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Australian Centre for International Agricultural Research

Final report

project	**Management of fruit quality and pest infestation on mango and mangosteen to meet technical market access.**
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Acronyms & Abbreviations

ACIAR	Australian Centre for International Agricultural Research
AMIA	Australian Mango Industry Association
ANSTO	Australian Nuclear Science and Technology Organisation
AMS	PT. Agung Mustika Selaras
CA	Controlled Atmosphere
DGH	Directorate General of Horticulture
GAP	Good Agricultural Practise
DPI&F	Department of Primary Industries and Fisheries Queensland, Australia
IAQA	Indonesian Agricultural Quarantine Agency
IAARD	Indonesian Agency for Agricultural Research & Development
ICHORD	Indonesian Centre for Horticultural Research & Development
ITFRI	Indonesian Tropical Fruit Research Institute
ICAPRD	Indonesian Centre for Agricultural Post Harvest Research & Development
IPB	Institut Pertanian Bogor (*Bogor Agricultural University*)
IVS	Invitro soil
HACCP	Hazard and Critical Control Point
NNEA	National Nuclear Energy Agency
NMBP	National Mango breeding project
NGO	Non-government organisation
RBMC	Red banded mango caterpillar
VHT	Vapour Heat Treatment.

2 Executive summary

Historically the mango and mangosteen industries have not only struggled with meeting phytosanitary requirements in various export markets, but have also found difficulties in supply of a consistent quality that the markets require. The aim of the "Management of fruit quality and pest infestation on mango and mangosteen to meet technical market access" was to assist these Indonesian industry's in raising their capacity to meet international market export protocols whilst also being able to supply a product that will meet these market requirements. The specific objectives of project were to:

1. Identify technical and phytosanitary requirements for fresh mango and mangosteen in key markets and appropriate strategies analysed to overcome these technical market access constraints.
2. To improve fruit quality from production to consumption using good agricultural practices.
3. To conduct the necessary phytosanitary disinfestation treatments to selected export markets.
4. To build capacity in the mango and mangosteen industries to conduct integrated and targeted research, development and extension programs

Market evaluation work was conducted on both the two main Indonesian and the three new Australian mango varieties. This identified some opportunities for Gedong and limitations of Harumanis as export varieties. This was followed up with trial export shipments initially by air and later on by sea to Hong Kong and Dubai. As a direct result of the work a commercial supply program was established with a leading Hong Kong supermarket chain. The export shipments proved very successful, indicating the robustness of the Gedong variety to export systems. However a number of physiological issues emerged on the Harumanis variety which until resolved severely limit this varieties capacity to be exported by sea.

Advances were made in a number of areas for improving mangosteen fruit quality thus enabling farmers to achieve higher percentages of export grade fruit. This led to the categorisation and identification of the causal agents of fruit scarring the single biggest quality issue, and the development of techniques to reduce its impact. Improvement in nutritional management of both mangosteen and mango has led to a reduction of a number of internal quality disorders. Significant improvement in the export quality of mangoes was achieved with the introduction of a sap management system and new generation post-harvest fungicide treatments which reduced disease incidences down to very low levels.

To develop an understanding of the constraints and opportunities facing the Indonesian mango industry moving forward into the export markets a strategic planning activity was conducted with the mango industry including, government research and policy, university researchers, farmers, exporters and other key industry stakeholders.

Methods of controlling quarantine pests particularly ants and mealybugs within the mangosteen supply chain proved very successful with population levels reduced by up to 70 to 90% in some cases and with further refinement of methods even high levels are achievable. This substantially enhances the efficacy of post-harvest disinfestation treatment's that are conducted on the fruit prior to export.

Significant investment was made in upgrading existing infrastructure and labs at NNEA and IAQA. This was combined with the development of intensive training programs for staff on equipment use and trial design thus greatly enhanced these departments capacity to undertake irradiation and fumigation work at a level that will be internationally acceptable, thus being able to supply the data that is necessary for negotiating market

access. This will have significant ongoing long term impact not only for the Indonesian mangosteen and mango industry but for other horticultural industries that can utilise this capacity for undertaking market access work.

In Australia work was completed on the new NMBP mango varieties which determined their maturity indices, shelf life and tolerances to current disinfestation treatments, from this a package has been developed for the release of the varieties that incorporates this information.

Significant capacity building work was conducted for researchers, policy makers, farmers and exporters into developing various aspects of the export systems from phytosanitary disinfestation, scientific techniques, quality management, economic evaluation and agronomic practices. This combined with the upgrading of the capacity in equipment will place the Indonesian mango and mangosteen in a very good position for being able to deliver the research results required for bilateral market access negotiations. In addition to this the industries have made substantial gains in the understanding of quality issues that affect them and how to address these in order to have the capacity to deliver the right quality product to the market. This gives them the potential to delivering a long lasting impact over many years.

3 Background

Mangoes and mangosteen are important horticultural commodities in Indonesia with 2.1 M tonnes of mangoes produced in 2011, making it the 6th largest producer in the world, and 72,000 tonnes of mangosteen produced in 2006, making it the world's largest mangosteen producer. Indonesia produced over 17 million ton of fruit in 2005 but exports were only 0.1% (16,800 tonnes) of production. Additionally, the majority of Indonesian fruit consumed in the domestic market is purchased through low value 'wet' markets, with higher value markets, such as modern retailers reliant on imported fruit (Morey, 2007) Most of Indonesia's limited fruit exports are destined for Asia with mangosteen (8,471 ton), banana (3,647 tonnes), mango (940 tonnes), pineapple (643 tonnes) and oranges (526 tonnes), noting that mangosteen exports accounted for 50% of all Indonesian fresh fruit exports in 2005.

Mango

The Indonesian mango market is almost exclusively the low value 'wet' domestic market, with little penetration into high value modern retail or global markets. This lack of market penetration is in spite of being an off-season producer, in close proximity to large mango consuming markets and often of higher value. There are a number of underlying reasons for this, primarily the main variety, Harumanis, ripens with a green skin. This characteristic is considered undesirable in higher value markets, including those domestic and export markets. This poor visual characteristic often relegate the product to the low value market segment, which means there is little incentive for a change of practice within the system. Other contributing factors to the lack of engagement with higher value markets, particularly export markets, include: poor fruit quality; limited market intelligence; technical quarantine barriers and poor supply chain management.

Mangoes are generally grown at subsistent levels with the application of traditional technologies. However, in some production centres (such as Sitobondo, Magetan, Pasuruan, Buleleng, Takalar, Cirebon, dan Majalengka) growers have applied some modern cultivation technologies.

The development of mango orchards by private companies has primarily been in Java, representing 1.5% of national production area. Recently, some private companies have developed mango orchards in East Java i.e. (1) PT. Trigatra Rajasa, 180 ha in Sitobondo, (2) PT. Citra Arumanis, 75 ha in Probolinggo, (3) PT. Sata Harum, 166 ha in Probolinggo, (4) PT. Friga, 50 ha in Pasuruan, and (5) PT. Galasari Gunung Swadaya, 253 ha in Gresik. The mango variety commonly grown by the private companies is Harumanis 143, the most widely grown variety that makes up the vast majority of the domestic markets.

With higher value markets, such as modern global retailers, seeking consistently long supply windows from a range of supply countries, a significant comparative advantage for the Indonesian mango industriy is the counter-seasonal supply window compared to other leading mango producing countries. This comparative advantage is unable to be utilised due to lack of market access and a restricted ability to deliver high quality fruit through to the market.

Recent varietal improvement programs in Indonesia have identified several new varieties including Gedong Gincu, which has yellow skin ripening characteristics with a red blush in its unblushed form it is known as Gedong. Global mango market development indicates this skin characteristic will have greater penetration into higher value markets, and if other contributing factors, identified above, can be resolved these new, more marketable

varieties, have significantly greater potential for success in these higher value markets, particularly the export market.

Mangosteen

Mangosteen is an important export crop for Indonesia with total exports ranging between 7,000 – 20,000 tonnes per annum (Source DGH 2015). The majority of exports are going to China, however it is uncertain whether the export is through bilaterally agreed technical protocols or through a commonly used informal channel via Hong Kong, often referred to as the grey channel. However whilst there appears to be good opportunity for expansion of mangosteen exports the growth has been slow in recent years (Muharam, 2008). This is due to a number of identified factors; quarantine issues with detection of live insects on the fruit, pericarp hardening which reduces fruit quality, gummosis and translucent flesh as well as blemish damage on the skin. There also appears to be a lack of information flowing in the supply chain in regards to market intelligence, product outturn, certification and quality specification requirements. Expansion into new markets with phytosanitary regulations has also been difficult to attain. Investment into new mangosteen varieties to meet market potential has been low due to the long lead in time to production and the low percentage of export grade fruit produced.

In 2013, 5.4% of Indonesia's mangosteen production of 139,602 tonnes was exported (DGH) with the majority destined for HK/China. Over the last four years, HK/China's share of Indonesia's mangosteen exports has increased steadily from 60% in 2002 to 85% in 2006. However, it is unclear to the extent of current Indonesia access to China for fresh fruits. During the same period, there has been a significant decline of export fruit to Europe and Taiwan. This can be attributed to the closure of the Taiwan market for Indonesian fresh fruits due to detection of ants and the introduction in Europe of EurepGAP[1] quality standards which makes it difficult for growers/suppliers to comply. Smaller quantities are been exported to the Middle East.

However, despite a growing market demand, mangosteen exports from Indonesia have not risen primarily due to inconsistent supply and low fruit quality, both of which are affected by on-farm production practices and postharvest handling. Less than 30 % of mangosteen production meets export quality standards. Producers do not have access to improved management information and techniques to obtain better quality and increased yields (apart from the use of fertilizer by a limited few). Current pre- and post- harvest pest and disease management and harvest and handling techniques are inadequate. There has been access to only basic primary post-harvest technologies including sorting, grading, packaging and cool chain technologies. Mangosteen quality problems encountered and reported include gamboge (gummosis), pericarp hardening and translucent pulp (or translucent flesh disorder) leading to lower prices and reduced shelf-life. Poor pre-harvest field practices and post-harvest handling result in high levels of pest damage and high insect pest infestation on fruit, increasing post-harvest handling costs - cleaning, sorting, grading and treatment costs, especially for export fruit.

Mangosteen production has gradually increased between 2002 and 2006 (Table 2). Harvested area in 2006 covered 8,275 ha with production at 72,634 tonnes or 8.78 tonnes/ha. Production centres for mangosteen are in 46 districts in 20 provinces. It is noted that the harvesting season is usually earlier in western than in eastern parts of the country.

[1] GlobalGAP has now replaced EurepGAP

Table1. National production of mangosteen, 2002-2006

Year	Harvested Areas (ha)	Production (tonnes)	Productivity (tonnes/ha)
2002	8,051	62,055	7.71
2003	9,354	79,073	8.45
2004	8,473	62,117	7.33
2005	9,119	64,711	7.10
2006	8,275	72,634	8.78

Source : DG of Horticulture, 2007

With a number of comparative advantages (counter seasonal supply, low cost high volume producer, variety of regions to offset seasonal risk etc.) the lack of successful international market penetration indicates limited capacity to support industry achieve greater success in the international market. To build capacity within Indonesia this project used mango and mangosteen industry models to develop their capacity to be able to meet technical market access requirements into higher value markets and develop quality management systems enabling fruit to compete in higher value markets.

The overall aim of the project is to improve the international competitiveness of the mango and mangosteen industries of Indonesia through the development of systems that will allow these industries to meet the requirements for technical market access and therefore to deliver high quality fruit into the market. The project has engaged supply chains in these accessed markets.

To meet this aim the project has the following objectives:

1. Identify technical and phytosanitary requirements for fresh mango and mangosteen in key markets and appropriate strategies analysed to overcome these technical market access constraints.
2. Improve fruit quality from production to consumption using good agricultural practices.
3. Conduct the necessary phytosanitary disinfestation treatments to selected export markets.
4. Build capacity in the mango and mangosteen industries to conduct integrated and targeted research, development and extension programs

The outcomes of this will improve the international competitiveness of the mango and mangosteen industries of Indonesia through the development of systems that allow improved technical market access with the ability to deliver high quality fruit into the market.

For Australia new R&D emerging from this project will include pre-harvest, harvest and post-harvest strategies and protocols to reduce pest infestation, fruit damage and post harvest rots on both mangoes and mangosteen using low input systems. This information

will facilitate export for the Australian mango industry and the fledgling mangosteen industry, through the development of soft chemical protocols for pest and disease management under GAP that meet stringent import requirements for food safety.

Domestic demand for mangoes is growing in Australia and there are good prospects for expansion of export markets. However, quality deterioration and in extreme cases losses, can vary returns by up to 30% in some cases, and in a recent Australian survey, 70% of lines monitored did not meet customer expectations for quality (Better Mangoes HAL Project FR01038 Final Report 2003).

The project will provide the opportunity to test emerging varieties from Australia's national mango breeding program for suitability into several key markets in consultation with the Australian Mango Industry Association (AMIA) as well as define the quality parameters of the newly developed hybrids from the National Mango Breeding Program (NMBP).

The project will also allow the development of an effective trapping grid for the red banded mango caterpillar (RBMC), a quarantine pest recently established in Cape York, to monitor its movements with the possibility to contain or eradicate the population.

4 Objectives

The aim of the project is to improve the international competitiveness of the mango and mangosteen industries of Indonesia through the development of systems that allow improved technical market access with the ability to deliver high quality fruit into the market. The project will engage supply chains in these accessed markets with the smallholder farmer, a key component of the chain. This aim aligns to the intent proposed under the Indonesian Horticultural Strategic Plan for the Mango and Mangosteen Industries to address the constraints currently limiting the market competiveness of the mango and mangosteen industries in Indonesia. The specific objectives of this project are:

1. Identify technical and phytosanitary requirements for fresh mango and mangosteen in key markets and appropriate strategies analysed to overcome these technical market access constraints.

(Note: the supply chain analysis being conducted in ADP/2005/066 will be used to inform the development of appropriate strategies)

Activities

- Identify key target market (opportunity) and market entry requirements (threat) for mango and mangosteen.
- Verify current information, such as pest/disease lists for each product, critical issues and assessing current capacity of government and industry to meet these market requirements.
- Assess variety and current quality parameters for export suitability in key markets.
- Develop an action pathway for accessing priority markets and improving market share in existing markets.

2. To improve fruit quality from production to consumption using good agricultural practices.

Activities

- Identify key technical constraints, such as agronomic practice, pest and disease impact, variety, postharvest management, which affects fruit quality and appropriate strategies that improve fruit quality through the supply chain.

In mangosteens, likely strategies will be

- IPM strategy for control of mites, ants and thrips
- on- farm management to improve fruit size

In mangoes, the approaches to improvement in fruit quality are likely to be:

- Define quality parameters for new varieties, such as Gedong Gincu
- Develop pheromone trapping guidelines for RBMC.
- Improved management practices including postharvest handling for targeted export markets

3. To conduct the necessary phytosanitary disinfestation treatments to selected export markets.

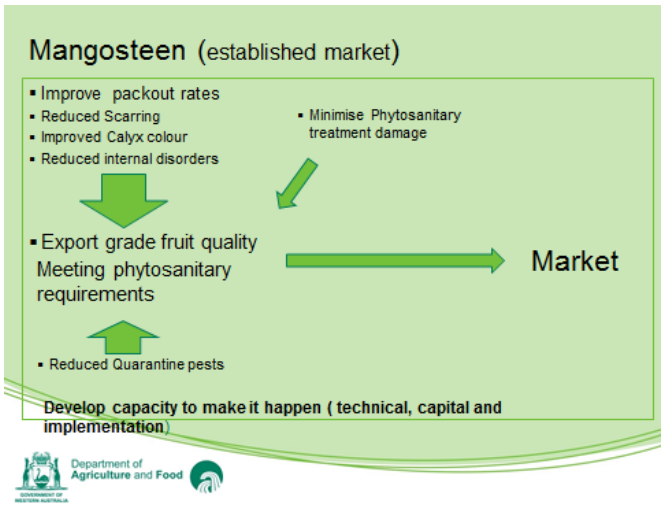
Activities

- Develop disinfestation protocols for access to high value market (eg mangosteen to Taiwan using ethyl formate/paraffinic oils/irradiation; VHT and Irradiation for mango.)
- Trial supply chain to meet market access requirements and phytosanitary requirements
- Initiate direct access negotiations into a market with phytosanitary requirements

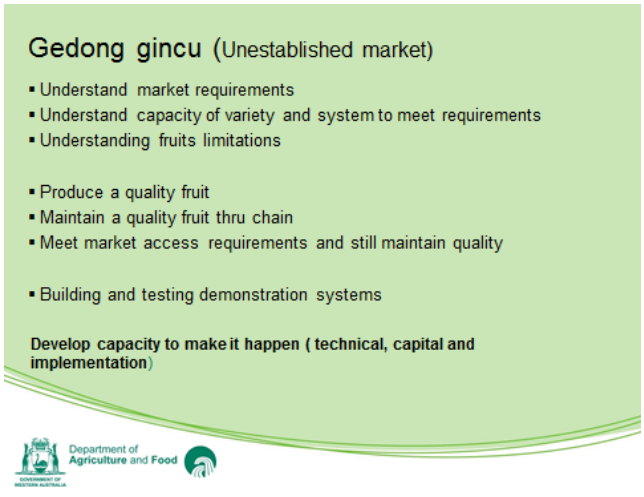
4. To build capacity in the mango and mangosteen industries to conduct integrated and targeted research, development and extension programs

Activities

- Capacity building of project staff and scientists in project management, extension and communication including information product development
- Develop and deliver workshop modules for researchers, extension agents and supply chain partners covering general orchard management (GAP) strategies particularly focused on integration of controls into a crop management approach
- Working with key mango and mangosteen exporters on a hands-on approach in improved post-harvest handling and management, and disinfestation procedures



- Mangosteen objectives summarised from workshop notes



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- Mango objectives summarised from workshop notes

5 Methodology

1. Identify technical and phytosanitary requirements for fresh mango and mangosteen in key markets and appropriate strategies analysed to overcome these technical market access constraints**.**

Activities

1.1 Study consolidating existing information and Identifying market entry requirements for each target market for mango and mangosteen.

- Identify target markets for mangoes and mangosteens and rate according to phytosanitary requirements (phytosanitary/non-phytosanitary markets).
- Identify phytosanitary requirements for entry to those markets requiring phytosanitary certification (desktop study).
- In market research, interviewing importers and retailers identify potential, market segment.
- Quantify current market issues quarantine, supply, quality etc.

1.2. Verify current pest/disease lists for each product, identifying, critical issues and assessing current capacity of industry to realistically meet these market requirements.

Australia

- Conduct an extensive review of the literature including NAQS reports for surveys of nearby Indonesian and Timorese localities.

Indonesia

- Search existing regional and national insect/pathogen collections for records of known pest/host occurrences, including Department of Agriculture's survey records.
- If reviews and collection searches reveal significant knowledge gaps, orchards in key representative regions will be surveyed for insect pests and diseases. This will involve fruit inspections in the field and fruit incubation. Pheromone trapping will be used to establish the regional presence or absence of pests for which attractants are available, such as fruit flies and red banded mango caterpillar
- Conduct inventory of available technology, including location and capacity of irradiation facilities, VHT facilities etc.
- Collate current pesticide registrations and identify where developmental work may lead to useful quarantine treatments.

1.3 Assess Indonesian and Australian Mango varieties for export suitability in key markets.

- Identify potential Indonesian varieties that could be assessed looking at selection programs, commercial orchards etc.
- Identify potential commercial partners capable of meeting export requirements.
- In market research to assess potential demand and market segment.
- Consumer focus groups to assess variety's suitability for market.
- Interview importers and exporters on current mango market trends and expectations.

1.4 Develop an action pathway for accessing priority markets and improving market share in existing markets.

- Review information collected in 1.1-1.3
- With working group prioritise markets based upon potential, ability to meet the demands, market access requirements.

- Document detailed plan including necessary pathways, responsibilities, costings, trial work (including methodology) required to meet importing countries protocols.

2. To improve fruit quality from fruit development through to harvest and consumption using good agricultural practices.

Activities

2.1 Identify key technical constraints, such as agronomic practice, pest and disease impact, variety, postharvest management, which affects fruit quality, and appropriate strategies that improve fruit quality through the supply chain.

- Conduct an analysis of current mango & mangosteen production across the major export producers to determine the production practices used, including skill levels of orchard managers and assess the impact of these practices on cost, yield and quality, acknowledging potential environmental issues
- Establish baseline data of current production practices and skill levels accounting for any major variations due to region, farm size or other relevant attributes
- Identify issues of mango & mangosteen production with the greatest potential for improvement in terms of cost, yield and quality
- Develop broad research strategies to address these identified issues
- Develop 'business cases' for the preferred research and development strategies to address these potential issues. The business cases are to include the broad R&D strategy, recommendations for implementation and a benefit cost analysis.

2.2. Develop IPM strategy for control of mites, ants and thrips

- Conduct preliminary investigations into field and seasonal abundance of outstanding IPM candidate agents, and current control methods.
- Where appropriate chemical controls are lacking, conduct field trials to develop recommendations and establish residue data to satisfy market MRL limits.
- Develop strategies to maintain area freedoms, if applicable.

2.3. Identify agricultural practices to improve mangosteen production systems

- Identify suitable trial sites and collaborators for conducting trial work
- Examine options for post harvest identification of internal mangosteen disorders.
- Conduct a key stakeholder study tour of mangosteen agronomic practices in Thailand, particularly concentrating on harvest technology.
- Examine factors influencing post harvest quality such as (pericarp hardening, fruit size, premature calyx browning, relative humidity during storage and mechanical injury.)
- Test DAFWA In vitro soil (IVS) propagation techniques to ascertain if there is an economic benefit for use on mangosteen. Test material at suitable sites in Indonesia and Australia.

2.4 Define quality parameters for varieties such as Gedong Gincu and new Australian hybrids

- Develop a protocol for defining quality parameters within mango varieties.
- Development of maturity standards,
- Assess suitability of the selected varieties for disinfestation treatments (VHT,HWT, Irradiation).
- Determine postharvest quality attributes, ripening and storage behaviour for selected varieties.

2.5 *Develop pheromone trapping guidelines for RBMC*

An effective pheromone for RBMC has been developed by QDPI. A pheromone trapping program may be of significant value to the Australian and Indonesian mango industry:

- In establishing whether the pest is present in a particular locality through the maintenance of a grid of pheromone traps
- The central component of a control program based on male annihilation

To determine the value of RBMC pheromones to the Indonesian mango industry it will be necessary to establish the following benchmarks through field experimentation:

- Trap design. What physical design (eg impregnated sticky traps, Steiner traps etc.)
- Formulation. How the pheromone is best presented in the trap?
- How effective is the pheromone under local conditions i.e. what proportion of RBMC males will be attracted? This question may be best answered using a known number of moths in a caged situation.
- Period of effective attraction. For how long is the trap attractive?
- Trap spacing. What is the distance over which traps are attractive? This may vary according to the philosophy underlying the trapping program, and will determine the design of the trapping grid.

The trap design and formulation work can be undertaken in Australia. All other activities will be done in Indonesia.

2.*6* Develop recommendations and capacity to improve and maintain quality suitable for export markets.

- Conduct a series of strategic workshops and field demonstrations with key industry participants. These will target the specific areas that have been identified in the other activities.
- These will also be accompanied by extension packages initially working with the key industry participants
- Information and training from this activity will form practices and procedures guidelines for producers and exporters.

3. To conduct the necessary phytosanitary disinfestation treatments for fruit and export shipment trials to selected export markets.

Activities

3.1 Technical knowledge transfer on available heat treatments.

- Visit HTFA Facility and participate in trial run and visit to Perth.

3.2 Develop disinfestation protocols for access to high value market (eg Irradiation/Ethyl formate/oils for mangosteen to Taiwan, VHT or HTFA and/or Irradiation for mango)

- Facilitate the upgrading of the Irradiation plant with a conveyor system.
- Conduct assessment of current facilities and research capacity
- Develop a workplan to address shortcomings in current capacity
- Initiate training both within Indonesia and Australia (Perth and Darwin) to address the identified needs.
- Provide advice on the proposed market access process and as it progresses.
- Develop disinfestation protocol for ants
    - This will be a two part approach firstly ascertaining the cause of the ants i.e. they may be indicative of another issue mealy bug, scale etc
    - Identify opportunities for field control using cultural, biological or chemical methods
    - Trial new fumigation technology as an option for exporters if field control proves not an effective option

3.3 Trial supply chain to meet market access, phytosanitary and regulatory requirements

- Monitor supply chain to target markets
- Document and follow two current export supply chains
- Undertake export trial under simulated commercial conditions in conjunction with commercial partner and Indonesian centre for Agricultural Post harvest Research and Development (ICAPRD)
- Conduct quality assessments throughout the chain and final outturn assessment.
- Training local staff on supply chain monitoring
- Quantify percentages quality losses at critical point in the chain, types of losses occurring and likely causes of these

3.4 Collate technical data and information to technically under pin market access negotiations for Mangosteen.

- Analyse and collate information generated from the previous activities,.
- This will be based on realistic market potential, and alibility to meet these requirements
- The activity will involve collation of pest lists, disinfestation data, possibly verification trials etc.

4. Enhance the capacity of research and extension personnel to carry our integrated research, development and extension programs.

- Facilitate needed RD&E training through different group and graduate degree programs in appropriate institutions so that they can continue with RD&E work in mangoes and mangosteen
- Link up and use existing farmer group approaches of Indo org to enhance the skills development and information flow to growers, collectors and field workers in mango productivity and quality
- Increase the capacity of research, extension & key regulatory staff in key areas related to integrated RD&E such as program/project development/management needs analysis etc, information production, correct approach for market access protocols, laboratory procedures

6 Achievements against activities and outputs/milestones

Objective 1: To Identify technical and phytosanitary requirements for fresh mango and mangosteen in key markets and appropriate strategies analysed to overcome these technical market access constraints

no.	activity	outputs/ milestones	completion date	comments
1.1	Study identifying market entry requirements for each target market for mango and mangosteen	Data collected, each markets requirements collated.		**Mango**: Existing export markets for Indonesian mangoes Singapore, Middle east and Malaysia where examined these markets primarily have no phytosanitary requirements at present. Further examination looked at China, New Zealand and Japan as potential target markets all of these markets have phytosanitary requirement. Specific entry requirements are determined via bilateral negotiations between the importing and exporting country. By examining the known pests present in Indonesia and protocols that these importing countries are placing on other exporting countries it was is quite apparent which of the local pest issues will require some form of phyto sanitary treatment. **Mangosteen** Significant exports were occurring to Taiwan and China as well as other SE Asian countries both these markets have phyto sanitary requirements in regards to the presence of live insects on the consignments. Just prior to the projects commencement Taiwan banned Indonesian mangosteens due the presence of ants and mealy bugs in many consignments. With China the fruit was moving through the grey channel via Hong Kong thus avoiding inspections, however this has recently been enforced and exports have virtually ceased to China which is Indonesia's largest market. The issue in both these markets and every other potential market including Australia and New Zealand for Indonesian mangosteens is the presence of ants and mealy bugs on the surface of the fruit and under the calyx. With the exception of Japan which is the only country that considers mangosteen a fruit fly host.

1.1		Quantifying information in market findings.		**Mango** With mango, Indonesia is currently not accessing markets with phyto sanitary requirements other than some of the Middle eastern markets which are not enforcing mango seed weevil protocol on exporters. Therefore phytosanitary markets such as China, where Indonesian fruit is sometimes found it is entering through the grey channels where is not possible to find official documentation that quantity's the requirements on market assess. However by reviewing market access protocols from other counties such as Australia that have been granted official access, the project was able to draw parallels on what each country requirements are most likely going to be based on. Interviews were held with importers in Singapore, Hong Kong, China and Dubai to ascertain a better understanding of the commercial potential and limitations of Mangoes from Indonesia. This was followed up with interviews of retailers and consumers to quantify the information gained from the importers. Whilst importer, retailers and consumers are not directly involved in the phyto sanitary regulations for market access it is important to understand the potential of these markets for prioritising the access process. **Mangosteen** The vast majority of Indonesian exports are to China, however on closer examination this was found to be entirely through the grey channels such as via Hong Kong. The was no current protocol to directly send to China. The main issue with direct access to China will be the same as to Taiwan the presence of live insects predominantly ants and mealy bugs. Mangosteen is not considered a fruit fly host with the exception of the Japanese market so no fruit fly disinfestation is required. Historically as it is considered a non-fruit fly host it has not received the same scrutiny when entering into countries such as China. This has changed recently with imports of mangosteen from Indonesia being stopped. The issue of live insects is going to be the same for any international market with phytosanitary requirements and the dominant insects are ants and mealy bugs with smaller incursions of thrips, scale, mites and spiders all being pests on the external skin of the fruit.

1.2	Verify current pest/disease lists for each product. Identifying, critical issues and assessing current capacity of industry to realistically meet these market requirements	Reviewing current information		Authorities in Indonesia were very reluctant to allow access to pest lists for either mango or mangosteen. It was known that some had been compiled previously but the project was unaware of how up to date this information was. **Mangosteen:** Work was undertaken on a regional level to identify and compile pest list in mangosteen and mango from existing collections with the partner institutes combined with field observations however this was not a complete list. The project was able to access the recent pest list that was compiled for mangosteen market access into Australia (AQIS 2012). This clearly identifies large number of species of ants and mealybugs as dominant pest. It also identifies spider mites as a significant risk. The important issue with mangosteen it that extensive research on the host status of mangosteen for both species as well as the related B. dorsalis has shown that sound fruit does not support the development of any of these fruit fly species, while infestations of damaged fruit, especially where the aril is accessible, are possible (Leach 1997; Unahawutti and Oonthonglang 2002; Iswari et al. 2011). With no other internal pests identified it is very realistic that a surface fumigant such as ethyl formate is a viable option for a phyto sanitary treatment. It was identified at the beginning of the project that the industry currently did not have the necessary infrastructure or technical capacity to undertake such fumigation work. **Mango** Mango ran into a similar impasse with accessing official lists The project team was able to undertake some field assessments of pest statuses. In the absence of official lists some calculated assumptions had to be made on what were the significant quarantine pests. What information that was available was cross referenced against the AQIS data base. This provided a level on information that gave researches the confidence to prioritise the quarantine pest risks that would need to be addressed in market access negotiations.

		Pest lists screened and evaluated against international standards, Impediment issues and capacities identified and prioritised.		**Mango** Fruit fly is the most significant issue with mango in respect to export; within the industry there was limited infrastructure and capacity to be able to undertake the necessary research for disinfestation for protocol development. The three options hot water, VHT and Irradiation all required critical infrastructure instillation or upgrades combined with an increase in the technical capacity to undertake the research at international standards. **Mangosteen:** The mangosteen pest list was reviewed by AQIS as part of the Australian market access protocols being negotiated at the time; the project supplied input into this process but was not directly part of the review. This was conducted under the proposal to use methyl bromide as a fumigant. The positive outcome of this was that fumigation was the main requirement, creating a significant opportunity to conduct the work with Ethyl formate which has far less quality and environmental impacts than methyl bromide. At the beginning of the project there was not the infrastructure or technical capacity to undertake the work with ethyl formate; this was given high priority for the market access work.
1.3	Assess Gedong Gincu and Aust varieties for export suitability in key markets. PC A	Target list of potential Indonesian varieties that are commercially suitable for export.		Studies were conducted by IFTRI to document all of the current and new commercial cultivars in Indonesia that may have potential for export development. The detailed description of the target list has been documented in the IFTRI final report. Initial assessments of the Indonesian cultivars indicates some potential for export however none of the cultivars are currently grown in significant commercial quantities so full detailed assessment for export suitability is beyond the scope and timeframe of the project . The midterm review discussed the list and it was recommended that this be expanded to include non-Indonesian cultivars that may also be present within Indonesia. This would expedite the development of a new export cultivar as much of the market potential and consumer acceptance for these cultivars is already known. Much of this work confirmed that Gedong is the only relatively new Indonesian cultivar that is in any position to be fully assessed for export suitability, the skill and capacity for doing this can be developed in Indonesia based on Gedong and applied to the new cultivars in the future.

1.3		Consumer focus groups, generating qualitative, results on varieties	December 2010	Consumer focus groups were conducted in Hong Kong December 2010, 2 separate groups were conducted with Hong Kong consumers and 1 focus group was held with importers from mainland China and Hong Kong. Two separate sessions were held with each group the first using the Indonesian cultivars Harumanis and Gedong Gincu the second using the 3 new Australian cultivars 1243, 4069 and 1201. Information from these groups generated a detailed understanding of consumers and importers preferences for the internal and external attributes of each of the cultivars. The results were reported to the Indonesian industry, researchers and policy makers during workshops in 2011 and formed the basis for the future export development work conducted by the project. Results for the Australian cultivars has been presented to the Australian industry through several field days In Kununurra and Mareeba and though presentations at the AMIA annual conference.
1.3		Market studies, identifying potential markets and market segments	November 2009 and December 2010	A number of markets were looked at during the course of the project Singapore 2009 Hong Kong 2010, 2011 and 2012. China 2010 and Dubai 2013. During the visits importers, retailers and consumers were interviewed, qualitative information was collected and analysed to ascertain the potential for Gedong in these markets. This information was also used in conjunction with the data gathered from the focus group work conducted in Hong Kong.
1.3		Quantitative and qualitative information on suitability of varieties to markets		Combining the quantitative data gathered from the focus group work and the qualitative information gathered from interviews a clear picture of the market potential for Gedong in Hong Kong and China has been developed. Focus group work was not conducted in Singapore or the UAE so information on the market suitability of these varieties has come from discussions with importers, retailers and consumers supported by test shipments of fruit. Additional studies were conducted in Indonesia with focus groups which specifically targeted the Non Indonesian consumers ie students and tourists, grouping them into their ethnic origin. This gave a greater insight into the suitability of Indonesian mango cultivars amongst different ethnic profiles.

1.4	Develop an action pathway for accessing priority markets and improving market share in existing markets	Work plan developed for targeting market access work and improving existing market share. Resource allocation		The results of the market research information were discussed with industry and project partners over a series of meetings and forums. From this a strategy was developed that took into consideration the time frame of the project and what realistically could be achieved within this. Time duration to access new markets with phytosanitary requirements can be a drawn out process with many factors at play that are well out of the influence of the project. The importance was to develop a functioning export system t so that moving into a new market with phytosanitary requirements is a natural progression. For this reason targeting Hong Kong was determined to be a priority with a view of accessing China once protocols could be formulated in bilateral meetings for direct market access. The other target market that was prioritised was the middle east. Results of the market research activities were used as a basis for the development of an industry strategic plan. A 2 day strategic planning meeting was held in Jakarta in Sept 2012 with key growers from West and East Java, exporters, researchers from IPB, IFTRI, IAQA, NNEA and , ICAPRD extension officers from DINAS and policy makers from DGH. From this a strategic plan was developed for the Indonesian mango industry.

PC = partner country, A = Australia

Objective 2: To improve fruit quality from fruit development through to harvest and consumption using good agricultural practices

no.	activity	outputs/ milestones	completion date	comments
2.1	Identify key technical constraints, such as agronomic practice, pest and disease impact, variety, postharvest management, which affects fruit quality, and appropriate strategies that improve fruit quality through the supply chain	Baseline data of current production practices and skill levels, Key issues with the greatest potential for improvement in terms of cost, yield and quality identified		Semi structured interviews were developed to survey the current practices of the mango industry, its needs, capacity for change and where it sources its information. These surveys were initially conducted with mango farmers in East Java to evaluate the quality of the information that the surveys were generating. As a result of the East Java activity modifications were made to the format of the survey to improve on the quality of information collected. The modified surveys were conducted by DGH with the Gedong growers in Cerebon, Majalenka and Idramayu. A modified version of the survey was developed For mangosteen growers and was conducted at Purwakarta and Leuwiliang. Further workshops were held with mangosteen and mango growers to map the current supply chains thus giving researchers a clear understanding of product flow, where quality issues may be occurring and who influences this. This was followed up by product monitoring excesses to obtain some quantifiable data on quality losses. From this information a strategy was developed for the project to 1: Research areas were quality was being loss to gain a better understanding of the issues and possible solutions, 2: Facilitate the development and/or Implementation of new practices within the chain that will have a positive impact on improving quality outturn's.

2.2	Develop IPM strategy for control of mites and thrips on Mangosteen	Effective methods evaluated and management strategy developed.		Trial work was conducted to ascertain the major cause of fruit scarring, the current perception that existed within the industry was that thrips and mites were the primary cause but no verification of this had been conducted. A scoring system was developed to rate scarring; this was followed up with trials to identify the causal effects of the different types of scarring. Initial trial work indicated that that thrips and mites were only partially responsible for fruit scarring. Trials were conducted in Solok based on non-chemical methods demonstrated significant control of thrips and mites can be achieved by creating environment inductive to beneficial insects and combining it with the creation of physical traps. Further trial work was conducted examining the impact of low chemical input on thrips and mites.
2.3	Identify agricultural practices to improve mangosteen production systems	Proof of concept IVS propagation		Mangosteen material was sort from Queensland to undertake the proof of concept trials. Due to freight logistics and quarantine issues it was not feasible to source from Indonesia. Only relatively juvenile material was available from Queensland. The trial work was conducted in DAFWA laboratories in South Perth, Initial work was successful in proof of concept demonstrating that this technique can be used for propagation. However due to the nature and availability of the material it was not possible to take this work further for field evaluation.

2.3		Data from postharvest trials, indicating which factors can be manipulated to improve quality.		As fruit quality is the most significant factor impacting on mangosteen grower returns. An extensive research program was developed to understand the quality issues, identify the causes and develop solutions. Fruit quality issues can be broken into several categories. • **Fruit Scarring**: Major problem on Indonesian Mangosteens, with some orchards often seeing levels of scaring over the majority of their crop thus minimising the amount of fruit available for the higher priced export markets. Historically the fruit scarring has been attributed to thrips and mite damage. • Identify scaring types, then linking causal agents to types of scarring. • Research methods of control of scaring types. • Demonstration sites to evaluate scaring reductions methods. A number of different fruit scaring types were categorised this gave some indication on the causal agents. Thrips and mites could account for some of the scarring however it was clear that there were other causal agents. Further research found that fungal disease was a major cause of fruit scaring this was confirmed by Koch's postulates. This is a major discovery for the Indonesian mangosteen industry and will lead to a different management approach in reducing fruit scaring. • **Physical damage:** Usually associated with impact damage during harvesting and transportation**.** • Monitoring harvest and transportation processes identify critical points where fruit damaging is occurring. • Introduce new techniques and system that will minimise impact damage to the fruit. Preliminary studied indicated significant impact damage was occurring in the collection and transportation of the fruit from the farm to the collection points. The introduction of plastic transportation crates for this purpose significantly reduced the impact damage on fruit arriving at the collection points. • **Calyx browning**: Significant issue with importing countries where the perception is that green calyx's on the fruit are a sign of fruit freshness. • Research techniques that could increase the shelf life of the calyx, Including 1MCP (Smartfresh), Wax, Gibberellic acid, 2-4D, Chitosan and temperature. All known techniques that have the potential to increase Calyx life but had never been tested on Mangosteen. • **Physiological disorders**: Gummosis the leaking of the yellow latex into the flesh, and translucent flesh are significant disorders impacting on mangosteen quality. • Examine the impact of nutritional management on the physiological disorders specifically looking at Calcium/ Boron relationship**.** The addition of Boron and calcium appeared to have mixed results in its impact on the amount of physiological disorders with mangosteen. However the foliar spray of boron at flowering significantly increased the tree yields.

2.3		Study tour examining mangosteen export practices in Thailand.	November 2010	Thailand is a substantial exporter of Mangosteen and has steadily adopted advanced productions practices and marketing systems. Consequently Thai mangosteen growers consistently get better yields, quality and premium in prices over their Indonesian counterparts. A study tour consisting of growers, exporter, researchers and extension officers was put together to look at the Thai mangosteen production. The group visited a number of farms, packhouses, research stations and food processors. Key findings The tour highlighted some of the stark differences between the two industries Seven Indonesians (growers, collectors, exporters, university research, and government) were taken on a mangosteen study tour in Thailand. Important points arising: 1. Thailand has a consistent yield of 80-100 kg of fruit/ mature tree/year due to good management especially irrigation, nutrition, and canopy management (pruning) including tree size control. 2. Thailand has reduced yellow latex and translucent flesh problems due to maintenance of consistent soil moisture from under tree irrigation. 3. Thailand has reduced fruit scarring from insects due to the use of chemicals (smaller tree size helps). 4. There is more transparency in price to farmers than in Indonesia. 5. There are good pack shed and export procedures. 6. There was a strong desire by all the participants to revisit during harvesting season to see harvesting and packing in season. The current visit was off season with no harvesting nor packing observed.
2.3		Determination of available options for detecting internal disorder		Currently the only available method of evaluating internal disorders with Mangosteen is destructive sampling. Due to the nature of occurrence of these disorders this is not a reliable or practical method for assessment. A number of potential non-destructive options were looked into which included near Infra red (NIR), ultrasonic and xray technology. Whilst some of these systems may have had some potential, the necessary equipment required to undertake trial work was not available. Inline NIR offers the most commercially practical detection system of the three, but there was some doubts on how effective it would be due to the different densities between the pericarp and the flesh of the mangosteen. This will require research to determine the efficacy of the technology.

2.3		Management techniques developed that will increase % of export quality fruit		The project developed a number of management techniques that could substantially improve the amount of fruit that reaches export quality. These techniques were incorporated into the demonstration sites in West Java and in Solok Sumatra. • **Fruit Scarring**: • Demonstration sites to evaluate scaring reductions methods • Introduction of an IPM approach to managing thrips and mites which included physical traps, the creation of micro climates around the trees that was inductive for beneficial predators. This resulted in reductions of thrip and mite associated scarring by up to 70% on the demonstration sites. • Introduction of strategic fungicides sprays demonstrated high levels of control of scarring associated with fungal infections. Whist this proved successful it is only suitable for newly developed mangosteen orchards with young trees. Spraying pesticides within existing established mangosteen orchards is not practical, trees are grown in a forest situation becoming very dense and tall. No existing spray equipment would be capable of reaching the upper canopy thus making it virtually impossible for effective spray penetration. • Demonstrations of strategic insecticide sprays gave very good control of insects associated with scarring and significantly reduced the damage. However the same issues exist with existing mature orchards, limiting its practical application. . • **Physical damage:.** • The introduction of plastic transportation crates for this purpose significantly reduced the impact damage on fruit arriving at the collection points. This was readily adopted by the industry • **Calyx browning**:. • It was somewhat unexpected that the majority of the treatments researched had no significant impact on fruit • Research techniques that could increase the shelf life of the calyx, Including 1MCP (Smartfresh), Wax, Gibberellic acid, 2-4D, Chitosan and temperature were assessed. Most of the techniques researched failed to have any significant impact on increasing the shelf life of the calyx. With the exception of low temperature combined with wax significantly extended the calyx life, this technique is relatively easy to implement within an export system. • **Physiological disorders**: Gummosis the leaking of the yellow latex into the flesh, and translucent flesh are significant disorders impacting on mangosteen quality. • Examine the impact of nutritional management on the physiological disorders specifically looking at Calcium/ Boron relationship**.**

2.3		Field evaluation of IVS propagated material in Aust and Indonesia.		As it was not possible due to quarantine restrictions to full complete the first section of the IVS work, material was not of a suitable advanced stage of development to be able to be sent out for field evaluation in Indonesia or Australia.
2.4	Define quality parameters for Indonesian varieties such as Gedong Gincu and new Australian hybrids	Protocol defined Maturity standards developed		Indonesia: Defining harvest maturity standards for Gedong Gincu provides growers with a valuable tool for determining harvest times to ensure optimum postharvest quality. Several attempts were made albeit unsuccessfully to conduct harvest maturity experiments on Gedong Gincu. Only basic indicative results were obtained. This was caused by a continual turn-over of key staff within the collaborating institute resulting in limited research output. Re-engagement with a new team that is both committed and technically capable of undertaking the work would be important for any future plans for completing the work. Australia: Harvest maturity studies were conducted on new cultivars NMBP-1243, -1201 and -4069 grown in Kununurra, WA and Mareeba, QLD. Several indicators of physiological maturity were identified for each variety, with flesh colour and dry matter content, in general, being applicable to all three cultivars. Harvest colour guides were developed for all three cultivars. Further trials to evaluate the efficacy of these indicators over several seasons would be of commercial importance.
2.4		Varieties tested for quarantine treatments		Indonesia: Gedong and Harumanis were evaluated for their suitability for Irradiation treatment both varieties performed well under different dosage levels with no symptoms of skin or flesh damage. Australia: Three new NMBP cultivars were evaluated for their suitability to undergo current accepted phytosanitary treatments. Trials showed that irradiation was not a suitable phytosanitary treatment, resulting in skin and flesh damage. The exception was NMBP-4069 which exhibited some symptoms at low doses, although the severity was possibly low enough to still be commercially acceptable. Hot water and vapour heat treatments (VHT) were effective phytosanitary treatments for all varieties.
2.4		Determination of post harvest attributes.		Indonesia: During project meetings, postharvest experiments were discussed and subsequent training was provided. However, (as described above) none of the planned experiments were undertaken in any detail due to staff turnover at the research centre. Some maturity results were obtained for Gedong but the quality of the data was insufficient to use the results to formulate a maturity guide for export. Australia: Storage and ripening responses were examined for three NMBP cultivars. In general storage at 12°C for a maximum of 2 weeks resulted in acceptable quality. Optimum postharvest ripening temperatures were similar to those of other Australian commercial cultivars (eg KP), being 20°C for 2 days with ethylene.

2.4		Data available to produce quality guidelines the export market.		Indonesia: As described above there was insufficient data collected on Gedong Gincu or Harumanis in order to produce quality guidelines for export markets. Australia: For the three NMBP cultivars, harvest maturity standards were determined and harvest colour guides were developed. The suitability of various disinfestation treatments were assessed although further work is possibly required to evaluate them using fruit grown under different conditions. Data on ripening and storage conditions were collated, although verification of fruit responses under commercial conditions would be imperative before export guidelines can be developed.
2.5	Develop pheromone trapping guidelines for RBMC	Formulate trap design Data generated from trial grid trapping system for RBMC. Guidelines developed for effective monitoring of RBMC populations		Pheromone lures were purchased form Hort research in New Zealand in 2009 early 2010. A trapping grid was designed and then established across east Java and West Java to test its efficacy. The traps failed to attract any RBMC in either east or west Java, in spite of repeated trapping and replacement with fresh lures. Subsequent lures were sent to Lombok to establish a grid in the mango districts where RMBC is a major pest, these traps also failed to attract any RMBC. Follow up consultations with Hort Science and specialist entomologists concluded one of 2 scenarios that the batch of pheromones were faulty or that the RMBC found in Java and Lombok is a subspecies and has a slightly different pheromone profile to that of those RBMC in Papua New Guinea where the pheromone was developed. To test this the lures were sent to Mareeba QLD where entomologists has an established colony of RMBC, unfortunately the colony was destroyed during a power outage and this work was not able to be undertaken. The only option was to go back to Hort research to re modify the pheromone. Whilst this still remains an option for the future it requires establishment of a colony of RMBC at Hort research and considerable funds. The issues with the lures was not one that project staff had anticipated and therefore without it being resolved it was not possible to develop and effective trapping grid.

2.6	Develop recommendations and capacity to improve and maintain quality suitable for export markets	Workshops conducted addressing key identified issues	April 2010 October 2010 June 2011 October 2012 June *2013* (April 2010) April 2011 November 2012 August 2013	A number of workshops were constructed and delivered to industry stakeholders a **Mango**: **Cirebon** ***Mapping the Supply chain*** 40 Participants, farmers, exporters and extension staff. Specific outcomes of the workshop were • Detailed understanding of how the different supply chains work and stakeholder interactions **Cirebon** & **Majalengka** ***Introduction to production practices to improve export quality fruit***. (50 Participants,Cirebon, 30 Majalengka) farmers, exporters and extension staff. Specific outcomes of the workshop were • Understanding of the principals involved in producing quality fruit for export **Cirebon** ***Sap and post-harvest management of mangoes*** 40 Participants farmers, exporters and extension staff • Working introduction to sap management and post-harvest technology **Bandung**: ***Procedures for exporting mangoes by sea*** 15 participants exporters and researchers Specific outcomes of the workshop were • Detailed understanding of the requirements for undertaking mango sea exports. **Bandung** ***Mango Export Production & Supply Chain Systems*.** 43 participants,. Majority of participants were mango growers who had been identified as industry leaders. Other participants were district extension officers, researchers and exporters and stakeholders in the export supply chain. Specific outcomes of the workshop were. • Mango training program covering key aspects affecting mango quality • Quality Risk & Disease risk assessment plans • Draft information resources to support specific workshops • Maps of export supply chains **Mangosteen**: **Purwakarta** ***Mapping the Supply chain*** 35 Participants, farmers, collectors and extension staff. Specific outcomes of the workshop were • Detailed understanding of how the different supply chains work and stakeholder interactions **Purwakarta & Leuwiliang** ***Minimising harvest damage to fruit.*** farmers, collectors and extension staff • Training in techniques to minimise harvest and transportation damage **Leuwiliang Fruit quality and IPM** • Training in nutritional management for quality fruit and implementing ant control for export. **Bogor** ***Developing a mangosteen production system for export*** 40 participants Work shop was pulling together the research results into a production packages which was combined with field demonstrations

2.6		Development of extension packages Package of management practices for growing export fruit developed and incorporated on targeted farms		**Mango** Dampak Penerapan Teknologi Inovasi Budidaya Mangga (Impact of applying recommended technologies in mango cultivation • Pemanfaatan minyak sereh wangi sebagai alternatif teknologi ramah lingkungan untuk menekan populasi semut dan gejala burik pada buah manggis (Applying citronella oil as an alternative technology that consider environment safety to control ant population and scarring symptom on mangosteen • Leaflet "Pengenalan koleksi plasma nutfah mangga (Introduction of mango collection)" • Guidelines for CA sea freighting of Gedong **Mangosteen** • Guidelines of Thrips Management (in Process) • Guidelines to control ant in mangosteen (in process) • Booklet "Introduction diseases that attack mangosteen" (In process)

PC = partner country, A = Australia

Objective 3: To conduct the necessary phytosanitary disinfestation treatments for fruit and export shipment trials to selected export markets.

no.	activity	outputs/ milestones	completion date	Comments
3.1	Visit HTFA Facility and participate in trial run and visit to Perth	Cognisance of HTFA facility and its efficiency cost and features	November 2010	Mrs Cahyaniati visited Australia and under took a study tour in the principles of Hot water treatment for fruit fly disinfestation, this was combined with training in the experimental techniques required to obtain data for most tolerant stage trials using hot water and vapour heat. Part of the visit was also to an operational VHT plant in Townsville undertaking the commercial treatment of mangoes for export to the Chinese market.

3.2	Develop disinfestation protocols for access to high value market (eg mangosteen to Taiwan, VHT and/or Irradiation for mango.)	Identification of capacity and training needs	November 2009	At the beginning of the project an evaluation of the capacity both in equipment and technical capability to undertake the necessary work for market access research this was conducted by Dr DeLima. This evaluation was conducted at the research laboratories in Karawang, under the responsibility of DGH, the quarantine training centre under the responsibility of Indonesian Agricultural Quarantine Agency and at the National Nuclear Energy Agency Battan. The evaluation identified a number of necessary equipment items and infrastructure upgrades that were required. In some areas this was confirming some of the findings in the original of the scoping study in others it identified new areas not picked up in the original report. The evaluation also identified a number of training needs for researchers, in techniques of trial design, data collection use of fumigation and hot water equipment and techniques in rearing insect colonies for undertaking research trials. This evaluation formed the basis of the training plan that was implementation through the duration of the project.
3.2		Upgrade of faciliites		Substantial input has been made in upgrading the facilities of IAQA, DGH , NNEA and ICAPRD. Which include. **IAQA** Installation of 2 fumigation chambers, ethyl formate fumigation facilities heat exchanger and fittings for Vapormate® and monitoring equipment. **DGH** Instillation of hot water treatment capacity and ancillary research equipment including software, monitoring equipment and consumables. **NNEA**: Upgrading of Irradiation plant to a continuous conveyor system, upgrading of fruit fly rearing facilities. **ICAPRD**: Installing ethylene ripening facilities, equipment to undertake dry matter evaluation, Temperature and humidity monitoring equipment for undertaking outturn assessments and field heat unit data collection.
3.2		Initiate training		Intensive training programs were constructed to provide Indonesian researchers training in Australia on the three major phyto-sanitary treatments, heat, fumigation and irradiation. Training schedules of personnel and activities has been documented in Section 7.
3.2		Trail ethyl formate fumigation/oils on mangosteen PC, A		Initial trial work was conducted to ascertain the phyto toxicity effects of ethyl formate on mangosteen, these results proved very encouraging. Follow up work was conducted researching its effect on mealy bug and ants (*which are the dominant pest problem associated with mangosteen*); It was demonstrated to be highly effective against these two insects. This was followed up with a larger evaluation trial to generate data that is of publishable quality and can be the basis for beginning the process of having the treatment recognises as a viable alternative to methyl bromide fumigation.

3.2		Development of external fruit pest disinfestation protocol		The first part of the management strategy for external pests is field control to reduce pest population. This was very successfully achieved by the development of baits suitable for field control of ants and mealybug reducing the populations in excess of 90%. The system developed is very suitable for the current mangosteen orchard environments where conventional spraying if not practical. This was also followed up by the development of a management plan to control the potential for reinfestation along the supply chain particularly at the sorting houses where cross contamination is a high risk. The trial work that was conducted at and acceptable international standard for the disinfestation of mangosteen using ethyl format. This demonstrated the efficacy of the fumigant on the mortality of quarantine pests primarily ants and mealy bug. The results are being submitted for publication. The primary work for the development of a disinfestation protocol using ethyl formate on Mangosteens has been completed. The next step will be for IAQA in bilateral arrangements with the importing country to negotiate this work as part of the formal export protocol. This may mean that further verification work on a larger scale could be required but this will be at the determination off the importing country.

3.3	Trial supply chain to meet market access, phytosanitary and regulatory requirements	Data generated identifying critical quality control points		**Mangosteen**: Most of the work with mangosteen was conducted at the beginning of the supply chain from harvest to the exporter. This work identified 2 critical areas that will impact on the export potential of the fruit. • Where quality was being lost with the transportation of the fruit from the farm to the sorting houses. This identified transportation damage in particular where traditional baskets were creating additional exocarp and calyx damage. • Where contamination of pests that will impact on quarantine were occurring. Whist most pest contamination was occurring on the tree, the existing supply chain proved a number of high risk areas for cross contamination of fruit particularly at the sorting houses, transportation,when loads from multiply growers were consolidated and at the exporters pack house itself. Fruit was also monitored in China at the wholesale markets to observe the quality outturn and the incidence of pest contamination. In both instances substantial loss in quality had occurred in transit particularly with the browning of the calyx and to some extent hardening of the exocarp. **Mango**: A number of activities were conducted with mango beginning with the quality monitoring between harvest and transportation to the sorting house and then on to the exporters pack house. This identified a number of critical issues. • Maturity the second stage of Gedong, the Gincu (Blush) phase fruit was too mature to be put into an existing export chain. For several reasons the ripening process has already begun and would severely compromise saleable life of the fruit, it would be far more prone to transportation damage, and most significantly its risk of being infested with fruit fly is very high. • Existing harvest techniques were detrimental to fruit quality sap burn was very high, due to stem breakages during picking, the placement of fruit in the transportation baskets, the transportation itself and cross contamination due the use of dirty equipment. From receival at the exporters pack house to the retailers in the importing countries a number of different supply chains were studied by air, standard reefer and controlled atmosphere reefer. • Hot water fungicide treatment a number of issues were identified with the existing systems that were leading to inadequate disease control of the fruit. • Cool chain: fruit was not been cooled down correctly and significant breaks in the cool chain were occurring. This was having a major impact on the saleable life of the fruit in the export markets and creating some physiological disorders resulting in the greying of the skin in the Harumanis variety. • Poor carton design in strength and airflow was causing compression damage due to carton collapse and poor heat exchange within the carton exacerbating the issued within the cool chain. • Poor pallet design creating substantial logistic issues. • Poor handling practices at freight forwarders were leading to significant carton and pallet damage. • Poor handling practices post arrival was compromising colour development and saleable life.

3.3		New supply chain developed and monitored		Extensive work was conducted in developing new supply chains by the use of trial shipments commercial and static and closely monitoring the results then building upon the lessons learned from the previous seasons. Trial export schedule Hong Kong by air Gedong (2010) Static Sea container standard Reefer Harumanis and Gedong (2011) Hong Kong Sea standard Reefer Harumanis and Gedong (2011) Hong Kong Sea standard Reefer Gedong small consignment of Harumanis(2012) Dubai Controlled atmosphere container Gedong small consignment of Harumanis (2013) The systems were thoroughly evaluated and monitored, including the training of Indonesian researches in evaluation methodology. Fruit was taken all the way through the supply chain to the retailer and customer to assess its export potential, the Indonesian exporter was also participated in this process. As a direct result of this work a new fully commercial supply chain was developed in Hong Kong supplying Gedong to Park and Shop supermarkets through the Indonesian season. In addition to this a commercial airfreight supply chain was established into Dubai with the intent to expand this to sea freight once the supply of enough Gedong from the farmers in Indonesian can be obtained.

3.4	Collate technical data and information to technically under pin market access negotiations for Mangosteen	Data analysed, collated and available to industry		Trial data that will be necessary for underpinning market access negotiations was generated by the project team. Research was conducted in the critical areas of efficacy against certain quarantine pests and the impact on fruit quality by the disinfestation treatment. **Irradiation:** Efficacy data was collected on the efficacy of irradiation on mealy bug. Data was collected on the impact of Irradiation dose rate on fruit quality of Gedong and Harumanis **Fumigation**: Efficacy data was collected on the efficacy of ethyl formate fumigation on mealy bug and ants. Data was generated on the impact of different concentrations of ethyl formate on mangosteen. **VHT**: Due to the intervention by the Japanese into undertaking the research into VHT on mango to support the instillation of their VHT machine the decision was made not to duplicate this work and divert the allocated resources into irradiation and fumigation research. Whilst the data was generated it was not by part of this project. **Hot Water Treatment**: Staff were trained and the equipment was installed to undertake this research, however due to changes in staff members in DGH combined with a change in policy direction away from HWT towards VHT by the organisation this work was no longer supported and did not proceed.

PC = partner country, A = Australia

Objective 4

To build capacity in the Mango and Mangosteen industries to conduct integrated and targeted research, development and extension programs

no.	activity	outputs/ milestones	completion date	Comments
4.1	Initiation workshop	Development of working plan for the project.	November 2008	The initiation workshop was held at the Hotel Salak in Bogor. This was attended by all of the project team members and heads of departments. Detailed work plans as well as communication plans were developed during the workshop which formed the basis of the work activities for the project. At this stage it was identified that changes had been made to the Indonesians financial system in the way they regulate funds from overseas projects. This was the first ACIAR project to come up against this system, these changes had significant negative impact on the funding of activities thru out the life of the project.
4.2	6 monthly project meetings	Video conferences between Australian partners	2008-2014	Video, teleconferences as well a once a year face to face meetings were help amongst the Australian partners and on a as needs basis with the Indonesian project partners. This was used for project updates, and activity planning requirements.
4.3	Midterm project review	Review of progress to date using this information evaluate project outcomes and adjust accordingly	March 2011	Midterm project review was held at IPB in March 2011. The workshop undertook an extensive review of the work conducted to date. This gave the project team an opportunity to look at achievements to date what was working well what was not. How far the project had progresses so far towards achieving its outcomes as well as reviewing the expected outcomes of the project to acertain if they were still relevant or needed adjusting to changing conditions. A detailed work plan for the coming seasons activities was developed and upon the findings of the review changes were made to some of the activities this was reflected the project variation document.
4.4	Develop and deliver workshop modules covering various aspects of mango orchard management	Training workshops conducted		A series of three modules were developed for mango and delivered to the mango growers and associated stakeholders. One training workshop was developed and delivered for Mangosteen. Details are outlined in objective 2.6

4.5	Final project workshop.	Evaluation of outcomes, and strategy for progressing beyond the project.	May 2014	The final workshop and review took place in Bogor May 2014. The review addressed the following areas • This review involved the presentation of the project results from each of the partners. • Compilation activities undertaken and information generated. • Analysis of highlight/lowlights, what worked and what didn't including lessons learnt from this. • Measuring outputs against project objectives • Impacts of projects now and future • How to carry activities forward from here on. The comprehensive review delivered a very good overall picture of the project and measure against its objectives.

PC = partner country, A = Australia

7 Key results and discussion

7.1 Key results

7.1.1 Mangosteen Fruit Quality:

- Identification of different types of fruit scarring enabled researches to be able to categorise into groups which have similar causes. This lead the research teams to a totally different approach to this major problem, which had historically been attributed solely to thrips and mite damage. Whilst a positive correlation existing between some of the types of scarring and thrips and mites populations. It did not explain other forms of scarring that were observed. Two fungal species *Pestolatia sp.* and *Phomopsis sp.* were also identified as causal agents for fruit scaring; this was confirmed with the Koch's postulate test. (Appendix 11.3).
- Work conducted using Confidor ® demonstrated cause and effect of thrip damage to mangosteen. (Appendix 11.4). Work conducted in creating an environment favourable for beneficial predatory thrips and mites demonstrated a significant level of control can be obtained without the use of chemicals. This was combined with physical trapping system control of thrips and mites which enhanced its efficacy.
- The application of Boron and Calcium when applied to the soil was found to have a positive effect on reducing the incidence of yellow latex leaking into the flesh of the fruit and on the surface of the fruit. There was also indication of yield improvement with some of the treatments. (Appendix 11.5)
- Calyx browning is a major quality issue with the Chinese market, a large number of treatments were conducted to look at prolonging the shelf life of the calyx which included 1MCPA, GA3, 2,4,D, Wax and temperature management. Most of the treatments failed to significantly extend the shelf life of the calyx. However storage temperature and the addition of a 6% wax concentration significantly inhibited the degradation of the calyx. (Appendix 11.6)
- Work with GA3 on increasing the size of seedless fruit proved inconclusive. (Appendix 11.7).
- Physical damage was observed during the harvesting and transportation of fruit to the sorting houses. Introduction of plastic transportation baskets helped minimise the amount of transportation damage that was occurring. (Appendix 11.8).
- IVS work demonstrated proof of concept for propagating mangosteen, but was at this point it is not able to yet demonstrate the impact of this technology on reducing juvenility in trees.
- Studies on specific pests on mangosteen were able to develop comprehensive identification of a number of ant, thrips and mite species that were associated with mangosteen. (Appendix 11.2).
- Mangosteen demonstration plots indicated an improvement from 13.6% pack out rates of grade A&B fruit to 64% pack out rate with class c fruit dropping from 86% to 36%. On a cost benefit analysis this equates to a 30% increase in net profit per tree. (Appendix 11.9).

7.1.2 Mangosteen Phytosanitary Requirements.:

- Observations on export fruit in the Chinese's markets where excessively high levels of contamination with ants and mealybug. (Appendix 11.10).

- Ants are the single greatest issue with mangosteen with very high levels of contamination occurring in the field and in many other areas along the supply chain, re contamination is a high risk. The development of ant bait has proved highly successful in reducing the populations down by 70 to 90%. Further refinement of the baiting grid could reduce the population to levels closer to 90-100%. This has been combined with control measures baiting and barrier spraying at the sorting houses to reduce reinfestation. By reducing the ant populations it significantly reduces the level of mealybug infestations on the fruit. Low ant and mealybug populations allow phytosanitary fumigation to be much more efficient as well as minimising the problem with insect carcass residue left on the fruit post fumigation. (Appendix 11.10).
- Instillation and training in the new technique of ethyl formate fumigation enabled a series of efficacy trials to be conducted on Mangosteen. This demonstrated the minimum impact of ethyl formate fumigation on fruit quality, the impact on quarantine pests mealybug and ants. The trials proved very successful in reducing quarantine pests to a level that would meet international requirements results and are currently in the process of being published. (Appendix 11.11).

7.1.3 Mango Fruit Quality:

- Studies were undertaken to ascertain the consumer acceptance of the Gedong and Harumanis mango as an export variety. In Hong Kong Gedong was found to have some appeal in colour and flavour, its small size and high fibre was seen as a negative. Harumanis was seen as good flavour and size but the green skin was a major negative. Studies on different consumer ethnic groups with Gedong found that it had good appeal ranking highest amongst Middle Eastern consumers, interestingly lowest amongst the Indonesian consumer groups. A stronger preference was for fruit at the Gedong Gincu stage of maturity. Amongst all groups the small size of Gedong was seen as a negative. (Appendix 11.12a & b).
- Studies were conducted trying to quantify the quality loss that was occurring within certain sections of the supply chain primarily between the farm and being received by the exporter indicating a 29 % loss. Primarily due to damage caused in the handling procedures, resulting in sap damage and wounding (Appendix 11.13). Other causes for quality loss included mealybug infestation, malformed fruit and small fruit.
- Demonstration plots using good agricultural practices were able to reduce mealy bug infestations by 78%.
- Research into boron applications on resulted in substantial reductions of internal disorders within the fruit and reduction in malformed fruit.
- Research on a number of compounds to assess their efficacy against anthracnose. In vitro test results found a number of compounds worked very well even at low concentrations with citronella oil giving the best result. Field trials demonstrated significant reduction in anthracnose levels when applied as a protectant but still not enough for a control measure on its own. Further studies are required to see if this could be incorporated into an integrated disease management program. (Appendix 11.14). The introduction of fludinoxinol Scholar® had significant impacts on reduction of post-harvest disease losses.
- A comprehensive audit was conducted of the available varieties currently in production in Indonesia these findings give researchers a base at which to start a genetic improvement program in the future. (Appendix 11.15).
- Studies on specific pest and diseases on Gedong were able to develop and identify a list of pests and diseases that were associated with mango. However the list was not comprehensive enough as yet to meet quarantine pest and disease list status. (Appendix 11.1).
- RMBC pheromone lures failed to work on the species within West Java and NTB

7.1.4 Mango Export market developments

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- Irradiation trials conducted on Gedong found that the variety is able to withstand the dose rate required by quarantine protocols up to 400 grays without any detrimental impact on fruit quality. (Appendix 11.16)
- Initial trial work with airfreight into Hong Kong identified some key opportunities for market development. Follow up trial sea shipments tested these opportunities and established a market program with one of the leading supermarket chains in Hong Kong.
- Static container work was conducted at ICAPRD which had mixed results in outturns.
- Live sea shipments with Harumanis identify some physiological problems with the variety. This resulted in a greying of the skin making the fruit unsaleable. The problem was observed in some of the trial air shipments but to a lesser extent. (*Kurniawan, F., Rachmat, R., Marlina, L., Jamal, I.B. and Simanjuntak, H. 2012. Penerapan Teknologi Penanganan Pascapanen pada uji coba ekspor manga melalui kapal laut* (sea freight) *ke Hong Kong*.)
- Controlled atmosphere trials of Gedong to the UAE proved very successful with exceptionally good outturns. Importers were actively seeking to run this into a seasonal program. The trial pallets of Harumanis did not perform well in the CA shipment with the fruit exhibiting the greying of the skin similar to what was observed in the Hong Kong trials. (*Setyabui, D.A., Kurniawan, F., Rachmat, R. and Febriyezi 2013. Penerapan teknologi penanganan pascapanen pada uji coba ekspor manga melalui kapal laut ke Duba*i).
- An audit was conducted of the available chemicals in Indonesia and their current registration status for mango. This formed the basis of developing a disease management strategy for export fruit. The diseased control program implemented on farm and within the export packhouses proved very successful with less than 2% disease incidence in the export consignment. (Appendix 11.17).

7.2 Discussion:

7.2.1 Fruit quality (Mangosteen)

Fruit scarring is the biggest single quality issue facing the mangosteen industry in Indonesia, levels observed on Indonesian fruit is substantially high than what is observed on fruit produced in Thailand or Malaysia. In Thailand and Malaysia mangosteen are grown in well laid out plantations often with supplemented irrigation, where as in Indonesia they are grown in what is locally called a forest situation. Under this system the tree height and size is unmanaged and often orchards are inter dispersed with other tree crops thus creating a fully covered canopy. This creates an ideal environment for pest and diseases and makes any type of control management extremely difficult if not impossible in some situations. Just how much this production system is contributing to the overall poor fruit quality has not been ascertained but is certain to be a significant amount. Unfortunately within the existing production system changeover to more manageable trees is extremely difficult due to the loss of income over the transition period.

It was hoped that the IVS work conducted by the project would be able to demonstrate the potential to shorten the juvenile phase of mangosteens making such transitions a viable option for small farmers. Unfortunately the work did not progress far enough to answer this question, it was able to prove that the concept is viable but due to lack of access to mature genetic material was not able to produce trees from this material to test the hypothesis. It is well known that

grafting mangosteens will reduce the juvenile phase down to three years but creates growth problems which make it a commercially unviable option. It is plausible that an IVS tree would also see the same reduction in juvenility without the growth problems of grafting. Having this as a viable option available for farmers to replace old orchards within a minimum time frame has the potential to revolutionise mangosteen production in Indonesia.

With the typical mangosteen plantation in Indonesia methods of effective control of the pests and disease that are the causal agents of much of the scaring is problematic. The project identified a number of non-chemical and chemical treatments that can be implemented in plantations that will significantly reduce pest populations resulting in a reduction of scarring. The efficacy of these treatments is greater in younger plantations than that which is achievable in the forest plantations but in both cases a significantly higher amount of export fruit can be attained. Any increase in the percentage of export grade fruit will have an immediate impact on the farmer's income, with those farmers that grade fruit on farm. This group are therefore the most likely to be the early adopters of the technology.

As the identification of fungal pathogens as causal agents of scaring was only recent there needs to be further research into control methods. Fungicides may be effective but efficient application within forest plantations would be virtually impossible other than with highly systemic compounds. Other non-chemical control methods that may have an impact are more open plantations allowing air flow as in Thailand and inoculum reduction.

Leakage of the yellow latex into the flesh is a significant issue with export fruit. The Boron/calcium nutritional work undertaken indicated that this can reduce the incidence of the problem as well as having an improvement in yield. Boron deficiency appears to be a quite wide spread issue in West Java. The linkage between Boron/Calcium and fruit quality is well known with other horticultural crops, to date there have been very few studies on this with Mangosteen, so whilst the trial demonstrated a reduction in latex leakage over time it is it probable that there could be other fruit quality improvements attributed to better Calcium levels within the plantations.

The appearance of the green calyx is an aesthetic quality issue particularly in the high valued export markets where it is perceived as a sign of freshness. Whist many techniques that work on other crops such as 2,4D on citrus buttons, MCPA on apples and GA3 were trailed none had any significant impact on reducing the desiccation of the calyx. It was found that a combination of lower temperature and 6% wax was able to significantly increase the shelf life of not only the calyx but the reduce hardening of the pericarp as well.

Considerable quality damage to the fruit occurs during the harvesting, collecting and particularly the transportation to the pack house. Traditionally bamboo baskets are used for this purpose which are due to their rough surface were contributing to the scaring of the fruit. With the plastic crates that were introduced there was a noticeable reduction in transportation damage to the fruit. Exporters have been using plastic baskets for some time in the transportation of the fruit from the collectors to the export pack house but it was not traditional practice to use them for transportation from the farm to the collectors.

The demonstration plots pulled together all of the best practices that were developed by the project. Whilst they were not operational within a time frame that was enough to see the full benefits of the nutritional work the combination of all the practices significantly increased the export pack out percentages. This has the potential to significantly improve the income of Mangosteen growers.

7.2.2 Fruit quality (Mango)

The studies on acceptance of the Indonesian mango varieties has in some aspects reinforced what was already suspected that there are some major negative attributes for these varieties as

export fruits. However it did identify there are niches in the export markets where theses varieties have potential. This gives the Indonesian industry an export platform in which begin to develop these markets initially with the Gedong and then other improved varieties as they become available. With the high domestic demand for the Gedong Gincu and the relatively low volumes currently produced, large scale Gedong exports are unlikely to happen in the short term. Whilst some progress was made on developing the export maturity standards for Gedong the general consensus with the researchers was that there was not enough data as yet to fully understand the maturity parameters of the variety. Even with this being the case, industry was meeting acceptable standards with the export shipments of the Gedong. At this stage export Gedong at the Gincu phase of maturity is a much higher risk and should be confined to small niche airfreight opportunities. The strong domestic demand for the Gedong at the Gincu phase at this stage provides a better option for the farmers.

Gedong is prone to a number of internal and external physiological disorders, internal breakdown, hardening of the flesh and misshapen fruit commonly known as buah duduk. Applications of Boron and Calcium to the trees were able to reduce the incidences of this. One study conducted in the project looked at the effect of paclobutrazol on buah duduk, whilst at the outset it looked if there's was a correlation between the paclobutrazol and buah duduk the most likely scenario is the paclobutrazol leads to yield increases which intern is exacerbating the boron deficiency. Significant reduction of these physiological disorders can be achieved my managing the Calcium and Boron levels.

Initial studies indicated that significant quality 28% is being lost at the production to exporters pack house stage of the supply chain mainly due to physical damages sap burn, buah daduk and undersized fruit. However with the lack of cool chain and post-harvest disease management the potential for further losses down the chain are substantial. The project introduced systems for reducing sap burn, integrated cool chain management and new generation post-harvest disease control chemicals. The combination of these had an outstanding effect on the minimising losses in the export chain for example disease losses were reduced from some 30 -40 % in the initial trial consignments down to less than 5% in later consignment's. This had a significant positive impact on the export partners business, to the extent that the company is now investing in new post-harvest disease control infrastructure and cool room upgrades. Whilst this practice change is currently limited to an individual business and their farmers that supply them, it represents a quantum leap in the outturns of Indonesian export mangoes and sets the bench mark for other exporters.

Red banded mango caterpillar work did not go according to plan it is quite evident that it is a significant pest in Indonesia as was confirmed by (the Mango project in Lombok) and the potential to become one in Australia. The pheromones were developed out of a previous project in PNG where they were demonstrated to be highly attractive to the RMBC. Numerous attempts over a period of 12 months in Indonesia both in East Java and Lombok failed to attract any insects at all. Without being able to attract the insect effectively, there was no reason to progress this activity any further in refining the grid trapping system. As commented on in section 6 several plausible reasons for the failure of the lure where put forward. The issue with RMBC is still unresolved and needs to be revisited at a future date. It was decided not to continue further with this due to the additional high costs that were involved in re modifying the pheromone.

7.2.3 Variety Evaluation (Australia)

The aim of the project was to develop postharvest protocols for three mango varieties from the National Mango Breeding Program (NMBP), namely NMBP-1243, NMBP-1201 and NMBP-

4069. Key findings from this project were in three critical postharvest research areas that underpin the commercial success of the new varieties. This included (i) developing reliable harvest maturity standards, (ii) investigating the impacts of phytosanitary treatments on fruit quality, and (iii) determining optimum storage and ripening conditions. First, developing accurate maturity standards is important for ensuring fruit are harvested at the right maturity to maximise flavour. In this study, minimum maturity standards were developed based on correlations of flavour (of ripe fruit) with fruit quality attributes at harvest. A key finding of the study was that flesh colour was the most reliable indicator of maturity, being significant for each variety and similar across the two growing districts of Mareeba and Kununurra. Additionally, for several of the varieties, dry matter, acidity and heat accumulation units were also significant indicators. The implication of these results is that when used collectively these indicators can serve as an accurate harvest guide for producers in order to deliver high quality product to consumers. However further work to ensure the validity and accuracy of these indicators is essential, particularly to account for variations that occur between growing seasons and production areas within Australia.

This project investigated the effects of phytosanitary treatments on fruit quality. Irradiation in general was not a viable treatment for at least two of the three varieties, resulting in unacceptable levels of skin or flesh disorders. The exception however was NMBP-4069. Low doses (150 – 300 Gy) caused only minor symptoms of lenticel damage and skin browning, which were possibly low enough for fruit to be commercially acceptable. Other Australian varieties such as 'Calypso' and 'Kensington Pride' are also sensitive to irradiation although keeping fruit unwashed after harvest appears to increase their resistance to irradiation damage (P. Hoffman, pers. com). In contrast to irradiation, both hot water dip and vapour heat treatments had no negative impacts on skin quality, albeit only a minor decrease in Brix. From a commercial perspective, if the same heat treatments prove effective against pests of quarantine concern, then they would likely be the most promising phytosanitary treatments for the new varieties. Hot water in particular would also be more cost effective and easier to implement than using irradiation.

Storage and ripening conditions were investigated on fruit quality. A key finding of this study was that unripe fruit from all varieties could be stored at 12°C for up to 2 weeks without compromising on ripe fruit quality. Given export transit times can generally take, depending on the destination and mode of transport, between 2-3 weeks, determining the effects of a slightly longer storage period (eg. 3 weeks) would be important and should be considered in any future studies. Another important finding from this project was that optimum ripening quality was achieved when fruit were held at 20°C with ethylene for two days. These results also match the current recommended ripening protocol for other Australian mango varieties. Given the similar findings, it is likely the new varieties could be adopted effortlessly into current mango supply chains within Australia.

In conclusion, findings from this project have made a significant contribution to our understanding the fundamental postharvest requirements of the new NMBP varieties. This work will serve as a foundation for future R&D research for developing comprehensive postharvest protocols for each new variety. Potential research directions include further refinement and testing of the current maturity standards, investigating further options for the use of irradiation for at least one variety, and further optimising storage conditions.

7.2.4 Disinfestation

Before the commencement of the project there was much misunderstanding in Indonesia on methods of heat disinfestation techniques for mango. VHT was being pushed heavily by vested interest groups without much understanding of the implications and limitations of this type of system. It was seen as an important priority to give researchers a balanced understanding capabilities and limitations of both VHT and Hot water systems. The reality in Indonesia is hot

water treatment initially offers more opportunity to the industry, this is due to it being relatively cheap to establish, with minimum infrastructure requirements and is able to do large volumes relatively quickly. Where VHT is very expensive and is limited on throughput. Both systems can have substantial quality issues if not operated correctly. The visit to Australia was able to address these issues and give exposure to the commercial operation of VHT facilities.

This was also followed up later with a visit by an Indonesian exporter to Australia to specifically look at hot water treatment facilities with the intention to invest in equipment in Indonesia.

Early on in the project it was recognised that the best options available for disinfesting Mangosteens to a level that would be international acceptable was fumigation as they are considered a non-host for fruit fly more elaborate disinfestation techniques such as irradiation or heat treatment simply aren't necessary. The entire pests of quarantine concern on mangosteen exist on the external surface of the fruit. Traditional Methyl Bromide fumigation whilst still a viable option does have a significant detrimental impact on fruit quality. Whilst still permissible to use methyl bromide under the Montreal protocol it is actively been discouraged from use where alternatives are available. It was seen as a great opportunity to develop a new fumigation Ethyl formate which would not be detrimental to fruit quality and have no negative environmental impacts. This would be a world first for mangosteen and potentially give Indonesia an advantage over its main competitor Thailand.

With mangoes fruit fly is the most significant quarantine issue for this the options are irradiation, hot water treatment, or vapour heat treatment. By the time the project had begun significant investment in VHT trials was being undertaken by a Japanese project and work in this area would only be duplication, so a decision was made by the project team to concentrate on hot water and irradiation.

The approach to progressing these treatments was assessing the current capacity both infrastructure and technical. Upgrading of these facilities and a heavy emphasis for developing the technical capacity of the various Indonesian agencies involved in the development of export protocols. This was followed up by preliminary trial work to understand the effects of fumigation, irradiation and hot water on the quality of the fruit. Unfortunately the hot water work did not progress due to staff changes and a change in policy direction away from HWT. However from the work conducted it was quite clear that the fumigation and irradiation had no detrimental quality impacts on mangosteen and mango respectively. This is a significant finding as ethyl formate had never been trailed on mangosteen before and it is well known that mango varieties respond quite differently to irradiation with respect to impact on fruit quality. Follow up trial work on the fumigation also demonstrated it was highly effective on both ants and mealybugs.

By combining the fumigation work with the methods developed for controlling of the ants and mealybug in the field and at other critical points in the supply chain creates a more effective management system that will meet international requirements.

The generation of efficacy data to international standard is critical for underpinning market access negotiation was conducted with ants and mealy bug for the ethyl formate fumigation and for mealybug with irradiation. The efficacy of irradiation on fruit fly is well documented already. The data generated is currently sufficient to begin negotiations on protocols, although it may be that the importing country will request further efficacy work this would be determined through the negotiations process between the respective quarantine departments.

7.2.5 Export Development

Extensive work was conducted in developing new supply chains by the use of trial shipments commercial and static and closely monitoring the results then building upon the lessons learned from the previous seasons.

Trial export schedule
Hong Kong Air Gedong (2010)

Static sea container standard reefer Harumanis and Gedong (2011)
Hong Kong sea standard reefer Harumanis and Gedong (2011)
Hong Kong sea standard reefer Gedong small consignment of Harumanis(2012)
Dubai Controlled atmosphere container Gedong small consignment of Harumanis (2013)

The systems were thoroughly evaluated and monitored, including the training of Indonesian researches in evaluation methodology. Fruit was taken all the way through the supply chain to the retailer and customer to assess its export potential with the Indonesian exporter being part of the process.

As a direct result of this work a new fully commercial supply chain was developed in Hong Kong supplying Gedong to Park and Shop supermarkets throughout the Indonesian season. In addition to this a commercial airfreight supply chain was established into Dubai with the intent to expand this to sea freight once the supply of enough Gedong from the farmers in Indonesian can be obtained. The trial work clearly identified the export opportunity that Indonesia has during its mango season whist also highlighting the limitations of the current available cultivars. The under skin greying of the Harumanis variety in almost all of the export consignments is of significant concern. Until this issue is addressed and better understood the development of a significant export market based on Harumanis would be high risk. The Gedong on the other hand proved to be a very robust variety in the export supply chains given very good outturns. The downside to the Gedong is its size, poor flesh to seed ratio and lack of blush these factors are going to present challenges for significantly expanding the export market. So as a variety to test the opportunity for Indonesian mangoes it has served this purpose very well and has established a foot hold into these markets. However to develop a sizable export industry there is a real need for some genetic improvement to happen.

The project undertook an audit of what varieties are currently present in Indonesia; this was to gain an understanding of what varieties are currently available in any number that could be used to undertake future export development work. Quite an extensive varietal collection exists at Pasuruan East Java being a valuable resource for future genetic improvement programs, however very few of what would be considered existing commercial export varieties have been planted outside of this collection. A number of local varieties already exist within the industry planted in significant numbers most of them like Gadung and Cengkir are green skin varieties and considered inferior to Harumanis. Others such as Podang are highly coloured which is generally not as well accepted domestically as it has a lower brix than Harumanis but may have potential as an export fruit.

7.2.6 Capacity Building

Throughout the life of the project there was a focus on building the capacity of the project staff and scientists to conduct integrated and targeted research, development and extension programs. Table 2 outlines the staff who received training and summarises what the training involved.

Table 2. Staff that received training and a summary of their training programs.

Staff and Organisation	Summary of training	Reports
Roedhy Poerwanto IPB	Development of fruit quality standards. Training in Smart Fresh®	Local travel reports

	application techniques. IVS techniques. Perth and Kununurra 2009	
Mizu Istianto ITFRI	1. January 2010, Brisbane, Cairns and Mareeba. Define quality parameters of different mango varieties. 2. April/May 2011, Darwin. 4th Annual Conference of Plant Pathology and associated workshops.	Local travel reports
Cahyaniati (Yani) DGH	Hot water disinfestation and trial design. Perth, Cairns and Townsville 2010	Local travel reports
Sobir IPB	Consumer evaluation and market research Hong Kong/China 2010	Local travel reports Presentations at midterm workshop
Nurdi Setyawan ICAPRD	20 October to 3 November 2010, Kununurra Development of mango maturity standards – training in techniques	Crawford Fund report 2010-359-WA
Hermawan and Turhadi Noerachman IAQA	7-11 March 2011, Perth Theoretical and practical application of fumigant ethyl formate.	Crawford Fund report 2010-379/380-WA
Dondi Setyabudi ICAPRD	5-17 December 2011, Queensland Development of mango maturity standards – training in techniques	Crawford Fund report 2011-399-ACT
Achmad Nasroh Kuswadi NNEA	December 2011 visited Queensland to meet staff involved in irradiation of mangoes. Also visited irradiation facilities in Sydney.	Local travel reports

Haposan DGH	Outturn receival assessments, Hong Kong 2011 and 2012	Local travel reports
Ridwan ICAPRD	Outturn receival assessments, Hong Kong 2011	Local travel reports
Komar Pt. Alamanda Sejati Utama	Outturn receival assessments and market research, Hong Kong 2012 Outturn receival assessments and market research, Dubai 2013 Visit pack houses and manufacturer of hot water treatment equipment, Queensland 2015	Presentation at final workshop.
Murni Indrawatmi NNEA	24 September to 7 October 2012, Perth Development of procedures to rear entomological specimens and associated quality control procedures	Crawford Fund Report WA-524-2012
Fajar ICAPRD	Outturn receival assessments Hong Kong 2012	Local travel reports Presentation at grower workshop.
Dondi ICAPRD	CA post shipment handling and outturn assessments. Dubai 2013	Local travel reports Presentation at final review workshop
Intan Fajarsari and Maulita Novelianti DGH	9-15 July 2013, Kununurra Cost benefit analysis of adopting new technology for the Indonesian mangosteen industry	Crawford Fund Report WA-556-2013
Roedhy, and Darda IPB	IHC Conference in Brisbane 2014 The project assisted IPB staff to attend the IHC 2014 Conference in Brisbane to present papers on research they and their students had	Local travel reports

	conducted for the project.	

1:**Training and applying phytosanitary disinfestation techniques.**

***Heat*:** Mrs Cahyaniati was trained in the experimental techniques required to obtain data for the most tolerant stage trials using hot water and vapour heat. She also visited a commercial VHT plant in Townsville.

The VHT work was taken over by a project funded from Japan. Due to staff changes and a change in policy direction towards VHT within DGH the Hot water work was not followed through. However hot water offers the most viable, very low cost, internationally accepted disinfestation treatment for the Indonesian mango industry. It is the most appropriate technology for price sensitive markets such as China and would be relatively easy to set up in the mango districts in Indonesia.

Fumigation: Mr Hermawan and Mr Tuhardi Noerachman were trained in applies techniques required to use ethyl formate doses in a 40ft refrigerated shipping container.

Ethyl formate fumigation is safer to use than methyl bromide and is not phytotoxic to mangosteens. Procedures were developed with quarantine research Institute and with BOC-Linde for horticultural produce. Good results have been obtained on mangosteen, strawberries ,bananas and pumpkins by the Quarantine Research Institute using Vapourmate® in a 20ft refrigerates shipping container. Ethyl formate at 10g/m3 (or 60b/m3 Vapourmate®) was found by quarantine Research Institute officers to be very effective against mealy bug and ants, the two biggest quarantine issues with Mangosteen.

Irradiation: Mrs Murni Indrawatmi was trained in the research techniques required to rear all stages of mealybugs, mites, thrips and fruit flies for the most tolerant stage trials using appropriate dose. She was also given training in basic gas chromatography work.

Procedures have been developed for rearing several species of insects in NNEA. Appropriate doses were proposes and tested against fruit flies and mealybugs. Calibration and dosimetry on the conveyor belt in the irradiation chamber have been developed and tested.

Dr Achmad Nasroh Kuswadi was trained in trial design and evaluation techniques for assessing the impact of irradiation dose rate on fruit quality. This was conducted at ANSTO in Sydney and at the post-harvest laboratories in Cairns.

This training assisted researches at NNEA to undertake successful the trial work that examined the impact of dose on quality of Indonesian mango cultivars gedong and harumanis.

2: Training and applying fruit quality assessments:

Fruit quality standards: Prof Roedhy Poerwanto and Dr Mizu Istianto were trained in the development and understanding of quality principles and for mango varieties.

Prof Poerwanto was also trained in the application of Smart Fresh® this was a company requirement for the undertaking of the trial work on increasing the shelf life of the Mangosteen Calyx.

This training has assisted researches in Indonesia to develop quality standards for export Gedong.

Maturity standards: Mr Dondi Setyabudi and Mr Nurdi Setyawan were trained in techniques for developing maturity standard in Mango.

The development of a maturity standard for Gedong is seen as critical for the successful exporting of the variety. The training was used to undertake preliminary work in developing this maturity standard.

3: Training and applying export development techniques.

Market research Prof Sobir, Dr Ridwan. and Mr Haposan. Infield training was conducted in Hong Kong in collecting qualitative market information from consumers, importers and retailers.

These techniques were used to complement the quantitative data that was collected from the focus groups. Market research was conducted with importers, consumers and retailers, thus a clear picture was developed for th potential of Gedong in the Hong Kong market.

Outturn assessments: Mr Fajar, Mr Dondi Mr Haposan were trained on the process for undertaking outturn assessment for export consignments. This is a critical component of the information gathering for evaluating fruit quality, interpretation of the results and implementing changes to system.

CA export Shipping: Mr Nurdi Setyawan, Mr Komar were part of an extensive training exercise that was conducted through workshops and pre shipment and post shipment management of CA fruit under export situations. This work has been adopted by the industry and components of this are now being used for commercial export consignments and with the intent of full commercial CA shipments to the UAE.

4: Project evaluation:

Cost benefit analysis Ms Intan Fajarsari and Ms Maulita Novelianti were trained in the techniques for conducting cost benefit analysis using some commercial Australian farming operations as case studies.

This training was then used to conduct cost benefit analysis of the impact of adopting new technologies developed by the project on the Mangosteen industry in Indonesia. Whilst the analysis conducted was quite rudimentary it did clearly indicate a significant cost benefit for the adoptions of new practices.

7.2.7 Workshops and Study Tours

Capacity building of researchers, extension agents and supply chain partners through workshops and study tours was also an objective of the project. Table 3 lists the workshops conducted and summarises their purpose.

Table 3: Workshops conducted

Workshop **Date and Place**	**Summary of workshop content**
Mango Supply Chain mapping Cerebon April 2010	Detailed understanding of how the different supply chains work and stakeholder interactions
Mangosteen Supply Chain Mapping Leuwiliang April 2010	Detailed understanding of how the different supply chains work and stakeholder interactions
Mango Grower Workshop X 2 March 2010, Cirebon & Majalengka	Principles in mango fruit quality an introduction.

Mango Grower Workshop Cirebon October 2010	Sap and post-harvest management of mangoes
Thailand Mangosteen Study Tour 26 October – 2 November 2010	Indonesian mangosteen growers (4), project staff (2) and a mangosteen exporter were accompanied to Thailand by two Australian project staff. The purpose of the tour was to observe the Thai mangosteen industry from orchard management to pack house procedures.
Mangosteen workshop X 2 Purwakarta & Leuwiliang April 2011	Minimising harvest damage to fruit
Mangosteen workshop Leuwiliang	Fruit quality and IPM
Mango workshop June 2013, Bandung	Implementing best practices for export quality.
Mangosteen workshop November 2013, Bogor	Best practice quality management.

8 Impacts

The management of fruit quality and pest infestation on mango and mangosteen to meet technical market access project has had an impact on the mangosteen and mango industry in Indonesia in terms of scientific approach towards industry issues with a market focus. Capacity building of researches and equipment has given Indonesia the necessary tools to address the technical issues that are associated with negotiating access to markets that have phytosanitary requirements. Accessing new markets and/or regaining access to recently lost markets will have substantial long term impact on the industry stakeholders and the wider community

Industry collaborators have already implemented the findings from trial shipments and developed export program with international supermarkets, and actively seeking to invest in infrastructure to increase their export capacity.

8.1 Scientific impacts – now and in 5 years

The project has demonstrated that the integrated system approach to research could produce better results than that by the traditional approach of addressing problems in individual sector of the supply chain.

- The physiology studies on the yellow latex has given a good understanding internal mechanisms of sap movement within the mangosteen fruit and its association with the quality issue gummosis. This understanding provided a good foundation for future research activities that will help minimise the impact of the disorder.
- The post-harvest research on calyx desiccation has given a far better understanding on the phenomenon and handling practices that will minimise its impact in the export markets. This has been a significant impediment into accessing the premium end of the Chinese mangosteen market.
- The nutrition work on mangosteen has given researches an important understanding of the micro nutrients in particular Boron and its relationship with internal fruit quality, yield and interaction with other elements. This has given researchers better direction on refining nutrient applications to improve yield and internal quality of the fruit.
- The different approach taken to research the fruit scarring on mangosteen has challenged traditional scientific thinking on the issue. This has given a far greater understanding of the issues cause and effects. Giving researches specific direction in where to undertake future research projects into the problem.
- The development of a baiting system for control of ants in Mangosteen has given researches the base for developing a fully integrated IPM program for Mangosteen that could reduce the problem with insect contamination of fruit down to negligible levels.
- Establishing the fumigation facilities and building the capacity of researchers at IAQA. has put them in the position now to be able to undertake quality research into fumigation techniques at a standard that will meet international requirements. Although the capacity has been developed and currently used for Mangosteen, already IAQA have plans to undertake future research on other horticultural crops utilising these facilities and skill base.
- The pre and post-harvest work conducted on Gedong linking maturity, temperature management, disease management, ripening procedures with export markets has given researchers at IFTRI and ICAPRD not only a better understanding of the issues but good exposure to an integrated scientific approach linking research to markets. Scientist

now have a better understanding of the importance of linking future research project to market needs.

- The scientific capacity has been strengthened at NNEA enabling researches to undertake high quality research in disinfestation using irradiation not only to meet protocol requirements but market requirements in the impact that the treatment has on fruit quality. The necessary base has been established with NNEA to be able to undertake the research requirements for market access via Irradiation.

8.2 Capacity impacts – now and in 5 years

- By investing in infrastructure at National Nuclear Energy Agency, combines with the intensive capacity building in research skills. The institute now has the capacity to carry forward research projects involve insect rearing, trial design, and impact of irradiation disinfestation on fruit quality at a high internationally accepted standard. This gives Indonesia the capacity between now and the next 5 years to conduct research that can be used for negotiating market access protocols using irradiation.
- The investment in fumigation chambers and the associated equipment combined with the training in ethyl formate use and trial design has given the Indonesian Agricultural Quarantine Agency the capacity to undertake high level research in fumigation disinfestation to a level that would meet international requirements. This gives Indonesia the immediate capacity now to conduct research that can be used for negotiating market access protocols using fumigation, over the next 5 years it will be expanded to other horticultural crops.
- Training and equipment upgrades at the Indonesian Centre for Agricultural Post Harvest Research & Development has given the institute the capacity undertake fruit maturity, ripening trials as well as the conducting of outturn assessments on export consignment. Given the success of the initial export work and commitment of exporter to expand upon this over the next 5 years this need for this type of research capacity will only increase. If there is development of a much needed genetic improvement of mangoes in Indonesia then having this capacity will be critical to its success.
- A large number of students were involved in the research project at Institut Pertanian Bogor. The project took a more integrated approach to the research linking a number of activities together focused on market requirements than what traditional research programs have done in the past in Indonesia. This has given the students and IPB staff significant capacity in taking a more holistic approach to research questions in future projects.
- The capacity with equipment has been established within DGH to undertake Hot water disinfestation research. Staff within DGH have also been trained in its use, calibrations trial design and insect rearing to a level that would meet international standards. However these staff members are currently now working within this area at the moment. If a shift in policy towards HWT in the future happens then DGH has the capacity to meet the needs.
- Capacity investment was also made in the economic evaluation of research activities with DGH. This gives DGH the capacity to better evaluate research projects and their impact. This potently impact of this is better decision making on the investment of research funds to maximise the benefits.
- Significant training and resources were invested with researchers at Indonesian Tropical Fruit Research Institute. Introduction of new skill, scientific techniques trial designs and a greater market focus to research has increases the capacity of the institute to undertake and This has resulted in better capacity for IFTRI to undertake research programs that are more integrated with a market focus.

- Working closely with the export company Alamanda has had a major impact on the company's capacity to build export supply chains. Senior staff were trained in building export systems. The pack house was reorganised to be more suitable for export and correct training in preparing export consignments. This was combined with the development of a capital improvement program for the pack house. The immediate result was the capacity of the business was lifted to a level where it is able to undertake both commercial sea and air mango export programs. With the continued investment in infrastructure over the next 5 years the operation will become a significant mango export business.

8.3 Community impacts – now and in 5 years

The project has highlighted to the Mango and Mangosteen stakeholders the potential for development of their export industries. It has developed the technical and infrastructure capacity with in Indonesia to begin the process of access to new markets which have phytosanitary requirements. It has also introduced the concept of an integrated market focus to research, thus giving industries the direction they need to resource R&D efforts effectively. This ultimately is able to produce product that meets the consumer's requirements.

This gives these industries the necessary tools to access and develop new export markets to which the impact will can extend well beyond 5 years.

8.3.1 Economic impacts

The projects focus was the approach of building the capacity for Indonesia to access new markets with phytosanitary requirements and being able to produce a product that will meet these markets requirements. The potential economic impacts of this are enormous with Indonesia the largest mangosteen producer and 6th largest mango producer in the world. This will not only have impact at the producer level but at a national level.

The project has delivered to the stakeholders the necessary expertise for Indonesia to renegotiate re-entry into the recently lost Chinese mangosteen market which is in excess of 10,000 tons per annum. The same for the Taiwanese, Australian New Zealand and USA markets.

At the farm level the identification of causes of many of the fruit quality issues with mangosteen will have immediate benefits by increasing the percentage of premium priced export grade fruit the farm produces.

The project was instrumental in developing new mango export supply chains into Hong Kong and UAE with mango. The immediate economic impact is the development of commercial export program with Hong Kong and UAE supermarkets which are steadily growing. The technical capacity now exists for Indonesia to undertake the necessary trial work to negotiate access the USA and New Zealand market using irradiation as a disinfestation treatment.

At the farm level better production practices especially in the use of chemical spraying reduces their production costs and is resulting in better export grade product.

8.3.2 Social impacts

The project has played a key role in identifying and addressing some of the key factors that are impeding Indonesia to capitalise on is large export potential for Mango and Mangosteen. Access to new markets and growth in existing ones means a greater demand for the supply of premium fruit. This impacts right down to the small farm level with improved returns for premium fruit and the social benefits of that come with increased income.

The project has worked on changing the traditional stakeholders' mindset towards the adoption of an integrated market focused approach to issues. This has resulted in the case of a project collaborator increasing their investment into the business and an increase in employment.

8.3.3 Environmental impacts

The project has addressed a number of issues that potentially have a positive environmental impact.

In mangosteen specific targeted systems were trialled and developed that incorporated very low chemical environmentally friendly baiting systems to control ants, Using IPM technology to increase beneficial insect populations to control thrips and mites input reduced to baits.

In mango there was a focus on developing a strategic pest and disease management program to better target their spray programs and significantly reduce the amount of spraying necessary thus reducing chemical input.

Replacement of Methyl bromide fumigation with ethyl formate has substantial global environmental benefits.

Ethylene ripening was introduced into the system with the intent to eventually eliminate the use of the hazardous practice of ripening fruit with calcium carbide.

8.4 Communication and dissemination activities

The project communicated its research findings to the relevant public and private stakeholders through workshops, seminars, trainings, export development programs, and newsletters through the project.

Newsletter

Five editions of the 'Mango and Mangosteen Newsletter' were disseminated to project members and interested parties between November 2011 and April 2013. The aim of the newsletter was to keep project members informed of the activities of other members and to build a sense of team work. Members were eager to contribute and grateful when they received a copy. This would have been a useful tool over the duration of the project given the disjointed nature of activities. However, time constraints did not allow for more editions to be published.

Presentations.

Throughout the project numerous presentations were made to researchers, industry groups and other stakeholders many were through the workshops and planning meetings held by the team as outlined in Table 3.

In addition presentations were made at the "International conference on agriculture post-harvest handling and processing" Jakarta November 2013 on Building mango export supply chains. Also at the international horticultural congress at the Gold Coast in 2014.

Training

For structures training and workshop seasons refer to training and workshop summary Table 2 and Table 3

Informal hands on training exercises were conducted frequently during visits of the project team with our Indonesian project partners and relative stakeholders. Topics covered by this were.

Postharvest:

Developing maturity standards

1-MPC trial design and usage.

Maturity assessments

Ethylene ripening

Temperature monitoring

Fruit quality assessment.

Developing heat unit standards.

Export development:

Export pack-house training, consolidation, product flow, cooling schedules post-harvest disease control, palletising.

Defect analysis

Mango exports by air

CA Container loading and setting

Outturn monitoring.

Walking the export value chain.

Quarantine:

Insect identification

Insect rearing

Trial design

Media Press

Nov 2013 Local Jakarta television interview and press release on mango CA Sea freight shipments.

9 Conclusions and recommendations

9.1 Conclusions

Mango:

Export Systems

Successful air and sea freight trials demonstrated the potential for a highly lucrative mango export industry in Indonesia. The enthusiasm and commitment of the exporter collaborating with the project means that the results achieved by this project will be carried forward and expanded on into the foreseeable future.

Cultivar:

The variety Harumanis has severe limitations on its export potential. This is primarily due to its significant post-harvest issues when put into a cool chain and its green skin which is widely seen as a negative attribute by consumers.

Gedong has proven to have some export potential with the export trials clearly demonstrating it is robust enough to handle sea and air export systems with good outturn results. Resulting in a commercial program has now been established in Hong Kong. However, to export Gedong it must be harvested at the pre-blush stage thus limiting its presentation appeal. Gedong is also a very small fruit which limits the number of market segments that will accept this. In addition the fruit has a relatively poor flesh to seed ratio and fibrous flesh. Both these are viewed as negatives attributes in almost every mango market around the world.

For Indonesia to be a significant mango exporter there must be genetic improvement on the existing commercial cultivars.

Post harvest Research.

The current capacity within Indonesia to undertake quality post-harvest research in Mango is putting a constraint on the industry being able to develop the quality systems that are required to develop an export mango variety.

Market Access:

The industry is now equipped with the technical and infrastructure capacity to undertake the necessary work for developing a protocol for mango using irradiation as a disinfestation treatment.

Mangosteen:

A strong base has been established from which significant research can continue. Through training and equipment upgrades the capacity now exists to start trials to meet phytosanitary access requirements. Trials have also proven methods to improve fruit quality and reduce quarantine risks such as live insects. The most significant findings of the project were:

- The application of calcium and boron, in combination, to the soil has been shown to reduce the percentage of fruit affected by gummosis.
- baits to control ants have been developed for all stages in the supply chain
- a link has been found between fungi, more specifically Pestalotia and Phomopsis , and scarring
- a link between insect numbers and fruit scarring has been shown from Confidor trials

- Significant increases in export grade fruit can be made through the adoption of best practices.
- Technical and infrastructure capacities are now at a level that negotiations for ethyl formate as a viable alternative to methyl bromide fumigation can be undertaken.

The study tour to Thailand demonstrated to Indonesian growers how to produce export quality fruit. This proves the potential for a highly lucrative mangosteen export industry from Indonesia.

9.1 Recommendations

Mango:

- Hot Water Treatment (HWT). The decision not to precede with the hot water trials was not one that was supported by the project. It is firmly believed that this disinfestation technology is the most appropriate one for the expansion of the Indonesian mango exports. This is due to its low cost and ease of establishment as well as it being readily accepted internationally as a disinfestation treatment. The capacity to undertake the necessary research for HWT has been established by the project within DGH and it is recommended that this work be followed up with the view for market access to China.
- It was quite clear from the work conducted that the current Indonesian mango varieties have significant limitations in export potential. Limited uncoordinated efforts in developing new local cultivars are producing rudimentary results at best. In the short to medium term a coordinated introduction program of suitable export varieties combined with the development of local researcher's capacity to undertake assessments is needed. In the long term the establishment of a breeding program would address the underlining issues with the current Indonesian cultivars.
- The export systems trailed by the project air, sea and CA proved to be very successful and have gained industry momentum. For Gedong to expand as an export variety these export systems will require substantial technical input along the chain with importers, exporters, transporters and producers. There is a keen industry interest to invest in the necessary infrastructure, although currently the skills or technical capacity to build the integrated systems that are required is not available within Indonesia.. For full commercial development of the whole export system a whole of value chain approach is required. Similar to the approach that has been taken in the Pakistan ASLP Value chains project.
- Post-harvest assessment of Gedong. In spite of a substantial amount of resources and training that was invested into ICAPRD, high staff turnover with almost no succession development within the organisation meant that many of the research results were inconclusive. Some of the critical post-harvest issues with Gedong such as refining the maturity indices' still need to be researched. For Indonesia to have a successful genetic improvement program it is essential to be backed up with good post-harvest research. As a genetic improvement program is a major undertaking future research partners in this area need to be in a position and capacity to commit to a long term program.
- Integration of systems. The project has developed and introduced a number of practices and systems within the mango value chain. Further development work is still required to build these into an integrated system.
- Significant opportunity exists within the Indonesian domestic market to expand the supply over a greater number of months by manipulation of flowering and production practices. Mango production in the equatorial regions where there is little seasonal differentiation between seasonal temperatures offers opportunities to manipulate the

flowering physiology to extend the season. This has been capitalised upon in countries such as Philippines, Thailand and Brazil but very little research has been conducted in Indonesia.

- Unfortunately most of the current industry information with pest and disease management is supplied via chemical companies resulting in overuse of products. As the industry moves towards export this is going to create significant problems with residues and chemical resistance. A number of pest and disease management practices have been developed through the project. However, this needs to be fully integrated into the newly developed export systems.
- New disease management practices were introduced by the project into the export system and proved to be very successful. Further work is required into providing technical input into the integration of these practices into the system.
- Work with policy makers to facilitate a more workable system of new chemical registrations in Indonesia.
- Throughout the project the market research was indicating that there is potential for the Harumanis variety for fresh in market processing such as juice fruit for street vendors.. As this variety currently dominates Indonesian production the benefits of developing a new market would be widespread. Further market research is required to explore this potential for fresh in market processing. This would also need to be backed up with postharvest research to address the physiological issues associated with the transportation of Harumanis.
- Market access using irradiation. The irradiation trial work was successful. Industry is very keen to develop this protocol for new markets. This needs to be followed up with applications for market access to markets such as US and /or New Zealand.
- At the policy level the potential for Indonesian mango exports is not fully understood. Indonesia sits in a unique position globally in respects to its timing and geographical location and could be a major mango exporter. However, there is no clear policy direction. This is creating mixed policy messages filtering down to researchers and industry. One way to begin to address this issue would start with a workshop with the key policy makers examining the potential for the export industry and build upon the industry strategic plan with the inclusions of an export and investment plan.

Mangosteen:

- The initial ethyl formate trials proved very successful. This needs to be followed up with formal application to targeted markets that is Taiwan, China and Australia as an alternative protocol treatment to Methyl bromide.
- The baiting control for ants proved highly effective. This work needs to be fully integrated into an export supply chain including addressing cross contamination issues. This would effectively eliminate the majority of ants and substantially reduce the amount of mealybugs on the fruit. This combined with ethyl formate fumigation will reduce the risk to a level that would be acceptable to most countries.
- There needs to be further refinement of nutrient rates, especially calcium. Timing of calcium and boron applications is also necessary to maximize leaf levels at flowering/ fruit set. There needs to be increased awareness of the time it takes for dolomite to become effective.

- Scarring : there needs to be further research in the fungal pathogens that are linked to scarring, such as identification of the optimum conditions and timing of inoculation. This

will generate the information required to develop control methods for minimising the impact of scarring.

- Further research into the potential for IVS propagation to reduce the juvenile phase of mangosteen.

- It was identified in the study tour that there is an opportunity for some research into the current market practices of the Indonesian mangosteen industry, in the view of adopting new approaches that would capture greater value for the producers

- Significant information has been generated from the project that will need more time before the real benefits are realised, expanding the work into the demonstration sites which incorporate all of the best practices from the project and learnings from the Thailand industry would be of enormous benefit to the Industry, researchers and extension officers.

Project Partners:

Staff turnover had a negative impact on the outcomes of this project. This happened within more than one of the government agencies over the life of the project. When staff were moved to other areas there was minimal transfer of skills and knowledge. The only cases were this worked successfully was within NNEA. Succession planning was implemented and training needs of new staff identified and delivered.

Staff turnover also meant that some data was lost. Essential data was not passed on before the staff member left and subsequent staff members were unable to locate this information.

Communication regarding staff movements was limited and DAFWA, as project leader, was often not informed until the last minute or sometimes even after the fact.

Careful selection of project partners is necessary in future, particularly with the management of finances through the DIPA system which proved to be highly inflexible and problematic.

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Uli Khusna Inayati, Roedhy Poerwanto (??) The Combination Effect of BA and Some Coating Substance for Storage Life of Mangosteen (Garcinia mangostana L) Journel ??

Zuraida Sagala (2010) Effect of using KMnO4 and Ascorbic acis with temperature storage to prevent degreening calyx mangosteen fruit (Garcinia mangostana L.) ??? Thesis Institut Pertanian Bogor Bogor Indonesia.

Tiara Septirosya (2012) The Effect of Calcium and Biopore Application on Gamboge Disorder and Quality of Mangosteen Fruit (Garcinia mangostana) ??? Thesis Institut Pertanian Bogor Bogor Indonesia.

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O.F. Kurniadinata, R. Poerwanto*, D. Efendi, A. Wachjar (???) Biopore Technology and Ca2+ Application to Reduce Yellow Sap Contamination on Mangosteen Fruits (Garcinia mangostana) Journel ??

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D. Efendi, E. Gunawan, Haniawati and M. Andriyanto (2014) The Effect of Boron Fertilization on Mangosteen (Garcinia mangostana L.) Fruit Quality Acta Horticulturae ??

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Progress Report 2011-2014

Final Report

Guidelines of Thrips Management (in Process)

Guidelines to control ant in mangosteen (in process)

Booklet “Introduction diseases that attack mangosteen” (In process)

Leaflet “Pengenalan koleksi plasma nutfah mangga (Introduction of mango collection)”

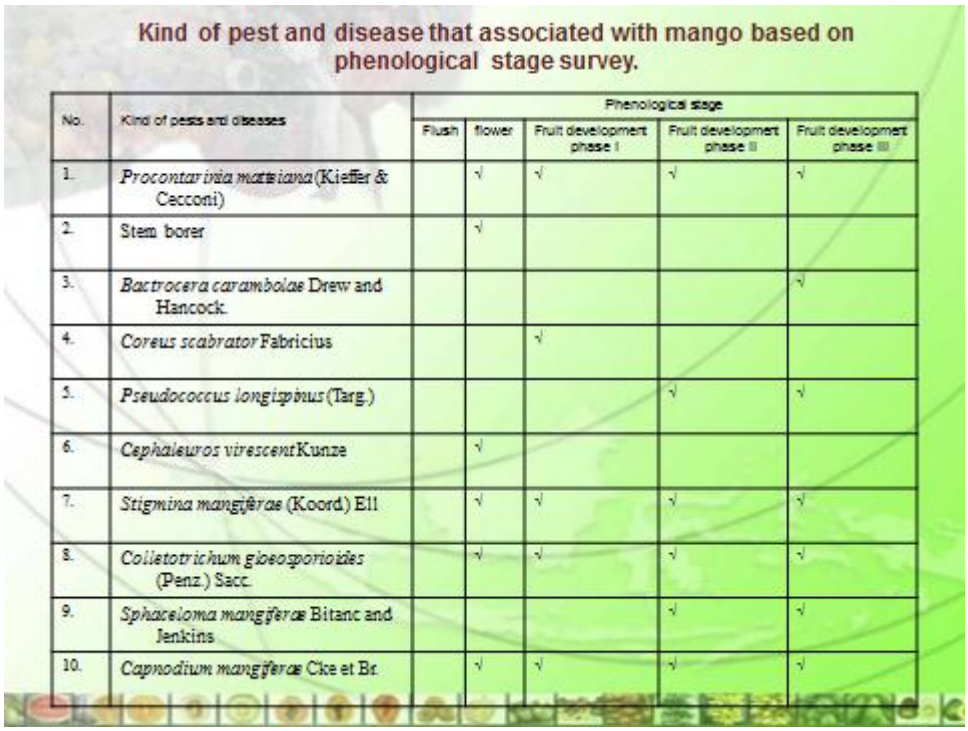
Dukungan Badan Litbang Pertanian terhadap Pengembangan Mangga Gedong Gincu di Cirebon (Supporting of IAARD for Gedong Gincu mango development in Cirebon)

Dampak Penerapan Teknologi Inovasi Budidaya Mangga (Impact of applying recommended technologies in mango cultivation)

Pemanfaatan minyak sereh wangi sebagai alternatif teknologi ramah lingkungan untuk menekan populasi semut dan gejala burik pada buah manggis (Applying citronella oil as an alternative technology that consider environment safety to control ant population and scarring symtomp on mangosteen

11 Appendixes

Appendix 11.1 Mango Pests



Kind of pest and disease that associated with mango based on phenological stage survey.

No.	Kind of pests and diseases	Phenological stage				
		Flush	flower	Fruit development phase I	Fruit development phase II	Fruit development phase III
1.	*Procontarinia matteiana* (Kieffer & Cecconi)		√	√	√	√
2.	Stem borer		√			
3.	*Bactrocera carambolae* Drew and Hancock.					√
4.	*Coreus scabrator* Fabricius			√		
5.	*Pseudococcus longispinus* (Targ.)				√	√
6.	*Cephaleuros virescent* Kunze		√			
7.	*Stigmina mangiferae* (Koord) Ell		√	√	√	√
8.	*Colletotrichum gloeosporioides* (Penz.) Sacc.		√	√	√	√
9.	*Sphaceloma mangiferae* Bitanc and Jenkins				√	√
10.	*Capnodium mangiferae* Cke et Br.		√	√	√	√

Appendix 11.2 Mangosteen pests

Pest List of Mangosteen

DORMANT STAGE

- Mites pest that associated with mangosteen i.e. *Brevipalpus* sp., and *Ultratenuipalpus* sp.
- Meanwhile, detrivore *Lamelobates hauseri*, *Tuberemaeus deletus* and *Tegeozetes tunicatus* were the most prominent species found.
- The most prominent predator was found involved *Uroseius* sp., *Asca butuanensis* and *Geolaelaps* sp., respectively.
- Thrips pests such *Selenothrips rubrocinctus* and *Frankliniella* sp.,were the most common species.

FLUSH STAGE

- *Brevipalpus* sp., *Panonychus ulmi* and *Schizotetranychus* sp., were the most prominent phytophagous mites associated with ecosystem of mangosteen.
- *Tegeozetes tunicatus*, *Lamelobates hauseri*, and *Tuberemaeus deletus* were the most common detrivore,
- *Amblyseius angelique*, *Am. lenis* and *Am. tamatavensis* were the most collected predator.
- *S. rubrocinctus*, *Haplothrips* sp., and *Dendropthrips innoxius* were the highest collected phytophagous thrips.

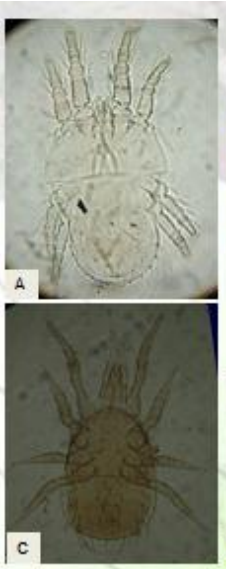


Figure 3. Phytophagous mites *Ultratenuipalpus* sp. (A) and *Brevipalpus* sp. (B) associated with ecosystem of mangosteen orchard including predatory mites *Asca butuanensis* (C) and *Uroselus* sp. (D).

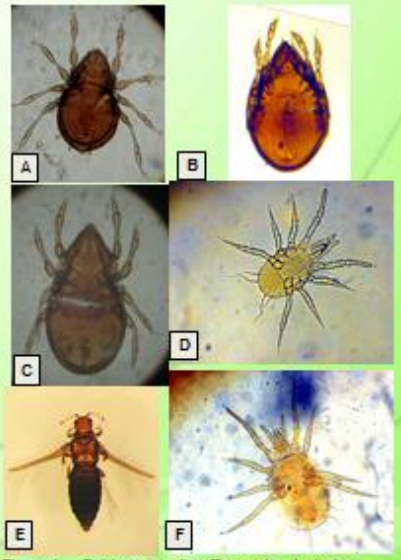


Figure 4. Detrivorous mites *Tegeozetes tunicatus* (A), *Lamelobates hauseri* (B), and *Tuberemaeus deletus* (C) including predatory mites *Amblyseius tamatavensis* (D), *Amblyseius lenis* (F) and thrips *Selenothrips ubrocinctus* (E) associted with ecosystem of mangosteen orchard

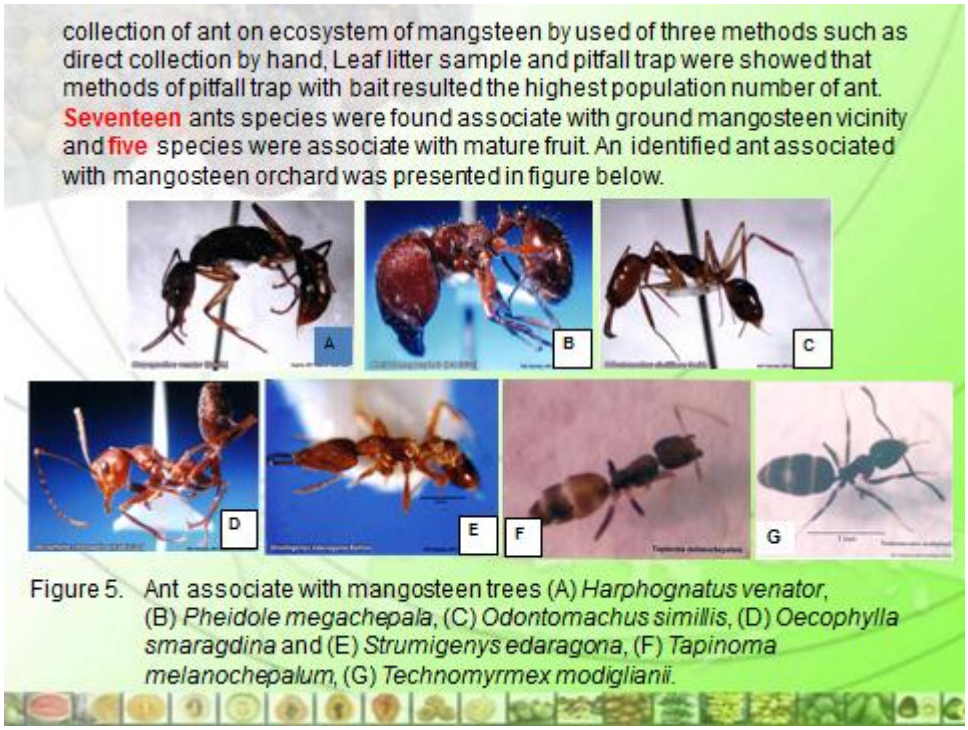


Table 1 Quarantine pests for mangosteen fruit from Indonesia

Pest	Common name
Spider mites [*Prostigmata: Tetranychidae*]	
Tetranychus spp.	Spider mites
Weevils [*Coleoptera: Curculionidae*]	
Curculio sp.	
Fruit flies [*Diptera: Tephritidae*]	
Bactrocera carambolae Drew & Hancock, 1994 [EP]	Carambola fruit fly
Bactrocera papayae Drew & Hancock, 1994 [EP]	Papaya fruit fly
Soft scales [*Hemiptera: Coccidae*]	
Drepanococcus chiton (Green, 1909) [EP]	Soft scale
Armoured scales [*Hemiptera: Diaspididae*]	
Diaspis boisduvalii Signoret, 1869 [WA]	Boisduval scale
Ischnaspis longirostris (Signoret, 1882) [EP, WA],	Black thread scale
Pseudaonidia trilobitiformis (Green, 1896) [EP, WA]	Trilobite scale
Mealybugs [*Hemiptera: Pseudococcidae*]	
Dysmicoccus lepelleyi (Betrem, 1937)	Annona mealybug
Exallomochlus hispidus (Morrison, 1921)	Cocoa mealybug
Hordeolicoccus heterotrichus (Williams, 2004)	Citrus mealybug
Paracoccus interceptus Lit, 1997	Intercepted mealybug

Paraputo odontomachi (Takahashi, 1951)	
Planococcus lilacinus (Cockerell, 1905) EP	Coffee mealybug
Planococcus minor (Maskell, 1897) EP, WA	Pacific mealybug
Pseudococcus aurantiacus Williams, 2004	Orange-coloured mealybug
Pseudococcus baliteus Lit, 1994	Aerial root mealybug
Pseudococcus cryptus Hempel, 1918 EP	Cryptic mealybug
Rastrococcus spinosus (Robinson, 1918) EP	Philippine mango mealybug
Ants [*Hymenoptera: Formicidae*]	
Camponotus sp.	
Cardiocondyla sp.	
Crematogaster sp.	
Dolichoderus sp. EP	
Iridomyrmex sp.	
Monomorium sp.	
Paratrechina sp.	
Pheidole sp.	
Plagiolepis sp.	
Polyrhachis sp.	
Tapinoma sp.	
Technomyrmex sp. EP	
Tetramorium sp.	
Wasmannia auropunctata EP (Roger, 1863)	Little fire ant

AQIS 2012

Appendix 11.3 Fungal Scarring

Presentation given by IPB at final Mangosteen workshop in Bogor, November 2013.

Study on Link Between Fungi and Scarring

- **Objective :** To studi the efficacy of biocontrol agens to control of fruit scar of mangosteen
- **Time and place :**
  - Time : September – October 2011
  - Place : Plant Clinic Departement of Plant Protection – IPB and Leuwiliang - Bogor
- **Methods :**
  - The causal agent of fruit scar isolated from mangosteen fruit with scar symptom used PDA medium.
  - Postulat Koch carried out on young mangosteen fruit
  - Biocontrol agens used in this research are M1 (not identified yet; isolated from health mangosteen fruit) and BioGard (commercial biofungicide).

Study on Link Between Fungi and Scarring

Method

- Biocontrol agens application
  - Both of biocontrol agens (M1 and BioGard) was sprayed to young mangesteen fruit (∅ ± 3 cm) which scar symptomless.
  - Number of sprayed fruit was 10 for each treatment and control. The treatments have 3 replications.
  - Concentration of biocontrol agens was 10 cc/liter.
  - Each fruit samples was sprayed with biocontrol agens (or aquades for control) until entirely wet. The fruit was sprayed 3 times with 1 week interval.
  - Fruit scar development was observed every week until the fruit harvested.

Study on Link Between Fungi and Scarring

BioGard, one of biocontrol agens used in this research (left) and application of biocontrol agens on mangosteen fruit (right)

Study on Link Between Fungi and Scarring

Results

- Identification of causal agent of fruit scar
  - There are several kinds of fruit scar, i.e. : smooth (above), irregularly (middle), and cork form (below).
  - Fruit scar evidence higher in rainy season than in dry season.
  - Fruit scar asociated with 2 fungi, i.e. : *Pestalotia* sp dan *Phomopsis* sp.

Study on Link Between Fungi and Scarring

Results

- Postulat Koch Test :
  - Postulat Koch test show *Pestalotia* sp. cause rotting on mangosteen fruit, otherwise *Phomopsis* sp. cause cork form scar on mangosteen fruit.

Mangosteen fruit injected by aquades (left), *Pestalotia* sp. (middle), and *Phomopsis* sp. (right) 7 days after inoculation

Study on Link Between Fungi and Scarring

Results

- Biocontrol agens application :
  - Fruit scar intensity on all of fruit samples is relative low, that is about 10%.
  - There is no different fruit scar intensity between biocontrol agens application compare to control, because biocontrol agens was applied on relative big fruit size. Pathogen of fruit scar infect small and young fruit, so the bigger fruit may escape from the pathogen.

Appendix 11.4 Insect Scarring

Presentation given by IPB at final Mangosteen workshop in Bogor, November 2013.

Insect control in flowers using Confidor

- **Objective :** To studi the effect of Confidor application on quality of mangosteen fruit, especially smothness of fruit skin and gamboge
- **Time and place :**
  - Time : September – October 2011
  - Place : Garokgek-Purwakarta, Cicantayan-Sukabumi, and Leuwiliang-Bogor
- **Materials :**
  - 18 mangosteen trees which height 4 – 5 meter (+ 15 years old) was selected in each location. 9 trees for confidor application and 9 tress as control (not applied with confidor).

Insect control in flowers using Confidor

Method

- Confidor application :
  - Confidor applied by soil dreching with 4 ml Confidor 200 SC in 10 liter of water at 1.0 – 1.5 m from the trunk.
  - The application of confidor was done at the early bearing until 2-3 weeks after anthesis.

- Observation of insect abundance :
  - Insect abuncande observed by pit-fall trap (3 trap each tree) which was set immediately after confidor application.
  - Insects in trap was collected 1 weeks after. Kinds and number of insect identified (clasified) in laboratory

Insect control in flowers using Confidor

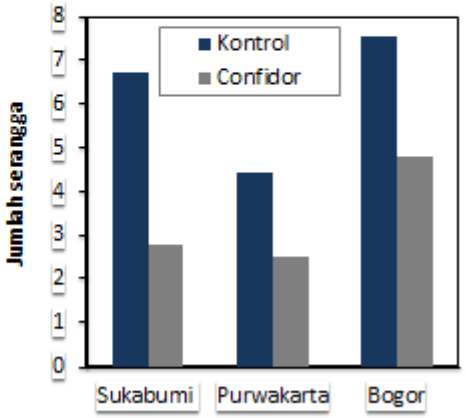
Area of Confidor application (left)
and pit-fall trap setting on the tree (right)

Insect control in flowers using Confidor

Results

- Observation of insect abundance

  - The insect abundance in Leuwiliang-Bogor is highest than Cicantayan-Sukabumi and Garokgek-Purwakarta.
  - Confidor application reduce the number of insect on the mangosteen tree



Effect of Confidor on Mangosteen Quality

Characters	Cicantayan-Sukabumi		Garokgek-Purwakarta		Leuwiliang-Bogor	
	Control	Confidor	Control	Confidor	Control	Confidor
Fruit Weight	96.188a	99.546a	86.176a	97.006a	91.648a	71.720b
Pericarp Weight	61.364a	60.646a	57.749a	64.55a	60.70a	47.114b
Fruit Diameter	5.81600a	5.85800a	5.571a	5.828a	5.6480a	5.2580a
Scarring	11.51a	13.77a	8.39a	14.1a	32.85a	19.56a
Yellow latex pericarp	3.16a	2.20a	1.99b	4.94a	4.05a	6.64a
Yellow latex arylus	2.89a	1.98a	0.38b	1.12a	1.07a	1.02a
TSS (°Brix)	17.4250b	17.8360a	18.321a	17.498b	18.7820a	18.7020a
Pericarp Thickness	0.72200a	0.67200a	0.759b	0.84a	0.72000a	0.74000a
Fruit Hardness	1.86100a	1.89200a	2.566a	2.69a	2.05400a	1.88400b
TTA	3.9240a	3.5900a	3.969a	3.856a	4.1240a	4.1880a
VIT C	1.98300a	1.94000a	2.406a	2.2a	1.99600a	1.50000b

Insect control in flowers using Confidor

Results

- Observation of fruit quality
  - Confidor application affect the fruit quality except fruit diameter, fruit scar, and total acid.
  - Confidor application in each location show inconsistent effect on the fruit quality
  - There is a positive correlation about fruit scar and insect abundance. Fruit scar is higher in location with higher insect abundance than in location with lower insect abundance

Insect control in flowers using Confidor

Conclusion

- Confidor application reduce the insect abundance around the mangosteen tree
- Confidor application in each location show inconsistent effect on the fruit quality
- Higher insect abundance give higher fruit scar intensity

Appendix 11.5 Nutrition mangosteen

Presentation given by IPB at final Mangosteen workshop in Bogor, November 2013.

Application of Boron and Calcium

- **Objective :** To studi the effect of Boron (B) and Calcium (Ca) on tree productivity and fruit quality of mangosteen
- **Time and place :**
  - Time : September – October 2011
  - Place : Garokgek-Purwakarta
- **Materials :**
  - 225 mangosteen trees of ≥ 15 years old. 220 trees for fertilizer (manure, NPK, B and Ca) application and 25 tress as control (not applied with B and Ca).
  - Dose of fertilizer per tree is 40 kg manure + 500 g NPK + 2,5 kg dolomit + 35 g finbor

Application of Boron and Calcium

Method

- Fertilizer application :
  - Mix of fertilizer applied at 1 month toward bearing.
  - The fertilizer was spread on the soil below the mangosteen tree at 1.0 – 1.5 m from the trunk.

Application of Boron and Calcium

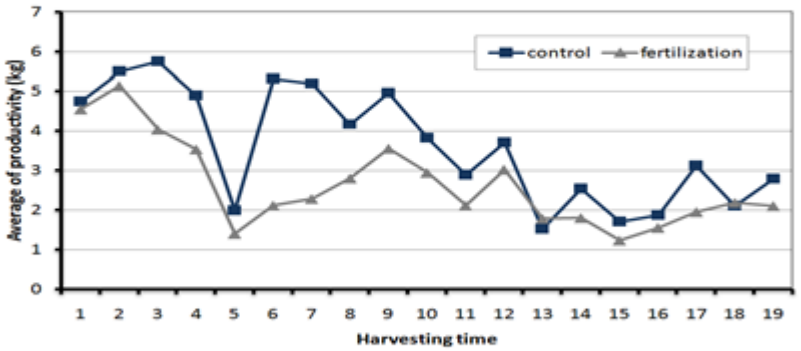
Method

- Observation of productivity and fruit quality :
  - Number of sampel : 40 tree, consist of 20 of treatments and 20 of controls
  - Productivity observed by count of total fruit produce by each tree in one season (from first harvest until last harvest)
  - Fruit quality observed from 20 fruits from each tree. The fruit was collected from several harvesting time.
  - The parameter of fruit quality that observed was weight of fruit, weight of rind, fruit diameter, fruit scar, gamboge (outside and inside of fruit), total soluble solid (°Brix), rind thickness, fruit hardness, total acid, and vitamin C.

Application of Boron and Calcium

Results

- Productivity :



  - The fertilization was not give affect on the productivity of mangosteen yet.
  - The productivity of control slightly higher than treatment due to canopy size and tree's age.

Application of Boron and Calcium

Results

- Fruit quality :
  - The fertilization effect the fruit quality significantly, i.e fruit weight, fruit diameter, gamboge, TSS, and fruit hardness.
  - Unfortunately, fertilization increase the fruit scar and gamboge. These are may be caused by root destruction when fertilizer application

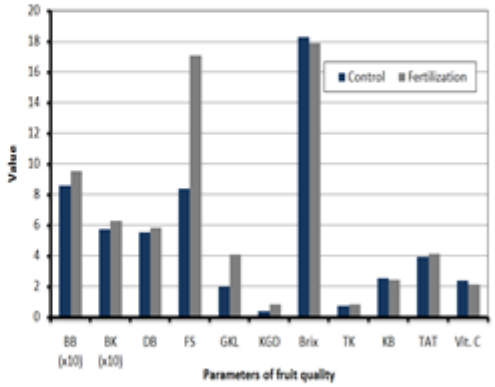
Application of Boron and Calcium

Results

- Fruit quality :

No.	Parameters	P	CV
1.	Fruit weight (BB)	*	7.1
2.	Rind weight (BK)	tn	7
3.	Fruit diameter (DB)	*	2.6
4.	Fruit scar (FS)	tn	25.4
5.	Outside gamboge (GKL)	*	20.1
6.	Inside gamboge (GKD)	*	21.6
7.	TSS (°Brix)	*	2.3
8.	Rind thickness (TK)	tn	15.8
9.	Fruit hardness (KB)	*	4.2
10.	Total acid	tn	6.9
11.	Vit. C	tn	7.4

Analysis of variance of fertilization effect on mangosteen fruit quality in Garokgek-Purwakarta



Effect of fertilization on mangosteen fruit quality in Garokgek-Purwakarta

Application of Boron and Calcium

Conclusion

- The fertilization was not give affect on the productivity of mangosteen yet.
- The fertilization effect the fruit quality significantly, i.e fruit weight, fruit diameter, gamboge, TSS, and fruit hardness.

Appendix 11.6 Calyx quality

Presentation given by IPB at final Mangosteen workshop in Bogor, November 2013.

Treatments		Pericarp Color					
		REd		Purple		Black/dark purple	
		start	end	start	end	start	end
		5R 5/11,5	5R 4/10	5R 3/10	5R 3/8	6R 3/8	6R 2,3/6
Coating	BAP (ppm)	Days					
Control	0	0	3	6	15	18	33
	5	0	<3 *	3	12	15	33
	10	0	3	6	18	21	33
	15	0	3	6	21	24	33
	20	0	9	12	33	~	~
Wax 6%	0	0	3	6	15	18	33
	5	0	3	6	9	12	33
	10	0	3	6	9	12	33
	15	0	6	9	21	24	33
	20	0	24	27	33	~	~
Chitosan 2%	0	0	3	6	15	18	33
	5	0	6	9	18	21	33
	10	0	15	18	33	~	~
	15	0	3	6	33	~	~
	20	0	3	6	21	24	33

Perlakuan		Spal Color					
		Green		Brownish green		brown	
		start	end	start	end	start	end
		2,5GY	10Y	10Y	7,5Y	7,5Y	7,5Y
		9/10	8,5/9	8,5/12	7,5/11	8,5/9	7,5/13
Coating	BAP (ppm)	.....days.....					
control	0	0	12	15	24	27	33
	5	0	12	15	24	27	33
	10	0	15	18	27	30	33
	15	0	15	18	24	27	33
	20	0	18	21	24	27	33
Wax 6%	0	0	12	15	18	21	33
	5	0	15	18	24	27	33
	10	0	15	18	21	24	33
	15	0	15	18	24	27	33
	20	0	21	>21 *	24	27	33
Chitosan 2%	0	0	12	15	18	21	33
	5	0	15	18	24	27	33
	10	0	18	21	24	27	33
	15	0	18	21	24	27	33
	20	0	15	18	21	24	33

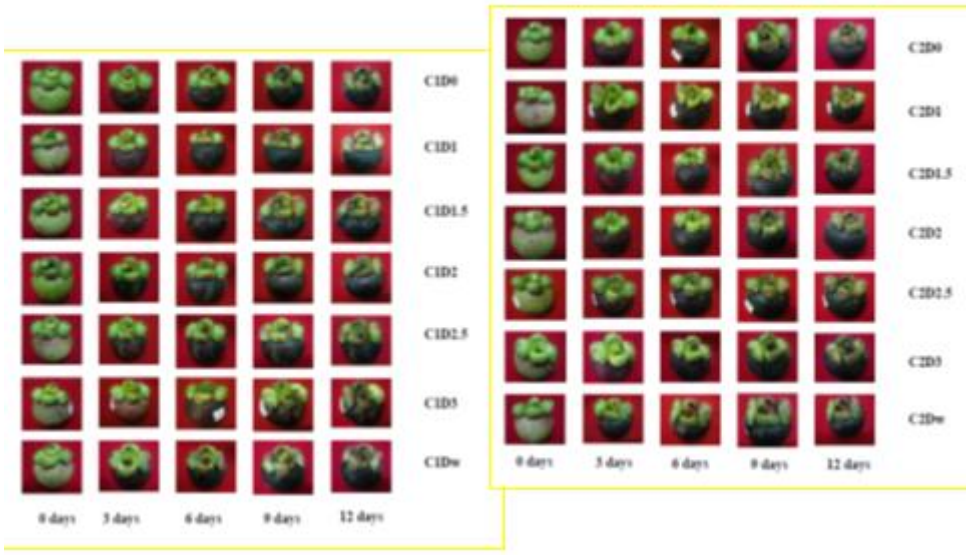
To determine the cutting of stalk and the concentration of 2,4-D on keeping green and fresh sepals

Figure 1. Wet cotton treatment on cutting stalk and 2,4D consentrations.

First factor was the condition of stalk, which were cut and uncutting. The second factor was the concentration of 2,4-D (0, 1, 1.5, 2, 2.5, 3 ppm, and dry/without water).

Days	Cutting stalk	Solutions 2,4D	Cutting stalk*Solutions 2,4D	CV
wrinkle sepals				
0	tn	tn	tn	0
3	tn	tn	tn	0
6	**	tn	**	20,2
9	tn	tn	tn	4,7
12	tn	tn	tn	

green color of sepals				
0	tn	tn	tn	22,9
3	tn	tn	tn	19,7
6	tn	tn	tn	29,73
9	*	tn	tn	28
12	*	tn	tn	8,7



Appendix 11.7 Fruit Quality Mangosteen

Presentation given by IPB at final Mangosteen workshop in Bogor, November 2013.

GA3 Application on Mangosteen

Figure 1. Flower stage on GA3 treatment 1 week before antesis (A), flower antesis (B) and 1 week after antesis (C).

GA3 Application on Mangosteen

Application	Obervation (month)		
Pasir Kuda farm field	1 MAA	2 MAA	3 MAA
GA3 0 ppm	4.04333^{a}	4.7600^{b}	4.9467^{b}
GA3 50 ppm	3.66000^{b}	5.6233^{a}	**5.6167^{a}**
GA3 100 ppm	4.21667^{a}	5.5867^{a}	**5.7167^{a}**
GA3 150 ppm	3.78000^{b}	5.5200^{a}	**5.7200^{a}**
Tajur farm field	1 MAA	2 MAA	3 MAA
GA3 0 ppm	4.20833^{a}	4.9417^{a}	5.22750^{b}
GA3 50 ppm	3.82500^{b}	5.2750^{a}	5.46250^{ab}
GA3 100 ppm	4.04167^{ab}	5.4833^{a}	**5.48667^{a}**
GA3 150 ppm	3.90000^{b}	5.2500^{a}	5.47417^{ab}

Appendix 11.8 Post harvest Transport

Plastic picking crates introduced to reduce mechanical damage to mangosteen when transporting fruit from the field to the pack house.

Appendix 11.9 Demonstration sites

Demonstration sites show improvements in fruit quality.

Establishment of Demo/Verification Site

- **Objective :** To studi the effect of Boron fetilization on productivity and quality of mangosteen fruit
- **Time and place :**
  - Time : September – October 2011
  - Place : Garokgek - Purwakarta
- **Methods :**
  - 140 mangosteen trees of ≥ 15 years old.
  - Levels of Boron : 0 (control), 30, 60, and 90 gram finbor per tree. Each level applied on 40 tree of mangosteen except control which only 20 tree of mangosteen.
  - Dose of fertiliizer is 50 kg manure + 500 g NPK + 250 g KCl
  - The fertilizer was spread on the soil below the mangosteen tree at 1.0 – 1.5 m from the trunk and then covered with soil or detached leaves.
  - Fertilizer applied at 1 month toward bearing.

Establishment of Demo/Verification Site

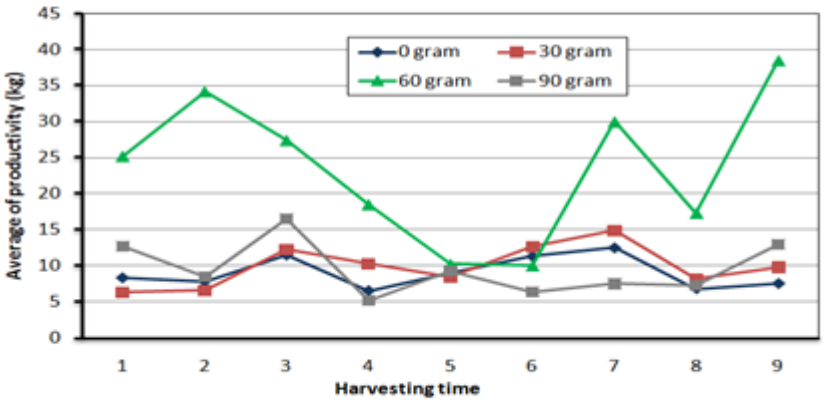
Method

- Observation of productivity and fruit quality :
  - Number of sampel : 40 tree consist of 10 tress for each level of Boron
  - Productivity observed by count of total fruit produce by each tree in one season (from first harvest until last harvest)
  - Fruit quality observed from 10 fruits from each tree. The fruit was collected from several harvesting time.
  - The parameter of fruit quality that observed was weight of fruit, weight of rind, fruit diameter, fruit scar, gamboge (outside and inside of fruit), total soluble solid (°Brix), rind thickness, fruit hardness, total acid, and vitamin C.

Establishment of Demo/Verification Site

Results

- Productivity :



Establishment of Demo/Verification Site

Results

- Fruit quality :

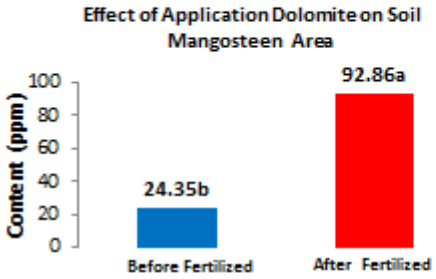
No.	Quality Parameters	Level of Finbor (gr)				Analysis of variance
		0	30	60	90	
1.	Fruit weight (BB)	86,20	92,53	95,18	93,69	tn
2.	Rind weight (BK)	58,11	59,70	61,79	60,57	tn
3.	Fruit diameter (DB)	5,59	5,71	5,75	5,71	tn
4.	Fruit scar (FS)	8,1	6,1	4,6	4,0	tn
5.	Outside gamboge (GKL)	1,9	1,1	0,5	0,6	tn
6.	Inside gamboge (GKD)	0,4	0,8	0,5	0,1	tn
7.	TSS (°Brix)	18,34	19,27	21,01	18,30	tn
8.	Rind thickness (TK)	0,76	0,70	0,68	0,75	*
9.	Fruit hardness (KB)	2,55	2,61	2,55	2,55	*
10.	Total acid	3,99	4,07	3,30	4,00	tn
11.	Vit. C	2,44	2,36	2,24	2,18	tn

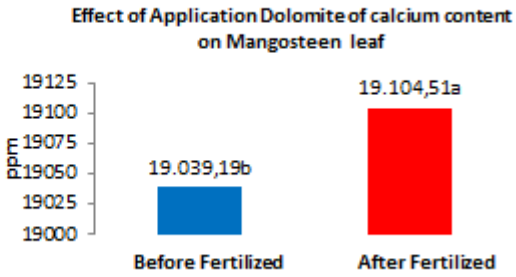
BORON and CALSIUM APLICATION AT LEUWLIANG, BOGOR

BORON and CALSIUM APLICATION

- Boron application trough two methods
  - Applied through Soil
  - Applied through Fruit Twice after Anthesis
- Application of Calcium through Soil only.
- Boron dosage 5 g/ m2 (soil); 4 gr/L water
- Calcium dosage 1.25 kg/m2.
- Objective : To reduce on Yellow gum (latex) in pericarp and Aril and to increase fruit Quality

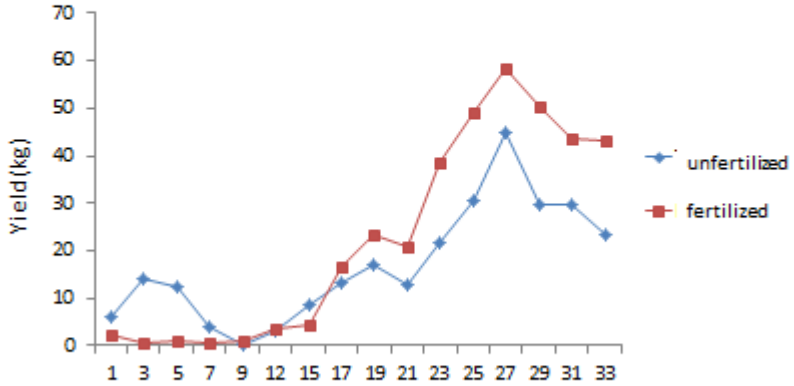
Leaf and Soil analysis





Treatment effect of calcium and boron

- Trend production



Parameter	Control	Boron and Calcium	F Test
Average of fruit Production (kg/tree)	25.879	35.955	**

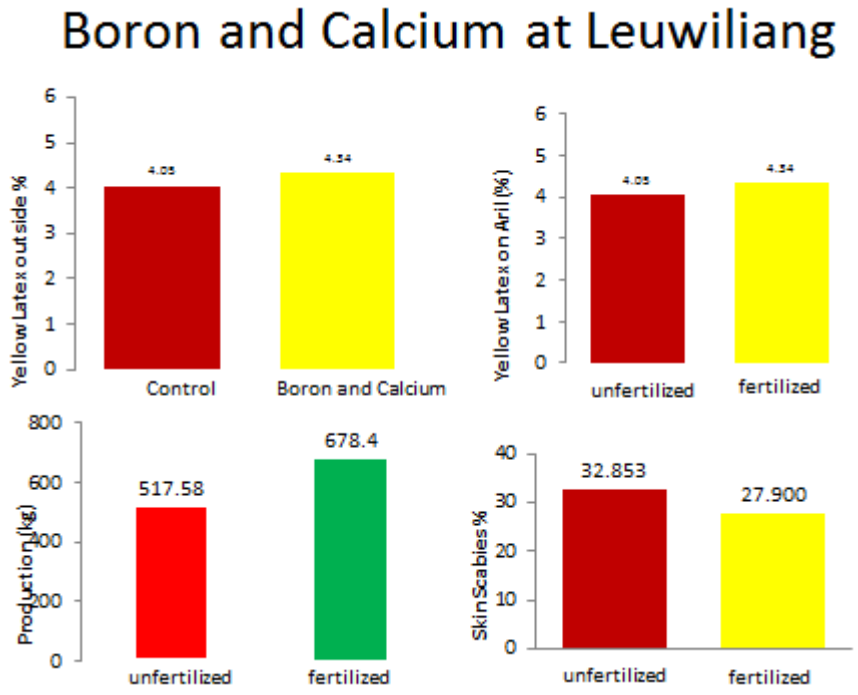
Treatment Calcium and Boron

Boron and Calcium at Leuwiliang

- Effect of Boron and Calcium on Mangosteen Fruit Quality (Leuwiliang, Bogor).

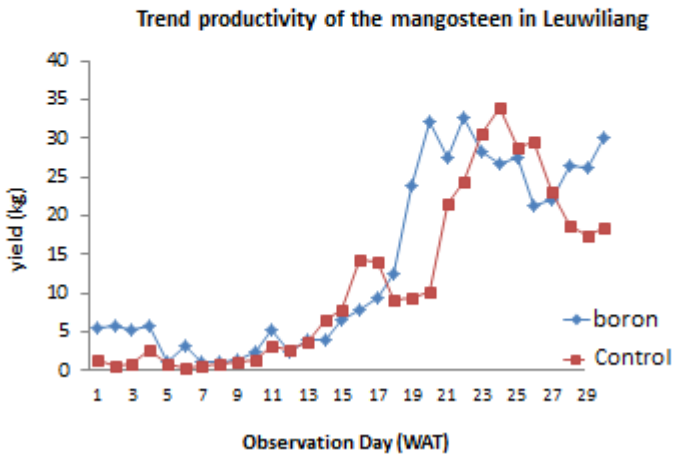
Parameters	Control	Boron and Calcium	F-Test
Fruit Weight (g)	84.629	81.154	ns
Skin Weight (g)	55.837	53.571	TN
Fruit Diameter	5.579	5.513	ns
Fruit Scaring (%)	29.23	24.74	ns
Yellow latex on Pericarp (%)	4.84	5.46	ns
Yellow latex Aril (%)	0.86	0.70	ns
Brix (%)	18.768	18.637	ns
Skin Thickness (cm)	0.735	0.745	ns
Fruit hardness (mm)	2.016	2.009	ns
Total Titrated Acid (TTA) (%)	4.185	4.238	ns
Level of vitamin C (mg/100)	1.880667	1.881667	ns

Note : ns : not significant, * : significantly (α=5 %).



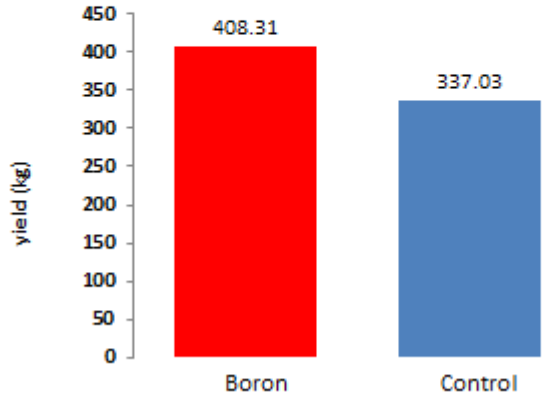
Effect of Boron on productivity (kg) at Leuwiliang

- Applied Boron through Spray to Surrounding Fruit



Effect of Boron on productivity (kg) at Leuwiliang

- Effect of Boron Treatment through Spray on Yield (kg)



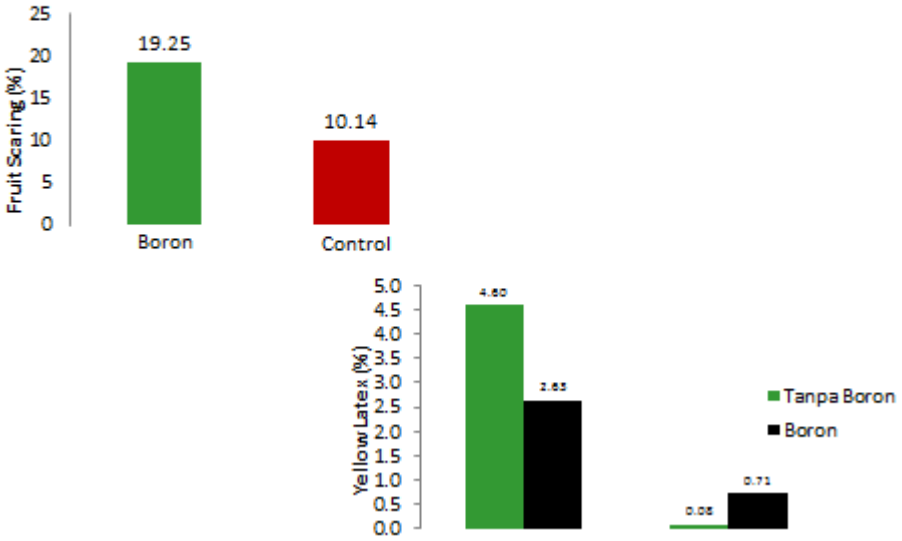
Effect of Boron on Quality of Fruit at Leuwiliang

- Effect of boron treatment trough spray on Mangosteen Quality at Leuwiliang, Bogor

Parameters	Boron	Control	F-Test
Fruit Weight (g)	83.338	81.894	ns
Skin Weight (g)	52.827	50.837	ns
Fruit Diameter	5.544	5.531	ns
Fruit Scaring (%)	10.137	19.25	ns
Yellow latex on pericarp (%)	2.631	4.598	ns
Yellow latex on aril (%)	0.71	0.08	ns
Brix (%)	17.58	17.87	ns
Skin Thickness (cm)	0.711	0.661	ns
Fruit hardness (mm)	1.87	1.732	ns
Total Titrated Acid (TAT) (%)	3.762	4.484	ns
Level of vitamin CC (mg/100)	1.822	1.752	ns

Note : ns : not significant, * : significantly (α =5 %).

Effect of Boron on Quality of Fruit at Leuwiliang



Conclusion

- Application Dolomite fertilizer significantly increased the potassium content in soil and leaf.
- According to variant data showed that fertilization treatment can be increased production of fruit and significantly different from unfertilized.
- Generally, the treatment of calcium and boron not affect significantly on *the* fruit quality
- Boron treatment through spray on fruit had a higher production than control and not effected on quality of fruit.

Application Boron & Calcium dosage to improve the productivity & quality of mangosteen in Sukabumi, West Java

Objective and Location

- To identify effect of boron and calcium dosage application on increasing mangosteen productivity and fruit quality

Location : Cicantayan, Sukabumi, West Java
Altitude : 600 – 700 m asl
Presipitation : 2000 – 2500 mm/year
Temperatur : 27 – 30*C

metodology

three level boron dosage (g/plant)

1. 0 g
2. Boron 30 g + Calcium 250 g
3. Boron 60 g + Calcium 250 g
4. Boron 90 g + Calcium 250 g

10 trees With 5 repetitions so we use 200 mangosteen trees

metodology

- Application boron by sidedressing under canopy
  - 2 weeks after flowering

Result

Boron Sukabumi

Effect of three level Boron dosage on mangosteen quality & productivity

Parameters	significancy	Kk (%)
Productivity	**	19.20
Fruit weight (g)	tn	11.89
Skin/exocarp weight (g)	**	10.63
Fruit diameter (cm)	tn	4.48
Fruit scarring (%)	tn	57.22

Result
Boron Sukabumi

Effect of three level Boron dosage on mangosteen quality & productivity.....continued

Parameter	significancy	cv (%)
Fruit gummosis (outside) %	tn	109.61
Fruit gummosis (inside) %	tn	176.40
Briks	tn	5.07
exocarp Thickness	tn	8.82
Fruit hardness	**	3.31
Total acid	tn	7.73
Vitamin C	**	9.13

Result
Boron Sukabumi

Effect of three level Boron dosage on mangosteen productivity

Application	Productivity (kg/trees)*) **)	Increasing trees productivity (%)
Control	8.45[b]	0
Boron 30 g + Calcium 250 g	9.88[b]	16.92
Boron 60 g + Calcium 250 g	14.61[a]	72.89
Boron 90 g + Calcium 250 g	11.37[b]	34.55

*) ± 20 years old
**) 10 th harvesting periode

Result

Boron Sukabumi

Effect of three level Boron dosage on mangosteen quality

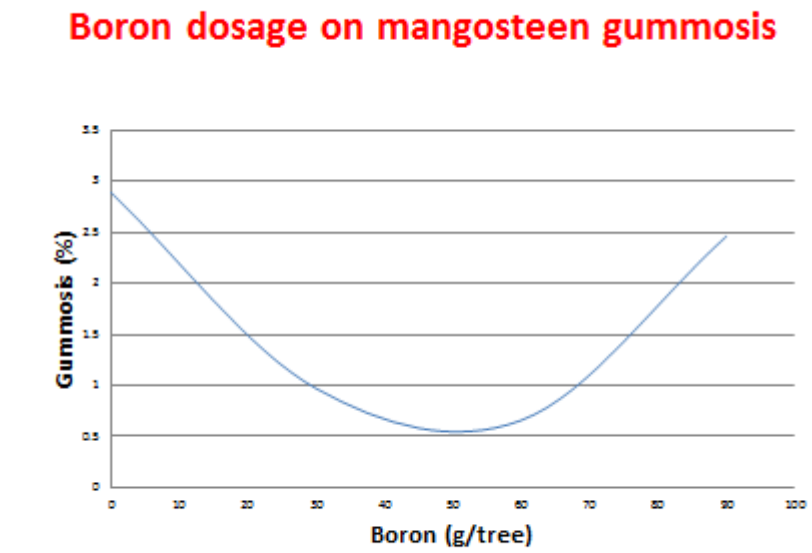
Application	Weight (g)		Fruit Diameter (cm)	Exocarp thickness (cm)
	fruit	exocarp		
Control	96.19	61.36[a]	5.82	0.72
Boron 30 g + calcium 250 g	97.78	60.53[a]	5.86	0.67
Boron 60 g + calcium 250 g	89.11	55.11[ab]	5.67	0.67
Boron 90 g + calcium 250 g	89.19	52.78[b]	5.71	0.65

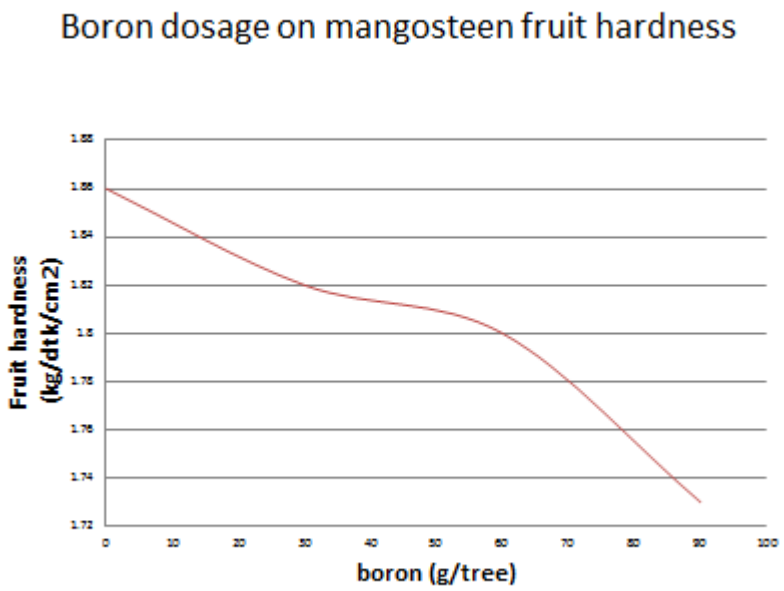
Result

Boron Sukabumi

Effect of three level Boron dosage on mangosteen quality

Application	Fruit scarring (%)	Gummosis (%)	Fruit hardness (kg/sc/cm^2)
Control	11.51	2.89	1.86[a]
Boron 30 g + calcium 250 g	7.40	0.97	1.82[a]
Boron 60 g + calcium 250 g	9.48	0.66	1.80[ab]
Boron 90 g + calcium 250 g	10.23	2.46	1.73[b]


Boron dosage on mangosteen gummosis
Gummosis (%)
Boron (g/tree)

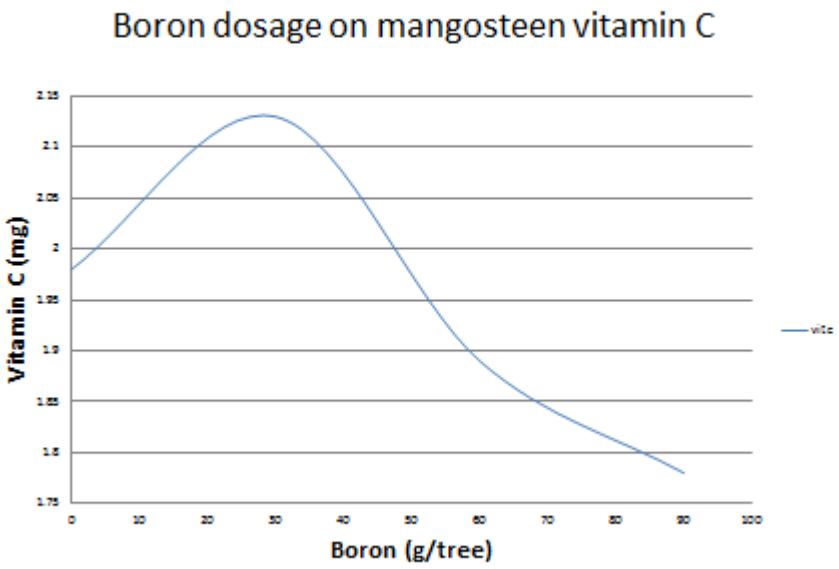

Boron dosage on mangosteen fruit hardness
Fruit hardness (kg/dtk/cm2)
boron (g/tree)

Result

Boron Sukabumi

Effect of three level Boron dosage on mangosteen quality

Application	Total acid	briks	Vitamin C (mg)
Control	3.92	17.42	1.98^{ab}
Boron 30 g + calcium 250 g	3.83	17.70	2.13^{a}
Boron 60 g + calcium 250 g	3.82	17.30	1.89^{b}
Boron 90 g + calcium 250 g	3.63	17.67	1.78^{b}



conclusion

- Boron 30 – 90 g + Calcium 250 g/tree, can increase mangosteen productivity more 16 – 72%.
- Boron 30 – 90 g + calcium 250 g/tree, can reduce exocarp weight until 1 – 13%.
- Boron 30 – 90 g + calcium 250 g/tree, can reduce fruit hardness until 1 – 13%.
- Boron 30 g + calcium 250 g/tree, can increase vitamin C of mangosteen more 7.57%

Appendix 11.10 Ant Baiting

Mangosteen infested with live ants.

Demonstration given on how to put ant baits in the field at the final mangosteen workshop in Bogor, November 2013.

Appendix 11.11 Fumigation ethyl formate

Containers installed by the project used to conduct ethyl formate trials.

Appendix 11.12a Mango consumer evaluation Hong Kong

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Consumer's preferences to Indonesian and Australian Mangoes

The consumer preference studies on Indonesian and Australian Mangoes was conducted on November 28 in Aus-Trade office of Hong Kong. Three groups of panellists were subjected to the study; consist of two groups of consumers and one group of tropical fruit importer in mainland China and Hong Kong.

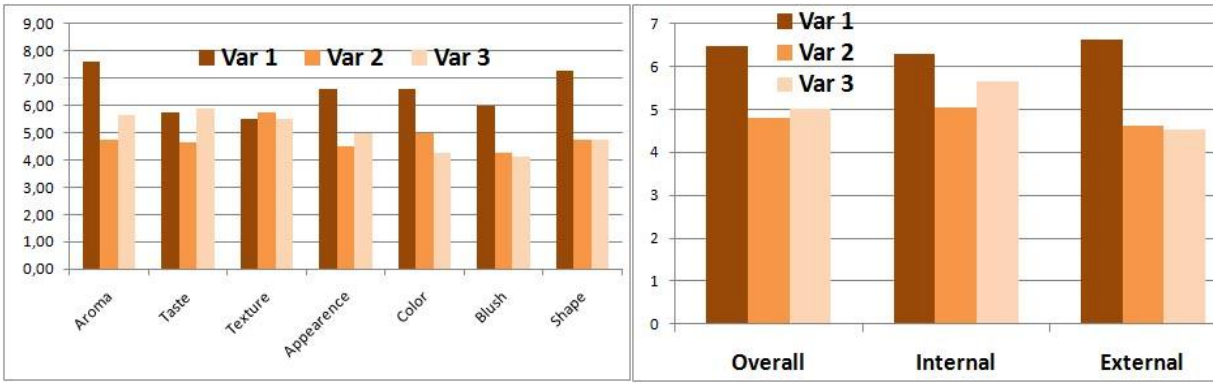
Panellist Group I

The Group I consisted of 8 consumer panellists were subjected for their preferences to Indonesian mangoes of Arumanis and Gedong Gincu regarding to internal and external quality attributes. The results presented in following figure.

Mango variety of Arumanis get higher preferences on internal quality attributes of aroma, taste, and external factor of appearance and shape. However its due inferiority in colour and skin blush, the internal and overall quality Gedong Gincu mango obtain higher preferences than Arumanis mango.

Panelist Group II

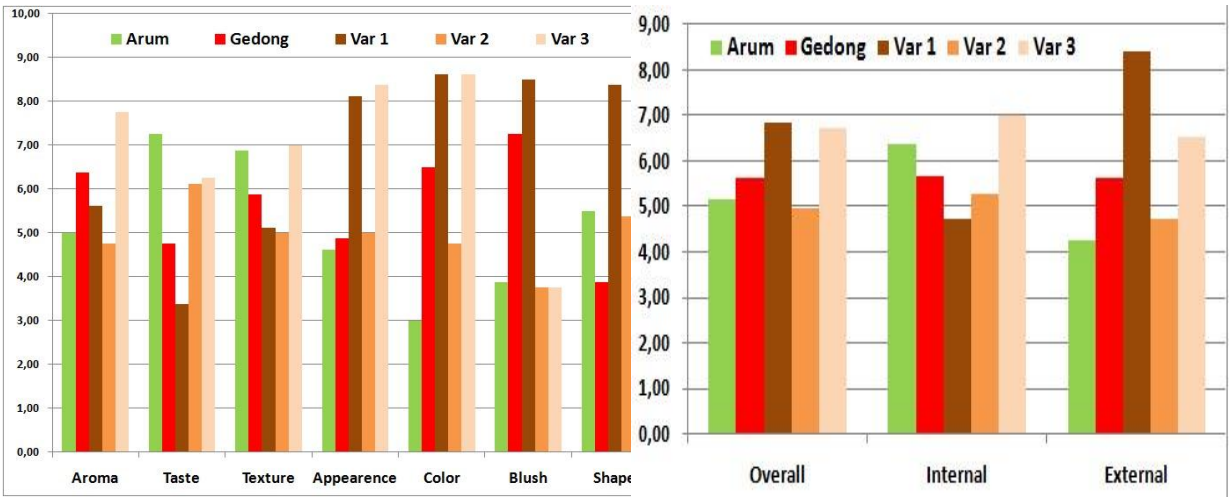
The Group II consisted of 8 consumer panellists were subjected for their preferences to new Australian mango varieties regarding to internal and external quality attributes. The results presented in following figure.



The new Mango Variety 1 respected highest consumer preferences on most quality attributes of aroma, appearance, color, blush and fruit shape, compare to Variety 2 and Variety 3. Therefore Variety 1 mango was considered superior to those Variety 2 and Variety 3 by Group II panelists.

Panelist Group III

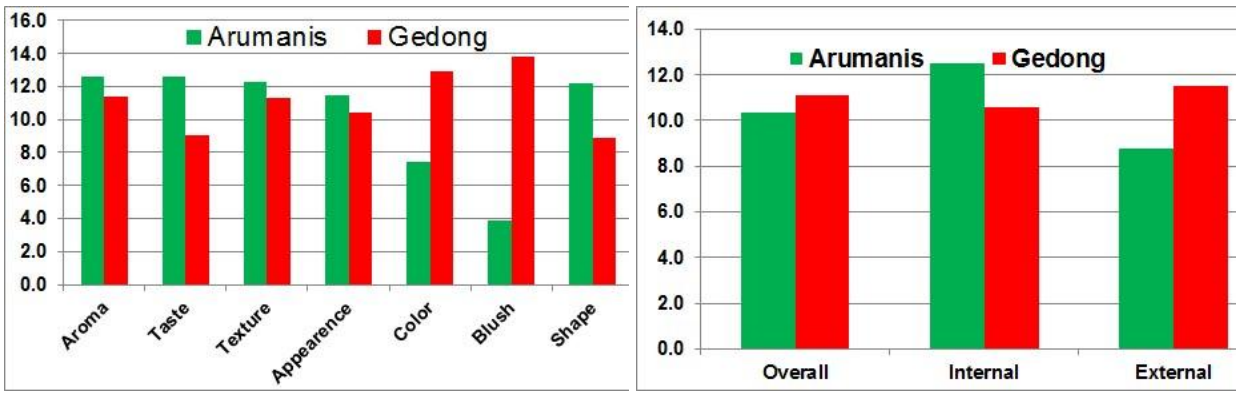
The Group III consisted of 8 panelists of tropical fruit importer in mainland China and Hong Kong. They were subjected for their preferences to two Indonesian mango varieties of Arumanis and Gedong Gincu, also new Australian mango varieties of Variety 1, Variety 2 and Variety 3, respectively. The results presented in following figure.



Arumanis superior for flesh taste and texture; Australian Variety 1 superior for fruit appearance, color, skin blush, and fruit shape; Australian Variety 3 superior for aroma, appearance, and color. The panen considered that Variety1 superior for external quality attributes, while Variety 3 superior for internal quality attibutes, and therefore both variety obtain high preferences from the importer panelists. Subsequently, Arumanis got high appreciation for its internal quality, however consiodered lack in external appearance, therefore the panelists considered Gedong Gincu superior than Arumanis for overall quality attributes.

Remarks

The preference of consumer panelist Group I was not significalty different to the importer panelist Group III regarding quality attributes of Arumanis and Gedong Gincu. Based on data of consumers and importers preferences, revealed that Arumanis superior for aroma, flesh texture and taste, appearance and fruit shape, while Gedong variety gained better perception for color and blush. Subsequently showed that Arumanis gained good perception on internal quality attributes, and Gedong gained good perception on internal quality, however due to very low perception on blush and colour attributes, Gedong mango has overall better perception to Arumanis mango.



Appendix 11.12b Consumer preference Gedong by ethnicity

Consumer preferences to Gedong

ACIAR MANGO AND MANGOSTEEN NEWSLETTER JULY 2012

Consumer preferences to Gedong

Information and photographs provided by Mizu Istianto

A consumer preference trial was conducted in Solok, West Sumatera and Jakarta. The consumers were Indonesian (West Sumatera) (Photo 3) and expatriates from Europe, Asia (Photo 1) and the Middle East (Photo 2) who live in Indonesia. The professions of the consumers included researchers, technicians, senior high school students, administration staff, cleaning services, fruit retailers, parliament members, and nutritionists.

It was found that Gedong gincu did not appeal to the Asian market, with the average score being around 6.5. Appearance (shape, size, colour) was not appealing for the Europe market. However, the European consumers gave a score of around 7.7 for taste and texture. West Sumateran and Middle Eastern consumers gave a favourable response to both the appearance and flavour. The results are summarised in Table 1.

Table 1 Consumer preferences for Gedong gincu.

Countries	Fruit Shape	Fruit size	Skin colour	Performance	Fruit odour	Flesh colour	Taste	Texture of flesh
West Sumatera	7.4	6.7	7.5	7.4	7.6	7.7	7.4	6.0
Europe	6.4	6.4	6.4	6.6	6.7	7.7	8.1	7.3
Asia	6.0	5.7	6.5	6.3	5.6	6.6	6.9	6.7
Middle East Country	7.4	7.4	7.4	7.4	7.7	7.7	7.9	7.7

Photo 1 Korean Chamber of Commerce day

Photo 2 Saudi Arabian community day

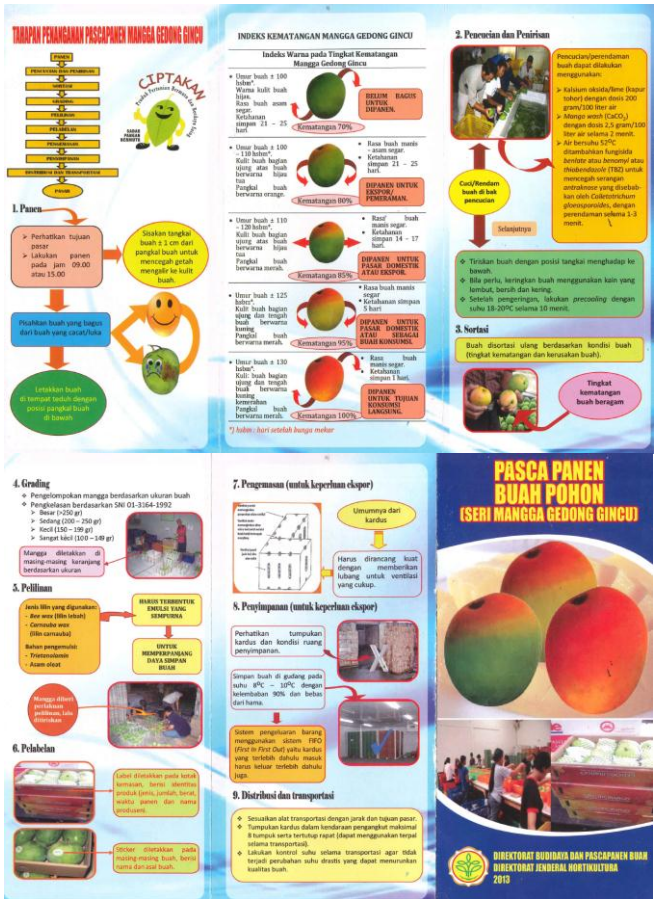
Photo 3 West Sumatera community day

Appendix 11.13 Sap management of Gedong

Damage to mangoes due to poor handling practices postharvest.

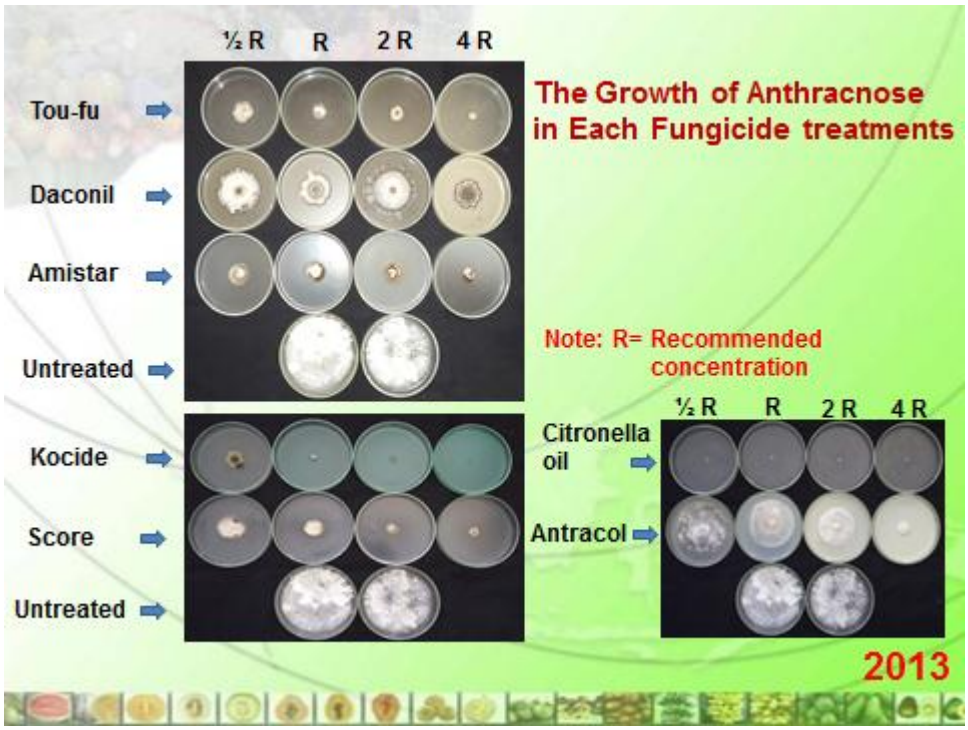
Traditional poor sap management practices. techniques.

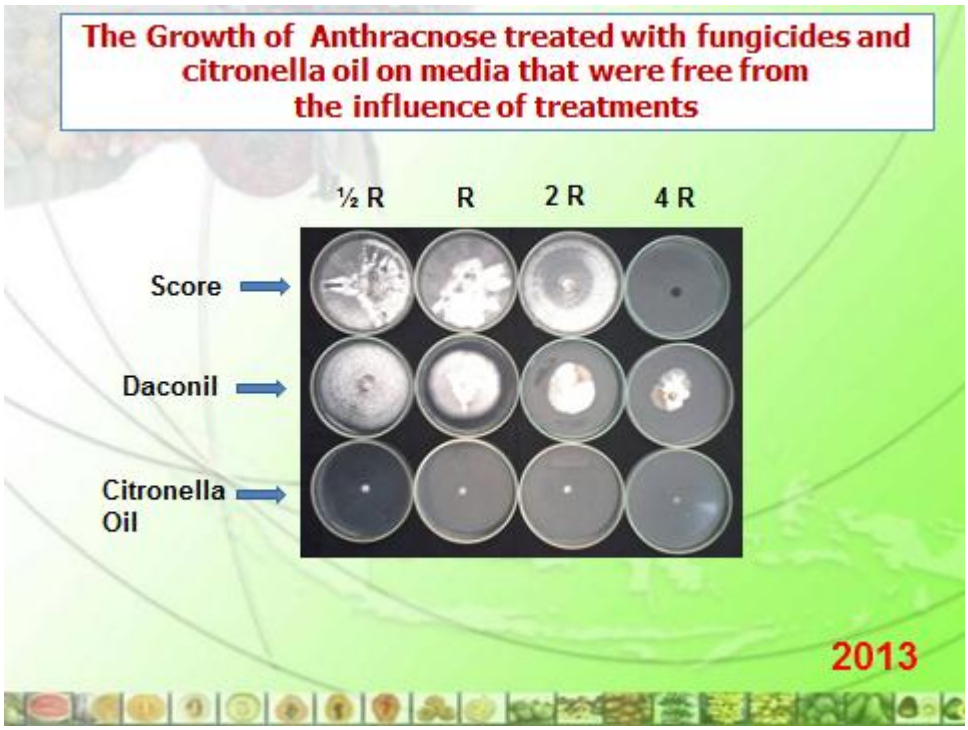
Training in management



Practice now incorporated into Gedong SOP's

Appendix 11.14 Post harvest disease management.

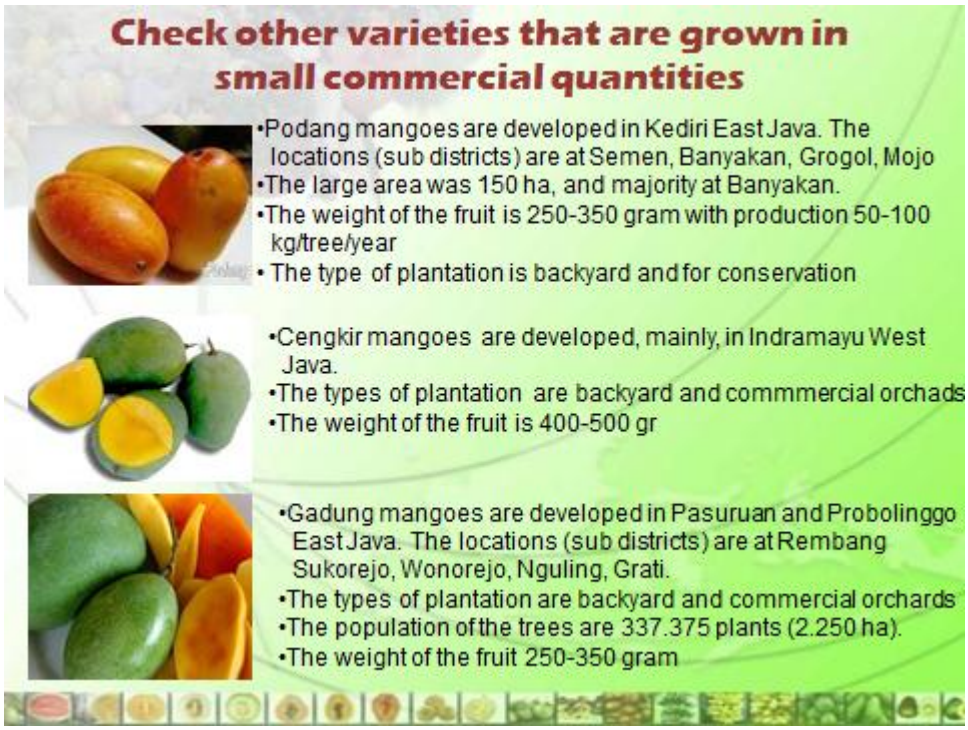




Istianto, M. 2014. Progress Report. Indonesian Tropical Fruit Research Institute.

Appendix 11.15 Indonesian mango varieties

Mango varieties in Indonesia



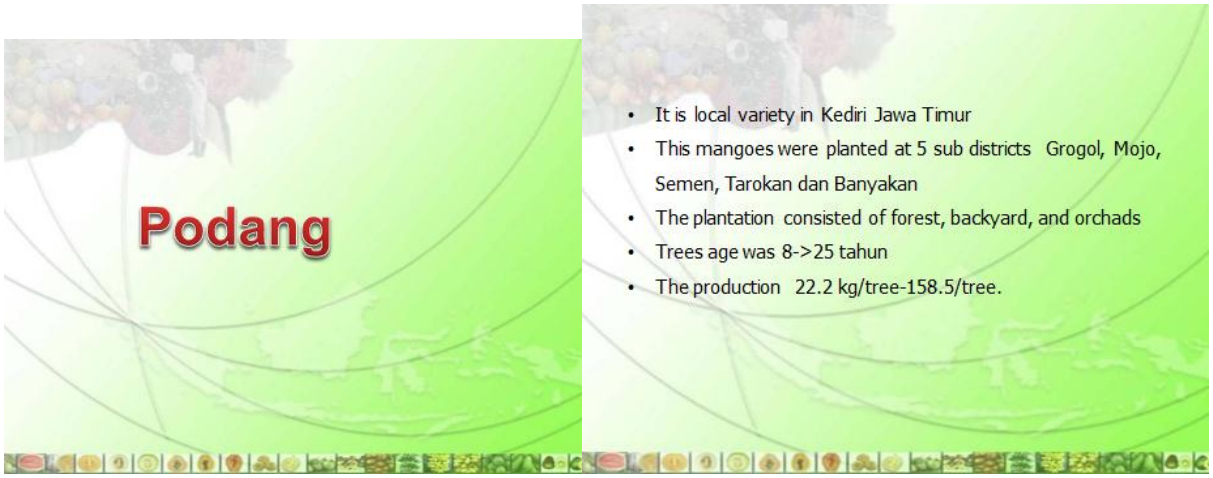


Table 2. Characters of Podang mango

No	TSS (Brix)			Water content (%)	Vit. C (mg/100g)	Total acid (%)	Fiber (%)
	P	T	U				
1.	16.0	12.0	12.4	85.25	42.83	0.63	0.89
2.	17.7	17.0	16.2	82.29	35.25	0.59	0.92
3.	13.0	11.8	13.4	85.25	43.17	0.30	0.71

Problems :

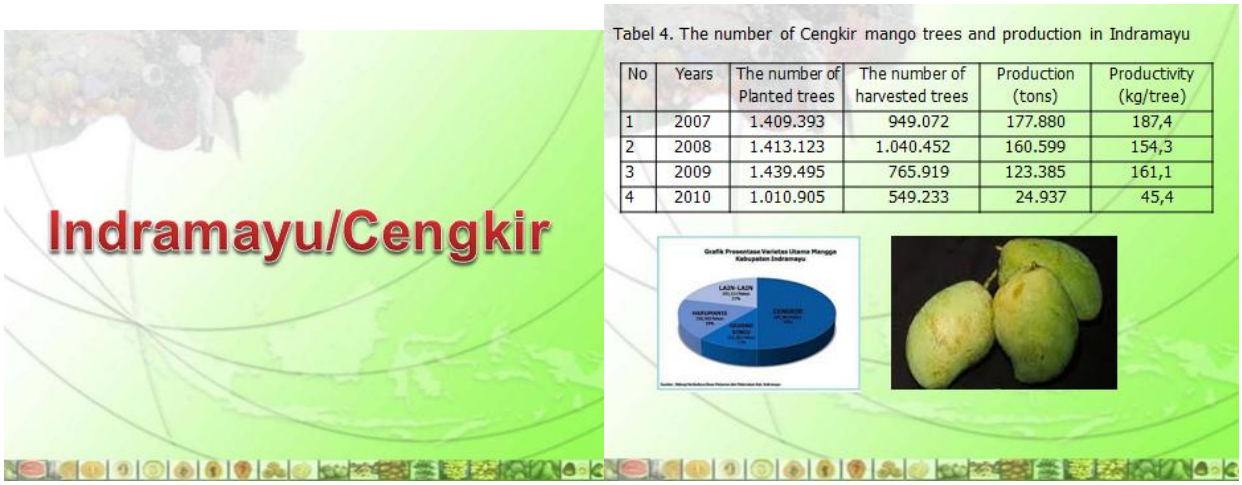
- Low price, about Rp. 3.000, so that it was not interesting for farmers develop this mango n
- Limited water availibility,
- Limited market

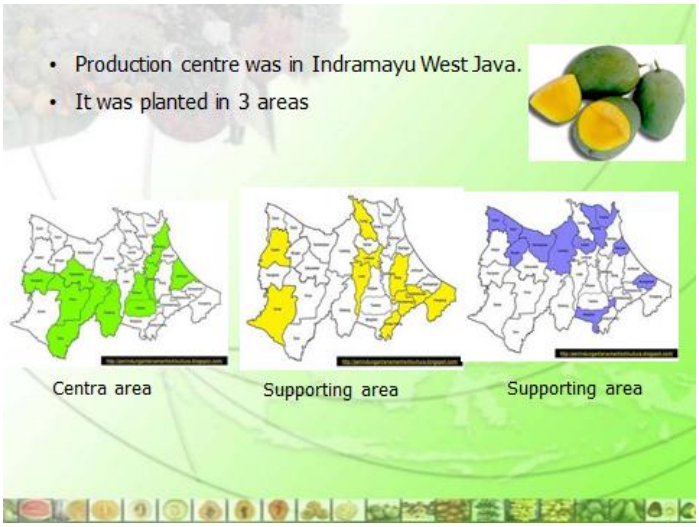
Tabel 5. Consumers preference to Podang

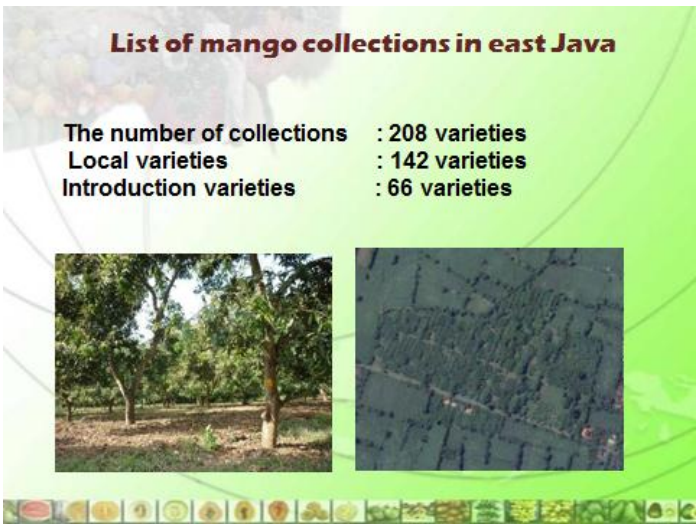
Consumers	Fruit shape	Fruit size	Peel colour	Fruit performance	Smell	Flesh colour	Taste	Flesh texture
Indonesia	7,,5	6,17	7,42	7,50	6,17	7,58	7,25	6,92
Euope								
Asia								
Middle East								

Gadung

- Production centre was in Pasuruan East Java
- It had been planted at 23 sub district
- The production was 25-65 kg/tree







Istianto, M. 2014. Final Workshop, Bogor, 21-22 May. Indonesian Tropical Fruit Research Institute.

Appendix 11.16 Irradiation on Gedong Quality

Executive Summary *Report by Indarwatmi, M., Arastuti, I., Sasmita, H. I., Kuswadi, A. N., Centre for Isoptopes and Radiation Application Indonesian National Nuclear Energy Agency*

Mango is an important export commodity as a source of revenue and national income earner of the country. Mango in Indonesia mainly affected by two important fruit fly pests are *Bactrocera carambolae* and *Bactrocera papayae* (Drew & Hancock). PATIR BATAN developed phytosanitary treatment using Gamma irradiation against fruit fly as mango pest and mealybug as mangosteen pest. ACIAR and Indonesian government collaborate to improve the quality of fruits to meet technical access requirement.

Conveyor installation was conducted in September 2011 and completed in January 2012. The dosimetry trial of mango (3 kg capacity) in Panoramic Irradiator using conveyor was done by Irradiation Section. The dosimeter used is Gafchromic HD-810. Dosimeter were placed on the right side of the box for minimum dose (Dmin) and on the middle of the box for maximum dose (Dmax). Material research is Gedong mango varietyy, taken from mango farmers in the Cirebon district, West Java. The mangoes, which reached 80% level of maturity, are directly picked from the plantation. One experimental unit consisted of 96 mangos which spread equally onto 8 boxes. The Mangoes were irradiated with the dose of 0, 150, 300, 600 and 800 Gy in Irpasena irradiator. Afterward, mangoes were kept in a room with a temperature of 20-22°C. Observations were made every 2 or 3 days covering lenticel damage, color and firmness according to mango quality assessment manual by ACIAR.

Table Chain Conveyor System has been installed properly on Irpasena irradiator and now operational. The results of measurement for a target dose of 150 Gy, the Dmin and Dmax obtained is 179 and 231 Gy. The target dose of 600 Gy, the Dmin and Dmax obtain is 852 and 669 Gy. The uniformity (Dmax / Dmin) is 1.29 for 150 and 1.27 Gy for 600 Gy respectively. With the conveyor, irradiation capacity increased. Capacity irradiator for irradiating with a dose of 150 Gy with 2 box 3 kg each (6 kg) was 3.93 tons per 24 hours.

Mango gedong quite resistant to gamma irradiation. No significant damage on mango gedong up to irradiation dose of 600 Gy. Lenticels less damage occurred on irradiation dose of 800 Gy and less yellow fruit skin colour perfectly. Gedong mango irradiated will be able to export and meet technical access requirements.

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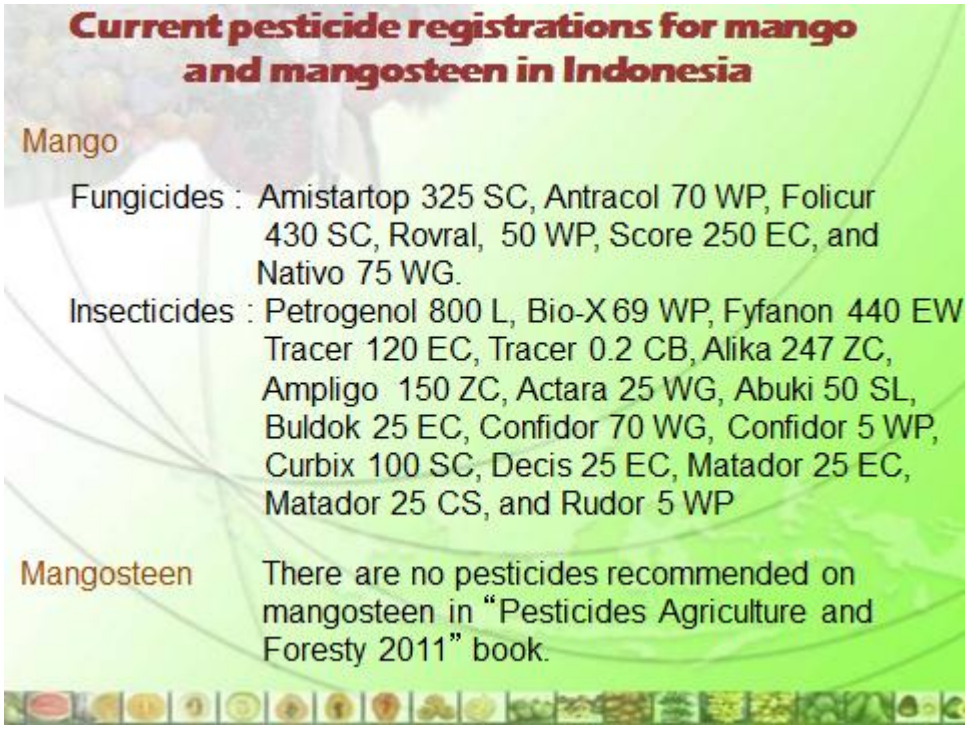
Conveyor installed at NNEA

Appendix 11.17 Pesticides register in Indonesia



Istianto, M. 2014. Final Workshop, Bogor, 21-22 May . Indonesian Tropical Fruit Research Institute.

Appendix 11.18 In-vitro soil propagation

Proof of Conept IVS Propagation

Sourcing plant material for TC

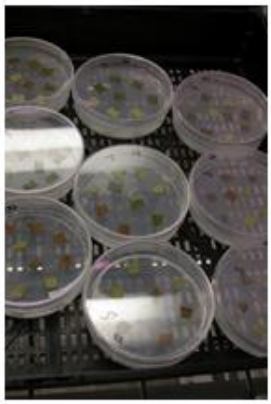
- Plants were sourced from Queensland
- As bare rooted plants , through AQIAS and QWAQIAS in WA to meet quarantine requirements:
- Plants were fungicide drenched
- Plants potted up and growing in heated glasshouse

Proof of Conept IVS Propagation

POC involved a number of steps:

Introduction into culture–

- leaf material sections of recently expanded leaves
- treated with 1.5% chlorine
- initiated into culture on MS media
- Cultures established and contamination free



Leaf segments in TC

Department of Agriculture and Food

Proof of Conept IVS Propagation

POC involved a number of steps:

Shoot explant growth in culture –

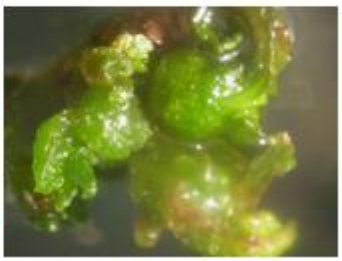
- New leaf material remained alive and new shoots grown from leaf sections

Tested various hormones to initiate new growth

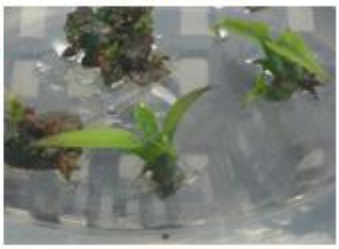
- Found TDZ (1,2,3-thiadiazol) to be more effective than BAP (6-*Benzylaminopurine)*
- *½ strength (0.5mg/L) TDZ with NAA (0.1 mg/L) found more effective in maintaining growth*

Limited multiplication may be clonal

- *Sourcing a range of selections needs to be tested*



Shoots initiated



Shoots growing in TC

Appendix 11.19 Mango Strategic Plan

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Indonesian Mango Research and Development Strategic Plan.

2011 – 2016.

Why this Plan has been prepared

This plan has been prepared following a joint meeting between the key institutional agencies (Government, Universities and NGO's) and Industry representatives. Its purpose is to guide research and development to support the growth of the Indonesia mango industry, including providing a framework and direction for investment. The activity was supported by the Australian Centre for International Agricultural Research (ACIAR).

The plan is prepared in the context of:

- Mangoes are a significant fruit commodity within various provinces of Indonesia and contribute strongly to the economic development of these regions.
- In comparison to many other mango producing countries across the South East Asian region, productivity and product quality of the Indonesian mango is very poor.
- Preliminary research to date has indicated that significant improvement can be achieved in productivity and fruit quality, providing excellent economic returns to growers and greater consumer acceptance of improved fruit quality.
- Greater efficiencies in the research and development expenditure will be achieved if a strategic plan for the industry is developed.
- Similarly improved policy development and harmonisation will also foster horticultural development

This plan will:

- Describe the current situation and key factors influencing the industry;
- Analyse the industry's strengths, weaknesses, opportunities and threats;
- Describe a vision for the future of the industry; and then
- Outline the strategies that need to be undertaken;

BACKGROUND.

Between 2008 and 2012, four ACIAR projects focusing on mango issues have been or are currently being conducted in the major mango production regions in Indonesia. These being;

1. SMAR/2006/036 – Management of fruit quality and pest infestation on mango and mangosteen to meet technical market requirements: Mr Peter Johnson.
2. SMAR/2007/193 - Quality management to enhance effective supply chains for mangoes and rambutans in Nusa Tenggara Barat (NTB), Indonesia and Australia: Dr Brian Thistleton
3. SMAR/2007/197 - Scoping horticulture projects in Eastern Indonesia (passionfruit, cashews and tropical tree crops): Mr Ian Baker.
4. HORT/2008/041 – Area-wide management of pest fruit flies in Indonesian mangoes: Dr Harry Fay.

The first two projects, although having a major focus on supply chain management, market access and market development, did have some pre-harvest research activities in the areas of insect and disease management and limited evaluation of strategies to manipulate the harvest window. The fourth project is specifically focusing on reducing yield losses caused by fruit fly.

SYNOPSIS OF INFORMATION PRESENTED AT PLANNING WORKSHOP

The Indonesian Mango Industry – A snapshoot.

Indonesia produces from approximately 195,503 ha of land over 1.5 million tonnes of mango (approximately 7.6 t/ha) by over 150,000 farmers across 33 provinces. Approximately 75% of production is located mostly on Java, Bali and NTB (Table 1). The major commercial varieties are Arumanis, Gedong Gincu, Indramayu, Manalagi, Golek, Gadung and Lalijiwo. However Arumanis and Gedong Gincu are currently the superior varieties.

The production is predominately targeted at meeting domestic demand, which allows for considerable opportunity to increase production though the increase in consumption (kg/head) and availability of supply.

Table 1. **Indonesian Mango Production by Major Province – 2010** [1]

	Province	Production (ton)
1	Java - East	416.803
2	Java - Central	203.912
3	Java - West	137.104
4	NTB	104.669
5	Sulawesi - Southern	100.935
6	Bali	28.924

Limited product is exported (1900 tonnes in 2008) resulting in the majority of production sold domestically in the period October – January.

[1] Director of Horticulture, Dr Kuntarish, Planning Workshop 2011.

Mango imports indicate good prospects for high quality mangoes in the domestic market, as well as challenges for developing Indonesia's own mango production. Two countries dominate export the fruit to Indonesia: Thailand and South Africa 71 % 17 % respectively. Since the Indonesia mango harvest occurs from August to January with the greatest supply from September to December There ia some off season production but not significant volumes. Imported mangoes fulfil a domestic demand gap from February to September. With low levels of imports during other periods filling niche market demands. One factor that permits a year-round mango supply is the development of supermarket demand, which relies on a modern supply chain for fresh agricultural products. When there is a lag in domestic supply, the supermarket procurement system drives an increase in import volumes, as supermarkets have good access the international market networks, either directly or through regional hubs.

Supermarket growth in Indonesia has occurred in parallel with urban residential clusters, with their increased demands for comfort and better food service provision. (Natawidjaja, RS; 2008).

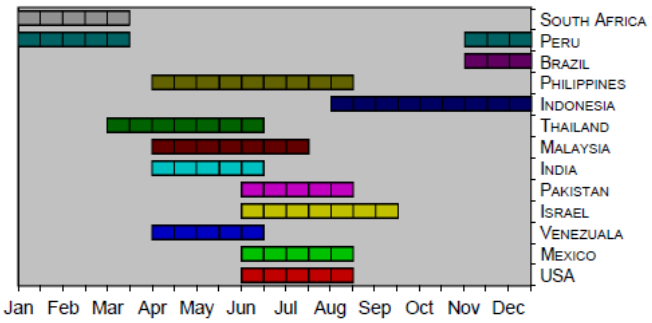
Current mango exports from Indonesia are very low this is in spite of a substantial opportunity existing.

It has been identified that Indonesia is very well placed to export mangoes through:

- Supplying at a time when world production is at its lowest, in the reverse season to the major producers of the northern hemisphere (India, Pakistan, Bangladesh, Thailand, Philippines) Figure 1.
- A low cost supplier,
- Close to the world's largest mango consumers in a region of rapidly growing economies (China, SE Asia)

However due to poor fruit shelf life (high disease incidence) and unacceptable fruit characteristics (large seed), the Indonesian export trade is small. Indonesian mango fruits have a low competitiveness in a global market.

Figure 1: **Main supply times from competing countries.**



There are strong market opportunities outside of Java, and outside of the current production period of August – January to address this supermarket demand for all year round supply. It has been suggested and preliminary research has indicated that varieties such as Arumanis can be manipulated to product fruit out of season (and outside of the wet season) to increase consumption and hence returns to growers. for example Figure 2.

Figure 2. **Manipulation of the production window.**

Major Factors Influencing Industry Development

Current Varieties:

Historically the mango industry has been dominated by the Arumanis and a strong domestic market has been built around this variety. It is widely appreciated by the Indonesian consumer. However, many of its attributes have actually proved to be an impediment for developing it as a major export variety, such as productivity, disease resistance, skin colour, flesh recovery and shelf life. Export market In particular show a strong resistance to green skin varieties.

Recent development of the coloured Gedong variety or known as Gedong Gincu in its blushed form, has had a significant impact on the Indonesian mango in industry. Whilst it is still struggling to find a niche as an export variety the domestic market has clearly demonstrated that it is willing to pay more for different varieties. Gedong attains a significant premium over Arumanis. This is a strong indication that opportunities for genetic improvements exist in the industry.

In 2008 ITFRI commenced an evaluation program of red skinned varieties such as Khrisapati Malda, Duren and Gayam for production in wet regions. Additionally a crossing program based on Arumanis 143 and red skin mangoes resulted in 120 plants being planted in Lampung. Limited further evaluation of these varieties has been done.

There is little evidence of the knowledge of rootstock and grafted plants to improve productivity and fruit quality.

Within Indonesia there is large genetic diversity within the *mangiferia* family that needs to be captured. Additionally there are a number of significant major germplasm collections across Indonesia. If the export and domestic market opportunity through the supermarkets and out-of-season production is to be captured, the evaluation of alternative varieties that are appealing to consumer needs to commence.

Closely linked to varietal improvement is the establishment of nursery practices to supply high quality material to growers.

Production Practices;

Baker (2007) concluded that there was very little use of normal management systems such as;

- Irrigation,
- Nutrition,
- Canopy management,

- Pest and disease management and
- Manipulation of flowering.

He attributed this to;

- Low prices not conducive to investing in management,
- Farm size too small to utilise better technology,
- Small holders who use mango as an opportunity crop.

Supporting his conclusions is the Trader's monopoly on decision making processes.

The three current ACIAR projects have addressed in part, some of the pest and disease management issues and some preliminary studies on flowering manipulation.

Studies by ITFRI with irrigation strategies on Arumanis in dry productions regions demonstrated 22.6% increase in fruit yield, however there is limited information to indicate that this has been adopted by growers or there is the capacity to adopt, especially those regions that are continually facing drought.

Fruit quality studies have identified jelly seed as a major defect found in supply chain studies. Evidence from other countries contributes much of the incidence of jelly seed to lack of attention to appropriate irrigation and nutrition management early in fruit development. However it is also known that cultivar susceptibly plays a major role in the incidence as well.

Traditionally Canopy management practices to

- minimised tree height for ease of harvest,
- to reduce pest and disease incidence and improve pesticide penetration, and
- to regulate flushing and flowering,

are not common. This is particularly evident with many Arumanis growers, however canopy management strategies are often practiced by Gendong growers.

Manipulation of flowering and fruit maturity has been a significant success achieved from the current ACIAR projects. Adoption has seen significant economic returns to growers and hence good adoption of the practice. Broader adoption of the technique into other production regions is required as referred to in Figure 2. Significant scope to spread existing production into the shoulder periods and off season exist.

Most of the critical insect and disease pests have been identified in the major production areas; however there is a reliance on pesticide usage and pesticide misuse. The utilisation of integrated management systems or areas of low pest pressure have not been fully developed. Pesticide residues in marketed fruit will be a concern as the demand for fruit into the supermarket and export markets chains increase.

The transfer and adoption of new technologies by all members of the production chain appears limited. This process is restricted by the trading terms and the low returns to farmers. New strategies for information transfer need to be developed as new supply chains that enhance economic returns are implemented.

Harvesting and Post Harvest Handling:

Substantial losses are occurring the in the chain due to poor post harvest management and handling practices. The main contributors to the losses are Post harvest disease, Physical damage to the fruit during harvest , packing and transport, little to no cool chain, Over ripe fruit, physiological disorders such as jelly seed, insect damage in particular fruit fly and immature fruit.

Both the current ACIAR projects have identified the major fruit defects that are occurring in the supply chain and have to a limited extent developed strategies to minimise these.

The use of pre and post harvest fungicides is limited and where it is used it is not often done correctly due to poor information and knowledge of their use. Correct use of pre and post-harvest fungicide treatments have increased shelf life and marketability, but where economic returns are low the practice is not implemented.

Whilst Fruit maturing standards have been developed for the two major varieties, and are proving useful for the traditional domestic market, they are inadequate for the export market this is being addressed for Gedong but will also need to be addressed for Arumanis and future varieties.

Traders and collectors are have limited interest in adopting better harvesting and post harvest practices, for the local wet markets. There are limited training tools for the harvesting teams, and little incentives for them to adopt these practices.

Supply Chain Management:

Infrastructure

Either for the domestic or export markets, appropriate infrastructure at all steps along the chain is limiting the development of fresh horticultural produce, especially fragile commodities such as mango. Improved infrastructure is needed in areas such as;

- Roads,
- Cool rooms at farms, consolidators, major ports and within the major domestic markets.
- Ripening rooms.
- Disinfestations facilities for export
- Reliable transport (trucks, boats and planes)

Technical capacity

Associated with this infrastructure is the need for operating guidelines such as transport temperatures, ripening practices, post harvest handing practices disinfestations protocols etc.

Market Access Protocols:

Both ACIAR projects have worked in developing product into a couple of targeted export markets, and have identified major constraints with product not meeting the import protocols. Research and technical capacity is being increased in the areas of Irradiation, fumigation, Vapour heat treatment and hot water treatment in order to develop market access protocols.

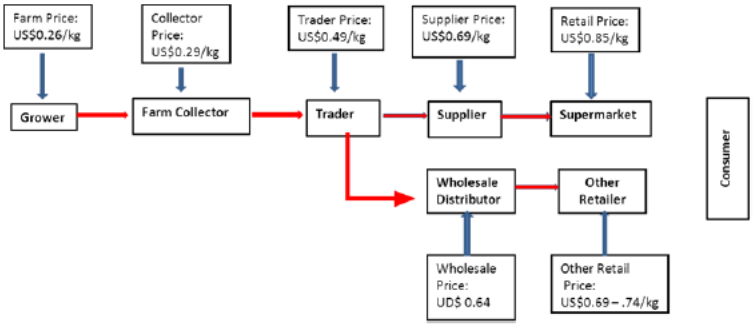
However outside of the research sphere of influence there appears to be a lack of understanding by other members within the supply chain as to what market access protocols mean and the cost if they are not addressed.

Marketing supply chains

As occurs in many developing nations such as Philippines and Pakistan, Indonesian farmers are generally bound by a loan received from a trader, which allows the trader to make the decisions regarding the sale of the harvest.

Therefore, farmers do not necessarily know the accurate volume of their mango production or its potential value. This kind of exchange system creates vulnerability in the farmers' bargaining position, so that they receive a relatively lower price in relation to the real market price. This allows for unbalanced information, the traders' monopoly, and the farmers' weak financial condition. As a consequence of this system, farmers' lacked motivation to improve the quality and productivity of mango farming. In a study by SPAT (Indonesia), Figure 3 demonstrates the flow of finance through a typical value chain, which often results in minimum returns to the farmer.

Figure 3: **Analysis of Value Chain**
Retail to farm-gate price ratio on mangoes (peak season) – Indonesia



This has been confirmed in studies by Natawidjaja (2008) on transparent margin partnership model: Linking mango farmers to dynamic markets, with growers in Pemalang, Central Java.

The partnership gives growers direct access to supermarkets with the support of a value chain champion. The system encourages growers to work both individually and/or as a group to transform the farmer's relationship to the market, moving from spot market-based to contract-based negotiations. The farmers have the most to gain in terms of increased income from the transparent margins systems.

Policy and Regulation:

Currently there are limitations on policies and/or regulations that encourage the development of horticultural production. This is particularly evident in areas of micro-financing, education and infrastructure. Where policies exist, they are often not compatible or consistent and involve considerable red tape which results in impeding development.

In the Natawidjaja study, key policy implications identified were around

- Tax incentives, technical support, information access to foster agribusiness development
- Capacity building for rural production organisations
- Facilitating financial systems that support public/private partnership and or agribusiness development

For export development, reducing the duplication of paper work for a number of government agencies appeared to be the major impediment.

KEY STRENGHTS, WEAKNESSES, OPPORTUNITIES and THREATS:

STRENGTHS.

- Large domestic consumption base.
- Genetic diversity.
- Diversity of production regions.
- RD&E capacity.
- Increasing standard of living in a number of major centres across Indonesia.
- Proximity to large export markets. Export destination countries: Singapore, Hong Kong and the Middle East (Saudi Arabia and United Arab Emirates).
- Mango harvest season counter seasonal to most other large producing countries.
- Low cost supplier

WEAKNESS.

- Growers lose control of their produce early in fruit development stage.
- Lack of infrastructure. (cold storage, roads, ports etc).
- Convoluted export policy.
- Poor performing varieties.
- Diverse and isolated production regions.
- Lack of coordinated export program.
- Inconsistent quality at retail level.
- Key industry information (facts)
- Lack of technical expertise
- Service providers
  - Range
  - Options
  - Integration

OPPORTUNITIES.

- Increase domestic consumption of high quality mangoes.
- Import replacement.
- Provide mangoes onto the domestic market all year round.
- Large export window for developing.
- Improve the economic returns to growers.
- Develop new value-added products
- Develop relationships with
  - Government
  - Industry sectors
- Grower involvement
- Key industry information services

THREATS.

- Fragmented industry
- Poor quality reducing demand
- Biosecurity (endemic & exotic threats)
- Failure to address market access protocols.

- Failure to address the inefficiencies within the value chain.
- Risk of over-supply during peaks
- Limited Government support for infrastructure development.

VISION

To supply Indonesian consumers and export markets with quality mangoes all year round

Mission

Through targeted RD&E provide Indonesian mango producers and supply chain participants the skills and capacity to provide consumers with quality mangoes all year round.

Objectives and Strategies.

1. Genetic improvement

Objective:

Identify market driven opportunities to improve Indonesian mango supply and competiveness in the domestic and export markets through genetic improvement

Rationale:

Historically the mango industry has been dominated by the Arumanis and a strong domestic market has been built around this variety. It is widely appreciated by the Indonesian consumer. However, many of its attributes have actually proved to be an impediment for developing it as a major export variety, such as productivity, disease resistance, skin colour, flesh recovery and shelf life. Recent development of the coloured Gedong variety in its blushed form has had a significant impact on the Indonesian mango in industry. Whilst it is still struggling to find a niche as an export variety the domestic market has clearly demonstrated that it is willing to pay more for different varieties. Export market in particular has shown a strong resistance to green skin varieties. If the export and domestic market opportunity through the supermarkets and out-of-season production is to be captured, the evaluation of alternative varieties that are appealing to consumer needs to commence.

Strategies:

a. Confirm from market research and other work on key qualities sought in a new variety to deliver consumer satisfaction, retailer consistency and reliability and grower profitability.
b. Review current germplasm collections in Indonesia and overseas to identify varieties (meeting "champion variety" specifications) for commercial development.
c. Develop a genetic improvement and evaluation plan of elite varieties and appropriate commercialisation strategies.
d. Commence implementation the genetic improvement and evaluation program as per the plan and build the research, development and extension capacity to address the overall strategy.

Drivers:

- Sound production and consumer market research upon which to base the variety specification.
- Committed and adequately funded research team.
- Commitment by key influential growers
- Fixed and tight timetable/deadlines
- Engaged commercialisation partner.
- Profitability

Barriers:

- Insufficient and committed funding
- Lack of innovation within the research team
- Capacity to change
- Lack of industry support
- Delays in delivering on time
- Apathy

Measurement

- Market and economic analysis of the impact of new varieties
- Genetic improvement plan developed
- Progress against genetic improvement plan in annual action plans
- Varieties confirmed and established in appropriate production regions across Indonesia.
- Measured performance in consumer satisfaction, retailer demand and economic benefit to growers.

2. Ensuring Sustainable Production

Objective:

To improve and maintain the quality and safety of Indonesian mangoes at all stages from harvest to the consumer in both domestic and export markets, utilising best management practices.

Rationale:

Production practices are the foundation of the mango industry and impact on consumers, growers and the wider community. From a consumer perspective, production practices can have a significant impact on fruit quality, consistency and food safety. From a grower's perspective, production practices can have a major impact on farm profitability. From the wider community's perspective, production practices need to be based on sound environmental management principles. Recent advances in pest and disease management need to be adopted across all production regions. Improving marketable yield, fruit quality and expanding the production window will significantly improve demand and profitability for growers.

Strategies:

a. Develop best practice agronomic practices that will maximise yield and quality potential of Indonesian mango orchards.
b. Develop improved pest and disease management practices that improve fruit shelf life and builds consumer confidence allowing Indonesian mangoes to meet both domestic and international market requirements.

Drivers:

- Availability of service providers (research, policy, extension and agribusiness) with the capacity, skills and desire to implement an integrated production system to achieve the targeted outcome.
- Adequate resources

Barriers:

- The existing trading system is restricting the adoption of new technologies
- Commitment by growers to face the change.

Measurement:

- Uptake of practice changes.
- Increased availability of mangoes on the domestic market for longer periods.
- Increase in consumer demand for mangoes.

3. Supply Chain.

Objective:

To continue the development of existing domestic markets, selected export markets and facilitate access to new markets, using technologies to maintain high fruit quality throughout the supply chain, value chain development and capacity building activities

Rationale:

The percentage of local fruit in modern markets is relatively low (20 to 40%), and as supermarket growth increases in line with urban development, there is a need to increase fruit quality to sustain consumer demand. Adoption of known technology such as fruit maturity standards, ripening strategies, transport and holding temperatures are essential to providing an environment of maintaining fruit quality not an environment delimiting quality.

Strategies:

a. Comprehensive analysis of key domestic and export supply chains from the major producing regions.
b. Build upon existing intervention activities that will lead to improved outcomes and decrease losses
c. Develop opportunities for extending the supply season to exploit existing market windows, by identifying production systems, cultivars and regions that will enhance longer supply of local mangoes
d. Expand development of new export supply chains.

Drivers:

- Consumer demand for quality and consistency of product.
- Production timing meeting export windows
- Increase growth of supermarkets in major population growth centres across Indonesia.
- Opportunities for processed product from out-of- grade or oversupplied fruit.

Barriers:

- Lack of appropriate infrastructure within major production regions to facilitate appropriate supply chain practices or processing technologies.

- The existing trading system is restricting the adoption of new technologies.
- Lack of communication within the existing chains

Measurement

- Uptake of practice changes.
- Accessing new markets and development of new supply chains
- Increased availability of mangoes on the domestic market for longer periods.
- Increase in consumer demand for mangoes.

4. Building Capacity

Objective: To work with key stakeholders including growers, commercial agribusiness, universities, government agencies and institutions to improve the knowledge, resources and skills required to understand the value chain management approach to development and implement improved value chain management practices

Rationale:

.

Strategies

a. Exemplars and demonstration activities as capacity building models for all stakeholders involved.
b. Improve skills, knowledge and practices of smallholders by identifying target group(s) with appropriate training packages and modalities across the full production and supply chain.
c. Co−planning with other stakeholders: Multi−agency, multi−stakeholder planning activities, publicise results.

Drivers:

- Consumer demand for better product
- Profitability of mango production

Barriers:

- The existing trading system is restricting the adoption of new technologies
- Industry willingness to change
- Existing supply chain stakeholders

Measurement:

- Increase in grower cooperatives and marketing groups
- Increased skills base within the chain
- Improved communication and adoption of technology within the chain.
- Growers becoming responsible for the production of quality fruit
- Closer relationships between growers and retail chains.

5. Harmonizing Government and Regulatory Policy

Objective: Harmonise policies and/or regulations that encourage the development of horticultural production in Indonesia.

Rationale: Increasing consumer preferences for quality and specific attributes, tightening food safety regulations, and the restructuring of the retail food sector (including the growth of supermarket chains) are imposing new requirements on suppliers. The challenge is to craft policies and regulations that establish a level playing field for different types of growers and to promote marketing institutions that facilitate *vertical coordination*—meaning the transfer of information, credit, inputs, and commitments—between farmers and buyers.

Strategies:

a. Identify constraints faced by farmers in their attempts to raise income to move into supply chains for high-value horticultural commodities;
b. Develop alternative policies, regulations, investments (public, private or mixed), and institutional arrangements that alleviate constraints;
c. Strengthen the capacity of policymakers and researchers to undertake policy research concerning the role of diversification and high-value agricultural commodities.

Drivers:

- The demand for increased volumes for longer periods of locally produced higher quality mangoes.
- Increasing consumer preferences for quality and specific attributes
- Profitability of mango production

Barriers:

- The existing trading system is restricting the adoption of new technologies
- Commitment by growers to face the change.

Measurement:

- Increase in grower cooperatives and marketing groups
- Growers becoming responsible for the production of quality fruit
- Closer relationships between growers and retail chains.

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Objective 1 Identify market driven opportunities to improve Indonesian mango supply and competiveness in the domestic and export markets through genetic improvement			
Strategy	**Activity**	**Outcome**	**Lead Agency**
1. Confirm from market research and other work the key qualities sought in a new variety to deliver consumer satisfaction, retailer consistency and reliability and grower profitability.	1. Analyse market research data on fruit quality from past projects and priorities germplasm to progress	Stakeholders informed on the market qualities of current available varieties	
	2. Establish a mango improvement advisory groups to oversee the program		
	3. Prepare report		
2. Review current germplasm collections in Indonesia and overseas to identify varieties (meeting "champion variety" specifications) for commercial development	1. Review status of germplasm collections	Stakeholders informed about status of current germplasm collections and target specification for Champion Varieties.	
	2. Engage the mango improvement advisory group in determining the specifications of a champion variety.		
	3. Prepare report		
3. Develop a genetic improvement and evaluation plan of elite varieties and appropriate commercialisation strategies.	1. From data collected in activities 1 & 2, develop short, medium and long term strategies for a genetic improvement program in Indonesia.	Full ownership by all stakeholder of the strategy.	
	Distribute the strategy to all stakeholders.		
4. Commence implementation the genetic improvement and evaluation program as per the plan and build the research, development and extension capacity to address the overall strategy	1. Priorities current germplasm collections.	Rationalisation of resources	
	2. Revitalise priority collections	Rationalisation of resources	
	3. Introduce specific targeted germplasm	Improved baseline of mango gene Poole	
	4. Establish regional trials of early priority best bet varieties	Transiting industry from anecdotal to objective data.	
	5. Annual review of the program by the Mango improvement advisory group to ensure the program is commercially focused	Varieties are meeting grower and consumer expectations	
	5. Build capacity in varietal evaluation, techniques of conventional and molecular breeding.	Focused competent research teams	
	6. Update mango varieties booklet of new germplasm and strengthen the focus on the publication commercial attributes of each variety.	Informed stakeholders	

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Objective 2: To improve and maintain the quality and safety of Indonesian mangoes at all stages from harvest to the consumer in both domestic and export markets, utilising best management practices.

Strategy	Activity	Outcome	Lead Agency
1. Develop best practice agronomic practices that will maximise yield and quality potential of Indonesian mango orchards.	1. Benchmark current and alternative agronomic practices by variety, location and tree age	Shared plan across all researchers	
	2. Review current and alternative crop manipulation practices by variety, location and tree age that will achieve desired outcome	Improved supply of quality fruit into the supply chain	
	3. Implement regional trials to quantify options.	Improved supply of quality fruit into the supply chain	
	4. Integrated best options into a total cropping system	Improved supply of quality fruit into the supply chain	
	5. Engage industry stakeholders regularly in R&D outcomes	Informed industry and stakeholders in R&D outcomes	
2. Develop improved pest and disease management practices that improve fruit shelf life and builds consumer confidence allowing Indonesian mangoes to meet both domestic and international market requirements.	1. Review progress in plant protection from three current IPM projects.	Gaps in R&D identified and strategies to address these gaps.	
	2. Review current status pesticide registrations and facilitate registration of critical products.	Improved Occupational Health and Safety standards to growers and improved food safety for consumers	
	3. Integration of improved agronomic and plant protection practices into a total production system to meet consumer expectations of fruit quality.	Improved production efficiency Improved fruit quality	
	4. Develop post harvest handling and ripening practices to ensure maintenance of fruit quality throughout the supply chain.	Increased consumer demand for Indonesian mangoes	
	5. Review ASEAN and other fruit standards and develop appropriate fruit standards for Indonesia including food safety and traceability.	Consumer confidence in food safety of Indonesia mangoes	
	6. Build capacity of commercial operators and research teams within the post harvest supply chain in new technologies.	Consumer confidence in food safety of Indonesia mangoes	
	7. Upgrading of post harvest research facilities and encourage the development of modern post harvest ripening and fruit handling infrastructure at key locations.	Improved research capacity. Efficiencies within the supply chain.	

Objective 3 To continue the development of existing domestic markets ,selected export markets and facilitate access to new markets, using the results to inform quality improvement, value chain development and capacity building activities

Strategy	Activity	Outcome	Lead Agency
1. Comprehensive analysis of key domestic and export supply chains from the major producing regions.	1. Build on previous supply chain mapping data and identify gaps	Greater understanding of the deficiencies within the supply chain	
	2. Monitoring and identifying critical control points within these key chains that will lead to improvements in outturn and reduced losses.		
2: Build upon existing intervention activates that will lead to improved outcomes and decrease losses	1. Further implementation of critical interventions to engage the wider industry, especially the domestic supermarket chain to minimise losses in fruit quality.	Improved fruit quality standards	
	2. Engage with all participate within supply chain to build capacity implement improved practices.		
	3. Evaluate regulatory and financial constraints limiting development of mango in specific geographic regions.	Greater development of domestic and export markets	
3: Develop opportunities for extending the supply season to exploit existing market windows, by identifying production systems, cultivars and regions that will enhance longer supply of local mangoes	1. Analyse geographic regions suitable for mango production that would potentially fill domestic supply chain gaps.	Greater regional diversity of mango production regions	
	2. Develop best bet production systems, identify infrastructure constraints and enhance capacity building programs in priority regions to meet the targeted supply chain window.	Expanded production and supply chain window.	
4. Expand development of new export supply chains.	1. Continue capacity building of quarantine and technical market access staff to meet importing countries phytosanitary requirements.	Improved capacity to negotiate market access with trading partners.	
	2. Build capacity of commercial operators of disinfestation facilities, especially hot water treatment.		
	3. Continue and expand market developed with leading supply captains.	Increased demand for Indonesian mangoes	

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Objective 4: To work with key stakeholders including growers, commercial agribusiness, universities, government agencies and institutions to improve the knowledge, resources and skills required to understand the value chain management approach to development and implement improved value chain management practices

Strategy	Activity	Outcome	Lead Agency
a. Exemplars and demonstration activities as capacity building models for all stakeholders involved	1		
	2		
	3		
	4		
Improve skills knowledge and practices of smallholders:; develop appropriate training packages and modalities;	1. Identify target group(s)		
	2. Develop appropriate training packages and modalities		
	3. Engage in value chain development activities		
	4. Monitor and evaluate outcomes for understanding and commercial results		
Co−planning with other stakeholders: Multi−agency, multi−stakeholder planning activities, publicise results	1		
	2		
	3		
	4		

Indonesian Mango RD&E Strategic Plan 2011. Page 18

Objective 5: Harmonise policies and/or regulations that encourage the development of horticultural production in Indonesia.

Strategy	Activity	Outcome	Lead Agency
1. Identify constraints faced by farmers in their attempts to raise income to move into supply chains for high-value horticultural commodities			
2. Develop alternative policies, regulations, investments (public, private or mixed), and institutional arrangements that alleviate constraints			
3. Strengthen the capacity of policymakers and researchers to undertake policy research concerning the role of diversification and high-value agricultural commodities.			

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Appendix 11.20 Newsletters

November 2011 ISSN 1839-6410 Vol. 1, No. 1

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Appendix 11.21 Mango survey questionnaire

Grower details

Grower (Optional): .....

Date of Survey: .....

Production region:

☐ East Java ☐ West Java ☐ Central Java

Question 1 . What is the name of your closest city? .....

Question 2 . Do you record you farm management practises?

☐ Yes

☐ No

Question 3 . If yes, which system do you use?

☐ Written notes

☐ Computer

☐ Other

Question 5 . Would you change your farming system to meet certain export protocols?

☐ Yes

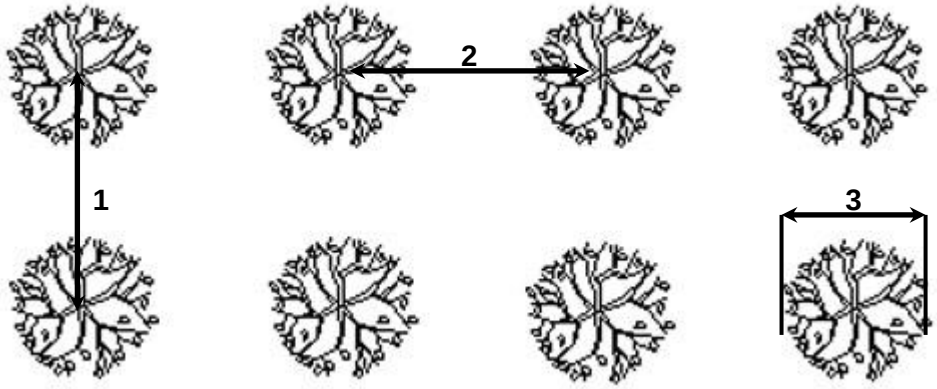
☐ No

Orchard Details

Question 6 . Background information about your mango orchard (tree number, variety, tree spacing, tree height etc.)

Variety	**No. of trees**	**Grafted (Y/N)**	**Rootstock**	**Year of planting (Age)**	**Row spacing (metres) (1)**	**Trees spacing (metres) (2)**	**Canopy diameter (metres) (3)**	**Tree height (metres)**	**Yield (block)**

Question 7 . Do you irrigate / water your mango trees? If so, how? (flood, micro sprinkle, trickle, by hand, rain-fed)



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General Phenology

Question 8 . What are the growth stages or events (week/month) with different varieties for main season & off-season production (Flowering, fruit harvest, leaf flush, how many flushes, Paclobutrazol, Flower induction (KNO3, CaNo3) etc.)

Growth stage	**Harumanis**		**Gedong Gincu**		**Golek**		**Other**					
	Week	**Month**	**Week**	**Month**	**Week**	**Month**	**Week**	**Month**	**Week**	**Month**	**Week**	**Month**
Growth regulator (PBZ, Paclobutrazo)												
Flower Induction												
First Flower												
Main Flowering												
First fruit harvest												
Number of flushes per year												

Orchard Management practises

Pruning & Canopy Management

Question 9 . How and when do you prune you mango trees?

.....

.....

.....

Question 10 . Do you use a growth regulator (eg. PBZ, paclobutrazol)? When is it applied (every year, every second year) & by who (grower, collector, contractor)?

.....

.....

Nutrition

Question 11 **.** What fertiliser do you use, when and how much?

.....

.....

.....

.....

.....

Question 12 **.** Do you use soil or leaf analysis or something else to decide on fertiliser?

☐ Yes

☐ No

Question 13 **.** If yes, are you able to interpret the soil/leaf analysis yourself?

☐ Yes

☐ No

Pest & Disease Management

Question 14 **.** Below is a list of insects and diseases. Can you rank them in order of importance and incidence for your orchard?

1. Major 2. Moderate 3. Minor 4. Not sure 5. Doesn't occur or haven't seen

Mango Insect pests

☐	Mango scale	☐	Mango shoot caterpillar
☐	Flower feeding caterpillars	☐	Fruit fly
☐	Tip borers	☐	Swarming leaf beetle
☐	Mango seed weevil	☐	Mites
☐	Thrips	☐	Mango leafminer
☐	Mango leafhopper	☐	Termites
☐	Fruit spotting bug	☐	Red Banded Mango Caterpillar
☐	Ants	☐	Gall Midge
☐	Pulp Weevil	☐	Others
☐	Mango planthopper	☐	

Mango Diseases & Disorders

☐	Anthracnose	☐	Bacterial black spot
☐	Powdery mildew	☐	Mango Scab
☐	Stem end rot	☐	Sunburn
☐	Decline or dieback	☐	Internal disorders

Question 15 . Do you spray?

☐ Yes

☐ No

Question 16 **.** What type of sprayer do you use? (tick)

☐ hand sprayer

☐ backpack

☐ mister

Integrated Pest Management

Question 17 **.** What does the term integrated pest management or IPM mean to you?

.....

.....

.....

Question 18 **.** Do you believe you use IPM on your farm? If yes, in what way?

.....

.....

.....

Question 19 **.** What does the term good agricultural practice or GAP mean to you?

.....

.....

.....

Question 20 **.** Do you believe you use GAP on your farm? If yes, in what way?

.....

.....

.....

Supply Chain: Harvesting, packing & marketing

Responsibilities

(We need to get an idea of who the main players are, who controls what so we know who to target our extension material at.)

Question 21 **.** Who harvests you mangoes?

.....

.....

Question 22 **.** If contracting when and how does the grower get paid? i.e. what time; either flowering, fruit set or at harvest.

.....

.....

Question 23 **.** How is the fruit marketed? Who does it? Grower, contractor, agent/exporter?

.....

.....

Question 24 **.** Who determines the fruit quality & fruit price? How does the money flow?

.....

.....

.....

Question 25 **.** Who is responsible for what in the supply chain? E.g. grading, packing, transport, selling?

.....

.....

.....

.....

Harvesting

Question 26 **.** How do you decide when fruit is ready to harvest? (eg, Blush, Flesh colour, Dry matter, days after flowering etc)

.....

.....

.....

Question 27 . Do you induce mango flowering?

☐ Yes

If Yes, what method (e.g. KNO_3, $CaNO_3$)? .....

☐ No

Question 28 **.** How do you harvest?

☐ Destemmed in the field

☐ Stem attached and destemmed in the packing shed

☐ Stem attached and no destemming

Question 29 . Is the harvested fruit

☐ Placed into baskets directly

☐ Placed onto the ground and then put into baskets

Question 30 **.** How is the fruit transported to the packing shed? .....

Packing shed

Question 31 **.** Do you pack your own fruit?

☐ Yes

☐ No

If no, How much does your packing cost you per box/wooden crate? Rp .....

Question 32 **.** What does this include? (carton, tray liner, cooling, freight, selling costs etc.)

.....

.....

.....

Question 33 **.** Do you have access to cold storage or refrigeration factilites? If yes, how far from your farm?

.....

.....

Post harvest and Chemical control

Question 34 **.** Do you use any chemicals to treat the fruit after harvest?

☐ Yes

If Yes, what chemical do you use? .....

☐ No

Question 35 **.** What method/tools do you use to standardise fruit grading?

- ☐ Charts (Visual Aids)
- ☐ Verbal instructions
- ☐ Training
- ☐ No standards

Marketing mangoes

Question 36 **.** What is the quality breakdown of the or boxes you pack each year?

Quality (Class 1, 2, 3 etc)	**Pack type (tray, wooden box etc)**	**Weight (kg)**

Question 37 **.** What were the main reasons for fruit being downgraded to processing?

.....

.....

Information

Question 38 . Where do you get information about growing, harvesting and packing mangoes? Please rate each of the information sources as:

A - *Important or often used* ***B*** *- Sometimes used or* ***C*** *- Never used or not important*

Chemical resellers		Market agents or merchants	
Other Growers		Agencies	
People in your Industry Association/Grower Groups		Contractors	
Local Departmental Officers		Internet	
Field days or seminars		Books	
Other sources (specify):			

Question 39 . What would you like more information about?

A - *Important* ***B*** *- Useful* ***C*** *- not important* ***D -*** *not sure*

Disease control		Canopy Management (pruning)	
Business Management (costs & returns)		Flowering control (eg. Paclobutrazol, KNO3, CaNo3)	
Export / Quarantine requirements		Harvesting methods	
Ripening & ripening chemicals (carbide, ethrel)		Insects & Integrated pest management	
Irrigation		Latest Research results	
Market prices		Nutrition	
Overseas Research		Packing shed design	
Postharvest handling		Spraying	
Varieties		Computers & software	
Other topics (specify):			

Thankyou for taking the time to help us by completing this survey

Appendix 11.22a Thailand study tour

THAILAND MANGOSTEEN STUDY TOUR

HORT/2006/146

OCTOBER/NOVEMBER 2010

TED WINSTON

TROPICAL HORTICULTURAL CONSULTING P/L

EDITED BY JOHN MOULDEN

Table of Contents

Summary

Seven Indonesians (growers, collectors, exporters, university research, and government) were taken on a mangosteen study tour in Thailand. Important points arising:

1. Thailand has a consistent yield of 80-100 kg of fruit/ mature tree/year due to good management especially irrigation, nutrition, and canopy management (pruning) including tree size control.

2. Thailand has reduced yellow latex and translucent flesh problems due to maintenance of consistent soil moisture from under tree irrigation.

3. Thailand has reduced fruit scarring from insects due to the use of chemicals (smaller tree size helps).

4. There is more transparency in price to farmers than in Indonesia.

5. There are good packshed and export procedures.

6. There was a strong desire by all the participants to revisit during harvesting season to see harvesting and packing in season. The current visit was off season with no harvesting nor packing observed.

Introduction

John Moulden and Ted Winston guided 7 Indonesians on an ACIAR (HORT/2006/146) funded mangosteen study tour of Thailand from 26 October to 2nd November 2010.

The list of participants included:

1. Nanang Koswara, grower/collector of mangosteen from Bogor district
2. H. Asep Tasrip Hidayat, grower/collector of mangosteen from Subang district
3. Aji Gunawan, collector of mangosteen from Tasikmalaya district
4. Rony Mansyur, Exporter mangosteen (PT. Agung Mustika Selaras)
5. Haposan Simanjuntak, Assistant officer (Directorate of Fruit Crops, DGH)
6. Mr. Samsuardi, the marketing office of Directorate of Fruit Crops, DGH)
7. Darda Efendi, researcher from Centre for Tropical Fruit Studies Institut Pertanian Bogor

Figure 1:
Front row : Asep Tasrip Hidayat, Darda Efendi, Samsuardi, Aji Gunawan, Nanang Koswara
Back row: Ted Winston, Haposan Simanjuntak, John Moulden, Rony Mansyur

Dr. Peyanoot Naka of the Thailand Department of Agriculture's Horticulture Research Institute in Bangkok very effectively organized the tour. Dr. Nantarat Suprakumnead (senior soil scientist) and Veeria Kripuk (Som) (tissue culturist of coffee and coconut) from the Thailand Department of Agriculture's Horticulture Research Institute from Bangkok were our most capable tour guides. Dr Nantarat is Mudoch Univertisty trained and has spent 20 years in Chiang Mai before a recent move to Bangkok. Som is new to the Department

Figure 2: Dr. Nantarat, Peyanoot, and Som

The purpose of the study tour was for our Indonesian colleagues to observe and learn how Thailand grows, processes, markets and exports mangosteen – i.e. the supply chain from production to export.

Chantaburi Province

Chantaburi Province in Eastern Thailand adjacent to Cambodia is one of the largest tropical fruit production areas of Thailand and considered the most modern production area. Mangosteen, durian, rambutan, longkong, salacca are major crops.

We passed a VHT plant outside of town which was said to be for mango and mangosteen for Japan.

Chantaburi Horticulture Research Centre

Uthai Uraket (Extension) and Theerawut Chutinanthakun (Ake) were our hosts.

Uthai gave general introduction talk about the Research Centre and the DOA horticulture Research Stations in general. There are 6 regional Horticulture centres around Thailand.

Chiengrai
Sukhotai
Srisaket
Chantaburi
Chumphon
Trang

The DOA has classified fruit into 3 groups:

Champion crops – Pineapple, durian, longan, mangosteen, mango, and lychee

Potential crops – Pummello, papaya, rose apple, banana

Others – Longkong, grape, sugar apple, guava, citrus, santol, salacca, sapota, dragon fruit, jack fruit, sweet tamarind

Similar classifications have been done for ornamentals, vegetables, industrial fruit crops, and herb and medicinal crops.

Chantaburi HR Centre has a wet tropical climate being hot and humid. Average rainfall is 3150 mm with average temperature of 25.2°C. The Centre is 12.5° North of the Equator.

The Centre is responsible for durian, rambutan, mangosteen, salacca and longkong fruit as well as orchids and black pepper. They also have an agro- tourism role.

The Station is 33 ha in size. Soil is sandy with a pH of 4-4.5 while other experimental sites are 5 – 5.5

Stations are all government funded. No private funding. [Situation on this and other stations was similar to 1980's on Queensland stations before cutbacks. Well maintained, research in progress and good variety collections]

Mangosteen is grown mostly in east and south Thailand. There is no triennial bearing in low areas as per Indonesia. Yields are consistent whereas in Indonesia there is one good year out of three.

Theerawut Chutinanthakun (Ake) gave a good talk on mangosteens. The talks are found in Powers points supplied separately. Main areas of work are:

Cultural practices and physiology for flowering

1. ***Fertilizer*** - Manure and chemical fertilizers are both used

2. ***Pruning*** – need to control canopy size and leaf flushing.
   - Trees are topped often yearly – to control height and to get light into tree.
   - Side branches are trimmed and trees skirted.
   - Dead wood removed.
   - Trees seen on station more resemble mango pruning programme although thicker canopy. Quite open inside

3. ***Flower induction and development.*** This is shown in Figure 1. Water management is very critical. Right stress and *consistent* water.

4. ***If too many fruit***, fruit thinning is also carried out. Thin by:
   - Heavy watering
   - Heavy fertilizer (double rate of 15-15-15)
   - NAA (100 ppm); Ethephon (200-250 ppm; Carbaryl 1000 ppm
   - Critical stage 1-2 weeks after fruit set
   -
5. ***Plant protection***
   - 15 weeks from set to harvest
   - Water 80-85% of Epan

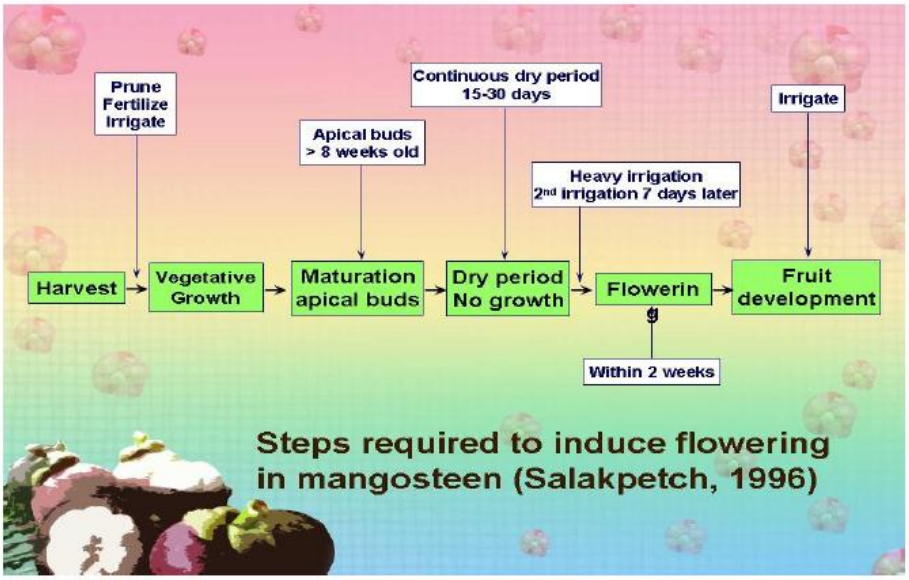

Figure 3: Steps required to induce mangosteen flowering.

Discussions notes:

- Translucent flesh – best way to reduce is to have constant soil moisture
- Ca/B sprays are applied on young fruit
- Sprinkler in trees for thrip control. Every 2 days, 3 hours, hot days, small fruit stage. (question is this is effective as high rainfall area anyway)
- Yield 80-100 kg/tree/year. Consistent as opposed to Indonesia
- Every 3 years cut tops. Maintain height
- Soil at station very sandy. Hot and humid. Can get 40C.
- When they get new growth from pruning. It fruits within 1 year
- Orchard visit showed well maintained trees, in rows, sides trimmed, topped, healthy.
- It was commented that the *Indonesian government subsidises good farmers by paying for fertilisers.*

Farm of Mr. Jomnong Pongam

30 ha of mangosteen, durian, longkong
Orchard was established by granddad

Fertilizer 4 times/year

- 2 organic (2-5 kg/tree)
- 2 inorganic (Urea 1-3 kg) and Dolomite
- Does soil analysis
- Used to apply high P but now not as very high soil P levels. Stopped 5 years ago.

Yield 80 - 100 kg/tree/year – depends on fertiliser. Fruit size 55-80 g.
100 YO tree – 300 kg fruit

Pests

- Leaf miners, thrips and mites
- Uses Lorsban and Confidor, pyrethroid
- "Bravado" also used. What is it?
- No sprinklers for thrips

10 x 10 spacing but many other trees planted in between

Want height kept to 5 m but now 10 m

Grades –
A >90 g; B 75-90; C 50-75

PBZ - Used but said no response. Said small leaves and no flowers

To harden flush: Spray twice with 100 ml of 6% Zn solution in 200 L of water

Employs 2 people and 3-5 for harvest (40 days)

150 farmers in group

- Every grower grades and transports to collection side
- Some fruit to China and some to US
- 70% of total fruit exported of which 30% US
- Collectors are not farmers

US market

- To US. 35B/kg. Minimum guaranteed price
- 2 companies export – Harmony Company sent without Calyx and other left Calyx on.
- US preferred calyx left on.
- Cost extra 2 B to clean fruit. Air pump. Ants and mealy bugs

- 6 fruit per box, then into larger containers then irradiated in BNK
- Paid about 1 month later
- (Growers do not know what price exporters get in US)

China

- Water clean, dry and wax
- Plastic bags into 9 kg boxes.
- Containers at 13C
- Sea freight
- Price depends on market
- 10 B/k paid at collection site

Japan

- Treat VHT for fruit fly
- 1 researcher said fruit fly but then said error but Japs insisted!

An Australian visitor said 2 cultivars – elongated and round types but growers said fruit came from same tree. Dr Nantarat later said DNA showed different. Darda said in Indo there are different ones by DNA. One in Kalimantan is nearly seedless. Elongated

Impressive orchard and making money!

OPTC = 1 Tambon 1 product

Figure 4. Mr. Jomnong Pongam demonstrating mangosteen harvesting pole to Haposan

Farm of Mr. Somwong

Studied in Manila 40 years ago
Small farm - 300 trees
Trees are 30-50 YO

3 undertree sprinkers per tree with massive output(??)

N fixing trees (Erythrina?) interplanted

Problems
- Pest and disease
- Hot in April
- Not much yellow gamboge

Figure 5: Haposan, Mr. Somwong, and John Moulden in discussion

Thrips – Confidor spray
4-5 times/year flowering and young fruit
5% scarring

75% of total is exported with >75 g A grade
If fruit too big market does not want. Small fruit with small seed better
10 B for small fruit

Last year 20B/kg overall
Avg 100 kg/tree/year of midsized fruit

ACIAR Thailand Mangosteen Study Tour 2010 11

6 labour at harvest over long time. 2 rest of time
200 B/8 hour day
Harvest about 100 kg/person or 2 b/kg or 1000 fruit
Cost of production 13-15 B/kb

Fertilizer

Urea	5-7 Kg/year	5 dates
0-0-16	5-7 kg/year	5 dates
Dolomite	+ Gypsum	20 kg/tree/year

pH about 6 is ideal
4.5 Natural

Zinc – foliar only to new flush
Ca/B spray before flowering
Cow manure 20 kg/tree one time

Does leaf and soil analysis
Another farmer soil test showed about 3000?? ppm Bray P. Has not applied P for 15 years.

No thinning but pruning to get balance of old and new leaf

Kamnantoh Packing House

Mr Narongsak Siriporn
Kamnantoh Packing House
Tambon Klongnarrai, Amphur Muang, Chantaburi

- Fruit comes from farmers or collectors in 20 kg crates
- Grade by eye into 5 grades ± scarring, hence 10 different lots
- Placed into 9 kg containers
- No cleaning of fruit.

Says <5% with ants. Farmers spray to keep clean
Do not spray within 30 days of harvest
However harvest daily over 2 months!

Shed handles 60 – 100 tonnes per day
Does this for 2 months
Said there are 10 sheds in area. Larger ones do 20 T/day
Season 2 months and then he moves to another plant in Chumphon

Anyone can bring fruit. Pay next day
If any farmer complaints on grading – management rechecks
~20 farmers and 40 collectors use shed

Only accept 2nd stage of maturity from growers

300 labour to pack.
Said most Issan (NE Thailand) but expect some Khmer as right near border
Start 9 AM until finished – sometimes early in morning
25 B/hr. No overtime

Last year A grade averaged 50B. Others 20 B
40% of fruit was A grade
7 grades by weight

Shed registered by DoA

Send in refrigerated containers. 4 containers hold 60 T fruit. 40 foot containers
80% of fruit is exported to China
Rest domestic
No overseas complaints on quality
9000 tonnes exported

Fruit packed in 9 kg crates

- First put layer of paper
- Then moist spongy layer
- Then 9 kg fruit
- Then spray wax
- Moist sponge
- Then cover.

Said prices paid set by market
Expect all sheds pay same price
Shed gets 4 B/kg for doing packing. This to cover all the costs
No contracts with growers

Village processing

Pattawee Group
Mr Ratthai Pongsak is head. Makham District, Chantaburi Province

97 people in group
Sell potations on site
Some send by Province to OTOP in BNK

Use mangosteen and materials from local bees. (Sweat bees or what we call native bees *(Trigona sp.)*)
Use 2-3 kg of reject mangosteen skins for 1 batch

Only going for 2 years. Could not give me how much $ made but said good
Fertilizers – Saw:

13-13-21 + Ca + Mg
27-6-6
8-24-24 + TE
12-3-6

Use 27-6-6 and 8-24-24 to help make flush come out

John McCommick (FNQ grower/manager) has visited. Uthai mentioned his name
Also Jodie Campbell (DEEDI)

Chumphon Horticulture Research Centre

29 -30 October

Dr Yupin Kasinkasaempong (acting director)
Dr Sureerat Panyatona (Coffee) – knew Ted's Lao manual and work
Prapaporn Chantanumat (Piew) – tissue culture

Station started in 1960 as Sawi station

- 500 km south of BNK
- 5 m.a.s.l.
- Flat, high water table with poor drainage
- Low fertility soils
- Sandy loam – to sandy clay
- pH 5.1 – 5.5
- Rainfall 2,057. Wet is May – December. Dry Jan – April
- Max temp 31.8 in April with minimum of 22.5 in Feb
- Relative Humidity 92% May-Dec
- 11 Researchers
  Also help with extension when asked
  Extension and Research different DG's. All goes via DG's in BNK unless emergency

Crops:

Major: Coconut, Robusta coffee
Minor: cocoa, betel nut, flowers

No mangosteen work – only at Chantaburi
Agro-tourism
Excellent herb collection

Robusta coffee

100,000 seedlings per year to sell to farmers
Tissue culture

3 Recommended cultivars:

Chumphon 1	Local	2462 kg/ha
Chumphon 2	FRT 65	2180 kg
Chumphon 3	FRT 17	1294 kg

To come:

Chumphon 4	FRT 09	3000 kg/ha
Chumphon 5	FRT 68	2670

Chumphon has 50% of Thai Robusta

Coconut – sell seedling of hybrid and aromatic
3 recommended cultivars
Sell seedlings for 10-15 B

Mangosteen

- All work at Chantaburi
- Export to China
- 9 Kg boxes
- <3% loss to scarring
- No field spraying
- Ants under calyx but not problem for China
- Spray with fungicide
- Average farm size 3-5 ha. Mixed mangosteen, coffee, coconut, papaya, etc
- GAP from DoA
    - Inspect farm monthly
    - Need to renew GAP yearly
    - Free service
- Thai total of 64,000 ha with production of 270,000 tonnes
- 4.2 t/ha
- Peak is July – August in South. Harvest Jan-Nov
- Peak is April-June in East
- Main areas:
    1. Chantaburi
    2. Nakhon Si Thammarat
    3. Chumphon
    4. Trat
    5. Rayong
- Early season 150 B/kg; mid season 20 B

Figure 6: Dr Darda making a point in meeting

Figure 7: Dr. Yupin, Dr. Nantarat, Dr. Sureerat Panyatona , and assistant at Chumphon Horticulture Research Station

Mangosteen shed of Mr Prasit Searmsab (Sinhoua Packing House)

Sinhoua Packing House (Season Fresh Company Ltd), Lungsuan District

Crop:

- 30-40 t/day in peak
- Peak is July-August
- Start July – October
- 100 workers at peak. 25 B/ha. Min of 8 hours. Most local but some other areas

Prices & Shed:

- Price to farmer depends on market. Pay direct
- Most fruit from farmers, not collectors
- 100 farmers, many are small
- Fruit graded at shed as opposed to Chantaburi shed where more done on farm
- About 20 sheds in areas
- His shed has a cool room
- No fruit bought on tree but sometimes may pay some retainer to get fruit
- Shed costs – 5.5B/kg charge
- Sooty mould an issue

- 4 grades + undergrade
- ± scaring = 10 grades

- Said sheds compete on price for grower fruit
- Prices posted on sheds daily
- Said grower service also important factor
- Also sheds compete for China market

Exports :

- 70-80% early but then this drops to 40% later. Size issue
- Most to China or local. 30 days by sea to China, 12-13 days by truck
- Vietnam a new market but they want larger size
- US and Australia are too much hassle
- Benomyl (banned in Australia and I think they mentioned banned in Thailand) used as spray in carton. General protectant for China. New container!

Durian shed of Sinhoua Packing House

- Packing some out of season fruit when we were there
- Fruit not ripe so cut stem and paint Ethephon
- Rate varies as needed
- Also adjust temp in containers to control speed of ripening
- Sent to China

Group Mangosteen farms in Luang Suan District

Grower group of 70 farms
Have mangosteen and some other fruits like sweet orange
Group meets monthly to discuss issues

Owner (Mr. Chulee) whom we visited had a very big house
His is common collection site for group
Each grower does own grading

They ***auction their fruit.***
Owners of packing sheds bid
Now second year
Feel better prices as good quality fruit
Low quality producers sell direct to pack shed
If market price is 12 B, they get 50B at auction

Use both organic and chemical fertilisers
60% organic
40% inorganic – mainly pre flower as need high P at flowering
- 15-15-15
- 16-16-16
- 13-13-21

Do soil and leaf yearly. Done by Land Development Department. 5 spots in test over 2 ha
Use 3-5 kg of organic and max of 2.5 kg of inorganic (less than Chantaburi)

Group used to use SOP book
Now taught by chief based on experience of team, Sometimes DoA helps
Keep records
All have GAP certificate

Some use irrigation, some don't
Sandy to clay soil – said wide range over group

Average tree age 30 YO
Production of 100 kg/tree/year
Consistent with management

Need 30-45 dry days to induce flowering. Most important factor

Pest and disease

Piak Fai = thrips
Leaf eating caterpillars = what are they??. Had been quite active on some trees
Leaf miner not a problem

Insecticides for thrips. Said to alternate
- Regent
- Cypermethrin
- Karate?
- Confidor

Use sprinklers in trees
Thrips most important problem.

Prune post harvest and fertiliser
Tree structure open with no obvious topping

Figure 8: The ugly and the good

Another farm

Lady in wheelchair – fell out of mangosteen 10 years ago
Has some 100 year old trees
Mixed orchard with mangosteen, langsat, longkong, nutmeg, etc
All very tall and jungle
~3 rai (~6 rai=1 ha)
Organic orchard
Labour gets 30+% of price to harvest. Owner at disadvantage

Many thrip marked fruit
No spraying

Many very early trees but poor quality.

Department of Agriculture Horticulture Research Institute at Kasasart University

We had good discussions with Dr Suwit Chaikiattiyos suwitdoa@yahoo.com who is the new Director of Hort Rec Centre. Ex Chataburi, planning, Ex UQ. Knows FNQ. Part of work was with Dr Chris Menzel from Nambour.

Haposan said he noted that

- Irrigation is very important –not done in Indo
- Packing houses – who grades, prices
- Indo exports 30% only
- Main contrast with Indo – less scarring and yellow latex – due to better water and management

Dr Suwit mentioned use of CO2 in research to increase rate of tree growth

Thai export ~50%

Figure 9: Dr Suwit receiving presentation from Haposan

The garden in honor of her Royal Highness Princess Maha Chakri Sirindhorn on her 55th birthday

(refer also to Appendix A)

The garden on ex rice paddy land has a large germplasm collection of rare and endangered plant species. There are more than 600 species which are divided into 7 groups

1. Vegetables
2. Scented plants
3. Thai Palms
4. Local plants
5. Economic plants
6. Medicinal plants
7. Bamboos.

This was well laid out and it would have been easy to spend a day just looking at the various plants.

The Garden also has a Learning Centre for H.M. King's New Theory in agriculture.

The King's philosophy to help poor farmers is that each with 2 ha of land which should be divided into 4 parts:

30% for a pond to conserve water for the dry season
30% is for rice cultivation
30% is for growing of fruits and perennials trees as main crop and for growing vegetables, field crops and herbs as intercrops
10% is for accommodation, rice barn and mushroom cultivation

The garden has a number of fruit tree plots interplanted with vegetables and other crops

Post Harvest and Processing Office

New section of DoA in 2004
Fruit & Vegetables and rubber
Agricultural products

Given a general introduction and the various sections and roles

Mangosteen work

- Juice –browning issue
- Jelly
- Jams
- Leather
- Freeze puree

Dr Komate Satayawat

- Xante wine – copyrighted. 12% alcohol
- Sell in Europe
- Feels big market in Indo (we mentioned most Indonesians are Muslim and do not drink)
- Whole fruit used

Talk was way over the head of everyone and of limited interest

Dr Wilaisri Limphapayom talked on cosmetics
Such as seen in village in Chataburi
Rind is 60-70% of fruit
Anti bacterial

Soap
Lotion – dry skin
Hygiene hand lotion

Durian seed powder – spray dry

Whole visit basically a waste of time

Nothing much learned,
Would not supply copy of talks

Au Tor Kor Wholesale market

(See also Appendix B)

80 ha of extensive facilities on the outskirts of Bangkok
Operates 24 hours/day.
Very large, clean facilities
Different sheds/areas for different crops

- Flower market
- Orange market
- Mixed fruit market
- Possec (Perishable one stop service export centre)
- Seasonal fruit ground
- Fish market
- Cold storage
- Crop market
- Vegetable market
- Fresh food market
- Meat market
- Fish and seafood market

Orange shed

- Only oranges – no other citrus
- Oranges are sweet oranges which are a mandarin type
- Fruit graded by size
- Sell both fresh and juice
- Said fruit from upper lands have less flavour than from drained paddy land with raised beds

Mixed fruit shed

- Pomegranate, pears, apples, persimmon from China
- NZ Granny Smith apples
- No local fruit
- No Oz fruit

Seasonal fruit shed

- Rambutan, papaya, Dragon fruit (Viet), longkong, sapodilla, Carambola
- Mangosteen had bad scarring. 18 B/kg
- Pomello. Said Viet was best
- Longan off season. 38 B/kg in 15 kg basket. E Daw cultivar
- Grapes – red and white
  - Thailand

    - 40B/kg if fruit bound together, 28 B if non bound.
- Papaya was 18-25B/kg in 20 kg baskets. 40B in shops
    - Cheap this time of year
- Jujube
    - 10 B/kg for medium size
    - 16-30 for bigger
    - Local 12-15 B for small fruit
- Mango
    - Chin Hua – China Cv grown in Thai
    - Very large 1 kg
    - Not much colour
    - Eat ripe –said sweet
    - Teds friend Sainarong said not good flavour
    - Teds sister in law said sour, no good green
    - 40B/kg sold to Malaysia
    - All exported

    - Nam Dok Mai
    - 1st to Singapore 80 B/kg
    - 2nd to Malaysia at 50 B
- Custard apples
    - African Pride and Pond Apple type
    - Thai prefer Pond apple type

Wrap up meeting

Group disappointed they did not see harvest
Want to return in April to see harvest and packing shed operation

Lack of Malay translator was not seen as an issue. People asked questions later

Post harvest and processing – not so good. Too technical for all

Benefits seen:

- GAP for irrigation, pruning and fertiliser
- Yellow latex and scarring better with irrigation

Growers felt good benefit

- Already had some information before tour, but now could see for themselves
- Shorter trees a good idea
- Want to see quality midseason as quality of out of season fruit was less than in Indonesia
- Prices more transparent here. Prices posted at pack house and growers can compare

Exporter Rony said:

- Same here as Indo
- Need to synergize Thai and Lao
- Fruit quality – can see benefits from better quality and quantity of all commodities
- Like idea of Kings garden and growing various things.
- Really seemed to have different ideas than rest of group

Dr. Darda

- Sees some more work on fertiliser, thinning, irrigation
- Need to boost Indonesian exports from 30 to 50%
- Some overlap in December fruit Indo and Chumphon
- More mature trees here
- More \efficient in transport and harvest sheds

Idea of income from 2 ha good

Need more farmer links in Indo with packing sheds and exports as here. Need group of all

Aji

- Uplift farmer spirits with fruit quantity and quality of life.
- Aji felt he was good farmer but now sees he can do better
- Aji liked good packing and value added
- Aji– do not sell fruit before harvest for low price as is currently done. Better here. Maybe need some microfinance help

More people in Thai working as group. Different crops on farm and hence more consistent income

They can go back and help other growers

Indonesia far behind in post harvest and processing

Note:

The Thai DOA Horticulture Research Institute/Centres were very professional and helpful. They did an excellent job. All participants were given a number of fruit publications.

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Appendix 11.22b Report on Thailand study tour by Haposan, DGH

THE COMPARATIVE STUDY OF MANGOSTEEN AGRIBISNIS TO THAILAND (THE ACIAR CO-OPERATION)

Report by Haposan, DGH

On the occasion of to increase mangosteens competitiveness in the international market, the Directorate General of Horticulture established the co-operation with the Australian Government through the Memorandum of Subsidiary Arrangment (Project no.Hort/2006/146) with the title ***"Management of fruit quality and pest investation on mangosteen to meet technical market accees requirements"***

One of the activities that was carried out during 2010 was study comparative of mangosteens agribusiness to Thailand that aimed at increasing the concept and knowledge of the perpetrators of efforts of mangosteens agribusiness.

In accordance with the document, this visit activity was carried out together with some holder related like the farmer, the collector from production centres (Bogor,Subang and Tasik malaya) and the exporter (PT. Agung Mustika Selaras) as well as the researcher's from the centre for study sub-tropical fruit-IPB Bogor. The visit was carried out on October 26 up until November 2, 2010 with the object of the visit in part: production centres of Thai mangosteens (the province Chantabury and Chumpon), the horticultural research centre(Bangkok, Chantabury and Chumpon) ,Packing house/the collector's warehouse and whole sale market of horticulture (Au Tor Kor Market).

Some information that was received from this visit including being:

I. THE FARMING AND THE APPLICATION OF TECHNOLOGY

1. In general ownership of the fruit farm to Thailand was big enough (2-3 ha/the family).

2. There are 5 production center of mangosteen which located in Province Chantaburry, Chumpon, Nakhonsitamarat, Trat dan Rayong)

3. Although mangosteen orchard which is managed by farmers generally still mix (there are also some other commodities such as durian, rambutan, coffee, bananas and others), but dominates mangosteen with regular spacing (10 x 10m).

4. The whole mangosteen development zone has been facilitated by irrigation facilities capable of supplying water to each crop in particulary the dry season. (according to the researchers this is what makes the quality of the resulting relatife

good with mangosteen fruit infected by yellow gum and mottled y sap is only about 5%). According to our farmers yellow gum and mottled sap is the main problem that resulted in fruit that can be exported is still limited.

5. Approximately 70-80% of production mangosteen Thailand has been able to penetrate foreign markets, especially China (90%), Korean, Japanese and Vietnam.

6. Mangosteen are generally aged between 30-100 years with an average productivity 100kg/tree. Productivity of this size can also be obtained by our farmers, but not permanent (fluctuate), whereas in Thailand according to farmers and researchers recognition productivity is constant from year to year.

7. Maintenance is done by the farmer include: fertilization (2-3 times per year) pruning shoots (plant height about 4-5 meters) and thinning of fruit.
8. The farm has register with validity period of 1 year
9. Mangosteen harvest season April - August

II. POST HARVEST / CHAIN MARKETING (SCM)

1. Sorting and grading done by the farmers. Grading consists of 5 classes, both smooth fruit and fruit that contain dotted.

2. Chain marketing of mangosteen in Thailand is relatively shorter, as most farmers own transport their harvest to the packing house by using minitruck, while small farmers use the services of middlemen. Farmers brought their products to the packing house by using a plastic bucket capacity of 20 kg, while for the export of mangosteen is packaged in a plastic basket 9kg size.

3. There are about 30 packing houses in every province where there are about 10 packing houses with a capacity of 80-100 tons / day of which 20 units are with a capacity of 30-40ton / day.

4. Packing house, especially at harvest time every morning will prevailing price that day, so each farmer can have to the packing house which sold its products.

5. Packing house services about 4-5 baht / kg which is used for payment of the cost of labor (25 baht / hour during 8 hours) ,electricity costs etc..

6. The time required since the harvest so that the product until departure(?) between 8-12 hours

7. Shipping mangosteen to China at this time carried by road to the crossing of Vietnam, Myanmar and Burma and takes about 12-15 days (agreement quarantine).

III. **INSTITUTIONAL**

1. Institutional farmers in production centers in the form of Farmer Groups with a relatively large membership of 75-100 people.
2. Function groups tend only to coordinate the technical problems of the field, while for market access made each farmer.
3. Capital farmers already strong enough so that there is no system of marketing with bonded / blow.

according to phonetics

CONCLUSION

1. This visit has added insights of all participants, especially regarding efforts to improve the quality of fruit mangosteen including the implementation of SOPs, maintenance and implementation of post-harvest technology.

2. Mangosteen marketing supply chain in Thailand is relatively shorter than the farmers into (collector) to the packing houses and exporters.

3. Scale farming in Thailand mangosteen relative larger to the average land ownership 2-3ha/kk.

4. Performance of mangosteen garden relatively better with regular spacing, although grown commodity mix with other fruits.

5. Most of the farm and packing house mangosteen has been registered with the validity period of 1 year.

6. Thailand Productivity mangosteen productivity to Indonesia, but Indonesia is more volatile compared with Thailand.

7. The successful development of mangosteen in Thailand most influenced of the role and research institutions and the seriousness of the farmers in the application of technology mangosteen.

Jakarta, 10 November 2010

Participants :

1. Haposan Simanjuntak
2. Samsuardi
3. Aji Gunawan
4. Nanang Koswara
5. Asep Syarip Hidayat
6. Rony Mansyur