pays growers $1.50/kg and suffers the loss.
- Lutu Cooperative which has been in existence for 16 years is the main supplier of taro to the AMA.
- Taveuni supplies the bulk of the pink taro for export from Fiji. Taro exports are private sector driven; exporters' agents collect the crop from growers and receive 30 – 60 cents / bag. Good quality taro from Taveuni requires 9 months to grow, but because demand is high harvesting may take place after 5 months resulting in poor quality. Yellow taro requires 6 months to mature and cassava can be harvested in 5 months.
- Tonga and Samoa also supply taro to NZ and issues of oversupply can occur. However, PIC nationals prefer sources from their home countries.
- Fiji can send up to 7 containers of pink and yellow taro as well as cassava to NZ on a bi-weekly basis.
- Because of the high levels of rejection farmers are trying to work to a bi-weekly supply quota. Fiji exported $8 million of taro in 2007 but much more can be supplied.
- Processed taro is being supplied to overcome the issues of fresh taro and HACCP compliance is in progress.
- 20 tonnes of processed cassava are exported weekly by Air Terminal Services which has ISO certification on product quality.
- AMA has received a $1 million grant from the Fiji government to develop a cool chain process.
- Ginger exports from Naitasiri Province had dropped from greater than 150 tonnes to 43 tonnes in 2007 due to competition from China, even though the Chinese ginger has little flavour compared with Fiji product.
- Papaya is exported under heat treatment but suffers from high rejection rate in NZ.
- The AMA is looking at developing Small to Medium size farmers and exporters (SMEs) over the next 3-5 years to progress Fiji exports for the rural economy.

31 March 2009 – Afternoon

Farm Visits Naitasiri Province:

Bureni Farm – Owner: Jone Liu (25 yrs old)

- Jone produces 25,000 heads of taro on 5 acres. He cultivates 3 varieties: Rewa (yellow), Bavia (Traditional) and Samo for the December – January exports.
- He gets 80 cents/kg cash on delivery. He sells his crop through Waisali Farm Produce Exports and Tongwah Exports.
- He has not found it worthwhile exporting cassava, and sells most on the local market.
- He produces 8 tonnes ginger annually for local market or export.
- He works fulltime on the farm for which he has a lease and is helped by his father and 2 casual employees.
- In the past his taro suffered 30% loss from taro beetle, but this has declined to 8% loss through better practices. He uses poultry fertilizer and NPK, keeps his own suckers and takes the rejects for home consumption. He harvests every week, bags the taro (30-40kg/ bag) and cassava (60 kg /bag) and hires transport to deliver to the exporters.
- His weekly income is $500.

Farmer: Netani kuila (70 years old)

- Netani has 15 acres at the site of his home and another 20 acres in lots elsewhere.
- He produces for taro exporters and for social orders (celebratory events). He has no problem selling his crop.
- He receives 80 cents/kg for taro and 40 cents/kg for cassava.
- He has 5 fulltime labourers and practices continuous rotation of crops: ginger - taro – cassava (2-3 plantings) – ginger again etc.
- He sells to Agro Marketing (AMA) which pays market price and not a fixed price. He also sells to 3 other exporters: Waisali Farm Produce, Tong Wah Exports and Tui Fong Exports.
- This morning he delivered 60 bags of cassava (2.5 – 3 tonnes) and received 55 cents/kg.
- He has leased the same property since 1970 and has recently renewed the lease for another 30 years.

1 April 2009 – 7:00 am

Farm Visits Naitasiri Province:

Lutu Cooperative Farm

1. Present: **Osea Nabulivula** (Extension Officer for region located at Vunidawa Government Research Station), **Josaia** (Lutu Cooperative Accountant).
2. A separate visit was made to **Eroni Sauvakacolo** (retired Magistrate) who supervises the operation of Lutu Cooperative Society which has 1,500 members.

- There are 3 villages in this cooperative. Two villages focus on dairy production and one village grows taro.
- The Coop. Society has been very successful in social development of the 3 villages and has graduated 14 persons, the highest in Fiji, from their own income.
- Taro has been continuously exported to New Zealand for 16 years (since 1993). Taro is sent to Nausori and cleaned at the AMA packing shed to remove soil and clean hairs. The work is done by labour provided from the village cooperative. Villagers who do this work receive payment. Each taro is individually cleaned. The clean taro is put into 30 kg clean bags with Lutu Cooperative Company label and held in a 20 ft refrigerated container which holds 12 tonnes, at 5 – 7 °C awaiting shipment to NZ.

- There is a well organised plan of work. Taro is harvested every Monday and the process of harvesting and cleaning takes 7 days, shipping time to Auckland is 3 days.
- The crop may be fumigated prior to shipment if taro mites are found or it is fumigated on arrival in NZ for pest issues.
- The Cooperative exports 1-2 container loads / month to Pacific Produce in Auckland. Produce is sourced from Naitasiri, Rewa, Tailleu and Serua.
- Re-export from NZ to Australia (Brisbane and Sydney) has been trialled and plans exist to increase this through Turners & Growers Pacific Produce NZ.
- Previously the Cooperative exported bananas, but this has declined.

2:00 pm Quarantine Inspector and Exporter

Nilesh Chandra (Quarantine Officer); Sam Foy (Managing Director, Waisali Farm produce Ltd)

- Approximately 75% of exported Taro is fumigated because of the presence of mites on inspection.
- Generally 3 containers (36 tonnes) are exported / week from Fiji.
- Exports to NZ, USA and Australia are valued at approx. 15$ Million per year.
- Taro is considered to be a niche market for the Pacific Islands because of the unique characteristics given to the crop grown in the Islands and consumed by the Islander Diaspora.

5:00 pm Takaniko Ruabete (SPC Nematologist)

- A number of nematodes are recorded in Taro.
- In ginger, an ACIAR project at Koronivia Research Station is doing hot water work and has found that holding ginger for 10 minutes at 51°C will successfully disinfest it.

2 April 2009 – 8:00 am

Visit to Sigatoka local vegetable market (9 am)

Items on sale were mainly sweet green oranges and other citrus; small chillies (Indian) large chillies (Fijian); several vegetables; taro leaves; fresh pink and white taro sold as mixed bundles (Fiji $10/per bundle) and dry taro in small piles (approx. 500gms / $3).

Meeting with quarantine officers for vegetable exports (10.30am)

Present: Ms Titilia Maramaca, Mr Soropepeli Tuwara (Quarantine Officers)

- Exporters to Australia and New Zealand are required to follow the guidelines of the Export Pathway System under Bilateral Quarantine Agreement (BQA).
- 1 BQA is used for export of papaya to NZ and Australia.
- For export to NZ there are 3 BQAs one each for eggplant, mango and breadfruit.
- As part of the pathway registration is done of field control and Packhouse quality and HTFA. The BQA is for fruitfly management pre-harvest and postharvest HTFA treatment. The exporters and farmers come to an agreement and a unique registration number is issued to the grower for use by both the grower and the exporter.
- A grower can be registered with more than one exporter. This registration is required for use on the quarantine form.

- Fruitfly control measures are monitored by the Extension Department. This includes protein bait sprays and 7-day withholding period. After quality grading by the farmer and the exporter and by Quarantine, a Transfer Form is issued before the crops are sent for HTFA treatment.
- Farm audits are carried out regularly by Plant Quarantine to check the protein bait diary maintained by each grower.
- Audits of the system are done by NZ once a year.
- Two exporters currently operate in Sigatoka (Mahens Exports and Rams Value Fresh Produce).
- This fruit is treated at the HTFA plant and exported by air from Nadi.
- A test container of HTFA treated papaya has been sent by sea freight to NZ and there are plans to send 4 containers per month to Australia. Papaya exports to Australia started in 2004 under a BQA.

Other Fresh Produce Exports

- Final Quarantine Certification of okra and long beans to NZ and Canada by air freight is done at Nadi.
- Chillies are exported to NZ from Sigatoka under non-host status. The varieties are Hot Rod, Red Fire and Birds Eye. The varieties must be true to type and new seed must be used for each new planting.

Training & Extension

- Course Managers (from Extension) provide training for BQA. The Quality Controller trained is an employee of the Exporter so a conflict of interest may exist. It is planned to provide for accreditation for training in the future.
- **Extension Officer, Lusiana Tumaitoga:** maintains Field Registration for eggplant, breadfruit and papayas for fruitfly control. Bait spray is made up of 50ml protein + 4ml Malathion 500g/L with water to make up one litre. This spray is used at weekly intervals for control of fruitfly for eggplant, breadfruit and mangoes. No bait spray is applied to papayas.
- Growers and exporters do not pay for this service. However, new Bio-security Legislation will require full cost recovery.

Sigatoka Research Station - 11 am

Present: Mr Mesake Nacola – Principal Research Officer, Horticulture

Mr Kalisito Biaukula – Principal Extension Officer, Western Division

- Taro Pathway Analysis study had been conducted by SPC together with the Department of Agriculture, Fiji. The aim is to specify quality standards and train growers in achieving these standards. The plan is to set basic standards and start in a small way. This plan is awaiting consideration and approval from the government.
- The absence of treatment for mites and nematodes is an issue for exports.
- Loss of quality occurs as a result of fumigation for interceptions of mites, scale insects, nematodes and other pests in root crops.
- Taro, yams, sweet potato and cassava are important fresh export crops for Fiji.
- The export of ginger to Australia is an issue to be addressed.

Mahens Export – 3 pm

Anil Kissun Kumar, Managing Director, Valley Foods & vegetables, Auckland, New Zealand

Saten Kumar, (Operations Manager) Sigatoka

- 30 species of vegetables are approved for export to NZ, under non-BQA conditions. Inspection in Fiji is done on 600 units and on arrival in NZ further inspection is done on a second lot of 600 units. MB fumigation is frequently done for mites, thrips, and other live insects found in the produce.
- Taro quarantine issues are the presence of soil, snails, nematodes and mites. Treatment in NZ is MB for 24 hours 80g/m3 at 21°C. A total of 6 containers/week are exported from Fiji to NZ. Each container contains 12 tons taro. The cost of fumigation is $140/container in NZ.
- Under BQA there are approximately 100 registered growers and 12 registered exporters.
- 6 exporters are registered for fruitfly disinfestation using HTFA.

3 April 2009 - 7.30am

Nature's Way Co-operative (Fiji Ltd.) - HTFA facility

Present: Mr Sant Kumar (General Manager), Mr Shameem Khan (Technician), Mr Seremaia Bolaitama (Quarantine Officer), Mr Sitiveni Vunibola(Quarantine Officer)

- The facility has 3 HTFA units with a new unit to be added shortly.
- The treatment is to disinfest export fruit from fruit fly species *Bactrocera passiflorae* and *Bactrocera xanthodes*.
- A small HTFA unit is planned for Rotuma Island for treatment of *Bactrocera kirki*.
- All treatments are done under Fiji Quarantine supervision.
- Exports of breadfruit, eggplant, mango and pawpaw have been approved over the past few years to NZ using 47.2°C for 20 min.
- NZ MAFF verifies the calibration of the units every year.
- The HTFA plants are running under capacity. The Nature's Way Co-operative plans to obtain access for other fruits to NZ. These are jackfruit, bitter gourd, bottle gourd, luffa, Fijian pumpkin, and Wi (a native Fijian fruit).
- The HTFA plants are modified shipping containers in which moist air (90% rh.) is circulated at approximately 45-50°C under a temperature ramp-up system of feedback and controls to achieve the specified treatment temperature within the required period. This system is controlled by a computer program under the supervision of a trained technician.

Maximum fruit size and treatment period:

- **Breadfruit** - 2,000g - 6 hours exposure;
- **Eggplant** - 600g – 4.5 hours exposure;
- **Mango** - 600g – 4.5 hours exposure;
- **Pawpaw** - 800g – 5.5 hours exposure;
- **Treatment temperature**: 47.2°C for 20 min. **rh** approx. 90%.
- **Sensors**: 4 fruit probes (placed in largest fruits), 2 air probes (I wet bulb, 1 dry bulb) to monitor relative humidity.
- **Weight of fruit per treatment run:**
- Eggplant – 300kg; Pawpaw – 400kg; Mango – 500kg; Breadfruit – 300kg
- **Maximum run**: 4 bins per treatment run.

- **Cooling post treatment**: Hydro-cooling to 30°C using tap water:
- 60 minutes - breadfruit & pawpaw;
- 30 minutes - eggplant & mango.
- **Certification**: After treatment produce is transferred to sealed quarantine cool area for final grading, inspection and issue of quarantine certificate.
- **Quarantine Supervision**: A quarantine officer is present throughout the treatment and data is logged for verification and audit.

South Sea Orchids, Nassau

Present: Don and Aileen Burness

- They manage a large floriculture project for AusAID supplying 15 out of 100 families in villages with plants in a 'not for profit' venture for social benefit.
- The project is aimed at helping widows. Recipients are required to set-up 4x4 metres shade houses for orchids mainly Dendrobiums. Other orchids supplied are Guzmania and Anthuriums; Ginger flowers and Heliconia.
- They are also growing Phalaenopsis species (hybrid orchids).
- Foliage is also supplied – crotons, cordyline, dracaena and palm leaves.
- Exports are to NZ and USA.
- They manage a very clean pre-harvest production but insects found in exports include mealy bugs, mites, ants, etc. which are impossible to completely control by field measures and this affects market access.
- They would like to use hot water treatments but do not have funds to set-up treatment facilities.
- They also wish to access the Australian market.

4 April 2009 – 8:00 am

Second visit to Mahens Export to view cleaning of taro

- 600 sacks of taro were received and approximately 30 sacks at a time were placed in a large wash area (15 x 15 metres) and subjected to high pressure washing to remove soil.
- Care was taken not to damage the taro hairs.
- Approx. 40 labourers were employed in this work. A rapid quality control was done after washing each batch and at the end about 3 tonnes out of 18 tonnes received were rejected. This rejection rate is one-sixth of the supplied crop. There was a very large amount of soil washed off the taro an estimated one-sixth. This is a large amount of soil. Thus only two-thirds of the supplied weight – about 12 tonnes was accepted. This was loaded into a shipping container and held at 8°C for transport to Lautoka Port for shipment to NZ on 06/04/2009. It was expected to arrive in Auckland on 13/04/09.
- It was observed that removing of soil was difficult and that a hot water treatment if incorporated in the process would have to cope with the residual soil but would have the advantage of providing clean crop and disinfesting from taro mites and nematodes.

Australian Quarantine Inspection Service – Fiji Imports (spreadsheets supplied by Nacanieli Waqa)

Records of imports from Fiji from September – November 2008 reveal that almost without exception, taro and taro leaves are fumigated with methyl bromide because of the

presence of mites, mealybugs, ants and snails. In contrast papaya imports subject to HTFA in Fiji are not found to contain live insects.

New Zealand MAF Quarantine Inspection Records – Fiji Imports (spreadsheets supplied by Nacanieli Waqa)

Records from New Zealand from November 2008 to January 2009 show that a taro fumigated in the majority of imports for the presence of mites, beetles, snails, nematodes in the roots and miscellaneous insects in leaves.

Biosecurity Australia

Fresh Taro Fiji Imports (spreadsheet records for taro and yam from 2006 supplied by Biosecurity Australia, Canberra) interceptions of live: centipedes, millipedes, earth worms, earwigs, spring tails, several nematode species, several mite species, taro mite, several species of ants, several snail species, slaters, mirids, mealy bugs, scales, midges, beetles (scarabids, nitidulids, staphylids, curculionids, etc.), and several other insect species probably contaminants in soil and handling.

Other Items under consideration by Biosecurity Australia:

Fiji's market access: request for fresh immature ginger to Australia

Review of import conditions for fresh taro from all countries are rated Priority A by the Import Market Access Advisory Group (IMAAG). This is a high level group within DAFF which is responsible for assigning priority to import proposals and monitoring progress of risk analyses undertaken by Biosecurity Australia (BA).

The review of import conditions for fresh taro is on the current BA work program and is not completed. Fresh immature ginger has not yet been placed on Biosecurity Australia's work program. However, preliminary work has been undertaken on the information provided by Fiji.

Queensland DPI

Dr Mike Smith and Dr Graham Stirling (ACIAR funded project titled - 'Improved farming systems for managing soil-borne pathogens of ginger in Fiji and Australia') mentioned the need as shown in their 2007-08 report that hot-water treatment for the control of Radopholus similis and Meloidogyne spp. in ginger planting material to be 54°C for 10 min (a Fiji Ministry of Agriculture recommendation) since this is very effective but only 9% of farmers follow the proper method. Usually their treatment temperature is too low (48°C to 50°C).

Acronyms:

ACIAR – Australian Centre for International Agricultural Research

MB – methyl bromide

EF – ethyl formate sold commercially in carbon dioxide as Vapormate® by BOC Gases.

NZ – New Zealand

AUSTRALIA – Australia

USA – United States of America

SPC - Secretariat of the Pacific Community

HTFA – High Temperature Forced Air treatment

HWT – Hot Water Treatment

FACT – Facilitating Agricultural Commodity Trade project

PIC – Pacific Island Countries

7.3 Appendix 3: Postharvest handling and disinfestation methods for taro and cutflowers

The expressed request by stakeholders is to understand and conduct disinfestation research to be able to export taro, cutflowers and foliage to overseas markets including Australia and New Zealand as well as to countries like USA, Japan, Taiwan, China, etc.

The Fijian government staff from horticultural research, quarantine and extension; commercial partners, and marketing institutions; and regional bodies SPC & ACIAR wish to progress this work.

The view was also expressed that other PICs will benefit from this research which if successful should be extended to other root crops and vegetables.

The proposed post harvest handling and disinfestation methods given here are based on the scientific and practical knowledge and experience of these areas developed by the consultant over a number of years. The disinfestation methods outlined below for taro and cutflowers contain the science that is relevant to access all markets. Taro and cutflowers have unique issues and are discussed separately.

7.3.1 Taro

In taro exported with root hairs, the main phytosanitary issues for USA, NZ and Australia are: mites, mealy bugs, snails, nematodes and soil. In taro leaves (exported as a vegetable) a range of external insect pests have been intercepted. Australia requires devitalisation by ‘topping & tailing’ fresh taro. This affects shelf life.

The postharvest handling, packaging and transport methods outlined below for taro are important for preserving soil fertility and taro quality besides addressing the phytosanitary issues of contamination by soil and snails.

7.3.2 Postharvest handling, packaging & transport

The following steps are suggested for retaining soil on-farm and quality in transport.

1. Primary processing, removal of soil from taro on farm, grading & packing into plastic bins

The existing process of transport is in sacks to which soil is added to buffer taro and reduce damage during transport. There is a tendency to send sub-standard product since payment is based by the sack. On-farm soil loss and taro quality can be preserved by washing or brushing taro free from soil, making preliminary selection and grading of marketable crop and packing into 50 to 500 litre returnable plastic bins as a first stage process. Farmers can be rewarded monetarily for supplying better crop.

These hard plastic bins are capable of being stacked into transport vehicles currently in use in Fiji and taken to collection points. The returnable plastic bins are similar to those used in Australia for bulk transport of crops like citrus, apples, potatoes, carrots, vegetables, etc from farms to supermarkets. It avoids multiple handling, reduces damage and lowers costs.

Benefits: (i) minimise on-farm soil loss (ii) less urban contamination (iii) reduced urban waste water disposal issues (iv) less multiple handling and labour costs (v) better quality marketable product.

2. Secondary processing & preliminary grading at collection points

Secondary processing includes further washing, visual examination for snails and quality of product (shape, size, damage, etc.) and preparation for hot water treatment (HWT) or fumigation.

3. Postharvest grading, waxing of topped & tailed ends

Final grading of crops after treatment, removal of dead insects and snails, wax topped and tailed ends to reduce moisture loss of taro exported to Australia. There is the possibility that the heat treatment will de-vitalize taro as a seed crop and may therefore be acceptable to Australia.

7.3.3 Disinfestation treatments

Hot water treatment (HWT) for nematodes, insects and mites:

Preliminary HWT tests in Fiji show that 10 minutes exposure at 51°C will kill nematodes and mites, but the data is not conclusive. Work done in New Zealand showed that taro could withstand hot water treatment, up to 55°C for 30 minutes without loss of quality (Biosecurity (NZ), page 16, Issue 70, 15 September 2006). This a potential de-vitalizing treatment.

It is proposed to conduct laboratory tests on taro infected with nematodes and separately of mites and mealybugs in culture to assess mortality with greater accuracy. This will provide data on temperature and exposure time required.

Laboratory tests will also provide data on quality effects on taro of selected treatments and the temperature range available to treat without damaging the product and affecting shelf life. Validation of devitalisation by heat may be possible.

- Basic Research

Learning how to conduct research trials in a precision hot water bath of naked insects in the temperature range of 48 to 54°C of important life stages of nematodes, mites and insects. This work will establish the most tolerant stage of the most tolerant species.

- Applied Research

Learning how to conduct research trials in HWT plants of infested crop with one or more stages of nematodes in taro, and insects and mites adhering to the surface of taro, using several marketable sizes. Learning how to calculate and test the optimum ramp-up times based on starting temperature and crop load and how to hold temperature for the required time to penetrate the infected zone (2 mm of skin) achieve disinfestation without affecting marketable quality. Tests to assess devitalisation by heat will require planting of treated taro.

- Data analysis and compilation of scientific report for market access

Tabulating and statistically analysing data (e.g. LT50, LT99) to prove efficacy of the selected treatments of insects, mites and nematodes. Present this information as well as the data on all the quality tests and crops used in the trials, in a format suitable for export submissions.

1. Small scale tests - treatment in precision water baths

The methods described below follow international protocols and satisfy the main requirements of Australia, NZ, USA and other countries.

1. Crop: 1 or 2 varieties of taro
2. Quality tests: Fruit of each variety at selected treatments to be assessed for quality.
3. Pests: nematodes (1 - 2 species), mites, mealy bugs and other external pests of quarantine concern.
4. Test methods to achieve the complete trial protocol:
   4.1 Life history identification and testing (if necessary) to establish the exposure period required for each stage for heat treatment.
   4.2 Most tolerant stage trials: each treatment in at least 3 replicates of test fruit containing not less than 200 individuals of each immature stage (if required). These are dose x time trials, and involve testing eggs, immature stages and adults for mortality to exposure dose (temperature, fumigant gas concentration) for a

series of treatment periods. The most tolerant stage is determined by the estimated LT50 and LT99 dose using probit analysis.

4.3 Large scale trials in at least 3 replicates of (>10,000 pests per variety, with no survivors) of the most tolerant stage. This involves selecting the stage most tolerant to the treatment in 2 above, and exposing this stage in semi-commercial trials repeating each trial 3 times with >10,000 insects killed in each repeat for each cultivar. If such numbers prove impossible to obtain, tests will be modified for lower numbers by negotiation with quarantine authorities.

4.4 For heat treatments: measurement of heat transfer time to infestation depth (approximately 2 mm for nematodes) based on largest mass / surface area, warm up time, holding period and cool down time. Devitalisation treatments also assessed.

4.5 For fumigants: measurement of sorption of fumigant by crop and packaging. Measuring de-gassing time and residues in crop. Continue at step 4.3 above.

2. Commercial scale HWT

A commercial scale facility will be similar to a heated ‘spa bath’ system with constantly circulating hot water at specified temperature with no ‘cold’ spots preferably in circular fibreglass insulated tanks of at least 1000 litre capacity. Immersion bins would be the same as the 500 litre transport bins to avoid additional handling. Immersion time is not expected to exceed 30 minutes. The time required would depend on load temperature after cold water cleaning. However, initial skin temperature >20°C would be normal and time to achieve a skin (2 mm) temperature of 52 - 54°C would have to be obtained through a series of tests. The appropriate (higher) starting temperature and final (lower) set-point temperature for treatment would have to be determined based on produce quality requirements. All such data will have to be obtained through the appropriate data logging and sensor calibration methods. The steps required to satisfy quarantine standards are quite straight forward, and will be determine the necessary trial work. For Australian exports, heat devitalisation will be tested and an idea gained if this is acceptable in terms of quality of product.

7.3.4 Cutflowers and ornamental foliage

POSTHARVEST HANDLING, PACKAGING & TRANSPORT

Cutflowers are high value products. Often individual packaging and cool storage is required to preserve quality. Hot water treatments can be done in bulk, and crops can be taken to processing tables for final quality assessment, packaging and transport. For fumigation, cutflowers can be packed ready for sale and provided sufficient ventilation exists, product can be fumigated with ethyl formate in CO_2 as the final treatment before export.

Hot water treatment (HWT) for insects and mites:

Some cutflowers (e.g. red ginger flowers) respond well to HWT but may require conditioning in warm air 38-40°C before dipping in hot water up to 50°C. Some chemical treatments e.g. 1-methylcyclopropene (1-MCP) before heat to enhance shelf may tested. In the consultants experience dipping the inflorescence in plain water alone will remove 70% of external insects. Addition of insecticides to dips is never 100% effective and causes allergies in some customers of flowers and does not benefit the reputation of the exporter.

Methods of disinfestation research are as described above for taro. However, for cut flowers that are damaged by heat treatment, fumigation with ethyl formate in CO_2 is a very viable option.

Fumigation Research for insects and mites:

The Vapormate® fumigation treatment is very likely to be suitable for disinfesting external insects of cutflowers & foliage, as well as taro leaves and possibly roots. It is not

phytotoxic to most crops. The pests of quarantine concern are external insects present on exported cutflowers - ants, mealy bugs, scales, thrips, mites, etc. The Fiji Quarantine Service is very keen to develop capability for fumigation research into alternatives to methyl bromide. The methods of testing for registration of ethyl formate in CO_2 (commercially produced as Vapormate® by BOC Gases) are relevant to Fiji as well as to other PICs.

- Basic Research

This involves learning how to conduct research trials in small sealed containers using naked insects in the treatment range of 8 to 48 g/m^3 in steps of 8 g/m^3 (or less if data points are insufficient) to establish the most tolerant stage of each target species including immature stages and adult insects in cutflowers e.g. mites, mealy bugs, thrips, ants, etc. to determine dosage at specified temperatures in the range 15 – 25 °C. Calculate LD50 and LD99.

- Applied Research

This involves learning how to conduct research trials in large scale commercial fumigation facilities of small batches of cutflowers and foliage infested with the most tolerant stages of each test species using temperatures in the range 15 – 25 °C and including packaging. Determine dosage required. On the basis of this data conduct trials to calculate and test the optimum dose and exposure times at each temperature to achieve disinfestation without affecting product quality. Determine venting periods and expelled fumigant dilution rates within occupational safety, health and environmental regulations.

- Data analysis and compilation of scientific report for market access

This involves tabulating and statistically analysing data to prove efficacy of the selected treatments and present this information as well as the data on all the quality tests of insects tested and flowers used in the trials, in a format suitable for export submissions.

(1) Small scale treatment in glass desiccators at controlled temperatures

The experimental methods are similar to those given in item 4 above. 7 litre desiccators are used with continuous stirring by magnetic rods to circulate the gas. Live insects and mites are introduced on host pieces or media. Gas samples are taken at regular intervals for analysis.

Initial phytotoxicity tests can be done in these containers before decisions on application doses for commercial purposes are considered.

(2) Commercial scale fumigation

The commercial formulated fumigant Vapormate® will be supplied by BOC gases in ‘G’ size cylinders (Gas Code 279): a mixture consisting of 16.7% Ethyl Formate and 83.3% CO2. Trials will be done in 20ft / 6m (28 m^3) or 40 ft / 12 m (68m^3) ISO refrigerated shipping containers or in commercial fumigation chambers loaded with test produce. The gas must pass through a heat-exchange unit consisting of a coil (stainless steel) immersed in boiling water. Gas concentrations are measured using ethyl formate Dräger Gas monitoring tubes as a check (and for use by quarantine officers in future auditing).

Carbon dioxide levels are also measured using a Vaisala CARBOCAP® Hand-Held Carbon Dioxide Meter GM70 with data logging capabilities. Measuring CO_2 is a potentially cheaper alternative to the use of Dräger detector tubes and can be used to monitor fumigation since the meter can be used for several years and will soon recover initial investment.

Temperatures are measured by placing thermistor probes at 3 positions in air and 3 points in product as the container is loaded. The probes are connected to a digital data logger programmed to record data at 10 minute intervals throughout each trial.

Plastic or glass vials (5cm long 2cm diameter fitted with plastic caps with 0.5 cm vent hole sealed with filter paper) containing live insects of all stages were placed throughout the cartons containing flowers or foliage before the fumigation starts and are retrieved after de-gassing and reared for the required period according to species and stage to assess mortality. Mortality is corrected based on untreated controls in every test.

Tests for sorption of fumigant on packaging and other materials are required to assess loss of applied dose and to compensate for applied to doses in all trials. Sorption does not occur on stainless steel surfaces in refrigerated containers. Generally a 25 – 30% loss (sorption in produce) occurs in the large scale fumigation process and final dose concentrations at least 60% of initial applied dose is sufficient for successful large scale fumigation. Refrigerated containers are excellent for fumigation provided drainage holes and vents were taped. Cold rooms that are more modern with a good seal are potentially suitable for Vapormate® fumigation. Fumigating at shipping temperature will ensure that the cool chain process is maintained and very high produce quality is achieved through to the consumer.

7.3.5 Plant and equipment budget

1. Small scale laboratory trials - List of essential items

Hot water treatment

(1) Grant Squirrel data logger Model 2020 – 16 channels	$ 3,700
(2) 18 Thermistors: DM VL 20mtrs of Cable $130.00 per probe x 18	$ 2,340
(3) Software Squirrel View Plus	$ 400
(4) Network Adaptor	$ 700
(5) Certified Thermometer (-10°C – 110°C) (x2)	$ 746
(6) De – ionized Water Machine 4.0 L / min Filter life 3,500 L	$ 740
(7) Replacement filters (x2)	$ 350
(8) Grant Precision Water Bath (40 litres)	$ 6,500
(9) Desktop computer with Office 2007	$ 2,500
(10) Miscellaneous media and glassware	$ 2,000
Total	$ 19,976

Fumigation treatment

(1) Trend® data logger 8 channels + software	$ 1,600
(2) 8 Thermistors: DM VL 20metres Cable $130.00 per probe x 8	$ 1,040
(3) 6 desiccators (7 litres each)	$ 3,000
(4) 5 magnetic stirrers	$ 1,250
(5) Miscellaneous media and glassware	$ 2,000
Total	$ 8,890

Note: Gas chromatography equipment is normally used for these trials, but the cost and skills required precludes their use in Fiji. Proving work can be done in the South Perth Disinfestation Research Laboratories with this specialised equipment. Funding can be sourced in a later project to build scientific capability, which can subsequently transferred to Fiji and other PICs.

2. Commercial scale trials - List of essential items

Hot water treatment

(1) Pressure circulation hot water spa type treatment unit 2m3 (circular)	$15,000
(2) Hoist for lifting and immersing 800 kg container	$ 4,000
(3) 2m3 cooling tank x 2	$ 1,000
(4) Miscellaneous grading, washing, transport bins & packaging	$ 2,000
Total	$22,000

Fumigation treatment

(1) Refrigerated shipping container	$ 5,000
(2) Dräger Gas monitoring tubes (10 packs of 10 tubes each)	$ 3,000
(3) Stainless steel heat exchange unit & gas burner	$ 2,000
(4) Miscellaneous consumable items to outfit for fumigation	$ 2,000
Total	$12,000

Temperature monitoring equipment will be transferred from the laboratory for field trials.

Total of above costs = $62,886 (Round up to $63,000)
Plus contingency funds: $12,000
Total P&E Budget (capital + operating) = $75,000

Project funds should provide for at least one set of these facilities in Fiji.
Example of ventilated plastic bins is MH6268 ventilated pallet bin 780
(1162 mm length x 1162 width x 780 mm height = 780 litres capacity A$340 each)
Silverlock Packaging (www.silverlock.com.au)

7.4 Appendix 4: Revised project proposal - alternative disinfestation treatments for fresh produce commodities from Pacific countries (PC/2007/118)

7.4.1 Project summary

The economic aspirations of most Pacific Islands Countries (PICs) include exporting fresh produce to Australia and New Zealand. This opportunity is being limited by inadequate options for postharvest treatment technologies that are sustainable, low cost and effective as both Australia and New Zealand have stringent biosecurity (quarantine) protocols. Therefore, the PICs with limited treatment facilities and technologies are unable to compete with better-resourced Asian countries.

The PICs export AUD75 million worth of agricultural, marine and timber products to Australia of which 60% are agricultural products. Coffee is the main PIC agricultural export, while taro is the largest PIC horticultural export (McGregor unpublished report 2007, DFAT website 2008). For taro, yam, ginger and ornamentals, Fiji alone in 2006 exported 11,918 tons, worth over FJD23 million, while in 2007 this increased two-fold to 24,274 tons worth FJD48,580 million (FAO/SPC trade statistics database). This value is very tiny considering the potential value of exports of horticultural products including root crops, not only from Fiji but other PICs.

The establishment of a High Temperature Forced Air (HTFA) Treatment Plant in Fiji for treatment of fruit fly host commodities has significantly increased export volumes and value of exports to Australia, New Zealand and the USA by Fiji (Fiji Quarantine, unpublished report 2006); the main commodity in this case being papaya, with smaller volumes of breadfruit, mango and eggplant. This demonstrates that the identification and development of suitable treatment systems can facilitate horticultural exports. HTFA is, however, not suitable for all commodities, since capacity is relatively costly to install and technically demanding and expensive to operate.

The quarantine concerns in exported root crops and cutflowers are external pests e.g. mites, mealy bugs, thrips, scales, ants, etc. Other quarantine concerns are the presence of soil and of nematodes typically present in root hairs and in 2mm of skin tissue. Point of entry interceptions of various living organisms lead to enforced fumigations which can increase costs and adversely affect the quality and shelf-life of produce, to the extent that potentially valuable commodity chains, such as that for taro export from Fiji to New Zealand, are only marginally profitable.

The project aims to identify appropriate alternative treatment regimes using hot water for external pests and nematodes and, where necessary, fumigation using ethyl formate (Vapormate® produced by BOC Gases), for PICs to adopt for key commodities. The project's primary focus will be on taro, with a subsidiary focus on ornamentals (cut flowers and foliage); preliminary studies may also be carried out on ginger, yam, cassava and sweet potato, depending on opportunities and needs identified by ACIAR and SPC research during the course of this project. The objective will be to produce data packages proving disinfestation of external pests acceptable to Australian and New Zealand Biosecurity Services. For exported taro, the issues of product quality and soil contamination, which interact with the disinfestation problem, will be addressed by better cleaning, handling, and packaging methods nearer the points of production, as well as better transport from production areas to market, using a pathway analysis developed by the Fiji Ministry of Agriculture and SPC. The project intends to encourage the private sector to establish the treatment facilities for export commodities, by adopting the technologies which will be proved in a set of commercial scale prototype units.

The full project proposal is available as a separate document.