Chapter 6
Pre-harvest Management Strategies for Post-harvest Disease Control in Mango

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Abstract Australia-Pakistan Agriculture Sector Linkage Program collaboration (2006–2013) is developing integrated crop management practices to enhance value chain outcomes for the mango industry in Pakistan and Australia. One component involves scaling up orchard management strategies which optimise nutrition, enhance constitutive resistance of mango fruit and reduce field disease inoculum as key underpinning the reduction of postharvest disease losses. The strategies include optimal tree nutrition, tree pruning and inoculum reduction and strategic use of field sprays with fungicides. This is coupled with a longer-term improvement of nursery stock, screening for cultivar resistance and selection of clean planting material as means of reducing stem end rot, anthracnose and (in - Australia) dendritic spot. The research outcomes of crop management research from 2005 to 2010 are being demonstrated at different grower orchards in 25 integrated research block sites in both the Punjab and Sindh mango growing areas of Pakistan. The blocks have been established in the form of village or district clusters for easy management and to serve as demonstration blocks to adjacent or neighbouring farms. Pre harvest management protocols will be validated in the research blocks to finetune and assess their agronomic and disease reduction potential, and to foster grower ready adoption. The disease reduction risk and shelf-life potential of fruit from the blocks will be further tested in domestic and export market situations.

Keywords Integrated crop management • Orchard management • Fruit resistance • Disease reduction • Shelf life potential

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Introduction

Anthracnose and Stem End Rot (SER) are the main postharvest diseases of mango in all regions around the world where mangoes are grown. The key for producing quality mango fruits with a long shelf life is hidden in management of these diseases effectively. The use of pre and post-harvest fungicide treatments has been the main mechanism of trying to achieve this objective (1). For the management of any disease issue the growers approach has been what fungicides should be used or how can we make our plants healthier. At the moment the current management option is use of chemicals, either at field through air blast tower sprayer or fruit treatment with chemical in the packing shed. SER management is hard without use of fungicide application, and research has identified many effective systemic and non-systemic fungicides against SER such as prochloraz (Peterson et al. 1991); mancozeb and carbendazim (Bavistin) (Rawal and Ullasa 1988). However these chemicals needs to be used wisely as there are certain concerns emerging from the use of chemicals:

- Overuse—routine calendar sprays
- Increasing costs of new ones
- Environmental concerns
- Resistance development—systemic
- Export market restrictions like dictation of what to use & MRL limitation

However the researcher's perspective is different. They are interested in understanding what is causing the problem, how and what could be done to solve this. Normally, researchers use disease management principles of exclusions, protection, reduction and inhibition of pathogen if these are combined with tree phenology, a comprehensive understanding of disease could be developed. This is called Integrated crop Management. Thus it is a holistic approach that considers crop protection, crop nutrition and the crop production practices. The ultimate goal is increase yields and obtain long-term sustainable production. The Integrated crop management for mango covers:

- Inoculum Reduction on Trees
- Improving Sanitation of Trees & Orchard
- Managing dose/time of Nutrition
- Time of Fungicidal Application

The practices are being tested under Australia-Pakistan Agriculture Sector Linkages Program (ASLP) project at 10 sites in the two main mango growing areas with participation of around 100 farmers (Fig. 6.1).

ASLP is Australian government funded program and implemented by Australian Centre for International Agricultural Research (ACIAR) in Pakistan with their collaboration. Under ASLP a mango project: Improving sustainable yields and quality of mangoes in Pakistan and Australia. The specific objectives of the project are:

Fig. 6.1 Map of Pakistan showing integrated research sites across Pakistan

- Establishing disease-free nurseries,
- Developing integrated orchard management protocols,
- Developing disease detection and integrated management approaches, and
- Building up capacity to undertake and deliver on-farm research and extension

Material and Methods

The package of practices being tested is based on following four areas:

1. Inoculum reduction strategy revolves around pruning which is used as a disease management tool. All dead branches are removed and trees are thin out. This process also helps old fruit to rot early.
2. Improving sanitation of trees & orchard by removing all old fruit & flower panicles. Limiting the tree contact with soil through skirting and wound treatment to avoid pathogen entry.
3. Managing dose/time of nutrition should be based on soil and water analysis. It's basically focus of Nitrogen application to improve fruit size at flowering and after fruit setting deteriorate the fruit quality a lot.

4. Time of fungicidal application and is very important to find the strategic times in each season so their use becomes effective in the inoculum reduction on mango.

The study was initiated in 2010. The sites where these practices are being tested belong to growers and 2 acres block with Common commercial varieties has been selected. Standard tree husbandry practices for irrigation, fertilisation and insect pest control were implemented. At harvest, 35 fruits were randomly picked from each treatment tree from which 25 more uniform ones were selected, desapped, washed and then placed in boxes and stored in a cool room at ~20–22 °C. Fruits were assessed for postharvest rots disease incidence 14 days after incubation.

Treat	N application time & dose
T1 Old Way	1/3: flowering, fruit set & after harvest
T2	2/3 after harvest, 1/3 at flowering
T3	2/3 at flowering, 1/3 after harvest
T4	1/5 after Harvest & 1/5 at flowering

Systemic fungicides azoxystrobin, tebuconazole, carbendazim, difenoconazole and azoxystrobin + difenoconazole were applied seven times starting from flowering (pre-bloom) to fruit development stages. Systemic and protectant fungicides were positioned during the most critical stages of phenological development of mango. During the anthesis stage (21–25 days after flower induction, DAFI) and full bloom to postbloom stage (28–30 DAFI), tank-mix of azoxystrobin and mancozeb was sprayed to control blossom blight and early infection of SER. Full doses of non-systemic fungicide mancozeb (30–35 DAFI—postbloom to fruit set) and systemic fungicides carbendazim (40–45 DAFI—young fruit; corn seed size), azoxystrobin (50–55 DAFI—young fruit; chicken egg size) and difenoconazole (70–80 DAFI—premature fruit) were successively sprayed at the most susceptible stages in mango fruit development. This was to determine their integrated effects with the inoculum reduction strategies on mango postharvest diseases.

Results and Discussion

Field evaluation indicated that, under extreme rainy events, the spray program sufficiently suppressed blossom blight, resulting in high harvestable fruit. Assessment of SER incidence on harvested fruits showed that the spray program minimised SER incidence 14 days after harvest, but prolonging the storage beyond 14 days after harvest resulted in a very high level of SER incidence.

All fungicide spray combinations were significantly ($P = 0.05$) better than the control in suppressing postharvest rots incidence on the fruits (Figs. 6.2 and 6.3). Fungicide treatment in combinations with total inoculum removal gives better results than partial removal of inoculum. The trees where inoculum was totally removed and no fungicide was applied gives less post-harvest issues compared to

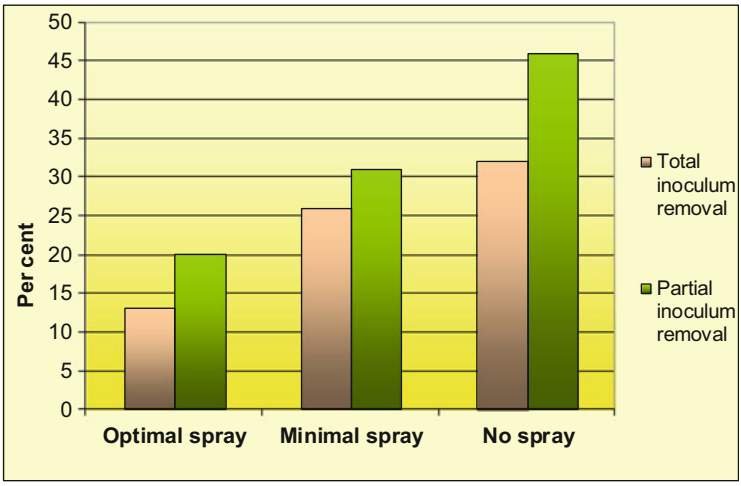

Fig. 6.2 Post-harvest rot disease incidence on fruits

Fig. 6.3 (**a**) Fruits from non-inoculum removed trees, (**b**) Fruits from inoculum removed

partially removed inoculum trees. Significant differences ($P = 0.05$) between partial and optimal inoculum reductions on fruit rots were observed on most treatments. The repeat of the inoculum reduction exercise significantly reduced the level of inoculum carrying dead materials within and underneath the treatment trees resulting in this accumulated significant effect.

The timing of fungicide application appeared to be very important. Growers have assumption that late application of fungicide was more effective in mangling the post-harvest diseases. But the Fig. 6.4; clearly indicate that same fungicide applied once at early fruit set was less effective compared to three applications at different phonological stages of mango.

It is clear that late application achieves the same level of disease control as compared to the low levels from the optimal inoculum reduction. These trial results

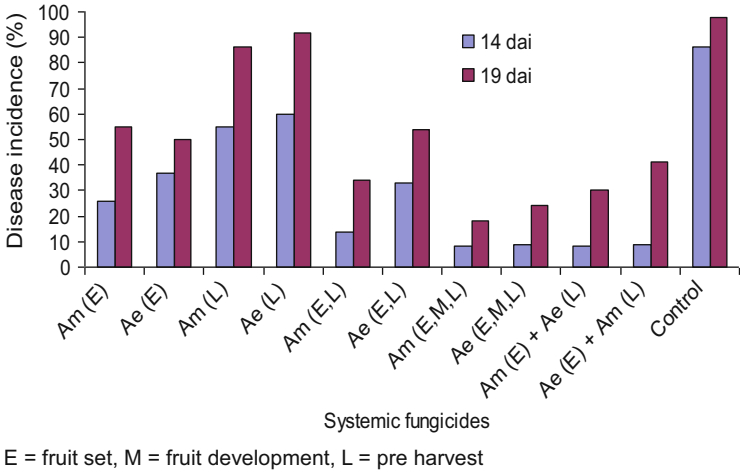

Fig. 6.4 Timing of fungicide application on post-harvest disease

Fig. 6.5 Fruit after 14 Days of harvesting where N was applied in traditional practice

demonstrate the role that basic orchard hygiene can play in field management of mango postharvest diseases, especially when integrated with minimal fungicide spray treatments.

In the control block growers was following the traditional practices. The Nitrogen was applied in split doses of 3, one-third at flowering , one –third after fruit set and last application of one-third after fruit harvest. The Fig. 6.5 shows the status of fruit after 14 days on harvest when kept at room temperature.

In Fig. 6.6, the fruit after 14 days of harvest at room temperature from the IRS block. At that block one-third of Nitrogen was applied at flowering while remaining two-third was applied after harvest. The result is clearly evident by comparing the two sets of fruits.

Fig. 6.6 Fruit after 14 Days of harvesting where N was applied in new practice

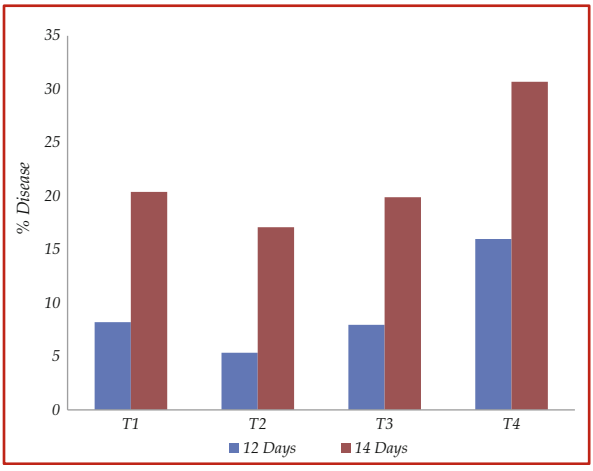

Fig. 6.7 Time & dose of Nitrogen in relation to disease

The Fig. 6.7; shows the impact of time & dose of Nitrogen application on disease percentages appearing on fruit after 12 and 14 days of harvest. The minimum disease after 12 days of harvest appeared on fruits where Nitrogen was applied in two doses: 2/3 after harvest and 1/3 at flowering. The fruit from same treatment also got less disease even after 14 days of harvest at room temperature. Application of Nitrogen in two doses: 2/3 at flowering and 1/3 after harvest gave second best result and fruits from such treatment around 8 % disease after 12 days of harvest.

The study has proved that fact the quality mango fruits are always produced in the fields while post-harvest treatments can help in refining and maintaining the quality. Again the success of post-harvest handling depends upon pre-harvest management. In the nutshell pre-harvest management makes the quality & post-harvest management preserves the quality.

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