Australian Government
Australian Centre for International Agricultural Research

Final report C2

Program

Improved domestic profitability and export competitiveness of selected fruit value chains in the southern Philippines.

Component

Component 2 – Integrated management of Phytophthora diseases of durian and jackfruit in the southern Philippines

project number	HORT2007/067-2
date published	2022
prepared by	Rosalie Daniel, David Guest The University of Sydney
co-authors/ contributors/ collaborators	Lucia Borines, Visayas State University Concepcion Soguilon, Bureau of Plant Industries
approved by	Irene Kernot
final report number	FR2022-024-C2
ISBN	Refer to FR2022-024-C6
published by	ACIAR GPO Box 1571 Canberra ACT 2601 Australia

Contents

1 Acknowledgments

We would like to acknowledge the input, commitment and enthusiasm of the farmers, extension staff and researchers who participated in the field trials to test the disease management strategies. The results from their trials have helped to shape the orchard management recommendations for the jackfruit and durian industries in the Philippines.

2 Executive summary

'*Integrated management of Phytophthora diseases of durian and jackfruit in the southern Philippines'* is one of 10 components that comprise the ACIAR Program HORT/2007/067. The Component aimed to address the major disease problems affecting jackfruit and durian production in the southern Philippines by testing disease management strategies in order to develop a package of options that could be presented to farmers and industry stakeholders.

Jackfruit and durian are marketed as 'flagship fruit' for their respective regions, the Eastern Visayas and Mindanao. Both fruits are high-value, commanding high prices with the potential to provide sustainable incomes for local farmers through domestic markets, and the prospect of being developed for export as quality and production increase and infrastructure improves.

At the beginning of the project, a workshop involving growers, researchers, extension staff and industry stakeholders was held to identify key constraints to the production of durian and jackfruit, currently available management strategies, sources of information and support for growers, and potential constraints to the adoption of new technologies. Participants were given theoretical and hands-on practical training on the biology, epidemiology and management of Phytophthora diseases, and in the design and conduct of on-farm trials. Participants then developed proposals to test farm management strategies on yield, disease losses and productivity in on-farm PAR trials.

Phytophthora disease was identified as a major limitation to the production of durian, but little information about management was available or disseminated to growers. Jackfruit has been promoted throughout the Eastern Visayas through a 'plant now, pay later' scheme. A disease survey conducted at the start of this project showed that in some cases as many as 100% of jackfruit trees in some orchards were affected by a decline syndrome progressing from leaf yellowing, leaf drop, girdling stem lesions and root rot, to tree death. *Phytophthora palmivora* was identified as the cause of this decline. Diagnosing the cause of jackfruit decline was fundamental to the development and dissemination of disease management strategies.

A high level of disease in jackfruit and durian nurseries, as a result of poor nursery practices, is also likely to have contributed to the spread of the pathogen and the incidence of disease. Seedlings were propagated in unsterilised soil and maintained on the ground, increasing the risk of infection by Phytophthora. Most of the planting material distributed through the 'plant now pay later' schemes came from these nurseries. Through this project, best practice nursery practices (such as raised benches and clean potting medium) have been introduced and efforts are now being made by the DA-RIARC (Department of Agriculture) to establish a nursery accreditation scheme.

Diagnostic capacity was limited and disease management strategies were underdeveloped and poorly disseminated. Durian and jackfruit growers and industry representatives were often unaware of the cause of the disease and effective disease management strategies. Improved orchard management was seen as a way of reducing disease losses, leading to sustained increased yields and higher fruit quality.

A participatory action research (PAR) approach was implemented to test and disseminate technologies for disease management in durian and jackfruit. PAR trials were established in collaboration with jackfruit and durian farmers, extension staff, agriculture officers, academics and researchers. Yield and disease data were collected and presented at a final workshop. The results were used to develop management recommendations for each industry. In jackfruit, improving drainage, application of organic materials and application of plant defence activators were particularly effective at reducing disease incidence and severity. In the durian trials, application of Garden Balsam extract, application of chicken manure and EM4 (Effective Microorganisms) and phosphonate were very effective against

Phytophthora. In some cases methods tested to manage Phytophthora were not effective, highlighting the importance of knowing to to critically evaluate potential control methods before recommending it to growers.

The low-, medium- and high-level input options identified during the workshops were tailored for adoption by growers from a range of backgrounds, resources and capacity. The recommendations were first presented at the Tagum City Durian Festival in September 2011, and were subsequently disseminated through farmer field days and training sessions with extension staff in collaboration with local government units.

3 Background

Component 2 '*Integrated management of Phytophthora diseases of durian and jackfruit in the southern Philippines'* is one of 10 components that comprise the ACIAR Program HORT/2007/067 '*Improved domestic profitability and export competitiveness of selected fruit value chains in the southern Philippines'*. The component aimed to identify and address the major disease problems affecting jackfruit and durian production and to test disease management strategies in order to develop recommendations to present to the industries as a series of options to accommodate growers from a range of backgrounds, capacity and resources.

The ACIAR Southern Philippines Fruit Program was administered by DEEDI, Queensland, and The University of Sydney was sub-contracted to design and deliver Component 2. This structure aimed to ensure good coordination of the program and to foster collaborations between projects. Unfortunately, it seemed to complicate the management of the project. From the beginning it was unclear what level of control DEEDI had over the project and its budget, and clarification from the RPM was required. The flow of information from DEEDI to the University of Sydney during the project was poor, and although we made many approaches to coordinate project activities, few of the potential benefits of collaboration were realised.

Jackfruit and durian are marketed as 'flagship fruit' for their respective regions, the Eastern Visayas and Mindanao. Both fruits are high-value, commanding high prices with the potential to provide sustainable incomes for local farmers through domestic markets, and the prospect of being developed for export, as quality and production increase and infrastructure improves.

Durian (*Durio zibenthinus* Murray; Bombacaceae) grows abundantly in the southern Philippines, notably in Mindanao. Almost 60 % of the durian grown in the Philippines is produced in Davao. A Plant Now Pay Later (PNPL) scheme was introduced in Davao del Norte and Comval Province in 1994 and is still being implemented by Local Government Units. The durian industry in Mindanao is composed of 80% smallholders with less than 1 ha of trees, often intercropped with other fruits or vegetables. While much of the durian produced is consumed domestically there is a large, unsatisfied demand from urban communities, particularly Manila. In 2005, approximately 47,296 metric tonnes of durian were harvested from more than 500,000 trees growing on 13,769 hectares (Philippine Bureau of Statistics (PBS), 2007). Since then, the yield has increased to 77,548 metric tonnes (PBS, 2010). Phytophthora was identified as a major limitation to durian production.

Jackfruit (*Artocarpus heterophyllus* Lam; Moraceae), known locally in the Philippines as 'Nangka', is grown throughout the country because of its ability to adapt to a range of growing conditions. In 2005, approximately 13,319 hectares of jackfruit were planted with a total jackfruit production of 52,647 metric tonnes, primarily coming from Mindanao, western Visayas and Luzon. From 1996 to 2008 jackfruit was promoted through a 'plant now, pay later' scheme resulting in large-scale plantings in the Eastern Visayas. A disease survey conducted at the start of this project showed that in some cases up to 100% of jackfruit trees were affected by a decline syndrome manifesting as a sequence of leaf yellowing, leaf drop, girdling stem lesions and root rot. By 2008, many growers were replanting with alternative crops. Diagnosing the cause of jackfruit decline was critical to the development and dissemination of disease management strategies. Since the start of this project, *Phytophthora palmivora* has been isolated from diseased jackfruit trees across the Eastern Visayas and confirmed as the causal organism of the decline by fulfilling Koch's Postulates and pathogenicity testing.

A high level of disease in jackfruit and durian nurseries, as a result of poor nursery practices, is also likely to have contributed to the spread of disease through orchards.

Seedlings were propagated in unsterilised soil and maintained on the ground, increasing the risk of infection by Phytophthora, resulting in high levels of seedling death. Most of the planting material distributed through the 'plant now pay later' schemes came from these nurseries.

Diagnostic capacity was limited, and disease management strategies were underdeveloped and poorly disseminated. Durian and jackfruit growers were unaware of the cause of the disease and of the availability of any effective disease management strategies. Improved orchard management was seen as a way of reducing disease losses, leading to sustained increased yields and higher fruit quality.

Participatory Action Research (PAR) has been used as an effective means for testing and disseminating new technologies to farmers (Black 2000). It also provides an opportunity to train participants in the design and execution of scientific experiments to critically evaluate the effectiveness of alternative disease management tools. In this project, 20 PAR trials were initiated in collaboration with jackfruit and durian farmers, extension staff, agriculture officers, academics and researchers. Each PAR participant tested a management strategy on his/her farm or in collaboration with a grower, where the collaborator was from a research institute or government agency. Yield and disease incidence data were collected throughout the trials and presented by the PAR participants at the final workshop. The results were used to develop disease recommendations for each industry. These recommendations were disseminated to the respective industries through farmer field days, training of extension staff and public forums.

4 Objectives

The overall aim of Component 2 was to improve the productivity of jackfruit growing in the Eastern Visayas and durian productivity in Mindanao. The project linked closely to previous ACIAR projects (PHT/1995/134 (*Phytophthora management in durian*), PHT/1996/153 (*Survey and Importance of Phytophthora in Southeast Asia*), CP/2000/102 (*Selection of improved quality and resistance to Phytophthora pod rot, cocoa borer and vascular streak dieback in cocoa in Indonesia*) in which a range of disease management strategies were developed and assessed. These strategies formed the basis of the disease management strategies tested in the current project.

The specific objectives are outlined below.

1. Identify key constraints to jackfruit and durian productivity

   A stakeholder workshop involving growers, industry representatives, scientists and extension staff was held at the commencement of the project to identify key constraints to production, to identify the current crop management practices and strategies and to evaluate information currently available.

2. Diagnose jackfruit decline symptoms in the southern Philippines

   Jackfruit decline in the Eastern Visayas was quantified through disease surveys in terms of occurrence and crop loss. The causal organism was identified and confirmed as the pathogen using Koch's Postulates. The aetiology of the pathogen was also determined.

3. Implement farmer trials to test farm management strategies on yield, disease losses and productivity

   Growers, extension workers, agricultural officers and researchers tested potential disease management strategies on jackfruit and durian farms using a PAR approach.

4. Evaluate and implement a limited series of disease management options designed for farmers of various backgrounds and capacity

   On the basis of appropriateness, cost-benefit and effectiveness, a limited series of integrated strategies were identified and disseminated to growers, scientists and extension workers.

This component aimed to link with Component 1 to share workshops, field days and other extension activities to improve crop management strategies in papaya. It was anticipated that many of the crop management strategies applied in this component would show benefits in Component 1.

This component also aimed to share cost-benefit and other economic information with Component 5 to develop an economic analysis of the management strategies.

5 Methodology

The activities for Component 2 were conducted on jackfruit and durian farms and nurseries in the Eastern Visayas (Samar, Leyte) and Mindanao because these areas have been identified as the flagship regions for jackfruit and durian, respectively. Activities involved the Australian and Filipino project leaders, jackfruit and durian farmers, local government agricultural officers, nursery staff, University researchers and Bureau of Plant Industry staff.

Objective 1. To identify key constraints to jackfruit and durian productivity

Activities

1.1 Stakeholder workshops

A three-day start-up workshop was run by the Australian project team at Del Monte's Camp Phillips, Mindanao in July 2008. Thirty-five people representing private industry, government organisations, universities and farmers from the jackfruit, durian and papaya (Component 1) industries participated in the workshop. The workshop included a summary of the Component aims and objectives, small group discussions and practical sessions.

Relevant information on pathogen biology, disease cycles, epidemiology, disease management exotic pests and diseases and PAR trial establishment and maintenance were presented in lectures. Participants were provided with a training manual. This information was supported by hands-on, practical diagnostic sessions that enabled participants to learn techniques for pathogen isolation and identification and to examine the isolated organisms under the microscope.

Small group discussions and a survey conducted during the workshop helped to identify farmer aspirations, constraints to production, potential pests and disease losses, current management strategies, current sources of advice and research priorities. The small group discussions were also used to integrate the information presented into the formulation of research questions for small-scale PAR trials to test individual strategies.

Participants were encouraged to test strategies in collaborative on-farm trials and to collect data to be presented at a second workshop toward the end of the project. The PAR trials served to develop and promote a range of levels of orchard management options from low to high input. The collaborating farmer, researcher or agricultural officer played a key role in demonstrating and disseminating the management strategies and information to other growers. PAR trial sites were used throughout the project for field days and farmer training.

1.2 Disease management

Disease surveys were conducted in 42 jackfruit orchards on Leyte, Samar and Biliran Islands and on durian orchards in six provinces in Region XI to determine the distribution and severity of Phytophthora disease in jackfruit and durian. The data can be related to climatic geographic and cultural information to provide a basis for the potential trial/demonstration sites and optimum management strategies. The jackfruit orchards in the Eastern Visayas are currently being mapped by a PCARRD-funded project led by Dr Elvira Torres of DA-EVIARC and Dr. Pastor Garcia from VSU.

Objective 2. To diagnose jackfruit decline symptoms in Leyte

Activities

2.1 Disease diagnosis (identification/Koch's postulates)

Plant and soil material was collected from jackfruit orchards during the disease survey. Potential pathogens were isolated by baiting with flower petals, eggplant, jackfruit leaves and seedlings and then plating onto selective medium. Once pure cultures were established, morphological and molecular techniques were used to identify the isolated organisms. Dr Lucia Borines and Ms Victoria Palermo from VSU travelled to Brisbane to spend one week in the laboratory of Dr André Drenth at the University of Queensland for specific training in the identification of Phytophthora species using morphological and fingerprinting techniques. They were also trained in conducting disease surveys and the maintenance of culture collections.

The isolated organisms were used to re-inoculate stems and leaves of jackfruit seedlings in the greenhouse to fulfil Koch's Postulates.

2.2 Aetiology Studies

Once the causal organism was confirmed by Koch's Postulates the pathogenicity and general aetiology were studied in a greenhouse trial at Visayas State University (VSU). Roots, stems and leaves of seedlings were inoculated and re-isolations made from inoculated plant material.

Objective 3. To implement farmer trials to test farm management strategies on yield, disease losses and productivity

Activities:

3.1 Farmer training workshop

A start-up training workshop, attended by 20 jackfruit and durian growers and industry representatives, and 10 papaya stakeholders, was run by the Australian project team in July 2008, as described in Section 1.1. Additional farmer training workshops and farmer field days were held throughout the project in Leyte, Samar and Mindanao. These were held at VSU, local agricultural offices or at the PAR sites and were organised by the Filipino partners. Participants included farmers, agricultural extension staff and other industry stakeholders.

3.2 Farmer PAR trials

Participants discussed and identified topics for the PAR trials at the first workshop held at Camp Phillips, Del Monte, in July 2008. The PAR trials (10 jackfruit, 10 durian) were established in 2008 – 2009 in collaboration with jackfruit and durian growers, university researchers, agricultural extension staff and industry stakeholders to test management strategies on yield, disease losses and productivity (Appendix I). Each participating researcher was responsible for designing a project to test a control measure and for collecting, collating, analysing and presenting data (with feedback provided by project leaders throughout).

The trials were visited throughout the project to monitor establishment and maintenance and changes in the crops and to make suggestions, if required. Collaborators evaluated the tested farm management strategies in the second workshop to develop a series of management options designed for farmers of various backgrounds and capacity.

3.3 Follow-up workshop

A follow-up workshop attended by nine of the participating jackfruit PAR collaborators and two durian participants was held at VSU in July 2011. All PAR collaborators presented the outcomes from their trials. From these trial results, a series of management options

was discussed and identified by participants. In September 2011, the final workshop for the durian component was held in Tagum City. The workshop was attended by all durian PAR collaborators, nine of the jackfruit PAR collaborators and three durian experts from Thailand and Vietnam. A series of management strategies were formulated by workshop participants from the results of the durian PAR trials. The disease management options from the jackfruit and durian sub-components were presented at a public forum held during the Tagum City Durian Festival on 21 September 2011.

Objective 4. To evaluate and implement a limited series of management options designed for farmers of various backgrounds and capacity

Activities

4.1 Evaluation of strategies and options for PAR trials

Based on information gathered from Objective 3, yield and disease severity, and a cost-benefit analysis were examined by project team members for the jackfruit PAR trials and some durian trials. The outcomes were presented at the final workshops.

Detailed economic analyses were conducted for the recommended options by Component 5. Lemuel Preciados (Component 5) participated in the final jackfruit and durian workshops and has compiled the analyses in the report for HORT2007/067/5.

4.2 Formulation of 'best' options

The disease management options identified during the final workshops were formulated into a limited number of management packages for dissemination to the broader jackfruit and durian industries. The options identified are suitable for adoption by farmers from a range of backgrounds, capacity and resources.

4.3 Design and implementation of dissemination strategies

The disease management options from 4.2 were disseminated to growers, industry, scientists and technicians using a range of strategies. The recommendations for both industries were first presented at the public forum during the Tagum City Durian Festival in September 2011.

Training has been conducted in collaboration with Municipal Agriculture Offices to disseminate the recommendations developed during the final workshop.

A video promoting the IPDM technologies was developed through an ACIAR Small Research Activity (Gordon Rogers and Sharron Olivier). This video was disseminated to participants during the training, and is available on "YouTube".

4.4 Evaluation of 'best' options and implementation

The 'best' options for disease management in durian and jackfruit orchards and nurseries were evaluated at the final workshops held in July and September 2011 (Objective 3.3). Each PAR collaborator presented the results of their trial at the workshop. Group discussions considered and evaluated the results and to formulate a series of draft recommendations that packaged the management recommendations into low-, medium- and high- input options.

The impact of the workshops and PAR trials was monitored using Bennett's Hierarchy, and responses to a questionnaire at the first and final workshops (Appendix II).

6 Achievements against activities and outputs/milestones

Objective 1: To identify key constraints to jackfruit and durian productivity

no.	activity	outputs/ milestones	completion date	comments
1.1	Stakeholder workshops	Identify key constraints to jackfruit and durian productivity	2008 and 2011	The final workshop for the jackfruit component was held in July 2011 at Visayas State University (VSU). The 10 participating jackfruit farmers and stakeholders presented the outcomes of their research trials. The final workshop for the durian component was held in September 2011 and was attended by participating durian famers and stakeholders as well as the jackfruit farmer researchers. Collaborators from previous ACIAR projects from Vietnam (Mr Mai Van Tri and Dr Nguyen Van Hoa, SOFRI) and one from Thailand (Prof. Somsiri Sangchote, Kasetsart University) also participated in the workshop. Their attendance and presentations at the public forum held during the Tagum City Durian Festival created much discussion about the differences in jackfruit and durian production and processing in Thailand, Vietnam and the Philippines. It is anticipated that new linkages will develop between the three countries. The data collected from surveys conducted during the final workshops to determine changes in participant skills and attitudes toward disease management were also currently being analysed (Appendix I).
1.2	Disease survey	List of major diseases of jackfruit (distribution and severity)	2011	Farms on Leyte and Samar were surveyed beginning in 2008. Soil and plant samples were taken to the laboratory at VSU to diagnose the cause of jackfruit decline. Following the training visit by jackfruit component partners (see 2.1 below) in September 2010 the disease survey was improved and continued. Farm size, number and age of trees, and disease incidence were recorded and additional soil and plant samples taken for laboratory analysis. Isolates of Phytophthora are now stored in a labelled culture collection at VSU. The major disease problem in all orchards is jackfruit decline caused by *Phytophthora palmivora*. This was confirmed by ITS sequencing. The incidence of disease due to Phytophthora incidence in jackfruit orchards in Leyte and Samar ranged from 5% in recently (<5y) established orchards to 100% in older (>8 y) orchards. High disease incidence was associated with periodic flooding and poor drainage. Other minor disease problems include sooty mould, fruit rots caused by Phytophthora, Sclerotium, Rhizoctonia, Lasiodiplodia and Colletotrichum and fruit bronzing, possibly caused by a bacterial pathogen. Phytophthora was also identified as the most serious cause of disease on durian. In Davao City and Davao del Norte disease incidence was as high as 30% in some orchards. Other diseases included Rhizoctonia, Downey Mildew and Pink Disease.

PC = partner country, A = Australia

Objective 2: To diagnose jackfruit decline symptoms in Leyte

no.	activity	outputs/ milestones	completion date	comments
2.1	Disease diagnosis	Koch's Postulates	2011	*Phytophthora* species have been identified as causing the decline of jackfruit in Leyte and Samar. *Phytophthora palmivora* was routinely isolated from diseased jackfruit trees. Cultures isolated during the disease survey were sequenced at the University of Queensland, Australia to confirm their identity. When used to inoculate healthy jackfruit seedlings in the greenhouse, the isolated *P. palmivora* resulted in the development of symptoms similar to those observed in the field, confirming Koch's postulates and *P. palmivora* and as the causal organism(s) of jackfruit decline.
2.2	Aetiology studies	Identification of causal organism(s) Understanding of lifecycle etc. of causal organisms	2010	The cultural and morphological characteristics of the isolates collected during the disease survey were studied and compared to published characteristics and cultures of known isolates of Phytophthora. The first species of Phytophthora isolated during the initial orchard surveys was identified as *P. palmivora* at the University of Queensland. Dr Lucia Borines and Ms Victoria Palermo visited the University of Queensland in September 2010 to undergo training in morphological and molecular diagnostics with Dr André Drenth. The training significantly improved the capacity and diagnostic skills of the Filipino project partners. Since their return to the Philippines they have re-sampled farms across the Eastern Visayas and established pure cultures of isolated organisms for accurate identification. Procedures used in establishing and maintaining the culture collection were improved. Pathogenicity and morphology studies have been conducted on the collected isolates.

PC = partner country, A = Australia

Objective 3: To implement farmer trials to test farm management strategies on yield, disease losses and productivity

no.	activity	outputs/ milestones	completion date	comments
3.1	Farmer training workshops	Training is given at the workshop on the biology and management of Phytophthora diseases, fruit fly management and other plant health issues		A start up workshop was run by Australian project staff in July 2008 at Del Monte, Camp Phillips, Mindanao. Participants from Component 1 and 2 were trained in diagnostics, pathogen biology and epidemiology, plant health, disease and orchard management with a particular emphasis on Phytophthora. The information presented is relevant to overall plant health and orchard management. Throughout the project, training workshops and farmer field days were organised by project collaborators in Leyte, Samar and Mindanao. These were held in local agricultural offices or at the field sites that formed part of this project's PAR sites. Participants included farmers, agricultural extension staff and other industry stakeholders.
3.2	Farmer PAR trials	Trials are established	2009	Participatory trials (Appendix I) were established in collaboration with jackfruit and durian growers, university researchers, agricultural extension staff and industry stakeholders in Leyte, Samar and Mindanao. Each participating researcher was responsible for designing a project to test a control measure (with feedback provided by project leaders) and for collecting, collating and presenting data. Trial sites were visited regularly by project leaders to observe changes in the crops, provide feedback and to suggest changes if necessary. Results of the trials, as presented by PAR participants in the final workshop, are reported in Appendix V.
3.3	Follow up workshop	Packages of management options tailored to different input levels	2011	A follow-up workshop attended by nine of the participating jackfruit researchers and two durian component participants was held in July 2011 at VSU. All researchers presented the outcomes from their trials. From these trials, a series of management options was discussed and identified by participants. In September, the final workshop for the durian component was held in Tagum City. It was attended by all durian participants, nine of the jackfruit researchers and three international durian experts from Thailand and Vietnam. A series of management options was formulated for the durian industry based on the results of PAR trials by workshop participants. These options were collated and presented at a public forum held during the Tagum City Durian Festival, 21 September 2011. A field day, which included a visit to three of the PAR trials around Tagum City, was held as part of the Durian Festival. At each farm, the participating farmer or researcher demonstrated methods used for disease management at the site and described their experiences. Approximately 40 people attended the farm visits. A public forum, supported by the Tagum City Mayor, was held on 21 September 2011 as part of the Durian Festival. Collaborators from previous ACIAR projects in Thailand and Vietnam presented at the forum generating much discussion and interest amongst 200 or so forum participants. The attendance of the three international experts (at their own expense) established new linkages between researchers from the two countries. Recommendations developed during the final project workshops were presented by the Filipino durian and jackfruit component leaders, and farmers who participated in the research trials gave testimonies about their experiences (Appendix III).

PC = partner country, A = Australia

Objective 4: To evaluate and implement a limited series of management options designed for farmers of various backgrounds and capacity

no.	activity	outputs/ milestones	completion date	comments
4.1	Evaluation of strategies and options for PAR trials	Data from PAR trials Data critically evaluated by stakeholders	2011	Data from PAR trials has been collected, collated and analysed. PAR participants critically evaluated the outcomes of the trials to present at the final workshops. The establishment of trials on the farms in collaboration with farmers and researchers or extension officers enabled farmers to understand the biology and epidemiology of the control measures as well as the directly observe changes in the severity and incidence of disease in their crops. The on-farm trials also improved the communication between farmers and extension agencies, strengthening relationships for future collaborations. Some farms, particularly in the durian industry, are managed by caretakers. If the caretaker did not participate in training (instead the owner went along), then the caretaker's skills and capacity have not changed.
4.2	Evaluation of 'best' options	Comparative economic analysis of management options Draft management options	2011	Cost-benefit analyses have been conducted for many of the jackfruit management options and some of the durian options. Economic analyses were conducted for the recommended options (Component 5). Lemuel Preciados (Component 5) participated in the final jackfruit and durian workshops. Draft management options have been developed and were presented at the public forum during the Tagum City Durian Festival (Appendix III). Good nursery management was seen as the first line of defence against soilborne pathogens such as *P. palmivora.* Raised benches and composted and amended potting medium significantly reduced disease incidence in seedlings, both in jackfruit and durian nurseries. Improving drainage by mounding or construction of drainage channels was shown to have a significant impact in reducing disease severity in established jackfruit orchards. The application of organic materials (mulches and soil amendments) and manures was beneficial in reducing disease incidence and severity in both jackfruit and durian orchards. In some cases, the indigenous farmer practices are as effective, or more effective than commercially available products. Application of Garden Balsam to Phytophthora cankers successfully healed cankers on infected durian trees. This control measure is particularly beneficial because the farmers can produce their own Garden Balsam, meaning they do not need to spend money on chemical control. Similarly, durian trees treated with locally available products such as coir dust ,"madre de cacao" (also known as kakawate or *Gliricidia sepium*), panyawan and hot chilli as a biopesticide showed better recovery than trees treated with commercially available control agents. Some trials, such as the application of goat urine or Trichoderma, had no effect on the incidence or severity of disease. The results highlight the importance of testing disease management measures in the field before broad scale adoption is encouraged.

4.3	Design and implementation of dissemination strategies	Dissemination strategies designed and implemented	2011, but ongoing	Recommendations developed from the PAR trials were disseminated by organising field days and workshops in collaboration with LGUs. Since January of 2012, up to 10 municipal agricultural extension technicians from five provinces have been trained in Phytophthora disease recognition, diagnosis and management. Training has been conducted in Northern Samar (30 participants, extension workers), Eastern Samar (25 participants, agricultural extension workers and staff from the Eastern Samar State University who are in-charge of their jackfruit scion grove), Leyte (95 participants; extension workers and jackfruit farmers), Southern Leyte (extension workers) and Biliran Province (20 extension workers). Three workshops have also been conducted in Davao City, Mindanao to disseminate the recommendations to durian growers, agricultural technicians and students. Brochures outlining the low, medium and high management options for the jackfruit and durian industries have been developed and distributed during training sessions (Appendix IV). The jackfruit IPDM extension video (http://www.youtube.com/watch?v=jRmg_d3uxeE&noredirect=1; ACIAR Small Research Activity) was launched together with the training in the Leyte Province. In June 2012 it had more than 265 hits.
4.4	Evaluation of 'best' options and implementation	Management options are implemented on farms in strategic locations Monitor adoption, aim for 50%		Disease management strategies were established and tested on jackfruit and durian farms during the project. The results were analysed and evaluated to identify the 'best' management options for recommendation and dissemination to the industry. A series of low, medium and high options have been identified for the jackfruit and durian industries to cater for farmers from a range of backgrounds. Low management options require less financial input for farmers that may not have the resources to invest highly. As yield increase following application of improved management practices, the farmer's income increases, and they may choose to allocate more money to adopt higher management input levels. Some farmers that have attended field days held during the project have already implemented management strategies in their own orchards with good results.

7 Key results and discussion

Diagnosis and identification of new pathogen of jackfruit

Jackfruit decline was the biggest limitation to jackfruit production in the Eastern Visayas prior to the commencing of this project. The disease survey showed that in some orchards up to 95% of trees were affected by the disease. The diagnosis and identification of the causal organism was fundamental to the development of disease management strategies.

Development and implementation of nursery best practice and a nursery accreditation system

A high level of disease and incidence of seedling death in nurseries existed prior to the project. This was likely to have contributed to the spread of the pathogen. One durian and one jackfruit PAR collaborator tested improved hygiene practices in their nurseries, including raised benches and adding organic amendments to potting medium. These improvements significantly reduced seedling death. The positive results have led to the introduction of a nursery accreditation scheme by the DA-RIARC in the jackfruit industry. This is being supported by the Department of Agriculture through the Bureau of Plant Industry (Plant Nursery Accreditation Circular No. 2, 1993; Plant Nursery Accreditation Circular No. 6, 1994.) and aims to encourage plant nursery operators to produce and distribute disease-free plant materials. The Plant Nursery Accreditation Circular was amended again in 2006 entailing more stringent requirements.

Capacity building of scientists, researchers, extension staff and farmers

The capacity for disease diagnosis, disease surveys and testing and development of disease management strategies amongst researchers, agricultural officers and extension staff and farmers was limited. Disease management options were underdeveloped and poorly disseminated and as a result farmers had little knowledge of how to manage diseases in their crops. The diagnostic training received by Filipino partners at the University of Queensland significantly improved the capacity of local scientists to identify the causal organism. Furthermore, the training in the start-up workshop and the involvement of farmers and extension staff in the on-farm trials with regular visits from project leaders improved the understanding that those collaborators had about disease epidemiology and the pathogen. The collaborators learnt to design experiments, collect and analyse data and to evaluate these results to develop a series of management recommendations. These collaborators are now able to train and advise other farmers.

Strengthening of linkages between growers, research organisations and extension offices

The participatory (PAR) approach used to test disease management strategies in this project was highly effective in strengthening the relationships between growers, extension staff, local agricultural officers and researchers from a range of institutions. These linkages are unlikely to have developed without this project and the participatory approach. The participants involved in this project are now leaders in the industry involved in grower groups and industry activities, such as a proposed jackfruit festival in the Eastern Visayas to be organised by VSU and the Department of Agriculture in July 2012.

Development and promotion of disease management options for durian and jackfruit industries

A series of low-, medium- and high-input disease management options were collated during the final project workshops based on the results from the PAR trials, economic analyses and discussions among participants (Appendix III). The availability of a range of options means that the disease management recommendations can be adopted by farmers from various backgrounds, resources and capacity. The economic analyses, including cost-benefit analysis done by component 2 participants, and the more extensive analysis completed by Component 5, means that farmers are also able to use the economic information before deciding on which options to implement in their orchard. It should be emphasised that the disease management recommendations that were developed are effective for a range of diseases, and really form the basis of good orchard management, which leads to good disease management.

8 Impacts

8.1 Scientific impacts – now and in 5 years

Participatory Research Trials

The participatory research approach has promoted the collaboration of scientists, extension staff and farmers in the development and assessment of disease management strategies. The process enabled the participants, and visitors to their trial site, to visualise and critically assess the effectiveness of the methods they are testing in their own trial and compare them with the previous management strategies as well as those being tested by other PAR participants. The impact of this approach is to build local capacity in conducting research trials and disseminating information. The approach develops and strengthens linkages between farmers, researchers and extension staff in the jackfruit and durian industries. It is anticipated that the strong partnerships established in this project will continue to be developed and expanded into the future.

International visitors to the final workshop, field day and public forum

Many of the management strategies tested in the PAR trials were built on experiences from previous ACIAR projects (PHT/1995/134, PHT/1996/153, CP/2000/102). Three participants from previous ACIAR projects (Mr Mai Van Tri, Dr Nguyen Van Hoa from Vietnam, and Dr Somsiri Sangchote from Thailand) participated, at their own expense, in the final project workshop, field day and public forum in September 2011. Their participation was very valuable as they were able to share their experiences in managing the same disease in Vietnam and Thailand. Participants in the public forum were astounded to see the differences in production methods and productivity between the countries. The three visitors were able to provide advice and also learnt a lot from what the Filipino PAR collaborators had been doing in their trials. Participants from all countries exchanged ideas and contact details and linkages have been established for future collaboration with the Filipino scientists.

Nursery Best Practice

A range of management options were tested in the durian and jackfruit nurseries at BPI and DA-RIARC, respectively. These trials clearly demonstrated that nursery hygiene and management determines the health of the seedlings that are available for purchase by growers. The two nurseries now used best practice management methods for cultivating planting material. See also Section 8.2.

8.2 Capacity impacts – now and in 5 years

Training in diagnostics

In September 2011 the jackfruit component leader, Dr Lucia Borines, and her technician, Ms Victoria Palermo, travelled to Brisbane for diagnostic training in the laboratory of A/Prof André Drenth at the University of Queensland. There had been problems with the purity, identity and maintenance of the collections made during the disease survey. During the visit Lucy and Vicky learnt to correctly identify the isolates based on morphological and cultural characteristics. They also learnt how to conduct molecular diagnostic tests to identify the isolates by PCR and RFLP. The training has helped to improve the capacity of Filipino researchers to conduct disease surveys, isolate and identify pure cultures and maintain culture collections that can be used in this project and future disease diagnostic

activities. The diagnostic skills learnt in Brisbane can be expanded to other pathogens in the future.

Students were involved in the PAR trials conducted at Central Mindanao University. In this way future generations of scientists are trained in experimental design, data collection and analysis and plant pathology.

Participatory Action Research

Farmers and extension staff involved in the collaborative research trials have developed skills in the formulation and testing of scientific questions and the collection, collation and analysis of data from their trials to assess a range of crop management strategies. These skills will enable them to consider any future options they may come across in a more rigorous manner.

Nursery accreditation scheme

Following the PAR testing of best practice management strategies in the nursery at the Department of Agriculture, a nursery accreditation scheme is being established by DA-RIARC to ensure that certified healthy planting material is available for purchase by growers. Improved nursery practice will benefit all tree crop industries.

8.3 Community impacts – now and in 5 years

Adoption by neighbouring growers

The PAR collaborators have been able to see the benefits of the management options in their orchards. Neighbouring farmers have witnessed these changes. Several growers not directly involved in the PAR trials have adopted management strategies, particularly low-input options such as sanitation, on their own orchards after participating in field days or talking with PAR collaborators. Adoption rates have been estimated by Component 5.

8.3.1 Economic impacts

Increased income through increased production

Economic impacts have been seen through improvements in yield, and subsequently farm income following the application and adoption of improved crop management strategies. For example, jackfruit grower Julio Muñoz harvested 1857 kg/ha more fruit (average of all treatments combined compared with control) one year after implementing them. At P25 a kilo farm gate price, that equated to an increase of gross income of P46,425. The availability and knowledge of effective management strategies also means that farmers use resources more efficiently.

One durian farmer PAR collaborator, Mr Rodillo Candido, manages a 2 ha durian farm. The orchard was planted 10 years ago as part of a Plant Now Pay Later scheme of the Davao del Norte government. He was previously a teacher earning P200,000 per year, but now works full time as a farmer and has earned P240,000 annually for the last two years.

8.3.2 Social impacts

Flow on effects from the increased production

Improvements in farm management and yield are expected to increase jackfruit and durian productivity, directly benefiting the farmers through increased income, and have flow-on affects for the wider community through the increased demand for support/postharvest industries and improvements to local infrastructure.

Increased linkages between growers, researchers and extension agents

The participatory research approach promoted the collaboration of scientists, extension staff and farmers in the development and assessment of disease management strategies. It also improved the networking between farmers themselves, including the establishment, or re-establishment, of several grower groups. It is anticipated that the strong partnerships established in this project will continue to be developed and expanded into the future. A jackfruit festival, similar to the durian festival experienced in Tagum City, has been planned by growers, VSU and the Department of Agriculture to be held in July 2012.

8.3.3 Environmental impacts

Targeted, sustainable approaches to manage disease

The majority of the management strategies tested were cultural or non-chemical and as a result have minimum impact on the environment, reducing contamination of soil and water. Knowledge and targeted application of chemicals also means a lesser impact on waterways and the general environment. The application of manures, vermicompost and mulch improved soil properties. The use of local materials also means lower transport costs.

8.4 Communication and dissemination activities

Field days and training workshops

Workshops and field days were held throughout the project to train farmers and extension staff in disease biology, epidemiology and management strategies. These were held at Local Government halls or at the PAR sites established in this Component.

Table 1. Time and location of extension activities held throughout the project.

Date	Location	Activity	Participants
August 2008	Camp Philips, Mindanao	Project start-up workshop	40
October 2008	Department of Pest Management, Leyte	Farmer training workshop	30
September 2009	Tagum City	Farmer Field Day (FFD)	30
November 2009	Digos City, Mindanao	FFD	35
February 2010	Job Abuyabor's Farm, San Isidro, Mahplag, Leyte	FFD	50
February 2010	DA-RIARC, Abuog Training Hall	In-house review	
July 2010	City Hall and Julio Munoz's farm, Calbayog City, Samar	Workshop and FFD	50
July 2010	Bukidnon, Mindanao	FFD	45
July 2010	Davao City, Mindanao	FFD	25
July 2010	Tagum City, Mindanao	FFD	33
January 2011	OVPRE training hall, Leyte	In-house review	
April 2011	Tagum City, Mindanao	FFD	40
July 2011	VSU, Leyte	Final jackfruit workshop	15
July 2011	DA-RIARC, Mahaplag, Leyte	FFD	100
July 2011	Ormoc City Hall, Luing Fran, Romueldo Marcelino and Mount Manna Farms, Leyte	Training and field day	100
September 2011	Tagum City, Mindanao	Field day	40
September 2011	Tagum City, Mindanao	Public Forum during Durian Festival	150
September 2011	Tagum City, Mindanao	Final project workshop	35
January 2012	Office of the Provincial Agriculture in Leyte, Mahaplag Municipal Agriculture Office and RIARC Abuyog,	Jackfruit Growers Membership Seminar Training	45

Extension materials

- Brochures for the jackfruit and durian industries were disseminated to extend the management recommendations developed during the final workshops (Appendix IV).
- A video has been made (ACIAR Small Research Activity) to promote project activities and disease management strategies. It will be used in training activities (www.youtube.com/watch?v=jRmg_d3uxeE; www.isppweb.org/nlapr12.asp#2)
- PAR trials were also promoted on the internet:
  - PCAARRD website (www.pcaarrd.dost.ph); shows use of phosponate injection,
  - http://blogs.inquirer.net/insidescience/2007/09/10/study-reveals-fungicidal-benefits-of-kamantigue-on-durian/;
  - http://www.mindanews.com/top-stories/2011/10/06/davao-tests-bio-agent-on-durian-pest/ for Trichoderma application and kamantigue extract for patch canker.

Conferences

- Borines LM, Daniel R, Guest D, de la Cruz C, Gerona R, Abuyabor J, Munoz J, Pedroso M, Marcelino R, Guadalquiver G and Palermo V (2011). Integrated Management of Phytophthora Diseases of Durian and Jackfruit in the Southern Philippines (Jackfruit Component) (Poster). 42nd Anniversary and Annual Scientific Convention of the Pest Management Council of the Philippines, Bacolod City, May 2011.
- Borines LM, Daniel R, Guest D, Guadalquiver G and Palermo V (2010). Jackfruit decline in the Philippines. Isolation and pathogenicity of *Phytophthora* species and evaluation of management strategies. Annual Meeting of the Pest Management Council of the Philippines. Davao City, Mindanao. March 2010.
- Borines LM, Daniel R and Guest D (2009). Jackfruit decline in the Philippines. Isolation and pathogenicity of *Phytophthora* sp. and evaluation of management strategies. Australasian Plant Pathology Society Conference, Newcastle Civic Precinct, Newcastle, Australia September 2009.
- Borines, L.M., Guadalquiver, G. Palermo, V., Pedroso, M., Abuyabor, J., Munoz, J.Marcelino, R., Daniel, R. And Guest, D. (2011). Integrated Management Approaches for the Control of Phytophthora Disease of Jackfruit (*Artocarpus heterophyllus* Lam) (Poster). Regional R&D Conference, Leyte, August 2011.
- Dionio BT (2010). Fruit extract of garden balsam for control of durian patch canker. Pest Management Council of the Philippines, Davao City, March 2010.
- Soguilon C, Montiel C, Daniel R and Guest D (2011). Integrated management of Phytophthora diseases of durian in the southern Philippines. Pest Management Council of the Philippines, Bacolod City, May 2011.

Other meetings and presentations

- Borines LM (2011). Highlights, outcomes and recommendations for jackfruit. Public Forum at the Tagum City Durian Festival, September 2011.
- Borines LM, Guest D, Daniel R, Guadalquiver G, Palermo V, de la Cruz C, Gerona R, Abuyabor J, Pedroso M, Munoz J and Marcelino R (2011). Integrated management of Phytophthora diseases of durian and jackfruit in the southern Philippines. ACIAR-PCARRD Fruits and Vegetable Annual Meeting, Tagbilaran City, July 2011.
- Borines LM, Palermo VG, Guadalquiver G, Daniel R and Guest D (2011). Mang Julio's dying jackfruits have become productive: thanks to the ACIAR jackfruit *Phytophthora* project. Integrated management of Phytophthora diseases of durian and jackfruit in the southern Philippines. ACIAR-PCARRD Fruits and Vegetable Annual Meeting, Tagbilaran City, July 2011. **Awarded best poster prize*.
- Borines LM, Palermo VG, Guadalquiver G, Daniel R and Guest D (2011). Pathogenicity, characterisation and identification of the pathgen causing jackfruit decline. NRCP Visayas Regional Cluster Meeting, Baybay City, Leyte. May 2011.
- Borines LM, Daniel R, Guest D, de la Cruz C, Gerona R, Abuyabor J, Munoz J, Pedroso M, Marcelino R, Guadalquiver G and Palermo V (2011). Integrated management of disases of durian and jackruit in the southern Philippines. Level 2 Inter-Agency Research and Development/Extension (RDE) Review Cluster. May 2011.
- Borines LM, Daniel R, Guest D, de la Cruz C, Gerona R, Abuyabor J, Munoz J, Pedroso M, Marcelino R, Guadalquiver G and Palermo V (2011). Integrated management of diseases of durian and jackfruit in the southern Philippines. 2nd Philippines Annual Program Review for the ACIAR-PCARRD-VSU Horticultural Program for Fruits and Vegetables. April 2011.
- Borines LM, Daniel R, Guest D, de la Cruz C, Gerona R, Abuyabor J, Munoz J, Pedroso M, Marcelino R, Guadalquiver G and Palermo V (2011). Integrated management of diseases of durian and jackfruit in the southern Philippines. Agency In-house Review, VSU, Leyte. February 2011.

- Dionio BT (2011). Fruit extract of garden balsam for control of durian patch canker. Regional Symposium R&D SMARRDEC. Digos City, February 2011.
- Borines LM, Daniel R, Guest D, de la Cruz C, Gerona R, Abuyabor J, Munoz J, Pedroso M, Marcelino R, Guadalquiver G and Palermo V (2010). Integrated management of diseases of durian and jackfruit in the southern Philippines. ACIAR-PCARRD souther Philippines Annual Program Meeting – Fruit and Vegetables. Leyte. August 2010.
- Borines LM, Daniel R, Guest D, Guadalquiver G and Palermo V (2010). Pathogenicity, characterisation and identification of the pathogen causing jackfruit decline. ACIAR-PCARRD southern Philippines Annual Program Meeting – Fruit and Vegetables. Leyte. August 2010.
- Borines LM (2010). Integrated management of diseases of durian and jackfruit in the southern Philippines. 2nd Philippine Annuarl Program Review for the ACIAR-PCARRD-VSU Horticultural Progarm for Fruits and Vegetables. Davao City, Mindanao. June 2010.
- Borines LM, Daniel R, Guest D, de la Cruz C, Gerona R, Abuyabor J, Munoz J, Pedroso M, Marcelino R, Guadalquiver G and Palermo V (2010). Integrated management of diseases of durian and jackfruit in the southern Philippines. Level 2 Inter-agency Research and Development/Extension RDE Review Cluster. Baybay, Leyte. June 2010.
- Borines LM, Daniel R, Guest D, de la Cruz C, Gerona R, Abuyabor J, Munoz J, Pedroso M, Marcelino R, Guadalquiver G and Palermo V (2010). Integrated management of diseases of durian and jackfruit in the southern Philippines. Level 2 Inter-agency Research and Development/Extension RDE Review Cluster. VSU, Leyte. April 2010.
- Borines LM, Daniel R, Guest D (2009). Integrated management of diseases of durian and jackfruit in the southern Philippines. PCARRD-ACIAR CDO Pre-Planning Meeting, Cagayan de Oro City, Mindanao, June 2009.

Awards received by project participants

- PARRFI Professorial Chair Award for 2009. Philippine Agriculture and Resources Research Foundation (PARRFI). SEPT. 14, 2009. Awarded to Lucia Borines
- Best On-going Research Paper for the Project entitled "Integrated Management of Phytophthora Diseases of Durian and Jackfruit in the Southern Philippines" given by VCARPP-RRDEN and VSU During the Level 2 Research and Development /Extension (RDE) Review Cluster on June 7-8, 2010.
- Best Research Paper, second place. Ms. Belly Dionio, Fruit extract of garden balsam for control of durian patch canker. (poster/paper) Regional Symposium R&D SMARRDEC. February 13, Digos City.
- First Prize Scientific Poster Competition for the paper entitled “Pathogenicity, Characterization and Identification of the Pathogen Causing Jackfruit Decline” during the 8th General Assembly of the NRCP Visayas Regional Cluster Meeting held at CCE Bldg., VSU, Visca, Baybay City, Leyte on May 17-18, 2011.
- Best Research Poster for the Paper entitled “ Mang Julio’s Dying Jackfruits Have Become Productive: Thanks to the ACIAR jackfruit Phytophthora Project” given during the Annual Meeting of the ACIAR-PCARRD Fruits and Vegetable Programs held at the Bohol Tropics Resort, Tagbilaran City, on July 201-22, 2011.
- Exemplary Researcher Award for 2011 for exemplary performance in research, given by the Visayas State University on August 11, 2011 awarded to Lucia Borines.
- Pest Management Award in Instruction - this is one of the major awards given by Pest Management Council of the Philippines annually fiven to Lucia Borines for her teaching and advising accomplishments.

- Philippine Phytopathological Society (PPS) Inc. - Best Poster Award for “Integrated Management of Phytophthora Disease of Jackfruit in the Southern Philippines”.

9 Conclusions and recommendations

9.1 Conclusions

- Initial training of collaborators provided a good, and necessary, introduction to the biology of the pathogen, epidemiology and potential options for disease management
- On-farm PAR trials gave the collaborators 'ownership' of their experiments and they took great pride in their work
- Testing management strategies on-farm, in collaboration with farmers, extension officers and agricultural scientists built capacity and skills in the development of experiments, collection and analysis of data and evaluation of results. In the future, the participants should be able to design and evaluate their own experiments to test recommended methods for orchard management. Refer to Appendix II for more comments from participants.
- PAR is an effect way to improve linkages between extension staff, farmers and researchers
- Nursery best practice is essential so that the growers are provided with healthy planting material.
- A final workshop, where PAR collaborators presented and evaluated the results of their trials meant that all participants were aware of the results of the other trials. It also taught the participants skills in data analysis and economic analysis.

9.2 Recommendations

In the final workshop, we conducted a survey and asked participants what they thought future research directions should include. The results of the survey can be found in Appendix II. The following recommendations are made based on the results of the survey, challenges faced throughout the project and discussions held with other project leaders and participants.

- Maintain linkages with PAR collaborators and use their skills and experience as a role-model to other growers in the industry, as well as an extension resource.
    - The PAR collaborators are now skilled in the design and conduct of experiments to test orchard management strategies. Their training should be put to good use in future activities. Farmers talk to other farmers, and this is a great information resource.
- Wider dissemination of recommendations for orchard management to the durian and jackfruit industries.
    - This can be done by showcasing the different management options at the PAR sites, holding more on-farm field days and establishing demonstration sites in visible locations. The video has been an integral part of the dissemination campaign, particularly because it was made in Bisayan language enabling locals to understand it.
    - The dissemination activities should include training of agri-technicians from local agriculture offices.
- Development of resistant rootstock and improved varieties.
    - The export market for durian prefers Thai varieties while the local market prefers Philippine selections because of the stronger flavour. A number of 'export' cultivars have been released by BPI with improved fruit quality and yield potential. These

cultivars are grafted onto genetically random rootstocks and suffer heavy losses due to Phytophthora diseases. There is a very real need for the selection of Phytophthora resistant rootstocks.

- Improve skills in diagnostics
    - Local scientists would benefit greatly from training in diagnostics. The diagnostic capacity of many agricultural scientists is limited and would benefit greatly from specialised training courses in the diagnosis and identification and management of fungal, bacterial, nematodal and viral pathogens.

10 References

10.1 References cited in report

Black AW (2000). Extension theory and practice: a review. *Australian Journal of Experimental Agriculture* **40**, 493–502.

10.2 List of publications produced by project

Three manuscripts are currently being prepared by project members. The first will describe the *Phytophthora palmivora* as the cause of the new disease of jackfruit, jackfruit decline. The second will describe the experiments used to develop best practice protocols in the durian and jackfruit nurseries. The third will present results from the PAR trials, outlining the use of participatory research in the development and dissemination of IPDM options to the jackfruit and durian industries in the Philippines.

11 Appendixes

11.1 Appendix 1: Participatory Action Research Trials and Collaborators

List of PAR trials for durian component in Mindanao

Name of PAR collaborator(s)	Title of PAR trial	Location of Study
Dr. Louella M. Cabahug	Boron and calcium application for the management and control of Phytophthora in durian and physiological disorders and fruit quality of durian	Valencia City, Bukidnon
Dr. Isidora M. Olazo	Efficacy of Goat Urine and Trichoderma Biocon against Phytophthora Disease and bark borers of durian (Durio zibethinus Murr.)	Panadtalan, Maramag Bukidnon
Prof. Belly T Dionio	Control of Durian Patch Canker using Garden Balsam Fruit Extract	Tagum City, Davao del Norte
Ms. Merlina H. Juruena	The effect of chicken dung and EM on the incidence of Phytophthora Diseases in durian	Cuambugan, Tagum City, Davao del Norte
Ms Julie Sagolili	The efficacy of phosphorus and organic carbon application for the control of *Phytophthora palmivora* causing dieback of durian	Binaton, Digos Davao del Sur
Ms. Concepcion E. Soguilon Mr. Danny Abad Mr. Cyril B. Montiel	Control of *Phytophthora palmivora* using *Trichoderma pseudokoningii*	Dacudao, Calinan, Davao City
Ms. Concepcion E. Soguilon Mr. Cyril B. Montiel	Comparative study between raised benches and ground level practice, and sterilized soil media against unsterilized soil media in nursery management.	BPI-DNCRDC Station, Bagi Oshiro, Mintal Davao City
Jeanna Masing, Evelyn Cayabyab	Application of *Trichoderma harzianum* and vermicast as control against Phytophthora disease on durian.	Tugbok district, Davao City
Marilou Infante	Techno demo trial on the use of phosphonate as a control of Phytophthora on durian.	Tagum City
Ms. Concepcion E. Soguilon Mr. Danny Abad Mr. Cyril B. Montiel	Phosphonate trunk injection or bark spray to control patch canker of durian.	Tagum City

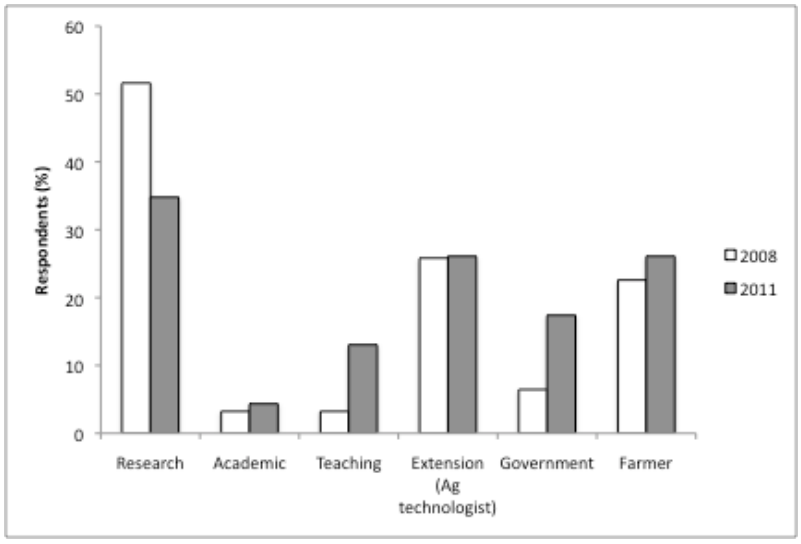
List of PAR trials for jackfruit component in Eastern Visayas

Name of PAR collaborator(s)	Title of PAR trial	Location of Study
Carlos De La Cruz	Plant Nursery Best Practices Demonstration on Phytophthora Disease Management (2 studies), Study 1: Effect of solarisation duration of potting media mixes on Phytophthora incidence on jackfruit seedlings; and Study 2: Effect of fermented organic additives (FOA) amendments of potting media mixes on Phytophthora incidence on jackfruit seedlings;	RIARC Experimental Station Department of Agriculture Balinsasayao, Abuyog, Leyte
Prof Reny Gerona	The effect of selected insect species on the incidence of the wilt disease of jackfruit to be conducted	Dept. of Pest Management, VSU, Visca, Baybay, Leyte
Romualdo Marcelino	The effect of drainage and mounding on the incidence of jackfruit decline on established jackfruit plantation	Sitio Soong, Brgy. Curva, Ormoc City.
Dr. Lucia M. Borines Mr. Gil Guadalquiver	Isolation, identification and pathogenicity of wilt-causing organism in jackfruit	Visayas State University
Job Abuyabor	The effect of chemical application and phosphonate injection on the management of decline syndrome on jackfruit	San Isidro, Mahaplag, Leyte.
Ruben M. Gapasin	Effect of Nematode-Fungi Interaction on the Wilt Syndrome in Jackfruit	Visayas State University
Miquel A. Pedroso	Demo Trial of Sanitation and Cultivation on the Incidence of Wilt Disease of Jackfruit	Calbayog City, Samar
Julio Munoz	An integrated approach to management of Phytophthora in jackfruit	Calbayog City, Samar

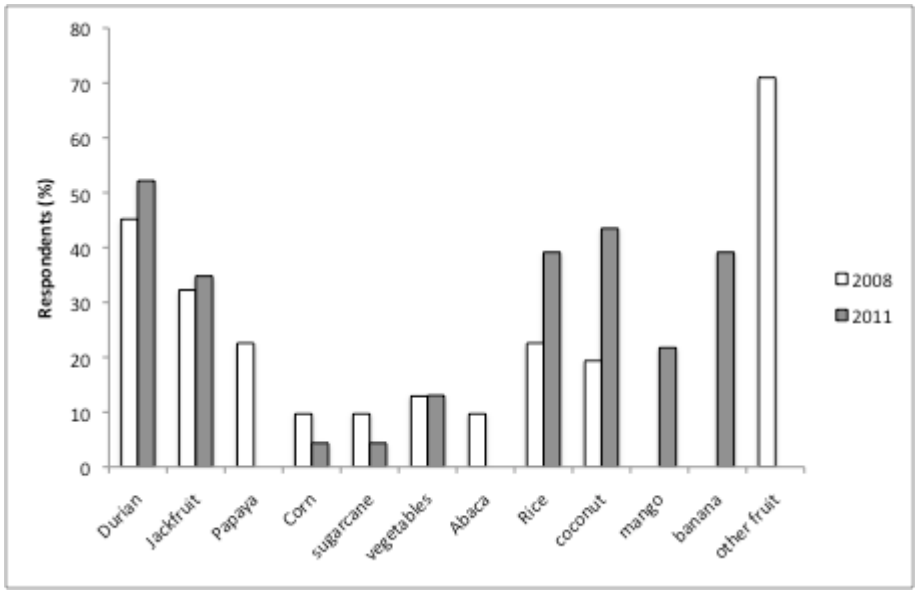
11.2 Appendix 2: Results from surveys conducted during the first and final workshops

Surveys were conducted at the start-up workshop in 2008 and at the final workshop in 2011. The first workshop was attended by 30 people from the durian, jackfruit and papaya industries. The second workshop was attended by 23 people from the durian and jackfruit industries who participated in the PAR trials.

1. What is your occupation?

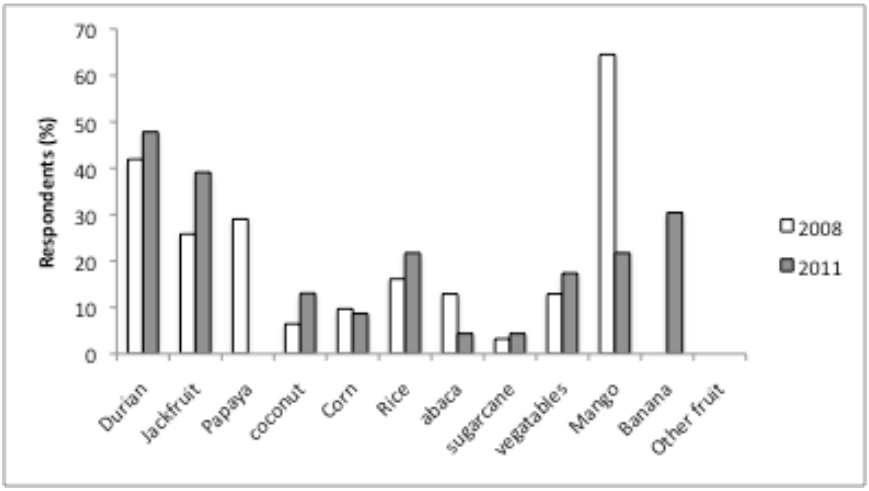


2. What are the three main crops grown in your area?

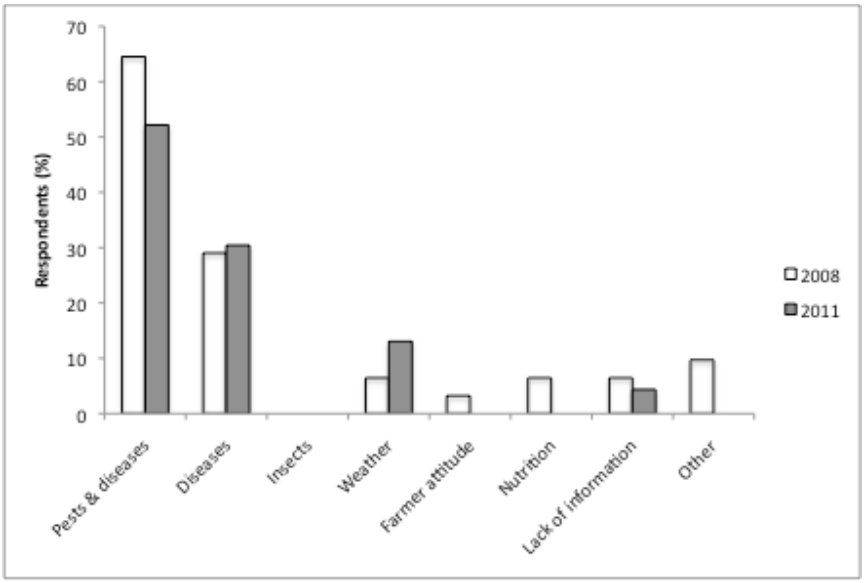


Banana and mango were not separated in the first survey.

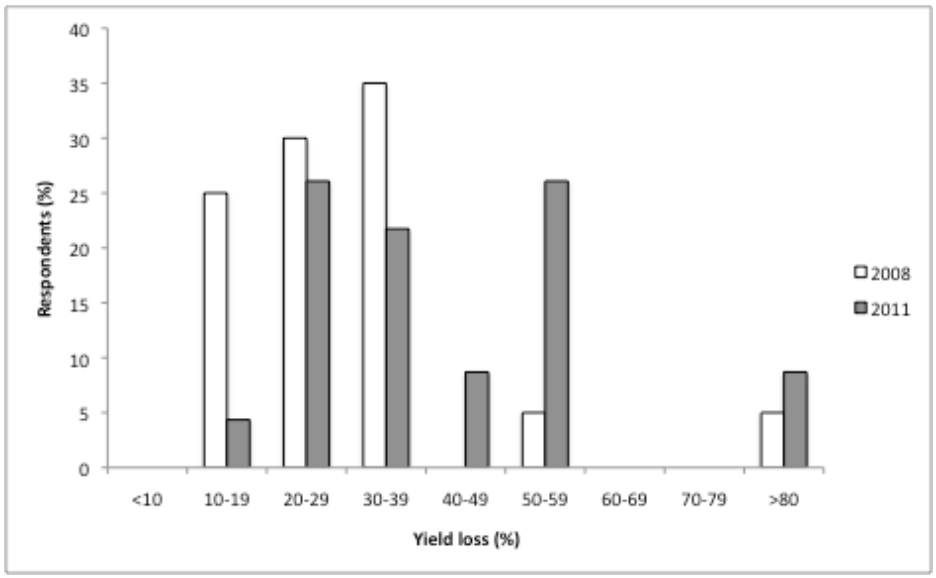
3. What are the three main crops that you work on?



4. What is the most important cause of crop failure?



5. What is the average yield loss?

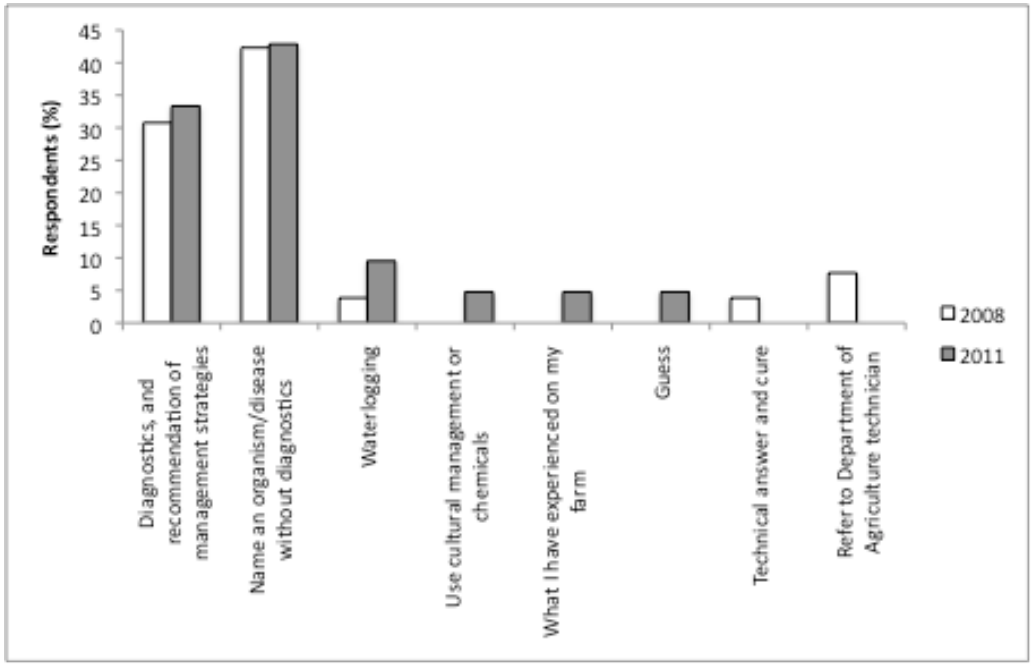


	2008	2011
Average (%)	27.5	41
Median (%)	25	32.5

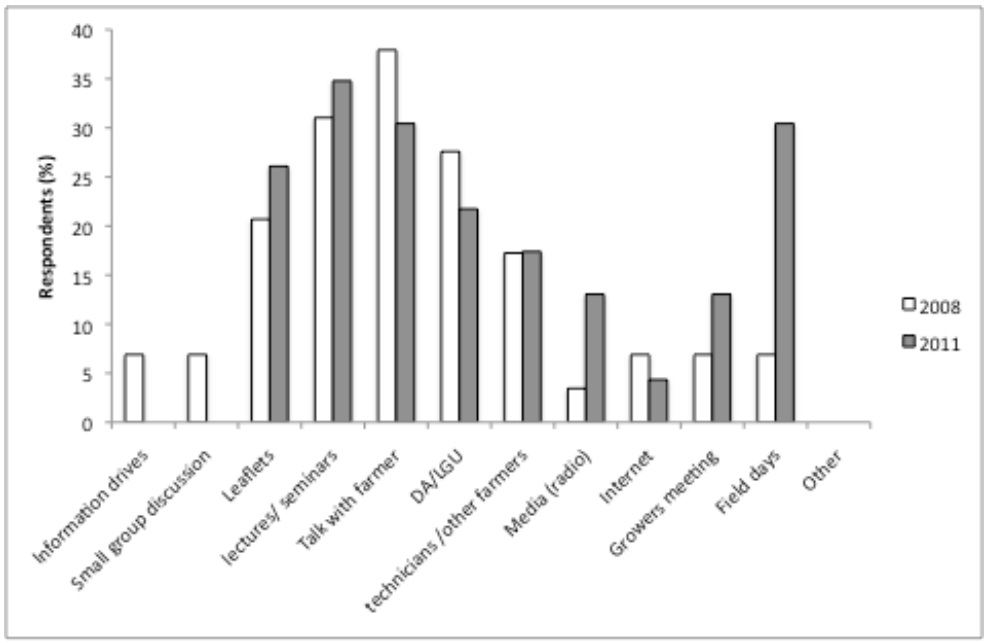
6. Do farmers ask you for advice?

2008: 87%; 2011: Yes: 96%

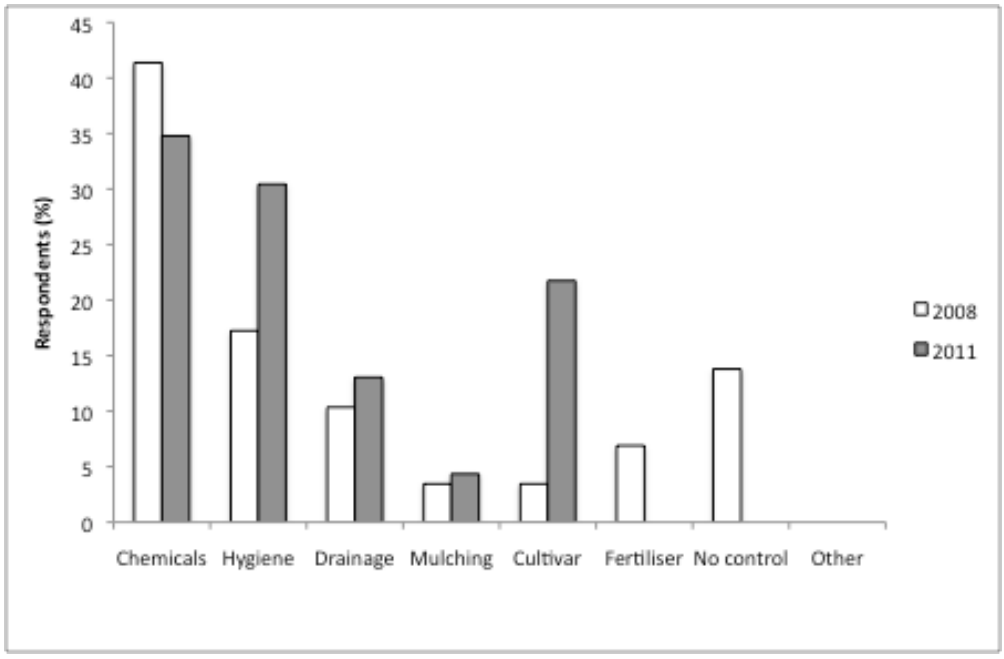
7. What do you tell farmers is wrong with their crops?



8. How do you distribute information?

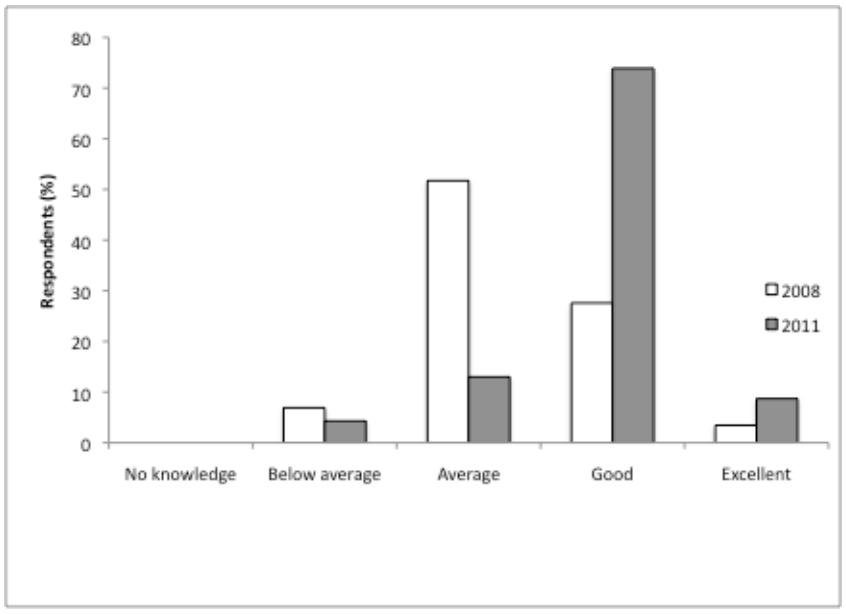


9. What are the main methods used for disease control?

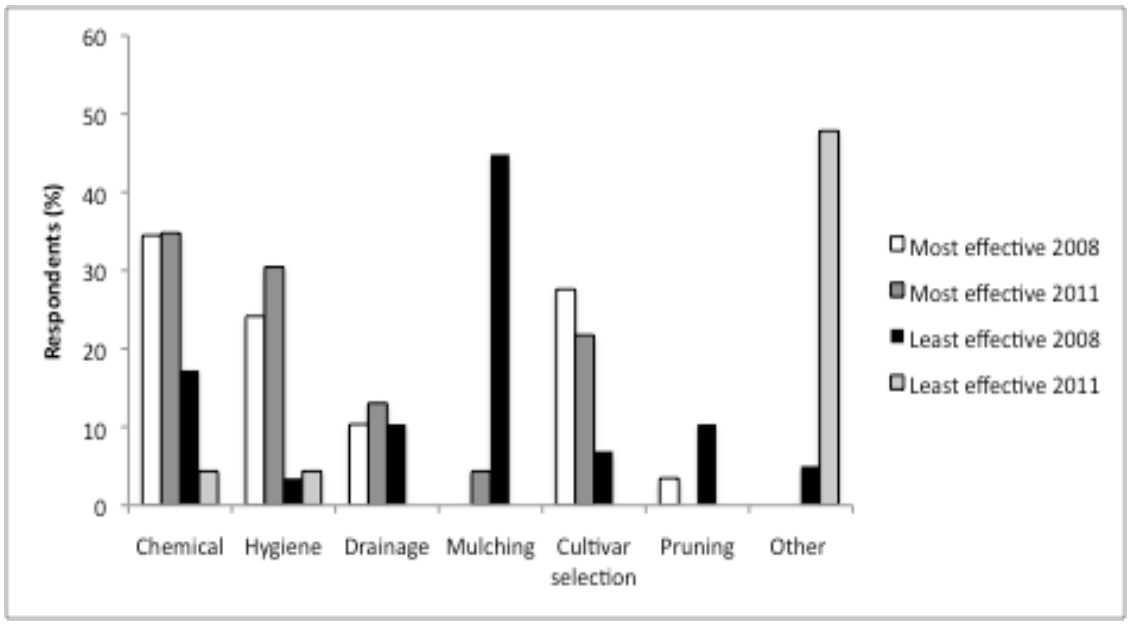


Interesting that cultivar ranks so highly in 2011, since not many cultivars are available.

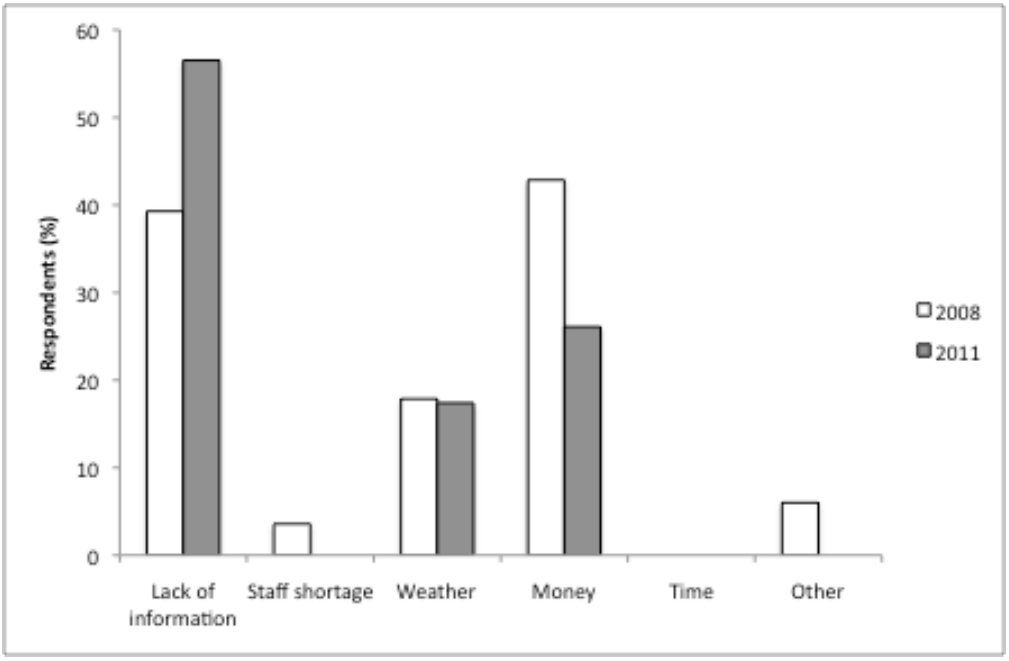
10. Rate your understanding of disease management.



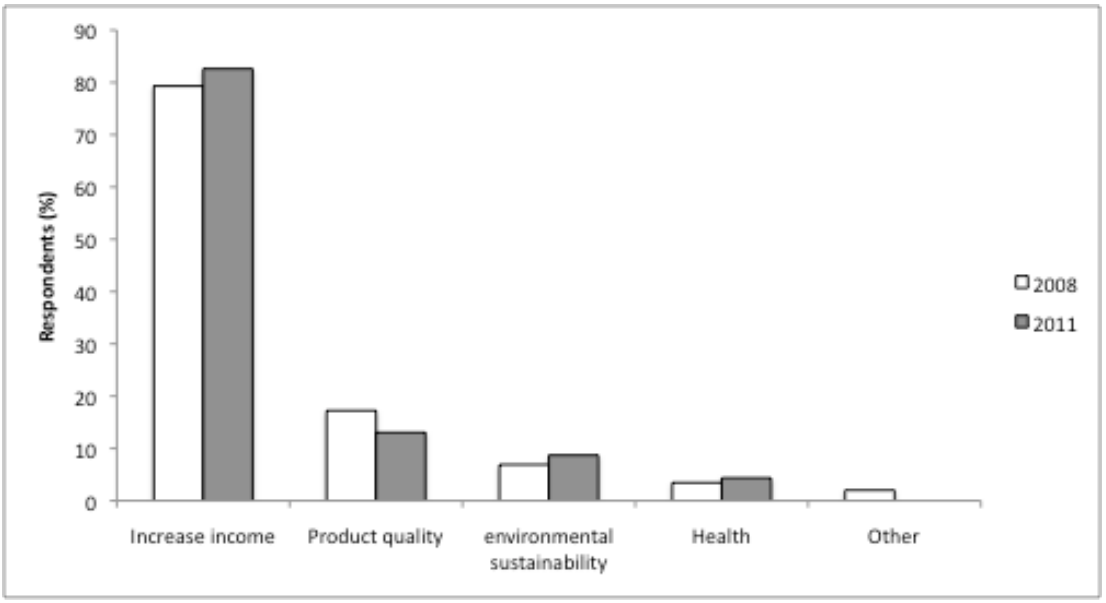
11. What are the most and least effective methods for disease control?



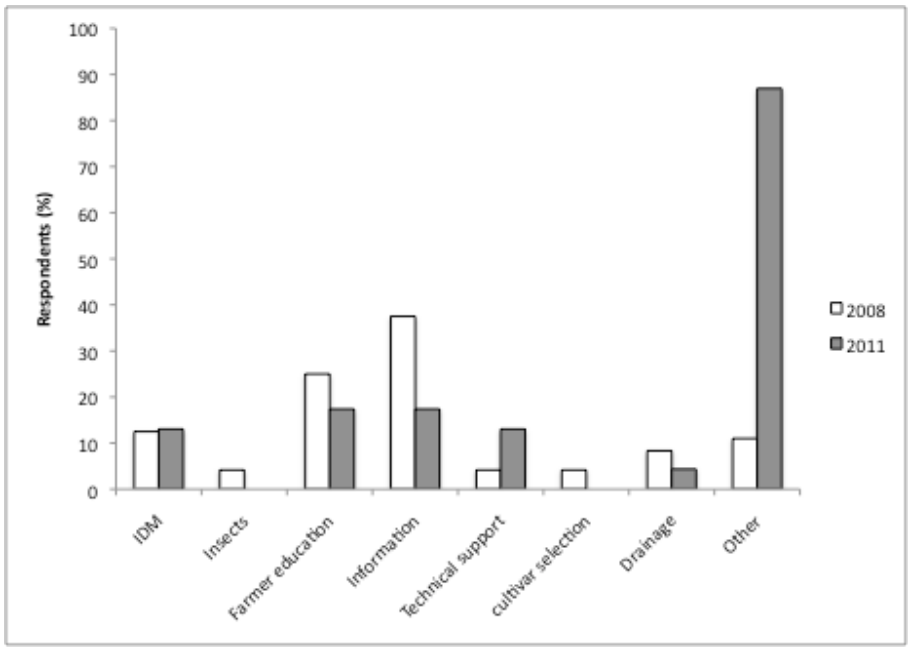
12. What are the main limitations for disease management?



13. What is the main incentive for farmers to improve their crop?



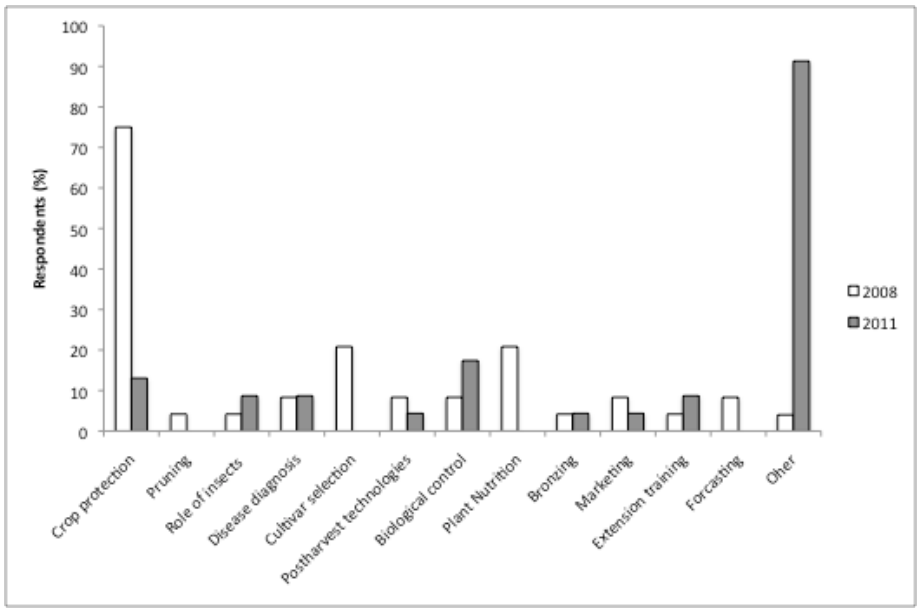
14. What is needed to improve disease management?



'Other' in 2011 includes:

- Extension
  - PAR and Techno demo
  - Demonstration farms
  - More information dissemination through FFS, leaflets, brochures, radio, training extension workers
  - More extension activities
  - Information drive on integrated management
  - Learn practices observed in other farms
  - Information dissemination on disease management options
  - Motivation to be interested in good results and disease management.
  - Training/farmers forum for disease management, workshops to educate farmers
- Economics
  - Example budget
  - Training on value adding, farmers don't apply recommendations because of lack of money
  - Marketing
- Diagnostics and research
  - More knowledge about the disease to control it early in the infestation where it can be controlled more efficiently
  - Ability to identify the disease and apply the different IDM measures
  - Proper monitoring
  - More research on unanswered questions
  - Cultural management
- Miscellaneous
  - Government support

15. What are the three most important research priorities?



16. Do you have any comments about the effectiveness of the PAR trials?

- Prevention is better than cure
- Excellent practice to educate farmers and for them to personally experience the same in their crops
- Very effective to improve the awareness of farmers
- Farmers/growers are not directly involved in the trials. Much work is delegated to labourers who are not committed
- Very useful
- Helps farmer to discover for himself what treatments are effective and to be the researcher
- Very effective because the problem and solution are addressed in short duration
- Very effective because farmers can evaluate
- Very effective, learn by doing
- Very good because it links research and extension
- Very effective because farmers learn from other farmers
- Highly recommended
- Farmers learn and become experts in their own crops
- Very effective to improve the level of understanding and adoption by farmers

17. What do you think needs to be done next to continue to manage disease in jackfruit or durian?

- Proper management and monitoring
- Disseminate information from PAR trials and encourage other jackfruit farmers
- PAR co-operators must continue to maintain their work and dedication as good role models for other farmers.
- Further research on disease management to determine the most effective ways of control
- Variability in ripeness in individual jackfruits
- How to control Phytophthora using biological or natural approach
- Test other treatments
- Develop technology to control Phytophthora diseases in an organic way
- Showcase the different management options
- Continue the program
- Maintain best practices, and apply new integrated management
- More farmer participation and dissemination
- Continue with the PAR trials with good results, adopt the best practice done by other farmers/researchers, implement good farm management practices, use better cultivars to replace unproductive trees or establish new orchards
- Preventative measures,
- Techno demo integrating phosphonate application with other PAR generated technologies
- More information dissemination regarding Phytophthora and its management, FFD, training of agri-technicians
- Showcase approaches in farmers fields in cluster areas of jackfruit
- Focus more on information dissemination
- More FFD to promote the technology
- Conduct PAR trials based on consultation with farmers based on their needs/problems first.
- Conduct techno demo in other areas with jackfruit
- Disseminate environmentally sound disease control measures to farmers

11.3 Appendix 3: Recommendations developed from PAR trials

Recommendations for the durian industry

Input	Current (no-input)	Low input	Medium input	High input
Sanitation		1	1	1
Mulching and weed management		Manual	Manual	Herbicide
Pruning and fruit thinning		1	1	1
Water Management (mounding, drainage and irrigation)		1	1	1
Organic soil amendments (vermicast, chicken manure/EM			1	1
Inorganic nutrient mgt (calcium, boron, phosphate & fertigation	1			1
Canker treatment with biocontrols (garden balsam extract, trichoderma)			1	1
Canker treatment with fungicides (Fosetyl-Al & copper based fungicides				1
(Phosphonate injection or bark spray)				1
Insecticide application, rodent mgt	1			1
Yield loss	40-60	30-50	20-40	0-15

Recommendations for jackfruit

Input	Current (no input)	Low input	Medium input	High input
Clean planting material		√	√	√
Underbrushing or ringweeding		√	√	√
Fruit bagging and regular harvesting		√	√	√
Tree mulching			√	√
Tree pruning			√	√
Tree mounding			√	√
Drainage canals			√	√
Chemical control of insects				√
Chemical control of Phytophthora				√
Expected Yield Gain	0-20%	30-40%	50-80%	80-100% or more

11.4 Appendix 4: Extension brochures for jackfruit and durian industries

7. If you farm is prone to flowing construct a main drainage canal (1 m x 1 m) and sub canals (0.5 m x 0.5 m) so the water will easily drain.

8. Insects like black and red ants, beetles, any crawling and flying insects may carry Phytophthora propagules up the tree so insect control is also empirical.

9. If your trees are already infected, they can still be treated. You may scrape the cankers on the trunk and paint the wound with fungicides such as copper oxychloride and mancozeb. Fungidice spray such as Aliette (Fosetyl Al) is also recommended. Injection with phosphonate or spraying the trunk with phosphonate and pentrabark can be done. Aspirin (acetyl salicylic acid) or salicylic acid spray at monthly interval can also be done.

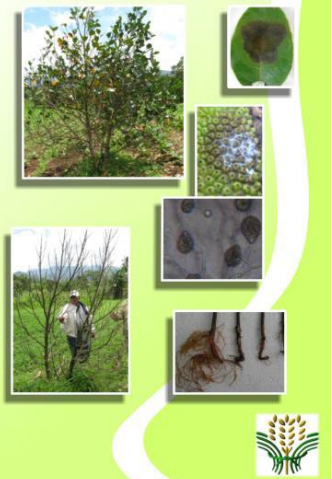
For more information, you may contact:

DR. LUCIA M. BORINES
Component Leader, ACIAR Jackfruit *Phytophthora Project* and Head
Plant Disease Diagnostic Laboratory
VSU, Visca, Baybay City, Leyte
Tel: (053) 563-7250

Contributors:
Dr. David Guest -Project Leader
Dr. Rosalie Daniel - component coordinator
Prof. Reny G. Gerona-VSU, Dr. Carlos de la Cruz-DA-RIARC, Abuyog, Mr. Gil Gaudalquiver-VSU,Ms. Victoria Palermo-VSU, Hon. Job Abuyabor-Mahaplag Leyte,Engr. Miguel Pedroso-Calbayog City, Samar Mr. Romualdo Marcelino- Ormoc City, Leyte

Australian Government
Australian Centre for International Agricultural Research

How to prevent and Manage Phytophthora Disease of Jackfruit

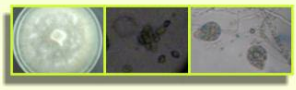


Symptoms of the Disease

- Yellowing of leaves and leaf fall
- Dying of shoots, twigs
- Canker on the stem
- Death of severely affected plant

The Cause of the Disease

- One kind of whitish fungal-like soil-borne organism called Phytophthora palmivora
- This microorganism have motile zoospores that swim in water that's why their population is favored in wet soil and infection usually results when there is stagnant water in the soil around the tree base and when the canopy do not dry easily due to very dense plantation especially during the rainy season.



Ways to avoid and control the disease

1. Start with a clean and healthy planting material. Obtain planting materials preferably from accredited nurseries that practiced sanitary measures.

2. Practice sanitation in the orchard, clean the tree surroundings by underbrushing or ringweeding. You may use the wastes to mulch your trees. Dispose fallen fruits properly, bury them especially the diseased ones.

3. You may mulch trees to prevent rainsplashes to the trunk. Gliricidia leaves can be a good mulching material.

4. Prune the trees every after harvest. Remove especially diseased and dead twigs and branches.

5. Mound trees to prevent ponding of water around the trunk. Plain soil can be used but one sack mudpress plus one sack dried chicken manure, or 1 sack mudpress plus one sack vermi-compost are effective in reducing Phytophthora disease.

6. Wrap the fruits when they are about the size of a 1 litter "Coke bottle". Clear plastic are better wrapping material than sack so you can clearly see the apperance and status of the fryuit. Tie at the upper end and leave the bottom open so rainwater will not stagnate inside the plastic.

Farmers' Options

Options are recommended for durian. Farmers can choose from low level of input to high level input.

Practices	Current	Low	Medium	High
Sanitation (remove and bury infected plant parts)		✓	✓	✓
Mulching and weed management		Manual	Manual	Herbicide
Pruning and fruit thinning		✓	✓	✓
Water management (mounding, drainage and irrigation)		✓	✓	✓
Organic soil amendments (vermicast, chicken manure/EM)			✓	✓
Canker treatment with biocontrols (garden balsam extract, Trichoderma)			✓	✓
Inorganic nutrient management (calcium, boron, phosphate, fertigation)	✓			✓
Canker treatment with fungicides (Fosetyl-Al or any copper based)			✓	✓
(Phosphonate injection or bark spray)				✓
Insecticide application, rodent management	✓			✓
Yield loss (estimate)	40-60	30-50	20-40	0-15

Contact:
Ms. Concepcion E. Soguilon
Component Leader ACIAR Durian
BPI-DNCRDC, Bago Oshiro Mintal, Davao City

Contributors:
Dr. David Guest and Dr. Rosalie Daniel- Univ. of Sydney
Dr. Louella Cabahug & Dr. Isidora Olazo- CMU, Ms. Belly Dinio-USP, Tagum City, Ms. Merlina Juruena- PAGRO, Tagum City, Ms. Marilou Infante, RCPC, Ms. Jeana Masing-CAO, Davao City, Ms. Julie Sagolili- OPAG, Davao del Sur, Mr. Cyril Montiel- BPI-DNCRDC

BUREAU OF PLANT INDUSTRY
Department of Agriculture
Davao National Crop Research and Development Center

Management of Phytophthora Disease of Durian




Symptoms

- Yellowing of the leaves
- Patch canker on the stem and trunk
- Rotting of the fruits
- Sudden dieback of seedlings
- Death of severely infected trees

Cause of the Disease

- *Phytophthora palmivora*
- Whitish fungus, soil-borne which thrives in moist and water logged conditions
- Plenty of alternate hosts (coconut, cacao taro,etc)


Prevention and management strategies

1. Plant only clean and healthy seedlings from accredited nursery.

2. Sanitation in the orchard. Clean around the base of the trees. Collect and bury all diseased plant parts in a pit. Apply *Trichoderma* to hasten decomposition.

3. Mulch trees to avoid water splash. Amend soil with organic materials like chicken dung or vermicompost to make the soil suppressive.


4. Prune unwanted branches for better aeration

5. Avoid water logging. Construct drainage canal around the area (1m x 1m). Plant new seedlings on mounds

6. Apply balsam extract or *Trichoderma* on patch canker infected areas around the trunk to avoid spread.

7. Use goat urine as repellent to insects that serve as carrier of the fungus.

8. In severely affected trees, apply copper based fungicides or Phosphonate or Fosetyl-Aluminum.


11.5 Appendix 5: Results from the Participatory Trials presented by participants in the final workshops

This is the reduced version of the Final Report. The presentations have been omitted to reduce the size of the file.