MANAGEMENT STRATEGIES FOR MAJOR PESTS AND DISEASES OF COCONUT AND ARECANUT

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Palm production faces serious challenges ranging from diseases to damage by insect pests, all of which may reduce productivity as high as 30% (Gitau *et al.*, 2009). The perennial nature of palms provide a continuous supply of food and shelter for the pest population build up which cause considerable damage to the crops during all stages of their growth.

Coconut and arecanut are two economically important tropical palms cultivated in India. India ranks third in area and production of coconut with a production of 12.83 billion nuts from an area of 1.93 million ha. The area under arecanut cultivation in India during 2009-10 was about 4 lakh ha with an annual production of 4.78 lakh tonnes. Both the palms are susceptible to a number of diseases and pests at different stages of growth. Some of them are fatal while others reduce its vigour and finally cause economic loss.

INTEGRATED PEST MANAGEMENT

Integrated Pest Management (IPM) technologies comprising compatible integration of various pest suppression techniques (cultural, prophylactic, chemical, biological and behavioural) have been developed against major pests and these technologies were field validated.

The major pests of coconut palm in India are rhinoceros beetle (*Oryctes rhinoceros* L.), red palm weevil (*Rhynchophorus ferrugineus* Oliv.), leaf eating caterpillar (*Opisina arenosella* Walk.), eriophyid mite (*Aceria guerreronis* Keifer) and the white grub (*Leucopholis coneophora* Burm.) (Rajan *et al.*, 2009). Pests like coreid bug, scale insects, mealy bugs, slug caterpillars and rodents cause considerable damage to coconut in certain locations. Among the various pests reported on arecanut, spindle bug (*Carvalhoia arecae* Miller & China) and the root grub (*Leucopholis burmeisteri* Brenske) are considered as the major pests of the crop on account of their wide distribution and economic damage (Nair *et al.*, 1997).

Adult rhinoceros beetle bores into the unopened spindle leaves and spathes resulting on an average 10% loss in production of nuts. Red palm weevil is the

most dreaded pest of coconut palm as the grubs of the weevil feed inside the palm on the growing point and results in the death of the palm. Leaf eating caterpillar feeds on the chlorophyll containing parenchymatous leaf tissues resulting in massive leaf drying especially in coastal and backwater areas. Eriophyid mite causes severe warting on the buttons and nuts resulting in shedding of buttons and reduction in size of nuts (Nair *et al.*, 2011). White grubs of coconut and arecanut feed on the roots of the palms as well as the intercrops resulting in retardation of growth, reduction in yield and in severe cases the arecanut palms fall down. Spindle bug attacks emerging spindle of arecanut and causes complete decay and death of the spindle.

Cultural / prophylactic control

This includes purposeful manipulation of farm cultural operations for the disadvantage of the pest and preventive measures for entry of the pest. Disposal of dead and decaying coconut logs and other organic debris in the vicinity of coconut plantations constitute an important step in the IPM of rhinoceros beetle as they act as breeding grounds for the pest. In addition, rhinoceros beetles from crown can be extracted using a beetle hook during peak periods of pest infestation (June-September) (Nair *et al.*, 2010).

Maintenance of field sanitation by removal, splitting and burning of dead palms, which harbour various stages of the pest, helps a lot in reducing fresh incidence and hence should be considered as one of the key IPM strategies in the management of red palm weevil. Prevention of pest entry into the palm is the major step to be adopted in the IPM package of this pest. Fermenting smell emanating from the injured portions of the palm attracts the weevils for egg laying. This can be prevented by avoiding injuries on the palm and by treating the wounds, if any, with coal tar + carbaryl. Whenever leaves are cut, a petiole length of 1.2 m should be retained on the palm to prevent the entry of the pest into the trunk through the cut petiole (Abraham and Kurian, 1972; Rajan and Nair, 1997).

Application of powdered oil cakes of neem (*Azadirachta indica* A. Juss.) or marotti (*Hydnocarpus wightiana* Bl.) @ 250g mixed with equal volume of sand, into the top most three leaf axils around the spindle leaf thrice a year during May, September and December is recommended as a prophylactic measure against rhinoceros beetle and red palm weevil. Timely fungicidal treatment for bud rot and leaf rot also is essential for the management of red palm weevil since this act as pre-disposing factors for weevil infestation (Nair *et al.*, 2010).

Raising of suitable green manure crop in coconut basin and its incorporation, application of NPK fertilizers as per recommendation and soil moisture conservation measures are the effective INM strategies for the management of coconut eriophyid mite (Rajan *et al.*, 2010b).

Cutting and burning of the heavily infested and fully dried outermost 2-3 leaves for removing the pupae and other life stages of the pest is a key technique for the management of leaf eating caterpillar. Adequate irrigation and fertilizer application should be provided to rejuvenate severely pest-affected palms (Chandrika Mohan *et al.*, 2010b).

Deep ploughing and digging of the soil during pre and post monsoon periods for exposing grubs to predators is one of the important strategies for the management of coconut root grub. Trapping of adult beetles through light traps during the emergence period (May-June) and their destruction is also widely practiced in root grub IPM. As root grub infestation in arecanut is predominantly seen in low lying and clayey soils where the water table is high, ensuring good drainage can reduce the pest infestation levels (Nair *et al.*, 1997).

Biological control

Biological control using entomopathogens and entomophaga is the widely adopted strategy for the management of rhinoceros beetle and leaf eating caterpillar. Two microbial pathogens *viz.*, green muscardine fungus, *Metarhizium anisopliae* and *Oryctes rhinoceros* virus are currently employed for the suppression of rhinoceros beetle in the field. Treatment of manure pits and other breeding sites with the entomopathogenic fungus, *Metarhizium anisopliae* @ 5×10^{11} spores/m^3 is the most successful technique in the management of rhinoceros beetle (Danger *et al.*, 1991; Nair *et al.*, 2010). In addition release of *Oryctes rhinoceros* virus (OrV) infected beetles @ 10-12 beetles/ha is recommended (Mohan *et al.*, 1989). The virus infects both adults and grubs. The pathogen kills the grubs in 15-20 days and reduces the longevity and fecundity of beetles by 45% and 95%, respectively. Introduction of the pathogen in the natural habitat of the pest causes epizootics has been successfully validated in different regions of the country including different islands of Lakshadweep.

No successful biocontrol agent is identified for the management of red palm weevil so far. Laboratory studies on the utilization of entomopathogenic nematodes (EPN) belonging to *Heterorhabditis* spp. have yielded encouraging results. Effective field delivery techniques using talc based formulation of EPN is being studied currently. EPN, *Heterorhabditis* sp. are effective

against red palm weevil in lab. assay. Talc based formulations of EPN are being assessed at field level.

Predatory mites especially the conservation of predatory phytoseiid mite, *Neosieulus baraki* is recommended as an IPM measure for eriophyid mite. The virulent strains of *H. thompsonii* for the management of the eriophyid mite currently investigated at field level preliminary results indicated 70-80% suppression of pest population (Chandrika Mohan *et al.*, 2010b).

Release of stage specific parasitoids is a successful biocontrol strategies employed against leaf eating caterpillar. The larval parasitoid *Goniozus nephantidis* (Bethylidae) is released if the pest is at 3rd larval stage or above @ 20 parasitoid /palm and *Bracon brevicornis* (Braconidae) @ 30 parasitoid/palm. The pre-pupal parasite *Elasmus nephantidis* Rohw. (Elasmidae) and the pupal parasite *Brachymeria nosatoi* Habu. (Chalcididae) are also very effective in managing the pest. They are released @ 49 and 32% respectively for every 100 pre-pupae and pupae estimated to be present on the palm (Sathiamma *et al.*, 1987). Before field releasing, the parasitoids should be fed with honey and newly emerged parasitoid can be released after 3 days of emergence.

Though no effective bioagents are available against coconut white grub, leads available with EPN particularly *Steinernema* sp. is being explored.

Chemical control

Placement of naphthalene balls in the leaf axils at the base of spindle leaf @ 12g/ palm (3-4 numbers) and covering them with sand to prevent quick evaporation provide good protection against rhinoceros beetle for 45-60 days. Treatment of breeding sites with carbaryl 0.01% is recommended in cases where bioagents are not available (Nair *et al.*, 2010; Rajan *et al.*, 2010a). Recent studies on prophylactic management of rhinoceros beetle revealed leaf axil filling of chlorpyriphos dust or chlorantriniprole granules @ 6g plus 250 g sand could reduce the pest incidence significantly in endemic areas.

For red palm weevil infested palms, curative treatment with 1.0% carbaryl or 0.02% imidaclorpid or 0.013% spinosad is recommended as stem injection method or crown pouring. In stem injection method, after plugging all the holes on the lower part of the palm the insecticide solution is administered into the palm with a funnel through the uppermost hole. If the entry of the pest is through the spindle area, cutting the highly rotten part and pouring the insecticide through the crown shall be adopted.

In severe sporadic outbreaks of leaf eating caterpillar, spraying 0.05% diclorvos or 0.1% malathion on under surface of leaves is recommended.

Drenching the coconut basin with chlorpyriphos @ 0.05% during June and September was found effective in the management of coconut and arecanut root grubs. The insecticide has to be applied in the active root zone of the palms. Insecticidal applications have to be continued for at least three consecutive years for effective management of the pest (Rajan *et al.*, 2009).

Spraying of dimethoate 0.05% in and around the spindle and inner whorls of leaves is recommended for curative treatment of spindle bugs in arecanut plantations (Nair *et al.*, 1997).

Since use of red and yellow labeled insecticides are currently banned in Kasaragod district of Kerala state, the insecticides *viz.* chlorpyriphos, imidacloprid, dimethoate and diclorvos are not permitted for use.

Use of botanicals in IPM

Incorporation of the weed plant *Clerodendron infortunatum* in the breeding sites reduces the population build up of rhinoceros beetle. This weed induces insect growth regulatory effects causing larval-pupal and pupal-adult intermediates of black beetle (Chandrika Mohan *et al.*, 2000).

For the management of coconut eriophyid mite, spraying 2% neem oil-garlic-soap emulsion or azadirachtin 10000 ppm @ 0.004% on young bunches / root feeding of neem based pesticides containing Azadirachtin 5% (7.5 ml + 7.5 ml water) or azadirachtin 1% (10 ml + 10 ml water) thrice a year during January, April and September is recommended (Rajan *et al.*, 2010b).

For the management of coconut and arecanut root grubs, incorporation of neem cake @ 5 kg/palm/year for coconut and 2 kg/palm/year for arecanut is helpful in improving the soil structure and reducing the pest infestation.

Behavioural pest management

Installation of PVC pheromone traps with aggregation pheromone Ethyl, 4-methyl Octonate @ 1 trap / 5 ha is recommended for monitoring and trapping beetles. The collected beetles can also be used for virus inoculation and re-release to the pest infested areas (Nair *et al.*, 2010; Rajan *et al.*, 2010a).

Trapping of red palm weevil using aggregation pheromone lures "Ferrugineol" (4-methyl, 5-nonanol) in food baited bucket traps forms an important component of the IPM strategy. Pheromone trapping @ 1 trap/ ha for monitoring and mass trapping of adults with adequate servicing of trap baits is recommended. Usually, the traps are

serviced once a week and the food bait is replaced. Food bait includes 200 g ripe banana/pineapple, 5 g yeast and 5 g carbaryl mixed with one litre of water. When the trap is set, the chemical from the sachet gets released (volatilized) into the surroundings, attracting the weevil towards the trap and the food attractant in the bucket orients the attracted weevil into the trap. Once trapped, the insect on contact with the insecticide mixed in the food gets killed (Rajan *et al.*, 2009). Presently, aggregation pheromone synthesized in CPCRI and a nanoporous delivery matrix for dispensing the pheromone is being explored.

A systematic and compatible integration of these management techniques is found to be the key factor for the sustainable management of major coconut and arecanut pests. Need based application of insecticides is also employed in the effective management of red palm weevil and root grubs at this point of time. Farmer participatory approach holds an important strategy in understanding the missing links in pest control programmes of these crops thereby resorting to an integrated approach towards innovative pest management. Emphasis should be given for popularization of bio- intensive integrated technologies among farming community through Farmer Field Schools and cluster approaches. The continuous and homestead nature of coconut and arecanut gardens and the flight range of insect pests warrant the necessity for adoption of various technologies on a group approach mode as it will reduce the cost of operation and can produce sustainable results.

Integrated Disease Management

The Integrated Disease Management (IDM) programme integrates all the suitable techniques and methods in a compatible way to prevent and manage diseases in crops and enhance profitability and sustainability of production systems.

COCONUT

Among the diseases affecting coconut palm in India, root (wilt), leaf rot, bud rot, stem bleeding and basal stem rot are the major problems owing to the nature of disease and extent of damage.

Root (wilt) disease

Root (wilt) disease (RWD) is prevalent in a contiguous manner in all the eight southern districts of Kerala starting from Trivandrum to Trichur and in isolated patches in the remaining six northern districts of the state. Apart from this the disease is also prevalent in the districts of Tamil Nadu and Karnataka adjoining to Kerala State. Recently the disease has also been recorded in Goa.

The disease is non lethal, but debilitating. Flaccidity, yellowing and marginal necrosis of leaflets of the leaves of central and outer whorls are considered to be the typical foliar symptoms of RWD (Varghese, 1934; Menon and Nair, 1952; Menon and Pandalai, 1958). Rotting of roots increases with the progress of the disease. Shedding of immature nuts, drying up of spathes and necrosis of spikelets in unopened inflorescence is noticed in certain cases. The husk, kernel and oil of the nuts of the disease affected palms are of poor quality.

Since root (wilt) disease is caused by phytoplasma it is not amenable to conventional plant protection measures. One of the significant features of the disease is that it is not lethal but a debilitating malady which responds to ideal management practices. Two strategies, one for the heavily diseased contiguous area, and another for the mildly affected area have been formulated (Anonymous, 1986; Krishnakumar and Maheswarappa, 2010).

In heavily diseased area, yield of palms can be sustained or even improved through adoption of integrated management practices *viz.* removal of disease advanced and diseased juvenile palms, management of leaf rot disease, balanced fertilizer application, addition of organic manures, raising of green manure crops in basins and incorporation, irrigation during summer months and adopting inter and mixed cropping. Mixed farming in the diseased gardens involving growing of fodder crops in the inter spaces, maintaining milch cows and recycling of organic wastes also enhances income per unit area. Spread of disease in mildly affected areas can be arrested by systematic surveillance and rouging of diseased palms as and when identified.

ELISA test has been developed at CPCRI for the early diagnosis of this disease (Solomon *et al.,* 1983). The varieties 'Kalparaksha', 'Kalpasree' and 'Kalpa Sankara' released from CPCRI have resistance/ tolerance to root wilt disease and can be used for replanting in RWD affected tracts. Disease free seedlings raised from healthy elite mother palms can also be used for replanting.

Leaf rot

Leaf rot occurs superimposed on root (wilt) affected palms. Symptoms appear as tiny water soaked lesions on spindle leaves which gradually enlarge, coalesce freely, leading to extensive rotting. When the spindle grows, the rotten portions dry up, turn dark brown to black, break and blow off in the wind. In many cases, the rotten distal portions of leaflet adhere to each other from

top to bottom on both sides thereby giving a fish bone appearance. Though several fungi have been reported to be associated with leaf rot of coconut, *Colletotrichum gloeosporioides* (Penzig) Penzig & Sacc. and *Exserohilum rostratum* (Drechsler) Leonard & Suggs are the major fungal pathogens (Srinivasan and Gunasekaran, 1996).

The integration of leaf rot management with pest management and general cultivation practices is very effective in improving the health of the palms and thereby increasing the yield (Koshy *et al.*, 2002). Before applying the fungicide, remove the rotten portions of the spindle and the adjacent two innermost fully opened leaves, if affected by leaf rot. Application of Hexaconazole (2 ml) or Mancozeb (3 g) in 300 ml water around the base of the spindle leaf effectively controls the leaf rot disease. The disease can also be controlled by the application of talc based formulation of consortium of *Pseudomonas fluorescens* and *Bacillus subtilis* (50 g in 500 ml). Apply *Hydnocarpus* cake or neem cake mixed with sand around the base of the spindle leaf to control insect pests. All the palms in the garden (healthy and diseased) have to be treated twice a year, in April-May and October-November. To make this operation more economical the treatment can be given along with harvest of nuts before and after south - west monsoon.

Bud rot

In India, bud rot disease has been reported to be caused by *Phytophthora palmivora* (Butler, 1906; Shaw and Sundararaman, 1914). Heavy incidence of bud rot disease leading to the destruction of thousands of coconut palms has been reported from Kuttiadi and Calicut regions of Kerala State.

The primary visible symptom of bud rot is the withering of the spindle. On dissecting such affected trees, rotting of internal tissues could be observed. The affected spindle can easily be pulled out. The inner leaves also fall away one by one, leaving only fully matured leaves in the crown. The rotting tissue emits a foul smell. The palm ultimately succumbs to the disease (Briton-Jones, 1940).

Bud rot disease can be effectively managed, in disease endemic areas, by adopting integrated management practices. Before the onset of rainy season, remove all disease advanced and dead palms and destroy the infected crown region. Measures like improved drainage, crown cleaning and field sanitation would help in reducing the disease incidence to a great extent. Prophylactic treatment with Mancozeb solution (5g in 300 ml water) in the innermost leaf axils coupled with the placement of two perforated sachets in the innermost leaf axils

(5 g Mancozeb/sachet) or Akomin @ 1.5 ml in 300 ml effectively protects the palms from bud rot incidence. Adopt management practices recommended for other pests and diseases especially rhinoceros beetle.

During rainy season repeat the prophylactic fungicide treatment at 2 months interval. If bud rot disease is observed, adopt curative treatment in the initial stage of disease and destroy the infected tissues removed by burning or burying deep in the soil. Remove infected tissues completely in the early stage of disease. Immediately after removing the infected tissue, treat the wound and inner most leaf axils with Mancozeb as in the case of prophylactic treatment. Cover the wound with a polythene sheet to prevent entry of rain water. The protective covering has to be retained till normal shoot emerges (ChandraMohanan, 2011).

Stem bleeding

Stem bleeding disease is known to occur in all coconut growing regions in the tropics. The disease is characterized by development of dark brown patches with dark reddish brown exudation appearing at the basal portion of the trunk. The exudates eventually dry up to form black encrustations with brownish orange margin. The tissues beneath the discoloured patch show decay. The internal decay can be observed even in areas beyond the margins of external lesions indicating that the internal decay is not confined to the area of external symptoms. The outer whorl of leaves become yellow rather prematurely, droops and finally dries up. Though nut fall is noticed in later stages of disease, it is more in palms exposed to drought conditions. The trunk gradually tapers towards the apex and the crown size is reduced. *Thielaviopsis paradoxa* (de Seynes) von Hohnel has been isolated from affected stem tissues (Nambiar, 1994). In advanced stages of the disease, infestation with *Diocalandra* weevil can be seen which quickens the deterioration of the palms.

The disease can be effectively managed if control measures are adopted in early stages of infection. The affected tissues should be completely removed using a chisel. Destroy the chiselled tissues by burning. Treat the wound with Tridemorph 5% followed by application of hot coal tar after 2 days. Root feeding with 100 ml 5% Tridemorph thrice a year during June, Sept. - Oct. and January is effective. Soil application of 5 kg neem cake fortified with *Trichoderma* per palm per year during Sept. - Oct. is also found beneficial. Summer irrigation improves the health of the palm as well as yield. Any type of wounding of palms is to be avoided.

Basal stem rot

Basal stem rot also known as *Ganoderma* wilt or Thanjavur wilt is a very important destructive disease of coconut. Wide spread occurrence of the disease is noticed in Tamil Nadu, the maidan tracts of Karnataka and coastal districts of Andhra Pradesh. The disease is reported to be caused by *G. applanatum* and *G. lucidum.*

Wilting of leaflets, yellowing of the leaves of lowest leaf whorl and decay and death of fine roots are the symptoms in the initial stage of disease development. As the disease advances, bleeding patches appear at the base of the stem near the ground level; the lesions gradually extend upwards; roots decay extensively and there is no new bunch production. The outer leaf whorl dries and drops off; other leaves also droop except the spindle leaf and surrounding two or three young leaves which remain erect and healthy. Ultimately all the leaves droop and fall off leaving the decapitated stem. Stem shrivels and dries up. The scolytid beetle, *Xyleborus perforans* and the weevil, *Diocalandra stigmaticollis* infesting the stem in large numbers accelerate the death of the palm.

The disease can be effectively contained by following an integrated approach with cultural, chemical and biological methods. Remove the dead palms and palms in advanced stages of the disease and destroy the bole and root bits of these palms. Isolate diseased palms from healthy palms by digging isolation trenches of 1 m deep and 30 cm wide. Provide regular basin irrigation during summer months or moisture conservation by coconut husk burial (250 husks/palm). Avoid flood irrigation or ploughing in infected gardens to prevent spread of the inoculum. Apply 50 kg of farmyard manure or green leaves or 200 kg tank silt per palm per year. Apply 5 kg neem cake per palm per year. Drench soil with 40 L of 1 per cent Bordeaux mixture thrice a year for one year. Tridemorph (2 ml/100 ml) can be used for root feeding. Fungicide treatments will be effective only for palms in early stages of the disease. If *Xyleborus* attack is found in the stem, smearing with an insecticide may be done. Raising banana as intercrop reduces spread of the disease.

ARECANUT

The arecanut palm is affected by a number of diseases during different stages of its growth and development. However, based on the extent of damage and nature of disease, the fruit rot, foot rot, yellow leaf disease, bud rot and inflorescence dieback are considered to be the major diseases.

Phytophthora diseases of arecanut

Fruit rot or *Mahali* or *Koleroga,* bud rot and crown rot are the important Phytophthora

diseases of arecanut causing direct loss in yield. The disease has been reported from all the arecanut growing areas of the country with varying intensities and crop loss ranging from 50-90% (Reddy and Anandaraj, 1980).

Rotting and excessive shedding of the nuts are characteristic symptoms of fruit rot. Typical symptoms on the fruit appear as dark green water soaked lesions on the nut surface near the perianth which gradually spread covering the entire nuts causing rotting and shedding of nuts (Saraswathy, 2003). Bud rot appear as yellowing of spindle leaf and rotting of growing bud and surrounding tissues. Palm emits a disagreeable odour. Crown rot symptom initiates from the leaf sheath of outermost leaves during South-West monsoon and gradually spreads towards the growing bud. Severe infection leads to death of the palm. Both the diseases are seen during monsoon and subsequent cooler months up to February

Phytophthora diseases can be greatly reduced by improving drainage in the gardens and by removing infected fruits on the trees and those that have fallen to the ground. Covering the bunches with polyethylene covers of size 85 X 75 cm and 200 gauge thickness, prior to the monsoon is very effective in preventing fruit rot incidence. Prophylactic spray with 1% Bordeaux mixture was found to be very effective in the management of fruit rot disease. Recently it has been found that drenching the root zone of the palms with phosphorous acid or tridemorph at 0.3% concentration (3 ml/litre of water) in the initial stages of the disease as very effective in the management of bud rot and crown rot diseases. Minimum of 5 litre fungicidal solution/palm (15 ml fungicide in 5 litre water) is required for drenching. In advanced stages of the disease, 250 ml of phosphorous acid or tridemorph at 0.3% concentration can be poured inside the crown.

Inflorescence die back

Wide spread occurrence of this disease has been reported from Kerala and Karnataka state. The symptom appears as yellowing and drying of rachis from the tip towards the base followed by shedding of female flowers. Hence the disease is known as inflorescence die back.

Phytosanitation is also equally important as fungicidal control. Remove fully affected inflorescences and destroy them by burning to prevent the spread and severity of the disease. Spray Indofil M 45 (@3g/L) or Zineb 75% (@4g/L) on opening of female flowers in most of the inflorescence. This should be followed by a second spray after 25 days.

Foot rot (basal stem rot / '*anaberoga*')

The disease is reported from Kerala, Assam, West Bengal, Nicobar Islands, Karnataka and from Mettupalayam areas of Tamil Nadu. The palms cannot be identified in the initial stage of the disease. The visual symptom of the disease is yellowing of the outer whorl of the leaves which gradually dry and hang like a skirt around the stem. In advance stages spindle also gets dried up and finally the crown topples down leaving the bare stem. Simultaneously symptoms are seen at the basal portion of the stem as small dull brown spots which coalesce to form bigger discoloured patches. In the acute stage of the disease a brown gummy liquid oozes out through these patches. The bracket shaped fruiting bodies of the fungus are formed at the base of the trunk usually after the death of the palm or on the stump or rarely on the live palm. The roots of affected palms are brittle, dry and have a musty smell. The pathogen causing basal stem rot is *Ganoderma lucidum*.

The disease can be effectively controlled in the early stages of infection by root feeding of 125 ml of 1.5% Tridemorph. To minimize the disease incidence the adjacent palms have to be given soil drenching with 1.5% Tridemorph at quarterly intervals (Kumar and Nambiar, 1996). The diseased palms are to be isolated by taking trenches. Dead and disease advanced palms should be removed and destroyed. Besides the fungicidal treatment the soil fertility and root formation can be improved by application of FYM, green leaf and neem cake in addition to the recommended dose of NPK fertilizers.

Yellow Leaf Disease

Yellow Leaf disease (YLD) is the most serious malady affecting arecanut cultivation in Kerala and Karnataka, which considerably reduced the production and quality of the product.

Characteristic yellowing of leaves is the most important visual symptom of the disease and hence the name yellow leaf disease. Yellowing starts from the tip of the leaflets on either side of the leaf and gradually extends to the base. When yellowing extends from the tip to the basal portion of leaflets there will be a clear band of green tissue adjacent to the midrib. There is a clear demarcation between the green and yellow region of the leaflet at this stage. The tip of the infected leaves become necrotic and eventually dry up. Immature nut fall, kernel discolouration and extensive root rot are also observed (Rawther, 1976; Nair, 1994). Extensive and systematic research conducted revealed phytoplasma as the causal organism of YLD.

One of the significant features of this disease is that it is not lethal but a slow declining malady. In managing the disease two strategies, one for the mildly affected

area and other for heavily diseased area, have been formulated. The strategy for mildly affected area is to contain the disease by removing all the diseased palms. If the programme is not continuously monitored the desired goal will not be achieved.

In heavily diseased areas, yield of the palms can be sustained or even improved through adoption of integrated management practices *viz.* removal of disease advanced and juvenile palms, balanced fertilizer application, application of additional amount of phosphorous, addition of organic manures, irrigation during summer months, improving drainage, growing cover crops and by practicing plant protection measures. The income from a unit area can be further increased by adopting inter and mixed cropping. Loss can be reduced to the minimum if the palms could be attended immediately on appearance of symptoms. Seedlings produced from disease free elite mother palms identified in hot spots may be used as quality planting material for the replanting programme in disease endemic areas.

Conclusion

Integration of various pest and disease management practices depends on several factors like the crop, the disease/ pathogen, cropping system, location and climatic factors. Integrated management needs vary with the crop and farming system. A holistic approach is needed for economic and efficient pest/disease management in coconut and arecanut. The synchronization of plant protection measures to be adopted will help to reduce the cost involved. Adoption of appropriate and economically viable management practices will help in enhancing the profitability and sustainability. Extensive research is going on to integrate the different components of pest/disease control in an effective manner to reduce losses due to various pests/diseases.

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