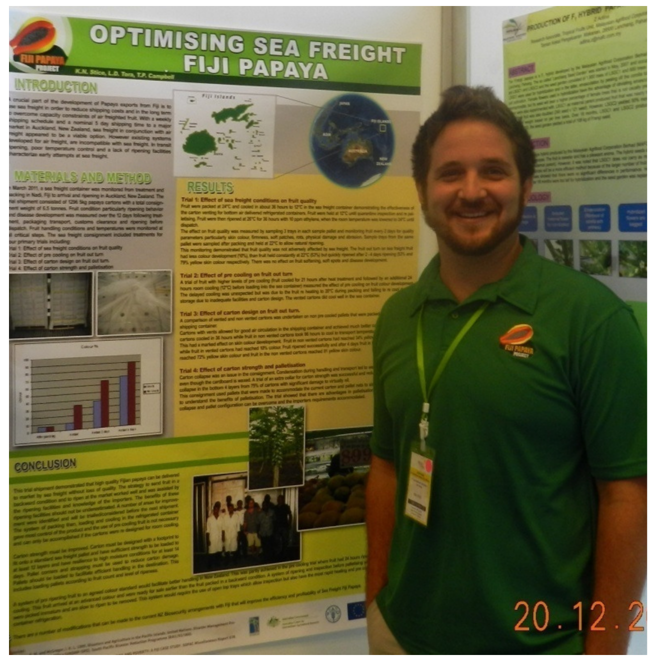
Trip Report: 3rd International Symposium on Papaya – Chiang Mai, Thailand



project	**NWC Fiji Papaya Project**
date	December 2011
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1 Introduction

The 3rd International Papaya Symposium was held at the **Imperial Mae Ping Hotel, Muang Chiang Mai, Thailand** on Dec 19-22, 2011. The symposium was co-organised by the Thailand Department of Agriculture and the International Society for Horticultural Sciences (ISHS).

The Australian Centre for International Agricultural Research (ACIAR) sponsored the attendance of Kyle Stice and Timote Waqainabete from the Fiji Papaya Project. Kyle Stice also attended the 2nd International Papaya Symposium in India where he presented a paper titled: *"Fiji Red" Papaya: Progress and Prospects in Developing a Major Agriculture Diversification Industry*. In the build up to the 3rd International Symposium on Papaya, Mr. Stice was nominated to serve on the International Advisory Committee.

Two research reports were presented from the Fiji Papaya Project including: *"The Economics of Organic Papaya Production in Fiji" and "Optimising Sea Freight Fiji Papaya".* This symposium was a unique opportunity to present research findings from the ACIAR Fiji Papaya Project as well as get peer feedback regarding on-going research activities under the project.

The symposium was attended by over 100 participants from 10 different countries. Altogether, there were 35 scientific papers presented at the symposium. The full scientific proceedings of the symposium, including the Fiji Papaya Project research papers, will be published by the International Society for the Horticultural Sciences (ISHS) and be available in late 2012.

Two scientists from the Queensland Department of Employment, Economic Development and Innovation (DEEDI), who are collaborators on the ACIAR Papaya Project were also in attendance at the symposium and presented papers on research carried out under the project. Having all of these collaborators attending the same workshop provided a valuable opportunity to discuss ongoing research as well as, plan for future collaborative research activities under the project.

The following report to the Fiji Papaya industry describes feedback from the scientific community on the research activities being carried in Fiji. The report also highlights the main areas of international papaya research that are relevant to the Fiji Papaya industry. Finally, the report describes a series of recommendations to the Fiji Papaya industry based on the outcomes from the symposium.

2 Fiji Papaya Project Research papers

Two scientific research abstracts were submitted to the International Society for Horticultural Sciences (ISHS) for presentation and publication through the 3rd International Papaya Symposium. Both abstracts were accepted by the organising committee; it was decided that the paper on *"The Economics of Organic Papaya Production in Fiji"* would be presented by FPP Activity Leader, Kyle Stice, while the paper entitled *"Optimising Sea Freight Fiji Papaya"* would be presented by Terry Campbell of DEEDI. A poster on this same subject was also presented by Kyle Stice.

2.1 The Economics of Organic Papaya Production in Fiji

Kyle Stice delivering his oral presentation on "The Economics of Organic Papaya Production in Fiji"

Organic agriculture is being promoted as a means to increase the income of Pacific Island farmers. It is usually assumed that farmers' income from growing organic products will be higher because the prices they receive for these products will be higher. Yet, little or no research has been undertaken on the economics of organic agriculture in the Pacific Islands. This research explores the economics of organic agriculture, with the case of Fiji papaya.

EU funded market studies have identified organic papaya as a product with considerable potential for Fijian farmers with high export prices on offer compared with conventional papaya. Significant export markets have been identified in the USA and Japan. With High Temperature Forced Air (HTFA) quarantine treatment, Fiji has an organic quarantine treatment, which most of our competitors do not have.

One exporter has begun experimenting with an organic production system. Despite the significantly higher export prices on offer, it is not known if it is financially worthwhile to produce organic papaya in Fiji, when the higher cost of inputs and expected lower yields is taken into account. To answer these questions, the NWC/Fiji Papaya Project conducted a field trial to compare an organic papaya production system with a conventional system.

In January 2010, a field trial to determine the economics of growing organic papaya in Fiji was established in the Sigatoka Valley. The package of practices developed for the organic system were based on meeting the nutritional requirements of the plant using locally available 'certifiable' inputs; lessons were also drawn from a Hawaiian model of organic papaya production. A wide range of data was collected to determine differences in yield, average fruit weight, percentage exportable, brix levels etc. Inputs for both systems were closely recorded providing accurate costs of production for both systems.

2.1.1 Feedback on presentation

The oral presentation was well received by the symposium and several questions were raised to the presenter, including:

- How were pests and diseases controlled under the organic system?
- What was the source of the fish bone meal product used in the organic system?

The presenter explained that the favourable pest and disease status of Fiji allows the grower to use only tools such as good sanitation and drainage in order to control diseases. The presenter further explained that even in the conventional papaya production systems in Fiji, insecticides and fungicides were not used because the losses are not high enough to warrant the extra cost. The presenter explained the source of fish bone meal and also the fact that this product is ‘certifiable’ under an organic system but not ‘certified organic’ as yet.

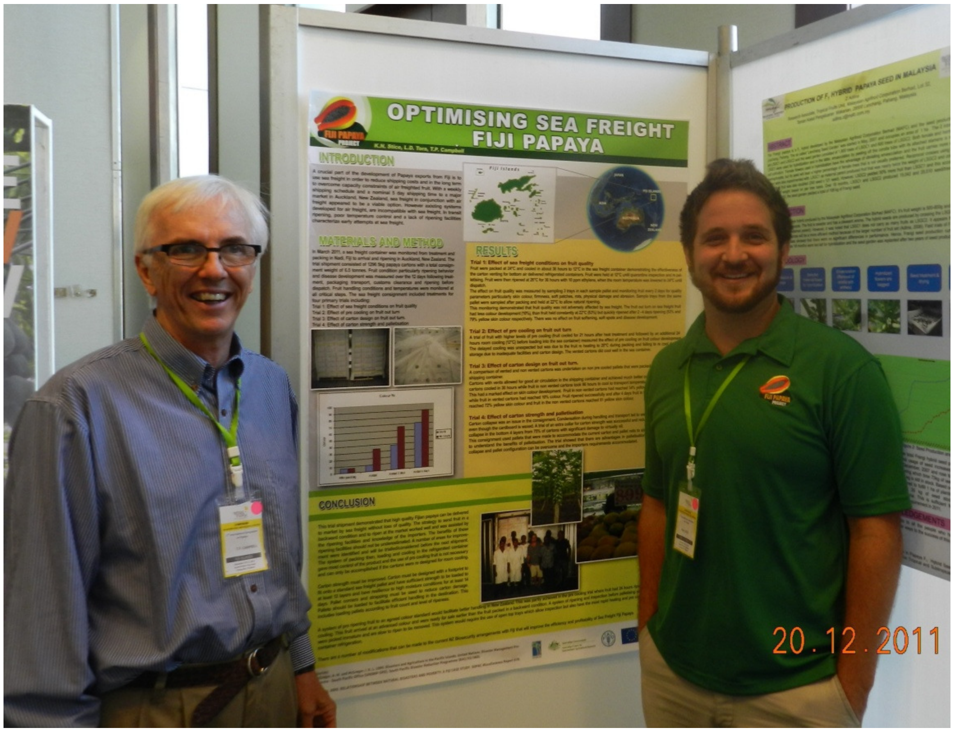
The chairman for the session suggested that there were some other economic models such as internal rates of return, which could be used to analyse this data, it was suggested such analysis would be relevant to other economists. The presenter acknowledged the comments and refrained from explaining the fact that the target audience for the research was not other economists but rather farmers and exporters interested in adopting these technologies.

2.2 Optimising Sea Freight Fiji Papaya

A crucial part of the development of Papaya exports from Fiji is to use sea freight, to reduce the shipping costs and in the long term to overcome capacity constraints of air freighted fruit. With a weekly shipping schedule and a nominal 5 day shipping time to a major market in Auckland, New Zealand, sea freight in conjunction with air freight appeared to be a viable option. However, existing systems developed for air freight, are often incompatible with sea freight. In transit ripening, poor temperature control and a lack of ripening facilities often characterize early attempts at sea freight.

In March 2011, a sea freight container was monitored from treatment and packing in Nadi, Fiji to arrival and ripening in Auckland, New Zealand. Fruit condition, particularly ripening behavior and disease development was measured over the 12 days following treatment, packaging transport, customs clearance and ripening before dispatch. Fruit handling conditions and temperatures were monitored at all critical steps. A number of innovations in carton design, pre cooling and palletizing were trialed and evaluated.

Research findings have demonstrated that high quality Fijian papaya can be delivered to market by sea freight, without loss of quality. The strategy to send fruit in a backward condition and to ripen at the market worked well and was assisted by the ripening facilities and knowledge of the importers. Pre-cooling of the shipments with existing facilities, failed to stabilise transport temperatures, however, with cartons modified for sea freight, good temperature management was achieved. Pallets and individual pallet nets for biosecurity provided good data on the likely efficiencies to be gained from palletisation.



DEEDI scientist Terry Campbell and FPP Activity Leader Kyle Stice beside the Optimising Sea Freight Fiji Papaya poster.

2.2.1 Feedback on presentation

The oral presentation of the paper *"Optimising Sea Freight Fiji Papaya"* was delivered by DEEDI collaborating scientist, Terry Campbell. The presentation was very well received with no questions raised, following the talk. During the poster presentation period, there was some feedback provided to Kyle Stice by leading postharvest specialist, Dr. Robert Paull of the University of Hawaii. Dr. Paull queried why we chose to use 12 deg C as our storage temperature; his experience was that a temperature of 7 deg C would have been more appropriate for this short duration. Dr. Paull further elaborated that if the fruit was riper, an even colder storage temperature could have been used. Despite the fact that ripening was nearly completely arrested during the trial at 12 deg C (our goal was achieved), this insight from a leading postharvest specialist should be taken on board, particularly for sea freight shipments of a longer duration.

3 Key points from research papers relevant to the Fiji Papaya industry

3.1 World Market

Several presentations at the symposium described the increase in demand for papaya worldwide. This demand continues to grow as supply, quality and marketing of this product are improved worldwide. It was also observed that a majority of the major papaya producing countries suffer from Papaya Ringspot Virus (PRSV) and are forced to use Genetically Modified Organism (GMO) varieties which are resistant to PRSV. The solo sunrise which is grown in Fiji is highly susceptible to PRSV therefore, there is very little solo sunrise grown around the world, which in turn highlights a unique opportunity for Fiji papaya to have an impact on the world market. Similarly, the high proportion of GMO varieties means that these countries are not likely to be able to supply organically grown papaya and with the FPP trials on organic papaya production in Fiji looking promising, this could yet be another niche market opportunity for Fiji farmers and exporters.

Presentations highlighted that the USA continues to be the largest importing country of papaya worldwide. Fiji Papaya Project market studies have confirmed that there exists significant demand for organic papaya in the US. On this basis, it is imperative that the Fiji industry and Biosecurity Authority of Fiji continue to push for US market access to Fiji Papaya.

3.2 Varieties and breeding

The 3rd international papaya symposium had a significant emphasis on papaya breeding. Breeding efforts were focused on improving disease resistance, improving vigour, yield and extending shelf life. Major papaya producing countries like Thailand, USA, Malaysia, Brazil, India, Taiwan etc. have substantial breeding programmes under way.

The two primary papaya breeding methods are traditional and transgenic. Some key varieties produced from each of these breeding techniques are provided below.

3.2.1 Traditional breeding (Non-GMO)

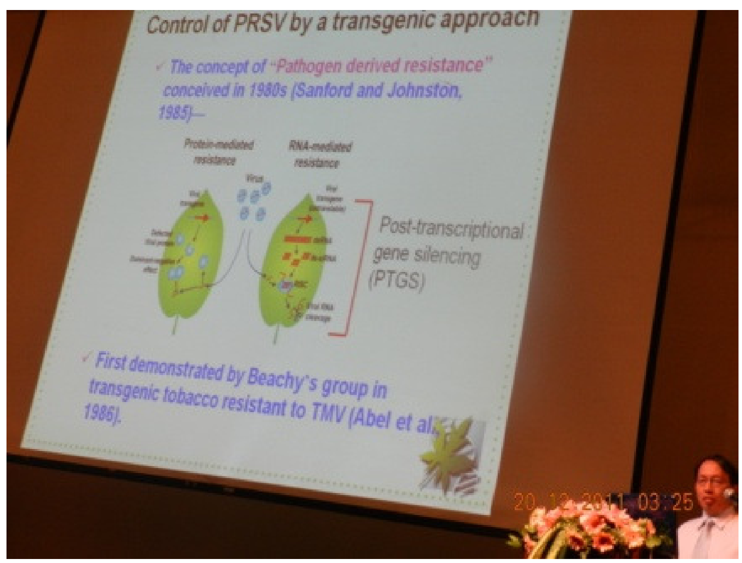
Traditional breeding is defined as the modification of plants and animals through selective breeding. Practices used in traditional plant breeding may include aspects of biotechnology such as, tissue culture and mutation breeding.

Papaya hybrids are the result of crossing two different stable inbred varieties. The hybrid will inherit some characteristics of each parent. Aside from just the combination of characteristics, hybrids generally produce more robust and higher yielding trees because of heterosis. Heterosis is also known as hybrid vigour and is essentially, the gene expression of the beneficial effects of hybridization. It is reported that hybrids are also more stable and uniform than inbred lines. Hybridisation of papaya is not a difficult task, particularly if the parents are good stable inbred lines. It was recommended by a Malaysian breeder, that Fiji should consider looking into producing local hybrids, if for no other reason, than to take advantage of the increase in vigour and yield.

'Frangi', F1 hybrid released in 2008 by Malaysian Agrifood Corporation (MAFC). Even golden skin colour at maturity, very firm and very long storage. Higher yield and more robust because of heterosis. Fruit weight 400-700g. The fruit has been branded and marketed as Paiola.

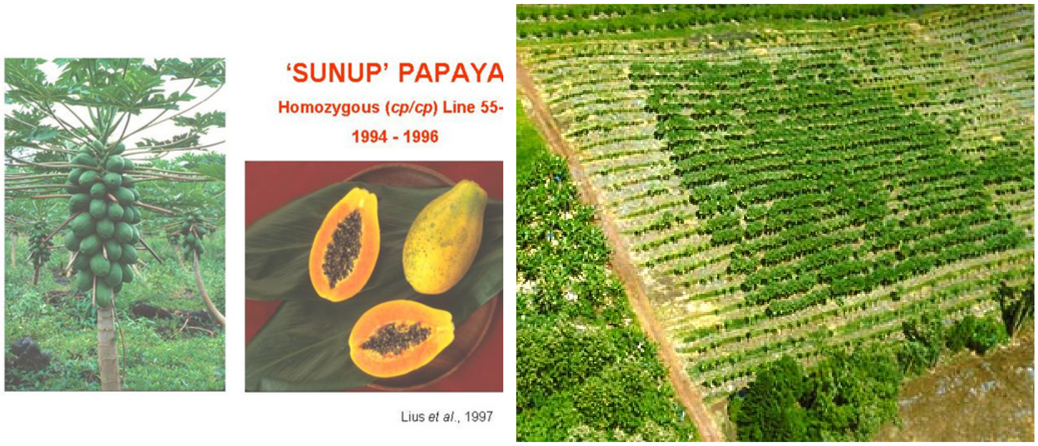
A continued effort to find the resistance for PRSV through non-transgenic breeding has been spear-headed by Australian Professor, Rod Drew of the Griffith University in Brisbane, Australia. Dr. Drew has expected that transgenic resistance could be found in distant papaya relatives such as the Vasconcellea species. Although Dr. Drew's work has been pioneering, it is yet to succeed.

3.2.2 Transgenic breeding (GMO)



Transgenic breeding refers to an organism whose genome has been altered by the transfer of a gene or genes from another species or breed. Papaya was one of the first GMO fresh food crops to be widely accepted. The first GMO papaya was produced in response to the devastating PRSV on the Hawaii papaya industry. The history of GMO papaya development which began in the 1980's, was presented by US scientist, Dr. Maureen Fitch. Presently, the Hawaii papaya industry grows approximately 85% GMO papayas.

Research in GMO development for PRSV resistance was also presented by Taiwanese researcher, Shyi-Dong Yeh and his team. This work has focused on the response to mutations of the PRSV. The Taiwanese scientists have been successful at overcoming these 'super strains' however, this highlights the need for continual research and breeding to combat PRSV.



GMO varieties make up around 85% of the total production in Hawaii. Picture on the right shows a PRSV reistant variety compared with a non-resitant variety.

Other papers presented at the symposium dealing with papaya breeding included; *PRSV-P resistance genes and the embryogenesis regeneration (Carica papaya)– Rod Drew* (presented by Richard Manshardt), *Studies on the Genetics of PRSV-P Resistance Genes in Intergeneric Hybrids between the Carica papaya and Vasconcellea quercifolia - Rod Drew* (presented by Richard Manshardt), *Papaya Breeding for Quality Improvement in Vietnam* – N.T.Nhat Hang, *Papaya Germplasm Collection in Sisaket Horticultural Research Center in Thailand* – U. Kumcha, *Breeding papaya for 'PRSV' tolerance* – Mr. Dinesh, *The Distribution and Prevalence of Papaya Ring Spot Virus (PRSV) in Kenyan Papaya* – F.K. Ombwara, *New High Yeilding Stable Hermaphrodite Type of Papaya from Coorg Honey Dew* – G. Karunakarar.

3.2.3 The escape of the GMO gene into non-GMO varieties

Dr. Richard Manshardt of the University of Hawaii presented a very interesting paper titled *"Seed Dispersal Is Major Means of Transgene Escape from GE Papaya Fields in Hawaii"*. This presentation confirmed that the GMO gene has escaped from GMO varieties into non-GMO varieties. According to the research, the main method of GMO escape is from seed dispersal, however pollen transfer was observed. This research confirms what many organic papaya farmers around Hawaii have been concerned about from the inception of the work on transgenic papaya – there is no way to ensure that the GMO gene will not spread to other non-GMO varieties and this affects the ability to grow certified organic papaya in the vicinity of GMO papaya[1]. The Fiji industry should be concerned about sourcing papaya seed from the University of Hawaii, in that it is possible that seed with the transgenic gene could be imported.

[1] A December 2010 report by Stice and Tora titled *"Snapshot of the Hawaii industry – considerations for Fiji"* reported: Organic papaya producer, Kumu Farms has recently been faced with a first time issue of a possible GMO contamination of their papaya varieties. The island of Molokai is GMO free and this is one of the major advantages for Kumu Farms to be successful in organic production. The issue arose when a high school science class on the island of Oahu went into a local Whole Foods store that carries Kumu Farms papaya as well as other non-GMO papaya. The class used kits to test for the presence of the transgenic gene and found it to be present in one of the fruits from Kumu Farms. Thankfully, the science class did the responsible thing and alerted the authorities before alerting the media. Subsequently, the University of Hawaii carried out an extensive survey at Kumu Farms (over 150 samples) and found no contamination.

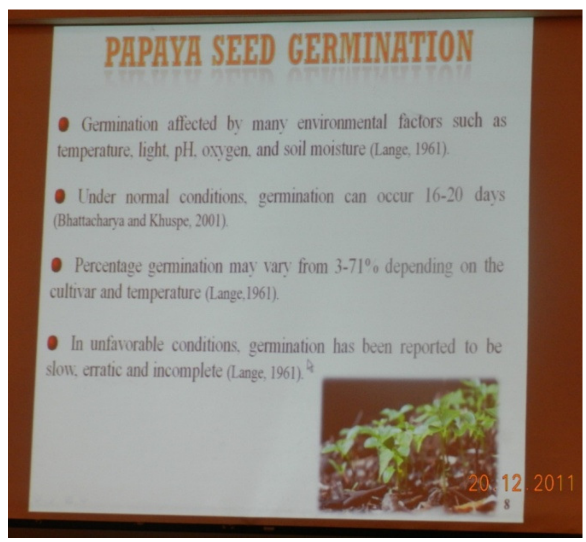
In a 2010 visit by the Fiji Papaya Project to Hawaii, Kyle Stice and Livai Tora were able to work with Dr. Manshardt, as he carried out field surveys to detect the presence of the transgenic gene in non-GMO papaya (see figures below).

Dr. Manshardt and Livai Tora harvesting young shoots from a non-GMO tree on Oahu to see if it carries the transgenic gene.

Symptoms of papaya ringspot virus on a solo papaya – Oahu.

3.3 Papaya seedling production

A paper was presented by scientists from India titled: *Standardization of Growing Media for Seed Germination in Papaya* - M.A.Hasan. In this trial, 9 treatments of different potting media were used to investigate: time to germination, % germination and seedling vigour. The potting media mix of soil:cocopit (1:3), produced the earliest germination followed by straight vermicompost. The percentage of seeds germinated was found highest in vermicompost. The seedling height and vigour after 20 days, was recorded highest in soil:cocopit (1:3). It was suggested that the germination and growth were improved with the media that provided better retention of water and air. which helped in quick and early enzymatic breakdown of the seed coat.



A paper was presented by scientists from Taiwan titled "*Effect of Smoke-Water Derived from Burnt Dry Rice Straw on Seed Germination and Growth of Papaya Seedling Cultivar Tainug No.2"* – J. Chumpookam. This study evaluated the efficacy of smoke-water on papaya seed germination and growth of papaya seedlings. The smoke water used in the trial is made by burning dry rice straw (Oryza sativa) and then bubbling the smoke through water. In the germination experiment, papaya seeds were soaked in different concentrations of smoke water for 24 hours prior to planting. The study revealed that even very low concentrations of smoke water promoted the maximum percentage of germination and shortened germination time. In the growth experiments, seedling potting media was saturated with smoke water which showed an increase in all growth parameters compared to the control.

3.3.1 Clonal propagation (tissue culture) of papaya

A paper by Fitch et al. 2005 published in HortScience describes the opportunities and constraints to using clonal propagation of papaya trees in commercial papaya production. The paper is titled "*Clonally Propagated and Seed-derived Papaya Orchards: I. Plant Production and Field Growth".* Some of the main benefits of micro propagation (either clonal propagation or rooting vegetative cuttings) are that there is no need to plant multiple seedlings per hole in order to improve the ratio of hermaphrodite plants. From these micro propagation techniques all plants will be hermaphrodite plants. Other benefits of clonally propagated plants compared with seed derived plants as described in the paper include:

- Clonally propagated plants were significantly shorter than seedlings
- Clonally propagated plants bore flowers earlier and lower on the trunk than seedlings
- Overall, the clonally propagated plants were more vigorous and earlier bearing than were the seedling plants.

The paper identifies two major bottlenecks to clonal propagation which are:

1. High cost of production as a result of low survival rates of plants grown as rooted cuttings or micro propagated plants and;
2. Timed output of propagules to enable farmers to plant when fields are prepared.

3.4 Papaya post -harvest

There were several interesting papers presented on papaya post-harvest, that are of relevance to the Fiji industry. Fiji Papaya Project collaborator, Yan Diczbalis from DEEDI, presented a paper titled "*Evaluation of the Use of Prochloraz in the Control of Post-Harvest Disease of Papaya in Australia".* The study which was conducted in N. Queensland, investigated the different ways Prochloraz was being used by commercial growers and evaluated its efficacy. The trial also compared Prochloraz to several other post-harvest fungicides. The results of the trial showed that several growers were not following the recommended application method (a non-recirculating spray for one minute) and when the solution was recycled or held for a long period of time there was a significant depletion of the active ingredient. The trial also demonstrated the important link between efficacy and the pH of the mixture. Prochloraz at the recommended rate provided more effective disease control than any of the other post-harvest fungicides trialled. The Fiji Papaya Project is currently scheduled to resume work with this product in Fiji, to test the efficacy and residue levels for a potential application to the Registrar of Pesticides.

A paper was presented by Indian scientists titled "*Effect of Wax Coating and NAA on the Storage Behaviour of Papaya"* – K.D. Bhutia. This paper presented the findings of a trial involving 10 treatments of different wax and NAA applications, to investigate the effects on loss of weight, colour development, fruit softening, total soluble solids (TSS), total sugar, reducing sugar and non-reducing sugar. The results indicated that the post harvest treatment with 6% wax coating + 250 ppm NAA (T9), resulted in better retention of physic-chemical characteristics and also in extending the shelf life of papaya up to 15 days at room temperature as opposed to the 7 days of shelf life in untreated fruits.

Another paper was presented by an Indian scientist titled "*Effect of Harvest Application of Calcium on Storage Behaviour, Ripening and Shelf Life of Papaya"* - Mr Raj Kumar. While this paper was interesting in its own right, the fact that it involves a pre-harvest application of calcium means that it is highly unlikely that farmers in Fiji will utilise the technology.

3.5 Pests and diseases

A paper presented by a Malaysian scientist was presented titled "*Experiences in Managing Bacterial Dieback Disease of Papaya in Malaysia"* - J. Mhod Khairil. The presentation described the devastating effects of the disease on the Malaysian industry, since it was first recorded in 2003. The paper reports that all commercial varieties are susceptible and management practice by farmers has not proven successful so far. The paper also reports that the bacterium typically enters the host through wounds, and passes through the petiole and into the green stem.

J. Mohd Kharil's paper reports "The Malaysian Agrifood Corporation Berhad established a large farm in Lanchang, Pahang in December 2006. The farm was initially disease free and therefore a BDB exclusion programme' could be imposed, whereby traffic and visitors were restricted entry to the farm. Those permitted entry were sanitized with shoe dips and disinfectant tyre sprays. Despite these measures, BDB was detected on the farm in late 2009, requiring that a 'BDB containment programme' be initiated. This description is evidence of the danger of *Erwininia papaya*e and a warning to all papaya producing countries to keep the disease out.

A leading papaya researcher, Chan Yink Kwok from the Malaysian AgriFood Corporation, stated in a discussion forum that Bacterial Dieback Disease (BDB) also known as Bacterial Crown Rot (BCR) caused by *Erwinia papayae,* is the most serious papaya disease worldwide and any country who does not have this disease needs to put in place measures to ensure that they keep it out. The author was able to discuss in private with Chan Yink Kwok about measures that could be taken to keep the disease out of Fiji. Chan Yink Kwok explained that because it is bacteria, it needs live tissue to survive so therefore there should never be any live papaya plant material introduced into the country. The author also asked about the possibility of importing the disease through seed and Chan Yink Kwok's response was that a properly dried seed should not have any living tissue in order to transmit the disease; the disease is not in the genetics of the seed.

A majority of the other pest and disease papers were dealing with Papaya Ringspot Virus (PRSV) and its primary vector, the aphid. PRSV is still regarded as the major constraint to papaya production in many parts of the world and Fiji should continue to be vigilant about the presence of this virus.

Bacterial Dieback Disease (BDB) also known as Bacterial Crown Rot (BCR) caused by Erwinia papayae is the most serious papaya disease worldwide and any country who does not have this disease needs to put in place measures to ensure that they keep it out.

Paraphrase from Chan Yink Kwok
Malaysian AgriFood Corporation

4 Fiji Papaya Project and DEEDI collaborative research planning meeting

Present at the Fiji Papaya Project and DEEDI collaborative research planning meeting were Kyle Stice, Timote Waqainabete, Terry Cambell, Yan Diczbalis.

Two DEEDI scientists, Terry Campbell and Yan Diczbalis who are collaborators on the ACIAR Papaya Project were also in attendance at the symposium and presented papers on research carried out under the project. Having all of these collaborators attending the same workshop provided a valuable opportunity to discuss ongoing research, as well as plan for future collaborative research activities under the project.

A planning meeting was held at the symposium venue on December 20th, 2011. A major outcome of the meeting was the planning of two collaborative research trials set to take place in Fiji during 2012. Discussions also took place on the opportunities for both Australia and Fiji to submit a project extension to ACIAR, to continue research work on papaya.

5 Recommendations for the Fiji Industry

Participation in this symposium confirmed many of the constraints that have been identified by the Fiji Industry. Significant opportunities for the Fiji industry were also identified. The necessity of the industry adopting the proposed projects that are in place was confirmed by information that came out of the symposium.

5.1 Continue papaya research and extension activities.

The Fiji Papaya project through funding support from ACIAR has been successful at addressing many of the major research constraints facing the industry to date. However, research is a long term initiative and it is critical that this work continue and that new areas of research are addressed. Funding from ACIAR will conclude in June 2013 and the Fiji papaya industry should seriously consider submitting an application for the extension of this work.

5.2 Implementation of a biosecurity plan for the Fiji papaya industry

At present, Fiji benefits from a relatively favourable pest and disease status, as it relates to papaya. There are a number of serious threats to this favourable status and the industry is not currently prepared with the necessary information to protect against introduction and handle eradication of these threats. It is proposed to implement a bio security plan for the Fiji Papaya Industry. It is envisioned that this bio security plan will target primarily the threats posed from;

- Papaya Ringspot Virus (PRSV)
- Bacterial Crown Rot (*Erwinia papayae*)

The plan may also include other pest and diseases that pose an unacceptably high level of quarantine risk. The proposed bio security plan will aim to describe clearly the threat and the potential impact, if introduced into Fiji. The plan will also describe means for preventing the introduction of these threats including promoting a greater awareness among quarantine officials and private sector participants. Activities likely to be carried out under the plan include:

- Literature review to clearly describe the threats including symptoms, the pathogen, development of disease/virus and methods of control.
- Survey to confirm threats are not present in Fiji
- Production of training materials to identify symptoms of the threat in the nursery and on the farm
- Utilizing existing literature draft a bio security plan for the Fiji Industry
- Implement the bio security plan through a series of trainings with FQIS, MPI Research, MPI Extension and farmers.

5.3 Fiji to host post congress tour (International Horticulture Congress, Brisbane – 2014)

Fiji was suggested as a post tour venue before the 4th International Papaya Symposium set for 2012 in Brisbane, Australia. The representative from Fiji has agreed to return to Fiji and begin dialogue with the likely collaboration agencies, while ISHS and other participants return to their home country and discuss this prospect. Likely collaborating agencies to host the symposium are Nature's Way Cooperative (the lead body for the Fiji Papaya Industry), Secretariat for the Pacific Community (SPC) and the Ministry of Agriculture and Primary Industries.

It is recommended that Fiji strongly consider hosting this post congress tour, as it will be a valuable opportunity to showcase the research and development work that has been going on in the Fiji Papaya industry. This tour also provides the opportunity to get feedback from some of the leading scientists in the field of papaya on the issues facing the industry.