

Scientific management of *Phytophthora* diseases in plantation crops

The coconut, arecanut and cocoa are grown in tropical high humid areas, where diseases caused by *Phytophthora* spp. are major constraints in their production. Fungicidal spray could control them only to a limited extent as heavy rains result in washing of fungicides from plant surfaces. An integrated disease management involving proper cultural practices, application of biocontrol agents, fungicidal sprays and host-plant resistance need to be employed for an effective management.

PLANTATION crops, coconut, areca nut and cocoa, are grown mainly in humid tropics. The high humidity prevailing in coconut and areca nut gardens is highly favourable for multiplication of *Phytophthora*. The pathogen causes the killer diseases like bud rot of coconut and arecanut causing huge economic losses to farmers by severe shedding of immature areca nuts due to fruit rot disease. Cocoa is another favourable host plant of *Phytophthora* which infects the seedlings in nursery, later stems, leaves and most importantly the pods. The pathogen causes 20-30% pod losses through black pod rot, killing up to 10% of trees annually through stem cankers in the world. In arecanut, disease may cause fruit drop of 50-100% in individual palms if timely and proper control measures are not adopted.

DISEASE MANAGEMENT

COCONUT

Bud Rot

Bud rot and fruit rot or immature nut fall are the two destructive diseases caused by *Phytophthora palmivora* in coconuts. The disease is sporadic in nature. However, severe epidemic outbreak is also common in major coconut-growing areas in Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Goa and Maharashtra. The intensity of disease increases year after year with the inoculum build-up, leading to heavy economic loss to coconut growers. Though coconut palms of all age groups are

susceptible, occurrence of disease and mortality of palms are high in these palms belonging to the age group of 15-20 years.

Symptoms

First visible symptom is withering of spindle marked by pale colour. The spear leaf or spindle turns brown and bends down. The affected spindle can easily be pulled out as the basal portion of spindle is completely rotten emitting a foul smell. Later, inner leaves also fall away one by one, leaving only outer whorl of matured leaves in the crown. Ultimately, the palms succumb to disease with the death of growing buds.

The disease is generally noticed during both south west and north east monsoon periods when wet weather prevails. In endemic areas, survival of *Phytophthora* propagules and inoculum build-up is very high due to



Bud rot on coconut



Treating bud rot on coconut

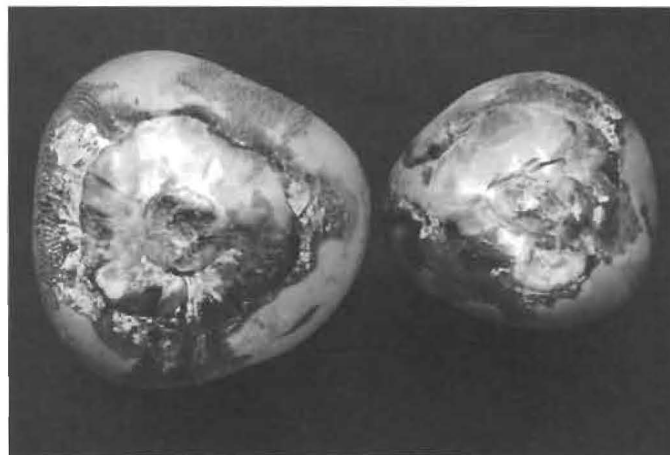
congenial wet weather prevailing almost throughout the year. The pathogen survives the short unfavourable conditions during post-monsoon period in affected coconut crown tissues and begins to multiply in subsequent rainy season. Though in plains or costal area, the incidence of bud rot is seen up to September, in the high humid hilly slopes of Kerala bud rot incidence is common throughout the year due to misty condition and low temperature prevailing even after the monsoon season.

Management

The *Phytophthora* inoculum present in the crown of coconut is the potential primary source of bud rot infection. Further, secondary spread of disease from freshly affected palm is very fast under favourable rainy season. Rain water acts as a carrier for infectious propagules, playing an important role in spread of disease. The snails/slugs prevailing on coconut trees during rainy season also harbour *Phytophthora* propagules. The damage to spindle by rhinoceros beetle or due to severe wind favours the chances of *Phytophthora* infection in endemic areas.

Immature Nut Fall

Immature nut fall in coconut is attributed to several factors, viz. characteristic feature of mother palm, high soil acidity or alkalinity, drought condition or water-logging and sudden changes in soil moisture, and also imbalance or deficiency of nutrients. Poor pollination is also one of the major factors responsible for button shedding in coconut. Shedding of buttons is also caused by insect attack. Eriophyid mite attack also leads to immature nut fall to some extent. The mite injury provides entry points to pathogenic fungi, causing rotting and nut fall. In certain cases, even though mite infestation or injury is negligible, the infection caused by fungal pathogen causes severe rotting and immature nut fall.



Immature nut fall in coconut

Control Measures

Apply curative control measures when the disease is in the initial stage, i.e. when the spindles just start showing symptoms of withering. Remove affected spindles by pulling it out; cut and remove the rotten tissues completely. One or two healthy leaves adjacent to spindle may have to be removed if necessary for easy removal of rotten portions and thorough cleaning. After cleaning, apply 10% Bordeaux paste to the wound and cover it with a polythene cover to protect it from entry of rain water. Retain the cover till the new shoots start emerging. The spindle and crown region of all healthy palms in the surroundings should be sprayed with 1% Bordeaux mixture. It is important to give prophylactic spraying of 1% Bordeaux mixture to all the palms just before the onset of monsoon in endemic areas with previous history of bud rot. Certain dwarf coconut palms namely Chowghat Orange Dwarf and Malayan Yellow Dwarf are sensitive to Bordeaux mixture and show phytotoxic effect after the spray. Hence avoid spraying of Bordeaux mixture to such palms. Alternatively, the *Trichoderma* coir pith cake (TCPC), a formulation of *T. harzianum* developed at CPCRI, Kasaragod, Kerala, has also found to be useful control of bud rot disease in coconut. Placing of two TCPCs in inner most leaf axil at bimonthly interval from May to December acts as prophylactic treatment and help in reducing the spread of the disease.

Nut fall due to fruit rot or Mahali or Kole roga caused by *Phytophthora palmivora* is common in high rainfall areas during monsoon period. Rotting starts from the point of mite infestation on nut surface near the perianth as dark brown to black discoloration and gradually extends to the entire surface area. The lesion also spreads deep into the internal tissues. As the lesions spread to about 30% surface area near the perianth region when lesion encircles the perianth region, the nuts are detached from the bunch and shed or remain on the bunch in between other nuts. The fungi, *Phytophthora palmivora*, *Thielaviopsis paradoxa* and *Lasiodiplodia theobromae* are found associated with rotted nuts. The *P. palmivora* infection is more common in high rainfall areas in monsoon season.

Management

Spraying of 1% Bordeaux mixture on bunches showing symptoms of fungal infection on nuts is helpful in preventing the nut fall. However, presence of other fungi, *L. theobromae* and *T. paradoxa* is also common. Spraying 0.1% Carbendazim on bunches of affected palms is helpful to control immature nut fall in coconut. If coconut is cultivated under organic farming system, spraying of garlic bulb extract (10%) can be recommended to manage the disease.

ARECA NUT

Fruit Rot

Fruit rot arecanut leads to severe shedding and rotting of nuts. It is an economically important disease causing huge losses. The disease may cause fruit drop of 50-100% in individual palms if timely and proper control measures are not



Fruit rot of areca nut

adopted. Fruit rot disease occurs in all areca nut-growing regions receiving heavy rainfall. Farmers face difficulty in taking up prophylactic control measures during uninterrupted continuous heavy rainfall (June-September) which may result in severe losses.

Symptoms

It is characterised by rotting and heavy shedding of immature green nuts. The symptoms appear as dark green water-soaked lesions on nut surface usually near the perianth. Fungus makes entry to the host tissue through stomata or epidermis. The entry is aided by mycelium or germ tube of germinating sporangia. In severe case, fruit stalk and the axis of inflorescence are also affected. Bud rot or crown rot is another manifestation of fruit rot and this may occur independently or following severe fruit rot. The fruit rot may cause loss in nuts during a particular season. However, bud rot and crown rot are fatal and kill the tree.

Bud rot is characterized by rotting of growing buds and surrounding tissues. The initial visible symptoms are yellowing of spindle leaf. The affected spindle loses its natural green colour. In the advanced stages, it turns to yellow and can be drawn out with a gentle pull. As a result of rapid spread of infection to the base of adjacent leaves, these leaves also become yellow, droop and drop off ultimately leaving a bare stem. In crown rot infection, initiates from the base of outer most leaf sheath or from the stalk ends of infected areca bunches or developing inflorescence and slowly spread to the internal tissues of the stem.

The first visible symptom is yellowing of



Bud rot on arecanut



Crown rot on arecanut



Polythene covering of bunches

the outermost leaf sheath. Inner portion of affected sheath exhibits water-soaked lesions and later the infection spreads to tender portion of stem and growing buds, resulting in yellowing of leaves, rotting of internal tissues of crown and finally death of palms.

The *Phytophthora meadii* is major causal agent. In few instances, association of *P. heaveae* with fruit rot of areca nut is observed.

It is also able to cause the disease. The fungus survives as oospores, chlamydospores and mycelium in soil, on fallen nuts, on dried nuts and on inflorescence remaining in the crown. The disease appears usually after 20-25 days after the onset of southwest monsoon and continues up to end of the rainy season. Severity and spread of the disease depends upon the pattern of rain. Continuous heavy rainfall coupled with low temperature (20-23 °C), high relative humidity (> 90%) and intermittent rain and sunshine hours favour the occurrence of fruit rot. Once initiated, the disease spreads quickly through wind-borne rain splashes. The fruit bunches infected towards the end of rainy season may remain

mummified on the palm and such nuts provide inoculums for bud rot or crown rot or the recurrence of fruit rot in the next season.

Management

Prophylactic spraying with one per cent Bordeaux mixture on bunches is needed to prevent the incidence of the disease. The initial spray should be done just before or immediately after the onset of monsoon showers, and the second spray after an interval of 40-45 days. The spraying should be taken up when there is no rain. If monsoon prolongs, one more spray is required. Care

should be taken to prepare the mixture to get the right quality as otherwise an acidic mixture can lead to copper injury and too alkaline mixture may not be effective in control of the disease.

A fine spray is needed for effective spread of spray fluid over the surface of nuts. As a mechanical control measure, the bunches can be covered with polythene covers (125-200 gauge 24 x 30 inches) before the start of heavy monsoon showers. Phytosanitary measures such as removal of all dried and infected bunch attached to the palm and collection and destruction of all shed nuts help in reducing the inoculum load in garden. If proper control prophylactic measures are not taken, not only incidence of fruit rot is severe, but the incidence of bud rot and crown rot more.

Bud rot affected trees can be cured if curative measure are applied in initial stage. Smearing with 10% Bordeaux paste after removal of affected tissues and drenching the crowns of surrounding palms with Bordeaux mixture (1%) is quite effective in saving bud rot affected palms as well as in reducing the incidence.

COCOA

Seedling Blight or Seedling Dieback

Cocoa (*Theobroma cacao* L.) is grown as an under-storey intercrop with sufficient shade in Kerala, Karnataka, Andhra Pradesh and Tamil Nadu. The shady conditions in cropping system with congenial climatic conditions during south-west monsoon season provide favourable conditions for development and spread of *Phytophthora* diseases. The black pod rot, stem canker, leaf and seedling blight /die back of cocoa are caused by *Phytophthora* spp.

Seedling blight is a major problem in nurseries having



Seedling dieback on cocoa

Solarization

Seedling dieback can be checked by solarization of potting mixture in sun or covering with black polythene sheets in summer and by sowing seeds well before the onset of monsoon. Drenching cocoa seedlings with Bordeaux mixture or copper oxychloride just before the onset of monsoon and thereafter at frequent intervals is essential in effective management of disease in nurseries with high disease intensity. A combination of seed dressing and soil drench with copper hydroxide at a concentration of 0.91 kg in 45 litres of water is very effective in controlling pre-and post-emergence seedling death caused by *P. palmivora*.



Black pod disease on cocoa fruits

very young seedlings during rainy season. Defoliation and dieback of seedlings are symptoms of the disease. Generally, infection starts from the tip of the stem and proceeds downwards as dark brown to black water-soaked linear lesions. The lesions also extend to leaves through the petioles, resulting in wilting and subsequent defoliation of seedlings. The infection also initiates from the collar region, cotyledonary stalk or leaves as dark brown to black discolouration. In all cases, infection spreads to entire stem causing wilting, defoliation and ultimately the death of seedlings. The *Phytophthora palmivora* is causal organism. Severe infection of grafted and budded cocoa seedlings is also common in India.

In such cases, infection mainly starts from the grafted or budded region and proceeds upwards and downwards. Infection continues to spread internally after the rainy season leading to high mortality.

Management

Removal and destruction of infected seedlings from nursery are very important management practices to check the secondary spread of the disease. The disease incidence can be considerably reduced by improving drainage facilities in nursery and by providing proper shade.

Black Pod Disease

Black pod rot is most serious disease. Losses can reach 50-100% if no control measures are adopted. The beans of affected pods are not suitable for processing and should be discarded. Disease incidence is maximum during south-west monsoon season (June-August). Infection starts anywhere on pod surface. Pods of all ages are susceptible. Pods damaged by rodents or



Trichoderma coir pith cake

insects or injured while harvesting or carrying out cultural operations are more prone to disease.

Symptom appears as chocolate brown spot which spreads rapidly and soon occupies the entire surface of the pod. As the disease advances, a whitish growth of fungus consisting of fungal sporangia is produced over the affected pod surface. Ultimately, affected pods turn brown to black. The internal tissues as well as beans become discolored as a result of infection. The beans in infected pods approaching ripeness may escape the infection and beans in such pods can be saved by timely harvesting.

Black pod disease is caused worldwide by various species of *Phytophthora*. In India, *Phytophthora palmivora* is most common causing black pod disease though other species namely *P. capsici* and *P. citrophthora* are also recorded. *Phytophthora megakarya*

Management of Black Pod

Phytosanitation, fungicidal application and host resistance are the three major aspects in the management of black pod disease. Periodic removal and destruction of infected pods alone help reduce the disease incidence to by 50% and spraying of Bordeaux mixture (1%) or copper oxychloride (0.5%) at 15 days interval starting from the onset of south-west monsoon is effective in controlling the disease in severely affected gardens. In gardens with less incidence of black pod disease, economic management of disease is possible by periodical removal of affected pods, regular pruning and maintaining proper spacing. Spraying of spores or mycelia suspension of *Trichoderma harzianum* also able to control the disease to some extent.

cause more severe damage on cocoa in African countries is present in India. In rainy season, spores of *Phytophthora* are liberated to soil surface and rain splashes carry these spores to the pods, which are at the lower part of the trunk causing infection. Pods, which are touching the soil surface, are infected directly.

Sporangia are produced abundantly when there is high humidity, rainfall and constant optimum temperature. The pods thus infected act as the source of inoculum for secondary spread of disease. The sporangia are spread by rain splashes, insects and rodents. Tent building ants and scolytid beetles can also carry sporangia from diseased pods to healthy pods. Dried cankers or mummified fruits (pods

infected during the end of rainy season of previous year) act as primary source of inoculum in spreading disease. Foliar infection or infection carried from the nursery also initiate the disease on pods during favourable condition.

Stem Canker

The symptoms appear as greyish-brown water-soaked lesion with a broad dark brown to black margin. A reddish brown liquid oozing out from such lesions dries up and forms a rusty deposit. The *P. palmivora* is only species causing stem canker of cocoa in India. Appearance of round to oval, greyish-brown to dark brown water-soaked lesions with broad dark brown margins anywhere on the main trunk, jorquettes or fan



Stem canker on cocoa (a), external symptom with water-soaked lesion with reddish brown liquid oozing out internal symptom with grayish brown streaks (b)

branches is earliest symptom of disease. This leads to reddish-brown lesion internally. Reddish-brown liquid oozes from these lesions, which later dries up to form rusty deposit. In certain cases, discoloration of bark without any oozing is also observed. Cocoa trees of more than 10 years are more susceptible to this disease compared to younger plants.

Infection on the internal tissues appears as reddish brown discolored area which can be easily distinguished from the surrounding healthy tissue. Lesions inside the bark coalesce, which leads to extensive rotting of internal tissues. The infection spreads from the cortical tissues into vascular tissue. Wood infection appears as greyish brown to black discoloration with black streaks. When canker girdles the main stem or branches we can see wilting and defoliation of leaves, ultimately the tree dies. It is difficult to recognize canker development without any external symptoms on the bark. Such cankers can be recognized only in the advanced stage of the disease

Management

The disease can be controlled in initial stage by the excision of diseased bark, followed by wound dressing with 10% Bordeaux paste. High-yielding trees with advanced stage of disease can be rejuvenated by cutting the whole tree below the



Treatment of stem canker on cocoa with *Trichoderma* coir pith cake

canker lesion and allowing a fresh chupon to develop from the basal portion of the stem. Treating the wound and soil around the base of cocoa tree with *Trichoderma* coir pith cake is also effective in reducing the incidence.

For further interaction, please write to:

Dr P Chowdappa (Director) and Dr Vinayaka Headge (Head), ICAR-Central Plantation Crops Research Institute, Kasaragod 671 124, Kerala.

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– Editor