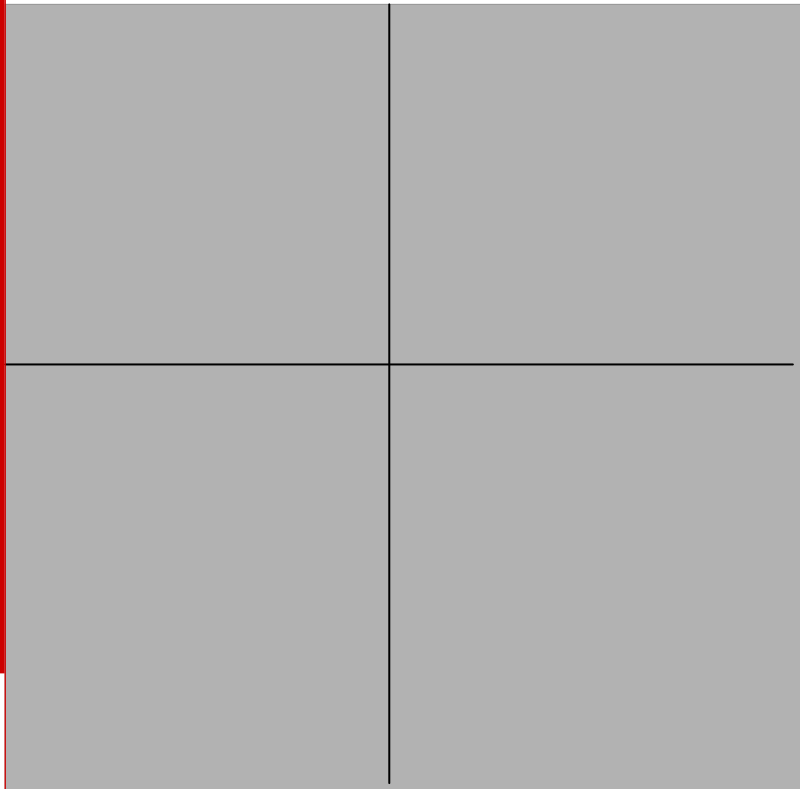


# Assessment of mango diseases, pest and production problems in Pakistan

Workshop and Mango Orchard Survey Visit to Pakistan, 27 March – 11 April 2006



*This report details the results of a Small Research Activity (SRA Hort/2005/154) conducted as part of the Agriculture Sector Linkages Program (ASLP) between Pakistan and Australia.*



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# Small Research Activity Report – (SRA HORT/2005/154)

## Executive Summary

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A Small Research Activity (SRA HORT/2005/154) was undertaken as part of an Agricultural Sector Linkage Program (ASLP) between Pakistan and Australia bringing together stakeholders involved in mango RD&E in Pakistan and Australia. In close co-operation with Pakistani counterparts, a team of 5 Australian mango R & D specialists, and one industry nominated Australian mango farmer, reviewed research, development and extension activities in the Pakistan mango industry to identify R & D issues that could be addressed through subsequent activities funded under the ASLP. The activity was an agreed priority under the ASLP, to address serious productivity constraints in the Pakistan mango industry, including the causes and control of mango sudden death syndrome (MSDS) which is reducing productivity in some orchards by more than 20%. Key elements of the SRA were:

- Documentation of the current industry status and available information
- A four day workshop for 13 Australians and 35 Pakistan participants
- Eight days of field surveys and visits to R & D agencies in the main mango production regions of the Punjab and Sindh provinces by the Australian study team and key Pakistani collaborators
- Detailed assessment of the background information, workshop and survey findings to develop recommendations for future R & D needs.

The documentation of the industry status provided insights into current management practices, key R & D providers and existing knowledge of causes and control of MSDS in Pakistan and elsewhere.

The workshop identified a number of R & D priorities on diseases and pests, orchard management and capacity building that could be investigated in an ASLP project. In diseases these included confirming the causes and pathogenicity of the mango sudden death syndrome (MSDS) and developing suitable strategies to control the syndrome.

For pests, it involved an economic analysis of the newly identified midge problem as well as establishing pre and post harvest protocols to deal with mango fruit fly issues. In orchard management, nutrition and irrigation management were singled out as the critical issues needing attention to improve mango productivity, quality and reduction of MSDS incidence. Improvement in nursery production of planting material was also identified as an area that needs urgent improvement to stop or slow down the re-cycling of disease and pest problems in old and new orchards.

In capacity building, training modules were identified as critical in educating growers, contractors, researchers and extension officers in different aspects of orchard management for production of quality mangoes. Other aspects of capacity building also identified included the training of researchers through graduate degree programs as well as the extension of new technologies to growers through the Farmer Field School model and other suitable methods of information dissemination.

During the survey visits that followed the workshop, there were interactions between growers, researchers and other industry stakeholders, and the problems and issues facing mango production and quality in Pakistan were examined and discussed. Disease symptomatic samples as well as soil and leaf samples were collected for laboratory analysis.

MSDS was confirmed as a major production issue of concern in just about every orchard that was visited averaging 3.2 trees per 10 tree sample in the Punjab and six trees per sample in the Sindh. The key issues of concern with MSDS were early identification and procedures to stop or slow its progress in orchards. A number of pathogens have been identified from field samples including *Ceratocystis* sp and *Lasiodiplodia* sp. Insect pests were mainly classified as a minor issue. Other major issues identified during the visits were problems of orchard management related to nutrition, irrigation, water quality and ways of synchronizing tree phenology.

Detailed assessment of the background information, workshop and survey findings has identified the following key areas to be addressed through the ACIAR project, “Development of integrated crop management practices to increase sustainable yield and quality of mangoes in Pakistan and Australia” (HORT/2005/153) and other ASLP activities to improve industry productivity within a relatively short period ( three to five years) that will deliver lasting benefits for the mango industry in Pakistan and Australia.

1. Develop improved nursery systems for the production of high quality disease-free planting material
2. Develop improved tree husbandry options for the sustainable production of high quality fruit
3. Develop improved detection and management strategies for mango sudden death syndrome disease and other critical pests of mangoes
4. Build capacity in the Pakistan & Australian mango industries to conduct integrated and targeted research, development and extension programs.

## **Background**

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The purpose of the Agriculture Sector Linkage Program (ASLP) is to build linkages between the agriculture sectors of Australia and Pakistan. Under a Record of Understanding (RoU) with the Australian Agency for International Development (AusAID), the Australian Centre for International Agricultural Research (ACIAR) has agreed to manage and implement the Agriculture and Linkages Program technical components. The main goals of the agriculture linkages component are:

1. To transfer Australian knowledge and expertise to key sectors of Pakistan agribusiness to increase profitability and enhance export potential
2. To contribute to poverty alleviation of small-holder farmers through collaborative research and development
3. To enhance the capacity of the Pakistan research, development and extension system to deliver targeted and practical research outputs to agribusiness and farmers.

Within the priority sectors of horticulture, mango and citrus were identified as commodities that will be addressed initially. The mango and citrus industries are the most important horticultural tree crops, with Pakistan an important global producer and increasingly, an exporter.

To meet the ASLP goals and priorities and to ensure the program delivers early impacts, it was necessary to configure the program into a flexible suite of short, medium and long term activities. These comprised:

- Initial short term scoping studies and constraints analysis
- Agro-enterprise exposure and fact finding trips to Australia
- Technical and scientific workshops
- Tailored training and capacity building packages delivered in Pakistan and in Australia
- 1-3 yr technical intervention and/or research and development projects

As part of the above plan, a Short Research Activity (SRA) project titled “Assessment of mango diseases, pests and production problems in Pakistan” (HOTR/2005/154) was commissioned by ACIAR, to the Queensland Department of Primary Industries and Fisheries (QDPI&F). This scoping study is to be followed by the development of a more comprehensive R & D project proposal to solve problems identified during an SRA supported workshop and field visits, as well as other mango production issues in Pakistan and Australia that hamper industry productivity.

The specific objectives of the SRA were:

- To provide a perspective on the status of mango diseases and pests in Pakistan and the field practices that are being implemented across the Pakistan mango industry.
- To provide recommendations on key research priorities and investment strategies required to address the productivity constraints to achieve increased and sustainable mango production in Pakistan.
- To provide a pathway to adoption for the mango industry of the research outcomes and insuring linkages to the supply chain.

The scoping study team assembled to carry out this SRA was made up of the following members:

- Dr Chrys Akem – Pathologist and Team Leader, QDPI&F Ayr
- Mr. Rowland Holmes – Extension Horticulturist, QDPI&F Ayr
- Mr. Bruno Pinese – Entomologist, QDPI&F Mareeba
- Mr. Ian Bally – Horticulturist, QDPI&F Mareeba
- Mr. Tony Cooke – Pathologist, QDPI&F Indooroopilly
- Dr Greg Johnson – Consultant/Pathologist, Canberra
- Mr. John Morton – Grower, Emu Exports, Alligator Creek, North Queensland

Critical logistical support for the SRA activities was provided by ACIAR (Dr. Christian Roth, Mr. Les Baxter, Mr Sosheel Solomon) and a Pakistan organising committee (Mr. M. Hashim Lagheri, Dr. Aman Ullah Malik and Dr. Haji Khan Keerio and their affiliations) as well as several stakeholder groups in the Pakistan Mango Industry. In parallel with this SRA, a second SRA (PLIA /2005/159 *A constraints analysis of mango supply chain improvement in Pakistan*) led by the University of Queensland undertook a preliminary constraints analysis of mango supply chain improvement in Pakistan.

## **Methodology**

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To meet the objectives of HORT/2005/154, the study team used a range of quantitative and qualitative techniques. These included:

### **1. Secondary data analysis and planning**

Prior to visiting Pakistan, the study team conducted literature reviews by discipline areas, to identify what research and extension had been conducted in Pakistan and elsewhere, specifically in relation to Mango Sudden Death Syndrome (MSDS), Mango Dieback, Mango Malformation, insect problems and more generally in relation to production practices and postharvest handling.

The citations of all the research literature sources consulted in relation to mango malformation and sudden death or decline are listed as **Appendix 1**.

These diseases were particularly targeted because of indications that these were the major areas of mango production concerns that needed to be addressed in a project, from our colleagues in Pakistan, prior to our visit to undertake the SRA workshop and farm visits.

A questionnaire was developed and emailed to key contacts in Pakistan prior to the mango workshop to obtain background relevant to the issues to be investigated within the SRA. A planning meeting involving the SRA team, the team involved in PLIA/2005/159 and ACIAR personnel, was held in Brisbane during February 2006, to co-ordinate and formulate SRA activities which would include a 4 day mango R & D workshop and field surveys/system assessment in Pakistan during March-April 2006.

The secondary data, along with inputs from the Pakistan organising committee and the Brisbane workshop, were used in the development of presentations for the Mango workshop by the Australian team and the methods used for the field surveys of mango orchards.

## **2. Workshop on Mango RD&E in Pakistan & Australia**

The four day workshop was organised to bring together researchers and other stakeholders from Pakistan and Australia working in mango research, extension and agri-business at the start of the field surveys. The aims of this workshop were:

- To build linkages between researchers, extension officers and agribusiness by sharing and jointly evaluating results and experiences in mango research and extension;
- To clarify future mango research and development needs in partnership with relevant agencies for collaborative activities under the auspices of the ASLP and
- To identify future capacity building and training needs in Pakistan mango research, development and extension officers, as well as growers and agribusiness.

Forty eight participants attended the workshop including 35 from Pakistan and 13 from Australian. The seating arrangement for the workshop was banquet-style with participants seating in round table groups, with no more than 10 people at a table. Participants were allocated to tables so that each table had a broad spectrum of skills and knowledge represented.

Sessions were divided into two segments, presentations and table discussions. Following each presentation, participants were asked to discuss the points raised by the speakers and identify the key issues for the Pakistan mango industry. These were collated for each table. The second day of the program included a field tour of local markets, nurseries and orchards to provide practical exposure to industry challenges. To provide additional attention to supply chain and information dissemination, two additional sessions on the third day used working groups to map supply chains and information flows. These enriched understanding of the critical issues affecting supply and information flows.

At the completion of the formal presentations, the field day and the mapping exercises, six working groups were formed around the key research areas identified during the workshop; diseases, insects, physiology, postharvest technology, supply chain management and capacity building & information.

Using the issues collated from the table discussions, these working groups prioritised the key researchable issues and actions points they felt should be addressed by an ASLP mango project. On the final day of the workshop, these issues were reported back to all participants in three presentations covering “Mango Production R&D”, “Mango Supply Chain R&D” and “Capacity Building and Information”.

A copy of the Workshop Programme is attached as **Appendix 2**.

### **Field surveys of mango orchards**

A six day survey of mango orchards in the Punjab and Sindh regions was carried out to understand and assess the issues affecting mango production and the impact of MSDS. The team split into two groups to enable coverage of more farms in the time available. In total, 50 farms were visited. The survey was conducted in parallel with supply chain mapping being undertaken under PLIA/2005/154 and some team members (Morton/Johnson) participated in part of both exercises. Each orchard survey was conducted in three parts.

(a) Each grower or farm manager was interviewed to establish the impact of MSDS on their business and to collect information on orchard management practices.

(b) The incidence and severity of MSDS and other diseases and insects in each orchard were rated based on visual observations. The diseases of particular attention were MSDS, dieback, mango malformation and blossom blight (anthracnose). The insects rated were midges, leaf hopper, scales, thrips, and mealy bug.

(c) Field samples of diseased tissue from infected trees were taken to diagnose or confirm agents associated with the various field symptoms, especially MSDS, as summarized below. Insect specimens, both pinned and in alcohol, were taken for specialist identification. Soil and leaf samples were also collected, especially from representative trees in orchards that appeared to be severely stressed, exhibiting various physiological disorders.

Pakistan R & D personnel Mr Munawar Kazmi (NARC), Mr Tariq Malik (University of Faisalabad), Mr Ikhtlaq and Mr Ghaffar (Mango Station, Shujabad) and Mr Zahid Gardezi (MGA) in the Punjab and Dr. Haji Khan Keerio, Dr Atta Soomo, Dr Abdul Sattar Buriro and Mr Ali Khaskheli in the Sindh accompanied the survey teams and provided critical introductions and insights to technical and cultural matters.

### ***Summary process of disease and insect diagnosis survey***

- In every orchard visited, 10 random trees were surveyed for sudden death symptoms and diseased samples were collected from a range of symptoms observed on the surveyed trees.
- The samples were placed in labelled bags and taken back to the hotel. To process the specimens, isolation plates and necessary equipment had been brought in from Australia in readiness to undertake the exercise and additional equipment was made available at the Mango Research Station, Shujabad in the Punjab.
- A series of isolations were undertaken at the Mango Research Station, Shujabad near Multan, from the first collections from Punjab, after the first day of survey visits. Symptoms on specimens included discoloured trunk bark and wood material and new growth mango branches which were all used for isolation of potential causal agents. These isolations were made in collaboration with the Pakistan pathologist at the station. Some isolation plates were left in the Multan laboratory for identification by the station pathologist and the remainder taken back to Australia under a Quarantine permit.
- A second group of isolations were undertaken in Karachi following surveys in the Sindh province, with samples collected from this second series of surveys. These were mostly carried out in hotel rooms using improvised sterile work stations.
- All isolation plates and some samples were packed and carried back to Australia at the end of the scoping study trip. On arrival in Australia all isolation plates and related sample material brought in were surrendered to quarantine authorities who transferred them to the AQIS Eagle Farm laboratory near Brisbane airport.
- Further isolations were undertaken on the samples brought in this AQIS laboratory on receipt of the samples, using selective media.
- All isolation plates were incubated at appropriate temperatures for growth and sporulation so that identification and diagnosis could be made.
- Similar protocols were followed in Multan.

## Results

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### 1. Secondary Data and Planning

A literature review on mango decline or dieback and mango malformation was undertaken prior to the sturdy tour. A list of references reviewed is listed in Appendix 1

### 2. The Workshop

The following key priority R&D areas specific to pre-harvest production were identified via participatory group discussions among the workshop participants (Please note that a range of issues related to supply chains and post harvest fruit management was also identified and is reported under project PLIA/2005/159).

#### **a. Disease and Pest Management Issues**

- Sudden Death Syndrome
  - Confirmation of pathogens or causal agents involved in the syndrome
  - Development of early diagnosis and detection methods
  - Development of grower-friendly management practices
- Progressive Decline
  - Investigations into possible roles of root rots, soil pH and tree nutrition.
  - Package known management recommendations for grower adoption
- Anthracnose and blossom blight
  - Package known management practices for grower adoption and use
  - Development of disease forecasting systems to improve timing of fungicide spray applications
- Fruit flies
  - Development of pre-harvest management guidelines
  - Development of post-harvest disinfestation protocols
- Mango Midges
  - Assessment of economic impact of the pests
  - Study the pest biology, ecology and control options
- Training and skills development. Development & Delivery of training modules on:
  - Mango crop production and protection principles
  - Disease recognition and management
  - Target: Mango growers, contractors, extension officers & researchers

#### **b. Orchard Management Issues**

- Nutrition management to optimise tree health, fruit production and quality
  - Develop nutritional recommendations for different growth stages
  - Develop nutritional monitoring tools
- Irrigation management to maximise fruit production and quality

- Understand tree/water requirements at each phenological stage
- Water application techniques, scheduling and monitoring
- Canopy management for reduced tree size, disease reduction and improved fruit quality
  - Demonstrate pruning techniques in pre-bearing trees to develop productive canopy
  - Demonstrate pruning techniques in bearing trees to reduce biennial production, increase yield and reduce disease epidemics
- Nursery production and certification
  - Introduce and evaluate salt tolerant and poly embryonic rootstocks
  - Develop a demonstration certified nursery producing disease-free containerised grafted trees

### ***c. Capacity Building Issues***

- Enabling project delivery: Skills development orchard management (production & protection), postharvest technology and supply chain management
  - Target: Mango growers, contractors, agribusiness, extension officers, researchers
- Project Management: Skills development planning & management of projects, evaluation and advocacy, financial management skills and human resource management
  - Target: Researchers, extension officers
- Extension & Communication: Skills development in Information skills (use, access etc.), facilitation & presentation skills and networking
  - Target: Extension officers, agribusiness, researchers

## **3. Field Surveys**

### ***(a) Orchard management in general***

The orchard management in most orchards visited during the survey could be easily improved. In most cases, nutrition appeared to be the main cause of poor performing trees. Growers were in many instances not sure of the nutrients to apply, the combinations and when to do so.

The growth stages of orchards surveyed in the Punjab was flowering to early fruit set with the most advanced being pea sized fruit. In the Sindh, most orchards were in the early stages of fruit development with pea to egg size fruit on most panicles. Trees in most orchards were flushing out of sequence even during flowering or fruiting. It was explained that this was desirable as flushes during flowering were certain to flower and produce a crop in the next season. In other orchards, some trees were neither fruiting nor flushing clearly suggesting some issues with production that will need to be sorted out for a consistent crop yield.

Frost damage from the recent cold winter was prevalent in many orchards in the Punjab. The severity ranged from a few branches in a tree to the whole canopy being burnt.

Specific comments about orchards management are;

- Soils: Soil types in orchards varied greatly with all having a rather higher pH than desired for mango growth. Most soils had a pH in the range of 8.0 to 10. In some cases organic matter was clearly lacking and could be reflected in the growth of the

stress. In orchards with younger trees where intercropping was practiced, cultivation often disturbed tree roots when cultivated too closely to the base of the trees.

- Irrigation: The quality of irrigation water from river fed channels was good but many farms were supplementing it with underground water that was generally saline. Both the high pH and saline water are putting trees under significant abiotic stress. Management practices to reduce the effects of the abiotic stress may also help in increasing canopy health, tree decline and sudden death.

Irrigation problems were also observed during visits to different orchards. In many instances, trees were not receiving adequate water especially during peak reproductive periods when this was critical. Irrigation scheduling varied from orchard to orchard but in most cases orchards were flood-irrigated.

- Rootstocks: Introduction and testing of salt tolerant rootstocks could provide positive short to medium term outcomes. This activity maybe able to be done in conjunction with the citrus project in the Punjab but not in the Sindh.
- Orchard Nutrition: Orchard nutrition varies greatly between orchards, but generally the trees are under-fertilized and fertilizer is not applied in a timely manner. Where it is done well the trees seem to have healthier canopies and heavier crop loads. Better use of fertilizer will help tree health and fruit yields.
- Canopy Management: The general method of canopy management in Pakistan is not to manage it. Trees are excessively large producing low yields per ha. Pruning is mainly done to remove dead wood and malformed flowers but not for canopy training or size control. Their understanding of the benefits of pruning is poor and in many cases misled.
- Growth Regulators: Paclobutrazol (Austar<sup>®</sup>) is being trialled on many farms but it was often not effective because it is applied at the wrong stage of tree growth. For pruning and canopy management to be widely adopted, most growers will need to see a model orchard over several years that is able to reduce biennial fluctuations and maintain yields.
- Fungicides: These were being applied as recommended by the chemical companies with little independent evaluations
- Current Cultural Practices: These appear to be contributing to the spread of pathogens throughout the orchards e.g. pruning malformed flowers, damaging tree roots by ploughing and flood irrigation.
- Nursery Practices: Nurseries were observed to be established mainly within orchards. In some cases these were positioned directly under trees infected with both malformation and dieback diseases complexes. Some of the young nursery seedlings were already showing vegetative and floral symptoms of malformation even before transplanting. Others also had gummosis oozing out of the tiny stems, again suggesting that dieback infection could be initiated on young seedlings and then transplanted into new or established orchards. Infected nurseries as a means of spread and re-circulation of these important diseases have to be addressed if sustainable options for these diseases are to be established.

The following observations were made in relation information and extension:

- Written information on mango management did not appear to be readily available to growers. Of the growers visited, only Hadi Leghari (Asim Agriculture farms) made reference to written information and that was the Australian Agrilink kits for Banana and mangoes.
- During the workshop, TV, radio & newspapers were identified as major information sources. Billboards had also proved popular with cotton for slogans and seasonal information
- Computer & Internet use was considered low
- Personal networks with specific researchers was an important information source for many particularly in the Sindh (All farmers visited mentioned Dr. Keerio and his team in finding out controls for MSDS)

### ***(b) Disease and insect diagnostic survey***

A summary of the Disease and insect diagnostic survey results for the Punjab and the Sindh Provinces is listed in Appendix 3, Table 1.

#### **Disease**

A number of diseases were observed at different intensities in the orchards visited. These were: the mango sudden death syndrome (MSDS) in different forms and stages, mango malformation, powdery mildew, blossom blight, foliar anthracnose and bacterial black spot. Among these diseases, sudden death stood out as the main concern occurring at different levels in virtually all the orchards visited. (Findings of sample diagnosis are described in (c) *Diagnostic analysis of field samples*, page 14). Mango malformation and bacterial black spot were also prevalent and current control practices appear inadequate. The timing of visits was unsuitable for observing additional problems identified at the workshop (e.g. powdery mildew, fruit diseases).

The key issues identified in the disease survey were;

- Almost every farm visited in the Punjab and the Sindh Provinces had trees with symptoms of sudden death, progressive decline and mango malformation,
- Although serious, mango malformation (caused by *Fusarium mangiferae*) appeared to be a pathogen that the growers are living with. Improved control measures, however, would definitely help,
- Sudden death and progressive decline (if related) was rampant. Of the farms surveyed, it was not uncommon for all trees to be showing one or more of the typical symptoms,
- Clean planting material was a major issue with infected plants and dying plants a common sight in nurseries situated under infected trees in orchards,
- Fungicides were being applied as recommended by the chemical companies with little independent evaluations,
- Current cultural practices appear to be contributing to the spread of pathogens throughout the orchards e.g. pruning malformed flowers, damaging tree roots by ploughing and flood irrigation.

#### ***The Mango Sudden Death Syndrome***

Different forms of the sudden death syndrome could be distinguished:

- a. **Progressive or Slow Decline or Dieback:** This is where a twig or branch dieback is observed on trees, starting generally from the tree top and progressing gradually down the larger branches. The first visual symptoms of progressive decline of old trees are the suppression of the normal seasonal flushes of growth, accompanied by leaf discoloration. The new growth tends to be weaker, the foliage more sparse and dead twigs more abundant. This phenomenon was prominent in poorly managed orchards and could readily be linked to poor nutrition and irrigation practices as well as general poor orchard management. Trees in orchards with this problem could be remedied by immediately improving on the identified cause of the decline.
- b. **Quick Dieback:** In this case the tree appears normal, and then gradually begins to lose form, usually starting with changes in its foliage from typical green to yellow. Massive leaf drop follows or if retained lose their dark green lustre and turn pale yellow in colour with gradual development of chlorosis. Close examination of tree trunk and branches would reveal gummosis of different colours and shapes coming out mainly from the bark layers. Scraping of these branches generally revealed that these oozes are mainly confined to the phloem section of the tree bark. Early intervention with appropriate fungicide pasting to infected areas after scrapping off the gummosis and improvements of the tree health by application of appropriate nutrients and irrigation general would lead to full recovery of the trees.
- c. **Sudden Death:** This is the most dramatic form of the decline syndrome. The tree looks or appears normal and suddenly starts to wilt and within a couple of days is completely wilted and dies. Observance of tree trunk and main branches reveal gummosis of different colours, forms and intensities coming out at different positions on the tree. Infection in this case is often not limited only to the bark of the tree but observed on the inner wood tissue of the xylem as striated brownish streaks within the woody tissue. In some cases, further scraping of the infected wood tissue releases stinking liquids of milky and sometimes brownish or blackish appearance. At this stage there is often little the grower can do to save the tree.

The development of slow decline or sudden death seemed to depend on the degree of infection of the tree, its age, the variety and its health. Weaker trees were highly susceptible and quicker to decline or die. It is possible that the three symptom types could have the same primary cause with symptom expression influenced by other factors.

In a few cases a 'resistant' scion effect was observed. In these cases, only the rootstocks showed visual symptoms of MSDS. The tree trunk above the graft appeared to be free of infection.

Other diseases commonly observed during the survey included malformation, especially in the Punjab province where most trees were at their flowering peak at the time of the survey visits, foliar anthracnose and blossom blight, powdery mildew as well as bacterial blight mainly on new flushes. In virtually all fields visited, floral malformation was being controlled by manually pruning back of symptomatic panicles. It appears this is the main means currently available to control this disease with typically two pruning rounds needed during each flowering period.

Growers and researchers were having problems distinguishing salinity or phytotoxicity symptoms on edges of leaves from foliar anthracnose symptoms and often tended to conclude that they were all foliar anthracnose symptoms, thereby doing nothing to try and correct the salinity or salt problems producing some of these symptoms.

Powdery mildew, especially on developing panicles, was not common but where present was at level that could cause significant production losses.

Bacteria blight was quite common in some orchards on new flushes and it was apparent that the spots were not being recognized or assumed to be associated with foliar midge damage.

### **Insect pests**

The main insects of concern identified by the study team were the mango leaf and blossom midges as well as fruit flies specifically as impediments to market access. No opinion could be formed on direct field fruit losses due to fruit fly because the field visits were conducted at or just after fruit set only when fruit fly are not active.

During field surveys high levels of midge infestation were observed primarily on flushes. Midges were much more prevalent in the Punjab but were only seen in low numbers in the Sindh. As this was reported to be a relatively new infestation of midges, these pests will need to be monitored and studied to determine their long term pest status in mango particularly in the Punjab province.

Leaf hoppers were reported as occasional severe pests by local researchers but were not observed by the project team and the honeydew and sooty mould usually associated with even low infestations was only rarely observed.

The common mango scale was only seen in very low numbers except on one orchard in the Sindh where the populations were very high.

Bark (Ambrosia) beetles were observed on trunks and collected for identification. The role, if any, in the spread of the disease could not be determined but these beetles are generally considered to be secondary.

### ***(c) Diagnostic analysis of field samples***

A table of the complete isolation results from sample isolates brought back to Australia and processed at the AQIS lab at the Brisbane airport is attached as Appendix 3, Table 2.

Photos of the different microscopic isolations are shown in Appendix 4.

Diagnosis results at time of writing the report

- Punjab and Mango Research Station samples: A range of fungi were isolated. These included *Ceratocystis* sp, *Alternaria* sp, *Lasiodiplodia theobromae*, *Dothiorella dominicana* and bacterial/*Aspergillus* sp. As these plates were carried with us under less than ideal conditions, there were issues of contamination.
- Sindh samples: The results from the Sindh district orchard isolations included: *Ceratocystis* sp, *Alternaria* sp, *Lasiodiplodia theobromae*, *Dothiorella dominicana* and bacterial/*Aspergillus* sp. And this was consistent with the isolations from the Punjab samples. The Diatloff method of isolation was used in this case.

### ***Comments on isolations and pathogen diagnosis***

*Ceratocystis* sp. was confirmed as present in the samples collected from both the Punjab and the Sindh. This is really significant considering some of the controversies surrounding the causal agents of sudden death of mangoes in Pakistan. It was important to confirm the presence of this pathogen, if involved in the sudden death syndrome, as it has been reported in a recent publication from Oman, as causing sudden tree death. As this has shown to be the case, other fungi isolated or associated with the syndrome at this stage would appear to belong to the category of secondary invaders.

The other pathogen of interest was *Lasiodiplodia theobromae* which has been largely reported as the cause of the syndrome in Pakistan. This pathogen was also isolated from some of the samples collected in both the Punjab and the Sindh districts. *Fusicoccum parva* formerly known as *Dothiorella dominicana* was also frequently isolated from the samples in both districts. It came from both twigs and stem samples.

## **Discussion & Recommendations**

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The mix of methodologies used for this SRA has provided the research team with the opportunity to identify numerous research priorities and capacity building strategies that will significantly minimise the impact of MSDS, improve orchard management and maximise the productivity of quality fruit for the domestic and export market. These research priorities have been structured around the four project objectives.

### **Research Priorities**

**Objective 1.** *“Develop improved nursery systems for the production of high quality disease-free planting material”*

- Improved Rootstocks
  - Introduction of salt and high pH resistant rootstocks such as 13-1 into the Pakistan mango industry research program.
  - Introduction of polyembryonic rootstocks from Australia and overseas including ‘Kensington Pride’ and some Thai varieties.
  - Evaluation of introduced rootstocks in saline and high pH soils at multi-locations to identify superior ones that could be multiplied and used in nursery.
- Nursery production
  - Establishment of a model nursery through collaboration between Pakistan and Australian nurseries to develop best nursery practise. This would involve the establishment and use disease-free bud wood to reduce the spread mango malformation & MSDS and enhance grafting methods.
  - Production and disseminate a nursery production manual.

**Objective 2.** *“Develop improved tree husbandry options for the sustainable production of high quality fruit”*

- Orchard management
  - Development of an integrated orchard management package to reduce disease, improve fruit quality and reduce biennial bearing. This research priority is important to help deliver quality fruit for the *“Optimising mango supply chains for more profitable agro-enterprises in Pakistan”* project (HORT/2005/157) to demonstrate the positive effects of good orchard management on the mango supply chain (this ACIAR project will follow on from PLIA/2005/159 *A constraints analysis of mango supply chain improvement in Palkistan*).

**Objective 3.** *“Develop improved detection and management strategies for mango sudden death syndrome disease and other critical pests of mangoes”*

- Pathological Studies
  - Conduct pathogenicity tests, focusing initially on *Ceratocystis* sp. and *Lasiodiplodia* sp. identified on mango trees to determine or confirm the role of each of the pathogens on the decline disease syndrome.
- Epidemiological Studies
  - Carry out a study on the epidemiology of the MSDS. The epidemiological studies could form a good graduate student thesis project. This should include:
    - Methods of detecting initial infection
    - Sources and methods of transmission and spread of the pathogens involved
    - Possible role of the bark beetle as a vector in pathogen dissemination and spread &
    - The role of temperature and soil moisture on the disease initiation and spread
- Integrated Disease/Pest Management Options
  - Screen a range of systemic fungicides including plant activators to identify those that could be applied as basal drenches to minimise the development of the MSDS.
  - Screen and identify a suitable systemic fungicide that could be applied following pruning to rejuvenate flushes and minimise the development of malformation on developing flushes and panicles, building on knowledge from South Africa, Brazil and the recently completed Pakistan project “Studies on malformation of mango”.
  - Compare different application methods (drenching, spraying and injecting) for fungicides and plant activators, to determine their efficacy on the early management of the MSDS in mango orchards.
  - Select problematic orchards to evaluate integrated crop management practices that could reduce the initiation and/or development of MSDS and improve fruit quality.
- Insect studies
  - Build on the Farmer Field School approach to review and enhance recommendations for fruit fly and other pests (spill over bait sprays, use of oil sprays etc).

**Objective 4.** *“Build capacity in the Pakistan & Australian mango industries to conduct integrated and targeted research, development and extension programs”*

- Capacity Building
  - Selection and facilitation of graduate student training for researchers and extension officers in appropriate institutions so that they can continue with RD&E work in mangoes.
  - Facilitation of short duration training courses during project visits to Australia and Pakistan to enhance the ability of project staff to conduct research, development and extension activities.
  - Project management: The focus here shall be on planning and evaluating projects using tools such as Bennett’s Hierarchy and developing and implementing communication plans.

- Extension: Social research, knowledge systems, facilitation, presentation skills and participatory research approaches
- Information product development: Computer desktop publishing, developing and designing targeted information products & services.
- Carry out workshops targeting RD&E staff and other information providers in the supply chain in a “Train the Trainer” way. Direct others at growers, contractors and field workers.
- Information & Extension
  - Investigation of a participatory extension model, using a knowledge systems approach to improve the fruit quality and productivity of mango orchards in Pakistan with emphasis on disease. This approach would strengthen linkages amongst the various Federal and Provincial RD&E personnel. The initial focus for this model would be the identification and management of MSDS.
  - Enhancement of the existing Mango Farmer Field Schools approach to enhance skills development and improve information availability to growers, contractors and field workers. Participatory (on-farm) research trials could include a model nursery and documenting phenology. Some of this work has already been initiated by the National IPM Programme (NARC).
  - Develop workshop modules covering various aspects of orchard management including disease and pest management, nutrition, irrigation, phenology etc. These modules could be based on management practice (nutrition disease etc.) or growth stage or phenological timing (harvest to flowering, flowering to harvest, harvest).
  - Compilation and publication of a range of information products. Initially these could include mango Information kits, disease (& Insect) laboratory identification manuals, growing manuals, pest & disease field id guides and phenology posters.

### **Suggested Project Collaborators and Research Locations**

#### ***National Agriculture Research Centre (NARC), Islamabad (Coordination and Research)***

- Under the National IPM program, Dr. Iftikhar Hussain & Mr Munawar Kazmi are leading a national project on MSDS and currently coordinating the expansion of the Farmer Field School (FFS) approach from cotton into mangoes.
- It is recommended that Dr. Iftikhar be the project leader for this project and Mr. Kazmi be the Research Leader.

#### ***Shujubad Research Station, Multan (Research/Training)***

- The Mango Research Station at Shujubad is part of the Punjab Ministry of Agriculture’s Ayub Agricultural Research Institute (AARI). Mr Tariq Malik, who is currently undertaking a PhD on MSDS will lead the research here.

#### ***Sindh Agricultural Research, Tandojam & Mirpur Khas (Research/Training)***

- Sindh Agric Research at both stations. Here the focus will largely be on- Farm evaluations of different research activities directly and indirectly linked to MSDS management. Leader nominated by Dr. Haji Khan Keerio and Dr Atta Soomro.

***Agriculture Extension, Punjab (Extension)***

- The Fruit & Vegetable Development project is currently collaborating with NARC in running FFS on cotton and their expansion into mangoes. Dr. Rana Shafiq (Lahore) & Mr. Khan (Multan) have been identified as key collaborators for this project.

***Additional Pakistan collaborators***

- Southern Agriculture Research Centre, University of Karachi (Mr Muhammad Mubarik).
- Nuclear Institute for Agriculture & Biology, Faisalabad (Director: Dr. Ahmad Khan)
- Asim Agriculture Farms, Hyderabad (Imdad Nizamani & Hadi Leghari)
- Tareen Farms, Multan.

## Appendix 1: Literature Reviewed

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### **Mango Decline or Dieback**

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### **Mango Malformation**

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## Appendix 2: Workshop Program

Workshop on mango research, development and extension in Pakistan and Australia.  
Multan, Pakistan, Tuesday to Friday, 28th to 31st March, 2006

<b>Monday, March 27, 2006</b>	
<b>Travel Lahore - Faisalabad - Multan</b>	
<ul style="list-style-type: none"> <li>• 08:00 - 11:00: Travel from Lahore to Faisalabad</li> <li>• 11:00 - 12:15: Visit the University of Agriculture, Faisalabad to meet VC, relevant Professors and to see lab facilities</li> <li>• 12:30 - 13:45: Working Lunch with relevant UAF Professors, DG AARI &amp; Director NIAB at Serena, Faisalabad</li> <li>• 14:00 - 15:00: Visit DG AARI office where briefing on the working of the organization followed by table discussion with relevant Directors</li> <li>• 15:00 - 19:30: Travel from Faisalabad to Multan and stay at Holiday Inn</li> </ul>	
<b>Tuesday, March 28, 2006</b>	
<b>8.30 - 10.00</b>	<b>Session I: Formal opening of Workshop</b> Chairman: Dr. Laghari, <ul style="list-style-type: none"> <li>• <i>Welcome Remarks</i> - Dr. Aslam Gill, Commissioner Minor Crops, MINFAL</li> <li>• <i>Outlines and Purpose of Workshop</i> - Dr. Christian Roth, ASLP Coordinator</li> <li>• <i>Process of Workshop</i> - Dr. Greg Johnson, Horticulture 4 Development</li> <li>• <i>Key Note Address</i> - Dr. Saeed Ahmad, President, Horticultural Foundation of Pakistan</li> <li>• <i>Formal Inauguration</i> - Federal Minister, MINFAL</li> </ul>
<b>10.00 - 10.30</b>	Tea
<b>10.30 – 13.00</b>	<b>Session II: Presentations - Improving market opportunities</b> Chairman: Dr. Haji Khan Keerio, Director General Research Sindh Facilitator: Dr. Greg Johnson Co-Facilitator: Dr. Khalid Mustafa (UAF) <ul style="list-style-type: none"> <li>• <i>Overview of the mango sector in Pakistan – economic significance, institutions, sector priorities and Agriculture sector policy framework</i> - Mr. M. Hashim Laghari, Senior Director, PARC</li> <li>• <i>Supply chain management: examples from Australia</i> - Prof. Ray Collins</li> <li>• <i>Mango export problems from a farmer's perspective</i> - Mr. Mahmood Nawaz Shah, Sindh</li> <li>• <i>Mango exports and linkages with Agri-business in Pakistan</i> - Mr. M. Iqbal, CEO, PHDEB</li> <li>• <i>Export market development: Case study from northern Australia</i> - Mr. Peter Johnson, DAWA</li> <li>• <i>Discussion in Working Groups</i></li> </ul>
<b>13.00 – 14.00</b>	Lunch/Prayer Break

14.00 – 17.30	<p><b>Session III - Plant protection and orchard management</b>  Chairman: Dr. Iftikhar Ahmad, Dy. Director General, NARC  Facilitator: Dr. Greg Johnson  Co-Facilitator: Mr. Munawar Kazmi, PARC</p> <ul style="list-style-type: none"> <li>• <i>Managing dieback and other mango diseases in Pakistan</i> - Dr. Ahmad Saleem Akhtar, AARI</li> <li>• <i>Managing mango insect pests in Pakistan</i> - Dr. A. Sattar Buriro, ARI, Tandojam</li> <li>• <i>Australian experiences in IPM research</i> - Mr. Bruno Pinese, DPI&amp;F, Qld</li> <li>• <i>Australian experience in systems approach to disease management</i> - Dr Chrys Akem, QDPI, Australia</li> </ul>
	Tea
	<p><b>Session III - Plant protection and orchard management (cont.)</b></p> <ul style="list-style-type: none"> <li>• <i>Overview of orchard management practices in Pakistan its impact on yield and quality</i> - Dr. Atta Hussain Soomro, ARI, Tandojam</li> <li>• <i>General orchard management practices in Pakistan</i> - Mr. Zahid Hussain Gardezi, Punjab</li> <li>• <i>Orchard management and its impact on productivity and profitability in Australia</i> - Mr. Ian Bally, DPI&amp;F Qld</li> <li>• <i>Discussion in Working Groups</i></li> </ul>
<b>Wednesday, March 29, 2006</b>	
<b>Field Trip</b>	Visit to local market and orchards
<b>Thursday, March 30, 2006</b>	
8.30 – 10.00	<p><b>Session IV - Presentations and Working Groups: Post harvest, supply chain and extension systems</b>  Chairman: Dr. Tony Dunne, University of Queensland  Facilitator: Dr. Greg Johnson  Co-Facilitator: Dr. Aman Ullah Malik, UAF &amp; Mr. M. Murad Dahrejo, Sindh Agriculture Extension</p> <ul style="list-style-type: none"> <li>• <i>Mango post harvest management: status and requirements</i> - Dr. Aman Ullah Malik, UAF</li> <li>• <i>Improving knowledge and practise in supply chains</i> - Jodie Campbell, DPI&amp;F Qld</li> </ul> <p>Working groups</p> <ul style="list-style-type: none"> <li>• <i>Mapping the supply chain – players &amp; their roles</i> - Facilitator: Dr. Greg Johnson</li> </ul>
10.00 - 10.30	Tea

10.30 - 13.00	<p>Presentation</p> <ul style="list-style-type: none"> <li>• <i>Mango extension systems in Pakistan</i> - Dr. Rana Shafique, Agri Extension, Punjab</li> <li>• <i>Working with mango growers and supply chains to improve knowledge and practise: An Australian perspective</i> - Mr. Rowland Holmes, DPI&amp;F Qld</li> </ul> <p>Working groups</p> <ul style="list-style-type: none"> <li>• <i>Mapping the information system – players &amp; their roles</i> - Facilitator: Dr. Greg Johnson</li> </ul>
13.00 – 14.00	Lunch/Prayer Break
14.00 – 17.30	<p><b>Session V - Working Groups</b> Facilitator: Dr. Greg Johnson Introductory presentations</p> <ul style="list-style-type: none"> <li>• <i>Processes used in planning R, D &amp; E for the Australian mango industry</i> - Mr. Rowland Holmes, DPI&amp;F Qld</li> <li>• <i>Mango R &amp; D planning in Pakistan</i> - Dr. Ahmed Saleem Akhtar, AARI</li> </ul> <p>Concurrent working groups working parties;</p> <ul style="list-style-type: none"> <li>• <i>Key mango production research issues to be addressed by ASLP</i></li> <li>• <i>Key mango supply chain research issues to be addressed by ASLP</i></li> <li>• <i>Key mango capacity building issues to be addressed by ASLP</i></li> </ul>
<b>Friday, March 31, 2006</b>	
10.00 – 12.00	<p><b>Session VI - Wrap up and Formal Closure of Workshop</b></p> <ul style="list-style-type: none"> <li>• <i>Opening Remarks</i> - Mr. M. Hashim Laghari, PARC</li> <li>• <i>Summary of key mango R&amp;D issues identified</i> - Prof. Aman Ullah Malik, UAF</li> <li>• <i>Summary of key mango supply chain R&amp;D issues identified</i> - Prof. Ray Collins, University of Queensland</li> <li>• <i>Summary of key capacity building and knowledge dissemination issues identified</i> - Mr. Rowland Holmes, DPI&amp;F Qld</li> <li>• <i>Recommendations/Outcome of workshop</i> - Dr. Christian Roth, ASLP Coordinator</li> <li>• <i>Closing Remarks</i> - State Minister Agriculture/Secretary MINFAL</li> <li>• <i>Vote of Thanks</i> - Dr. Haji Khan Keerio, Agri Research Sindh</li> </ul>
12.00	Tea

### Appendix 3: Summary of Disease and Insect Diagnostic Survey

**Table 1. Average ratings for MSDS and other diseases and insects identified during orchards surveys in Punjab and Sindh provinces**

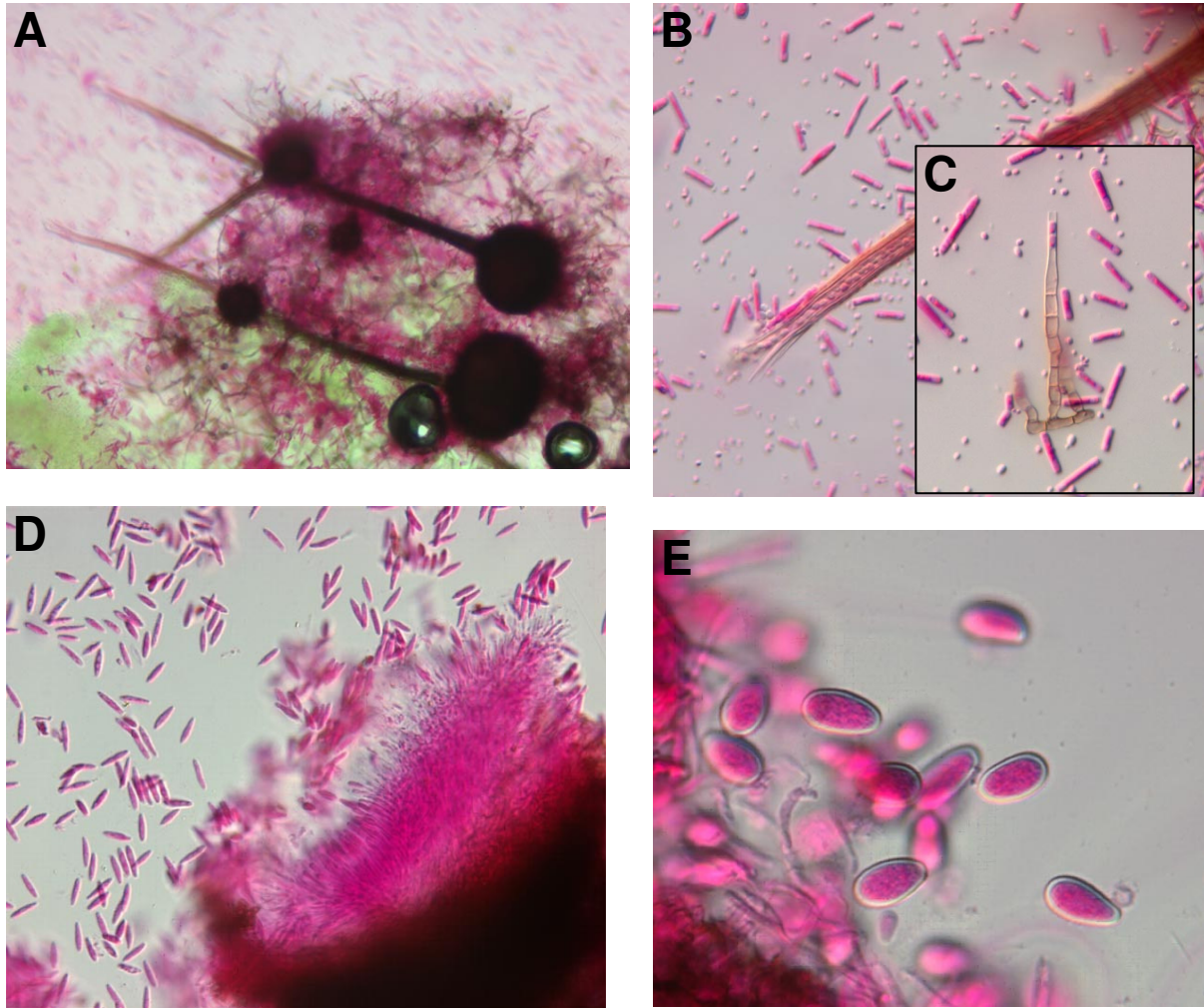
Province	Punjab	Sindh
Sudden death (%) - with gummosis	31.8	60.0
Progressive Decline (%)	26.8	10.2
Malformation (%)	21.2	1.6
Blossom blight (%)	0.5	0.25
Bacteria black spot (%)	3.5	0.62
Mango Midge (%)	34.9	0.25
New Flush (%)	37.5	3.4
Fruit Set	25.7	32.2

**Table 2. Isolation results of field samples taken during the disease diagnostic survey of the Punjab and Sindh districts. The original samples are held in the Queensland Herbarium under permit.**

Date collected	Grower	District	Sample	Isolation Results
3/4/2006	Sher Muhammad Lahir	Punjab	mango stem	<i>Ceratocystis sp</i>
5/4/2006	Umer Hayat Farm Multan	Punjab	mango stem	<i>Lasiodiplodia theobromae</i>
7/4/2006	Mir Ghullam Sarwar Farm (Tando Jam)	Sindh	mango stem	<i>Fusicoccum parva</i> ( <i>Dothiorella dominicana</i> )
7/4/2006	M.H.Panwah Farm	Sindh	Mango stem	<i>Lasiodiplodia theobromae</i>
7/4/2006	Mir Ghullam Sarwar Farm (Tando Jam)	Sindh	mango stem	<i>Ceratocystis sp</i>
7/4/2006	Noor Ahmed Nizamani Farm	Sindh	mango stem/bark	Bacterial / <i>Aspergillus sp</i>
7/4/2006	Noor Ahmed Nizamani Farm	Sindh	Twigs	<i>Fusicoccum parva</i> ( <i>Dothiorella dominicana</i> )
8/4/2006	Buzhmo Farm	Sindh	mango stem	<i>Ceratocystis sp</i>
8/4/2006	Bhurgari Farm	Sindh	mango stem/bark	Bacterial / <i>Aspergillus sp</i>
8/4/2006	Agha Farm Tando Ghulam Ali	Sindh	mango stem/bark	<i>Ceratocystis sp</i>
8/4/2006	Shahnawaz Magsi Farm (Untreated)	Sindh	mango stem/bark	<i>Ceratocystis sp</i>
10/4/2006	S.H.R.I. Mirpurkhas	Sindh	mango stem/bark	Bacterial / <i>Aspergillus sp</i>

## Appendix 4: Microscopic Isolations

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These pictures show various morphological characteristics of the different isolations from infected tissues samples collected in Pakistan as seen under the compound microscope. These samples tissues samples were brought back to Australia and processed at the AQIS lab at the Brisbane

(A) *Ceratocystis* sp. ascomata (B) *Ceratocystis* sp. ascomata neck showing ostiolar hyphae (C) *Ceratocystis* sp. phialide (D) Conidia and part of the conidioma wall of *Fusicoccum parvaluteum* (formerly *Dothiorella dominicana*). (E) Immature, hyaline, unicellular conidia of *Lasiodiplodia theobromae*.

## **Appendix 5: Summaries of Orchard Management Practises from Grower Interviews and Field Surveys**

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### **General notes**

In Pakistan, more than 90% of mangoes are sold to contractors or commissioned agents prior to harvest. Quality is not as important to growers or contractors as, according to them, it does not affect price.

The local market is limited due to many Pakistanis living below the poverty line and cannot afford to purchase mangoes. Prices for mangoes can be as low as 10Rp (25cents) per Kg.

The growing conditions in Pakistan are extreme in many areas due to salinity problems with underground water (conductivity. 1000+) and high pH (8.5 to 10.5).

### **Entomological notes from farm visits**

Insect issues appear to be minor. Cecid fly, (midge) possibly a complex of 3 or more species is regarded by locals as a severe pest and a new introduction. Damage seen on new flush but no damage seen on inflorescences and none on fruit.

Need to clear up taxonomy and determine real economic impact on yield/quality

Leaf hoppers present but appear minor; no sooty mould or yield impact. Locals claimed that pesticides had been used and therefore no damage. Leafhoppers do not appear to be an issue on the farms visited even where the use of pesticides is very low or none are used.

Scales were highlighted at the workshop as a severe pest. This did not appear to be the case in the field. Mango scale, *Aulacaspis tubercularis*, was not seen on a number of farms visited and was only severe on one farm in the Sindh. Transparent scale, *Aspidiotus destructor*, was present in low numbers as was also what looked like oriental scale. Parasitism levels on these scale was >80% indicating low levels of pesticide disruption.

No flower feeding caterpillars were seen. Presence of bunched up flowers, due to malformation, would have created a perfect environment for flower feeding caterpillars. Hence these pests are unlikely to pose a problem.

Only minor presence of what appeared to be tip borer damage was observed.

Thrips damage to fruit was particularly prevalent in the Sindh. Chemical treatments are being applied but work on timing, biology plus appropriate pesticides should be considered.

Application of pesticides is left primarily up to the contractors who take over full control of the crop, sometimes post flowering and at times later on after fruit set. Spray equipment ranged from hand held lances to tractor operated 3 point linkage orchard sprayers. The orchard sprayers were poorly maintained and some were broken and there appeared to be a poor or nil level of understanding of spray application principles. Tractor operated sprayers not suitable in many situations due to closeness of trees.

### **Orchard visits in the Multan Area**

Tareen Farms (Punjab) was identified as a potential model or demonstration farm through which research, especially on MSDS, could be carried out and results demonstrated to other area growers.

One farm visited had direct linkages to research providers as well as an Extension Agent. The general farm management and protocols in place clearly demonstrated what could be expected if linkages could be established between research and extension with growers.

Root damage was readily noticed from cultivation for weed control coming too close to base of trees. This could be a likely route of entry of MSDS pathogens. Growers were advised to avoid or minimize the practice and keep the ploughing away from the tree base

In one orchard good results were apparent from MSDS treatment by simply scrapping off the gummosis point of infection and covering the hole created with Bordeaux paste (copper, sulphur and lime). Good healing of such holes was consistently observed. This suggests that early detection and intervention could be useful.

In another orchard, infection by MSDS seemed to be strictly localized in a linear manner. Up to 17 plants had been lost within 2 months in same vicinity. The possibility of the soil borne nature of the pathogen was discussed and grower was accordingly advised on the need to practice some form of equipment sterilization to restrict moving and spreading the apparent localized infection to the rest of his orchard.

Stock and scion incompatibility was observed on a felled tree that had suddenly developed MSDS as there was severe infection on the lower stock side of the base but apparently no symptoms on the lower section of the tree base above the grafted portion.

In other orchards, there was severe salt leaf burn with edges showing lots of phytotoxicity symptoms. This appears to have stressed some heavy-bearing young trees and the leaves were already showing symptoms of wilting with expected SD to follow.

From discussions, it was apparent that some immediate spray is needed to follow malformation pruning because of exposed wounds which may become an avenue for other infections

Pruning as a means of solving many production problems may need to be re-assessed. There was no apparent clear understanding of what this practice is meant for. In some cases productive branches had actually been pruned out leading to lower yields, at advice of a Consultant.

It was unclear why some trees were heavily flushed at flowering while others were not. Attempts at trying to synchronize the flushes must first understand the cultivar by environment interactions as well as earlier studies and findings in this area.

Severe foliar midge attack on most new flushes may or may not have an effect on the crop yields or quality. There is need to screen and identify an insecticide that can control this pest so that an impact assessment study could be undertaken.

### **Orchard Visits in the Sindh Area**

The clear positive visiting activities in this province are the link of growers with the researchers. MSDS trials are in progress at different orchards and growers seem to be generally pleased with the progress of the research.

There are however, direct contradictions in findings between the Sindh and the Punjab. In the Sindh orchards researchers are showing that Aliette® is the most effective fungicide to stop or slow the advancement of MSDS when injected into tree trunks at early signs of infection. Here Topsin-M® is ranked as least effective both as a spray and as an injector. This is contrary to the Punjab findings where Aliette® is ineffective and Topsin-M® is effective and has even been recommended to growers for use in controlling MSDS.

There will be a need to bring both the Punjab and the Sindh teams together so that some common trials could be planned and conducted using same protocol on carefully selected trees. This will establish what fungicides are effective and in what forms so that these could be recommended to growers for use. This should be an early project activity on the management of MSDS.

One grower strongly suspected a link to the movement of wooden crates of mango made of sishum wood to the introduction of MSDS pathogens to orchards in the Sindh. According to him, these crates came from areas in the Punjab where trees had been killed by a similar attack of MSDS as now prevalent on mangoes. He even claimed that growers who used jute bags do not have MSDS problems.

This may be another activity for an epidemiology study of MSDS in the project - investigating the role of the sishum material as possible sources of inoculum introduction and infection.

The Sindh Agricultural Research entomologist is still strongly of the opinion that the bark beetle has some direct role in the cause and possible spread of the disease. He reluctantly accepts that the beetle may be acting as a vector and admits that this has not been investigated or established.

A carefully planned activity on the role of the bark beetle in the transmission of MSDS pathogens will be another useful study in the epidemiology of the disease during the project.

A critical first year project activity will be a 2-day workshop with all researchers directly involved in MSDS research, so that summary of what has been done could be presented and plans of what needs to be done next, debated and agreed upon as part of the project work plan.

This could be undertaken sometimes in early 2007 just before flowering starts in both regions.

Another grower suspects a strong link with the appearance of MSDS to drought. He thinks that it was only after several years (14) of severe drought that the problem suddenly showed up when the rains returned.

It was declared by most researchers that mango malformation is generally a minor problem on trees in the Sindh area when compared to the situation in the Punjab. Pruning of infected panicles was still the only effective way of control, as also practiced in the Punjab.

From questions asked and apparent confusion of salt injury symptoms as anthracnose, there will be an urgent need in the project, to train researchers and extension officers on basic diagnosis to differentiate common diseases such as anthracnose from other foliar disorders.

An infected nursery tree recently transplanted to replace a dead tree was observed in one orchard with early infection symptoms of gummosis on the bark. The importance of sourcing planting material mainly or only from clean nurseries, if available, was discussed and emphasized.

### **Nizamani Farm Visit**

This is clearly a good example of a successful farming operation that could add value to the functioning and operations of the project. This could be in one or all of the following ways:

- As an Experimental Farm in which trials could be set up to investigate options for the management of MSDS;

- As a Demonstration Farm in which demonstration of working techniques such as trunk sprays, trunk injections and basal drenches with different compounds could be carried out for growers to observe and adopt.
- As a Training Farm where growers and may be researchers in the Hyderabad area, could be given training on a range of farm management operations including nutrition, pest and diseases identification and management options.

Mr Hadi Legheri, the Technical Manager of Asim Agric Farms, could add value to the project if included as a Sindh province project team member. He could play a strong role in facilitating training at their farm and in on-farm grower participatory research.

### **Visit to Southern Zone Agricultural Research Centre (SARC), Karachi**

Our program had been changed to arrive in Karachi on Monday evening mainly because of the need to visit SARC lab in Karachi on Tuesday morning, after interactions with Mr Mubarik, the director of the lab, during the workshop in Multan.

During the visit Mr. Mubarik gave a very good presentation, sharing the activities in the lab on MSDS as well as their general observations and feelings about the problem. He also shared areas of possible future focus.

His lab will likely be involved in the project but activities will focus mainly on areas where they seem to have strength or a comparative advantage such as basic lab research involving screening new products, filling in gaps on the epidemiology of MSDS etc.

Overall, SARC has a well equipped laboratory that could handle basic research. It could also be a good laboratory for the assessment of postharvest diseases, especially on sample fruits from domestic and export markets. This will be a good linkage point with the supply chain project where samples from cool store chains being analysed for other issues are also evaluated for postharvest rots and residue levels from pesticide uses.