8.7 Integrated Management of Phytophthora Diseases of Durian: Recommendations and Benefit–Cost Analysis

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Abstract

Durian is a favourite fruit throughout Southeast Asia. Increasing areas have been planted to durian orchards in recent years, especially in the Mekong Delta and southeastern provinces of Vietnam, in marginal areas of Thailand and in northern Australia. Durian growers face significant losses due to phytophthora diseases, and there is an urgent need for recommendations to control these diseases. Integrated disease management recommendations, based on an understanding of the biology of the pathogen, optimal growing conditions and soil health, promise sustainable durian production with minimal environmental impact. We have developed integrated orchard management recommendations based on an appreciation of the natural rainforest conditions in which durians co-evolved with the pathogen.

Introduction

Phytophthora is a serious pathogen of durian that has the ability to attack the plant at various stages of its life cycle. Roots, stems and leaves of seedlings, young trees and mature trees are affected, as well as flowers and fruit. *Phytophthora palmivora* is a pathogen on a wide range of host plants grown throughout Southeast Asia. Major epidemics occurred in 1994 in Thailand, and in 2001 in Vietnam. Hence, it is easy to understand that to control *P. palmivora* in durian, we need an integrated approach that takes the disease cycle, host range and cultivation practices for durians into account.

Integrated disease management (IDM) is the long-term reduction of disease losses to economically acceptable levels through a holistic approach that combines the use of resistant varieties, cultural control methods, biological control methods, and the judicious application of appropriate chemicals. The principle of integrated management of phytophthora diseases in durian has been promoted since the early 1990s (Lim 1990; Bong 1993; Lee 1994), but detailed recommendations appropriate for all regions have been lacking, and subsequent implementation patchy. A systematic approach to developing recommendations was undertaken as part of an ACIAR-funded project, 'Management of *Phytophthora* diseases in durian' (Project no. PHT/1995/134), which commenced in 1998. As part of the project, practical disease-control options were investigated, regionally optimised and disseminated to durian farmers in Thailand, Vietnam and Australia. The project culminated in a

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workshop in Chiang Mai, Thailand in November 2002, discussions at which formed the nucleus for the production of this monograph.

The recent and rapid expansion of the durian industries in Thailand and Vietnam has seen the establishment of orchards on increasingly marginal sites, including rice paddy in Vietnam (Figure 6.7.9), where phytophthora diseases can be exacerbated. Sources of disease resistance in durian and the development of tolerant rootstocks have yet to be identified, although the screening techniques described in Chapter 8.3 should facilitate the search. Nursery standards have to be improved to ensure that infected planting material is not released to growers (Chapter 8.4).

In the past, gaps in our understanding of the epidemiology of *P. palmivora* in durian have hampered effective management, and have resulted in the application of inappropriate and ineffective management practices. Although effective against phytophthora diseases of avocado and cocoa, the lack of specific recommendations for the rate and timing of phosphonate trunk-injection of durian have so far limited efficient application and effective disease control using this technique.

Integrated disease management of durians aims to minimise infection at various points in the disease cycle. Initially, this includes using clean, disease-free planting material and properly prepared planting sites. After establishment of an orchard, management priorities include improving and maintaining soil health through the use of organic matter and green manure, manipulation of soil moisture and drainage, and correct nutrient management. Care must be taken to prevent the spread of soil-borne inoculum into the canopy.

Disease development can also be slowed down through the removal of infected fruit from the canopy and by general orchard hygiene. If stem cankers are active, they may be treated with phosphonate injections to cure them. Details of the various components of the IDM practice developed are given below.

Planting and Pruning

Farmers should select disease-free planting stock from a reputable nursery. Grafted seedlings can be useful if disease-resistant rootstocks are available, or if the farmer wants to multiply an elite, selected scion cultivar. Avoid planting directly on old rubber, cocoa or pawpaw land, as these plants are susceptible hosts for *Phytophthora palmivora*, and high levels of soil inoculum may have built up. If this is not possible, grow a legume groundcover for at least one year before transplanting durian, slash the green vegetation and use as a green manure to build-up soil organic matter and microbial activity.

If the green manure is fermented or composted it may also suppress existing *Phytophthora* infestations of the planting hole. One technique is to excavate a 2 m diameter by 50 cm deep planting hole, fill it with green manure, add fresh chicken manure and a microbial starter culture such as EM (Effective Microorganisms, <http://www.emtrading.com/index.html>), trample to remove air, and cover with compacted soil. Leave the material to ferment for 8–10 weeks, before forming into a mound at least 50 cm high, into which the durian is transplanted. Anaerobic fermentation of green manure, particularly using fresh chicken manure, will eradicate *Phytophthora* and other pathogens, while leaving an active population of beneficial soil microbes and a rich source of nutrients for the young seedling.

The watertable should be at least 80 cm below ground level. This can be achieved by planting on a mound 50–60 cm above ground level in lowlands such as the Mekong Delta, or 30–40 cm above ground level elsewhere. Mix pelleted or composted chicken manure and lime into the soil before planting. Select strong and healthy saplings grafted onto disease-resistant rootstocks, like the Vietnamese cv. La queo. Do not plant the saplings too deep and ensure the graft is well above the soil line. Drench the transplanted saplings with phosphonate solution around the base of the plant (10 mL of 400 g/L a.i./10 L water).

When establishing an orchard, space trees widely enough (no more than 80–100 trees/ha for most cultivars), and regularly prune to remove branches within 80–100 cm of the ground to provide adequate ventilation, to reduce canopy humidity, and to minimise soil splash into the canopy. Avoid susceptible clonal monocultures and close interplanting, especially with susceptible plants, as uniformly susceptible monocultures provide ideal conditions for epidemic development. Durian interplanted densely with papaya, coconut, or cocoa which act as alternative hosts, may increase the risk of high levels of disease.

An alternative approach to orchard establishment is to establish a diverse community of plants that mimics the rainforest habitat in which durian evolved. This approach, a type of garden agroforestry, aims to create a biologically diverse, sustainable and highly profitable farming system (Leakey 1998). As a large tree normally forming the

upper canopy of rainforests, durian is ideally suited to this type of planting as a shade tree for understorey fruit trees, vegetables and medicinal plants. The genetic diversity of these mixed plantings significantly retards the development of explosive epidemics, even if some of the intercrops are susceptible to *Phytophthora*.

Mulching

Durian evolved as a rainforest tree. In rainforests, ectomycorrhizal roots absorb mineral nutrients and water from the organic-matter-rich leaf litter layer in the top 50 cm of the soil. Cultivating durian in orchards with bare soil exposes the surface roots to direct sunlight, kills the mycorrhizal fungi, and depletes the biological activity, nutrient availability and health of the topsoil. Irrigation of bare soils under direct sunlight creates a baked crust that inhibits water absorption, forms temporary ponds of water that stimulate sporangial development and zoospore release, and facilitates rainsplash dissemination of *Phytophthora* inoculum.

To recreate the litter layer, especially during orchard establishment, mulch the soil surface under the drip zone of the tree with straw and manure. Mulching encourages mycorrhizal root development, improves soil microbial activity and soil health, suppresses *Phytophthora* and other pathogens and weeds, and improves soil moisture retention in the dry season (Chapter 7.3).

Fresh straw may need to be applied regularly, depending on the local conditions. In the humid wet tropics, such as in north Queensland, the straw decomposes within a few weeks and should be reapplied frequently. In the monsoonal tropics, straw applied toward the end of the rainy season will persist well into the dry season, providing adequate protection for the mycorrhizal roots. Irrigation, whether by spray, drip or flood, can be applied without disturbing the mulch layer, which will also reduce evaporative water loss. During the wet season, it may be wise to clear the mulch from immediately around the base of the trunk to prevent excess moisture persisting directly around the trunk, as this may encourage canker development.

Water and Nutrient Management

Irrigation may be required in environments with a protracted dry season. Spray or drip irrigation is preferred to flood irrigation, with any spray nozzles directed away from the trunk, so that the drip zone, but not the trunk, is wetted. Water that might come from a source at risk of contamination with *Phytophthora* should not be used for irrigation. Apply a straw or leaf mulch to cover the ground around the durian tree in the dry season, to reduce water loss from the topsoil.

Organic fertilisers, especially composted chicken manure, are preferred to inorganic fertilisers, as there is evidence that excess inorganic nitrogen increases the risk of phytophthora canker and root rot (Chapter 7.2). Potash fertilisers (supplying potassium) added one month before fruit harvest will prevent the development of 'wet core' and improve fruit quality.

Paclobutrazol, or manipulation of soil water deficits during the rainy season using plastic mulch (Figure 8.1.6) to induce flowering, should be used carefully and not every year. This will avoid stressing the trees.

Harvesting

Once a fruit becomes infected, it takes only about 4 days for it to become completely colonised by *Phytophthora* and then forms an abundant source of inoculum. Regular harvesting and removal of infected fruit reduces the amount of inoculum when fruits are ripening, usually in the rainy season. Remove and bury infected fruit (see below). Fruit should ideally be harvested only when they are still on the tree, and not from the ground. Avoid contact with soil and damage to ripe fruit, as this causes postharvest rot (Chapter 8.6).

Orchard Hygiene and Fruit Disposal

During pruning and harvesting, tools should be disinfected with a quaternary ammonium detergent before they are used on the next tree. Avoid moving soil between orchards on tyres or footwear by washing boots and equipment with a quaternary ammonium detergent.

Infected fruit is a significant source of *Phytophthora* inoculum and should be removed from the orchard. Piles of rotting fruit are also breeding grounds for flying beetles that are potential vectors of the pathogen (Konam and Guest 2004). When composted, fruit also improves soil health and provides a valuable source of nutrients.

If in some years disease pressure is very high and a lot of fruit rot does occur, it is a good practice to anaerobically ferment infected fruit to prevent further spread of the disease, eradicate inoculum and recycle nutrients. This technique is similar to that described for preparing planting holes. Anaerobic fermentation takes approximately 10

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weeks, and could be completed in furrows between the rows of trees. Furrows could be constructed every three or four rows, and filled in continuous rotation. Dig a furrow approximately 50 cm deep between rows of trees, and place the diseased fruit into the furrow. Add green manure (such as legume leaves, cut grass and prunings), fresh chicken manure and a starter culture such as EM. When the furrow is almost full, stamp down to exclude as much air as possible, and cover with 5– 10 cm of soil.

Canker Treatment

Stem cankers can cause serious tree decline due to damage to the cambium. Cankers reduce tree vigour and yield. They must be diagnosed promptly and accurately for IDM to be successful, and to prevent tree deaths. Once diagnosed, the bark on the surface of cankers should be scraped back and painted with a copper fungicide such as Bordeaux mixture. Ridomil Plus may be used as an alternative, but it is more expensive. The most effective long-term control of canker is achieved through trunk injection of phosphonate.

Trunk Injection of Phosphonate

Potassium salts of phosphorous acid, neutralised to pH 6.5–7.0, and injected into the trunks of trees, give outstanding control of canker and fruit rot (Chapters 8.5 and 8.6). Potassium phosphonate is available under many brand names including Fosject, Foli-R-Fos, Agri-Fos Supa and Phos-Acid. Concentrations of 200 g/L, 400 g/L and 600 g/L a.i. are available. All these concentrations may be injected. The optimal dose for mature durian trees is two or three injections of 16 g a.i. potassium phosphonate annually (depending on the size of the tree and the disease pressure), applied during leaf flush. In mature Vietnamese orchards, trees should be trunk-injected with phosphonate (40 mL of phosphonate 400 g/L a.i.) twice in the first year. As the disease pressure decreases with improved orchard management and the adoption of IDM, injections may be reduced to once a year.

Trunk injection involves drilling a hole 6.5 mm in diameter and 40 mm deep with a sharp drill, about 50 cm from the base of the trunk. Modified veterinary syringes do not work as well on durians as on avocado. Chemjet® injectors (<http://www.chemjet.com.au/>) hold 20 mL of phosphonate solution, requiring three or four holes drilled evenly spaced around the trunk, preferably directly under each main branch. Fill an injector and screw into the hole, without pushing, until a clicking sound is heard. Release the spring to allow the injection to proceed. Under normal conditions injection should take 10–20 minutes. After all the solution has been taken up by the tree, unscrew the injector, rinse first in a quaternary ammonium detergent solution, then in water and refill, and use to inject the next tree. Injectors should be dismantled and thoroughly washed in clean, soapy water at the end of each day.

The Sidewinder® (<http://www.treeinjectors.com/>) drills and injects the trunk in one operation, and although it is more expensive, may be practical in large orchards where labour costs are relatively high. Inject trees in the morning, as uptake slows significantly in the afternoon. Care must be taken with high-pressure, trunk-injection systems, as durian trees are prone to splitting of their bark.

Benefit–Cost Analysis

The total cost of phosphonate trunk injection includes the cost of injectors, phosphonate and labour. Chemjet® injectors retail for approximately USD5 each, but last for several years if properly maintained. An average-size, mature durian tree requires 80 mL (four 20 mL injectors) of 200 g/L a.i. formulation, taking up to 30 minutes for complete uptake. A farmer will need at least 20 injectors and one drill for continuous operation, although the cost may be shared by a group of farmers, as each farmer uses them only once or twice a year and they last for several years.

The cost of 32 g a.i. phosphonate required per tree is about USD1 per year (assuming a 400 g/L a.i. formulation costs USD12 per litre). Labour costs vary but, on average, each worker could inject 10 trees per hour. Therefore, the total annual cost of injecting would be about USD2 per tree. If a good-quality durian fruit sells for USD2–5, this means that the cost of injecting a mature tree would be repaid by one extra fruit per tree each year. However, it takes up to 9 years for a tree to become profitable, so the overall cost for the lifetime of an orchard, including the cost of injecting immature trees, might require an extra fruit per tree once the trees are mature.

Assuming an average loss of 20% due to *Phytophthora* and a typical yield of 80 kg, disease control would raise the yield to 100 kg per tree, an increase of 20 kg. At USD2 a fruit, disease control through trunk injection yields a net benefit of USD40 for a cost of USD2. This is a conservative estimate that does not include the savings of not having to replace trees that would otherwise have been killed by canker. The cost of other inputs also varies, and should include the cost of chicken manure, straw mulch and orchard hygiene.

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References

Bong, C.L. 1993. Destructive diseases of selected fruit trees and species. In: Wong, W.W.W. and Lamb, A., ed., Fruits, nuts and spices. Proceedings of an in-house seminar and workshop, Lagud Sebrang, Tenom, Malaysia, 24–26 October 1990. Sabah, Malaysia, Department of Agriculture, 122–129.

Konam, J.K. and Guest, D.I. 2004. Role of beetles (Coleoptera: Scolytidae and Nitidulidae) in the spread of *Phytophthora palmivora* pod rot of cocoa in Papua New Guinea. Australasian Plant Pathology, 33, 55–59

Leakey, R.R.B. 1998. Agroforestry in the humid lowlands of West Africa: some reflections on future directions for research. Agroforestry Systems, 40, 253–262

Lee, B.S. 1994. Integrated control of Phytophthora stem canker in durian. Recent developments in durian cultivation. Kuala Lumpur, Malaysian Agricultural Research and Development Institute.

Lim, T.K. 1990. Durian diseases and disorders. Kuala Lumpur, Malaysia, Tropical Press Sdn Bhd.